

73.09.02.010_FR_EPC – EPC FINAL PERFORMANCE TEST REPORT

Grand River Energy Center Unit 3

KED PROJECT NO. 2014-071

ISSUED: 10/25/2017

REVISION 0 – Initial Issue

Rev.	Prepared by	Checked by	Comments
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EPC – FINAL PERFORMANCE TEST REPORT

TABLE OF CONTENTS

SECTION 1: EXECUTIVE SUMMARY

1.1	Overview	1
-----	----------------	---

SECTION 2: TEST DESCRIPTION

2.1	Test Overview	3
-----	---------------------	---

2.2	Test Facility Information	3
-----	---------------------------------	---

2.3	Test Boundary	3
-----	---------------------	---

2.4	Key Party Representatives	3
-----	---------------------------------	---

SECTION 3: TEST EQUIPMENT

3.1	Equipment Overview	5
-----	--------------------------	---

3.2	Equipment Information	5
-----	-----------------------------	---

3.3	DAS Description	5
-----	-----------------------	---

3.4	Calibration Summary	5
-----	---------------------------	---

SECTION 4: TEST DEVIATIONS AND DISCUSSION

4.1	Major Test Deviations	6
-----	-----------------------------	---

4.2	Test Discussion	7
-----	-----------------------	---

SECTION 5: DATA COLLECTION AND CALCULATIONS

5.1	Data Collection	10
-----	-----------------------	----

5.2	Data Reduction	10
-----	----------------------	----

5.3	Definition of Terms	10
-----	---------------------------	----

5.4	Correction Factors	12
-----	--------------------------	----

5.5	Test Calculations	14
-----	-------------------------	----

SECTION 6: TEST RESULTS AND CONCLUSIONS

6.1	Test Results	15
-----	--------------------	----

6.2	Test Conclusions	15
-----	------------------------	----

APPENDICES

Appendix A	Test Calculations
Appendix B	Unit Stability Analysis
Appendix C	Test Uncertainty Analysis
Appendix D	Test Equipment Information
Appendix E	Equipment Calibrations
Appendix F	Correction Curves
Appendix G	Performance Test Data
Appendix H	Fuel Analysis
Appendix I	Signed Deviation Letter

REFERENCES

Engineer, Procure and Construct Contract (EPC Contract)

ASME PTC Test Codes: 1-2011, 4.4-2008, 6.2-2011, 19.1-2005, 19.2-2010, 19.3-2004,
19.5-2004, 22-2005, 46-1996

ASTM Standards: D1945-1996, D3588-1998

AGA Report 8

ASME Steam Tables – 1997

ASHRAE Psychrometric Properties – 2009

GPA 2145-2009

SECTION 1

EXECUTIVE SUMMARY

1.1 Overview

The Engineer, Procure and Construct (EPC) testing at the Grand River Energy Center Unit 3 (GREC U3) project was conducted from 23:00 to 24:00 on July 6th, 2017 and from 3:15 to 5:15 on July 7th 2017 to verify the facilities capabilities to satisfy Kiewit's EPC contractual guarantees with the Grand River Dam Authority (GRDA). The facility includes one MHI M501J Combustion Turbine Generators (CTG), one Heat Recovery Steam Generators (HRSG) with supplemental firing capability, one axial exhaust Steam Turbine Generator (STG) and associated balance of plant (BOP) equipment. The CTGs are natural gas fired only. Performance testing was conducted with the CTG at base load, with the plant operating as outlined in the test procedure over three (3) separate one (1) hour test periods to determine the following:

- Facility-Wide Unfired Net Electrical Output and Heat Rate

The performance test data collected during the test periods indicates failing results. Details about the calculations performed for this performance test are included in Section 4 of this report. A summary of the performance test results are included below:

Parameter	Units	Guarantee	Measured Test Results	Corrected Test Results	Margin	Pass / Fail
Unfired Net Electrical Output	kW	449,960	444,232	450,521	561	Pass
Unfired Net Heat Rate	Btu/kWh LHV	5,723	5,800.1	5,714.4	8.6	Pass

Any major deviations from the test requirements and/or procedures are documented in Section 4. These deviations were agreed to by all parties to the test. The major deviations along with brief discussions of the reason for deviations are included below:

- Section 2.3 and Appendix C of the procedure state that the auxiliary power will be measured using a temporary instrument at five-minute time intervals. All parties to the test agreed to use the station instruments (which have been validated using temporary instruments) for the HRSG Aux Power measurement and to use the STG Aux Power measurements taken using a temporary instrument one time after the performance test.
- All parties to the test agreed two closed cooling water heat exchangers will be in service during testing as one heat exchanger was insufficient to support plant operation.

- All parties to the test agreed the fuel gas heater 3 way gas bypass valve will not be closed during the testing. This is inconsistent with the thermal design of the plant, but required by MHPSA to support CTG operation.
- All parties to the test agreed that an IGV inspection shall not be performed within 24 fired hours of the start of testing.
- All parties to the test agreed that a separate pretest need not be performed.
- All parties to the test agreed that in order to accurately measure the cooling steam going to the gas turbine, the HP backup steam warming line and the associated DSH (03-V035635 and 03-TV-035636) were to be closed for the duration of the testing.
- All parties to the test agreed that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in “high power” mode after a load change.

The following deviations from the test requirements and/or procedures occurred during the performance test. The deviations along with brief discussions of the reason for deviation are included below:

- None

END OF SECTION

SECTION 2

TEST DESCRIPTION

2.1 Test Overview

The objective of the EPC Performance Test was to determine the capability of the facility to satisfy the guarantees set forth in the contractual agreement to GRDA. All performance testing was conducted with the CTGs at base load with the chiller off and the HRSG unfired.

The Performance Test for the GREC U3 EPC was conducted from 23:00 to 24:00 on July 6th, 2017 and from 3:15 to 5:15 on July 7th 2017. The performance test was conducted over three (3) one (1) hour test periods to determine the following:

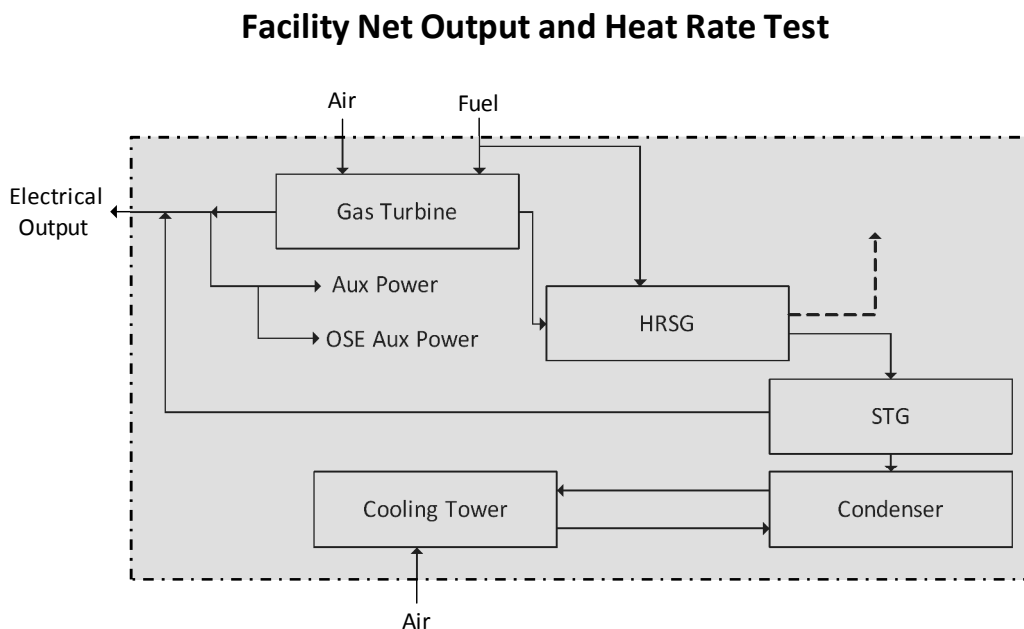
- Facility-Wide Unfired Net Electrical Output and Heat Rate

2.2 Test Facility Information

The Grand River Energy Center Unit 3 is a new power production facility located on the property of the existing Grand River Energy Center near Chouteau, Oklahoma. The facility consists of one MHI M501J Combustion Turbine Generator (CTG), one three-pressure Heat Recovery Steam Generator (HRSG) with supplemental firing capability, one axial exhaust Steam Turbine Generator (STG) and associated Balance of Plant (BOP) equipment.

2.3 Test Boundary

A schematic of the scope for the performance tests is shown below:



2.4 Key Party Representatives

The following parties and their designated representatives were present for the Grand River Energy Center Unit 3

Performance Tests.

Kiewit: Adam Decker, Parag Pathak, Chris Stelzer, Russ
McLandsborough
GRDA: Jammie Burrow
B&V: Travis Brockmeyer, Erik Keltner

END OF SECTION

SECTION 3

TEST EQUIPMENT

3.1 Equipment Overview

To the greatest extent possible the test data was monitored and recorded by the permanent plant instrumentation using the Facility's Distributed Control System (DCS). Temporary test instrumentation and metering equipment was used where there was not permanent plant instrumentation and/or where performance test instrument accuracy was required. Data from the DCS was recorded electronically at 10-second time intervals and temporary test instruments was recorded electronically at 30-second time intervals.

3.2 Equipment Information

The general information for the temporary and permanent plant instrumentation used during the performance test is included in Appendix D and includes the following:

- Measured Parameter
- Instrument Location
- Instrument Tag Number

3.3 DAS Description

Performance test data were recorded from permanent plant instruments via the DCS, temporary test instrumentation, and manual data taken by personnel. Temporary instrument measurements were compiled to centralized computers provided by McHale Performance. Following the completion of the performance test, this data was distributed to all key witnessing parties. Data was gathered every 10 or 30 seconds.

3.4 Calibration Summary

Instruments used for data collection were classified as Primary or Secondary before commencement of the performance test. A Primary instrument is any instrument used in the performance test calculations. All other instruments recording data during testing are considered secondary instruments.

All Primary instruments were calibrated by a third party within 6 months prior to the start of testing with the exception of flow meters. Primary instruments were calibrated to a NIST traceable standard. Secondary instruments having factory calibrations were acceptable. Secondary instruments were required for loop calibration before commencement of testing.

Copies of the calibration certificates were provided to interested parties upon request. The calibration certificates are included in Appendix E.

END OF SECTION

SECTION 4

TEST DEVIATIONS AND DISCUSSION

4.1 Major Test Deviations

The following deviations from the test requirements and/or procedures are documented along with brief discussions of the reason for deviation below:

4.1.1 Test Deviations Discussed Prior to Testing

The following major deviations from the test requirements and/or procedures were discussed and agreed to by all parties to the test prior to testing. The major deviations along with brief discussions of the reason for deviation are included below:

- Section 2.3 and Appendix C of the procedure state that the auxiliary power will be measured using a temporary instrument at five-minute time intervals. All parties to the test agreed to use the station instruments (which have been validated using temporary instruments) for the HRSG Aux Power measurement and to use the STG Aux Power measurements taken using a temporary instrument one time after the performance test.
- All parties to the test agreed two closed cooling water heat exchangers will be in service during testing as one heat exchanger was insufficient to support plant operation.
- All parties to the test agreed the fuel gas heater 3 way gas bypass valve will not be closed during the testing. This is inconsistent with the thermal design of the plant, but required by MHPSA to support CTG operation.
- All parties to the test agreed that an IGV inspection shall not be performed within 24 fired hours of the start of testing.
- All parties to the test agreed that a separate pretest need not be performed.
- All parties to the test agreed that in order to accurately measure the cooling steam going to the gas turbine, the HP backup steam warming line and the associated DSH (03-V035635 and 03-TV-035636) were to be closed for the duration of the testing.
- All parties to the test agreed that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in “high power” mode after a load change.

4.1.2 Test Deviations Found During Testing

The following major deviations from the test requirements and/or procedures occurred during the performance test. The major deviations along with brief discussions of the reason for deviation are included below:

- None

4.2 Test Discussion

The following are not test deviations, but are items of note:

- At this time, testing was only conducted for the unfired conditions.
- The vacuum pump heat exchangers were be run on service water in between test runs, and switched to circulating water for the test runs to minimize fouling of the strainers and heat exchangers.

4.2.1 Other Test Deviations

The following are not deviations to the CTG test, but are deviations to the other tests performed simultaneously. They are included to give a more complete picture of the testing.

STG Test

- Section 3.5.2.7 of the procedure states the unfired f_{Design} is 0.0693. All parties to the test agreed the correct value is 0.0369.
- Section 2.3 and Appendix C of the procedure state that the auxiliary power will be measured using a temporary instrument at five-minute time intervals. All parties to the test agreed to use the STG Aux Power measurements taken using a temporary instrument one time after the performance test.
- One of the steam turbine LP balance pipe sensing lines on DP2 was plugged and could not be cleared. All parties to the test agreed to use the design value for the flows through the LP balance piping.
- All parties to the test agreed that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in “high power” mode after a load change.
- The data collected during the N2 packing test did not evaluate into a result that made sense. The data predicts approximately 36% N2 packing leakage. MHPS believes the location of the HP to LP balance piping is influencing the measurements taken during the N2 packing test. For results purposes, the N2 packing leakage was calculated as follows:

$$Q_{N_2} = Q_{HP_FW} + Q_{HP_TCA} + Q_{HP_DSH} - Q_{HP_FGH} - Q_{HP_CS} - Q_{HP_Gland} - Q_{HP_to_LP} - Q_{CRH} - U_{N_2}$$

Where U_{N_2} is the uncertainty of the calculated N2 flow and $Q_{CRH_Measured}$ is the CRH flow measured using the CRH flow element.

- The stability of the LP steam flow was outside the procedure limits during test run 2. In order to meet the procedure stability criteria, the analysis period for test run 2 was changed from 3:15-4:15 to 3:45-4:15.
- The leakage out of the cycle was greater than the test code requirement of 0.25% of the condensate flow. This leakage has been subtracted from calculated flows on a flow weighted basis.

HRSG Test

- Appendix C of the procedure states the auxiliary power will be measured using a temporary instrument. All parties to the test agreed to use the station instruments (which have been validated using temporary instruments) for this measurement.
- All parties to the test agreed that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in “high power” mode after a load change.
- The HP feedwater flow did not meet the stability criteria for variation during a test run listed in the test procedure for any of the test runs.
- The TCA flow did not meet the stability criteria for variation from the reference conditions listed in the test procedure for any of the test runs.
- The TCA duty did not meet the stability criteria for variation from the reference conditions listed in the test procedure for any of the test runs
- The measured HRH temperature at the STG was used to calculate the HRSG performance as the HRH temperature measured at the HRSG was suspect as it was lower than the temperature at the STG.
- The Ammonia Vaporizer power was not measured during the performance test. The vaporizer supplier provided a curve of power consumption vs ammonia flow which was used to add to the measured HRSG aux power.

CTG Test

- All parties to the test agreed the fuel gas heater 3 way gas bypass valve will not be closed during the testing. This is inconsistent with the thermal design of the plant, but required by MHPSA to support CTG operation.
- All parties to the test agreed that an IGV inspection shall not be performed within 24 fired hours of the start of testing.
- All parties to the test agreed that a separate pretest need not be performed.

- All parties to the test agreed that in order to accurately measure the cooling steam going to the gas turbine, the HP backup steam warming line and the associated DSH (03-V035635 and 03-TV-035636) shall be closed for the duration of the testing.
- All parties to the test agreed that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in “high power” mode after a load change.
- All parties to the test agreed that the CTG is not required to operate only in exhaust temperature control mode, but rather operation on either blade path temperature control or exhaust temperature control is acceptable.

END OF SECTION

SECTION 5

DATA COLLECTION AND CALCULATIONS

5.1 Data Collection

Performance test data were recorded on the DCS, temporary test instrumentation, and manual data were taken by personnel. Data from the DCS and temporary test instruments were recorded electronically. Manual data were recorded on data sheets and was scanned for storage and distribution.

All the data and information gathered were used to correct the measured test results to the base reference conditions listed in Appendix A of the Test Procedures. Data used to calculate the corrected performance results for the Performance Tests were provided to the key witnessing parties.

5.2 Data Reduction

Performance test data collected were arithmetically averaged for each test period. The averaged data were used to correct the initial test results of each test period. After all corrections were completed, the corrected results were arithmetically averaged for comparison to the contractual guarantee values.

Data collected were analyzed for bad data and outliers. The methods contained in ASME PTC 19.1 were used to conduct the outlier analysis. No data was excluded as a result of this analysis.

5.3 Definition of Terms

The following is a summary of the terms used in the computation of test results

FGH – Fuel gas heater

DSH – Desuperheater

TCA – Turbine cooling air cooler

Design – Subscript indicates design value

5.3.1 Power Measurements

P_{CTG} = CTG Generator Gross Power Output, kW

P_{STG} = STG Generator Gross Power Output, kW

P_{UAT} = Aux Transformer Low Side Power, kW

P_{RAT} = Reserve Aux Transformer Low Side Power, kW

PF_{CTG} = CTG Generator Power Factor

PF_{STG} = STG Generator Power Factor

PF_{CTG_GSU} = CTG GSU Power Factor

PF_{STG_GSU} = STG GSU Power Factor

PF_{UAT} = Aux Transformer Power Factor

PF_{RAT} = Reserve Aux Transformer Power Factor

HZ_{CTG} = CTG generator frequency, Hz

$P_{\text{Non_Design}}$ = Non-Design Aux Loads in Operation, kW

5.3.2 Boundary Measurements

$T_{\text{DB_CTG}}$ = Ambient dry bulb temperature at CTG, Deg F
 $T_{\text{WB_CTG}}$ = Ambient wet bulb temperature at CTG, Deg F
 P_{Baro} = Barometric pressure, psia
 $T_{\text{DB_CT}}$ = Cooling tower dry bulb inlet temperature, Deg F
 $T_{\text{WB_CT}}$ = Cooling tower wet bulb temperature, Deg F
 T_{FG} = Fuel gas temperature at metering station outlet, Deg F
 P_{FG} = Fuel gas pressure upstream compressor suction, psig
 $N_{\text{Fuel_x}}$ = Fuel gas composition, mole % (x=components)

5.3.3 Flow Measurements

$Q_{\text{FG_ACF}}$ = Plant fuel gas flow, ACF/h
 P_{FG} = Plant fuel gas pressure, psia
 T_{FG} = Plant fuel gas temperature, Deg F
 P_{DB} = Duct burner fuel gas pressure, psia
 T_{DB} = Duct burner fuel gas temperature, Deg F
 DP_{DB} = Duct burner fuel gas DP, inH2O

5.3.4 Corrected CTG Test Data

$P_{\text{Corr_CTG}}$ = Corrected CTG Net Output, kW
 $HR_{\text{Corr_CTG}}$ = Corrected CTG Net Heat Rate, Btu/kWh
 $T_{\text{Corr_CTG}}$ = Corrected CTG Exhaust Temp, Deg F
 $EF_{\text{Corr_CTG}}$ = Corrected CTG Exhaust Flow, kW
 $E_{\text{Corr_CC}}$ = Corrected CTG Combustor Cooler Energy, mmBtu/h
 $E_{\text{Corr_TAC}}$ = Corrected CTG TAC Energy, mmBtu/h

These values were obtained from concurrent CTG testing

5.3.5 Corrected HRSG Test Data

$Q_{\text{Corr_HP}}$ = Corrected HP Steam Flow, lb/h
 $Q_{\text{Corr_IP}}$ = Corrected IP Steam Flow, lb/h
 $Q_{\text{Corr_LP}}$ = Corrected LP Steam Flow, lb/h
 $T_{\text{Corr_HP}}$ = Corrected HP Steam Temp, Deg F
 $T_{\text{Corr_HRH}}$ = Corrected HRH Steam Temp, Deg F
 $T_{\text{Corr_IP}}$ = Corrected IP Steam Temp, Deg F
 $T_{\text{Corr_LP}}$ = Corrected LP Steam Temp, Deg F
 $DP_{\text{Corr_HRSG}}$ = Corrected HRSG Backpressure, inH2O
 $DP_{\text{Corr_RHTR}}$ = Corrected Reheater Pressure Drop, psi
 $P_{\text{HRSG_Aux}}$ = Corrected HRSG Aux Power, kW

These values were obtained from concurrent HRSG testing

5.3.6 Corrected STG Test Data

$P_{\text{Corr_STG}}$ = Corrected STG Net Output, kW
This values was obtained from concurrent STG testing

5.3.7 Calculated Values

$P_{\text{CTG_GSU_Loss}}$ = CTG GSU Transformer losses, kW
 $P_{\text{STG_GSU_Loss}}$ = STG GSU Transformer losses, kw
 $P_{\text{UAT_Loss}}$ = Aux Transformer losses, kW
 $P_{\text{RAT_Loss}}$ = Reserve Aux Transformer losses, kW
 $A_{\text{CTG_Excite}}$ = CTG Excitation Current from V curve, A
 $A_{\text{STG_Excite}}$ = STG Excitation Current from V curve, A
 $P_{\text{CTG_Excite}}$ = CTG excitation power, kW
 $P_{\text{STG_Excite}}$ = STG excitation power, kW
 P_{PN} = Net Plant Output, kW
 HR_{PN} = Net Plant Heat Rate, Btu/kWh
 Q_{FG} = Plant fuel gas flow, lb/h
 Q_{DB} = Duct burner fuel gas flow, lb/h
 HV_{FG} = Fuel gas heating value, Btu/lb LHV
 HI_{PN} = Net Plant Heat Input, Btu/h
 HI_{DB} = Duct burner heat input, Btu/h
 $P_{\text{Corr_PN}}$ = Corrected Net Plant Output, kW
 $HR_{\text{Corr_PN}}$ = Corrected Net Plant Heat Rate, Btu/kWh

5.4 Correction Factors

Corrections were made to the performance of plant equipment using additive and multiplicative correction factors.

5.4.1 Additive Corrections

The following corrections were made to the performance of plant using additive correction factors.

Corrections for OFE performance

Corrections were based on the corrected performance of each parameter as determined using the appropriate equipment test procedure with the exception that any degradation correction (if present) was not applied.

ΔP_{CTG} = Correction for power output of CTG during test, kW
 ωP_{CTG} = Correction for power output of CTG during test, Btu/h
 ΔP_{STG} = Correction for power output of STG during test, kW
 ΔP_{HRSG} = Correction for auxiliary power of HRSG during test, kW
 ΔHR_{CTG} = Correction for heat rate of CTG during test, kW
 ωHR_{CTG} = Correction for heat rate of CTG during test, Btu/h

ΔET_{CTG}	=	Correction for exhaust temp of CTG during test, kW
ΔEF_{CTG}	=	Correction for exhaust flow of CTG during test, kW
ΔTCA_{CTG}	=	Correction for TCA cooler energy during test, kW
ΔSCE_{CTG}	=	Correction for steam cooling energy during test, kW
$\Delta RHDP_{HRSG}$	=	Correction for HRSG RHTR pressure drop during test, kW
ΔDP_{HRSG}	=	Correction for HRSG backpressure during test, kW
ωDP_{HRSG}	=	Correction for HRSG backpressure during test, Btu/h
ΔQ_{HP}	=	Correction for HRSG HP steam flow during test, kW
ΔT_{HP}	=	Correction for HRSG HP steam temp during test, kW
ΔQT_{RHTR}	=	Correction for HRSG IP added flow and reheater temperature during test, kW
ΔQT_{LP}	=	Correction for HRSG LP flow and temp during test, kW

Corrections for plant performance

$\Delta 2_{GSU}$	=	Correction for GSU Losses, kW
$\Delta 2_{Gen}$	=	Correction for generator power factor, kW
$\Delta 5_A$	=	Correction for ambient conditions at cooling tower, kW
$\Delta 6_{OD}$	=	Correction for off design auxiliary loads in operation, kW
$\Delta 6_{FGC}$	=	Correction for fuel gas pressure, kW
$\Delta 7$	=	Correction for duct burner duty different than design, kW
$\omega 7$	=	Correction for duct burner duty different than design, Btu/h

5.4.2 Multiplicative Corrections to Power

The following corrections were made to the performance of plant using multiplicative correction factors.

$\alpha 1\&3$	=	Correction for ambient temperature and RH at CTG
$\alpha 2$	=	Correction for barometric pressure
$\alpha 4$	=	Correction for fuel supply temperature
$\alpha 5$	=	Correction for fuel composition
$\alpha 6$	=	Correction for speed/frequency

5.4.3 Multiplicative Corrections to Heat Input

$\beta 1\&3$	=	Correction for ambient temperature and RH at CTG
$\beta 2$	=	Correction for barometric pressure
$\beta 5$	=	Correction for fuel composition
$\beta 6$	=	Correction for speed/frequency

5.4.4 Corrections for Degradation

No corrections for degradation were applied. Specifically, the OFE equipment corrected results for use in calculating the Corrected Facility Net Results were calculated without application of any degradation corrections.

5.5 Calculations

The Corrected Net Output and Heat Rate were calculated as follows:

5.5.1 Miscellaneous Calculations

$$P_{CTG_Excite} = 12.5 + 6.4 + 20.8 * \frac{A_{CTG_Excite} * \frac{\sqrt{2}}{\sqrt{3}}}{2890} + \frac{A_{CTG_Excite}^2 * 0.1113 + 2 * A_{CTG_Excite}}{1000}$$

$$P_{STG_Excite} = 11.2 + 5.69 + 10.67 * \frac{A_{STG_Excite} * \frac{\sqrt{2}}{\sqrt{3}}}{2870} + \frac{A_{STG_Excite}^2 * 0.0966 + 2 * A_{STG_Excite}}{1000}$$

5.5.2 Corrected Facility Net Electrical Output

$$P_{PN} = P_{CTG} + P_{STG} - P_{UAT} - P_{RAT} - P_{CTG_Excite} - P_{STG_Excite} - P_{CTG_GSU_Loss} - P_{STG_GSU_Loss} - P_{UAT_Loss} - P_{RAT_Loss}$$

$$P_{Corr_PN} = (P_{PN} + P_{Non_Design} + \Delta 2_{GSU} + \Delta 2_{Gen} + \Delta 5_A + \Delta 6_{OD} + \Delta 6_{FGC} + \Delta 7) * \alpha 1 \& 3 * \alpha 2 * \alpha 4 * \alpha 5 * \alpha 6 + \Delta P_{STG} + \Delta P_{CTG} + \Delta P_{HRSG} + \Delta HR_{CTG} + \Delta ET_{CTG} + \Delta EF_{CTG} + \Delta TCA_{CTG} + \Delta SCE_{CTG} + \Delta RHDP_{HRSG} + \Delta DP_{HRSG} + \Delta Q_{HP} + \Delta T_{HP} + \Delta QT_{RHTR} + \Delta QT_{LP}$$

5.5.3 Corrected Facility Net Heat Rate

$$HI_{PN} = HV_{FG} * Q_{FG}$$

$$HR_{PN} = \frac{HI_{PN}}{P_{PN}}$$

$$HR_{Corr_PN} = \frac{(HI_{PN} + \omega 7) * \beta 1 \& 3 * \beta 2 * \beta 5 * \beta 6 + \omega HR_{CTG} + \omega P_{CTG} + \omega DP_{HRSG}}{P_{Corr_PN}}$$

Additional detail regarding the calculation can be found in Appendix A.

END OF SECTION

SECTION 6

TEST RESULTS AND CONCLUSIONS

6.1 Test Results

The calculated test results for the STG Tests are listed in the tables below:

Parameter	Units	Guarantee	Measured Test Results	Corrected Test Results	Margin	Pass / Fail
Unfired Net Electrical Output	kW	449,960	444,232	450,521	561	Pass
Unfired Net Heat Rate	Btu/kWh LHV	5,723	5,800.1	5,714.4	8.6	Pass

6.2 Test Conclusions

The Corrected Unfired Net Electrical Output greater than the Guarantee value and the Corrected Unfired Net Heat Rate less than the Guarantee value has indicated the facility's ability to satisfy the Kiewit contractual guarantees to GRDA.

END OF SECTION

APPENDIX A

TEST CALCULATIONS

GREC U3 Net Plant Test Input Data Summary

Linked Row				17	27	37		
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Power Measurements								
CTG generator gross power output	kW	CTGDAS	ACTUAL POWER	315,362.7	307,546.5	311,860.0	313,016.5	
CTG generator gross power factor	-	CTGDAS	POWER FACTOR	0.900	0.997	0.996	0.997	Verify leading/lagging. Lagging
CTG generator frequency	HZ	CTGDAS	FREQUENCY	60.0	60.0	60.0	60.0	
STG generator gross power output	kW	PwrDAS	STG Meter-MW	150,888.29	142,949.1	143,925.2	143,994.0	
STG generator gross power factor	-	PwrDAS	STG Meter-PF	0.900	0.999	0.998	0.999	Verify leading/lagging. Lagging
UAT low side power	kW	PwrDAS	UAT Power	14,012.8	8,564.0	8,579.3	8,568.8	
UAT low side power factor	-	PwrDAS	Device 3-PF	0.900	0.810	0.810	0.810	
RAT low side power	kW			0.0	0.0	0.0	0.0	Offline
RAT low side power factor	-			0.900	0.81	0.81	0.81	Equal to UAT PF
CTG excitation current	A	CTGDACS	GT GENERATOR FIELD CURRENT	65.00	2,020.5	2,045.3	2,040.1	
STG excitation current	A	STGDACS	30CHC00CE021	600.00	1,407.3	1,416.0	1,408.9	
Non-design auxiliary loads	kW	DCS		0.00	0.00	0.00	0.00	
Pressure Measurements								
Barometric pressure	psia	CTGDAS	Baro	14.367	14.426	14.424	14.424	
Fuel gas pressure upstream compressor suction	psig	DCS	03-PIT-650617.UNIT3@NET3	424.00	695.780	695.230	695.223	
Temperature Measurements								
Ambient dry bulb temperature at CTG	Deg F	CTGDAS	CTG Ambient Temp	59.00	79.3	75.4	74.1	
Ambient RH at CTG	%	TCDAS	CTG Inlet RH	65.00%	76.19%	81.11%	84.12%	
Cooling tower dry bulb temperature	Deg F	TowerDAS	Tower DBT	59.00	77.1	73.1	72.0	
Cooling tower wet bulb temperature	Deg F	TowerDAS	Tower WBT	52.41	73.2	70.7	70.2	
Fuel gas temperature at outlet of regulating station	Deg F	DCS	03-TT-560500.UNIT3@NET3	40.00	68.7	67.9	67.8	At enable gas yard
CTG Test Data								
Corrected CTG net power output	kW			314,200	325,123	325,603	325,414	
Corrected CTG net heat rate (LHV)	btu/kWh			8,195	8,326	8,130	8,139	
Corrected CTG exhaust flow	lb/h			4,765,000	4,943,461	4,930,019	4,915,961	
Corrected CTG exhaust temperature	Deg F			1,188.0	1,173.8	1,174.2	1,174.4	
Corrected CTG rotor air cooler energy	mmbtu/h			32.85	37.83	37.97	38.08	
Corrected CTG cooling steam energy	mmbtu/h			26.98	28.98	28.71	28.62	
HRSG Test Data								
Corrected HRSG HP steam flow rate	lb/h			631,030.0	617,730.0	623,621.0	623,091.0	
Corrected HRSG HP steam temperature	Deg F			1,052.0	1,046.6	1,045.2	1,045.3	
Corrected HRSG IP steam flow rate	lb/h			137,460.0	146,738.0	147,736.0	148,224.0	
Corrected HRSG IP steam flow temperature	Deg F			570.0	573.4	573.5	573.5	
Corrected HRSG HRH steam temperature	Deg F			1,051.5	1,050.8	1,047.9	1,047.3	
Corrected HRSG LP steam flow rate	lb/h			64,700.0	68,082.0	68,169.0	68,493.0	
Corrected HRSG LP steam temperature	Deg F			486.2	507.0	507.7	507.2	
Corrected HRSG gas side pressure drop	inH2O			16.0	15.4	15.6	15.7	
Corrected HRSG reheater pressure drop	psi			15.4	14.9	15.0	15.0	
Corrected HRSG Auxiliary Power	kW			928.00	368.70	368.90	367.30	
STG Test Data								
Corrected STG net power output	kW			150,330.0	146,544	146,768	146,600	STG 2nd Test Run is 30 mins
Design Data								
STG Thyristor loss	kW			11.20	11.20	11.20	11.20	Design value
CTG Thyristor Losses	kW			12.50	12.50	12.50	12.50	Design value

GREC U3 Net Plant Test Input Data Summary

Linked Row				17	27	37	
Flow Measurements							
Plant Fuel Gas Flow							
Meter Type	-			Ultrasonic	Ultrasonic	Ultrasonic	Ultrasonic
Tap Type	-			N/A	N/A	N/A	N/A
Inlet Diameter	in			10.0210	10.0210	10.0210	10.0210
Throat Diameter	in			10.0210	10.0210	10.0210	10.0210
Diameter Measurement Temperature	Deg F			72	72	72	72
Calibration Temperature	Deg F			48.4	48.4	48.4	48.4
Inlet Material	-			SS3xx	SS3xx	SS3xx	SS3xx
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx
Fluid Type	-			Vapor	Vapor	Vapor	Vapor
Upstream Pressure	psia	DCS	03-ENBL-PSI.UNIT3@NET3	450.0	806.9	840.8	841.9
Downstream Temperature	Deg F	DCS	03-TT-560500.UNIT3@NET3	67.8	68.7	67.9	67.8
Meter Reported Flow Rate	KACF/h	DCS	03-FT-560500B.UNIT3@NET3	86.8	45.23	42.43	42.53
HRSG DB Fuel Gas							
Meter Type	-			Orifice	Orifice	Orifice	Orifice
Tap Type	-			Flange	Flange	Flange	Flange
Inlet Diameter	in			4.0260	4.0260	4.0260	4.0260
Throat Diameter	in			2.6970	2.6970	2.6970	2.6970
Diameter Measurement Temperature	Deg F			72	72	72	72
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A
Inlet Material	-			CS	CS	CS	CS
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx
Fluid Type	-			Vapor	Vapor	Vapor	Vapor
Flow Pressure	psia	MainDAS	DB fuel flow Pressure	340.5	345.4	341.1	340.5
Flow Temperature	Deg F	DCS	03-TT-980840.UNIT3@NET3	78.9	85.9	79.4	78.9
Flow DP	inH2O	MainDAS	DB fuel flow DP	0.0	0.0	0.0	0.0
Fuel Analysis (lab)							
Methane, CH4	mole %			93.280%	90.29%	90.00%	89.93%
Ethane, C2H6	mole %			3.535%	6.85%	7.02%	7.03%
Propane, C3H8	mole %			0.530%	0.33%	0.36%	0.35%
Iso-Butane, i-C4H10	mole %			0.039%	0.01%	0.01%	0.01%
N-Butane, n-C4H10	mole %			0.072%	0.02%	0.03%	0.03%
Iso-Pentane, i-C5H12	mole %			0.009%	0.00%	0.01%	0.01%
N-Pentane, n-C5H12	mole %			0.008%	0.00%	0.01%	0.01%
N-Hexane, n-C6H14	mole %			0.016%	0.01%	0.01%	0.01%
Heptane, C7H16	mole %			0.000%	0.00%	0.00%	0.00%
Octane, C8H18	mole %			0.000%	0.00%	0.00%	0.00%
Nonane, C9H20	mole %			0.000%	0.00%	0.00%	0.00%
Decane, C10H22	mole %			0.000%	0.00%	0.00%	0.00%
Nitrogen, N2	mole %			1.971%	1.80%	1.86%	1.90%
Carbon Monoxide, CO	mole %			0.000%	0.00%	0.00%	0.00%
Carbon Dioxide, CO2	mole %			0.540%	0.63%	0.65%	0.66%
Water, H2O	mole %			0.000%	0.00%	0.00%	0.00%
Hydrogen Sulphide, H2S	mole %			0.000%	0.00%	0.00%	0.00%
Hydrogen, H2	mole %			0.000%	0.00%	0.00%	0.00%
Helium, He	mole %			0.000%	0.04%	0.04%	0.04%
Oxygen, O2	mole %			0.000%	0.00%	0.00%	0.00%
Argon, Ar	mole %			0.000%	0.01%	0.01%	0.01%

Assumed

Assumed

Offline

ASTM D1945

GREC U3 Net Plant Test Flow Calculations

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Plant Fuel Flow							
<i>Design Information</i>							
Meter Type	-		Ultrasonic	Ultrasonic	Ultrasonic	Ultrasonic	
Tap Type	-		N/A	N/A	N/A	N/A	
Inlet Diameter	in		10.0210	10.0210	10.0210	10.0210	
Throat Diameter	in		10.0210	10.0210	10.0210	10.0210	
Diameter Measurement Temperature	Deg F		72.0	72.0	72.0	72.0	
Calibration Temperature	Deg F		48.4	48.4	48.4	48.4	
Inlet Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		450.0	806.9	840.8	841.9	
Downstream Temperature	Deg F		67.8	68.7	67.9	67.8	
Meter Reported Flow Rate	KACFM		86.8	45.2	42.4	42.5	
<i>Fuel Analysis (lab)</i>							
Methane, CH4	mole %		93.28%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %		3.53%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %		0.53%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %		0.04%	0.01%	0.01%	0.01%	
N-Butane, n-C4H10	mole %		0.07%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Pentane, n-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Hexane, n-C6H14	mole %		0.02%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %		0.00%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %		0.00%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %		0.00%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %		0.00%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %		1.97%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %		0.00%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %		0.54%	0.63%	0.65%	0.66%	
Water, H2O	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %		0.00%	0.00%	0.00%	0.00%	
Helium, He	mole %		0.00%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %		0.00%	0.00%	0.00%	0.00%	
Argon, Ar	mole %		0.00%	0.01%	0.01%	0.01%	
<i>Calculated Parameters</i>							
Gas MW (Lab Composition)	lb/lb mole		17.14	17.51	17.56	17.57	
Fluid Density (Lab Composition)	lb/ft^3	pSCF_Lab	0.045	0.046	0.046	0.046	SCF
Fluid Density (Lab Composition)	lb/ft^3	pACF_Lab	1.452	2.813	2.964	2.972	ACF
Calculated Flow	lb/h		126,093	127,242	125,776	126,378	QACF*pACF_Lab
Calculated Flow	gpm		10,825	5,639	5,290	5,302	

GREC Net Plant Test Transformer Loss Calculation							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Inputs							
CTG generator gross power output	kW		315,362.666	307,546.520	311,859.982	313,016.512	
CTG generator gross power factor	-		0.900	0.997	0.996	0.997	
CTG generator frequency	HZ		60.000	60.005	59.999	60.003	
STG generator gross power output	kW		150,888.293	142,949.099	143,925.248	143,994.017	
STG generator gross power factor	-		0.900	0.999	0.998	0.999	
UAT low side power	kW		14,012.816	8,564.022	8,579.314	8,568.830	
UAT low side power factor	-		0.900	0.810	0.810	0.810	
RAT low side power	kW		0.000	0.000	0.000	0.000	
RAT low side power factor	-		0.900	0.810	0.810	0.810	
Calculations							
CTG GSU Power	kW		301,350	298,982	303,281	304,448	Gen-UAT
CTG GSU Power Factor	-		0.900	0.997	0.996	0.997	Gen PF
CTG GSU VA	MVA		334.83	299.96	304.45	305.37	
CTG GSU VA at design PF	MVA		334.83	332.20	336.98	338.28	
STG GSU Power	kW		150,888	142,949	143,925	143,994	Gen-RAT
STG GSU Power Factor	-		0.900	0.999	0.998	0.999	Gen PF
STG GSU VA	MVA		167.65	143.16	144.18	144.19	
STG GSU VA at design PF	MVA		167.65	158.83	159.92	159.99	
UAT VA	MVA		15.57	10.57	10.59	10.58	
UAT VA at design PF	MVA		15.57	9.52	9.53	9.52	
RAT VA	MVA		0.00	0.00	0.00	0.00	
RAT VA at design PF	MVA		0.00	0.00	0.00	0.00	
Calculations							
CTG GSU Transformer Loss	kW		691.16	590.88	603.16	605.70	
STG GSU Transformer Loss	kW		341.62	292.97	294.60	294.60	
UAT Transformer Loss	kW		40.74	29.30	29.33	29.31	
RAT Transformer Loss	kW		32.40	32.40	32.40	32.40	
CTG GSU Transformer Loss at design PF	kW		691.16	683.21	697.69	701.65	
STG GSU Transformer Loss at design PF	kW		341.62	321.75	324.05	324.21	
UAT Transformer Loss at test PF	kW		40.74	29.30	29.33	29.31	
RAT Transformer Loss at test PF	kW		32.40	32.40	32.40	32.40	
Corrected Transformer Loss	kW		0.00	(121.10)	(123.98)	(125.56)	

CTG GSU. Tap 3 at 85C		
MVA	No-load losses (w)	Load losses (w)
249	183,260	280,880
332		499,340
415		780,220
X2	X	C
4.53041	-0.12048	20.00000
Check	MVA	334.83
	Curve Fit	507,899
	Total Loss	691,159

STG GSU. Tap 3 at 85C		
MVA	No-load losses (w)	Load losses (w)
159	116,890	205,210
212		364,820
256		570,040
X2	X	C
17.03692	-3309.18879	3.007E+05
Check	MVA	167.65
	Curve Fit	224,733
	Total Loss	341,623

UAT. Tap 3 at 85C		
MVA	No-load losses (w)	Load losses (w)
	19,520	
30		78,776
X2	X	C
87.52889	0.00000	0.000
Check	MVA	15.57
	Curve Fit	21,219
	Total Loss	40,739

RAT. Tap N at 85C		
MVA	No-load losses (w)	Load losses (w)
21	32,300	62,230
28		110,080
35		171,500
X2	X	C
138.46939	50.71429	100.000
Check	MVA	0.00
	Curve Fit	100
	Total Loss	32,400

GREC Net Plant Test Output and Heat Rate Calculation						
Description	Unit	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Inputs						
Power Measurements						
CTG generator gross power output	kW	315,363	307,547	311,860	313,017	
CTG generator gross power factor	-	0.900	0.997	0.996	0.997	
CTG generator frequency	HZ	60.000	60.005	59.999	60.003	
STG generator gross power output	kW	150,888	142,949	143,925	143,994	
STG generator gross power factor	-	0.900	0.999	0.998	0.999	
UAT low side power	kW	14,013	8,564	8,579	8,569	
UAT low side power factor	-	0.900	0.810	0.810	0.810	
RAT low side power	kW	0	0	0	0	
RAT low side power factor	-	0.900	0.810	0.810	0.810	
CTG excitation current	A	65	2,020.46	2045.34876	2040.064463	
STG excitation current	A	600	1,407.26	1416.029752	1408.93	
Non-design auxiliary loads	kW	0	0	0	0	
Pressure Measurements						
Barometric pressure	psia	14.367	14.426	14.424	14.424	
Fuel gas pressure upstream compressor suction	psig	424.0	695.8	695.2	695.2	
Temperature Measurements						
Ambient dry bulb temperature at CTG	Deg F	59.00	79.31	75.38	74.06	
Ambient RH at CTG	%	65.00	76.19%	81.11%	84.12%	
Cooling tower dry bulb temperature	Deg F	59.00	77.07	73.07	71.99	
Cooling tower wet bulb temperature	Deg F	52.41	73.21	70.66	70.16	
Fuel gas temperature at outlet of regulating station	Deg F	40.00	68.72	67.94	67.78	
CTG Test Data						
Corrected CTG equipment net power output	kW	314,200.0	325,123.2	325,603.4	325,413.7	
Corrected CTG equipment net heat rate (LHV)	btu/kWh	8,195.0	8,326.4	8,130.4	8,138.8	
Corrected CTG exhaust flow	lb/h	4,765,000	4,943,461	4,930,019	4,915,961	
Corrected CTG exhaust temperature	Deg F	1,188.0	1,173.8	1,174.2	1,174.4	
Corrected CTG rotor air cooler energy	mmbtu/h	32.85	37.83	37.97	38.08	
Corrected CTG cooling steam energy	mmbtu/h	26.98	28.98	28.71	28.62	
HRSR Test Data						
Corrected HRSR HP steam flow rate	lb/h	631,030	617,730	623,621	623,091	
Corrected HRSR HP steam temperature	Deg F	1,052.00	1,046.60	1,045.20	1,045.30	
Corrected HRSR IP steam flow rate	lb/h	137,460	146,738	147,736	148,224	
Corrected HRSR IP steam flow temperature	Deg F	570.00	573.40	573.49	573.53	
Corrected HRSR HRH steam temperature	Deg F	1,051.50	1,050.80	1,047.90	1,047.30	
Corrected HRSR LP steam flow rate	lb/h	64,700	68,082	68,169	68,493	
Corrected HRSR LP steam temperature	Deg F	486.20	507.00	507.70	507.20	
Corrected HRSR gas side pressure drop	inH2O	16.00	15.44	15.58	15.73	
Corrected HRSR reheater pressure drop	psi	15.40	14.90	15.00	15.00	
Corrected HRSR Auxiliary Power	kW	928.00	368.70	368.90	367.30	
STG Test Data						
Corrected STG equipment net power output	kW	150,330	146,544	146,768	146,600	
Design Data						
STG Thyristor loss	kW	11.2	11.2	11.2	11.2	
CTG Thyristor Losses	kW	12.5	12.5	12.5	12.5	
Calculated Flows						
Plant Fuel Gas Flow	lb/h	126,093.3	127,242.2	125,776.2	126,377.5	
HRSR DB Fuel Gas	lb/h	0.0	0.0	0.0	0.0	
Fuel Analysis (lab)						
Methane, CH4	mole %	93.28%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %	3.53%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %	0.53%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %	0.04%	0.01%	0.01%	0.01%	
N-Butane, n-C4H10	mole %	0.07%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %	0.01%	0.00%	0.01%	0.01%	
N-Pentane, n-C5H12	mole %	0.01%	0.00%	0.01%	0.01%	
N-Hexane, n-C6H14	mole %	0.02%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %	0.00%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %	0.00%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %	0.00%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %	0.00%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %	1.97%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %	0.00%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %	0.54%	0.63%	0.65%	0.66%	
Water, H2O	mole %	0.00%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %	0.00%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %	0.00%	0.00%	0.00%	0.00%	
Helium, He	mole %	0.00%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %	0.00%	0.00%	0.00%	0.00%	
Argon, Ar	mole %	0.00%	0.01%	0.01%	0.01%	

GREC Net Plant Test Output and Heat Rate Calculation					
Calculations					
Misc Calculations					
Ambient WBT at CTG	%	52.41	73.44	71.01	70.47
Fuel gas heating value LHV	Btu/lb	20,422.4	20,401.3	20,367.9	20,348.2
Fuel C/H Ratio	-	3.05	3.09	3.10	3.10
Power Calculations					
STG Excitation					
Generator MVA	MVA	167.7	143.2	144.2	144.2
Excitation current	A	1,792.4	1,352.7	1,359.3	1,356.4
Field loss	kW	314	179	181	180
Thyristor loss	kW	11.2	11.2	11.2	11.2
Excitation transformer Loss	kW	8.5	7.3	7.3	7.3
Total STG excitation loss	kW	334	198	200	199
CTG Excitation					
Generator MVA	MVA	350.4	308.6	313.1	314.0
Excitation current	A	2,680.5	1,981.7	2,006.8	2,002.2
Field Losses	kW	805.085	441.068	452.244	450.169
Thyristor Losses	kW	12.50	12.50	12.50	12.50
Excitation Transformer Losses	kW	18.33	12.92	13.09	13.06
Total CTG excitation loss	kW	835.9	466.5	477.8	475.7
CTG GSU Transformer Loss	kW	691.2	590.9	603.2	605.7
STG GSU Transformer Loss	kW	341.6	293.0	294.6	294.6
UAT Transformer Loss	kW	40.7	29.3	29.3	29.3
RAT Transformer Loss	kW	32.4	32.4	32.4	32.4
Plant Net Power Output	kW	449,962.7	440,321.6	445,568.9	446,805.0
Heat Input Calculations					
Duct burner heat input	mmBtu/h	0	0.0	0.0	0.0
Plant Heat Input	mmBtu/h	2,575	2,596	2,562	2,572
Plant Net Heat Rate	Btu/kWh	5,723.0	5,895.5	5,749.5	5,755.4
Unfired Corrections					
Unfired Power Corrections					
Additive Power Corrections for Plant					
Correction for GSU Losses	kW	0.00	-121.10	-123.98	-125.56
Correction for CTG generator power factor	kW	0.00	-157.54	-156.69	-157.93
Correction for STG generator power factor	kW	0.00	-48.01	-47.85	-48.07
Correction for ambient conditions at cooling tower	kW	0.00	-47.12	-63.38	-55.45
Correction for off design auxiliary loads	kW	0.00	0.00	0.00	0.00
Correction for fuel gas pressure	kW	0.00	-1,928.00	-1,928.00	-1,928.00
Correction for duct burner duty different than design	kW	-	-	-	-
Additive Power Corrections for OFE					
Correction for power output of CTG	kW	0.00	-11,013.09	-11,497.16	-11,305.92
Correction for power output of STG	kW	0.00	3,811.95	3,586.41	3,755.56
Correction for auxiliary power of HRSG	kW	0.00	-559.30	-559.10	-560.70
Correction for heat rate of CTG	kW	0.00	-63.52	31.22	27.15
Correction for exhaust temp of CTG	kW	0.00	2,955.90	2,871.79	2,840.81
Correction for exhaust flow of CTG	kW	0.00	-4,776.47	-4,418.43	-4,043.98
Correction for TCA cooler energy	kW	0.00	-645.34	-663.26	-677.61
Correction for steam cooling energy	kW	0.00	-299.15	-257.90	-244.01
Correction for HRSG reheater pressure drop	kW	0.00	-12.99	-10.39	-10.39
Correction for HRSG backpressure	kW	0.00	-79.23	-59.42	-38.20
Correction for HRSG HP steam flow	kW	0.00	999.40	556.80	596.64
Correction for HRSG HP steam temp	kW	0.00	197.59	252.43	247.77
Correction for HRSG IP added flow and RHTR temp	kW	0.00	-1,315.26	-1,233.50	-1,257.95
Correction for LP flow and temp	kW	0.00	-329.13	-338.48	-358.75
Multiplicative Power Corrections for Plant					
Correction for ambient temp and RH at CTG	-	1.000000	1.058027	1.046337	1.042411
Correction for barometric pressure	-	1.000000	0.995773	0.995940	0.995960
Correction for fuel supply temperature	-	1.000000	0.999873	0.999876	0.999877
Correction for fuel composition	-	0.999968	1.000592	1.000597	1.000563
Correction for speed/frequency	-	1.000000	0.999956	1.000010	0.999971
Sum of plant additive power corrections	kW	0.00	-2,301.77	-2,319.89	-2,315.01
Sum of OFE additive power corrections	kW	0.00	-11,128.63	-11,739.01	-11,029.60
Product of multiplicative power corrections	-	0.999968	1.053997	1.042592	1.038627
Unfired Heat Input Corrections					
Additive Heat Input Corrections for Plant					
Correction for duct burner duty different than design	Btu/h	-	-	-	-
Additive Heat Input Corrections for OFE					
Correction for power output of CTG	mmBtu/h	0.00	-89.53	-93.46	-91.91
Correction for heat rate of CTG	mmBtu/h	0.00	-41.30	20.30	17.66
Correction for HRSG backpressure	mmBtu/h	0.00	0.00	0.00	0.00
Multiplicative Heat Input Corrections for Plant					
Correction for ambient temp and RH at CTG	-	1.000000	1.046670	1.036788	1.033322
Correction for barometric pressure	-	1.000000	0.995872	0.996035	0.996055
Correction for fuel composition	-	0.999997	1.000473	1.000473	1.000445
Correction for speed/frequency	-	1.000000	0.999947	1.000011	0.999965
Sum of plant additive heat input corrections	mmBtu/h	0.00	0.00	0.00	0.00
Sum of OFE additive heat input corrections	mmBtu/h	0.00	-130.83	-73.16	-74.25
Product of multiplicative heat input corrections	-	0.999997	1.042787	1.033177	1.029668
Unfired Results					
Plant Net Power Output	kW	449,962.73	440,321.62	445,568.90	446,805.03
Corrected Plant Net Power Output	kW	449,948.26	450,542.77	450,388.99	450,629.84
Plant Heat Input	mmBtu/h	2,575.1	2,595.9	2,561.8	2,571.6
Corrected Plant Heat Input	mmBtu/h	2,575.1	2,576.1	2,573.6	2,573.6
Plant Net Heat Rate	Btu/kWh	5,723.0	5,895.5	5,749.5	5,755.4
Corrected Plant Net Heat Rate	Btu/kWh	5,723.1	5,717.9	5,714.2	5,711.1

GREC U3 Unfired Net Plant Test Results

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Average TR 1-3	Pass/Fail	Notes
Plant Net Output									
Measured Plant Net Output	kW		449,963	440,322	445,569	446,805	444,232		
Corrected Plant Net Output	kW		449,948	450,543	450,389	450,630	450,521		
Guarantee Plant Net Output	kW		449,960	449,960	449,960	449,960	449,960		
Margin (units)	kW		-12	583	429	670	561	Pass	Positive is passing
Margin (%)	%		0.00%	0.13%	0.10%	0.15%	0.12%		Positive is passing
Plant Net Heat Rate									
Measured Plant Net Heat Rate (LHV)	btu/kWh		5,723.0	5,895.5	5,749.5	5,755.4	5,800.1		
Corrected Plant Net Heat Rate (LHV)	btu/kWh		5,723.1	5,717.9	5,714.2	5,711.1	5,714.4		
Guarantee Plant Net Heat Rate (LHV)	btu/kWh		5,723.0	5,723.0	5,723.0	5,723.0	5,723.0		
Margin (units)	btu/kWh		-0.1	5.1	8.8	11.9	8.6	Pass	Positive is passing
Margin (%)	%		0.00%	0.09%	0.15%	0.21%	0.15%		Positive is passing

GREC U3 CTG Test Input Data Summary for HRS&G & EPC

Linked Row				17	27	37		
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Power Measurements								
Generator Gross Power Output	KW	CTGDAS	ACTUAL POWER	314,700.0	307,546.5	311,860.0	313,016.5	
Power Factor	-	CTGDAS	POWER FACTOR	0.900	0.997	0.996	0.997	Note if leading or lagging. Lagging
Frequency	Hz	CTGDAS	FREQUENCY	60.0	60.00	60.0	60.0	
Measured Excitation Current	A	CTGDAS	GT GENERATOR FIELD CURRENT	65.0	2,020.5	2,045.3	2,040.1	Check only
Auxiliary Power	KW			500.0	114.2	115.0	113.0	
Pressure Measurements								
Barometric Pressure	psia	CTGDAS	Baro	14.367	14.426	14.424	14.424	
Static Inlet Chiller Coil Loss	inH2O	CTGDAS	Chiller DP	1.000	0.646	0.645	0.649	
Static Exhaust Pressure Loss	inH2O	CTGDAS	CTG Exhaust DP	16.000	15.356	15.550	15.624	
Fuel Supply Pressure	psia	DCS	03-PIT-922611.UNIT3@NET3	650.000	706.0	705.4	705.5	
TCA Inlet Pressure	psia	MainDAS	TCA Inlet Pressure Corr	3000.0	2,664.2	2,672.0	2,666.7	
TCA Outlet Pressure	psia	DCS	03-PIT-065606.UNIT3@NET3	3000.0	2,604.8	2,613.8	2,607.9	
CT Cooling Steam Inlet Pressure	psia	DCS	03-PDIT-035625.UNIT3@NET3	517.6	528.0	530.8	531.1	DP + outlet pressure
CT Cooling Steam Outlet Pressure	psia	DCS	03-PIT-034602.UNIT3@NET3	419.9	430.7	432.4	433.0	
Temperature Measurements								
Ambient DB Temp	Deg F	CTGDAS	CTG Ambient Temp	59.0	79.3	75.4	74.1	
Ambient RH	%	TCDas	CTG Inlet RH	65.00%	76.19%	81.11%	84.12%	All 9 instruments
Compressor Inlet Temp	Deg F	CTGDAS	CTG CIT	59.0	79.3	75.3	74.2	
Compressor Inlet RH	%	TCDas	CTG Inlet RH	65.00%	76.19%	81.11%	84.12%	Equal to ambient RH
Fuel temp at turbine	Deg F	DCS	03-TE-992678.UNIT3@NET3	449.0	454.9	455.5	455.0	
Exhaust Temp	Deg F	TCDas	HRS&G Inlet Temp	1188	1,191.5	1,188.9	1,188.2	Average temporary TCs
TCA Inlet Temperature	Deg F	DCS	03-TE-065601.UNIT3@NET3	323.8	332.4	332.6	333.0	
TCA Outlet Temperature	Deg F	DCS	03-TE-065607.UNIT3@NET3	600.5	589.1	591.6	590.6	
CT Cooling Steam Inlet Temperature	Deg F	MainDAS	CT CS Inlet Temp	565.6	570.7	570.9	571.1	
CT Cooling Steam Outlet Temperature	Deg F	MainDAS	CT CS Outlet Temp	926.4	940.5	937.3	936.3	
Other Measurements								
Fired Hours	h	CTGDAS	GT OPERATION HOUR (GAS)	0	997.9	1,002.1	1,003.1	
Number of starts	#	CTGDAS	GT START No (GAS)	0	42.0	42.0	42.0	
Number of load rejections	#	CTGDAS	TOTAL EQUIVALENT COUNT OF LD OFF (GAS)	0	0.0	0.0	0.0	
Number of trips	#	CTGDAS	TOTAL EQUIVALENT COUNT OF TRIP (GAS)	0	66.0	66.0	66.0	
Number of rapid loads	#	CTGDAS	TOTAL EQUIVALENT COUNT OF RAPID LOAD	0	11.0	11.0	11.0	
Equivalent Degradation Hours for permanent degradation, EDH1	h		EDH1		2,238.0	2,243.0	2,244.0	From MHPS Historical Tabulation
Equivalent Degradation Hours for recoverable degradation by mch	h		EDH2		1,090.0	1,095.0	1,096.0	From MHPS Historical Tabulation
CTG exhaust flow from HRS&G energy balance	lb/h			4,765,000.0	4,699,828.7	4,755,427.4	4,755,269.4	From HRS&G test
CTG exhaust flow uncertainty from HRS&G energy balance	%			0.00%	0.78%	0.78%	0.78%	From HRS&G test
Flow Measurements								
Fuel Gas Flow								
Meter Type	-			Turbine	Turbine	Turbine	Turbine	03-FIT-992601
Meter Diameter	in			10.00	10.00	10.00	10.00	
Flow Pressure	psia	CTGDAS	FG Supply Press	600.0	706.2	705.6	705.6	
Flow Temperature	Deg F	CTGDAS	FG Supply Temp	40.0	68.3	63.4	63.1	
Starting Pulse Count	Pulses		=CTGDASIAH76	0.0	881618	103149	393195	
Ending Pulse Count	Pulses			340,817.6	173168	393195	683871	
TCA Flow								
Meter Type	-			ASME Nozzle	ASME Nozzle	ASME Nozzle	ASME Nozzle	03-FE-065618
Tap Type	-			Throat	Throat	Throat	Throat	
Inlet Diameter	in			5.1880	5.1880	5.1880	5.1880	
Throat Diameter	in			2.5635	2.5635	2.5635	2.5635	
Diameter Measurement Temperature	Deg F			74	74	74	74	Assumed
Calibration Temperature	Deg F			106	106	106	106	Assumed
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	TCA Flow Pressure Corr	3,000.0	1,888.1	1,893.0	1,894.6	
Flow Temperature	Deg F	DCS	03-TE-065607.UNIT3@NET3	323.8	589.1	591.6	590.6	
Flow DP	inH2O	MainDAS	TCA Flow DP	32.7	68.3	67.0	67.9	
CT Cooling Steam Flow								
Meter Type	-			Venturi	Venturi	Venturi	Venturi	03-FE-035622
Tap Type	-			Throat	Throat	Throat	Throat	
Inlet Diameter	in			7.981	7.981	7.981	7.981	
Throat Diameter	in			5.428	5.428	5.428	5.428	
Diameter Measurement Temperature	Deg F			72	72	72	72	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	CTG Cooling Steam Flow Pressure Corr	419.9	528.4	531.2	532.1	
Flow Temperature	Deg F	DCS	03-TE-035623.UNIT3@NET3	560.0	570.2	570.7	570.9	
Flow DP	inH2O	MainDAS	CTG Cooling Steam Flow DP	157.3	124.2	125.5	125.9	
Plant Fuel Gas Flow								
Meter Type	-			Ultrasonic	Ultrasonic	Ultrasonic	Ultrasonic	
Tap Type	-			N/A	N/A	N/A	N/A	
Inlet Diameter	in			10.0210	10.0210	10.0210	10.0210	
Throat Diameter	in			10.0210	10.0210	10.0210	10.0210	
Diameter Measurement Temperature	Deg F			72	72	72	72	Assumed
Calibration Temperature	Deg F			48.4	48.4	48.4	48.4	
Inlet Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Upstream Pressure	psia	DCS	03-ENBL-PSI.UNIT3@NET3	450.0	806.9	840.8	841.9	
Downstream Temperature	Deg F	DCS	03-TT-560500.UNIT3@NET3	67.8	68.7	67.9	67.8	
Meter Reported Flow Rate	KACF/h	DCS	03-TT-560500B.UNIT3@NET3	86.8	45.23	42.43	42.53	

Fuel Analysis							ASTM D1945
Methane, CH4	mole %		93.280%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %		3.535%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %		0.530%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %		0.039%	0.01%	0.01%	0.01%	
N-Butane, n-C4H10	mole %		0.072%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %		0.009%	0.00%	0.01%	0.01%	
N-Pentane, n-C5H12	mole %		0.008%	0.00%	0.01%	0.01%	
N-Hexane, n-C6H14	mole %		0.016%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %		0.000%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %		0.000%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %		0.000%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %		0.000%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %		1.971%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %		0.000%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %		0.540%	0.63%	0.65%	0.66%	
Water, H2O	mole %		0.000%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %		0.000%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %		0.000%	0.00%	0.00%	0.00%	
Helium, He	mole %		0.000%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %		0.000%	0.00%	0.00%	0.00%	
Argon, Ar	mole %		0.000%	0.01%	0.01%	0.01%	

GREC U3 CTG Flow Calculations for HRSG & EPC

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
TCA Flow							03-FE-065618
<i>Design Information</i>							
Meter Type	-		ASMENozzle	ASMENozzle	ASMENozzle	ASMENozzle	
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		5.1880	5.1880	5.1880	5.1880	
Throat Diameter	in		2.5635	2.5635	2.5635	2.5635	
Diameter Measurement Temperature	Deg F		74.0	74.0	74.0	74.0	
Calibration Temperature	Deg F		106.0	106.0	106.0	106.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		3,000.0	1,888.1	1,893.0	1,894.6	
Downstream Temperature	Deg F		323.8	589.1	591.6	590.6	
DP	inH2O		32.7	68.3	67.0	67.9	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		57.24	43.70	43.50	43.59	
Fluid Viscosity	lbm/(ft*s)		0.000116	0.000056	0.000056	0.000056	
Calculated Flow	lb/h		105,578	134,057	132,444	133,457	105,578.05
Calculated Flow	gpm		230	382	380	382	

Calibration Data
 Meter Serial Number
 Meter Location
 Tap Set

20171-09									
FW from TCA									
1		2		3		4			
Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd		
1	1,688,016	0.9972	1,688,016	0.9972	1,688,016	0.9974	1,688,016	0.9977	
2	1,563,992	0.9971	1,563,992	0.9971	1,563,992	0.9973	1,563,992	0.9976	
3	1,436,064	0.9969	1,436,064	0.9969	1,436,064	0.9972	1,436,064	0.9975	
4	1,307,741	0.9968	1,307,741	0.9968	1,307,741	0.9971	1,307,741	0.9974	
5	1,187,818	0.9967	1,187,818	0.9966	1,187,818	0.9969	1,187,818	0.9972	
6	1,061,224	0.9964	1,061,224	0.9963	1,061,224	0.9967	1,061,224	0.9969	
7	934,926	0.9963	934,926	0.9962	934,926	0.9966	934,926	0.9968	
8	809,963	0.9963	809,963	0.9962	809,963	0.9966	809,963	0.9968	
9	684,209	0.9965	684,209	0.9964	684,209	0.9968	684,209	0.997	
10	559,839	0.9973	559,839	0.9971	559,839	0.9974	559,839	0.9976	
11	1,626,844	0.9972	1,626,844	0.9971	1,626,844	0.9974	1,626,844	0.9976	
12	1,499,559	0.997	1,499,559	0.997	1,499,559	0.9973	1,499,559	0.9975	
13	1,374,447	0.997	1,374,447	0.9969	1,374,447	0.9973	1,374,447	0.9974	
14	1,248,249	0.9968	1,248,249	0.9968	1,248,249	0.9972	1,248,249	0.9973	
15	1,121,754	0.9965	1,121,754	0.9964	1,121,754	0.9968	1,121,754	0.997	
16	996,593	0.9964	996,593	0.9964	996,593	0.9967	996,593	0.9969	
17	873,458	0.9963	873,458	0.9963	873,458	0.9966	873,458	0.9969	
18	747,062	0.9964	747,062	0.9964	747,062	0.9968	747,062	0.997	
19	622,247	0.9968	622,247	0.9967	622,247	0.9971	622,247	0.9973	
20	497,926	0.9975	497,926	0.9974	497,926	0.9978	497,926	0.9979	
21	172,349	0.9974	172,349	0.9971	172,349	0.9973	172,349	0.9976	
22	122,789	0.9936	122,789	0.9931	122,789	0.9926	122,789	0.9936	
23	334,718	0.9982	334,718	0.998	334,718	0.9983	334,718	0.9986	

GREC U3 CTG Flow Calculations for HRSG & EPC

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
CT Cooling Steam Flow							03-FE-035622
<i>Design Information</i>							
Meter Type	-		Venturi	Venturi	Venturi	Venturi	
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		7.981	7.981	7.981	7.981	
Throat Diameter	in		5.428	5.428	5.428	5.428	
Diameter Measurement Temperature	Deg F		72.0	72.0	72.0	72.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		419.9	528.4	531.2	532.1	
Downstream Temperature	Deg F		560.0	570.2	570.7	570.9	
DP	inH2O		157.3	124.2	125.5	125.9	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		0.75	0.96	0.96	0.96	
Fluid Viscosity	lbm/(ft*s)		0.000013	0.000013	0.000013	0.000013	
Calculated Flow	lb/h		129,494	130,348	131,362	131,716	129,494.82
Calculated Flow	gpm		21,479	16,993	17,033	17,053	

GREC U3 CTG Flow Calculations for HRSG & EPC

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Plant Fuel Flow							
<i>Design Information</i>							
Meter Type	-		Ultrasonic	Ultrasonic	Ultrasonic	Ultrasonic	
Tap Type	-		N/A	N/A	N/A	N/A	
Inlet Diameter	in		10.0	10.0	10.0	10.0	
Throat Diameter	in		10.0	10.0	10.0	10.0	
Diameter Measurement Temperature	Deg F		72.0	72.0	72.0	72.0	
Calibration Temperature	Deg F		48.4	48.4	48.4	48.4	
Inlet Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		450.0	806.9	840.8	841.9	
Downstream Temperature	Deg F		67.8	68.7	67.9	67.8	
Meter Reported Flow Rate	KACFM		86.8	45.2	42.4	42.5	
<i>Fuel Analysis (lab)</i>							
Methane, CH4	mole %		93.28%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %		3.53%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %		0.53%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %		0.04%	0.01%	0.01%	0.01%	
N-Butane, n-C4H10	mole %		0.07%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Pentane, n-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Hexane, n-C6H14	mole %		0.02%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %		0.00%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %		0.00%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %		0.00%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %		0.00%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %		1.97%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %		0.00%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %		0.54%	0.63%	0.65%	0.66%	
Water, H2O	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %		0.00%	0.00%	0.00%	0.00%	
Helium, He	mole %		0.00%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %		0.00%	0.00%	0.00%	0.00%	
Argon, Ar	mole %		0.00%	0.01%	0.01%	0.01%	
<i>Calculated Parameters</i>							
Gas MW (Lab Composition)	lb/lb mole		17.14	17.51	17.56	17.57	
Fluid Density (Lab Composition)	lb/ft^3	pSCF_Lab	0.045	0.046	0.046	0.046	SCF
Fluid Density (Lab Composition)	lb/ft^3	pACF_Lab	1.452	2.813	2.964	2.972	ACF
Calculated Flow	lb/h		126,093	127,242	125,776	126,378	QACF*pACF_Lab
Calculated Flow	gpm		10,825	5,639	5,290	5,302	

GREC U3 C TG Exhaust Flow by C TG Energy Balance Calculation for HRSG & EPC

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Power Measurements							
Generator Gross Power Output	kW		314,700.0	307,546.5	311,860.0	313,016.5	
Power Factor	-		0.90	1.00	1.00	1.00	
Frequency	Hz		60.0	60.0	60.0	60.0	
Measured Excitation Current	A		65.0	2,020.5	2,045.3	2,040.1	
Auxiliary Power	V		500.0	114.2	115.0	113.0	
Pressure Measurements							
Barometric Pressure	psia		14.367	14.426	14.424	14.424	
Static Inlet Chiller Coil Loss	inH2O		1.000	0.646	0.645	0.649	
Static Inlet Loss	inH2O		5.000	5.000	5.000	5.000	
Static Exhaust Pressure Loss	inH2O		16.000	15.356	15.550	15.624	
Fuel Supply Pressure	psia		650.000	706.016	705.446	705.451	
TCA Inlet Pressure	psia		3000.0	2664.2	2672.0	2666.7	
TCA Outlet Pressure	psia		3000.0	2604.8	2613.8	2607.9	
CT Cooling Steam Inlet Pressure	psia		517.6	528.0	530.8	531.7	
CT Cooling Steam Outlet Pressure	psia		419.9	430.7	432.4	433.0	
Temperature Measurements							
Ambient DB Temp	Deg F		59.0	79.3	75.4	74.1	
Ambient RH	%		65.00%	76.19%	81.11%	84.12%	
Compressor Inlet Temp	Deg F		59.0	79.3	75.3	74.2	
Compressor Inlet RH	%		65.00%	76.19%	81.11%	84.12%	
Fuel temp at turbine	Deg F		449.0	454.9	455.5	455.0	
Exhaust Temp	Deg F		1,188.0	1,191.5	1,188.9	1,188.2	Using temporary TCS
TCA Inlet Temperature	Deg F		323.8	332.4	332.6	333.0	
TCA Outlet Temperature	Deg F		600.5	589.1	591.6	590.6	
CT Cooling Steam Inlet Temperature	Deg F		565.6	570.7	570.9	571.1	
CT Cooling Steam Outlet Temperature	Deg F		926.4	940.5	937.3	936.3	
Fuel Analysis							
Methane, CH4	mole %		93.28%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %		3.53%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %		0.53%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %		0.04%	0.01%	0.01%	0.01%	
n-Butane, n-C4H10	mole %		0.07%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
n-Pentane, n-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
n-Hexane, n-C6H14	mole %		0.02%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %		0.00%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %		0.00%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %		0.00%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %		0.00%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %		1.97%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %		0.00%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %		0.54%	0.63%	0.65%	0.66%	
Water, H2O	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %		0.00%	0.00%	0.00%	0.00%	
Helium, He	mole %		0.00%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %		0.00%	0.00%	0.00%	0.00%	
Argon, Ar	mole %		0.00%	0.01%	0.01%	0.01%	
Calculated Flows							
CTG Fuel Flow	lb/h		126,093.3	127,242.2	125,776.2	126,377.5	Using Enable Meter
TCA Flow	lb/h		105,578.0	134,056.6	132,444.5	133,456.6	
CT Cooling Steam Flow	lb/h		129,494.0	130,348.0	131,362.2	131,716.1	
Calculations							
TCA Inlet Enthalpy	btu/lb		299.52	307.67	307.89	308.27	
TCA Outlet Enthalpy	btu/lb		610.67	596.63	600.00	598.59	
TCA Energy	btu/h		32,850,159.22	38,736,613.22	38,687,933.71	38,744,640.09	
CT Cooling Steam Inlet Enthalpy	btu/lb		1,275.39	1,277.61	1,277.50	1,277.51	
CT Cooling Steam Outlet Enthalpy	btu/lb		1,483.74	1,490.97	1,489.17	1,488.65	
CT Cooling Steam Energy	btu/h		26,979,981.60	27,810,977.58	27,805,230.71	27,809,438.88	
Compressor inlet pressure	psia		14.186	14.245	14.243	14.243	
Generator Losses	kW		2,466.22	2,276.46	2,297.12	2,301.22	
CTG Mechanical and Radiation Losses	kW		600	600	600	600	
2C Cooler Losses							
4S Cooler Losses							
Total CTG Losses	mmBtu/h		61.877	68.595	68.540	68.601	Includes TCA and CT Cooling Steam
Results							
CTG Exhaust Enthalpy	btu/lb		302.36	300.18	300.47	300.54	
CTG Exhaust Flow	lb/h		4,827,144	4,990,106	4,822,703	4,840,786	

GREC U3 CTG Calculations for HRSG & EPC							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Inputs							
Power Measurements							
Generator Gross Power Output	kW		314,700.0	307,546.5	311,860.0	313,016.5	
Power Factor	-		0.900	0.997	0.996	0.997	
Frequency	Hz		60.000	60.005	59.999	60.003	
Measured Excitation Current	A		65.000	2020.459	2045.349	2040.064	
Auxiliary Power	V		500.000	114.200	115.000	113.000	
Pressure Measurements							
Barometric Pressure	psia		14.367	14.426	14.424	14.424	
Static Inlet Chiller Coil Loss	inH2O		1.000	0.646	0.645	0.649	
Static Inlet Loss	inH2O		5.000	5.000	5.000	5.000	
Static Exhaust Pressure Loss	inH2O		16.000	15.356	15.550	15.624	
Fuel Supply Pressure	psia		650.000	706.016	705.446	705.451	
TCA Inlet Pressure	psia		3000.000	2664.245	2671.983	2666.711	
TCA Outlet Pressure	psia		3000.000	2604.759	2613.794	2607.934	
CT Cooling Steam Inlet Pressure	psia		517.560	527.964	530.801	531.664	
CT Cooling Steam Outlet Pressure	psia		419.860	430.652	432.422	432.963	
Temperature Measurements							
Ambient DB Temp	Deg F		59.000	79.310	75.384	74.063	
Ambient RH	%		65.00%	76.19%	81.11%	84.12%	
Compressor Inlet Temp	Deg F		59.000	79.303	75.251	74.170	
Compressor Inlet RH	%		65.00%	76.19%	81.11%	84.12%	
Fuel temp at turbine	Deg F		449.000	454.883	455.459	454.999	
Exhaust Temp	Deg F		1188.000	1191.506	1188.907	1188.187	
TCA Inlet Temperature	Deg F		323.841	332.378	332.578	332.962	
TCA Outlet Temperature	Deg F		600.516	589.089	591.616	590.558	
CT Cooling Steam Inlet Temperature	Deg F		565.634	570.652	570.906	571.060	
CT Cooling Steam Outlet Temperature	Deg F		926.356	940.512	937.254	936.315	
Other Measurements							
CTG exhaust flow from HRSG energy balance	lb/h		4,765,000	4,699,829	4,755,427	4,755,269	
CTG exhaust flow uncertainty from HRSG energy balance	%		1.00%	0.78%	0.78%	0.78%	
Fuel Analysis							
Methane, CH4	mole %		93.28%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %		3.53%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %		0.53%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %		0.04%	0.01%	0.01%	0.01%	
N-Butane, n-C4H10	mole %		0.07%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Pentane, n-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Hexane, n-C6H14	mole %		0.02%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %		0.00%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %		0.00%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %		0.00%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %		0.00%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %		1.97%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %		0.00%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %		0.54%	0.63%	0.65%	0.66%	
Water, H2O	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %		0.00%	0.00%	0.00%	0.00%	
Helium, He	mole %		0.00%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %		0.00%	0.00%	0.00%	0.00%	
Argon, Ar	mole %		0.00%	0.01%	0.01%	0.01%	

GREC U3 CTG Calculations for HRSG & EPC							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Calculated Flows							
CTG Fuel Flow	lb/h		126,093.3	127,242.2	125,776.2	126,377.5	Using Enable Meter
TCA Flow	lb/h		105,578.0	134,056.6	132,444.5	133,456.6	
CT Cooling Steam Flow	lb/h		129,494.0	130,348.0	131,362.2	131,716.1	
CTG Exhaust Flow (CTG energy balance)							
CTG Exhaust Flow (CTG energy balance)	lb/h		4,765,000	4,990,106	4,822,703	4,840,786	
CTG exhaust flow uncertainty from CTG energy balance	%		1.00%	1.76%	1.33%	1.60%	
CTG Exhaust Flow (HRSG energy balance)							
CTG exhaust flow uncertainty from HRSG energy balance	lb/h		4,765,000	4,699,829	4,755,427	4,755,269	Not used for CTG results. HRSG and Plant test only
CTG exhaust flow uncertainty from HRSG energy balance	%		1.00%	0.78%	0.78%	0.78%	
Uncertainty Weighted CTG Exhaust Flow	lb/h		4,765,000	4,747,969	4,772,811	4,771,706	Not used for CTG results. HRSG and Plant test only
Uncertainty Weighted CTG Exhaust Flow uncertainty	%		1.00%	0.95%	0.92%	0.94%	
Additive Corrections							
<i>Output Corrections</i>							
Correction for generator power factor	kW		0	150	153	156	Loss @ Design PF - Test PF all at Test MW
Correction for off design auxiliary power	kW		0	0	0	0	Non design aux loads in operation
Sum of additive corrections	kW		0	150	153	156	
Multiplicative Corrections							
<i>Output Corrections</i>							
Ambient Temperature (Chiller Off)	ON		1.000000	0.937771	0.949793	0.953837	
Compressor Inlet Temperature (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Relative Humidity (Chiller Off)	ON		1.000000	1.000904	1.001174	1.001342	
Compressor Inlet Relative Humidity (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Pressure	ON		1.000004	1.004351	1.004180	1.004159	
Frequency	ON		0.999969	1.000018	0.999960	1.000001	
LHV and C/H Ratio	ON		1.000010	0.999179	0.999011	0.998954	
Inlet Chiller Module DP	ON		1.000000	1.001262	1.001265	1.001251	
Exhaust DP (Chiller Off)	ON		1.000000	1.000591	1.000413	1.000345	
Exhaust DP (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Fuel Gas Temperature at CTG	OFF						
Degradation	OFF		1.000000	1.000000	1.000000	1.000000	
Product Output Corrections			0.999983	0.943692	0.955500	0.959616	
<i>Heat Rate Corrections</i>							
Ambient Temperature (Chiller Off)	ON		1.000000	1.017186	1.013418	1.012204	
Compressor Inlet Temperature (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Relative Humidity (Chiller Off)	ON		1.000000	1.000699	1.000902	1.001030	
Compressor Inlet Relative Humidity (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Pressure	ON		1.000017	0.999828	0.999835	0.999836	
Frequency	ON		1.000093	1.000100	1.000092	1.000098	
LHV and C/H Ratio	ON		1.000003	1.000288	1.000349	1.000370	
Inlet Chiller Module DP	ON		1.000000	0.999634	0.999633	0.999637	
Exhaust DP (Chiller Off)	ON		1.000000	0.999411	0.999589	0.999657	
Exhaust DP (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Fuel Gas Temperature at CTG	ON		0.999835	0.999496	0.999461	0.999489	
Degradation	OFF		1.000000	1.000000	1.000000	1.000000	
Product Heat Rate Corrections			0.999948	1.016632	1.013277	1.012321	
<i>Exhaust Flow Corrections</i>							
Ambient Temperature (Chiller Off)	ON		1.000000	0.957087	0.965456	0.968262	
Compressor Inlet Temperature (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Relative Humidity (Chiller Off)	ON		1.000000	0.998373	0.997914	0.997625	
Compressor Inlet Relative Humidity (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Pressure	ON		1.000006	1.004190	1.004024	1.004004	
Frequency	ON		1.000000	1.000081	0.999985	1.000053	
LHV and C/H Ratio	ON		1.000001	0.999959	0.999913	0.999887	
Inlet Chiller Module DP	ON		1.000000	1.000919	1.000921	1.000911	
Exhaust DP (Chiller Off)	OFF						
Exhaust DP (Chiller On)	OFF						
Fuel Gas Temperature at CTG	OFF						
Degradation	OFF		1.000000	1.000000	1.000000	1.000000	
Product Exhaust Flow Corrections			1.000008	0.960454	0.968112	0.970656	

GREC U3 CTG Calculations for HRSG & EPC							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
<i>Exhaust Temperature Corrections</i>							
Ambient Temperature (Chiller Off)	ON		0.000004	17.252128	13.639801	12.458315	
Compressor Inlet Temperature (Chiller On)	OFF		0.000000	0.000000	0.000000	0.000000	
Ambient Relative Humidity (Chiller Off)	ON		0.000000	1.509210	1.948985	2.224173	
Compressor Inlet Relative Humidity (Chiller On)	OFF		0.000000	0.000000	0.000000	0.000000	
Ambient Pressure	ON		-0.001659	-0.126971	-0.122076	-0.121479	
Frequency	ON		-0.113840	-0.140011	-0.108882	-0.130840	
LHV and C/H Ratio	ON		0.001028	-0.096316	-0.099912	-0.096420	
Inlet Chiller Module DP	ON		0.000000	-0.247516	-0.248085	-0.245470	
Exhaust DP (Chiller Off)	ON		0.000000	-0.462808	-0.322987	-0.269517	
Exhaust DP (Chiller On)	OFF		0.000000	0.000000	0.000000	0.000000	
Fuel Gas Temperature at CTG	OFF						
Degradation	OFF		0.000000	0.000000	0.000000	0.000000	
<i>Sum Exhaust Temperature Corrections</i>			-0.114467	17.687715	14.686845	13.818761	
<i>TCA Cooler Heat Duty Corrections</i>							
Ambient Temperature (Chiller Off)	ON		1.000000	1.020209	1.016131	1.014773	
Compressor Inlet Temperature (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Relative Humidity (Chiller Off)	ON		1.000000	0.998793	0.998416	0.998181	
Compressor Inlet Relative Humidity (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Pressure	ON		1.000008	1.004140	1.003976	1.003956	
Frequency	ON		0.999922	1.000147	0.999879	1.000068	
LHV and C/H Ratio	ON		1.000001	0.999623	0.999514	0.999468	
Inlet Chiller Module DP	ON		1.000000	1.000866	1.000868	1.000859	
Exhaust DP (Chiller Off)	OFF						
Exhaust DP (Chiller On)	OFF						
Fuel Gas Temperature at CTG	OFF						
<i>Product TCA Cooler Heat Duty Corrections</i>			0.999931	1.023847	1.018821	1.017336	
<i>Cooling Steam Heat Duty Corrections</i>							
Ambient Temperature (Chiller Off)	ON		1.000000	0.953890	0.962548	0.965490	
Compressor Inlet Temperature (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Relative Humidity (Chiller Off)	ON		1.000000	1.001603	1.002078	1.002375	
Compressor Inlet Relative Humidity (Chiller On)	OFF		1.000000	1.000000	1.000000	1.000000	
Ambient Pressure	ON		0.999992	1.004150	1.003986	1.003966	
Frequency	ON		0.999996	1.000052	0.999985	1.000032	
LHV and C/H Ratio	ON		0.999994	0.999370	0.999247	0.999207	
Inlet Chiller Module DP	ON		1.000000	1.000926	1.000928	1.000918	
Exhaust DP (Chiller Off)	OFF						
Exhaust DP (Chiller On)	OFF						
Fuel Gas Temperature at CTG	OFF						
<i>Product Cooling Steam Heat Duty Corrections</i>			0.999981	0.959719	0.968548	0.971773	
Calculations							
Measured Excitation Current	A		65.00	2,020.46	2,045.35	2,040.06	Reference
Measured MVA	MVA		349.67	308.56	313.06	313.96	
Calculated Excitation Current	A		2,676.5	1,981.7	2,006.8	2,002.2	From V Curve
Generator Excitation Power	kW		833.5	466.5	477.8	475.7	
<i>Field Losses</i>	kW		802.695	441.068	452.244	450.169	R is 0.1113 Ω @ 95 C
<i>Thyristor Losses</i>	kW		12.50	12.50	12.50	12.50	Constant from procedure
<i>Excitation Transformer Losses</i>	kW		18.29	12.93	13.09	13.06	6.420 kW NLL, 2890A rated LS, 20.764 kW rated loss
Fuel Heating Value (LHV)	btu/lb		20,422.37	20,401.32	20,367.93	20,348.21	
TCA Inlet Enthalpy	btu/lb		299.52	307.67	307.89	308.27	
TCA Outlet Enthalpy	btu/lb		610.67	596.63	600.00	598.59	
TCA Energy	btu/h		32,850,159	38,736,613	38,687,934	38,744,640	
CT Cooling Steam Inlet Enthalpy	btu/lb		1,275.39	1,277.61	1,277.50	1,277.51	
CT Cooling Steam Outlet Enthalpy	btu/lb		1,483.74	1,490.97	1,489.17	1,488.65	
CT Cooling Steam Energy	btu/h		26,979,982	27,810,978	27,805,231	27,809,439	

GREC U3 CTG Calculations for HRSG & EPC							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Results							
Gas Turbine Generator Gross Power Output	kW		314,700	307,547	311,860	313,017	
Gas Turbine Generator Net Power Output	kW		313,867	307,080	311,382	312,541	Gross-Excitation
Gas Turbine Generator Net Equipment Power Output	kW		313,367	306,966	311,267	312,428	Net Generator-Aux
Corrected Gas Turbine Generator Net Equipment Power Output	kW		313,372	325,123	325,603	325,414	(Net Equipment - Additive Corr)/Multiplicative Corr
Gas Turbine Heat Consumption Rate (LHV)	BTU/h		2,575,123,601	2,595,907,654	2,561,800,692	2,571,557,073	
Gas Turbine Generator Net Heat Rate (LHV)	BTU/kWh		8,205	8,454	8,227	8,228	
Gas Turbine Generator Net Equipment Heat Rate (LHV)	BTU/kWh		8,218	8,457	8,230	8,231	
Corrected Gas Turbine Generator Net Equipment Heat Rate (LHV)	BTU/kWh		8,218	8,326	8,130	8,139	
Gas Turbine Exhaust Temperature	Deg F		1,188.0	1,191.5	1,188.9	1,188.2	
Gas Turbine Corrected Exhaust Temperature	Deg F		1,188.1	1,173.8	1,174.2	1,174.4	
Gas Turbine Exhaust Flow Rate	lb/h		4,765,000	4,747,969	4,772,811	4,771,706	Uncertainty weighted average of CTG and HRSG for plant test
Corrected Gas Turbine Exhaust Flow Rate	lb/h		4,764,964	4,943,461	4,930,019	4,915,961	
Turbine Cooling Air Heat Duty	btu/h		32,850,159	38,736,613	38,687,934	38,744,640	
Corrected Turbine Cooling Air Heat Duty	btu/h		32,852,442	37,834,395	37,973,228	38,084,410	
Steam Cooling Heat Duty	btu/h		26,979,982	27,810,978	27,805,231	27,809,439	
Corrected Steam Cooling Heat Duty	btu/h		26,980,488	28,978,257	28,708,160	28,617,215	

GREC U3 CTG Unfired Results for HRSG & EPC

Description	Unit	Guarantee	Test Run 1	Test Run 2	Test Run 3	Average TR 1-3	Pass/Fail	Notes
Equipment Net Power Output	kW	-	306,966	311,267	312,428	310,220	-	
Corrected Equipment Net Power Output	kW	314,200	325,123	325,603	325,414	325,380	-	
Margin	kW	-	10,923	11,403	11,214	11,180	Pass	
Margin	%	-	3.48%	3.63%	3.57%	3.56%		
Equipment Net Heat Rate (LHV)	BTU/kWh	-	8,457	8,230	8,231	8,306		
Corrected Equipment Net Heat Rate (LHV)	BTU/kWh	8,195	8,326	8,130	8,139	8,199		
Margin	BTU/kWh	-	-131	65	56	-4	Fail	
Margin	%	-	-1.60%	0.79%	0.69%	-0.04%		
Gas Turbine Exhaust Temperature	Deg F	-	1,191.5	1,188.9	1,188.2	1,189.5		
Corrected Gas Turbine Exhaust Temperature	Deg F	1,188.0	1,173.8	1,174.2	1,174.4	1,174.1		Temporary TCs
Margin	Deg F	-	-14.2	-13.8	-13.6	-13.9	Fail	
Gas Turbine Exhaust Flow Rate	lb/h	-	4,747,969	4,772,811	4,771,706	4,764,162		
Corrected Gas Turbine Exhaust Flow Rate	lb/h	4,765,000	4,943,461	4,930,019	4,915,961	4,929,814		Uncertainty weighted average of CTG and
Margin	lb/h	-	178,461	165,019	150,961	164,814	Pass	
Margin	%	-	3.75%	3.46%	3.17%	3.46%		
Turbine Cooling Air Heat Duty	Btu/h	-	38,736,613	38,687,934	38,744,640	38,723,062		
Corrected Turbine Cooling Air Heat Duty	Btu/h	32,850,000	37,834,395	37,973,228	38,084,410	37,964,011		
Margin	Btu/h	-	4,984,395	5,123,228	5,234,410	5,114,011	Pass	
Margin	%	-	15.17%	15.60%	15.93%	15.57%		
Steam Cooling Heat Duty	Btu/h	-	27,810,978	27,805,231	27,809,439	27,808,549		
Corrected Steam Cooling Heat Duty	Btu/h	26,980,000	28,978,257	28,708,160	28,617,215	28,767,877		
Margin	Btu/h	-	1,998,257	1,728,160	1,637,215	1,787,877	Pass	
Margin	%	-	7.41%	6.41%	6.07%	6.63%		

GREC HRSG Test Input Data Summary

Linked Row					17	27	37	
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Temperature Measurements								
HP steam temp	Deg F	MainDAS	HRSG HP Steam Temp	1,052.00	1,046.6	1,043.9	1,043.6	
CRH steam temp	Deg F	MainDAS	CRH Steam Temp (HRSG Inlet)	662.20	677.4	676.4	676.2	
HRH steam temp	Deg F	MainDAS	STG HRH Steam Temp	1,051.50	1,050.8	1,047.9	1,047.3	STG HRH temp
IP steam temp	Deg F	MainDAS	HRSG IP Steam Temp	570.00	572.2	572.6	572.7	
LP steam temp	Deg F	MainDAS	LP Steam Flow Temp	486.20	517.2	517.8	517.0	
Condensate before FGH return temp	Deg F	DCS	03-TE-052608.UNIT3@NET3	93.69	110.4	109.1	109.5	
Condensate temp	Deg F	MainDAS	Condensate flow entering HRSG Temp	99.00	131.8	129.3	129.2	Downstream FGH return
BFWP suction temp	Deg F	DCS	03-TE-060605.UNIT3@NET3	316.6	325.8	325.9	326.2	A pump running
IP FW temp	Deg F	MainDAS	IP FW Temp	318.1	327.7	328.0	328.3	
HP FW temp	Deg F	MainDAS	HP FW Temp	320.6	330.3	330.6	330.8	
HP FW to FGH supply temp	Deg F	DCS	03-TE-062607.UNIT3@NET3	521.018	524.6	525.2	525.5	
HP FW return from FGH supply temp	Deg F	DCS	03-TE-062615.UNIT3@NET3	175.252	293.9	286.0	284.0	
TCA suction temp	Deg F	DCS	03-TE-063619.UNIT3@NET3	316.64	325.5	325.7	326.0	B pump running
TCA supply temp	Deg F	DCS	03-TE-065601.UNIT3@NET3	323.84	332.4	332.6	333.0	
TCA return temp	Deg F	DCS	03-TE-065607.UNIT3@NET3	600.52	589.1	591.6	590.6	
CTG cooling steam supply temp	Deg F	MainDAS	CT CS Inlet Temp	565.634	570.7	570.9	571.1	
CTG cooling steam return temp	Deg F	MainDAS	CT CS Outlet Temp	925.70	940.5	937.3	936.3	
DB fuel temp	Deg F	DCS	03-TT-980840.UNIT3@NET3	59.00	85.9	79.4	78.9	
CTG exhaust temp	Deg F	TCGDAS	HRSG Inlet Temp	1,186.0	1,191.5	1,188.9	1,188.2	
Stack temp	Deg F	TCGDAS	HRSG stack temp	177.8	191.2	190.1	190.5	
CTG compressor inlet temp	Deg F	CTGDAS	CTG CIT	59.0	79.3	75.3	74.2	
CTG compressor inlet RH	%	TCGDAS	CTG Inlet RH	65.00%	76.19%	81.11%	84.12%	Equal to ambient RH
CTG ambient temp	Deg F	CTGDAS	CTG Ambient Temp	59.00	79.3	75.4	74.1	
CTG ambient RH	%	TCGDAS	CTG Inlet RH	65.00%	76.19%	81.11%	84.12%	All 9 instruments
Pressure Measurements								
HP steam pressure	psia	MainDAS	HP Steam Pressure (HRSG Outlet) Corr	1,752.2	1,769.4	1,774.2	1,775.6	
CRH steam pressure	psia	MainDAS	CRH Steam Pressure (HRSG Inlet) Corr	422.6	424.1	425.8	426.3	
HRH steam pressure	psia	MainDAS	HRH Steam Pressure (HRSG Outlet) Corr	407.2	410.8	412.4	413.0	
LP steam pressure	psia	MainDAS	LP Steam Flow Pressure Corr	79.0	91.1	91.5	91.7	
Condensate before FGH return pressure	psia	DCS	03-PIT-052609.UNIT3@NET3	450.0	574.9	574.7	574.2	
Condensate pressure	psia	DCS	03-PIT-108609.UNIT3@NET3	450.0	524.4	524.1	523.5	Downstream FGH return
BFWP suction pressure	psia	DCS	03-PIT-060604.UNIT3@NET3	86.0	130.6	131.0	131.3	
IP FW pressure	psia	DCS	03-PIT-104604.UNIT3@NET3	550.5	818.3	820.3	820.9	
HP FW pressure	psia	DCS	03-PIT-101616.UNIT3@NET3	1,908.1	1,938.6	1,944.5	1,946.0	
HP FW to FGH supply pressure	psia	MainDAS	HP FW Flow to FGH Pressure Corr	1,878.3	1,905.5	1,911.3	1,912.8	
HP FW return from FGH supply pressure	psia	DCS	03-PIT-062616.UNIT3@NET3	500.0	1,905.8	1,911.6	1,913.2	
TCAIP suction pressure	psia	DCS	03-PIT-063608.UNIT3@NET3	86.0	135.3	135.8	136.1	
TCA supply pressure	psia	MainDAS	TCA Inlet Pressure Corr	2,000.0	2,664.2	2,672.0	2,666.7	
TCA return pressure	psia	DCS	03-PIT-065606.UNIT3@NET3	2,000.0	2,590.3	2,599.4	2,593.5	
CTG cooling steam supply pressure	psia	DCS	03-PIT-035616.UNIT3@NET3	517.6	532.0	534.8	535.7	
CTG cooling steam return pressure	psia	DCS	03-PIT-034602.UNIT3@NET3	419.9	430.7	432.4	433.0	
DB fuel pressure	psia	MainDAS	DB fuel flow Pressure	20.0	345.4	341.1	340.5	
CTG compressor inlet pressure loss	inH2O			5.0	5.0	5.0	5.0	Estimated
Barometric pressure	psia	CTGDAS	Baro	14.370	14.426	14.424	14.424	
HRSG backpressure	inH2O	MainDAS	HRSG backpressure	16.0	15.5	15.7	15.9	
HP drum pressure	psia	DCS	HP Drum pressure	1,848.5	1,867.5	1,872.7	1,874.2	
IP drum pressure	psia	DCS	IP Drum pressure	530.1	539.7	542.6	543.5	
LP drum pressure	psia	DCS	LP Drum pressure	85.5	97.7	98.3	98.5	
Level Measurements								
Starting HP Drum Level	in		=DCS\YO436	20	14.27	14.79	14.48	
Ending HP Drum Level	in			20	14.70	14.48	14.49	
Starting IP Drum Level	in		=DCS\YP436	20	19.85	19.50	19.66	
Ending IP Drum Level	in			20	19.97	19.66	19.74	
Starting LP Drum Level	in		=DCS\YQ436	20	54.31	54.12	53.63	
Ending LP Drum Level	in			20	53.95	53.63	53.95	
Other Measurements								
HRSG Auxiliary Power	kW			928	368.71	368.88	367.35	
N2 packing leakage flow	lb/h			11,680	59,923	59,923	59,923	
HPS to cooling steam DSH flow	lb/h	DCS	03-FIT-035601.UNIT3@NET3	0.0	435.1	293.9	230.9	03-FIT-035601
CTG Exhaust Gas Flow (CTG Energy Balance)	lb/h			4,826,706	4,990,106	4,822,703	4,840,786	From CTG Testing using temp TC grid and Enable fuel flow
CTG Exhaust Gas Flow Uncertainty (CTG Energy Balance)	%			1.00%	1.76%	1.33%	1.60%	From CTG Testing using temp TC grid and Enable fuel flow

GREC HRSG Test Input Data Summary

Linked Row					17	27	37		
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes	
Flow Measurements									
<i>HP FW Flow</i>									
Meter Type	-			Orifice	Orifice	Orifice	Orifice	03-FE-101604	
Tap Type	-			Flange	Flange	Flange	Flange		
Inlet Diameter	in			7.7430	7.7430	7.7430	7.7430		
Throat Diameter	in			4.9659	4.9659	4.9659	4.9659		
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0		Assumed
Calibration Temperature	Deg F			120.0	120.0	120.0	120.0		Calibrated
Inlet Material	-			CS	CS	CS	CS		
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx		
Fluid Type	-			Liquid	Liquid	Liquid	Liquid		
Flow Pressure	psia	MainDAS	HP FW Flow Pressure Corr	1,908.1	2,199.3	2,203.6	2,206.2		
Flow Temperature	Deg F	DCS	03-TE-061623.UNIT3@NET3	320.6	330.5	330.7	331.1		
Flow DP	inH2O	MainDAS	HP FW Flow DP SQRT	187.8	202.4	205.5	203.6		
<i>HP FW to FGH Flow</i>									
Meter Type	-			ASMENozzle	ASMENozzle	ASMENozzle	ASMENozzle	03-FE-062605	
Tap Type	-			Throat	Throat	Throat	Throat		
Inlet Diameter	in			3.6230	3.6230	3.6230	3.6230		
Throat Diameter	in			1.7939	1.7939	1.7939	1.7939		
Diameter Measurement Temperature	Deg F			73	73	73	73		
Calibration Temperature	Deg F			106	106	106	106		
Inlet Material	-			CS	CS	CS	CS		
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx		
Fluid Type	-			Liquid	Liquid	Liquid	Liquid		
Flow Pressure	psia	MainDAS	HP FW Flow to FGH Pressure Corr	1,870.0	1,905.5	1,911.3	1,912.8		
Flow Temperature	Deg F	DCS	03-TE-062607.UNIT3@NET3	521.0	524.6	525.2	525.5		
Flow DP	inH2O	MainDAS	HP FW Flow to FGH DP SQRT	77.0	206.6	202.5	200.3		
<i>HP FW from TCA Flow</i>									
Meter Type	-			ASMENozzle	ASMENozzle	ASMENozzle	ASMENozzle	03-FE-065618	
Tap Type	-			Throat	Throat	Throat	Throat		
Inlet Diameter	in			5.1880	5.1880	5.1880	5.1880		
Throat Diameter	in			2.5635	2.5635	2.5635	2.5635		
Diameter Measurement Temperature	Deg F			74	74	74	74		Assumed
Calibration Temperature	Deg F			106	106	106	106		Assumed
Inlet Material	-			CS	CS	CS	CS		
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx		
Fluid Type	-			Liquid	Liquid	Liquid	Liquid		
Flow Pressure	psia	MainDAS	TCA Flow Pressure Corr	1,908.1	1,888.1	1,893.0	1,894.6		
Flow Temperature	Deg F	DCS	03-TE-065607.UNIT3@NET3	320.6	589.1	591.6	590.6		
Flow DP	inH2O	MainDAS	TCA Flow DP SQRT	32.7	68.3	67.0	67.9		
<i>HP DSH Flow</i>									
Meter Type	-			Orifice	Orifice	Orifice	Orifice	03-FE-103607	
Tap Type	-			Flange	Flange	Flange	Flange		
Inlet Diameter	in			2.2920	2.2920	2.2920	2.2920		
Throat Diameter	in			1.3582	1.3582	1.3582	1.3582		
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0		Assumed
Calibration Temperature	Deg F			68.5	68.5	68.5	68.5		Calibrated
Inlet Material	-			CS	CS	CS	CS		
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx		
Fluid Type	-			Liquid	Liquid	Liquid	Liquid		
Flow Pressure	psia	MainDAS	HP DSH flow pressure Corr	2,269.0	2,172.5	2,178.6	2,180.3		
Flow Temperature	Deg F	DCS	03-TE-103608.UNIT3@NET3	318.0	285.1	280.9	280.6		
Flow DP	inH2O	MainDAS	HP DSH flow DP SQRT	0.0	0.1	0.1	0.1	Spray intermittent during testing	
<i>HP to LP Leakage 1 Flow</i>									
Meter Type	-			Orifice	Orifice	Orifice	Orifice	DP2A	
Tap Type	-			Corner	Corner	Corner	Corner		
Inlet Diameter	in			5.0470	5.0470	5.0470	5.0470		
Throat Diameter	in			3.7874	3.7874	3.7874	3.7874		
Diameter Measurement Temperature	Deg F			68	68	68	68		Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A		
Inlet Material	-			IAS	IAS	IAS	IAS		
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx		
Fluid Type	-			Vapor	Vapor	Vapor	Vapor		
Flow Pressure	psia	MainDAS	HP to LP Leakage flow 1 Pressure Corr	70.0	91.0	91.4	91.6		
Flow Temperature	Deg F	DCS	03-TE-103608.UNIT3@NET3	659.9	638.0	638.0	638.1		
Flow DP	inH2O	STGDSC	STG Bal Pipe DP1	9.4	318.4	315.5	318.8	Calc from CRH enthalpy and measured pressure Error in instrument. Use design value for flow	

GREC HRSG Test Input Data Summary

Linked Row					17	27	37	
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP to LP Leakage 2 Flow								DP2B
Meter Type	-			Orifice Corner	Orifice Corner	Orifice Corner	Orifice Corner	
Tap Type	-							
Inlet Diameter	in			5.0470	5.0470	5.0470	5.0470	
Throat Diameter	in			3.7874	3.7874	3.7874	3.7874	
Diameter Measurement Temperature	Deg F			68	68	68	68	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	
Inlet Material	-			IAS	IAS	IAS	IAS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	HP to LP Leakage flow 2 Pressure Corr	70.0	90.6	90.9	91.1	
Flow Temperature	Deg F			659.9	637.9	638.0	638.0	Calc from CRH enthalpy and measured pressure
Flow DP	inH2O	STGDGS	STG Bal Pipe DP2	9.4	4.4	4.5	4.6	
IP FW Flow								03-FE-104630
Meter Type	-			Orifice Flange	Orifice Flange	Orifice Flange	Orifice Flange	
Tap Type	-							
Inlet Diameter	in			3.8460	3.8460	3.8460	3.8460	
Throat Diameter	in			2.2695	2.2695	2.2695	2.2695	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			72.0	72.0	72.0	72.0	Calibrated
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	IP FW flow pressure Corr	550.5	796.5	797.6	797.9	
Flow Temperature	Deg F	MainDAS	IP FW flow Temp	318.1	473.3	474.0	474.0	
Flow DP	inH2O	MainDAS	IP FW flow DP SQRT	203.9	259.7	265.0	267.3	
CT Cooling Steam Flow								03-FE-035622
Meter Type	-			Venturi Throat	Venturi Throat	Venturi Throat	Venturi Throat	
Tap Type	-							
Inlet Diameter	in			7.981	7.981	7.981	7.981	
Throat Diameter	in			5.428	5.428	5.428	5.428	
Diameter Measurement Temperature	Deg F			68	68	68	68	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	CTG Cooling Steam Flow Pressure Corr	419.9	528.4	531.2	532.1	
Flow Temperature	Deg F	DCS	03-TE-035623.UNIT3@NET3	550.0	570.2	570.7	570.9	
Flow DP	inH2O	MainDAS	CTG Cooling Steam Flow DP SQRT	225.5	124.2	125.5	125.9	
HPS to CT Cooling Steam Flow								03-FE-035604
Meter Type	-			Venturi Throat	Venturi Throat	Venturi Throat	Venturi Throat	
Tap Type	-							
Inlet Diameter	in			4.8970	4.8970	4.8970	4.8970	
Throat Diameter	in			3.3790	3.3790	3.3790	3.3790	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	Calibrated
Inlet Material	-			IAS	IAS	IAS	IAS	
Throat Material	-			IAS	IAS	IAS	IAS	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	HP Steam to CT cooling steam flow Pressure Corr	1,700.0	1,768.0	1,772.9	1,774.2	
Flow Temperature	Deg F	MainDAS	HRSG HP Steam Temp	1,070.0	1,046.6	1,043.9	1,043.6	
Flow DP	inH2O	MainDAS	HP Steam to CT cooling steam flow DP	0.5	0.0	0.0	0.0	Valve closed
LP Steam Flow								03-FE-110636
Meter Type	-			Venturi Throat	Venturi Throat	Venturi Throat	Venturi Throat	
Tap Type	-							
Inlet Diameter	in			11.9830	11.9830	11.9830	11.9830	
Throat Diameter	in			7.0853	7.0853	7.0853	7.0853	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			45.5	45.5	45.5	45.5	Calibrated
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	LP Steam Flow Pressure Corr	77.1	91.1	91.5	91.7	
Flow Temperature	Deg F	MainDAS	LP Steam Flow Temp	482.9	517.2	517.8	517.0	
Flow DP	inH2O	MainDAS	LP Steam Flow DP SQRT	79.0	59.8	60.7	61.8	

GREC HRSG Test Input Data Summary

Linked Row					17	27	37	
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Condensate Flow Entering HRSG								
Meter Type	-			Orifice Flange	Orifice Flange	Orifice Flange	Orifice Flange	03-FE-108604
Tap Type	-							
Inlet Diameter	in			10.0200	10.0200	10.0200	10.0200	
Throat Diameter	in			5.8995	5.8995	5.8995	5.8995	
Diameter Measurement Temperature	Deg F			68	73	73	73	
Calibration Temperature	Deg F			N/A	106	106	106	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	Condensate flow entering HRSG Pressure Corr	450.0	567.5	567.0	566.9	
Flow Temperature	Deg F	MainDAS	Condensate flow entering HRSG Temp	100.5	131.8	129.3	129.2	
Flow DP	inH2O	MainDAS	Condensate flow entering HRSG DP SQRT	204.2	228.0	230.0	228.5	
DB Fuel Flow								
Meter Type	-			Orifice Flange	Orifice Flange	Orifice Flange	Orifice Flange	03-FE-980840
Tap Type	-							
Inlet Diameter	in			4.0260	4.0260	4.0260	4.0260	
Throat Diameter	in			2.6970	2.6970	2.6970	2.6970	
Diameter Measurement Temperature	Deg F			68	73	73	73	
Calibration Temperature	Deg F			N/A	106	106	106	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	DB fuel flow Pressure	300.0	345.4	341.1	340.5	
Flow Temperature	Deg F	DCS	03-TT-980840.UNIT3@NET3	70.0	85.9	79.4	78.9	
Flow DP	inH2O	MainDAS	DB fuel flow DP	0.0	-0.1	-0.1	-0.1	Off
CTG Fuel Gas Flow								
Meter Type	-			Turbine	Turbine	Turbine	Turbine	03-FIT-992601
Meter Diameter	in			10.00	10.00	10.00	10.00	
Flow Pressure	psia	CTGDAS	FG Supply Press	600.0	706.2	705.6	705.6	
Flow Temperature	Deg F	CTGDAS	FG Supply Temp	40.0	68.3	63.4	63.1	
Starting Pulse Count	Pulses			318,041.0	881,618.0	103,349.0	393,195.0	
Ending Pulse Count	Pulses			597,171.0	173,168.0	393,195.0	683,871.0	
Plant Fuel Gas Flow								
Meter Type	-			Ultrasonic	Ultrasonic	Ultrasonic	Ultrasonic	
Tap Type	-			N/A	N/A	N/A	N/A	
Inlet Diameter	in			10.0210	10.0210	10.0210	10.0210	
Throat Diameter	in			10.0210	10.0210	10.0210	10.0210	
Diameter Measurement Temperature	Deg F			72	72	72	72	Assumed
Calibration Temperature	Deg F			48.4	48.4	48.4	48.4	
Inlet Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Upstream Pressure	psia	DCS	03-ENBL-PSI.UNIT3@NET3	450.0	806.9	840.8	841.9	
Downstream Temperature	Deg F	DCS	03-TT-560500.UNIT3@NET3	67.8	68.7	67.9	67.8	
Meter Reported Flow Rate	KACF/h	DCS	03-FE-560500B.UNIT3@NET3	86.8	45.23	42.43	42.53	
Fuel Analysis								
Methane, CH4	mole %	DCS	03-XY-992273.UNIT3@NET3	93.280%	90.29%	90.00%	89.93%	ASTM D1945
Ethane, C2H6	mole %	DCS	03-XY-992274.UNIT3@NET3	3.535%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %	DCS	03-XY-992275.UNIT3@NET3	0.530%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %	DCS	03-XY-992276.UNIT3@NET3	0.039%	0.01%	0.01%	0.01%	
n-Butane, n-C4H10	mole %	DCS	03-XY-992277.UNIT3@NET3	0.072%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %	DCS	03-XY-992278.UNIT3@NET3	0.009%	0.00%	0.01%	0.01%	
n-Pentane, n-C5H12	mole %	DCS	03-XY-992279.UNIT3@NET3	0.008%	0.00%	0.01%	0.01%	
n-Hexane, n-C6H14	mole %	DCS	03-XY-992280.UNIT3@NET3	0.016%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %			0.000%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %			0.000%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %			0.000%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %			0.000%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %	DCS	03-XY-992282.UNIT3@NET3	1.971%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %			0.000%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %	DCS	03-XY-992281.UNIT3@NET3	0.540%	0.63%	0.65%	0.66%	
Water, H2O	mole %			0.000%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %	DCS	03-XY-992284.UNIT3@NET3	0.000%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %			0.000%	0.00%	0.00%	0.00%	
Helium, He	mole %			0.000%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %			0.000%	0.00%	0.00%	0.00%	
Argon, Ar	mole %			0.000%	0.01%	0.01%	0.01%	

GREC U3 HRSG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP FW Flow							
<i>Design Information</i>							
Meter Type	-		Orifice	Orifice	Orifice	Orifice	03-FE-101604
Tap Type	-		Flange	Flange	Flange	Flange	
Inlet Diameter	in		7.7430	7.7430	7.7430	7.7430	
Throat Diameter	in		4.9659	4.9659	4.9659	4.9659	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		120.0	120.0	120.0	120.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,908.1	2,199.3	2,203.6	2,206.2	
Downstream Temperature	Deg F		320.6	330.5	330.7	331.1	
DP	inH2O		187.8	202.4	205.5	203.6	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		57.08	56.83	56.82	56.81	
Fluid Viscosity	lbm/(ft*s)		0.000116	0.000112	0.000112	0.000112	
Calculated Flow	lb/h		610,391	632,203	637,142	634,126	610,209.49
Calculated Flow	gpm		1,333	1,387	1,398	1,392	

17769-01			
HP FW Flow			
1		2	
Inlet Re	Cd	Inlet Re	Cd
311,150	0.605	311,150	0.6052
386,257	0.6038	386,257	0.6049
456,231	0.6043	456,231	0.6041
533,408	0.6044	533,408	0.6033
602,964	0.6043	602,964	0.6037
667,309	0.6042	6.67E+05	0.6046
742,020	0.6037	7.42E+05	0.6044
803,433	0.604	8.03E+05	0.6048
862,114	0.6046	8.62E+05	0.6047
928,944	0.6042	9.29E+05	0.6043
1,024,286	0.6044	1.02E+06	0.6041
1,065,251	0.6043	1.07E+06	0.6047
1,143,311	0.6038	1143311	0.6041
1,235,619	0.6038	1235619	0.6044
1,259,580	0.6035	1259580	0.604
1,365,260	0.6035	1365260	0.6039
1,414,187	0.6039	1414187	0.6041
1,470,232	0.6034	1470232	0.6039
1,577,685	0.6033	1577685	0.6035
1,630,434	0.6031	1630434	0.6032

GREC U3 HRSG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP FW to FGH Flow							
<i>Design Information</i>							
Meter Type	-		ASMENozzle	ASMENozzle	ASMENozzle	ASMENozzle	03-FE-062605
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		3.623	3.623	3.623	3.623	
Throat Diameter	in		1.794	1.794	1.794	1.794	
Diameter Measurement Temperature	Deg F		73.0	73.0	73.0	73.0	
Calibration Temperature	Deg F		106.0	106.0	106.0	106.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,870.0	1,905.5	1,911.3	1,912.8	
Downstream Temperature	Deg F		521.0	524.6	525.2	525.5	
DP	inH2O		77.0	206.6	202.5	200.3	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		48.38	48.19	48.15	48.14	
Fluid Viscosity	lbm/(ft*s)		0.000067	0.000066	0.000066	0.000066	
Calculated Flow	lb/h		73,202	119,739	118,500	117,857	
Calculated Flow	gpm		189	310	307	305	

20171-08							
HP FW to FGH							
1		2		3		4	
Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd
1,309,849	0.9967	1,309,849	0.9972	1,309,849	0.9968	1,309,849	0.9969
1,224,140	0.9967	1,224,140	0.9971	1,224,140	0.9968	1,224,140	0.9969
1,139,421	0.9967	1,139,421	0.9971	1,139,421	0.9968	1,139,421	0.9969
1,051,335	0.9966	1,051,335	0.997	1,051,335	0.9967	1,051,335	0.9967
966,864	0.9965	966,864	0.9969	966,864	0.9966	966,864	0.9967
8.81E+05	0.9964	8.81E+05	0.9969	8.81E+05	0.9966	8.81E+05	0.9967
7.95E+05	0.9965	7.95E+05	0.9968	7.95E+05	0.9966	7.95E+05	0.9966
7.07E+05	0.9964	7.07E+05	0.9968	7.07E+05	0.9965	7.07E+05	0.9965
6.25E+05	0.9967	6.25E+05	0.9971	6.25E+05	0.9968	6.25E+05	0.9969
5.39E+05	0.997	5.39E+05	0.9974	5.39E+05	0.9971	5.39E+05	0.9972
1.26E+06	0.9967	1.26E+06	0.9972	1.26E+06	0.9969	1.26E+06	0.9969
1.18E+06	0.9968	1.18E+06	0.9972	1.18E+06	0.9969	1.18E+06	0.9969
1096294.229	0.9968	1096294.229	0.9971	1096294.229	0.9969	1096294.229	0.9968
1007317.185	0.9966	1007317.185	0.997	1007317.185	0.9968	1007317.185	0.9967
1419176.423	0.9965	1419176.423	0.9969	1419176.423	0.9967	1419176.423	0.9966
838325.1697	0.9965	838325.1697	0.9969	838325.1697	0.9967	838325.1697	0.9966
752071.4077	0.9966	752071.4077	0.9969	752071.4077	0.9967	752071.4077	0.9967
667847.7284	0.9967	667847.7284	0.9971	667847.7284	0.9968	667847.7284	0.9968
582881.3359	0.997	582881.3359	0.9973	582881.3359	0.9971	582881.3359	0.9971
497469.3155	0.9974	497469.3155	0.9978	497469.3155	0.9976	497469.3155	0.9976

GREC U3 HRSG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP FW from TCA Flow							
<i>Design Information</i>							
Meter Type	-		ASME Nozzle	ASME Nozzle	ASME Nozzle	ASME Nozzle	03-FE-065618
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		5.188	5.188	5.188	5.188	
Throat Diameter	in		2.564	2.564	2.564	2.564	
Diameter Measurement Temperature	Deg F		74.0	74.0	74.0	74.0	
Calibration Temperature	Deg F		106.0	106.0	106.0	106.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,908.1	1,888.1	1,893.0	1,894.6	
Downstream Temperature	Deg F		320.6	589.1	591.6	590.6	
DP	inH2O		32.7	68.3	67.0	67.9	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft ³		57.08	43.70	43.50	43.59	
Fluid Viscosity	lbm/(ft*s)		0.000116	0.000056	0.000056	0.000056	
Calculated Flow	lb/h		105,471	134,056	132,443	133,456	
Calculated Flow	gpm		230	382	380	382	

20171-09							
FW from TCA							
1		2		3		4	
Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd
1,688,016	0.9972	1,688,016	0.9972	1,688,016	0.9974	1,688,016	0.9977
1,563,992	0.9971	1,563,992	0.9971	1,563,992	0.9973	1,563,992	0.9976
1,436,064	0.9969	1,436,064	0.9969	1,436,064	0.9972	1,436,064	0.9975
1,307,741	0.9968	1,307,741	0.9968	1,307,741	0.9971	1,307,741	0.9974
1,187,818	0.9967	1,187,818	0.9966	1,187,818	0.9969	1,187,818	0.9972
1,061,224	0.9964	1,061,224	0.9963	1,061,224	0.9967	1,061,224	0.9969
934,926	0.9963	934,926	0.9962	934,926	0.9966	934,926	0.9968
809,963	0.9963	809,963	0.9962	809,963	0.9966	809,963	0.9968
684,209	0.9965	684,209	0.9964	684,209	0.9968	684,209	0.997
559,839	0.9973	559,839	0.9971	559,839	0.9974	559,839	0.9976
1,626,844	0.9972	1,626,844	0.9971	1,626,844	0.9974	1,626,844	0.9976
1,499,559	0.997	1,499,559	0.997	1,499,559	0.9973	1,499,559	0.9975
1,374,447	0.997	1,374,447	0.9969	1,374,447	0.9973	1,374,447	0.9974
1,248,249	0.9968	1,248,249	0.9968	1,248,249	0.9972	1,248,249	0.9973
1,121,754	0.9965	1,121,754	0.9964	1,121,754	0.9968	1,121,754	0.997
996,593	0.9964	996,593	0.9964	996,593	0.9967	996,593	0.9969
873,458	0.9963	873,458	0.9963	873,458	0.9966	873,458	0.9969
747,062	0.9964	747,062	0.9964	747,062	0.9968	747,062	0.997
622,247	0.9968	622,247	0.9967	622,247	0.9971	622,247	0.9973
497,926	0.9975	497,926	0.9974	497,926	0.9978	497,926	0.9979
172,349	0.9974	172,349	0.9971	172,349	0.9973	172,349	0.9976
122,789	0.9936	122,789	0.9931	122,789	0.9926	122,789	0.9936
334,718	0.9982	334,718	0.998	334,718	0.9983	334,718	0.9986

GREC U3 HRSG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP to LP Leakage 1 Flow							
<i>Design Information</i>							
Meter Type	-		Orifice	Orifice	Orifice	Orifice	
Tap Type	-		Corner	Corner	Corner	Corner	
Inlet Diameter	in		5.047	5.047	5.047	5.047	
Throat Diameter	in		3.787	3.787	3.787	3.787	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		IAS	IAS	IAS	IAS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		70.0	91.0	91.4	91.6	
Downstream Temperature	Deg F		659.9	638.0	638.0	638.1	
DP	inH2O		9.4	318.4	315.5	318.8	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		0.11	0.14	0.14	0.14	
Fluid Viscosity	lbm/(ft*s)		0.000015	0.000015	0.000015	0.000015	
Calculated Flow	lb/h		3,769	23,917	23,872	24,007	3,775.00
Calculated Flow	gpm		4,438	21,160	21,033	21,115	Error in instrument

HP to LP Leakage 2 Flow							
<i>Design Information</i>							
Meter Type	-		Orifice	Orifice	Orifice	Orifice	
Tap Type	-		Corner	Corner	Corner	Corner	
Inlet Diameter	in		5.0	5.0	5.0	5.0	
Throat Diameter	in		3.8	3.8	3.8	3.8	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		IAS	IAS	IAS	IAS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		70.0	90.6	90.9	91.1	
Downstream Temperature	Deg F		659.9	637.9	638.0	638.0	
DP	inH2O		9.4	4.4	4.5	4.6	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		0.11	0.14	0.14	0.14	
Fluid Viscosity	lbm/(ft*s)		0.000015	0.000015	0.000015	0.000015	
Calculated Flow	lb/h		3,769	2,976	3,002	3,037	3,775.00
Calculated Flow	gpm		4,438	2,647	2,659	2,685	

GREC U3 HRSG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
CT Cooling Steam Flow							
<i>Design Information</i>							
Meter Type	-		Venturi	Venturi	Venturi	Venturi	03-FE-035622
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		7.981	7.981	7.981	7.981	
Throat Diameter	in		5.428	5.428	5.428	5.428	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		419.9	528.4	531.2	532.1	
Downstream Temperature	Deg F		550.0	570.2	570.7	570.9	
DP	inH2O		225.5	124.2	125.5	125.9	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		0.76	0.96	0.96	0.96	
Fluid Viscosity	lbm/(ft*s)		0.000013	0.000013	0.000013	0.000013	
Calculated Flow	lb/h		155,393	130,338	131,352	131,705	129,494.82
Calculated Flow	gpm		25,420	16,991	17,032	17,052	

HPS to CT Cooling Steam Flow							
<i>Design Information</i>							
Meter Type	-		Venturi	Venturi	Venturi	Venturi	03-FE-035604
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		4.9	4.9	4.9	4.9	
Throat Diameter	in		3.4	3.4	3.4	3.4	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		IAS	IAS	IAS	IAS	
Throat Material	-		IAS	IAS	IAS	IAS	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,700.0	1,768.0	1,772.9	1,774.2	
Downstream Temperature	Deg F		1,070.0	1,046.6	1,043.9	1,043.6	
DP	inH2O		0.5	0.0	0.0	0.0	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		1.99	2.12	2.13	2.13	
Fluid Viscosity	lbm/(ft*s)		0.000022	0.000021	0.000021	0.000021	
Calculated Flow	lb/h		4,685	0	0	0	0.00
Calculated Flow	gpm		293	0	0	0	All valves were closed, no flow

GREC U3 HRSG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
LP Steam Flow							03-FE-110636
<i>Design Information</i>							
Meter Type	-		Venturi	Venturi	Venturi	Venturi	
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		11.983	11.983	11.983	11.983	
Throat Diameter	in		7.085	7.085	7.085	7.085	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		45.5	45.5	45.5	45.5	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		77.1	91.1	91.5	91.7	
Downstream Temperature	Deg F		482.9	517.2	517.8	517.0	
DP	inH2O		79.0	59.8	60.7	61.8	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		0.14	0.16	0.16	0.16	
Fluid Viscosity	lbm/(ft*s)		0.000012	0.000013	0.000013	0.000013	
Calculated Flow	lb/h		62,310	58,496	59,034	59,643	62,158.76
Calculated Flow	gpm		55,531	45,706	45,947	46,277	

17769-09				
LP Steam Flow				
1		2		
Inlet Re	Cd	Inlet Re	Cd	
269,692	0.9889	269,692	0.9896	
327,975	0.9878	327,975	0.9895	
382,210	0.9881	382,210	0.9907	
439,548	0.9879	439,548	0.9905	
490,545	0.9882	490,545	0.9901	
551,391	0.9885	551,391	0.9905	
608,325	0.9884	608,325	0.9904	
666,877	0.9878	666,877	0.9898	
724,620	0.9883	724,620	0.9906	
776,966	0.9881	776,966	0.9897	
837,003	0.9887	837,003	0.9908	
893,532	0.9889	893,532	0.9907	
954,243	0.9891	954,243	0.9906	
1,003,891	0.9886	1,003,891	0.9903	
1,057,452	0.9893	1,057,452	0.9908	
1,114,520	0.9897	1,114,520	0.9911	
1,171,858	0.9895	1,171,858	0.9909	
1,229,736	0.9903	1,229,736	0.9914	
1,294,360	0.9899	1,294,360	0.9914	
1,343,603	0.9897	1,343,603	0.9914	

GREC U3 HRSG Flow Calculations

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Plant Fuel Flow							
<i>Design Information</i>							
Meter Type	-		Ultrasonic	Ultrasonic	Ultrasonic	Ultrasonic	
Tap Type	-		N/A	N/A	N/A	N/A	
Inlet Diameter	in		10.0	10.0	10.0	10.0	
Throat Diameter	in		10.0	10.0	10.0	10.0	
Diameter Measurement Temperature	Deg F		72.0	72.0	72.0	72.0	
Calibration Temperature	Deg F		48.4	48.4	48.4	48.4	
Inlet Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		450.0	806.9	840.8	841.9	
Downstream Temperature	Deg F		67.8	68.7	67.9	67.8	
Meter Reported Flow Rate	KACFH		86.8	45.2	42.4	42.5	
<i>Fuel Analysis (lab)</i>							
Methane, CH4	mole %		93.28%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %		3.53%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %		0.53%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %		0.04%	0.01%	0.01%	0.01%	
n-Butane, n-C4H10	mole %		0.07%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
n-Pentane, n-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
n-Hexane, n-C6H14	mole %		0.02%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %		0.00%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %		0.00%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %		0.00%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %		0.00%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %		1.97%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %		0.00%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %		0.54%	0.63%	0.65%	0.66%	
Water, H2O	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %		0.00%	0.00%	0.00%	0.00%	
Helium, He	mole %		0.00%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %		0.00%	0.00%	0.00%	0.00%	
Argon, Ar	mole %		0.00%	0.01%	0.01%	0.01%	
<i>Calculated Parameters</i>							
Gas MW (Lab Composition)	lb/lb mole		17.14	17.51	17.56	17.57	
Fluid Density (Lab Composition)	lb/ft^3	pSCF_Lab	0.045	0.046	0.046	0.046	SCF
Fluid Density (Lab Composition)	lb/ft^3	pACF_Lab	1.452	2.813	2.964	2.972	ACF
Calculated Flow	lb/h		126,093	127,242	125,776	126,378	QACF*pACF_Lab
Calculated Flow	gpm		10,825	5,639	5,290	5,302	

GREC U3 C TG Exhaust Flow by HRSG Energy Balance Calculation

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Inputs							
<i>Temperature Measurements</i>							
HP steam temp	Deg F		1,052.00	1,046.61	1,043.92	1,043.59	
CRH steam temp	Deg F		662.20	677.42	676.36	676.25	
HRH steam temp	Deg F		1,051.50	1,050.80	1,047.86	1,047.31	
IP steam temp	Deg F		570.00	572.19	572.58	572.72	
LP steam temp	Deg F		486.20	517.18	517.81	516.99	
Condensate before FGH return temp	Deg F		93.69	110.43	109.13	109.53	
Condensate temp	Deg F		99.00	131.77	129.32	129.21	
BFWP suction temp	Deg F		316.64	325.78	325.93	326.23	
IP FW temp	Deg F		318.14	327.66	327.98	328.25	
HP FW temp	Deg F		320.64	330.28	330.58	330.84	
HP FW to FGH supply temp	Deg F		521.02	524.58	525.23	525.49	
HP FW return from FGH supply temp	Deg F		175.25	293.86	285.97	283.96	
TCA suction temp	Deg F		316.64	325.49	325.69	326.00	
TCA supply temp	Deg F		323.84	332.38	332.58	332.96	
TCA return temp	Deg F		600.52	589.09	591.62	590.56	
CTG coling steam supply temp	Deg F		565.63	570.65	570.91	571.06	
CTG cooling steam return temp	Deg F		925.70	940.51	937.25	936.31	
DB fuel temp	Deg F		59.00	85.87	79.43	78.92	
CTG exhaust temp	Deg F		1,186.00	1,191.51	1,188.91	1,188.19	
Stack temp	Deg F		177.79	191.16	190.09	190.49	
CTG compressor inlet temp	Deg F		59.00	79.30	75.25	74.17	
CTG compressor inlet RH	%		65.00%	76.19%	81.11%	84.12%	
CTG ambient temp	Deg F		59.00	79.31	75.38	74.06	
CTG ambient RH	%		65.00%	76.19%	81.11%	84.12%	
<i>Pressure Measurements</i>							
HP steam pressure	psia		1,752.20	1,769.39	1,774.22	1,775.63	
CRH steam pressure	psia		422.60	424.11	425.78	426.28	
HRH steam pressure	psia		407.20	410.84	412.45	412.97	
LP steam pressure	psia		79.00	91.08	91.49	91.69	
Condensate before FGH return pressure	psia		450.00	574.94	574.68	574.20	
Condensate pressure	psia		450.00	524.42	524.09	523.55	
BFWP suction pressure	psia		86.00	130.64	131.04	131.33	
IP FW pressure	psia		550.49	818.28	820.30	820.87	
HP FW pressure	psia		1,908.12	1,938.56	1,944.55	1,945.99	
HP FW to FGH supply pressure	psia		1,878.32	1,905.50	1,911.28	1,912.82	
HP FW return from FGH supply pressure	psia		500.00	1,905.80	1,911.57	1,913.20	
TCA suction pressure	psia		86.00	135.31	135.81	136.09	
TCA supply pressure	psia		2,000.00	2,664.24	2,671.98	2,666.71	
TCA return pressure	psia		2,000.00	2,590.33	2,599.37	2,593.51	
CTG cooling steam supply pressure	psia		517.56	531.97	534.78	535.68	
CTG cooling steam return pressure	psia		419.86	430.65	432.42	432.96	
DB fuel pressure	psia		20.00	345.44	341.06	340.53	
CTG compressor inlet pressure loss	inH2O		5.00	5.00	5.00	5.00	Estimated
Barometric pressure	psia		14.37	14.43	14.42	14.42	
HRSG backpressure	inH2O		16.00	15.47	15.73	15.86	
HP drum pressure	psia		1,848.55	1,867.54	1,872.68	1,874.15	
IP drum pressure	psia		530.12	539.70	542.61	543.51	
LP drum pressure	psia		85.48	97.74	98.25	98.54	
<i>Level Measurements</i>							
Starting HP Drum Level	in		20.00	14.27	14.79	14.48	
Ending HP Drum Level	in		20.00	14.70	14.48	14.49	
Starting IP Drum Level	in		20.00	19.85	19.50	19.66	
Ending IP Drum Level	in		20.00	19.97	19.66	19.74	
Starting LP Drum Level	in		20.00	54.31	54.12	53.63	
Ending LP Drum Level	in		20.00	53.95	53.63	53.95	
<i>Other Measurements</i>							
HRSG Auxiliary Power	kW		928.00	368.71	368.88	367.35	
N2 packing leakage flow	lb/h		11,680.00	59,923.34	59,923.34	59,923.34	
HPS to cooling steam DSH flow	lb/h		0.00	435.05	293.91	230.89	
CTG Exhaust Gas Flow (CTG Energy Balance)	lb/h		4,826,706	4,990,106	4,822,703	4,840,786	
CTG Exhaust Gas Flow Uncertainty (CTG Energy Balance)	%		1.00%	1.76%	1.33%	1.60%	

GREC U3 CTG Exhaust Flow by HRSG Energy Balance Calculation

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Calculated Flows							
HP FW flow	lb/h		610,209	632,203	637,142	634,126	
HP FW to FGH flow	lb/h		73,183	119,739	118,500	117,857	
HP FW to TCA flow	lb/h		105,578	134,056	132,443	133,456	
HP DSH flow	lb/h		0	1,288	932	907	
HP to LP leakage 1 flow	lb/h		3,775	23,917	23,872	24,007	Error in instrument. Using design value for HP to LP leakage flows.
HP to LP leakage 2 flow	lb/h		3,775	2,976	3,002	3,037	Design value used
IP FW flow	lb/h		129,976	138,587	139,942	140,551	
CT cooling steam flow	lb/h		129,495	130,338	131,352	131,705	
HPS to CT Cooling Steam Flow	lb/h		0	0	0	0	Valve was closed, no flow
LP steam flow	lb/h		64,700	58,496	59,034	59,643	
Condensate flow entering HRSG	lb/h		907,922	956,757	961,255	958,077	
DB fuel flow	lb/h		0	0	0	0	
CTG fuel flow	lb/h		126,087	127,242	125,776	126,378	Using Enable meter
HP Steam Flow (measured)	lb/h		642,605	656,934	659,908	659,722	Not used
CRH Steam Flow (measured)	lb/h		619,289	565,401	567,057	567,516	Not used. Pitot tube DCS measurement
IP Steam Flow (measured)	lb/h		0	0	0	0	Not used
Fuel Analysis							
Methane, CH4	mole %		93.28%	90.29%	90.00%	89.93%	
Ethane, C2H6	mole %		3.53%	6.85%	7.02%	7.03%	
Propane, C3H8	mole %		0.53%	0.33%	0.36%	0.35%	
Iso-Butane, i-C4H10	mole %		0.04%	0.01%	0.01%	0.01%	
N-Butane, n-C4H10	mole %		0.07%	0.02%	0.03%	0.03%	
Iso-Pentane, i-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Pentane, n-C5H12	mole %		0.01%	0.00%	0.01%	0.01%	
N-Hexane, n-C6H14	mole %		0.02%	0.01%	0.01%	0.01%	
Heptane, C7H16	mole %		0.00%	0.00%	0.00%	0.00%	
Octane, C8H18	mole %		0.00%	0.00%	0.00%	0.00%	
Nonane, C9H20	mole %		0.00%	0.00%	0.00%	0.00%	
Decane, C10H22	mole %		0.00%	0.00%	0.00%	0.00%	
Nitrogen, N2	mole %		1.97%	1.80%	1.86%	1.90%	
Carbon Monoxide, CO	mole %		0.00%	0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %		0.54%	0.63%	0.65%	0.66%	
Water, H2O	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %		0.00%	0.00%	0.00%	0.00%	
Hydrogen, H2	mole %		0.00%	0.00%	0.00%	0.00%	
Helium, He	mole %		0.00%	0.04%	0.04%	0.04%	
Oxygen, O2	mole %		0.00%	0.00%	0.00%	0.00%	
Argon, Ar	mole %		0.00%	0.01%	0.01%	0.01%	
Calculations							
Compressor inlet pressure	psia		14.189	14.245	14.243	14.243	
Leakage lookups							
HP to LP leakage	lb/h		7,550	7,769	7,827	7,808	
Gland LP leakoff (HP side)	lb/h		3,440	3,533	3,564	3,553	
Gland subatmospheric leakoff (HP side)	lb/h		590	613	613	613	
LP gland sealing steam	lb/h		2,680	2,669	2,669	2,669	
Gland subatmospheric leakoff (LP side)	lb/h		1,020	1,024	1,024	1,024	
Flow Calculations							
HP drum level change flow	ft3		0	-7	5	0	Negative indicates water stored in drum
IP drum level change flow	ft3		0	-2	-3	-1	
LP drum level change flow	ft3		0	14	20	-13	
HP drum density	lb/ft3		40.1	40.0	39.9	39.9	
IP drum density	lb/ft3		50.3	50.2	50.2	50.2	
LP drum density	lb/ft3		56.8	56.4	56.4	56.4	
HP drum level change flow	lb/h		0.0	-299.2	213.9	-2.4	
IP drum level change flow	lb/h		0.0	-100.8	-137.8	-68.9	
LP drum level change flow	lb/h		0.0	817.6	1,106.2	-719.7	
Total HP to CRH STG leakage			23,260	71,838	71,927	71,897	
HP Steam Flow	lb/h		631,030	647,509	652,231	650,630	HP FW + HP DSH + TCA - FGH Extraction + HP Drum Level
CRH Steam Flow	lb/h		618,914	575,670	580,304	578,733	HP Steam - STG leakages- HPS to CT Cooling Steam
IP Steam Flow	lb/h		137,460	138,486	139,804	140,482	IP FW + IP Drum Level
HRH Steam Flow	lb/h		748,890	714,592	720,402	719,446	CRH Steam + IP Steam + HP cooling steam + HP cooling steam DSH

GREC U3 CTG Exhaust Flow by HRSG Energy Balance Calculation

Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Entering Enthalpies							
Condensate enthalpy	btu/lb		68.2	101.1	98.6	98.5	
IP FW enthalpy	btu/lb		289.3	299.6	300.0	300.2	
HP FW enthalpy	btu/lb		294.3	304.3	304.6	304.9	
TCA return enthalpy	btu/lb		615.1	596.7	600.0	598.6	
CTG cooling steam return enthalpy	btu/lb		1,483.4	1,491.0	1,489.2	1,488.6	
CRH steam enthalpy	btu/lb		1,340.6	1,349.0	1,348.3	1,348.2	
Exiting Enthalpies							
BFWP suction enthalpy	btu/lb		287.0	296.5	296.7	297.0	
FGH supply enthalpy	btu/lb		512.2	516.5	517.2	517.5	
TCA suction enthalpy	btu/lb		287.0	296.2	296.4	296.7	
CTG cooling steam supply enthalpy	btu/lb		1,275.4	1,277.2	1,277.1	1,277.1	
HP steam enthalpy	btu/lb		1,514.9	1,511.1	1,509.3	1,509.1	
HRH steam enthalpy	btu/lb		1,551.3	1,550.8	1,549.2	1,548.9	
LP steam enthalpy	btu/lb		1,274.5	1,288.8	1,289.1	1,288.6	
Entering Energies							
Condensate energy	btu/h		61,944,638	96,695,376	94,807,402	94,382,788	
IP FW energy	btu/h		37,604,960	41,524,959	41,976,921	42,199,879	
HP FW energy	btu/h		179,582,054	192,352,238	194,058,870	193,313,373	
TCA return energy	btu/h		64,936,465	79,987,738	79,472,188	79,892,188	
CTG cooling steam return energy	btu/h		192,091,052	194,329,894	195,604,605	196,062,696	
CRH steam energy	btu/h		829,714,454	776,571,161	782,419,090	780,246,550	
Exiting Energies							
BFWP suction energy	btu/h		212,403,047	228,927,311	230,809,132	230,329,896	HP FW + HP DSH + IP FW
FGH supply energy	btu/h		37,485,637	61,840,961	61,293,183	60,997,067	
TCA suction energy	btu/h		30,296,614	39,709,154	39,259,095	39,602,263	
CTG cooling steam supply energy	btu/h		165,156,426	166,469,477	167,749,853	168,203,257	
HP steam energy	btu/h		955,960,883	978,468,681	984,438,263	981,862,959	
HRH steam energy	btu/h		1,161,747,610	1,108,203,014	1,116,043,560	1,114,339,923	
LP steam energy	btu/h		82,459,263	75,388,961	76,099,956	76,858,741	
HRSG water side duty	btu/h		1,279,635,857	1,277,546,193	1,287,353,966	1,286,096,633	
Correction parameters							
Fuel heating value (LHV)	btu/lb		20,422.37	20,401.32	20,367.93	20,348.21	
Duct burner heat input (LHV)	btu/h		0	0	0	0	
CRH Return Flow %	%		98.08%	88.91%	88.97%	88.95%	% of HP Flow
TCA Cooler Pressure Drop	psi		0	74	73	73	Check on from where to where
TCA supply enthalpy	btu/lb		297.7	307.7	307.9	308.3	
TCA Energy Addition	mmBtu/h		33.5	38.7	38.7	38.8	Verify this is just TCA, not pump as well
FGH return enthalpy	btu/lb		144	267	259	257	
FGH Energy reduction	mmBtu/h		26.92	29.88	30.61	30.72	
HP Pump Temperature Rise	Deg F		4.0	4.5	4.7	4.6	
IP Pump Temperature Rise	Deg F		1.5	1.9	2.0	2.0	
TCA Pump Temperature Rise	Deg F		7.2	6.9	6.9	7.0	
Results							
CTG exhaust flow (CTG energy balance)	lb/h		4,765,000	4,990,106	4,822,703	4,840,786	From CTG Testing using temp TC grid and Enable fuel flow
CTG exhaust flow uncertainty (CTG energy balance)	%		1.00%	1.76%	1.33%	1.60%	
CTG exhaust flow (HRSG energy balance)	lb/h		4,765,000	4,699,829	4,755,427	4,755,269	
CTG exhaust flow uncertainty (HRSG energy balance)	%		0.98%	0.79%	0.78%	0.78%	
CTG exhaust enthalpy (HRSG energy balance)	btu/lb		302.16	301.12	300.69	300.82	
HRSG stack exhaust flow (HRSG energy balance)	lb/h		4,765,000	4,699,829	4,755,427	4,755,269	
HRSG stack enthalpy (HRSG energy balance)	btu/lb		30.06	28.56	29.25	29.63	
HRSG heat loss	btu/h		3,441,425	3,434,208	3,463,323	3,460,076	
HRSG heat loss %	%		0.27%	0.27%	0.27%	0.27%	
CTG exhaust composition							
Wet N2	mole %		73.79%	72.66%	72.87%	72.86%	
Wet O2	mole %		10.83%	10.48%	10.75%	10.72%	
Wet CO2	mole %		4.58%	4.63%	4.53%	4.55%	
Water	mole %		9.91%	11.35%	10.97%	11.00%	
Wet SO2	mole %		0.00%	0.00%	0.00%	0.00%	
Wet Ar	mole %		0.88%	0.87%	0.88%	0.88%	
Gas MW	lb/lb mole		28.29	28.14	28.17	28.17	
CTG exhaust flow (Uncertainty Weighted)	lb/h		4,765,000	4,748,007	4,772,823	4,771,718	
CTG exhaust flow uncertainty (Uncertainty Weighted)	%		0.99%	0.96%	0.92%	0.94%	

GREC U3 HRSG Corrections							
Description	Units	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HRSG Rate Program Inputs							
Ambient Temperature	Deg F		59.00	79.31	75.38	74.06	
Exhaust Gas Exhaust Temperature	Deg F		1,186.00	1,191.51	1,188.91	1,188.19	
Exhaust Gas Exhaust Flow	lb/h		4,765,000	4,748,007	4,772,823	4,771,718	Uncertainty weighted average of CTG and HRSG
Exhaust Gas Exhaust Composition N2	% vol		73.79	72.66	72.87	72.86	
Exhaust Gas Exhaust Composition O2	% vol		10.98	10.48	10.75	10.72	
Exhaust Gas Exhaust Composition CO2	% vol		4.50	4.63	4.53	4.55	
Exhaust Gas Exhaust Composition H2O	% vol		9.80	11.35	10.97	11.00	
Exhaust Gas Exhaust Composition SO2	% vol		0.00	0.00	0.00	0.00	
Exhaust Gas Exhaust Composition Ar	% vol		0.93	0.87	0.88	0.88	
Exhaust Gas Exhaust Composition Molecular Weight	% vol		28.30	28.14	28.17	28.17	
Duct Burner On / Off	(Y/N)		Unchecked	Unchecked	Unchecked	Unchecked	Manual Input
Duct Burner Duty	MMBTU/h		0	0.00	0.00	0.00	
RH Outlet Set Pressure	psia		407.20	410.84	412.45	412.97	Boundary pressure
HP Outlet Set Pressure	psia		1,752.20	1,769.39	1,774.22	1,775.63	Boundary pressure
LP Outlet Set Pressure	psia		100.30	91.08	91.49	91.69	Boundary pressure
CRH Return Fixed Temperature	Deg F		662.00	677.42	676.36	676.25	CRH temp at HRSG
CRH Return Flow Return	%		96.23	88.91	88.97	88.95	CRH % of HP
HP Desuperheater Set Temperature	Deg F		1,052.00	1,052.00	1,052.00	1,052.00	Set temp (as measured during test)
RH Steam Bypass Set Temperature	Deg F		1,052.00	1,051.50	1,051.50	1,051.50	Set temp (as measured during test)
HP Steam Drum Blowdown %	%		0.00	0.00	0.00	0.00	Off during test
IP Steam Drum Blowdown %	%		0.00	0.00	0.00	0.00	Off during test
IP to RH Control Valve Inlet Set Pressure	psia		537.00	536.12	539.06	539.93	Set pressure (as measured during test 03-PIT-106621)
Combustor Cooler Return Fixed Temperature	Deg F		925.70	940.51	937.25	936.31	
Combustor Cooler Return Fixed Flow	lb/h		132,500	130,338	131,352	131,705	Steam from combustor cooler to HRSG
CC From IP Extraction Drawoff Flow	lb/h		132,500	129,903	131,058	131,474	Steam from IP to steam cooler
HP Combustor Back Up CV Set Flow	lb/h		132,500	130,338	131,352	131,705	Backup supply to above if IP cannot produce enough steam
HP Steam to CC Steam Cooling Desuperheater Spray Drawoff Flow	lb/h		0	435	294	231	DSH flow for HP supply to steam cooler
TCA Extraction Drawoff Flow	lb/h		153,900	134,056	132,443	133,456	LP drum to TCA pumps
Condensate Bypass To TCA Cooler Drawoff Flow	lb/h		0	0	0	0	Condensate to TCA pumps (startup only)
TCA Cooler Exit Inlet Set Pressure	psia		2,415.00	2,590.33	2,599.37	2,593.51	TCA FW to HP drum pressure
TCA Cooler - (Across TCA Cooler) Set Pressure Drop	psi		14.00	14.60	14.60	14.00	
TCA Energy Addition	MMBTU/h		32.82	38.74	38.69	38.75	
TCA Cooler - (From TCA Pump Discharge to TCA Cooler Inlet Set Pressure Drop	psi		30.20	30.20	30.20	30.00	
FGH Control Valve Set Temperature	Deg F		142.00	293.86	285.97	283.96	
FGH Energy Reduction	MMBTU/h		24.42	29.88	30.61	30.72	
Preheat Bypass Diverted (Y/N)	(Y/N)		Unchecked	Unchecked	Unchecked	Unchecked	Manual Input
Condensate Fluid Source Fixed Temperature	Deg F		99.00	110.43	109.13	109.53	Upstream FGH return
Pressure for Preheater Bypass Minimum Pressure	psia		40.00	40.00	40.00	40.00	40 if not bypassed, 78.7 if bypassed
HP Pump Temperature Rise	Deg F		5.10	4.50	4.65	4.62	
IP Pump Temperature Rise	Deg F		2.50	1.89	2.05	2.03	
TCA Pump Temperature Rise	Deg F		9.70	6.89	6.89	6.97	

GREC U3 HRSRG Corrections							
Description	Units	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HRSRG Rate Program Outputs							
Exhaust Gas Exhaust Temperature	Deg F		1,186.0	1,191.50	1,188.90	1,188.20	
Exhaust Gas Exhaust Flow	lb/h		4,765,000	4,748,010	4,772,820	4,771,720	
Exhaust Gas N2	% vol		73.79	72.67	72.87	72.85	
Exhaust Gas O2	% vol		10.98	10.48	10.75	10.72	
Exhaust Gas CO2	% vol		4.5	4.63	4.53	4.55	
Exhaust Gas H2O	% vol		9.8	11.35	10.97	11	
Exhaust Gas SO2	% vol		0	0	0	0	
Exhaust Gas Ar	% vol		0.93	0.87	0.88	0.88	
Duct Burner On / Off	-	Off	Off	Off	Off	Off	
Duct Burner Duty	MMBTU/h		0	0	0	0	
RH Outlet Set Pressure	psia		407.2	410.8	412.5	413	
HP Outlet Set Pressure	psia		1,752.20	1,769.40	1,774.20	1,775.60	
LP Outlet Set Pressure	psia		100.3	91.1	91.5	91.7	
CRH Return Fixed Temperature	Deg F		662.2	677.4	676.4	676.3	
CRH Return Flow Return	%		96.23	88.91	88.97	88.95	
HP Desuperheater Set Temperature	Deg F		1,052	1,052.00	1,052.00	1,052.00	
RH Steam Bypass Set Temperature	Deg F		1,052	1,051.50	1,051.50	1,051.50	
HP Steam Drum Blowdown %	%		0	0	0	0	
IP Steam Drum Blowdown %	%		0	0	0	0	
IP to RH Control Valve Inlet Set Pressure	psia		537	536.1	539.1	539.9	
Combustor Cooler Return Fixed Temperature	Deg F		925.7	940.5	937.3	936.3	
Combustor Cooler Return Fixed Flow	lb/h		132,500	130,340	131,350	131,710	
CC From IP Extraction Drawoff Flow	lb/h		132,500	129,900	131,060	131,470	
HP Combustor Back Up CV Set Flow	lb/h		132,500	130,340	131,350	131,710	
HP Steam to CC Steam Cooling Desuperheater Spray Drawoff Flow	lb/h		0	440	290	230	
TCA Extraction Drawoff Flow	lb/h		153,900	134,060	132,440	133,460	
Condensate Bypass To TCA Cooler Drawoff Flow	lb/h		0	0	0	0	
TCA Cooler Exit Inlet Set Pressure	psia		2,415.00	2,590.30	2,599.40	2,593.50	
TCA Cooler - (Across TCA Cooler) Set Pressure Drop	psi		14	14.6	14.6	14	
TCA Energy Addition	MMBTU/h		32.85	38.74	38.69	38.75	
TCA Cooler - (From TCA Pump Discharge to TCA Cooler Inlet Set Pressure Drop	psi		30.2	30.2	30.2	30	
FGH Control Valve Set Temperature	Deg F		141.7	293.9	286	284	
FGH Energy Reduction	MMBTU/h		24.42	29.88	30.61	30.72	
Preheat Bypass Diverted (Y/N)	-	No	No	No	No	No	
Condensate Fluid Source Fixed Temperature	Deg F		98.8	110.4	109.1	109.5	
Pressure for Preheater Bypass Minimum Pressure	psia		40	40	40	40	
HP Pump Temperature Rise	Deg F		5.1	4.5	4.65	4.62	
IP Pump Temperature Rise	Deg F		2.5	1.89	2.05	2.03	
TCA Pump Temperature Rise	Deg F		9.7	6.89	6.89	6.97	
Outlet							
HP Outlet In Temperature	Deg F		1,052.0	1,052.00	1,050.70	1,050.30	
HP Outlet In Flow	lb/h		631,030	661,450	659,980	658,920	
RH Outlet In Temperature	Deg F		1,051.5	1,051.50	1,051.50	1,051.50	
IP Outlet Inlet Temperature	Deg F		570.0	568.8	569.1	569.2	
IP Outlet Inlet Flow	lb/h		137,460	129,730	130,080	130,280	
LP Outlet In Temperature	Deg F		486.2	496	495.9	495.6	
LP Outlet In Flow	lb/h		64,700	55,590	56,030	56,340	
Static Pressure Drop Out Pressure	inH2O		16	16.03	16.16	16.14	
RH Pressure Drop Pressure Drop	psi		15.4	13.69	13.73	13.71	
FGH Extraction Secondary Temperature	Deg F		533.0	520.8	521.4	521.8	
TCA Injection Out Temperature	Deg F		536.8	587.2	589.7	588.7	
HP Steam/Water Side Pressure Loss	psi		130.0	152.86	152.57	151.74	Need to exclude control valve DP
LP Steam/Water Side Pressure Loss	psi		91.0	100.33	100.38	100.22	Need to exclude control valve DP
Correction Calculations (Guarantee/Software Test)							
HP Steam Flow Correction	-		1.000000	0.954010	0.956135	0.957673	Guarantee/Rate Program
IP Steam Flow Correction	-		1.000000	1.059585	1.056734	1.055112	Guarantee/Rate Program
LP Steam Flow Correction	-		1.000000	1.163878	1.154739	1.148385	Guarantee/Rate Program
HP Steam Temperature Correction	-		1.000000	1.000000	1.001237	1.001619	Guarantee/Rate Program
HRH Steam Temperature Correction	-		1.000000	1.000000	1.000000	1.000000	Guarantee/Rate Program
IP Steam Temperature Correction	-		1.000000	1.002110	1.001581	1.001405	Guarantee/Rate Program
LP Steam Temperature Correction	-		1.000000	0.980242	0.980440	0.981033	Guarantee/Rate Program
Gas Side Pressure Loss Correction	-		1.000000	0.998129	0.990099	0.991326	Guarantee/Rate Program
Reheater Pressure Loss Correction	-		1.000000	1.124909	1.121631	1.123268	Guarantee/Rate Program
HP Pressure Loss Correction	-		1.000000	0.850451	0.852068	0.856729	Guarantee/Rate Program
LP Pressure Loss Correction	-		1.000000	0.907007	0.906555	0.908002	Guarantee/Rate Program
Uncorrected Values (Test Values)							
HP Steam Flow	lb/h		631,030	647,509	652,231	650,630	
IP Steam Flow	lb/h		137,460	138,486	139,804	140,482	
LP Steam Flow	lb/h		64,700	58,496	59,034	59,643	
HP Steam Temperature	Deg F		1,052.00	1,046.61	1,043.92	1,043.59	
HRH Steam Temperature	Deg F		1,051.50	1,050.80	1,047.86	1,047.31	
IP Steam Temperature	Deg F		570.00	572.19	572.58	572.72	
LP Steam Temperature	Deg F		486.20	517.18	517.81	516.99	
Gas Side Pressure Loss	inH2O		16.00	15.47	15.73	15.86	
Reheater Pressure Loss	psi		15.40	13.27	13.33	13.31	
HP Pressure Loss	psi		155.92	169.17	170.33	170.36	
LP Pressure Loss	psi		371.00	433.34	432.60	431.86	
Corrected Values ((Test*Guarantee)/Software Test)							
HP Steam Flow Corrected	lb/h		631,030	617,730	623,621	623,091	Test * Correction
IP Steam Flow Corrected	lb/h		137,460	146,738	147,736	148,224	Test * Correction
LP Steam Flow Corrected	lb/h		64,700	68,082	68,169	68,493	Test * Correction
HP Steam Temperature Corrected	Deg F		1,052.00	1,046.61	1,045.21	1,045.28	Test * Correction
HRH Steam Temperature Corrected	Deg F		1,051.50	1,050.80	1,047.86	1,047.31	Test * Correction
IP Steam Temperature Corrected	Deg F		570.00	573.40	573.49	573.53	Test * Correction
LP Steam Temperature Corrected	Deg F		486.20	506.96	507.68	507.19	Test * Correction
Gas Side Pressure Loss Corrected	inH2O		16.00	15.44	15.78	15.73	Test * Correction
Reheater Pressure Loss Corrected	psi		15.40	14.92	14.95	14.96	Test * Correction
HP Pressure Loss Corrected	psi		155.92	143.87	145.13	145.96	Test * Correction
LP Pressure Loss Corrected	psi		371.00	393.04	392.18	392.13	Test * Correction

GREC U3 HRSG Unfired Results

Description	Unit	Guarantee	Test Run 1	Test Run 2	Test Run 3	Average TR 1-3	Pass/Fail	Notes
HP Steam Flow	lb/h	-	647,509	652,231	650,630	650,123		
Corrected HP Steam Flow	lb/h	631,030	617,730	623,621	623,091	621,481		
Margin	lb/h		-13,300	-7,409	-7,939	-9,549	Fail	
Margin	%		-2.11%	-1.17%	-1.26%	-1.51%		
IP Steam Flow	lb/h		138,486	139,804	140,482	139,591		
Corrected IP Steam Flow	lb/h	137,460	146,738	147,736	148,224	147,566		
Margin	lb/h		9,278	10,276	10,764	10,106	Pass	
Margin	%		6.75%	7.48%	7.83%	7.35%		
LP Steam Flow	lb/h		58,496	59,034	59,643	59,058		
Corrected LP Steam Flow	lb/h	64,700	68,082	68,169	68,493	68,248		
Margin	lb/h		3,382	3,469	3,793	3,548	Pass	
Margin	%		5.23%	5.36%	5.86%	5.48%		
HP Steam Temperature	Deg F		1,046.6	1,043.9	1,043.6	1,044.7		
Corrected HP Steam Temperature	Deg F	1,052.0	1,046.6	1,045.2	1,045.3	1,045.7		
Margin	Deg F		-5.4	-6.8	-6.7	-6.3	Fail	
HRH Steam Temperature	Deg F		1,050.8	1,047.9	1,047.3	1,048.7		
Corrected HRH Steam Temperature	Deg F	1,051.5	1,050.8	1,047.9	1,047.3	1,048.7		
Margin	Deg F		-0.7	-3.6	-4.2	-2.8	Fail	
IP Steam Temperature	Deg F		572.2	572.6	572.7	572.5		
Corrected IP Steam Temperature	Deg F	570.0	573.4	573.5	573.5	573.5		
Margin	Deg F		3.4	3.5	3.5	3.5	Pass	
LP Steam Temperature	Deg F		517.2	517.8	517.0	517.3		
Corrected LP Steam Temperature	Deg F	486.2	507.0	507.7	507.2	507.3		
Margin	Deg F		20.8	21.5	21.0	21.1	Pass	
Gas Side Pressure Loss	inH2O		15.47	15.73	15.86	15.69		
Corrected Gas side Pressure Loss	inH2O	16.0	15.44	15.58	15.73	15.58		
Margin	inH2O		0.56	0.42	0.27	0.42	Pass	
Margin	%		3.47%	2.65%	1.71%	2.61%		
Reheater Pressure Loss	psi		13.3	13.3	13.3	13.3		
Corrected Reheater Pressure Loss	psi	15.4	14.9	15.0	15.0	14.9		
Margin	psi		0.5	0.4	0.4	0.5	Pass	
Margin	%		3.10%	2.89%	2.89%	2.96%		
Auxiliary Load	kW		368.7	368.9	367.3	368		
Corrected Auxiliary Load	kW	928	N/A	N/A	N/A	N/A		
Margin	kW		559.29	559.12	560.65	560	Pass	
Margin	%		60.27%	60.25%	60.42%	60.31%		

GRECU3 STG Test Input Data Summary

Linked Row					17	27	37	
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Electrical Measurements								
STG gross power output	kW	PwrDAS	STG Meter-MW	151,333.0	142,949.1	143,816.7	143,994.0	
STG excitation current	A	STGDAS	30CHC00CE021	600	1,407.3	1,413.2	1,408.9	Check only
STG generator power factor	-	PwrDAS	STG Meter-PF	0.900	0.999	0.998	0.999	
STG Frequency	Hz	PwrDAS	STG Meter-Hz	60.000	60.007	59.998	60.005	Info Only
Temperature Measurements								
HP steam temp	Deg F	MainDAS	STG HP Steam Temp	1,050.00	1,045.7	1,043.1	1,042.9	
CRH steam temp	Deg F	MainDAS	STG CHR Steam Temp	672.00	683.1	681.0	680.9	
HRH steam temp	Deg F	MainDAS	STG HRH Steam Temp	1,050.00	1,050.8	1,047.9	1,047.3	
LP steam temp	Deg F	MainDAS	LP Steam Temp (STG Inlet)	496.90	513.4	513.1	512.9	
Hotwell temperature	Deg F	DCS	03-TE-050602.UNIT3@NET3	90.79	118.0	117.0	117.3	
Pressure Measurements								
HP steam pressure	psia	MainDAS	HP Steam Pressure (STG Inlet) Corr	1,729.3	1,764.4	1,768.3	1,770.6	
CRH steam pressure	psia	MainDAS	CRH Steam Pressure (STG Inlet) Corr	432.1	430.3	431.9	432.5	
HRH steam pressure	psia	MainDAS	HRH Steam Pressure (STG Inlet) Corr	398.5	406.4	407.9	408.5	
LP steam pressure	psia	MainDAS	LP Steam Pressure (STG Inlet) Corr	91.4	89.8	90.2	90.4	
STG Exhaust Pressure	psia	MainDAS	STG Exhaust Pressure	0.732	1.088	1.061	1.063	
HP drum pressure	psia	DCS	HP Drum pressure	1,848.5	1,882.2	1,886.5	1,888.8	
IP drum pressure	psia	DCS	IP Drum pressure	530.1	554.4	557.1	558.2	
LP drum pressure	psia	DCS	LP Drum pressure	85.5	112.4	113.0	113.2	
Generator H2 Pressure	psig	STGDAS	30MKG01CP101	43.5	44.290	43.978	43.917	
Barometric pressure	psia	DCS	03-ATMOS-PRESSURE.UNIT3@NET3	14.370	14.380	14.380	14.380	
Level Measurements								
Starting HP Drum Level	in		=DCS1Y76	20	14.27	14.43	14.48	
Ending HP Drum Level	in			20	14.70	14.48	14.49	
Starting IP Drum Level	in		=DCS1Y76	20	19.85	19.68	19.66	
Ending IP Drum Level	in			20	19.97	19.66	19.74	
Starting LP Drum Level	in		=DCS1YK76	20	54.31	54.32	53.63	
Ending LP Drum Level	in			20	53.95	53.63	53.95	
Starting Hotwell Level	in		=DCS1Dz76	20	3.55	3.52	2.88	
Ending Hotwell Level	in			20	1.88	2.88	0.81	
Other Measurements								
HPS to cooling steam DSH flow	lb/h	DCS	03-FIT-035601.UNIT3@NET3	0	435.1	296.9	230.9	03-FIT-035601
STG Auxiliary Power	kW	DCS		928	74.1	74.1	74.1	
N2 packing leakage flow	lb/h	DCS		11,680	59,923	59,923	59,923	
Mechanical Loss	kW	DCS		1,100	1,100	1,100	1,100	Design value
Design condensate entering HRSG enthalpy	btu/lb	DCS		280	280	280	280	Design value
Design Measurement Point to STG DP								
HP	psi	N/A	N/A	0.00	0.77	0.77	0.77	0.77 unfired, 1.04 fired
CRH	psi	N/A	N/A	0.00	-0.35	-0.35	-0.35	-0.35 unfired, -0.48 fired
HRH	psi	N/A	N/A	0.00	0.45	0.45	0.45	0.45 unfired, 0.58 fired
LP	psi	N/A	N/A	0.00	0.27	0.27	0.27	0.27 unfired, 0.04 fired
Flow Measurements								
HP FW Flow								
Meter Type	-			Orifice	Orifice	Orifice	Orifice	03-FE-101604
Tap Type	-			Flange	Flange	Flange	Flange	
Inlet Diameter	in			7.7430	7.7430	7.7430	7.7430	
Throat Diameter	in			4.9659	4.9659	4.9659	4.9659	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			120.0	120.0	120.0	120.0	Calibrated
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	HP FW Flow Pressure Corr	1,908.1	2,199.3	2,205.7	2,206.2	
Flow Temperature	Deg F	DCS	03-TE-061623.UNIT3@NET3	320.6	330.5	330.8	331.1	
Flow DP	inH2O	MainDAS	HP FW Flow DP SQRT	187.8	202.4	203.5	203.6	
HP FW to FGH Flow								
Meter Type	-			ASME Nozzle	ASME Nozzle	ASME Nozzle	ASME Nozzle	03-FE-062605
Tap Type	-			Throat	Throat	Throat	Throat	
Inlet Diameter	in			3.6230	3.6230	3.6230	3.6230	
Throat Diameter	in			1.7939	1.7939	1.7939	1.7939	
Diameter Measurement Temperature	Deg F			73	73	73	73	
Calibration Temperature	Deg F			106	106	106	106	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	HP FW Flow to FGH Pressure Corr	1,870.0	1,905.5	1,910.3	1,912.8	
Flow Temperature	Deg F	DCS	03-TE-062607.UNIT3@NET3	521.0	524.6	525.4	525.5	
Flow DP	inH2O	MainDAS	HP FW Flow to FGH DP SQRT	77.0	206.6	199.4	200.3	
HP FW from TCA Flow								
Meter Type	-			ASME Nozzle	ASME Nozzle	ASME Nozzle	ASME Nozzle	03-FE-065618
Tap Type	-			Throat	Throat	Throat	Throat	
Inlet Diameter	in			5.1880	5.1880	5.1880	5.1880	
Throat Diameter	in			2.5635	2.5635	2.5635	2.5635	
Diameter Measurement Temperature	Deg F			74	74	74	74	Assumed
Calibration Temperature	Deg F			106	106	106	106	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	TCA Flow Pressure Corr	1,908.1	1,888.1	1,892.1	1,894.6	
Flow Temperature	Deg F	DCS	03-TE-065607.UNIT3@NET3	320.6	589.1	590.7	590.6	
Flow DP	inH2O	MainDAS	TCA Flow DP SQRT	32.7	68.3	67.4	67.9	
HP DSH Flow								
Meter Type	-			Orifice	Orifice	Orifice	Orifice	03-FE-103607
Tap Type	-			Flange	Flange	Flange	Flange	
Inlet Diameter	in			2.2920	2.2920	2.2920	2.2920	
Throat Diameter	in			1.3582	1.3582	1.3582	1.3582	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			68.5	68.5	68.5	68.5	Calibrated
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	HP DSH flow pressure Corr	2,269.0	2,172.5	2,180.1	2,180.3	
Flow Temperature	Deg F	DCS	03-TE-103608.UNIT3@NET3	318.0	285.1	279.6	280.6	
Flow DP	inH2O	MainDAS	HP DSH flow DP SQRT	0.0	0.1	0.1	0.1	

GRECU3 STG Test Input Data Summary

Linked Row					17	27	37	
Description	Unit	Data Source	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
<i>HP to LP Leakage 1 Flow</i>								DP2A
Meter Type	-			Orifice Corner	Orifice Corner	Orifice Corner	Orifice Corner	
Tap Type	-							
Inlet Diameter	in			5.0470	5.0470	5.0470	5.0470	
Throat Diameter	in			3.7874	3.7874	3.7874	3.7874	
Diameter Measurement Temperature	Deg F			68	68	68	68	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	
Inlet Material	-			IAS	IAS	IAS	IAS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	HP to LP Leakage flow 1 Pressure Corr	70.0	91.0	91.4	91.6	
Flow Temperature	Deg F			659.9	643.6	641.1	640.9	Calculated from CRH enthalpy and measured pre
Flow DP	inH2O	STGDSCS	STG Bal Pipe DP1	9.4	318.4	316.3	318.8	Error in instrument.
<i>HP to LP Leakage 2 Flow</i>								DP2B
Meter Type	-			Orifice Corner	Orifice Corner	Orifice Corner	Orifice Corner	
Tap Type	-							
Inlet Diameter	in			5.0470	5.0470	5.0470	5.0470	
Throat Diameter	in			3.7874	3.7874	3.7874	3.7874	
Diameter Measurement Temperature	Deg F			68	68	68	68	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	
Inlet Material	-			IAS	IAS	IAS	IAS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	HP to LP Leakage flow 2 Pressure Corr	70.0	90.6	90.9	91.1	
Flow Temperature	Deg F			659.9	643.5	641.1	640.8	Calculated from CRH enthalpy and measured pre
Flow DP	inH2O	STGDSCS	STG Bal Pipe DP2	9.4	4.4	4.5	4.6	
<i>IP FW Flow</i>								03-FE-104630
Meter Type	-			Orifice Flange	Orifice Flange	Orifice Flange	Orifice Flange	
Tap Type	-							
Inlet Diameter	in			3.8460	3.8460	3.8460	3.8460	
Throat Diameter	in			2.2695	2.2695	2.2695	2.2695	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			72.0	72.0	72.0	72.0	calibrated
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	IP FW flow pressure Corr	550.5	796.5	797.2	797.9	
Flow Temperature	Deg F	MainDAS	IP FW flow Temp	318.1	473.3	473.9	474.0	
Flow DP	inH2O	MainDAS	IP FW flow DP SQRT	203.9	259.7	266.0	267.3	
<i>CT Cooling Steam Flow</i>								03-FE-035622
Meter Type	-			Venturi Throat	Venturi Throat	Venturi Throat	Venturi Throat	
Tap Type	-							
Inlet Diameter	in			7.981	7.981	7.981	7.981	
Throat Diameter	in			5.428	5.428	5.428	5.428	
Diameter Measurement Temperature	Deg F			68	68	68	68	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	CTG Cooling Steam Flow Pressure Corr	419.9	528.4	531.0	532.1	
Flow Temperature	Deg F	DCS	03-TE-035623.UNIT3@NET3	926.4	570.2	570.7	570.9	
Flow DP	inH2O	MainDAS	CTG Cooling Steam Flow DP SQRT	225.5	124.2	125.4	125.9	
<i>HPS to CT Cooling Steam Flow</i>								03-FE-035604
Meter Type	-			Venturi Throat	Venturi Throat	Venturi Throat	Venturi Throat	
Tap Type	-							
Inlet Diameter	in			4.8970	4.8970	4.8970	4.8970	
Throat Diameter	in			3.3790	3.3790	3.3790	3.3790	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	calibrated
Inlet Material	-			IAS	IAS	IAS	IAS	
Throat Material	-			IAS	IAS	IAS	IAS	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	HP Steam to CT cooling steam flow Pressure Corr	1,700.0	1,768.0	1,772.1	1,774.2	
Flow Temperature	Deg F	MainDAS	HRSRG HP Steam Temp	1,070.0	1,046.6	1,043.9	1,043.6	
Flow DP	inH2O	MainDAS	HP Steam to CT cooling steam flow DP	0.5	0.0	0.0	0.0	Valve closed
<i>LP Steam Flow</i>								03-FE-110636
Meter Type	-			Venturi Throat	Venturi Throat	Venturi Throat	Venturi Throat	
Tap Type	-							
Inlet Diameter	in			11.9830	11.9830	11.9830	11.9830	
Throat Diameter	in			7.0853	7.0853	7.0853	7.0853	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			45.5	45.5	45.5	45.5	Calibrated
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Vapor	Vapor	Vapor	Vapor	
Flow Pressure	psia	MainDAS	LP Steam Flow Pressure Corr	77.1	91.1	91.5	91.7	
Flow Temperature	Deg F	MainDAS	LP Steam Flow Temp	482.9	517.2	517.2	517.0	
Flow DP	inH2O	MainDAS	LP Steam Flow DP SQRT	79.0	59.8	61.3	61.8	
<i>Condensate Flow (from STG)</i>								03-FE-052610
Meter Type	-			Orifice Flange	Orifice Flange	Orifice Flange	Orifice Flange	
Tap Type	-							
Inlet Diameter	in			12.0000	12.0000	12.0000	12.0000	
Throat Diameter	in			7.2035	7.2035	7.2035	7.2035	
Diameter Measurement Temperature	Deg F			68.0	68.0	68.0	68.0	Assumed
Calibration Temperature	Deg F			N/A	N/A	N/A	N/A	
Inlet Material	-			CS	CS	CS	CS	
Throat Material	-			SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-			Liquid	Liquid	Liquid	Liquid	
Flow Pressure	psia	MainDAS	Condensate flow from STG Pressure Corr	450.0	573.2	573.0	572.8	
Flow Temperature	Deg F	MainDAS	Condensate flow from STG Temp	100.5	108.9	107.8	107.9	
Flow DP	inH2O	MainDAS	Condensate flow from STG DP SQRT	204.2	77.3	77.7	78.0	

GREC U3 STG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP FW Flow							
<i>Design Information</i>							
Meter Type	-		Orifice	Orifice	Orifice	Orifice	03-FE-101604
Tap Type	-		Flange	Flange	Flange	Flange	
Inlet Diameter	in		7.743	7.743	7.743	7.743	
Throat Diameter	in		4.966	4.966	4.966	4.966	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		120.0	120.0	120.0	120.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,908.1	2,199.3	2,205.7	2,206.2	
Downstream Temperature	Deg F		320.6	330.5	330.8	331.1	
DP	inH2O		187.8	202.4	203.5	203.6	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		57.08	56.83	56.82	56.81	
Fluid Viscosity	lbm/(ft*s)		0.000116	0.000112	0.000112	0.000112	
Calculated Flow	lb/h		610,391	632,203	633,946	634,126	
Calculated Flow	gpm		1,333	1,387	1,391	1,392	

HP FW to FGH Flow							
<i>Design Information</i>							
Meter Type	-		ASME Nozzle	ASME Nozzle	ASME Nozzle	ASME Nozzle	03-FE-062605
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		3.623	3.623	3.623	3.623	
Throat Diameter	in		1.794	1.794	1.794	1.794	
Diameter Measurement Temperature	Deg F		73.0	73.0	73.0	73.0	
Calibration Temperature	Deg F		106.0	106.0	106.0	106.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,870.0	1,905.5	1,910.3	1,912.8	
Downstream Temperature	Deg F		521.0	524.6	525.4	525.5	
DP	inH2O		77.0	206.6	199.4	200.3	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		48.38	48.19	48.14	48.14	
Fluid Viscosity	lbm/(ft*s)		0.000067	0.000066	0.000066	0.000066	
Calculated Flow	lb/h		73,202	119,739	117,576	117,857	
Calculated Flow	gpm		189	310	305	305	

Calibration Data
Meter Serial Number
Meter Location
Tap Set

17769-01				
HP FW Flow				
1		2		
Inlet Re	Cd	Inlet Re	Cd	
1	311,150	0.605	311,150	0.6052
2	386,257	0.6038	386,257	0.6049
3	456,231	0.6043	456,231	0.6041
4	533,408	0.6044	533,408	0.6033
5	602,964	0.6043	602,964	0.6037
6	6.67E+05	0.6042	6.67E+05	0.6046
7	7.42E+05	0.6037	7.42E+05	0.6044
8	8.03E+05	0.604	8.03E+05	0.6048
9	8.62E+05	0.6046	8.62E+05	0.6047
10	9.29E+05	0.6042	9.29E+05	0.6043
11	1.02E+06	0.6044	1.02E+06	0.6041
12	1.07E+06	0.6043	1.07E+06	0.6047
13	1143311	0.6038	1143311	0.6041
14	1235619	0.6038	1235619	0.6044
15	1259580	0.6035	1259580	0.604
16	1365260	0.6035	1365260	0.6039
17	1414187	0.6039	1414187	0.6041
18	1470232	0.6034	1470232	0.6039
19	1577685	0.6033	1577685	0.6035
20	1630434	0.6031	1630434	0.6032

Meter Serial Number
Meter Location
Tap Set

20171-08								
HP FW to FGH								
1		2		3		4		
Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd	
1	1,309,849	0.9967	1,309,849	0.9972	1,309,849	0.9968	1,309,849	0.9969
2	1,224,140	0.9967	1,224,140	0.9971	1,224,140	0.9968	1,224,140	0.9969
3	1,139,421	0.9967	1,139,421	0.9971	1,139,421	0.9968	1,139,421	0.9969
4	1,051,335	0.9966	1,051,335	0.997	1,051,335	0.9967	1,051,335	0.9967
5	966,864	0.9965	966,864	0.9969	966,864	0.9966	966,864	0.9967
6	8.81E+05	0.9964	8.81E+05	0.9969	8.81E+05	0.9966	8.81E+05	0.9967
7	7.95E+05	0.9965	7.95E+05	0.9968	7.95E+05	0.9966	7.95E+05	0.9966
8	7.07E+05	0.9964	7.07E+05	0.9968	7.07E+05	0.9965	7.07E+05	0.9965
9	6.25E+05	0.9967	6.25E+05	0.9971	6.25E+05	0.9968	6.25E+05	0.9969
10	5.39E+05	0.997	5.39E+05	0.9974	5.39E+05	0.9971	5.39E+05	0.9972
11	1.26E+06	0.9967	1.26E+06	0.9972	1.26E+06	0.9969	1.26E+06	0.9969
12	1.18E+06	0.9968	1.18E+06	0.9972	1.18E+06	0.9969	1.18E+06	0.9969
13	1096294	0.9968	1096294	0.9971	1096294	0.9969	1096294.2	0.9968
14	1007317	0.9966	1007317	0.997	1007317	0.9968	1007317.2	0.9967
15	1419176	0.9965	1419176	0.9969	1419176	0.9967	1419176.4	0.9966
16	838325.2	0.9965	838325.2	0.9969	838325.2	0.9967	838325.17	0.9966
17	752071.4	0.9966	752071.4	0.9969	752071.4	0.9967	752071.41	0.9967
18	667847.7	0.9967	667847.7	0.9971	667847.7	0.9968	667847.73	0.9968
19	582881.3	0.997	582881.3	0.9973	582881.3	0.9971	582881.34	0.9971
20	497469.3	0.9974	497469.3	0.9978	497469.3	0.9976	497469.32	0.9976

GREC U3 STG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP FW from TCA Flow							
<i>Design Information</i>							
Meter Type	-		ASME Nozzle	ASME Nozzle	ASME Nozzle	ASME Nozzle	03-FE-065618
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		5.188	5.188	5.188	5.188	
Throat Diameter	in		2.564	2.564	2.564	2.564	
Diameter Measurement Temperature	Deg F		74.0	74.0	74.0	74.0	
Calibration Temperature	Deg F		106.0	106.0	106.0	106.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,908.1	1,888.1	1,892.1	1,894.6	
Downstream Temperature	Deg F		320.6	589.1	590.7	590.6	
DP	inH2O		32.7	68.3	67.4	67.9	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		57.08	43.70	43.57	43.59	
Fluid Viscosity	lbm/(ft*s)		0.000116	0.000056	0.000056	0.000056	
Calculated Flow	lb/h		105,471	134,056	132,982	133,456	
Calculated Flow	gpm		230	382	380	382	

HP DSH Flow							
<i>Design Information</i>							
Meter Type	-		Orifice	Orifice	Orifice	Orifice	03-FE-103607
Tap Type	-		Flange	Flange	Flange	Flange	
Inlet Diameter	in		2.292	2.292	2.292	2.292	
Throat Diameter	in		1.358	1.358	1.358	1.358	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		68.5	68.5	68.5	68.5	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		2,269.0	2,172.5	2,180.1	2,180.3	
Downstream Temperature	Deg F		318.0	285.1	279.6	280.6	
DP	inH2O		0.0	0.1	0.1	0.1	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		57.26	58.26	58.43	58.40	
Fluid Viscosity	lbm/(ft*s)		0.000118	0.000134	0.000137	0.000137	
Calculated Flow	lb/h		0	1,288	1,093	907	
Calculated Flow	gpm		0	3	2	2	

Calibration Data
Meter Serial Number
Meter Location
Tap Set

20171-09								
FW from TCA								
1		2		3		4		
Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd	Inlet Re	Cd	
1	1,688,016	0.9972	3,416,200	0.9972	3,416,200	0.9974	3,416,200	0.9977
2	1,563,992	0.9971	3,165,200	0.9971	3,165,200	0.9973	3,165,200	0.9976
3	1,436,064	0.9969	2,906,300	0.9969	2,906,300	0.9972	2,906,300	0.9975
4	1,307,741	0.9968	2,646,600	0.9968	2,646,600	0.9971	2,646,600	0.9974
5	1,187,818	0.9967	2,403,900	0.9966	2,403,900	0.9969	2,403,900	0.9972
6	1,061,224	0.9964	2,147,700	0.9963	2,147,700	0.9967	2,147,700	0.9969
7	934,926	0.9963	1,892,100	0.9962	1,892,100	0.9966	1,892,100	0.9968
8	809,963	0.9963	1,639,200	0.9962	1,639,200	0.9966	1,639,200	0.9968
9	684,209	0.9965	1,384,700	0.9964	1,384,700	0.9968	1,384,700	0.997
10	559,839	0.9973	1,133,000	0.9971	1,133,000	0.9974	1,133,000	0.9976
11	1,626,844	0.9972	3,292,400	0.9971	3,292,400	0.9974	3,292,400	0.9976
12	1,499,559	0.997	3,034,800	0.997	3,034,800	0.9973	3,034,800	0.9975
13	1,374,447	0.997	2,781,600	0.9969	2,781,600	0.9973	2,781,600	0.9974
14	1,248,249	0.9968	2,526,200	0.9968	2,526,200	0.9972	2,526,200	0.9973
15	1,121,754	0.9965	2,270,200	0.9964	2,270,200	0.9968	2,270,200	0.997
16	996,593	0.9964	2,016,900	0.9964	2,016,900	0.9967	2,016,900	0.9969
17	873,458	0.9963	1,767,700	0.9963	1,767,700	0.9966	1,767,700	0.9969
18	747,062	0.9964	1,511,900	0.9964	1,511,900	0.9968	1,511,900	0.997
19	622,247	0.9968	1,259,300	0.9967	1,259,300	0.9971	1,259,300	0.9973
20	497,926	0.9975	1,007,700	0.9974	1,007,700	0.9978	1,007,700	0.9979
21	172,349	0.9974	348,800	0.9971	348,800	0.9973	348,800	0.9976
22	122,789	0.9936	248,500	0.9931	248,500	0.9926	248,500	0.9936
23	334,718	0.9982	677,400	0.998	677,400	0.9983	677,400	0.9986

Meter Serial Number
Meter Location
Tap Set

17769-025				
HP DSH Flow				
1		2		
Inlet Re	Cd	Inlet Re	Cd	
1	287435.4	0.6098	287445.1	0.6084
2	257684.7	0.6096	257695.4	0.6085
3	223322.8	0.6105	223347.6	0.6086
4	189134.8	0.6101	189134.8	0.609
5	149605.4	0.6118	149605.4	0.6096
6	111860.4	0.6127	111860.4	0.6114
7	289973.7	0.6096	289944.9	0.6084
8	259521.4	0.6097	259532.1	0.608
9	223423.5	0.6107	223498	0.6088
10	189048.1	0.6106	189048.1	0.6093
11	151524.6	0.6112	151524.6	0.6109
12	110386.8	0.6133	108047.6	0.6115
13				
14				
15				
16				
17				
18				
19				
20				

GREC U3 STG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
IP FW Flow							
<i>Design Information</i>							
Meter Type	-		Orifice	Orifice	Orifice	Orifice	03-FE-104630
Tap Type	-		Flange	Flange	Flange	Flange	
Inlet Diameter	in		3.846	3.846	3.846	3.846	
Throat Diameter	in		2.270	2.270	2.270	2.270	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		72.0	72.0	72.0	72.0	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		550.5	796.5	797.2	797.9	
Downstream Temperature	Deg F		318.1	473.3	473.9	474.0	
DP	inH2O		203.9	259.7	266.0	267.3	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		56.83	50.44	50.41	50.40	
Fluid Viscosity	lbm/(ft*s)		0.000116	0.000073	0.000073	0.000073	
Calculated Flow	lb/h		129,970	138,587	140,207	140,551	
Calculated Flow	gpm		285	343	347	348	

CT Cooling Steam Flow							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
CT Cooling Steam Flow							
<i>Design Information</i>							
Meter Type	-		Venturi	Venturi	Venturi	Venturi	03-FE-035622
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		7.981	7.981	7.981	7.981	
Throat Diameter	in		5.428	5.428	5.428	5.428	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		419.9	528.4	531.0	532.1	
Downstream Temperature	Deg F		926.4	570.2	570.7	570.9	
DP	inH2O		225.5	124.2	125.4	125.9	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		0.52	0.96	0.96	0.96	
Fluid Viscosity	lbm/(ft*s)		0.000019	0.000013	0.000013	0.000013	
Calculated Flow	lb/h		129,386	130,338	131,292	131,705	
Calculated Flow	gpm		31,003	16,991	17,032	17,052	

Calibration Data
 Meter Serial Number
 Meter Location
 Tap Set

17769-06				
IP FW Flow				
	1		2	
	Inlet Re	Cd	Inlet Re	Cd
1	407335.1	0.6088	386194.2	0.6085
2	364084.6	0.6091	345174.7	0.609
3	314740.6	0.6094	298455.5	0.609
4	267561.2	0.6098	253656.1	0.6092
5	212686.3	0.6104	201673	0.6096
6	156662.8	0.6116	148532.7	0.6109
7	410207	0.6088	388894.5	0.6086
8	363662.5	0.6088	349466.9	0.6086
9	314601.7	0.6096	302320.7	0.6088
10	266616.9	0.6095	256189.8	0.6092
11	212299.9	0.6105	204012.4	0.6098
12	154441.6	0.6117	148413	0.611
13				
14				
15				
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Meter Serial Number
 Meter Location
 Tap Set

Uncalibrated			
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GREC U3 STG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HPS to CT Cooling Steam Flow							
03-FE-035604							
<i>Design Information</i>							
Meter Type	-		Venturi	Venturi	Venturi	Venturi	
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		4.9	4.9	4.9	4.9	
Throat Diameter	in		3.4	3.4	3.4	3.4	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		IAS	IAS	IAS	IAS	
Throat Material	-		IAS	IAS	IAS	IAS	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		1,700.0	1,768.0	1,772.1	1,774.2	
Downstream Temperature	Deg F		1,070.0	1,046.6	1,043.9	1,043.6	
DP	inH2O		0.5	0.0	0.0	0.0	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		1.99	2.12	2.13	2.13	
Fluid Viscosity	lbm/(ft*s)		0.000022	0.000021	0.000021	0.000021	
Calculated Flow	lb/h		4,685	0	0	0	
Calculated Flow	gpm		293	0	0	0	

LP Steam Flow							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
LP Steam Flow							
03-FE-110636							
<i>Design Information</i>							
Meter Type	-		Venturi	Venturi	Venturi	Venturi	
Tap Type	-		Throat	Throat	Throat	Throat	
Inlet Diameter	in		11.983	11.983	11.983	11.983	
Throat Diameter	in		7.085	7.085	7.085	7.085	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		45.5	45.5	45.5	45.5	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Vapor	Vapor	Vapor	Vapor	
<i>Measured Parameters</i>							
Upstream Pressure	psia		77.1	91.1	91.5	91.7	
Downstream Temperature	Deg F		482.9	517.2	517.2	517.0	
DP	inH2O		79.0	59.8	61.3	61.8	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		0.14	0.16	0.16	0.16	
Fluid Viscosity	lbm/(ft*s)		0.000012	0.000013	0.000013	0.000013	
Calculated Flow	lb/h		62,310	58,496	59,324	59,643	
Calculated Flow	gpm		55,531	45,706	46,130	46,277	

Calibration Data
 Meter Serial Number
 Meter Location
 Tap Set

Uncalibrated			
1		2	
Inlet Re	Cd	Inlet Re	Cd
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Meter Serial Number
 Meter Location
 Tap Set

17769-09				
LP Steam Flow				
1		2		
Inlet Re	Cd	Inlet Re	Cd	
1	269,692	0.9889	269,692	0.9896
2	327,975	0.9878	327,975	0.9895
3	382,210	0.9881	382,210	0.9907
4	439,548	0.9879	439,548	0.9905
5	490,545	0.9882	490,545	0.9901
6	551,391	0.9885	551,391	0.9905
7	608,325	0.9884	608,325	0.9904
8	666,877	0.9878	666,877	0.9898
9	724,620	0.9883	724,620	0.9906
10	776,966	0.9881	776,966	0.9897
11	837,003	0.9887	837,003	0.9908
12	893,532	0.9889	893,532	0.9907
13	954,243	0.9891	954,243	0.9906
14	1,003,891	0.9886	1,003,891	0.9903
15	1,057,452	0.9893	1,057,452	0.9908
16	1,114,520	0.9897	1,114,520	0.9911
17	1,171,858	0.9895	1,171,858	0.9909
18	1,229,736	0.9903	1,229,736	0.9914
19	1,294,360	0.9899	1,294,360	0.9914
20	1,343,603	0.9897	1,343,603	0.9914

GREC U3 STG Flow Calculations							
Description	Unit	Tag Number	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Condensate Flow (from STG)							
<i>Design Information</i>							
Meter Type	-		Orifice	Orifice	Orifice	Orifice	03-FE-052610
Tap Type	-		Flange	Flange	Flange	Flange	
Inlet Diameter	in		12.000	12.000	12.000	12.000	
Throat Diameter	in		7.204	7.204	7.204	7.204	
Diameter Measurement Temperature	Deg F		68.0	68.0	68.0	68.0	
Calibration Temperature	Deg F		N/A	N/A	N/A	N/A	
Inlet Material	-		CS	CS	CS	CS	
Throat Material	-		SS3xx	SS3xx	SS3xx	SS3xx	
Fluid Type	-		Liquid	Liquid	Liquid	Liquid	
<i>Measured Parameters</i>							
Upstream Pressure	psia		450.0	573.2	573.0	572.8	
Downstream Temperature	Deg F		100.5	108.9	107.8	107.9	
DP	inH2O		204.2	77.3	77.7	78.0	
<i>Calculated Parameters</i>							
Fluid Density	lb/ft^3		62.07	61.98	62.00	61.99	
Fluid Viscosity	lbm/(ft*s)		0.000455	0.000418	0.000422	0.000422	
Calculated Flow	lb/h		1,361,460	837,729	839,622	841,453	
Calculated Flow	gpm		2,735	1,685	1,689	1,692	

Calibration Data
 Meter Serial Number
 Meter Location
 Tap Set

Uncalibrated			
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GREC U3 STG Calculation						
Description	Unit	Design	Test Run 1	Test Run 2	Test Run 3	Notes
Inputs						
Electrical Measurements						
STG gross power output	KW	151,333.00	142,949.10	143,816.67	143,994.02	
STG excitation current	A	600.00	1,407.26	1,413.19	1,408.93	
STG generator power factor	-	0.900	0.999	0.998	0.999	
STG Frequency	Hz	60.000	60.007	59.998	60.005	
Temperature Measurements						
HP steam temp	Deg F	1,050.00	1,045.72	1,043.14	1,042.90	
CRH steam temp	Deg F	672.00	683.14	681.03	680.88	
HRH steam temp	Deg F	1,050.00	1,050.80	1,047.87	1,047.31	
LP steam temp	Deg F	496.90	513.39	513.13	512.88	
Hotwell temperature	Deg F	90.79	117.95	117.03	117.28	
Pressure Measurements						
HP steam pressure	psia	1,729.30	1,764.39	1,768.31	1,770.61	
CRH steam pressure	psia	432.10	430.31	431.86	432.49	
HRH steam pressure	psia	398.50	406.36	407.85	408.46	
LP steam pressure	psia	91.40	89.83	90.24	90.40	
STG Exhaust Pressure	psia	0.732	1.088	1.061	1.063	
HP drum pressure	psia	1,848.55	1,882.20	1,886.49	1,888.81	
IP drum pressure	psia	530.12	554.35	557.13	558.17	
LP drum pressure	psia	85.48	112.39	112.98	113.20	
Generator H2 Pressure	psig	43.50	44.29	43.98	43.92	
Barometric pressure	psia	14.37	14.38	14.38	14.38	
Level Measurements						
Starting HP Drum Level	in	20.00	14.27	14.43	14.48	
Ending HP Drum Level	in	20.00	14.70	14.48	14.49	
Starting IP Drum Level	in	20.00	19.85	19.68	19.66	
Ending IP Drum Level	in	20.00	19.97	19.66	19.74	
Starting LP Drum Level	in	20.00	54.31	54.32	53.63	
Ending LP Drum Level	in	20.00	53.95	53.63	53.95	
Starting Hotwell Level	in	20.00	3.55	3.52	3.52	
Ending Hotwell Level	in	20.00	1.88	2.88	0.81	
Other Measurements						
HPS to cooling steam DSH flow	lb/h	0.00	435.05	296.94	230.89	03-FIT-035601
STG Auxiliary Power	kW	928.00	74.10	74.10	74.10	
N2 packing leakage flow	lb/h	11,680.00	59,923.34	59,923.34	59,923.34	
Mechanical Loss	kW	1,100.00	1,100.00	1,100.00	1,100.00	
Design condensate entering HRSG enthalpy	btu/lb	280.02	280.02	280.02	280.02	
Design Measurement Point to STG DP						
HP	psi	0.00	0.77	0.77	0.77	
CRH	psi	0.00	-0.35	-0.35	-0.35	
HRH	psi	0.00	0.45	0.45	0.45	
LP	psi	0.00	0.27	0.27	0.27	
Calculated Flows						
HP FW flow	lb/h	610,391	632,203	633,946	634,126	
HP FW to FGH flow	lb/h	73,202	119,739	117,576	117,857	
HP FW to TCA flow	lb/h	105,471	134,056	132,982	133,456	
HP DSH flow	lb/h	0	1,288	1,093	907	
HP to LP leakage 1 flow	lb/h	3,769	23,857	23,866	23,976	Error in instrument. Using design value for HP to LP leakage flows.
HP to LP leakage 2 flow	lb/h	3,769	2,969	3,000	3,033	Design value used
IP FW flow	lb/h	129,970	138,587	140,207	140,551	
CT cooling steam flow	lb/h	129,386	130,338	131,292	131,705	Not used
HPS to CT Cooling Steam Flow	lb/h	4,685	0	0	0	Valve was closed, no flow
Measured LP steam flow	lb/h	62,310	58,496	59,324	59,643	
Condensate flow	lb/h	1,361,460	837,729	839,622	841,453	
HP steam flow (measured)	lb/h	1,060,028	656,925	659,237	659,713	Not used
CRH steam flow (measured)	lb/h	607,840	565,401	566,659	567,516	Not used
IP steam flow (measured)	lb/h	153,558	0	0	0	Not used
Calculations						
Leakage lookups						
HP to LP leakage	lb/h	7,550	7,724	7,744	7,764	Design value from table (leakage 1)
Gland LP leakoff (HP side)	lb/h	3,440.00	3,509.41	3,519.63	3,530.35	Design value from table (leakage 2)
Gland subatmospheric leakoff (HP side)	lb/h	590.00	612.48	612.60	612.72	Design value from table (leakage 3)
LP gland sealing steam	lb/h	2,680.00	2,668.31	2,668.44	2,668.56	Design value from table (leakage 4)
Gland subatmospheric leakoff (LP side)	lb/h	1,020.00	1,023.64	1,023.77	1,023.89	Design value from table (leakage 5)
Corrected Pressures						
Corrected HP Steam Pressure	psia	1,729.30	1,763.63	1,767.55	1,769.85	
Corrected CRH Steam Pressure	psia	432.10	430.69	432.25	432.88	
Corrected HRH Steam Pressure	psia	398.50	405.86	407.35	407.96	
Corrected LP Steam Pressure	psia	91.40	89.60	90.01	90.18	
Level Change Flow Calculations						
HP drum level change	ft3	0	20195.20	-1	0	Negative indicates water stored in drum
IP drum level change	ft3	0	-7	0	-1	
LP drum level change	ft3	0	-2	0	-13	
Hotwell level change	ft3	0	14	28	87	42'-11" x 11'-10" hotwell
HP drum density	lb/ft3	40.1	39.9	39.8	39.8	Saturated at pressure
IP drum density	lb/ft3	50.3	50.1	50.1	50.1	Saturated at pressure
LP drum density	lb/ft3	56.8	56.1	56.1	56.1	Saturated at pressure
Hotwell density	lb/ft3	62.1	61.7	61.8	61.8	
HP drum level change flow	lb/h	0.0	-298.4	-70.7	-2.4	1 hour test periods (except TR2)
IP drum level change flow	lb/h	0.0	-100.5	35.2	-68.7	1 hour test periods (except TR2)
LP drum level change flow	lb/h	0.0	812.5	3,103.6	-715.2	1 hour test periods (except TR2)
Hotwell level change flow	lb/h	0.0	4,362.5	3,379.9	5,391.5	1 hour test periods (except TR2)
Total STG leakage between HP and CRH		23,260	71,770	71,799	71,831	

GREC U3 STG Calculation						
Description	Unit	Design	Test Run 1	Test Run 2	Test Run 3	Notes
HP steam flow	lb/h	631,100	647,509	650,374	650,630	HP FW + HP DSH + TCA - FGH Extraction + HP Drum Level - HPS to CT Cooling Steam
CRH steam flow	lb/h	607,840	575,740	578,575	578,799	HP Steam - STG leakages
IP steam flow	lb/h	139,600	138,486	140,242	140,482	IP FW + IP Drum Level
IP and CTG cooling steam	lb/h	139,600	138,921	140,539	140,713	IP Steam + HPS to CT cooling steam + HPS to CT cooling steam DSH
HRH steam flow	lb/h	747,430	714,661	719,114	719,512	CRH Steam + IP and CTG cooling steam
LP steam flow	lb/h	55,420	58,496	59,324	59,643	LP Steam flow
STG exhaust flow (calculated)	lb/h	823,740	842,449	847,749	848,487	HRH Steam + LP steam + HP to LP - LP leakages
STG exhaust flow (condensate)	lb/h	823,740	837,729	839,622	841,453	
Leakage out of cycle	lb/h	0	4,776	6,448	4,605	
Leakage out of cycle (% of condensate flow)	%	0.00%	0.57%	0.77%	0.55%	Should be less than 0.25%
Leakage adjusted flows						
HP steam flow (leakage adjusted)	lb/h	631,100	643,861	645,448	647,112	Leakage subtracted on flow weighted basis as noted
CRH steam flow (leakage adjusted)	lb/h	607,840	572,091	573,649	575,281	
IP steam flow	lb/h	139,600	138,486	140,242	140,482	
IP and CTG cooling steam (leakage adjusted)	lb/h	139,600	138,114	139,449	139,935	
HRH steam flow	lb/h	747,430	710,206	713,098	715,216	
LP steam flow	lb/h	55,420	58,496	59,324	59,643	
STG exhaust flow (calculated)	lb/h	823,740	837,994	841,734	844,191	
STG exhaust flow (condensate)	lb/h	823,740	837,729	839,622	841,453	
Excitation Power						
Generator MVA	MVA	168.1	143.2	144.1	144.2	
Excitation current	A	1,795	1,356	1,361	1,359	From V curve
Field loss	kW	297	170	172	171	
Thyristor loss	kW	16	16	16	16	Design value
Excitation transformer Loss	kW	25	25	25	25	Design value
Total excitation loss	kW	338	211	213	212	Sum of losses
Enthalpy/Entropy						
HP steam enthalpy	btu/lb	1,514.4	1,510.8	1,509.1	1,508.8	
HP steam entropy	btu/lb-F	1.6020	1.5975	1.5962	1.5959	
CRH steam enthalpy	btu/lb	1,345.5	1,351.8	1,350.5	1,350.4	
CRH steam entropy	btu/lb-F	1.6169	1.6227	1.6213	1.6210	
HRH steam enthalpy	btu/lb	1,550.7	1,551.0	1,549.3	1,549.0	
HRH steam entropy	btu/lb-F	1.7822	1.7803	1.7789	1.7785	
LP steam enthalpy	btu/lb	1,278.6	1,287.0	1,286.9	1,286.7	
LP steam entropy	btu/lb-F	1.7178	1.7287	1.7281	1.7277	
Correction Parameters						
Reheater Pressure Drop	%	7.78%	5.77%	5.76%	5.76%	
HP steam specific volume	ft³/lb	0.48	0.47	0.47	0.47	
Stodola's law of ellipse correction 'S'	-	1.0000	0.9983	0.9984	0.9984	Using IP Steam + CTG Cooling steam
Change in flow capacity	%	0.00%	-0.39%	-0.48%	-0.37%	
HP Exhaust Enthalpy on RH heat consumption parameters						
Test adjusted HRH pressure	psia	398.50	399.90	400.26	399.84	Using IP Steam + CTG Cooling steam
Test adjusted HRH enthalpy	btu/lb	1550.71	1550.68	1550.67	1550.68	
Change in test adjusted HRH enthalpy	btu/lb	0.00	-0.04	-0.05	-0.04	
Test adjusted CRH pressure	psia	432.10	433.62	434.01	433.55	
HP section available energy at design conditions	btu/lb	185.5	185.5	185.5	185.5	
HP section available energy at test adjusted conditions	btu/lb	185.55	185.15	185.04	185.16	
HP turbine efficiency	%	91.02%	84.96%	85.01%	85.00%	
Change in HP exhaust enthalpy	btu/lb	0.00	11.59	11.59	11.51	
HP turbine leakage fraction	%	3.69%	11.15%	11.12%	11.10%	
Change in HP steam flow	lb/h	0.0	4,641.3	4,644.1	4,607.6	
Test adjusted HP steam flow	lb/h	631,100	626,459	626,456	626,492	Design - change
HP Exhaust Flow on RH heat consumption parameters						
Change in HP turbine leakage fraction	%	0.00%	7.46%	7.44%	7.41%	
Less than design leakage (HP steam flow)						
Change in HP steam flow	lb/h	0.0	6,872.0	6,850.8	6,828.3	
Test adjusted HP steam flow	lb/h	631,100	624,228	624,249	624,272	Design - change
Greater than design leakage (reheat spray flow)						
Change in RH DSH spray flow	lb/h	0.0	8,797.3	8,770.4	8,742.4	Not used as there's no RH DSH
Test adjusted IP steam flow	lb/h	139,600	130,803	130,830	130,858	Design - change
Unfired Corrections						
HP steam flow correction	kW	0.0	2,564.1	2,879.1	3,212.0	
HP steam temperature correction	kW	0.0	-166.5	-267.6	-277.9	
HP turbine flow capacity correction	kW	0.0	54.9	67.9	52.4	
Reheater pressure drop correction	kW	0.7	371.0	373.1	374.6	
IP steam flow and HRH steam temp correction	kW	0.0	-142.9	-178.9	-156.3	Using IP steam + CTG cooling steam
HP exhaust enthalpy effect on reheater heat consumption correction	kW	0.0	-978.9	-979.4	-971.7	
HP exhaust flow effect on reheater heat consumption correction	kW	0.0	-1,449.3	-1,444.9	-1,440.1	Always using HP steam flow correction. No RH DSH
HP steam flow correction	kW	0.0	-1,449.3	-1,444.9	-1,440.1	
Reheat spray flow correction	kW	0.0	-1,203.6	-1,200.0	-1,196.1	Not used as there's no RH DSH
LP steam flow and enthalpy correction	kW	0.0	307.5	369.0	391.9	
Exhaust pressure correction	kW	0.0	-4,478.9	-4,096.8	-4,118.5	
Power factor correction	kW	0.0	42.1	42.5	42.8	
H2 gas pressure correction	kW	0.0	-3.6	-2.1	-1.9	
Deterioration	kW	0.0	0.0	0.0	0.0	
Sum of unfired corrections	kW	0.8	-3,880.3	-3,238.2	-2,892.8	
Unfired						
STG net power output	kW	150,066.5	142,663.6	143,530.0	143,707.7	Gross - Aux - Excitation
Corrected STG net power output	kW	150,065.8	146,543.9	146,768.2	146,600.5	Net - corrections

GREC U3 STG Unfired Results

Description	Unit	Guarantee	Test Run 1	Test Run 2	Test Run 3	Average TR 1-3	Pass/Fail	Notes
STG Net Output	kW	-	142,664	143,530	143,708	143,300		
Corrected STG Net Output	kW	150,330	146,544	146,768	146,600	146,638		
Margin	kW		-3,786	-3,562	-3,730	-3,692	Fail	
Margin	%		-2.52%	-2.37%	-2.48%	-2.46%		

APPENDIX B

UNIT STABILITY ANALYSIS

GREC EPC Test Stability															
	Parameter	Inlet Air Temperature		Barometric Pressure		Power Output		Plant Inlet Gas Pressure		Fuel Flow		Exhaust Backpressure		Electrical Frequency	
Averages	Test Period 1	79.3°F		14.43 PSIA		307,547 KW		695.8 PSIA		43976.9 SCFM		15.4 inH2O		3600.3 RPM	
	Test Period 2	75.4°F		14.42 PSIA		311,860 KW		695.2 PSIA		44410.3 SCFM		15.5 inH2O		3599.9 RPM	
	Test Period 3	74.1°F		14.42 PSIA		313,017 KW		695.2 PSIA		44567.3 SCFM		15.6 inH2O		3600.2 RPM	
	Max Test Deviations	1.3°F		0.33%		1.3%		0.65%		1.3%		0.33%		0.65%	
Actual Test Stability	Test Period 1	0.56	Pass	0.01%	Pass	0.00%	Pass	0.05%	Pass	0.26%	Pass	0.27%	Pass	0.00%	Pass
	Test Period 2	0.25	Pass	0.01%	Pass	0.00%	Pass	0.04%	Pass	0.30%	Pass	0.11%	Pass	0.00%	Pass
	Test Period 3	0.88	Pass	0.01%	Pass	0.00%	Pass	0.04%	Pass	0.40%	Pass	0.32%	Pass	0.00%	Pass

APPENDIX C

TEST UNCERTAINTY ANALYSIS

GREC U3 EPC Multiple Test Uncertainty						
			$B_{\bar{x}}$	T_{inv}	$S_{\bar{x}}$	$T_{inv}S_{\bar{x}}$
Description	Units	Mean	Total Systematic (Absolute)	Student T	Random	Total Random
Corrected Plant Net Power Output						
Test Run 1	kW	450,542.770	4,078.953	4.303	86.236	371.042
Test Run 2	kW	450,388.986	3,113.057			
Test Run 3	kW	450,629.836	3,141.674			
Average	kW	450,520.530		Systematic	Random	Total
Total Uncertainty (units)				3,473.67	371.04	3,493.43
Total Uncertainty (%)				0.77%	0.08%	0.78%
Corrected Plant Net Heat Rate						
Test Run 1	kW	5,717.876	113.304	4.303	2.392	10.293
Test Run 2	kW	5,714.246	162.370			
Test Run 3	kW	5,711.116	161.588			
Average	kW	5,714.413		Systematic	Random	Total
Total Uncertainty (units)				147.55	10.29	147.91
Total Uncertainty (%)				2.58%	0.18%	2.59%

GSU 5 Measured Power Uncertainty TR 2															
Column	G		R		X		AJ		AP		Power Uncertainty (kW)				
Description	Units	Mean	B _{inst} Instrument		B _{spatial} Spatial		B _{xbar} Total		T _{inv}	S _{xbar}	T _{inv} S _{xbar}	Θ	Θ _{xbar}	Θ _{sbar}	311,860
			units	Systematic	Systematic	Systematic	Student T	Random	Total Random	Sensitivity %/%	Systematic %	Random %	Total %		
UAT Measured Power	kW	311,859.98	311.86	0.00	0.10%	1.98	65.84	0.04%	100.00%			0.10%	0.04%	0.11%	
PT Ratio	Deg F	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%			0.30%	0.00%	0.30%	
CT Ratio	%	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%			0.30%	0.00%	0.30%	
												RSS	0.44%	0.04%	0.44%
													1,359.4	130.4	1,365.6

GSU 6 Measured Power Uncertainty TR 2															
Column	G		R		X		AJ		AP		Power Uncertainty (kW)				
Description	Units	Mean	B _{inst} Instrument		B _{spatial} Spatial		B _{xbar} Total		T _{inv}	S _{xbar}	T _{inv} S _{xbar}	Θ	Θ _{xbar}	Θ _{sbar}	143,925
			units	Systematic	Systematic	Total Spatial	Student T	Random	Total Random	Sensitivity %/%	Systematic %	Random %	Total %		
UAT Measured Power	kW	143,925.25	143.93	0.00	0.10%	1.98	13.34	0.02%	100.00%			0.10%	0.02%	0.10%	
PT Ratio	Deg F	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%			0.30%	0.00%	0.30%	
CT Ratio	%	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%			0.30%	0.00%	0.30%	
												RSS	0.44%	0.02%	0.44%
													627.4	26.4	627.9

Plant Fuel Flow Uncertainty TR 2 (enable meter)															
Column	G		R		X		AJ		AP		Flow Uncertainty (lb/h)				
Description	Units	Mean	B _{inst} Instrument		B _{spatial} Spatial		B _{xbar} Total		T _{inv}	S _{xbar}	T _{inv} S _{xbar}	Θ	Θ _{xbar}	Θ _{sbar}	125,776
			units	Systematic	Systematic	Total Spatial	Student T	Random	Total Random	Sensitivity %/%	Systematic %	Random %	Total %		
Meter Type	-	Ultrasonic													
Tap Type	-	N/A													
Inlet Diameter	in	10.02	0.00	0.00	0.01%	0.00	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Throat Diameter	in	10.02	0.00	0.00	0.01%	0.00	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Diameter Measurement Temperature	Deg F	72.00	4.00	0.00	5.56%	0.00	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Calibration Temperature	Deg F	48.40	4.00	0.00	8.26%	0.00	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Inlet Material	-	SS3xx													
Throat Material	-	SS3xx													
Fluid Type	-	Vapor													
Upstream Pressure	psia	840.84	1.00	0.00	0.12%	1.97	0.09	0.02%	112.72%			0.13%	0.02%	0.14%	
Downstream Temperature	Deg F	67.94	0.73	0.00	1.07%	1.97	0.01	0.04%	-19.92%			-0.21%	-0.01%	0.21%	
Meter Reported Flow Rate	KACF/h	42.43	0.14	0.00	0.33%	1.97	0.01	0.03%	100.00%			0.33%	0.03%	0.33%	
Fuel Analysis															
Methane, CH4	mole %	90.00%	0.00	0.00	0.17%	4.30	0.00	0.17%	-9.82%			-0.02%	-0.02%	0.02%	
Ethane, C2H6	mole %	7.02%	0.00	0.00	1.71%	4.30	0.00	0.70%	7.07%			0.12%	0.05%	0.13%	
Propane, C3H8	mole %	0.36%	0.00	0.00	19.56%	4.30	0.00	2.50%	6.42%			1.26%	0.16%	1.27%	
Iso-Butane, i-C4H10	mole %	0.01%	0.00	0.00	142.86%	4.30	0.00	17.74%	0.03%			0.05%	0.01%	0.05%	
N-Butane, n-C4H10	mole %	0.03%	0.00	0.00	73.17%	4.30	0.00	20.99%	0.06%			0.05%	0.01%	0.05%	
Iso-Pentane, i-C5H12	mole %	0.01%	0.00	0.00	348.84%	4.30	0.00	25.02%	0.02%			0.06%	0.00%	0.06%	
N-Pentane, n-C5H12	mole %	0.01%	0.00	0.00	400.00%	4.30	0.00	49.68%	0.02%			0.06%	0.01%	0.06%	
N-Hexane, n-C6H14	mole %	0.01%	0.00	0.00	164.84%	4.30	0.00	7.19%	0.05%			0.08%	0.00%	0.08%	
Heptane, C7H16	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Octane, C8H18	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Nonane, C9H20	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Decane, C10H22	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Nitrogen, N2	mole %	1.86%	0.00	0.00	5.38%	4.30	0.00	5.34%	0.81%			0.04%	0.04%	0.06%	
Carbon Monoxide, CO	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Carbon Dioxide, CO2	mole %	0.65%	0.00	0.00	10.77%	4.30	0.00	0.00%	0.98%			0.11%	0.00%	0.11%	
Water, H2O	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Hydrogen Sulphide, H2S	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Hydrogen, H2	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Helium, He	mole %	0.04%	0.00	0.00	50.00%	4.30	0.00	0.00%	-0.03%			-0.02%	0.00%	0.02%	
Oxygen, O2	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%			0.00%	0.00%	0.00%	
Argon, Ar	mole %	0.01%	0.00	0.00	200.00%	4.30	0.00	0.00%	0.01%			0.03%	0.00%	0.03%	
												RSS	1.34%	0.18%	1.35%
													1,686.9	227.0	1,702.1

GSU 5 Measured Power Uncertainty TR 3															
Column	H		S		Y		AK		AQ		Power Uncertainty (kW)				
Description	Units	Mean	B _{inst} Instrument		B _{spatial} Spatial		B _{xbar} Total		T _{inv}	S _{xbar}	T _{inv} S _{xbar}	Θ	Θ _{xbar}	Θ _{s_xbar}	313,017
			units	Systematic	Systematic	Systematic	Student T	Random	Total Random	Sensitivity	Systematic	Random	Total		
UAT Measured Power	kW	313,016.51	313.02	0.00	0.10%	1.98	98.28	0.06%	100.00%	0.10%	0.06%	0.12%			
PT Ratio	Deg F	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%	0.30%	0.00%	0.30%			
CT Ratio	%	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%	0.30%	0.00%	0.30%			
									RSS	0.44%	0.06%	0.44%	1,364.4	194.6	1,378.2

GSU 6 Measured Power Uncertainty TR 3															
Column	H		S		Y		AK		AQ		Power Uncertainty (kW)				
Description	Units	Mean	B _{inst} Instrument		B _{spatial} Spatial		B _{xbar} Total		T _{inv}	S _{xbar}	T _{inv} S _{xbar}	Θ	Θ _{xbar}	Θ _{s_xbar}	143,994
			units	Systematic	Systematic	Systematic	Student T	Random	Total Random	Sensitivity	Systematic	Random	Total		
UAT Measured Power	kW	143,994.02	143.99	0.00	0.10%	1.98	11.42	0.02%	100.00%	0.10%	0.02%	0.10%			
PT Ratio	Deg F	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%	0.30%	0.00%	0.30%			
CT Ratio	%	0.00	0.00	0.00	0.30%	0.00	0.00	0.00%	100.00%	0.30%	0.00%	0.30%			
									RSS	0.44%	0.02%	0.44%	627.7	22.6	628.1

GSU 7 Measured Power Result Uncertainty TR 3															
Column	H		S		Y		AK		AQ		Flow Uncertainty (lb/h)				
Description	Units	Mean	B _{inst} Instrument		B _{spatial} Spatial		B _{xbar} Total		T _{inv}	S _{xbar}	T _{inv} S _{xbar}	Θ	Θ _{xbar}	Θ _{s_xbar}	126,378
			units	Systematic	Systematic	Total Spatial	Student T	Random	Total Random	Sensitivity	Systematic	Random	Total		
Meter Type	-	Ultrasonic													
Tap Type	-	N/A													
Inlet Diameter	in	10.02	0.00	0.00	0.01%	0.00	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Throat Diameter	in	10.02	0.00	0.00	0.01%	0.00	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Diameter Measurement Temperature	Deg F	72.00	4.00	0.00	5.56%	0.00	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Calibration Temperature	Deg F	48.40	4.00	0.00	8.26%	0.00	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Inlet Material	-	SS3xx													
Throat Material	-	SS3xx													
Fluid Type	-	Vapor													
Upstream Pressure	psia	841.92	1.00	0.00	0.12%	1.97	0.05	0.01%	112.75%	0.13%	0.01%	0.13%			
Downstream Temperature	Deg F	67.78	0.73	0.00	1.08%	1.97	0.01	0.03%	-19.89%	-0.21%	-0.01%	0.21%			
Meter Reported Flow Rate	KACF/h	42.53	0.14	0.00	0.33%	1.97	0.01	0.04%	100.00%	0.33%	0.04%	0.33%			
Fuel Analysis															
Methane, CH4	mole %	89.93%	0.00	0.00	0.17%	4.30	0.00	0.14%	-9.85%	-0.02%	-0.01%	0.02%			
Ethane, C2H6	mole %	7.03%	0.00	0.00	1.71%	4.30	0.00	0.23%	7.08%	0.12%	0.02%	0.12%			
Propane, C3H8	mole %	0.35%	0.00	0.00	19.85%	4.30	0.00	5.61%	6.35%	1.26%	0.36%	1.31%			
Iso-Butane, i-C4H10	mole %	0.01%	0.00	0.00	146.34%	4.30	0.00	20.99%	0.03%	0.05%	0.01%	0.05%			
N-Butane, n-C4H10	mole %	0.03%	0.00	0.00	71.43%	4.30	0.00	15.37%	0.06%	0.05%	0.01%	0.05%			
Iso-Pentane, i-C5H12	mole %	0.01%	0.00	0.00	327.87%	4.30	0.00	21.16%	0.02%	0.06%	0.00%	0.06%			
N-Pentane, n-C5H12	mole %	0.01%	0.00	0.00	333.33%	4.30	0.00	0.00%	0.02%	0.06%	0.00%	0.06%			
N-Hexane, n-C6H14	mole %	0.01%	0.00	0.00	160.43%	4.30	0.00	9.42%	0.05%	0.08%	0.00%	0.08%			
Heptane, C7H16	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Octane, C8H18	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Nonane, C9H20	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Decane, C10H22	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Nitrogen, N2	mole %	1.90%	0.00	0.00	5.25%	4.30	0.00	7.19%	3.73%	0.20%	0.27%	0.33%			
Carbon Monoxide, CO	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Carbon Dioxide, CO2	mole %	0.66%	0.00	0.00	10.66%	4.30	0.00	4.37%	9.99%	0.11%	0.04%	0.11%			
Water, H2O	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Hydrogen Sulphide, H2S	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Hydrogen, H2	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Helium, He	mole %	0.04%	0.00	0.00	50.00%	4.30	0.00	0.00%	-0.03%	-0.02%	0.00%	0.02%			
Oxygen, O2	mole %	0.00%	0.00	0.00	0.00%	4.30	0.00	0.00%	0.00%	0.00%	0.00%	0.00%			
Argon, Ar	mole %	0.01%	0.00	0.00	150.00%	4.30	0.00	107.57%	0.02%	0.03%	0.02%	0.03%			
									RSS	1.36%	0.45%	1.43%	1,717.1	570.1	1,809.2

APPENDIX D

TEST EQUIPMENT INFORMATION

APPENDIX E

EQUIPMENT CALIBRATIONS

BFW 3.1

Rosemount Production Flow Facility Calibration Data

12001 Technology Drive, Eden Prairie, MN 55344 USA

Model number: **8800DF010SA8N1D1E5M5Q4Q8**

Serial Number: **0285524**

Sales Order: **4495472**

Customer Tag: **03-FIT-035601**

Calibration Date: **Mar 22, 2016**

Trace Number: **270719**

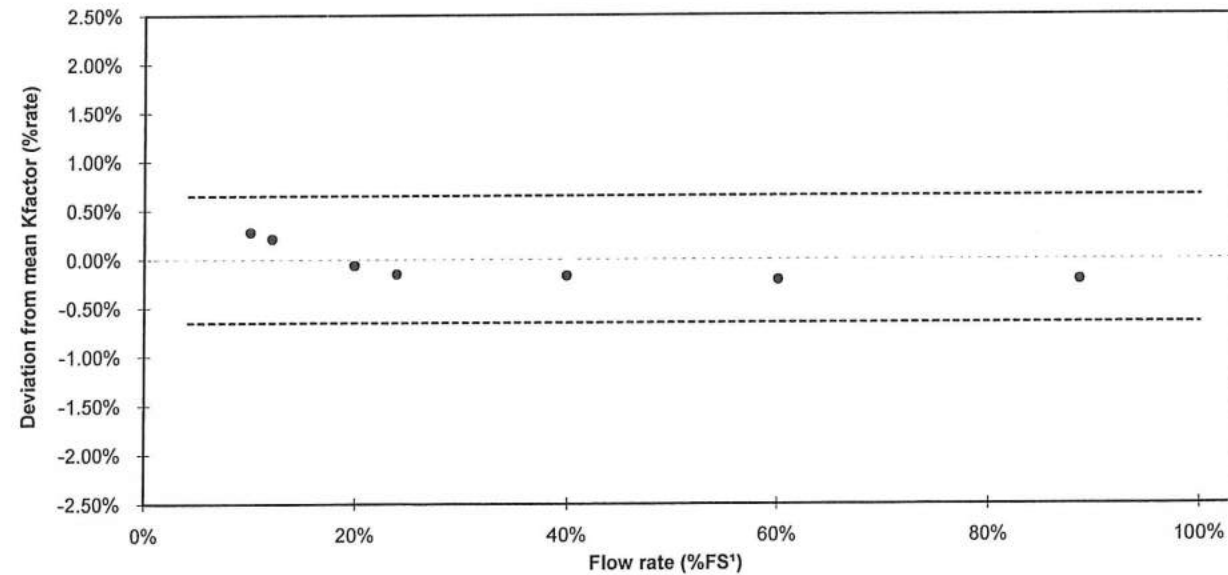
Computed mean K-factor: **301.51**



Pass/Fail: PASS

Run #	Flow rate % FS ¹	Velocity ft/s	Velocity m/s	Reynolds number	Flow rate US gpm	Flow rate m ³ /hr	Deviation % rate
1	88.6%	22.1	6.75	174,273	60	13.6	-0.21%
2	60.0%	15.0	4.57	118,038	40	9.2	-0.21%
3	39.9%	10.0	3.04	78,460	27	6.1	-0.17%
4	23.9%	6.0	1.82	46,980	16	3.7	-0.15%
5	19.8%	5.0	1.51	39,019	13	3.0	-0.06%
6	12.1%	3.0	0.92	23,790	8	1.8	0.21%
7	10.0%	2.5	0.76	19,639	7	1.5	0.28%

Deviation vs Flow rate



Calibration conditions:

Water temperature = 65.9 °F (18.9 °C), water density = 62.329 lb/ft³ (998.41 kg/m³)

¹100% flow rate = 25 ft/sec (7.62 m/s) in schedule 40 pipe.

Measuring and test equipment used in the manufacture and inspection of the above flowmeter are directly traceable to the National Institute of Standards and Technology. The calibration system was designed to meet the intent of ANSI Z540.3-2006.



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION.

DATE: 11-11-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: BFW 3.1 Work Package #: WP-INST-004

Location: PIPERACK Area: DSE

Drawing #: 2014.071.1A.08042B Specification: 94.03.14.100.03

Description (Type): VORTEX FLOWMETER

INSTRUMENT TAG # 03FIT 035601	P&ID PS-035	SERVICE IP FW SPRAY FAN TO HPS DSH	INSTRUMENT DATA SHEET # N/A
MANUFACTURER ROSEMOUNT	MODEL NUMBER 8800DF01	INSTRUMENT SERIAL NUMBER 0285524	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # 03-1" - BFW 6402-1FAA1	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: BENCH HART 475 USED

ADDITIONAL INSTRUMENT INFORMATION

Configuration Check ONLY
ATTACHED TO FE

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
ATEK	334A	2662011	3/4/16

TEST EQUIPMENT	MODEL #	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	N/A	N/A	N/A	N/A	N/A
?	?	?	?		
N/A	N/A	N/A	N/A	N/A	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE: 0-29250 lb/hr

CALIBRATED BY: Stanley Umast DATE: 10/26/16 ACCEPTED BY: NA DATE: _____

FORSMAN (SIGN): [Signature] DATE: 11-11-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____

TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 11-14-16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 11/11/16

PL: MVS Serial Number: 0285524

Configuration Date: 22-Mar-2016 Time: 11:21

Transmitter Order Information

Sales Order: 4495472

Model: 8800DF010SA8N1D1E5M5Q4Q8

Name Tag: 03-FIT-035601
Short Tag: 03-FIT-0

Unit: 1
Line: 4
Device ID: 205689

Message:

Descriptor:

Address 000

Configuration Information

SW Revision: 5.2.5

K-Factor: 301.51 pulses/US gal (4-20mA) PV: 0 to 29250 lb/hr
Process Fluid: Liquid
Pipe ID: 0.815 in
Fixed Process Temp: 330.000000 °F
Fixed Process Density: 56.564 lb/ft3
Fixed Density Ratio: N/A
Flow Damping: 2 Second(s) Totalizer: Mass

Velocity Flow Based On: Mating Pipe ID

LFC Response Type: Stepped

Installation Effects: 0
Pulse Output Mode: N/A
Pulse Output Factor: N/A

Security: Off
Alarm: RMT High

LCD Disp: PV, % Range

Meter Body

Meter Body S/N: 0285524B
Flange Type: A8
Wetted Material: S



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 1-02-17

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: CDN 3.1 Work Package #: INST-8120-INST-003
 Location: STEAM TURBINE GENERATOR Area: CHA-5TG1
 Drawing #: PS-050 Specification: 88.15.02.002D
 Description (Type): COND HOTWELL LVL A. LEVEL IND. TRANSMITTER (PRESSURE TYPE)

INSTRUMENT TAG # <u>03-LIT-050610A</u>	P&ID <u>PS-050</u>	SERVICE <u>NA</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051LZAG</u>	INSTRUMENT SERIAL NUMBER <u>2509454</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low psi hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>Ametek</u>	<u>XP2i300</u>	<u>367824</u>	<u>3/3/2016</u>
<u>Altek</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/2016</u>

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>-59.315" H2O</u>	<u>4.01ma</u>	<u>4.01ma</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>-20.8425" H2O</u>	<u>12.01ma</u>	<u>12.01ma</u>	<u>12mA</u>	<u> </u>
<u>N/A</u>	<u>17.63" H2O</u>	<u>20.01ma</u>	<u>20.01ma</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: -59.315 - 17.63 in H2O

Stanley Vincent 9/23/16
 CALIBRATED BY _____ DATE _____ ACCEPTED BY _____ DATE _____
Kelvin Lusk 1-02-17
 FOREMAN (SIGN) _____ DATE _____ OPERATIONS REPRESENTATIVE (SIGN) _____ DATE _____
[Signature] 1-10-17
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) _____ DATE _____ CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) _____ DATE 12/20/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 1-02-17

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CDN 31 Work Package #: INST-8120-INST-003

Location: STEAM TURBINE GENERATOR Area: 04A-STG1

Drawing #: PS-050 Specification: 88.15.02.002D

Description (Type): COND HOTWELL LVL A. LEVEL IND. TRANSMITTER (PRESSURE TYPE)

INSTRUMENT TAG # <u>03-LIT-050610B</u>	P&ID <u>PS-050</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051L2AG</u>	INSTRUMENT SERIAL NUMBER <u>2509455</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINK SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low psi hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>Ametek</u>	<u>xp2i 300</u>	<u>367824</u>	<u>3/3/2016</u>
<u>Altek</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/2016</u>

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>-59.315" H₂O</u>	<u>4.01ma</u>	<u>4.01ma</u>	<u>4mA</u>	<u>N/A</u>
	<u>-20.8425" H₂O</u>	<u>12ma</u>	<u>12ma</u>	<u>12mA</u>	
<u>N/A</u>	<u>17.63" H₂O</u>	<u>20ma</u>	<u>20ma</u>	<u>20mA</u>	<u>N/A</u>


INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: -59.315 - 17.63 in H₂O

Stanley Vincent 9/23/16 _____
 CALIBRATED BY DATE ACCEPTED BY DATE
[Signature] 1-02-17 _____
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
[Signature] 1-10-17 [Signature] 12/20/16
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE

CDM

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>12-20-16</u>
	Project Name: <u>Grand River Energy Center Unit 3</u> Project #: <u>102739</u>	

System #: CDN 3.1 Work Package #: INST-8120-INST-003
 Location: STEAM TURBINE GENERATOR Area: 04A-ST01
 Drawing #: PS-050 Specification: 88.15.02.002D
 Description (Type): COND HOTWELL LVL C. LEVEL IND. TRANSMITTER (PRESSURE TYPE)

INSTRUMENT TAG # <u>03-LIT-050610C</u>	P&ID <u>PS-050</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>30S1LZAG</u>	INSTRUMENT SERIAL NUMBER <u>2509456</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low psi hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>Ametek</u>	<u>Xp2i300</u>	<u>367824</u>	<u>3/3/2016</u>		
<u>Altek</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/2016</u>		
TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>-59.315" H₂O</u>	<u>4.01ma</u>	<u>4.01ma</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>-20.8425" H₂O</u>	<u>12.01ma</u>	<u>12.01ma</u>	<u>12mA</u>	<u> </u>
<u>N/A</u>	<u>17.63" H₂O</u>	<u>20ma</u>	<u>20ma</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS
Range: -59.315 - 17.63 in H₂O

<u>Stanley Vento</u> CALIBRATED BY	<u>9/23/16</u> DATE	ACCEPTED BY	DATE
<u>[Signature]</u> FOREMAN (SIGN)	<u>12-20-16</u> DATE	<u>[Signature]</u> OPERATIONS REPRESENTATIVE (SIGN)	DATE
<u>[Signature]</u> TIC QUALITY CONTROL (SIGN IF APPLICABLE)	<u>2/16/17</u> DATE	<u>[Signature]</u> CLIENT REPRESENTATIVE (SIGN IF APPLICABLE)	<u>12/20/16</u> DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HR031 Work Package #: INST-8120-INST-002
 Location: NA Area: 03A-HRSG11
 Drawing #: 100-PD-0003-001 Specification: 88.15.02.002D

Description (Type): _____

INSTRUMENT TAG # 03-LT-102635A	P&ID 100-PD-0003-001	SERVICE N/A	INSTRUMENT DATA SHEET # N/A
MANUFACTURER Rosemount	MODEL NUMBER 3051CD2A	INSTRUMENT SERIAL NUMBER 2758709	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # N/A	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: Bench Hart 475
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
Fluke	724	3365061	3/20/2016
Ametek	xp01300	367824	3/31/2016

TEST EQUIPMENT	APPLIED PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	0 in H₂O	4.00ma	4.00ma	4 mA	N/A
N/A	33.75 in H₂O	12.02ma	12.02ma	12 mA	N/A
N/A	67.5 in H₂O	20.02ma	20.02ma	20 mA	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0 - 67.5 in H₂O

Stanley Vincent 9/30/16 NA _____
 CALIBRATED BY DATE ACCEPTED BY DATE
Kramer Jackson 9-30-16 NA _____
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
PCA 10/31/16 _____ 10/3/16
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CALIBR. REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRC 3.1 Work Package #: INST-8120-INST-CO2

Location: MA Area: OSA-HRSG 3.1

Drawing #: 100-PD-0003-001 Specification: 88.15.02.0020

Description (Type): LEVEL IND TRANS 2-WIRE

INSTRUMENT TAG # <u>03-LIT-102635B</u>	P&ID <u>100-PD-0003-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051002A</u>	INSTRUMENT SERIAL NUMBER <u>2758710</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>Fluke</u>	<u>724</u>	<u>3365061</u>	<u>3/20/2016</u>
<u>Ametek</u>	<u>xp21300</u>	<u>367824</u>	<u>3/3/2016</u>

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 in H₂O</u>	<u>4.01ma</u>	<u>4.01ma</u>	<u>4 mA</u>	<u>N/A</u>
}	<u>33.75 in H₂O</u>	<u>12.01ma</u>	<u>12.01ma</u>	<u>12 mA</u>	}
	<u>67.5 in H₂O</u>	<u>20.02ma</u>	<u>20.02ma</u>	<u>20 mA</u>	

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0-67.5 in H₂O

Stanley Vincent 9/20/16 NA _____
CALIBRATED BY DATE ACCEPTED BY DATE

Kelley Lashon 9-30-16 NA _____
FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE

[Signature] 10/31/16 [Signature] 10/3/16
TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



**TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION**

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRG1 3.1 Work Package #: INST-8120-INST-002

Location: NA Area: 03A-HRSG1

Drawing #: 100-PD-0006-001 Specification: 88.15.02.002D

Description (Type): LEVEL IND. TRANS. 2-WIRE

INSTRUMENT TAG # <u>03-LIT-102635C</u>	P&ID <u>100-PD-0006-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>305102A</u>	INSTRUMENT SERIAL NUMBER <u>2762408</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>NA</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>Flyke</u>	<u>724</u>	<u>3365061</u>	<u>7/20/2016</u>		
<u>Ametek</u>	<u>XPR1300</u>	<u>367824</u>	<u>8/3/2016</u>		
TEST EQUIPMENT	APPLIED PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 in H2O</u>	<u>4.0ma</u>	<u>4.0ma</u>	<u>4mA</u>	<u>N/A</u>
<u>S</u>	<u>33.75 in H2O</u>	<u>12.02ma</u>	<u>12.02ma</u>	<u>12mA</u>	<u>S</u>
<u>N/A</u>	<u>67.5 in H2O</u>	<u>20.01ma</u>	<u>20.01ma</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0 — 67.5 in H2O

Stanley Vincent 9/20/16 NA
CALIBRATED BY DATE ACCEPTED BY DATE

Klaus Schuber 9-30-16 NA
FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE

Joe 10/3/16
TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRG 3.1 Work Package #: INST-8120-INST-002

Location: NA Area: 03A-HRSG 1

Drawing #: 100-FD-0006-001 Specification: 88.15.02.0020

Description (Type): LEVEL IND. TRANS. 2-WIRE

INSTRUMENT TAG # 03-LIT-105665A	P&ID 100-FD-0006-001	SERVICE N/A	INSTRUMENT DATA SHEET # N/A
MANUFACTURER Rosemount	MODEL NUMBER 30SICDZA	INSTRUMENT SERIAL NUMBER 2762409	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # N/A	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL. DATE
Flyke	789	26360053	3/4/2016
Ametek	XP21300	367824	3/31/2016

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 in H2O</u>	<u>4.02ma</u>	<u>4.02ma</u>	<u>4 mA</u>	<u>N/A</u>
	<u>20 in H2O</u>	<u>12.02ma</u>	<u>12.02ma</u>	<u>12 mA</u>	
<u>N/A</u>	<u>40 in H2O</u>	<u>20.01ma</u>	<u>20.01ma</u>	<u>20 mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0-40 in H2O

CALIBRATED BY: Stanley Vincent DATE: 9/20/16 ACCEPTED BY: NA DATE: _____

FOREMAN (SIGN): [Signature] DATE: 9-30-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____

TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 10/31/16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 10/3/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HRG1 3.1 Work Package #: INST-8170-INST-002
 Location: NA Area: 03A-HRSG1
 Drawing #: 100-PD-0006-001 Specification: 88.15.02.002D
 Description (Type): LEVEL IND. TRANS. 2-WIRE

INSTRUMENT TAG # <u>03-LIT-10565B</u>	P&ID <u>100-PD-0006-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3061C02A</u>	INSTRUMENT SERIAL NUMBER <u>2762410</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 476 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>Fluke</u>	<u>724</u>	<u>3365061</u>	<u>7/20/2016</u>		
<u>Ametek</u>	<u>XP21300</u>	<u>367824</u>	<u>3/3/2016</u>		
TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 in H₂O</u>	<u>4.0ma</u>	<u>4.0ma</u>	<u>4mA</u>	<u>N/A</u>
}	<u>20 in H₂O</u>	<u>12.02ma</u>	<u>12.02ma</u>	<u>12mA</u>	}
	<u>40 in H₂O</u>	<u>20.02ma</u>	<u>20.02ma</u>	<u>20mA</u>	

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0 - 40 in H₂O

Stanley Smart 9/20/16 NA
 CALIBRATED BY DATE ACCEPTED BY DATE
Ronan Lachar 9-30-16 NA
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
JCO 10/31/16 DD
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE
10/3/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HRG 3.1 Work Package #: INST-8120-INST-002
 Location: NA Area: 03A-HRSG1
 Drawing #: 100-PD-0006-001 Specification: 88.15.02.0020
 Description (Type): LEVEL IND. TRANS 2-WIRE

INSTRUMENT TAG # 03-LIT-105665C	P&ID 100-PD-0006-001	SERVICE N/A	INSTRUMENT DATA SHEET # N/A
MANUFACTURER Rosemount	MODEL NUMBER 3051CD2A	INSTRUMENT SERIAL NUMBER 2762411	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX NA	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # N/A	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
Fluke	724	8365061	7/20/2016		
Ametek	Xp21300	367824	3/31/2016		
TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	0 in H2O	4.01ma	4.01ma	4 mA	N/A
N/A	20 in H2O	12.02ma	12.02ma	12 mA	N/A
N/A	40 in H2O	20.01ma	20.01ma	20 mA	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0 - 40 in H2O

Stanley Vincent 9/30/16 NA DATE
 CALIBRATED BY DATE ACCEPTED BY DATE
Klaus Lasker 9-30-16 NA DATE
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
P. C. C. 10/31/16 [Signature] 10/3/16
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRG 3.1 Work Package #: INST-8120-INST-002

Location: NA Area: DBA-HRSG11

Drawing #: _____ Specification: 88.15.02.002D

Description (Type): LP DRM LVL A

INSTRUMENT TAG # <u>03-LIT-109665 A</u>	P&ID <u>100-PD-0010-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051CDZA</u>	INSTRUMENT SERIAL NUMBER <u>2775648</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>Floke</u>	<u>789</u>	<u>26360063</u>	<u>3/4/2016</u>
<u>Ametek</u>	<u>XP21300</u>	<u>367824</u>	<u>3/3/2016</u>

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 in H₂O</u>	<u>4.02ma</u>	<u>4.02ma</u>	<u>4 mA</u>	<u>N/A</u>
}	<u>35.75 in H₂O</u>	<u>12.01ma</u>	<u>12.01ma</u>	<u>12 mA</u>	}
	<u>71.5 in H₂O</u>	<u>20.02ma</u>	<u>20.02ma</u>	<u>20 mA</u>	

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0 - 71.5 in H₂O

CALIBRATED BY Stanley Vincent DATE 9/20/16 ACCEPTED BY NA DATE _____

FOREMAN (SIGN) [Signature] DATE 9-30-16 OPERATIONS REPRESENTATIVE (SIGN) NA DATE _____

TIC QUALITY CONTROL (SIGN IF APPLICABLE) [Signature] DATE 10/31/16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) [Signature] DATE 10/3/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HRG 3.1 Work Package #: INST-8120-INST-002
 Location: NA Area: 03A-HRSG1
 Drawing #: 100-PD-0010-001 Specification: 38.15.02.002D
 Description (Type): LEVEL, IND. TRANS. 2-WIRE

INSTRUMENT TAG # <u>03-LIT-109665B</u>	P&ID <u>100-PD-0010-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051C02A</u>	INSTRUMENT SERIAL NUMBER <u>2758711</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL. DATE		
<u>Fluke</u>	<u>789</u>	<u>2636053</u>	<u>3/4/2016</u>		
<u>Ametek</u>	<u>XP21300</u>	<u>367824</u>	<u>3/3/2016</u>		
TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 in H2O</u>	<u>4.02ma</u>	<u>4.02ma</u>	<u>4 mA</u>	<u>N/A</u>
	<u>35.75 in H2O</u>	<u>12.02ma</u>	<u>12.02ma</u>	<u>12 mA</u>	
<u>N/A</u>	<u>71.5 in H2O</u>	<u>20.02ma</u>	<u>20.02ma</u>	<u>20 mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range: 0 - 71.5 in H2O

Stanley Pleasant 9/20/16 NA
 CALIBRATED BY DATE ACCEPTED BY DATE
K. M. Jackson JR 9-30-16 NA
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
PCO 10/31/16 DD 10/3/16
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRC 3.1 Work Package #: INST-8120-INST-002

Location: NA Area: 03A-HRSG1

Drawing #: 100-PD-0010-001 Specification: 88.15.02.002D

Description (Type): LEVEL IND. TRNS 2-WIRE

INSTRUMENT TAG # <u>03-LIT-109665C</u>	P&ID <u>100-PD-0010-001</u>	SERVICE <u>NA</u>	INSTRUMENT DATA SHEET # <u>NA</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051CD2A</u>	INSTRUMENT SERIAL NUMBER <u>2775649</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench HART 475 used
Low pressure hand pump

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>ALTEK</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/16</u>		
<u>AMETEK</u>	<u>XP21300</u>	<u>367824</u>	<u>3/3/16</u>		
TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 in H2O</u>	<u>4.0 ma</u>	<u>4.0 ma</u>	<u>4 mA</u>	<u>N/A</u>
	<u>35.75 in H2O</u>	<u>12.02 ma</u>	<u>12.02 ma</u>	<u>12 mA</u>	
	<u>71.5 in H2O</u>	<u>20.07 ma</u>	<u>20.07 ma</u>	<u>20 mA</u>	<u>N/A</u>

N/A INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS
Range: 0-71.5 in H2O

Stanley Vincent 9/30/16 NA
CALIBRATED BY DATE ACCEPTED BY DATE

[Signature] 9-30-16 NA
FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE

[Signature] 10/31/16 [Signature] 10/3/16
TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-13-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: CSS 3.1 Work Package #: WP-INST-004
 Location: Pipe rack Area: OSE
 Drawing #: 2014-071.1A.08042A Specification: 94.03.14.100.00
 Description (Type): Pressure Diff Lnd TRANSMITTER

INSTRUMENT TAG # 03 PPT 035625A	PRID PS-035	SERVICE GT COMB COOLING STW LNL OUTL DIFF PRESS A	INSTRUMENT DATA SHEET # N/A
MANUFACTURER Rosemount	MODEL NUMBER 3051C04A	INSTRUMENT SERIAL NUMBER 2791911	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # 03-8" HRH 6518	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: Bench Hart 475 used
 Low PSI Hand Pump Used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
Altek	334A	2667001	3/4/16
AMETEK	XP21300	367824	3/3/16

TEST EQUIPMENT	AS FOUND	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	0 psid	4mA	4mA	4mA	N/A
	75 psid	12mA	12mA	12mA	
N/A	150 psid	20mA	20mA	20mA	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-150 psid

Stanley Kriest 11/11/16 ACCEPTED BY NA DATE
 James Jackson 11-13-16 OPERATIONS REPRESENTATIVE (SIGN) NA DATE
 Joe 11-14-16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE 11/14/16
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE



**TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION**

DATE: 11-13-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CSS3.1 Work Package #: NP-INST-004

Location: Piperack Area: 05E

Drawing #: 2014.071.1A.08042A Specification: 94.03.14.100.00

Description (Type): Pressure Diff Ino Transmitter

INSTRUMENT TAG # <u>03 PDIT 03562518</u>	P&ID <u>PS-035</u>	SERVICE <u>GT COMB COOLING STM INL OUTL DIFF PRESS</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051C04A</u>	INSTRUMENT SERIAL NUMBER <u>2791912</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>03-8" HRW 6518</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH HART 475 used
Low PSI HAND Pump used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>AI TIC</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/16</u>
<u>ANATEK</u>	<u>XP2-300</u>	<u>367824</u>	<u>3/3/16</u>

TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 psid</u>	<u>4mA</u>	<u>4mA</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>75 psid</u>	<u>12mA</u>	<u>12mA</u>	<u>12mA</u>	<u> </u>
<u>N/A</u>	<u>150 psid</u>	<u>20mA</u>	<u>20mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-150 PSID

Stanley Vincent 11/11/16 NA DATE
 CALIBRATED BY DATE ACCEPTED BY DATE
Kilmer Jackson 11-13-16 NA DATE
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN)
PCO 11-14-16 [Signature] 11/14/16
 QC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-13-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CSS 3.1 Work Package #: WP-INST-004

Location: Piperack Area: OSE

Drawing #: 2014.07.1A.08042A Specification: 94.03.14.100.00

Description (Type): Pressure Diff 1.0 Transmitter

INSTRUMENT TAG # 03 PDIT 035625C	P&ID PS-035	SERVICE GT COMB COOLING	INSTRUMENT DATA SHEET # N/A
MANUFACTURER ROSEMOUNT	MODEL NUMBER 3051C04A	INSTRUMENT SERIAL NUMBER 2792913	TOLERANCE N/A
BOOK OF DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # 03-8" HRH6518	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: Bench HART 475 used
Low PSI HAND Pump Used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
Aitek	334A	2667001	3/4/16		
AMETEK	XP21300	367824	3/3/16		
TEST EQUIPMENT	APPLIED Pressure	OUTPUT AS FOUND	OUTPUT AS LEFT	DESIRED	AS LEFT DEVIATION
N/A	0 psid	4mA	4mA	4mA	N/A
	75 psid	12mA	12mA	12mA	
N/A	15.0 psid	20mA	20mA	20mA	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-150 psid

Stanley Vincent 11/12/16 CALIBRATED BY DATE
 OPERATIONS REPRESENTATIVE (SIGN) DATE
 Kimer Schwan 11-13-16 FOREMAN (SIGN) DATE
 OPERATIONS REPRESENTATIVE (SIGN) DATE
 JCO 11/14/16 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE
 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-11-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: C553.1 Work Package #: WP-INST-004

Location: Pipe rack Area: OSE

Drawing #: 20140711A.08042A Specification: 94.03.14.100.00

Description (Type): Pressure I/A TRANSMITTER

INSTRUMENT TAG# <u>03 PIT 034602A</u>	P&ID <u>PS:084</u>	SERVICE <u>CT COMB PIECE</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051TG4A</u>	INSTRUMENT SERIAL NUMBER <u>2792594</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>03-10" HRH 6405</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH HART 475 USED
N2 Bottle w/ Reg used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>AMETEK</u>	<u>XP213K</u>	<u>461540</u>	<u>3/3/16</u>		
<u>ALTEK</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/16</u>		
TEST EQUIPMENT	APPLIED Pressure	OUTPUT AS FOUND	OUTPUT AS LEFT	DESIRED	AS LEFT DEVIATION
<u>N/A</u>	<u>0 psig</u>	<u>4mA</u>	<u>4mA</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>385 psig</u>	<u>12mA</u>	<u>12mA</u>	<u>12mA</u>	<u> </u>
<u>N/A</u>	<u>770 psig</u>	<u>20mA</u>	<u>20mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0 - 770 psig

Stanley Vincent 11/02/16 NA
CALIBRATED BY DATE ACCEPTED BY DATE

Kenneth Jackson 11-11-16 NA
FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE

[Signature] 11-14-16 [Signature]
TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-11-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CSS3.1 Work Package #: WP-INST-004

Location: Piperack Area: 05E

Drawing #: 2014.071.1A.08042A Specification: 94.03.14.100.00

Description (Type): Pressure I/O TRANSMITTER

INSTRUMENT TAG # <u>03PIT039602B</u>	P&ID <u>PS-034</u>	SERVICE <u>OT Cool Stm Return PSI B</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>ROSEMOUNT</u>	MODEL NUMBER <u>3051TG4A</u>	INSTRUMENT SERIAL NUMBER <u>2792595</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>03-10" HRH 6405</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH HART 475 USCO
N^o Bottle w/Reg

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>AMETEK</u>	<u>XP213K</u>	<u>461540</u>	<u>3/2/16</u>
<u>ALTEK</u>	<u>334A</u>	<u>2667007</u>	<u>3/4/16</u>

TEST EQUIPMENT	AS FOUND	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 psig</u>	<u>4mA</u>	<u>4mA</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>385 psig</u>	<u>12mA</u>	<u>12mA</u>	<u>12mA</u>	<u> </u>
<u>N/A</u>	<u>770 psig</u>	<u>20mA</u>	<u>20mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

RANGE 0-770 psig

Stanley Vincent 11/02/16 NA
CALIBRATED BY DATE ACCEPTED BY DATE

[Signature] 11-11-16 NA
FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE

[Signature] 11-14-16 [Signature]
TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-13-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
System #: CSS 3.1 Work Package #: WP-INST-004
Location: Pipemack Area: OSE
Drawing #: 2014.07.1A, 08047A Specification: 94.03.14.102.00
Description (Type): Pressure W/O Transmitter

INSTRUMENT TAG # 03 PIT 034602C	P&ID PS-034	SERVICE GT COMB TRANK PIECE COOLING STM OUTL PRESSURE	INSTRUMENT DATA SHEET # N/A
MANUFACTURER Rosemount	MODEL NUMBER 3051T64A	INSTRUMENT SERIAL NUMBER 2792596	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # 03-10"-HR6405	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA
METHOD: Bench Hours: 475 used
N² Bottle w/Reg

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
Aitek	334A	2662001	3/4/16
Ametek	XP213K	461540	3/3/16

TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT			AS LEFT DEVIATION
		AS FOUND	AS LEFT	DESIRED	
N/A	0 psig	4mA	4mA	4mA	N/A
	385 psig	12mA	12mA	12mA	
N/A	770 psig	20mA	20mA	20mA	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-770 psig

CALIBRATED BY: Stanley Vincent DATE: 11/11/16 ACCEPTED BY: NA DATE: _____
 FOREMAN (SIGN): Kelmer Schmitt DATE: 11-13-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): Geo DATE: 11-14-16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): _____ DATE: 11/14/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-11-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CSS3.1 Work Package #: WP-INST-002

Location: HRSG-1 Area: 03A

Drawing #: 2014-071A-08042A Specification: 94.03, 14.100.00

Description (Type): Press. Ind TRANSMITTER

INSTRUMENT TAG # 03PIT035616	P&ID PS-035	SERVICE IP Cooling 80m SUPPLY PSI	INSTRUMENT DATA SHEET # N/A
MANUFACTURER ROSEMOUNT	MODEL NUMBER 3051T64A	INSTRUMENT SERIAL NUMBER 2792599	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # 03-8" HRH6517	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: BENCH
N = HART 475 used
Bottle w/ Reg

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
ALTEK	334A	2667001	3/4/16
AMETEK	XP2i3K	461540	3/3/16

TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	0 psig	4mA	4mA	4mA	N/A
	415 psig	12mA	12mA	12mA	
N/A	830 psig	20mA	20mA	20mA	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-830 psig

CALIBRATED BY: Stanley Vinit DATE: 11/10/16 ACCEPTED BY: NA DATE: _____
 FOREMAN (SIGN): Kebun Lockwood DATE: 11-11-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): JCC DATE: 11-14-16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 11/11/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-02-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: CND 3.1 Work Package #: WP-INST-002
 Location: HRSG7 Area: 03A-HRSG-1
 Drawing #: 2014.07.1A.08041 Specification: 94.03.14.100.00
 Description (Type): Pressure Indicating Transmitter

INSTRUMENT TAG # 03 PIT 062616	P&ID PS-062	SERVICE 76 PERFF HTR	INSTRUMENT DATA SHEET # N/A
MANUFACTURER ROSEMOUNT	MODEL NUMBER 305T64A	FW OUTL PSI	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # 03-BFW6217	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: BENCH HART 475 used
 N° 13716 w/ Reg used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
AMETEK	XP213K	2161540	3/3/16
ALTEK	334A	2667001	3/4/16

TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	0 psig	4mA	4mA	4mA	N/A
	1500 psig	12mA	12mA	12mA	}
N/A	3000 psig	20mA	20mA	20mA	

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-3000 PSIG

CALIBRATED BY: Stanley Vincent DATE: 11/01/16 ACCEPTED BY: NA DATE: _____
 FOREMAN (SIGN): Kelvin Jackson DATE: 11-02-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 11-14-16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 11/14/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 11-02-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: TCA 3.1 Work Package #: WP-INST-004
 Location: PIPE RACK Area: OSE-PIPE RACK
 Drawing #: 2014.071.1A.08042B Specification: 94.03.14.100.00
 Description (Type): Pressure Indicating Transmitter

INSTRUMENT TAG # 03 PIT 065606	P&ID PS-065	SERVICE CT COOL AIR CLR OUTC PSI	INSTRUMENT DATA SHEET # N/A
MANUFACTURER Rosemount	MODEL NUMBER 305TIG5A	INSTRUMENT SERIAL NUMBER 2793474	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # 03-6" BFW 6605	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: BENCH N^o 1 HART 475 used
 N^o 2 Bottle w/ Reg used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
AMETEK	XP213K	461540	3/3/16
AITEK	334A	2667001	3/4/16

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	0 psig	3.99mA	3.99mA	4mA	N/A
N/A	1825 psig	11.99mA	11.99mA	12mA	N/A
	2737.5 psig	15.99mA	15.99mA	16mA	
N/A	N/A			20mA	N/A

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-3650 PSIG: DIGITAL GAUGE ONLY 6000 TO 3000 PSIG. Checked 75%, not 100%

CALIBRATED BY: Stanley Vincent DATE: 11/01/16 ACCEPTED BY: NA DATE: _____
 FOREMAN (SIGN): Khmer. Sackon DATE: 11-02-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): JCO DATE: 11-14-16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): _____ DATE: 11/14/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HRG 3.1 Work Package #: INST-8120 INST-002
 Location: UNIT 03 HRSG Area: 03A-HRSG1
 Drawing #: 2014-071-7A-07044B Specification: 88.15.02.002D
 Description (Type): HP FW PRESS

INSTRUMENT TAG # <u>03-PIT-101616</u>	P&ID <u>100-PD-0002-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>30SIT64A</u>	INSTRUMENT SERIAL NUMBER <u>2758721</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench Hart 475 used
N² bottle w/reg used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL. DATE		
<u>Floke</u>	<u>724</u>	<u>3865061</u>	<u>7/20/2016</u>		
<u>Ametek</u>	<u>XP213K</u>	<u>461540</u>	<u>3/3/2016</u>		
TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 psi G</u>	<u>4.0ma</u>	<u>4.0ma</u>	<u>4mA</u>	<u>N/A</u>
<u>N/A</u>	<u>1697.5 psi G</u>	<u>12.02ma</u>	<u>12.02ma</u>	<u>12mA</u>	<u>N/A</u>
<u>N/A</u>	<u>3395 psi G</u>	<u>20.01ma</u>	<u>20.01ma</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS
Range: 0 - 3395 psi G

Stanley Vincent 9/20/16 NA
 CALIBRATED BY DATE ACCEPTED BY DATE
[Signature] 9-30-16 NA
 OPERATOR (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
[Signature] 10/31/16 NA
 TIE QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 10-11-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HR01 3.1 Work Package #: INST-8120-INST-002

Location: Area: 03A - HRSG 1

Drawing #: 100 PD-0003-001 Specification: 88.15.02.002D

Description (Type): HD DRM PRESS A. PRESSURE IND. TRANS. 2-WIRE.

INSTRUMENT TAG # 03 PIT 102670A	P&ID 100-PD-0003-001	SERVICE N/A	INSTRUMENT DATA SHEET # N/A
MANUFACTURER ROSEMOUNT	MODEL NUMBER 3051T64A	INSTRUMENT SERIAL NUMBER 2758724	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # N/A	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: BENCH HART 475 USED

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL. DATE
AMETEK D.W	T-150	95336	8/12/16

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
N/A	0 psig	4mA	4mA	4mA	N/A
}	1482.50 psig	12mA	12mA	12mA	}
	2965 psig	20mA	20mA	20mA	

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-2965 psig

CALIBRATED BY: Stanley Vincent DATE: 9/16/16

ACCEPTED BY: NA DATE: _____

FOREMAN (SIGN): [Signature] DATE: 10-11-16

OPERATIONS REPRESENTATIVE (SIGN): [Signature] DATE: _____

TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 9/29/16

CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 9/29/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 10-11-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRG 3.1 Work Package #: INST-8120-INST-002

Location: Area: 03A-HRSG1

Drawing #: 100-PD-0003-001 Specification: 88.15.02.02DD

Description (Type): HP DBM PRESS B. PRESSURE IND. TRANS. 2-WIRE

INSTRUMENT TAG # 03 P/T 102670B	P&ID 100-PD-0003-001	SERVICE N/A	INSTRUMENT DATA SHEET # N/A
MANUFACTURER Rosemount	MODEL NUMBER 3051TG4A	INSTRUMENT SERIAL NUMBER 2758723	TOLERANCE N/A
HOOK UP DRAWING NUMBER N/A	JUNCTION BOX N/A	LOOP DIAGRAM NUMBER N/A	
LINE / VESSEL # N/A	LINE SIZE / SCHEDULE # N/A		

CALIBRATION DATA

METHOD: Bench Hars 475 USED

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
AMETEK DW	T-150	95536	8/12/16

TEST EQUIPMENT	APPLIED Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
n/a	0 psig	4mA	4mA	4mA	n/a
}	1482.50 psig	12mA	12mA	12mA	}
	2965 psig	20mA	20mA	20mA	

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-2965 PSIG

CALIBRATED BY: Stanley Vincent DATE: 9/16/16 ACCEPTED BY: NA DATE: _____

FOREMAN (SIGN): [Signature] DATE: 10-11-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____

TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 9/29/16 OPERATIONS REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 9/29/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 12-20-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HR01 3.1 Work Package #: INST-8120-INST-002
 Location: HRSG Area: 03A-HRSG1
 Drawing #: 100-PD-0003-001 Specification: 88.15.02.002D
 Description (Type): HP DRM. PRESS C. PRESSURE IND. TRANS. 2-WIRE.

INSTRUMENT TAG # <u>03 PIT 102670C</u>	P&ID <u>100-PD-0003-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>ROSEMOUNT</u>	MODEL NUMBER <u>305IT64A</u>	INSTRUMENT SERIAL NUMBER <u>2758702</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH HYDRAULIC HAND PUMP US60
HART 475 US60

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>ALTER</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/16</u>		
<u>AMETEK</u>	<u>XP2.3K</u>	<u>461540</u>	<u>3/3/16</u>		
TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 PSIG</u>	<u>3.99mA</u>	<u>3.99mA</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>1482.5 PSIG</u>	<u>11.99mA</u>	<u>11.99mA</u>	<u>12mA</u>	<u> </u>
<u>N/A</u>	<u>2965 PSIG</u>	<u>19.99mA</u>	<u>19.99mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

RANGE 0-2965 PSIG

Stanley Vinit 9/14/16
 CALIBRATED BY DATE ACCEPTED BY DATE
Kelmer Jackson 12-20-16
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
Joe 2/18/17
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE
12/20/16



**TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION**

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRG 31 Work Package #: INST-8120-INST-002

Location: NA Area: 03A-HRSG1

Drawing #: 100-PD-0004-001 Specification: 88.15.02-002D

Description (Type): HP SH, STM OUTL PRESS

INSTRUMENT TAG # <u>03 PIT 104604</u>	P&ID <u>100-PD-0004-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>ROSEMOUNT</u>	MODEL NUMBER <u>3051TG4A</u>	INSTRUMENT SERIAL NUMBER <u>2758726</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH HART 475 USED
N² Bottle w/ Reg USED

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>AITEK</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/16</u>		
<u>AMETEK</u>	<u>XP213K</u>	<u>461540</u>	<u>3/3/16</u>		
TEST EQUIPMENT	APPLICABLE PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 psig</u>	<u>4mA</u>	<u>4mA</u>	<u>4mA</u>	<u>N/A</u>
	<u>857.50 psig</u>	<u>12mA</u>	<u>12mA</u>	<u>12mA</u>	
<u>N/A</u>	<u>1715 psig</u>	<u>20mA</u>	<u>20mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-1715 PSIG

CALIBRATED BY: Stanley Vincent DATE: 9/20/16 ACCEPTED BY: NA DATE: _____
 FOREMAN (SIGN): [Signature] DATE: 9-30-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 10/3/16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 10/3/16



**TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION**

DATE: 8/19/16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRGT 3.1 Work Package #: INST-8120-INST-002

Location: HRSG Area: 03A-HRSG 1

Drawing #: 2040111A-01044E Specification: 88.15.02.002D

Description (Type): PRESSURE IND. TRANS. 2-WIRE

INSTRUMENT TAG # <u>173 PIT 105670A</u>	P&ID <u>04.03.32.100-PD-0000-001</u>	SERVICE <u>1P DRM PRESS A.</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>KOCOMOUNT</u>	MODEL NUMBER <u>3051 T64</u>	INSTRUMENT SERIAL NUMBER <u>2758729</u>	TOLERANCE <u>N/A</u>
HOO UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench - Hart 475 used to interface XMF2
N2 w/ TIC w/ Reg

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>Altek</u>	<u>334A</u>	<u>266701</u>	<u>3/4/16</u>
<u>AMETEK</u>	<u>XP213K</u>	<u>461540</u>	<u>3/3/16</u>

TEST EQUIPMENT	APPLIED PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 PSIG</u>	<u>3.97mA</u>	<u>4mA</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>415 PSIG</u>	<u>11.97mA</u>	<u>12mA</u>	<u>12mA</u>	<u> </u>
<u>N/A</u>	<u>830 PSIG</u>	<u>19.99mA</u>	<u>20mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: Range 0-830 Zero Trim Performed

CALIBRATED BY: Stanley DATE: 8/19/16 ACCEPTED BY: _____ DATE: _____
 FOREMAN (SIGN): [Signature] DATE: 12-15-16 OPERATIONS REPRESENTATIVE (SIGN): _____ DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 12/14/16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): _____ DATE: 12/14/16



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 12/15/16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HRSG 3.1 Work Package #: INST-8120-INST-002
 Location: HRSG Area: 03A-HRSG 1
 Drawing #: 2014-0711A-07044E Specification: 88.15.02.002D
 Description (Type): PRESSURE IND. TRANS. 2-WIRE.

INSTRUMENT TAG # <u>03 PIT 105620R</u>	P&ID <u>9405.32.100 PD-0006-001</u>	SERVICE <u>1P DEM PRESS B</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051T64A</u>	INSTRUMENT SERIAL NUMBER <u>275 8728</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench - Hand 475 used to interface xmtk
N^o Bottle w/ Reg.

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>Aitek</u>	<u>334A</u>	<u>266 9001</u>	<u>3/4/16</u>		
<u>Ametek</u>	<u>XP213K</u>	<u>461540</u>	<u>3/3/16</u>		
TEST EQUIPMENT	APPLIED PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 psig</u>	<u>3.97mA</u>	<u>4 mA</u>	<u>4 mA</u>	<u>N/A</u>
<u> </u>	<u>415 psig</u>	<u>11.97mA</u>	<u>12 mA</u>	<u>12 mA</u>	<u> </u>
<u>N/A</u>	<u>830 psig</u>	<u>19.97mA</u>	<u>20 mA</u>	<u>20 mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range 0-830 PSIG Zero Trim Performed

Stanley Vincent 8/19/16 ACCEPTED BY _____ DATE _____
 CALIBRATED BY _____ DATE _____
Khmer Jackson 12-15-16 OPERATIONS REPRESENTATIVE (SIGN) _____ DATE _____
 FOREMAN (SIGN) _____ DATE _____
JCA 12/14/16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) _____ DATE _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) _____ DATE _____



TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION

DATE: 9-30-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRG 3.1 Work Package #: INST-8120-INST-002

Location: NA Area: 03A-HRSG1

Drawing #: 100-PD-0009-001 Specification: 88.15.02.002D

Description (Type): CONDENSATE INL PRESS PRESSURE IND. TRANS. 2-WIRE

INSTRUMENT TAG # <u>03 PIT 108609</u>	P&ID <u>100-PD-0009-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET #
MANUFACTURER <u>ROSEMOUNT</u>	MODEL NUMBER <u>3051TG3A</u>	INSTRUMENT SERIAL NUMBER <u>2958933</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER	<u>N/A</u>
LINE / VESSEL # <u>N/A</u>	LINK SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BEUCH HART 425 USED
N₂ BOTTLE W/REG USED

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	OUTPUT		CAL DATE
<u>ALTEK</u>	<u>334A</u>	<u>2667001</u>			<u>3/4/16</u>
<u>AMTEK</u>	<u>XP213K</u>	<u>471540</u>			<u>3/8/16</u>
TEST EQUIPMENT	APPLICABLE PRESSURE	AS FOUND	AS LEFT	DESIRED	AS LEFT DEVIATION
<u>N/A</u>	<u>0 PSIG</u>	<u>4mA</u>	<u>4mA</u>	<u>4mA</u>	<u>N/A</u>
<u>2</u>	<u>375 PSIG</u>	<u>12mA</u>	<u>12mA</u>	<u>12mA</u>	<u>2</u>
<u>N/A</u>	<u>750 PSIG</u>	<u>20mA</u>	<u>20mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE 0-750 PSIG

CALIBRATED BY: Stanley Vincent DATE: 9/20/16 ACCEPTED BY: NA DATE: _____
 FOREMAN (SIGN): [Signature] DATE: 9-30-16 OPERATIONS REPRESENTATIVE (SIGN): NA DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 10/31/16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): [Signature] DATE: 10/3/16



**TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION**

DATE: 12-15-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: HRG 3.1 Work Package #: INST-8120-INST-002

Location: HSG. Area: 03A-HRSG 1

Drawing #: 2014-011-1A-07044E Specification: 88.15.02.002D

Description (Type): PRESSURE IND. TRANS. 2-WIRE

INSTRUMENT TAG # <u>03 PIT 109670A</u>	P&ID <u>94.03.32.100-PD-0010-001</u>	SERVICE <u>LP DRM PRESS A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051 T63A</u>	INSTRUMENT SERIAL NUMBER <u>2760016</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench - Abut 475 used to interface XMTK
N² bottle w/Reg used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>Altek</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/16</u>		
<u>AMETEK</u>	<u>AP215K</u>	<u>161540</u>	<u>3/3/16</u>		
TEST EQUIPMENT	APPLIED Pressure	OUTPUT AS FOUND	OUTPUT AS LEFT	DESIRED	AS LEFT DEVIATION
<u>N/A</u>	<u>0 psig</u>	<u>4.01 mA</u>	<u>4.01 mA</u>	<u>4 mA</u>	<u>N/A</u>
<u> </u>	<u>82.50 psig</u>	<u>12.01 mA</u>	<u>12.01 mA</u>	<u>12 mA</u>	<u> </u>
<u>N/A</u>	<u>165 psig</u>	<u>20.01 mA</u>	<u>20.01 mA</u>	<u>20 mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range 0-165 psig

Stanley 8/19/16
CALIBRATED BY DATE

ACCEPTED BY DATE

Kelvin Jackson JR 12-15-16
FOREMAN (SIGN) DATE

OPERATIONS REPRESENTATIVE (SIGN) DATE

[Signature] 12/14/16
TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE

[Signature] 12/14/16
CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE



**TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION**

DATE: 12-15-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: HRG 3.1 Work Package #: INST-8120-INST-002
 Location: HRSG Area: 03A-HRSG 1
 Drawing #: 2014-011-1A-01044E Specification: 88.15.02.002D
 Description (Type): PRESSURE IND. TRANS. 2-WIRE

INSTRUMENT TAG # <u>03 PIT 109670B</u>	P&ID <u>94.03.32.100-PD-001W-001</u>	SERVICE <u>LP DRM PRESS B</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>ROSEMOUNT</u>	MODEL NUMBER <u>3051T63A</u>	INSTRUMENT SERIAL NUMBER <u>2758735</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench - Hunt 475 used to interface XMT2 N^o 13716 w/Reg

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>Altex</u>	<u>334A</u>	<u>2667001</u>	<u>3/4/16</u>
<u>AMETEK</u>	<u>XP213K</u>	<u>461540</u>	<u>3/3/16</u>


TEST EQUIPMENT	APPLIED PRESSURE	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0 psig</u>	<u>3.99mA</u>	<u>3.99mA</u>	<u>4mA</u>	<u>N/A</u>
<u> </u>	<u>82.50 psig</u>	<u>11.99mA</u>	<u>11.99mA</u>	<u>12mA</u>	<u> </u>
<u>NA</u>	<u>165 psig</u>	<u>19.99mA</u>	<u>19.99mA</u>	<u>20mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

Range 0-165

Stanley 8/19/16 DATE ACCEPTED BY DATE
Kenneth Jackson JR 12-15-16 DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
GCA 12/14/16 DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE

 Southham District	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>8/24/16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: FGIS 3.1 Work Package #: INST-8120-1WST-002
 Location: 03A-HRSG11 Area: 03A-HRSG
 Drawing #: PS-650 Specification: 88.15.02.0020
 Description (Type): FGIS FLT SEP OUTL PRESS.

INSTRUMENT TAG # <u>23 PIT-650617</u>	P&ID <u>PS-650</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>Rosemount</u>	MODEL NUMBER <u>3051TG4A</u>	INSTRUMENT SERIAL NUMBER <u>2793294</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: Bench - Hart 475 used to interface with N= Bottle w/ Reg used

ADDITIONAL INSTRUMENT INFORMATION

N/A

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE		
<u>Aitek</u>	<u>234A</u>	<u>2667001</u>	<u>3/4/16</u>		
<u>AMETER</u>	<u>XP213K</u>	<u>461540</u>	<u>3/3/16</u>		
TEST EQUIPMENT	APPLIED P. Pressure	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>0</u>	<u>3.97mA</u>	<u>4 mA</u>	<u>4 mA</u>	<u>N/A</u>
	<u>430</u>	<u>11.97 mA</u>	<u>12 mA</u>	<u>12 mA</u>	
<u>N/A</u>	<u>860</u>	<u>19.97 mA</u>	<u>20 mA</u>	<u>20 mA</u>	<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: Range 0-860 PSIG zero Trim Performed

CALIBRATED BY: [Signature] DATE: 8/24/16 ACCEPTED BY: _____ DATE: _____
 FOREMAN (SIGN): [Signature] DATE: 12-15-16 OPERATIONS REPRESENTATIVE (SIGN): _____ DATE: _____
 TIC QUALITY CONTROL (SIGN IF APPLICABLE): [Signature] DATE: 12/14/16 CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): _____ DATE: 12/14/16



**TRANSMITTER,
TRANSDUCER, INDICATOR,
RECORDER CALIBRATION**

DATE: 12-15-16

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CSS 31 Work Package #: INST-8120-INST-003

Location: STEAM TURBINE GENERATOR Area: 04A-STGT1

Drawing #: 2014-071-1A-08042A Specification: 88.15.02.002D

Description (Type): HRH STM TEMP.

INSTRUMENT TAG # <u>03-TE-035623</u>	P&ID <u>PS-B5</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>3EKBNM7</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

RTD

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>Fluke</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>

TEST EQUIPMENT	MODEL #	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>AMBIENT</u>		<u>70.1 °F</u>		<u>N/A</u>
<u>N/A</u>					<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

RANGE: -328-032 °F

Ambient + Function check only.

Stanley Vincent 8/12/16
CALIBRATED BY DATE

ACCEPTED BY DATE


Kumar Lakshon 12-15-16
FOREMAN (SIGN) DATE

OPERATIONS REPRESENTATIVE (SIGN) DATE

[Signature] 12/14/16
TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE

[Signature] 12/15/16
CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE

CDN 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>12-09-16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CDN 3.1 Work Package #: INST-8120-INST-003

Location: STEAM TURBINE GEN. Area: 04A-STG1

Drawing #: 2014-0711A-08051 Specification: 88.15.02.002D

Description (Type): COND HOTWELL TEMP.

INSTRUMENT TAG # <u>03-TE-050602</u>	P&ID <u>PS-050</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>1E4BKU9SH6PZZZMX1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E.

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>


TEST EQUIPMENT	MODEL #	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>Ambient.</u>		<u>67.8°F</u>		<u>N/A</u>
<u>N/A</u>					<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE: 0-1200°F Ambient + Function check only.

Stanley Vincent 8/11/16 NA DATE
 CALIBRATED BY DATE ACCEPTED BY DATE
[Signature] 12-09-16 NA DATE
 FOREMAN (SIGN) DATE OPERATIONS REPRESENTATIVE (SIGN) DATE
[Signature] 12/8/16 [Signature] 12/9/16
 TIC QUALITY CONTROL (SIGN IF APPLICABLE) DATE CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) DATE

BFW 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>12-02-16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: BFW 3.1 Work Package #: INST-8120-INST-004
 Location: BOILER FEED WATER Area: OSE-PIPERACK
 Drawing #: 204-071-1A-07042 Specification: 88.15.02.002D
 Description (Type): BFP OIA SUCT TEMP.

INSTRUMENT TAG # <u>03-TE-060605</u>	P&ID <u>P5060</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTH EAST</u>	MODEL NUMBER <u>1E4BKU7.5SHUPZZIMX1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>FLUKE</u>	<u>724</u>	<u>336 5061</u>	<u>7/20/16</u>

TEST EQUIPMENT	INPUT	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>AMBIENT</u>	<u>67.7 F</u>	<u>67.7 F</u>	<u>N/A</u>	<u>N/A</u>
<u>N/A</u>					<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE: 180°-420° F AMBIENT+ FUNCTION CHECK ONLY.

CALIBRATED BY: <u>Stanley V. Vint</u> FOREMAN (SIGN): <u>[Signature]</u> TIC QUALITY CONTROL (SIGN IF APPLICABLE): <u>[Signature]</u>	DATE: <u>8/9/16</u> DATE: <u>12-02-16</u> DATE: <u>12/17/16</u>	ACCEPTED BY: <u>NA</u> OPERATIONS REPRESENTATIVE (SIGN): <u>[Signature]</u> CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): <u>[Signature]</u>	DATE: _____ DATE: _____ DATE: <u>12/2/16</u>
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BFW 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION.	DATE: <u>12-02-16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: BFW 3.1 Work Package #: INST-8120-INST-004

Location: BOILER FEED WATER Area: OSE - PIPE RACK

Drawing #: 2014-071-1A-07042 Specification: 88.15.02.002D

Description (Type): BFP 01B SUCT TEMP

INSTRUMENT TAG # <u>03-TE-060615</u>	P&ID <u>PS-060</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>IF4BKU7.5SHG0ZZMK</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>NA</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH ~~N/A~~

ADDITIONAL INSTRUMENT INFORMATION

TIC TYPE E

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>


TEST EQUIPMENT	INPUT	OUTPUT		DESIRED	AS LET DEVIATION
		AS FOUND	AS LET		
<u>N/A</u>	<u>AMBIENT</u>		<u>71.9 F</u>		<u>N/A</u>
<u>N/A</u>					<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS: RANGE: 180 F - 420 F AMBIENT + FUNCTIONS CHECK ONLY

<u>Stanley Vincent</u> <small>CALIBRATED BY</small>	<u>8/8/16</u> <small>DATE</small>	<u>NA</u> <small>ACCEPTED BY</small>	 <small>DATE</small>
<u>Chris Lachar</u> <small>FOREMAN (SIGN)</small>	<u>12-02-16</u> <small>DATE</small>	<u>NA</u> <small>OPERATIONS REPRESENTATIVE (SIGN)</small>	 <small>DATE</small>
<u>JCA</u> <small>TIC QUALITY CONTROL (SIGN IF APPLICABLE)</small>	<u>12/7/14</u> <small>DATE</small>	<u>[Signature]</u> <small>CLIENT REPRESENTATIVE (SIGN IF APPLICABLE)</small>	<u>12/2/16</u> <small>DATE</small>

BFW 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION.	DATE: <u>12-02-16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: BFW 3.1 Work Package #: INST-8120-INST-004

Location: BOILER FEED WATER Area: OSE-PIPE RACK.

Drawing #: 204-011-1A-01044B Specification: 88.15.02.002D

Description (Type): BFW HP ECON INL TEMP.

INSTRUMENT TAG # <u>03-TE-061023</u>	P&ID <u>PS-061</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST.</u>	MODEL NUMBER <u>1E4BKUTSHGPZZMX1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE	
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/10</u>	
TEST EQUIPMENT	MODEL #	OUTPUT		AS LEFT DEVIATION
		AS FOUND	AS LEFT	
<u>N/A</u>	<u>AMBIENT</u>	<u>69.8 °F</u>	<u>N/A</u>	
<u>N/A</u>			<u>N/A</u>	

INSTRUMENT IS IN TOLERANCE: YES NO


COMMENTS

RANGE: 180 °F - 420 °F

AMBIENT + FUNCTION CHECK ONLY.

<u>Stanley Vincent</u>	DATE <u>8/9/16</u>	<u>NA</u>	DATE
<u>Kumar Lakshmi</u>	DATE <u>12-02-16</u>	<u>NA</u>	DATE
<u>JCO</u>	DATE <u>12/7/16</u>	<u>[Signature]</u>	DATE <u>12/2/16</u>

BFW 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>12-02-16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: BFW 3.1 Work Package #: INST-8120-INST-004

Location: BOILER FEED WATER Area: 05E-PIPE RACK

Drawing #: 2014-071-1A-07043 Specification: 88.15.02.002D

Description (Type): FGI PERF HTR FW INL TEMP.

INSTRUMENT TAG # <u>03-TE-0022607</u>	P&ID <u>PS-062</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>ZE4BKU6HUPZZI</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>

TEST EQUIPMENT	INPUT	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>AMBIENT</u>	<u>69.7</u>	<u>°F</u>	<u>N/A</u>	<u>N/A</u>
<u>N/A</u>					<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS
RANGE: 180°F - 610°F AMBIENT + FUNCTION CHECK ONLY.

CALIBRATED BY <u>Stanley Vincent</u>	DATE <u>8/8/16</u>	ACCEPTED BY <u>NA</u>	DATE
FOREMAN (SIGN) <u>[Signature]</u>	DATE <u>12-02-16</u>	OPERATIONS REPRESENTATIVE (SIGN) <u>NA</u>	DATE
TIC QUALITY CONTROL (SIGN IF APPLICABLE) <u>[Signature]</u>	DATE <u>12/7/16</u>	CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) <u>[Signature]</u>	DATE <u>12/2/16</u>

CND 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION.	DATE: <u>12-09-16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: CND 3.1 Work Package #: INST-8120-INST-003

Location: STEAM TURBINE Area: 04A-STG1

Drawing #: 2014-071-1A-08041 Specification: 88.15.02.002D

Description (Type): FG1 PERF HTR FW CMTL TEMP.

INSTRUMENT TAG # <u>03-TE-062615</u>	P&ID <u>PS-062</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>IE4BKUL6SH6PZZ11</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E.

TEST EQUIPMENT	MODEL #	SERIAL #	CAL. DATE
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/10</u>
TEST EQUIPMENT	MODEL #	OUTPUT	AS LEFT DEVIATION
		AS FOUND	AS LEFT
<u>N/A</u>	<u>AMBIENT</u>	<u>69.8 °F</u>	<u>N/A</u>
<u>N/A</u>			<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO


COMMENTS

RANGE: 180°F - 610°F

Ambient + Function check only

<u>Stanley Vincent</u>	<u>9/11/16</u>	<u>NA</u>	
<small>CALIBRATED BY</small>	<small>DATE</small>	<small>ACCEPTED BY</small>	<small>DATE</small>
<u>Shawn Jackson JR</u>	<u>12-09-16</u>	<u>NA</u>	
<small>FOREMAN (SIGN)</small>	<small>DATE</small>	<small>OPERATIONS REPRESENTATIVE (SIGN)</small>	<small>DATE</small>
<u>JC@</u>	<u>12/8/16</u>	<u>[Signature]</u>	<u>12/7/16</u>
<small>TIC QUALITY CONTROL (SIGN IF APPLICABLE)</small>	<small>DATE</small>	<small>CLIENT REPRESENTATIVE (SIGN IF APPLICABLE)</small>	<small>DATE</small>

TCA 3.1

 Transmitter, Indicator, Recorder Calibration	TRANSMITTER, TRANSUDCER, INDICATOR, RECORDER CALIBRATION.	DATE: <u>AUG 8, 2016</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: TCA 3.1 Work Package #: INST-8120-INST-006

Location: TCA/ROTOR AIR COOLER. Area: 08A - BOP

Drawing #: 2014-071-1A-07044B Specification: 88.15.02.002D

Description (Type): BFW TCA PMP 03A SUCT TEMP.

INSTRUMENT TAG # <u>03-TE-063609</u>	P&ID <u>PS-064</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER	MODEL NUMBER <u>1E4BKU45H6.5PZZ2MX1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE	
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>	
TEST EQUIPMENT	INPUT	OUTPUT		AS LEFT DEVIATION
		AS FOUND	AS LEFT	
<u>N/A</u>	<u>AMBIENT</u>	<u>67.9 °F</u>	<u>N/A</u>	
<u>N/A</u>			<u>N/A</u>	

INSTRUMENT IS IN TOLERANCE: YES NO


COMMENTS

RANGE: 180°F - 420°F

AMBIENT + FUNCTION CHECK ONLY.

<u>Stanley Vincent</u>	<u>8/8/16</u>	<u>NA</u>	
<small>CALIBRATED BY</small>	<small>DATE</small>	<small>ACCEPTED BY</small>	<small>DATE</small>
<u>[Signature]</u>	<u>12-07-16</u>	<u>NA</u>	
<small>FOREMAN (SIGN)</small>	<small>DATE</small>	<small>OPERATIONS REPRESENTATIVE (SIGN)</small>	<small>DATE</small>
<u>[Signature]</u>	<u>12/7/16</u>	<u>[Signature]</u>	<u>12/7/16</u>
<small>TIC QUALITY CONTROL (SIGN IF APPLICABLE)</small>	<small>DATE</small>	<small>CLIENT REPRESENTATIVE (SIGN IF APPLICABLE)</small>	<small>DATE</small>

TCA 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION.	DATE: <u>Aug 8, 2016</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: TCA 31 Work Package #: INST-8120-INST-006

Location: TCA/ROTOR AIR COOLE Area: 08A-BOP

Drawing #: 2014-011-1A-07044B Specification: 88.15.02.002D

Description (Type): BFW TCA PMP 03B SUCT TEMP.

INSTRUMENT TAG # <u>03-TE-063619</u>	P&ID <u>PS-063</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTH EAST</u>	MODEL NUMBER <u>1E4BKU4SH6.SPZZAW</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E.

TEST EQUIPMENT	MODEL #	SERIAL #	CAL. DATE		
<u>FLUKE</u>	<u>724</u>	<u>3305061</u>	<u>7/20/16</u>		
TEST EQUIPMENT	INPUT	AS FOUND	AS LEFT	DESIRED	AS LEFT DEVIATION
<u>N/A</u>	<u>AMBIENT</u>			<u>60.8 °F</u>	<u>N/A</u>
<u>N/A</u>					<u>N/A</u>


INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

RANGE: 180°F - 420°F AMBIENT + FUNCTION CHECK ONLY

<u>Stanley Vincent</u> <small>CALIBRATED BY</small>	<u>8/8/16</u> <small>DATE</small>	<u>NA</u> <small>ACCEPTED BY</small>	 <small>DATE</small>
<u>[Signature]</u> <small>FOREMAN (SIGN)</small>	<u>12/07/16</u> <small>DATE</small>	<u>NA</u> <small>OPERATIONS REPRESENTATIVE (SIGN)</small>	 <small>DATE</small>
<u>[Signature]</u> <small>TIC QUALITY CONTROL (SIGN IF APPLICABLE)</small>	<u>12/7/14</u> <small>DATE</small>	<u>[Signature]</u> <small>CLIENT REPRESENTATIVE (SIGN IF APPLICABLE)</small>	<u>12/7/16</u> <small>DATE</small>

TCA 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>Aug 8, 2016</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: TCA 3.1 Work Package #: INST-8120-INST-006
 Location: TCA/ROTOR AIR COOLER Area: OBA-BOP
 Drawing #: 2014-011-1A-08042B Specification: 88.15.02.002D
 Description (Type): GIT COOLING AIR COOLER INLET FEED WATER.

INSTRUMENT TAG # <u>03-TE-045601</u>	P&ID <u>PS-065</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>1E4BKWT.56HDPZZMX1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E. N/A


TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE	
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>	
TEST EQUIPMENT	MODUL INPUT	OUTPUT		AS LEFT DEVIATION
		AS FOUND	AS LEFT	
<u>N/A</u>	<u>AMBIENT</u>	<u>67.2°F</u>	<u>N/A</u>	
<u>N/A</u>			<u>N/A</u>	

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS
RANGE: 32°F - 1652°F AMBIENT + FUNCTION CHECK ONLY.

<u>Stanley Vincent</u> CALIBRATED BY	<u>8/8/16</u> DATE	<u>N/A</u> ACCEPTED BY	DATE
<u>Kimberly Jackson</u> FOREMAN (SIGN)	<u>12-07-16</u> DATE	<u>N/A</u> OPERATIONS REPRESENTATIVE (SIGN)	DATE
<u>[Signature]</u> TIC QUALITY CONTROL (SIGN IF APPLICABLE)	<u>12/7/16</u> DATE	<u>[Signature]</u> CLIENT REPRESENTATIVE (SIGN IF APPLICABLE)	<u>12/7/16</u> DATE

TCA 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>AUG 8, 2016</u>
---	---	--------------------------

Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: TCA 3.1 Work Package #: INST-8120-INST-006

Location: TCA/ROTOR AIR FEED WATER Area: 08A-BOP

Drawing #: 20K-071-1A-08042B Specification: 88.15.02.002D

Description (Type): GT COOLING AIR COOLER OUTLET FEED WATER

INSTRUMENT TAG # <u>03-TE-065607</u>	P&ID <u>PS-065</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>1E4BK19.5SHUPZZNX1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

TC TYPE E NA

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>


TEST EQUIPMENT	OUTPUT <u>INPUT</u>	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>AMBIENT</u>		<u>77.9°F</u>		<u>N/A</u>
<u>N/A</u>					<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS
RANGE: 32°F - 1652°F AMBIENT + FUNCTION CHECK ONLY.

<u>Stanley Vincent</u>	<u>8/8/16</u>	<u>NA</u>	
CALIBRATED BY	DATE	ACCEPTED BY	DATE
<u>[Signature]</u>	<u>12-07-16</u>	<u>NA</u>	
FOREMAN (SIGN)	DATE	OPERATIONS REPRESENTATIVE (SIGN)	DATE
<u>[Signature]</u>	<u>12/7/16</u>	<u>[Signature]</u>	<u>12/7/16</u>
TIC QUALITY CONTROL (SIGN IF APPLICABLE)	DATE	CLIENT REPRESENTATIVE (SIGN IF APPLICABLE)	DATE

TCA 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>Aug 8, 2016</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739

System #: TCA 3.1 Work Package #: INST-8120-INST-006

Location: TCA/ROTOR AIR FEED WATER Area: 08A-BOP

Drawing #: 2014-0711-1A-08042B Specification: 88.15.02.002D

Description (Type): GT COOLING AIR COOLER OUTLET FEED WATER

INSTRUMENT TAG # <u>03-TE-065607</u>	P&ID <u>PS-065</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>JMS SOUTHEAST</u>	MODEL NUMBER <u>1E4BK19.5SH6PZZNX1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH.

ADDITIONAL INSTRUMENT INFORMATION

TIC TYPE E ~~N/A~~

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE
<u>FLUKE</u>	<u>724</u>	<u>3365061</u>	<u>7/20/16</u>


TEST EQUIPMENT	DESIRED # INPUT	OUTPUT		DESIRED	AS LEFT DEVIATION
		AS FOUND	AS LEFT		
<u>N/A</u>	<u>AMBIENT</u>		<u>77.9°F</u>		<u>N/A</u>
<u>N/A</u>					<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS
RANGE: 32°F - 1652°F AMBIENT + FUNCTION CHECK ONLY.

CALIBRATED BY <u>Stanley Vincent</u>	DATE <u>8/8/16</u>	ACCEPTED BY <u>NA</u>	DATE
FOREMAN (SIGN) <u>[Signature]</u>	DATE <u>12-07-16</u>	OPERATIONS REPRESENTATIVE (SIGN) <u>NA</u>	DATE
TIC QUALITY CONTROL (SIGN IF APPLICABLE) <u>[Signature]</u>	DATE <u>12/7/16</u>	CLIENT REPRESENTATIVE (SIGN IF APPLICABLE) <u>[Signature]</u>	DATE <u>12/7/16</u>

BFW 3.1

	TRANSMITTER, TRANSDUCER, INDICATOR, RECORDER CALIBRATION	DATE: <u>12-02-16</u>
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Project Name: Grand River Energy Center Unit 3 Project #: 102739
 System #: BFW 3.1 Work Package #: INST-8120-INST-003
 Location: HRS01 Area: 03A-HRS01 1
 Drawing #: 2014-071-1A-08042C Specification: 88.15.02.002D
 Description (Type): HP DSH SPRAY WTR TEMP.

INSTRUMENT TAG # <u>03-TE-103608</u>	P&ID <u>94.03.32.100-PD-0004-001</u>	SERVICE <u>N/A</u>	INSTRUMENT DATA SHEET # <u>N/A</u>
MANUFACTURER <u>PYROMATION</u>	MODEL NUMBER <u>EB42U-H410070135-SL-6P031AS,1</u>	INSTRUMENT SERIAL NUMBER <u>N/A</u>	TOLERANCE <u>N/A</u>
HOOK UP DRAWING NUMBER <u>N/A</u>	JUNCTION BOX <u>N/A</u>	LOOP DIAGRAM NUMBER <u>N/A</u>	
LINE / VESSEL # <u>N/A</u>	LINE SIZE / SCHEDULE # <u>N/A</u>		

CALIBRATION DATA

METHOD: BENCH

ADDITIONAL INSTRUMENT INFORMATION

T/C TYPE E

TEST EQUIPMENT	MODEL #	SERIAL #	CAL DATE	
<u>FLUKE</u>	<u>724</u>	<u>336 5061</u>	<u>7/20/16</u>	
TEST EQUIPMENT	MORSE INPUT	OUTPUT		AS LEFT DEVIATION
		AS FOUND	AS LEFT	
<u>N/A</u>	<u>AMBIENT</u>		<u>77.9 F</u>	<u>N/A</u>
<u>N/A</u>	<u>N/A</u>	<u>N/A</u>		<u>N/A</u>

INSTRUMENT IS IN TOLERANCE: YES NO

COMMENTS

RANGE: 0-380 F AMBIENT + FUNCTION CHECK ONLY

CALIBRATED BY: <u>Stanley Vincent</u> FOREMAN (SIGN): <u>[Signature]</u> TIC QUALITY CONTROL (SIGN IF APPLICABLE): <u>[Signature]</u>	DATE: <u>8/9/16</u> DATE: <u>12-02-16</u> DATE: <u>12/7/16</u>	ACCEPTED BY: <u>NA</u> OPERATIONS REPRESENTATIVE (SIGN): <u>[Signature]</u> CLIENT REPRESENTATIVE (SIGN IF APPLICABLE): <u>[Signature]</u>	DATE: _____ DATE: _____ DATE: <u>12/2/16</u>
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OEM Inc.
 835 Heron Drive
 Bridgeport
 NJ 08014
 USA
 t. (856) 487-4200
 f. (856) 467-1212
 e. info@oem1.com



M.I. THERMOCOUPLE CABLE CALIBRATION CERTIFICATION REPORT

Cable Type: 304-K-.125 **Nom. O/D:** .125
Customer Name: MCHALE & ASSOCIATES
Customer PO Number: DR033012 **Our Order Number:** 203928841

The following coils of **Omega Thermocouple Cable** have been calibrated at the temperatures shown and conforms to ASTM E230-03, ANSI MC96.1 or IEC 584, with limits of error as indicated.

EMF Characteristics **NIST Test Standard No.:** 280791
Coil I.D. #: VK120116-05 **Tolerance Results:** SLE (Class 1)

Deviation at	Deviation at	Deviation at	Deviation at	Deviation at	Deviation at
212.00 °F (100.00 °C)	392.00 °F (200.00 °C)	572.00 °F (300.00 °C)	752.00 °F (400.00 °C)	1500.00 °F (815.56 °C)	-
-0.80 °F (-0.4 °C)	-0.10 °F (-0.0 °C)	-1.50 °F (-0.8 °C)	-2.30 °F (-1.2 °C)	3.30 °F (1.8 °C)	-

Nominal Sheath Typical Analysis		Nominal Conductor Typical Analysis		Insulation Typical Analysis	
Batch No. 948112		Coil No. RCH15021P		Coil No. RAL15022P	
C:	0.023	Alloy:	CHROMEGA	Alloy:	ALOMEGA
Mn:	1.70				MgO:
S:	0.016	Ni:	90.0	Ni:	94.0
Si:	0.46	Cr:	9.57	Cr:	-
Cr:	18.18	Mn:	-	Mn:	2.0
Ni:	8.5	Si:	0.46	Si:	1.0
N:	-	Al:	-	Al:	2.0
P:	-	Fe:	-	Fe:	-
Mo:	-	Co:	-	Co:	-
Al:	-	Cu:	-	Cu:	-
Fe:	BAL.	C:	-	C:	-
Cu:	-				
Titanium:	-				
Co:	-				
Columbium:	-				
Tantalum:	-				

Dan Harrity

Quality Assurance Supervisor

Date 13 April 2012

UNIT UNDER TEST: DMM	TEST RESULT: PASS
SERIAL NUMBER: 80550063	CAL DATE: 24 March 2017
ASSET NUMBER: 7146	CAL DUE: 24 March 2018
PROCEDURE NAME: Fluke 112 : (1 year) CAL VER /5520	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 11/31/2005	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

This report may not be reproduced, except in full, unless permission for the publication of an approved abstract is obtained in writing from McHale Performance.

REMARKS: Unit is operating within tolerance as found and as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	3/14/2017	3/14/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AMPS FUSE TEST						
FUSE TEST				Pass		
BACKLIGHT TEST						
BACKLIGHT TEST				Pass		
DISPLAY TEST						
DISPLAY TEST				Pass		
PUSHBUTTON SWITCH TEST						
PUSHBUTTON SWITCH TEST				Pass		
AC VOLTAGE TEST						
0.300 V @ 50 Hz	0.300V	6.0000V	0	Pass	5.8e-004V	
0.300 V @ 500 Hz	0.300V	6.0000V	0	Pass	5.8e-004V	
5.000 V @ 50 Hz	5.003V	0.0530V	5.66	Pass	1.2e-003V	
5.000 V @ 500 Hz	4.990V	0.0530V	18.9	Pass	1.2e-003V	
50.00 V @ 500 Hz	50.10V	0.530V	18.9	Pass	1.1e-002V	
600.0 V @ 500 Hz	601.0V	6.30V	15.9	Pass	1.6e-001V	
FREQUENCY TEST						
50.00 kHz @ 5 V	49.95kHz	70Hz	71.4	Pass	5.8e+000Hz	
DC VOLTAGE TEST						
0.000 V	0.000V	0.0020V	0	Pass	5.8e-004V	
5.000 V	5.005V	0.0370V	13.5	Pass	5.8e-004V	
-50.00 V	-50.09V	0.370V	24.3	Pass	5.8e-003V	
600.0 V	601.4V	4.40V	31.8	Pass	5.9e-002V	
CONTINUITY						
beeper on						
Result of Operator Evaluation				Pass		
beeper off						
Result of Operator Evaluation				Pass		
RESISTANCE TEST						
0.0 Ohm	0.1Ohm	0.20Ohm	50	Pass	5.8e-002Ohm	
500.0 Ohm	500.2Ohm	4.70Ohm	4.26	Pass	5.9e-002Ohm	
5.000 kOhm	4.999kOhm	46.0Ohm	2.17	Pass	5.9e-001Ohm	
50.00 kOhm	50.01kOhm	460Ohm	2.17	Pass	5.9e+000Ohm	
500.0 kOhm	500.6kOhm	4600Ohm	13	Pass	5.9e+001Ohm	
5.000 MOhm	5.000MOhm	46000Ohm	0	Pass	7.9e+002Ohm	
30.00 MOhm	30.01MOhm	480000Ohm	2.08	Pass	9.7e+003Ohm	
DIODE TEST						
2.000 V	2.003V	0.0200V	15	Pass	5.8e-004V	
CAPACITANCE TEST						
800 nF	799nF	0.0000000170F	5.88	Pass	2.4e-009F	
AC AMPS TEST						
9.00 A @ 500 Hz	9.03A	0.170A	17.6	Pass	1.0e-002A	

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DC AMPS TEST						
5.000 A	5.005A	0.0530A	9.43	Pass	2.4e-003A	
-5.000 A	-5.007A	0.0530A	13.2	Pass	2.4e-003A	
9.00 A	9.04A	0.120A	33.3	Pass	7.0e-003A	

***** End of Report *****

UNIT UNDER TEST: Data Logger	TEST RESULT: PASS
SERIAL NUMBER: 950849	CAL DATE: 30 May 2017
ASSET NUMBER: 10158	CAL DUE: 30 May 2018
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."


Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	0.0003mV		6.53	Pass		
1 VDC Range						
0.000000 V	0.000000V		1.86	Pass		
10 VDC Range						
0.00000 V	0.00000V		0	Pass		
100 VDC Range						
0.0000 V	0.0000V		2.17	Pass		
300 VDC Range						
0.000 V	0.000V		0.778	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	-0.0000Ohm		0.00388	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	0.0006Ohm		15.2	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	-0.000242kOhm		24	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	0.000001kOhm		12.9	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	-0.00024kOhm		21.9	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	0.00001kOhm		7.8	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0002kOhm		9	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	0.0001kOhm		7.7	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	0.000000MOhm		2.36	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	0.000001MOhm		5.2	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	0.00000MOhm		2.57	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00001MOhm		5.2	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mADC Range						
0.00000 mA	0.00003mA		1.73	Pass		
100 mADC Range						
0.00000 mA	0.00003mA		0.52	Pass		
1 ADC Range						
0.000000 A	0.000001A		1.44	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	50.0008mV	0.00000650V	12.2	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	100.0004mV	0.00000900V	4.11	Pass	2.3e-006V	3.00
1V Range						
0.5000000 V	0.5000005V	0.00002700V	1.74	Pass	5.8e-006V	3.60
1.000000 V	1.000000V	0.0000470V	0.851	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00002V	0.000225V	10.5	Pass	6.2e-005V	2.81
10.00000 V	10.00005V	0.000400000000001V	13.2	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0000V	0.00285V	0.456	Pass	8.2e-004V	2.71
100.0000 V	99.9998V	0.00510V	3.86	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	149.9983V	0.01575V	11.1	Pass	2.2e-003V	
300.0000 V	299.9960V	0.02250V	17.6	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	99.9691mV	0.00010000V	30.9	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	99.9471mV	0.00017000V	31.1	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	0.999689V	0.0010000V	31.1	Pass	1.6e-004V	
1.000000 V @ 50 kHz	0.999300V	0.0017000V	41.2	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	9.99696V	0.010000V	30.4	Pass	1.6e-003V	
10.00000 V @ 50 kHz	9.99315V	0.017000V	40.3	Pass	3.2e-003V	
10.00000 V @ 10 Hz	9.99606V	0.010000V	39.4	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	99.9696V	0.10000V	30.4	Pass	1.6e-002V	
100.0000 V @ 50 kHz	99.9787V	0.17000V	12.5	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	299.929V	0.4200V	17	Pass	4.6e-002V	
300.000 V @ 50 kHz	299.959V	0.7200V	5.71	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	99.8665Ohm	1.01400Ohm	13.2	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	0.999900kOhm	1.1100Ohm	9	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00020kOhm	2.100Ohm	9.71	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	100.0032kOhm	12.00Ohm	26.7	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000054MOhm	111.0Ohm	48.4	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	10.00000MOhm	4100Ohm	0.0488	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	99.8692MOhm	810000Ohm	16.2	Pass	4.1e+004Ohm	
4-WIRE OHMS: 100 Ohm Range 100.0000 Ohm	100.0020Ohm	0.01400Ohm	14.4	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	1.000035kOhm	0.1100Ohm	31.7	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	10.00035kOhm	1.100Ohm	32.2	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	100.0034kOhm	11.00Ohm	30.5	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	99.9696Hz	0.10000Hz	30.4	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0001kHz	10.00Hz	1.4	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	9.99996mA	0.000007000A	0.553	Pass	9.7e-007A	
100mA Range 100.0000 mA	99.9985mA	0.00005500A	2.66	Pass	9.7e-006A	
1A Range 1.000000 A	0.999764A	0.0011000A	21.4	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99433mA	0.000014000A	40.5	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	99.8840mA	0.00060000A	19.3	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	0.999660A	0.0014000A	24.3	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: Pitot Tube, Stinger	TEST RESULT: PASS
SERIAL NUMBER: WF-26	CAL DATE: 13 September 2016
ASSET NUMBER: 10289	CAL DUE: 13 September 2019
PROCEDURE NAME: Pitot Tube: CAL VER 3 Pt	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 4/23/09	TEMPERATURE: 23.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as left with new coefficients

 <hr style="width: 100%;"/> <p>Calibrated By:</p>	 <hr style="width: 100%;"/> <p>Approved By:</p>
---	---

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Average Area of Test Pipe = 1.985ft²
Calculated Blockage of Test Instrument= 0.061ft²
Corrected Average Area of Test Pipe = 1.924ft²

Average Square Root Deflection of Test Instrument
at Low Flow Test Point= 2.154InH₂O

Average Square Root Deflection of Test Instrument
at Mid Flow Test Point= 4.149InH₂O

Average Square Root Deflection of Test Instrument
at High Flow Test Point= 6.217InH₂O

--- Flow Calibration Results---

Low Flow Coefficient: 0.817						
3516.8600 -gpm	3519.130-gpm	35.1686-gpm	6.45	Pass	2.6e+001-gpm	1.35
Mid Flow Coefficient: 0.816						
6772.7800 -gpm	6770.200-gpm	67.7278-gpm	3.81	Pass	5.0e+001-gpm	1.35
High Flow Coefficient: 0.817						
10152.0300 -gpm	10157.120-gpm	101.5203-gpm	5.01	Pass	7.5e+001-gpm	1.35

Averaged Flow Coefficient: 0.8167

Equation Used to Calculate Flow from Deflection:

Water Flow in gpm= 1039.352*c*A*d^{0.5}
where:
c= Average Coefficient
A= Average Corrected Area
d= Deflection of Instrument at Flow rate
1039.352= Combined conversion factors of sec-min,
ft³-gal, ft-in, and acceleration of gravity.

***** End of Report *****

UNIT UNDER TEST: Data Logger	TEST RESULT: PASS
SERIAL NUMBER: US37025906	CAL DATE: 26 May 2017
ASSET NUMBER: 21136	CAL DUE: 26 May 2018
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

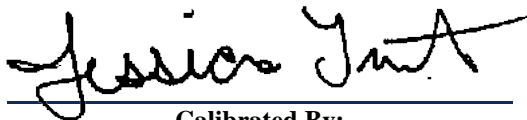
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	-0.0032mV		80.6	Pass		
1 VDC Range						
0.000000 V	-0.000003V		45.4	Pass		
10 VDC Range						
0.00000 V	-0.00000V		5.4	Pass		
100 VDC Range						
0.0000 V	-0.0000V		6.67	Pass		
300 VDC Range						
0.000 V	-0.000V		0.333	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	0.0002Ohm		0.0173	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	0.0009Ohm		23.5	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	-0.000010kOhm		1.02	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	0.000001kOhm		12.1	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	-0.00004kOhm		3.43	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	0.00000kOhm		4	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0003kOhm		13.5	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	0.0001kOhm		6.7	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	-0.000001MOhm		12.2	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	0.000001MOhm		5.4	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	0.00000MOhm		2.67	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00000MOhm		0	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mADC Range						
0.00000 mA	-0.00006mA		3.23	Pass		
100 mADC Range						
0.00000 mA	-0.00016mA		3.12	Pass		
1 ADC Range						
0.000000 A	-0.000007A		7.3	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	49.9986mV	0.00000650V	21.9	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	99.9996mV	9.00000000001e-006	4.57	Pass	2.3e-006V	3.00
1V Range						
0.5000000 V	0.5000031V	0.00002700V	11.4	Pass	5.8e-006V	3.60
1.000000 V	1.000010V	0.0000470V	22.3	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00006V	0.000225V	28.7	Pass	6.2e-005V	2.81
10.00000 V	10.00013V	0.000400000000001V	33.5	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0003V	0.00285V	12.1	Pass	8.2e-004V	2.71
100.0000 V	100.0003V	0.00510V	5.1	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	149.9995V	0.01575V	3.11	Pass	2.2e-003V	
300.0000 V	299.9985V	0.02250V	6.58	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	99.9637mV	0.00010000V	36.3	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	99.9826mV	0.00017000V	10.2	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	0.999610V	0.0010000V	39	Pass	1.6e-004V	
1.000000 V @ 50 kHz	0.999786V	0.0017000V	12.6	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	9.99613V	0.010000V	38.7	Pass	1.6e-003V	
10.00000 V @ 50 kHz	9.99696V	0.017000V	17.9	Pass	3.2e-003V	
10.00000 V @ 10 Hz	9.99564V	0.010000V	43.6	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	99.9587V	0.10000V	41.3	Pass	1.6e-002V	
100.0000 V @ 50 kHz	99.9629V	0.17000V	21.8	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	299.883V	0.4200V	27.8	Pass	4.6e-002V	
300.000 V @ 50 kHz	299.869V	0.7200V	18.3	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	100.1204Ohm	1.01400Ohm	11.9	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	1.000135kOhm	1.1100Ohm	12.2	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00018kOhm	2.100Ohm	8.48	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	100.0009kOhm	12.00Ohm	7.83	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000020MOhm	111.0Ohm	17.7	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	9.99903MOhm	4100Ohm	23.8	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	99.8739MOhm	810000Ohm	15.6	Pass	4.1e+004Ohm	
4-WIRE OHMS:						
100 Ohm Range 100.0000 Ohm	99.9991Ohm	0.01400Ohm	6.3	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	1.000016kOhm	0.1100Ohm	14.9	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	10.00009kOhm	1.100Ohm	7.91	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	100.0014kOhm	11.00Ohm	13	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	100.0275Hz	0.10000Hz	27.5	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0000kHz	10.00Hz	0.4	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	10.00003mA	0.000007000A	0.5	Pass	9.7e-007A	
100mA Range 100.0000 mA	100.0003mA	0.00005500A	0.473	Pass	9.7e-006A	
1A Range 1.000000 A	0.999791A	0.0011000A	19	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99252mA	0.000014000A	53.4	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	99.9998mA	0.00060000A	0.0348	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	0.999513A	0.0014000A	34.8	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: Handheld Barometer	TEST RESULT: PASS
SERIAL NUMBER: 74001081	CAL DATE: 17 April 2017
ASSET NUMBER: 21352	CAL DUE: 17 April 2018
PROCEDURE NAME: Druck DPI 740: Cal Ver DHI RPM4	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 07/18/2008	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 10~15
	CAL UNITS: psia

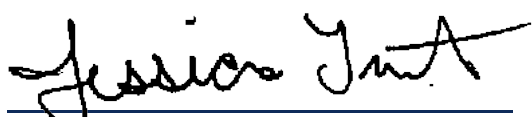
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
PRESSURE VERIFICATION						
10.00000 -PSIA	9.9992-PSIA	0.00330-PSIA	24.2	Pass	8.0e-004-PSIA	
11.00000 -PSIA	10.9992-PSIA	0.00330-PSIA	24.2	Pass	8.8e-004-PSIA	3.75
12.00000 -PSIA	11.9992-PSIA	0.00330-PSIA	24.2	Pass	9.7e-004-PSIA	3.42
13.00000 -PSIA	12.9992-PSIA	0.00330-PSIA	24.2	Pass	1.0e-003-PSIA	3.17
14.00000 -PSIA	13.9992-PSIA	0.00330-PSIA	24.2	Pass	1.1e-003-PSIA	2.95
15.00000 -PSIA	14.9992-PSIA	0.00330-PSIA	24.2	Pass	1.2e-003-PSIA	2.75
14.00000 -PSIA	13.9993-PSIA	0.00330-PSIA	21.2	Pass	1.3e-003-PSIA	2.58
13.00000 -PSIA	12.9992-PSIA	0.00330-PSIA	24.2	Pass	1.3e-003-PSIA	2.58
12.00000 -PSIA	11.9993-PSIA	0.00330-PSIA	21.2	Pass	1.3e-003-PSIA	2.58
11.00000 -PSIA	10.9992-PSIA	0.00330-PSIA	24.2	Pass	1.3e-003-PSIA	2.58
10.00000 -PSIA	9.9993-PSIA	0.00330-PSIA	21.2	Pass	1.3e-003-PSIA	2.58

***** End of Report *****

UNIT UNDER TEST: Current Clamp, Flexible	TEST RESULT: PASS
SERIAL NUMBER: 31680065	CAL DATE: 14 February 2017
ASSET NUMBER: 21930	CAL DUE: 14 February 2018
PROCEDURE NAME: Fluke i2000FLEX: CAL VER 3458	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 09/08/05	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 31 %
	CAL RANGE: N/A
	CAL UNITS: N/A

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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as found and as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017
14024	Hewlett Packard 3458A DMM	2823A14550	10/21/2016	10/21/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AC CURRENT ACCURACY						
200A RANGE						
50.0 AAC @ 60 Hz	50.07AAC	2.000AAC	3.5	Pass	1.8e-001AAC	
100.0 AAC @ 60 Hz	100.15AAC	2.000AAC	7.5	Pass	1.6e-001AAC	
200.0 AAC @ 60 Hz	200.31AAC	2.000AAC	15.5	Pass	9.6e-001AAC	2.08
2000A RANGE						
200.0 AAC @ 60 Hz	199.89AAC	20.000AAC	0.55	Pass	3.4e-001AAC	
500.0 AAC @ 60 Hz	499.67AAC	20.000AAC	1.65	Pass	7.4e-001AAC	
750.0 AAC @ 60 Hz	749.50AAC	20.000AAC	2.5	Pass	1.1e+000AAC	
1000.0 AAC @ 60 Hz	999.57AAC	20.000AAC	2.15	Pass	1.6e+000AAC	

***** End of Report *****

UNIT UNDER TEST: Meteorological Station	TEST RESULT: PASS
SERIAL NUMBER: 81513	CAL DATE: 08 March 2017
ASSET NUMBER: 23084	CAL DUE: 08 March 2018
PROCEDURE NAME: RM Young 05103VM/05305VM-AQ: Cal Ver CH.309_310	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 2 - 03/08/2017	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

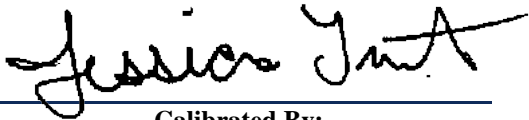
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REMARKS: Instrument passed calibration as found-left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14004	R.M. Young 18802 Anemometer Drive	CA02996	No Calibration Required	
14008	R.M. Young 18802 Anemometer Drive	CA2990	2/28/2017	2/28/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Wind Direction Test						
Wind Station Output = 0.88336308 VDC						
45.0000 °	44.800	2.0000	10	Pass	5.0e-001	4.00
Wind Station Output = 0.7565669 VDC						
90.0000 °	90.280	2.0000	14	Pass	5.0e-001	4.00
Wind Station Output = 0.5053837 VDC						
180.0000 °	180.360	2.0000	18	Pass	5.0e-001	4.00
Wind Station Output = 0.2579119 VDC						
270.0000 °	269.120	2.0000	44	Pass	5.0e-001	4.00
Wind Station Output = 0.0311339 VDC						
350.0000 °	350.450	2.0000	22.5	Pass	5.0e-001	4.00

Regression Values
Equation: $y = mX + b$
 $m = -358.645172021$
 $b = 361.614254893$

Wind Speed Test						
Wind Station Output DC Volts= 0.020993714 VDC						
2.2900 -mph	2.310-mph	0.6000-mph	3.33	Pass	1.1e-002-mph	
Wind Station Output DC Volts= 0.041175097 VDC						
4.5800 -mph	4.560-mph	0.6000-mph	3.33	Pass	1.1e-002-mph	
Wind Station Output DC Volts= 0.061779 VDC						
6.8700 -mph	6.860-mph	0.6000-mph	1.67	Pass	1.1e-002-mph	
Wind Station Output DC Volts= 0.10290344 VDC						
11.4500 -mph	11.450-mph	0.6000-mph	0	Pass	1.1e-002-mph	
Wind Station Output DC Volts= 0.51336276 VDC						
57.2500 -mph	57.250-mph	0.6000-mph	0	Pass	1.1e-002-mph	

Regression Values
Equation: $y = mX + b$
 $m = 111.581872798$
 $b = -0.0308931237407$

***** End of Report *****

UNIT UNDER TEST: Handheld Power Quality Analyzer	TEST RESULT: PASS
SERIAL NUMBER: DM9440528	CAL DATE: 10 February 2017
ASSET NUMBER: 23098	CAL DUE: 10 February 2018
PROCEDURE NAME: Fluke 43/43B: CAL VER	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 08/01/05	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

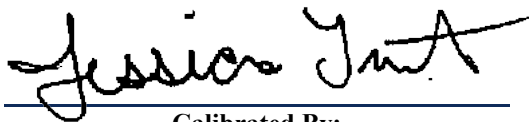
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

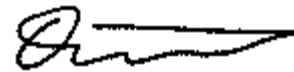
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Unit is operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	2/24/2016	2/23/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Display and Backlight Test				Pass		
Input 1 DC Voltage Accuracy Test						
15.0 mV	15.4mV	0.00060V	66.7	Pass	5.8e-005V	
30.0 mV	30.0mV	0.00070V	0	Pass	5.8e-005V	
60.0 mV	60.0mV	0.00080V	0	Pass	5.8e-005V	
150.0 mV	149.6mV	0.00130V	30.8	Pass	5.8e-005V	
300.0 mV	300.0mV	0.00200V	0	Pass	5.8e-005V	
500.0 mV	500.0mV	0.00300V	0	Pass	5.8e-005V	
-500.0 mV	-500.2mV	0.00300V	6.67	Pass	5.8e-005V	
0.0 mV	-0.2mV	0.00050V	40	Pass	5.8e-005V	
1.500 V	1.497V	0.0130V	23.1	Pass	5.8e-004V	
3.000 V	3.002V	0.0200V	10	Pass	5.8e-004V	
5.000 V	4.998V	0.0300V	6.67	Pass	5.8e-004V	
-5.000 V	-5.001V	0.0300V	3.33	Pass	5.8e-004V	
0.000 V	0.000V	0.0050V	0	Pass	5.8e-004V	
15.00 V	14.96V	0.130V	30.8	Pass	5.8e-003V	
30.00 V	30.01V	0.200V	5	Pass	5.8e-003V	
50.00 V	49.98V	0.300V	6.67	Pass	5.8e-003V	
-50.00 V	-49.98V	0.300V	6.67	Pass	5.8e-003V	
0.00 V	0.01V	0.050V	20	Pass	5.8e-003V	
150.0 V	149.7V	1.30V	23.1	Pass	5.8e-002V	
300.0 V	300.0V	2.00V	0	Pass	5.8e-002V	
Input 2 DC Voltage Accuracy Test						
15.00 mV	15.01mV	0.000130V	7.69	Pass	5.9e-006V	
30.00 mV	29.99mV	0.000200V	5	Pass	5.9e-006V	
60.00 mV	60.00mV	0.000350V	0	Pass	6.0e-006V	
150.0 mV	150.0mV	0.00130V	0	Pass	5.8e-005V	
300.0 mV	300.0mV	0.00200V	0	Pass	5.8e-005V	
500.0 mV	500.1mV	0.00300V	3.33	Pass	5.8e-005V	
-500.0 mV	-500.0mV	0.00300V	0	Pass	5.8e-005V	
0.0 mV	0.0mV	0.00050V	0	Pass	5.8e-005V	
1.500 V	1.502V	0.0130V	15.4	Pass	5.8e-004V	
3.000 V	3.001V	0.0200V	5	Pass	5.8e-004V	
5.000 V	5.001V	0.0300V	3.33	Pass	5.8e-004V	
-5.000 V	-4.999V	0.0300V	3.33	Pass	5.8e-004V	
0.000 V	0.001V	0.0050V	20	Pass	5.8e-004V	
15.00 V	15.01V	0.130V	7.69	Pass	5.8e-003V	
30.00 V	29.99V	0.200V	5	Pass	5.8e-003V	
50.00 V	50.00V	0.300V	0	Pass	5.8e-003V	
-50.00 V	-49.99V	0.300V	3.33	Pass	5.8e-003V	
0.00 V	0.01V	0.050V	20	Pass	5.8e-003V	
150.0 V	150.1V	1.30V	7.69	Pass	5.8e-002V	
300.0 V	300.0V	2.00V	0	Pass	5.8e-002V	
Input 1 AC Voltage Accuracy Test						
500.0 mV @ 60 Hz	496.2mV	0.00600V	63.3	Pass	1.2e-004V	
500.0 mV @ 20 kHz	501.6mV	0.01400V	11.4	Pass	1.3e-004V	
5.000 V @ 20 kHz	5.036V	0.1400V	25.7	Pass	1.5e-003V	
5.000 V @ 60 Hz	4.961V	0.0600V	65	Pass	1.2e-003V	
50.00 V @ 60 Hz	49.60V	0.600V	66.7	Pass	1.1e-002V	
50.00 V @ 20 kHz	50.25V	1.400V	17.9	Pass	1.5e-002V	

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Input 2 AC Voltage Accuracy Test						
500.0 mV @ 60 Hz	496.5mV	0.00600V	58.3	Pass	1.2e-004V	
5.000 V @ 60 Hz	4.966V	0.0600V	56.7	Pass	1.2e-003V	
50.00 V @ 60 Hz	49.65V	0.600V	58.3	Pass	1.1e-002V	
Input 1 AC Input Coupling Test						
500.0 mV @ 10 Hz	403.7mV	0.15600V	61.7	Pass	1.7e-004V	
500.0 mV @ 33 Hz	487.8mV	0.03100V	39.4	Pass	1.7e-004V	
500.0 mV @ 60 Hz	496.0mV	0.01350V	29.6	Pass	1.2e-004V	
Input 2 AC Input Coupling Test						
500.0 mV @ 10 Hz	408.7mV	0.15600V	58.5	Pass	1.7e-004V	
500.0 mV @ 33 Hz	489.3mV	0.03100V	34.5	Pass	1.7e-004V	
500.0 mV @ 60 Hz	496.6mV	0.01400V	24.3	Pass	1.2e-004V	
Input 1 Volts Peak Measurement Test						
5.00 Vpp @ 1 kHz	4.96Vpp	0.500Vpp	8	Pass	5.8e-003Vpp	
Input 2 Volts Peak Measurement Test						
5.00 Vpp @ 1 kHz	4.93Vpp	0.500Vpp	14	Pass	5.8e-003Vpp	
Phase Measurements Test (-2 to +2 Indication)				Pass		
Input 1 High Voltage AC & DC Accuracy Test						
0.0 V	0.0V	0.50V	0	Pass	5.8e-002V	
500.0 V	500.0V	3.00V	0	Pass	5.8e-002V	
-500.0 V	-499.4V	3.00V	20	Pass	5.8e-002V	
600.0 V	600.0V	8.00V	0	Pass	5.9e-002V	
-600.0 V	-599.0V	8.00V	12.5	Pass	5.9e-002V	
0.0 V	0.0V	5.00V	0	Pass	5.8e-002V	
600.0 V @ 10 kHz	603.0V	30.00V	10	Pass	1.6e-001V	
600.0 V @ 60 Hz	600.0V	16.00V	0	Pass	1.6e-001V	
500.0 V @ 60 Hz	499.0V	6.00V	16.7	Pass	1.4e-001V	
500.0 V @ 10 kHz	500.8V	14.00V	5.71	Pass	1.4e-001V	
Input 2 High Voltage AC & DC Accuracy Test						
0.0 V	0.0V	0.50V	0	Pass	5.8e-002V	
500.0 V	499.9V	3.00V	3.33	Pass	5.8e-002V	
-500.0 V	-499.3V	3.00V	23.3	Pass	5.8e-002V	
600.0 V	601.0V	8.00V	12.5	Pass	5.9e-002V	
-600.0 V	-601.0V	8.00V	12.5	Pass	5.9e-002V	
0.0 V	0.0V	5.00V	0	Pass	5.8e-002V	
600.0 V @ 60 Hz	601.0V	16.00V	6.25	Pass	1.6e-001V	
500.0 V @ 60 Hz	499.6V	6.00V	6.67	Pass	1.4e-001V	
Resistance Measurements Test						
0.0 Ohm	0.0Ohm	0.50Ohm	0	Pass	5.8e-002Ohm	
400.0 Ohm	400.0Ohm	2.90Ohm	0	Pass	5.9e-002Ohm	
4.000 kOhm	4.003kOhm	29.0Ohm	10.3	Pass	5.9e-001Ohm	
40.00 kOhm	40.02kOhm	290Ohm	6.9	Pass	5.9e+000Ohm	
400.0 kOhm	400.1kOhm	2900Ohm	3.45	Pass	5.9e+001Ohm	
4.000 MOhm	4.000MOhm	29000Ohm	0	Pass	7.3e+002Ohm	
30.00 MOhm	30.02MOhm	230000Ohm	8.7	Pass	9.7e+003Ohm	

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Diode Test Function Test						
0.500 V	0.488V	0.0750V	16	Pass	5.8e-004V	
1.000 V	0.998V	0.0250V	8	Pass	5.8e-004V	
Continuity Function Test						
Beeper "ON" @ 25 Ohms and Below				Pass		
Beeper "OFF" @ 35 Ohms and Above				Pass		
Capacitance Measurements Test						
40.00 nF	40.20nF	0.00000000900F	22.2	Pass	1.6e-010F	
300.0 nF	300.0nF	0.00000000700F	0	Pass	8.2e-010F	
3.000 µF	3.000µF	0.0000000700F	0	Pass	8.2e-009F	
30.00 µF	30.06µF	0.0000000700F	8.57	Pass	1.2e-007F	
300.0 µF	300.5µF	0.000000700F	7.14	Pass	1.3e-006F	
UUT Indication 0.00 to 0.10 with Inputs Removed				Pass		
Inrush Current Test						
1.50 kA	1.50kA	120A	0	Pass	5.8e+000A	
Input 1 Sags & Swells Test Result				Pass		
Input 2 Sags & Swells Test Result				Pass		
Harmonics Test Result				Pass		
Volts Test						
0 V	0V	0.1V	4	Pass	5.8e-001V	
5.50 V @ 70 Hz	5.48V	0.160V	12.5	Pass	5.9e-003V	
Hertz Test						
70.0 Hz @ 5.5 V	70.0Hz	0.60Hz	0	Pass	5.8e-002Hz	
70.0 Hz @ 4.5 V	70.0Hz	0.60Hz	0	Pass	5.8e-002Hz	
Amps Test						
0.00 A	0.02A	0.100A	20	Pass	5.8e-003A	
5.50 A @ 70 Hz	5.50A	0.160A	1.25	Pass	5.8e-003A	
4.500 A @ 70 Hz	4.498A	0.0550A	3.64	Pass	5.8e-004A	
Watts Test						
0.0 W	0.0W	0.40W	0	Pass	5.8e-002W	
20.0 W @ 60 Hz	20.0W	0.60W	0	Pass	5.8e-002W	
35.0 W @ 60 Hz	35.0W	0.70W	0	Pass	5.8e-002W	
VA Test						
0.0 _VA_	0.0_VA_	0.40_VA_	0	Pass	5.8e-002_VA_	
20.0 _VA_ @ 60 Hz	20.0_VA_	0.60_VA_	0	Pass	5.8e-002_VA_	
35.0 _VA_ @ 60 Hz	35.0_VA_	0.70_VA_	0	Pass	5.8e-002_VA_	
VAR Test						
0.0 _VAR_	0.0_VAR_	0.40_VAR_	0	Pass	5.8e-002_VAR_	
0.0 _VAR_ @ 60 Hz	0.0_VAR_	0.40_VAR_	0	Pass	5.8e-002_VAR_	
0.0 _VAR_ @ 60 Hz	0.0_VAR_	0.40_VAR_	0	Pass	5.8e-002_VAR_	
PF Test						
1.00 _PF_ @ 60 Hz	1.00_PF_	1.000e+099_PF_	0	Pass	5.8e-003_PF_	
1.00 _PF_ @ 60 Hz	1.00_PF_	1.000e+099_PF_	0	Pass	5.8e-003_PF_	
DPF Test						
1.00 _dPF_ @ 60 Hz	1.00_dPF_	1.000e+099_dPF_	0	Pass	5.8e-003_dPF_	
1.00 _dPF_ @ 60 Hz	1.00_dPF_	1.000e+099_dPF_	0	Pass	5.8e-003_dPF_	
Hz Test						
60.0 Hz	60.0Hz	0.50Hz	0	Pass	5.8e-002Hz	
60.0 Hz	60.0Hz	0.50Hz	0	Pass	5.8e-002Hz	
Operation of Transients Test Function				Pass		

***** End of Report *****

UNIT UNDER TEST: Current Clamp, Flexible	TEST RESULT: PASS
SERIAL NUMBER: 197326FDDV	CAL DATE: 14 December 2016
ASSET NUMBER: 23735	CAL DUE: 14 December 2017
PROCEDURE NAME: AEMC 24-3001/24-3002 Flexible Current Clamp	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 9/21/2010	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 28 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

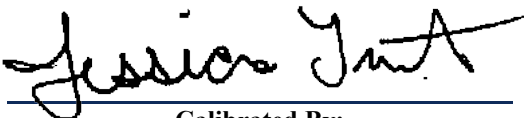
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as found and as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	2/24/2016	2/23/2017
14003	Hewlett Packard 3458A DMM	2823A13699	3/3/2016	3/3/2017
14027	Fluke 5500A/Coil 50 Turn Coil	MCH0731	No Calibration Required	

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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CURRENT ACCURACY

LIMITED CALIBRATION Calibrated up to 1000AAC only

300A Range

60 A	60.052A	1.7000A	3.06	Pass	1.6e-001A	
90 A	90.091A	2.3000A	3.96	Pass	2.3e-001A	
150 A	150.115A	3.5000A	3.29	Pass	4.6e-001A	
210 A	210.174A	4.7000A	3.7	Pass	6.0e-001A	
270 A	270.226A	5.9000A	3.83	Pass	7.4e-001A	

3000A Range

200 A	200.143A	4.5000A	3.18	Pass	5.8e-001A	
400 A	400.302A	8.5000A	3.55	Pass	1.0e+000A	
600 A	600.506A	12.5000A	4.05	Pass	1.5e+000A	
800 A	800.755A	16.5000A	4.58	Pass	2.0e+000A	
1000 A	1001.307A	20.5000A	6.38	Pass	2.5e+000A	

***** End of Report *****

UNIT UNDER TEST: Current Clamp	TEST RESULT: PASS
SERIAL NUMBER: 23	CAL DATE: 02 December 2016
ASSET NUMBER: 24243	CAL DUE: 02 December 2017
PROCEDURE NAME: Fluke 80i-500s: CAL VER	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 3/28/16	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 32 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

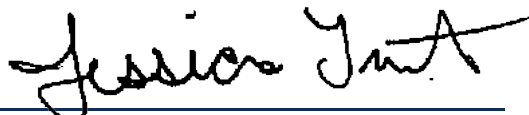
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as found and as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	2/24/2016	2/23/2017
14021	Fluke 8508A Reference Multimeter	45963	4/20/2016	4/20/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AC CURRENT ACCURACY						
50 AAC @ 50 Hz	49.780AAC	2.5000AAC	8.8	Pass	1.8e-001AAC	
50 AAC @ 60 Hz	49.795AAC	2.5000AAC	8.2	Pass	1.8e-001AAC	
300 AAC @ 50 Hz	303.131AAC	6.0000AAC	52.2	Pass	1.1e+000AAC	
300 AAC @ 60 Hz	303.326AAC	6.0000AAC	55.4	Pass	1.1e+000AAC	
300 AAC @ 100 Hz	303.569AAC	15.0000AAC	23.8	Pass	1.1e+000AAC	
500.0 AAC @ 50 Hz	499.431AAC	10.0000AAC	5.69	Pass	1.6e+000AAC	
500.0 AAC @ 60 Hz	500.318AAC	10.0000AAC	3.18	Pass	1.6e+000AAC	

***** End of Report *****

UNIT UNDER TEST: Data Logger	TEST RESULT: PASS
SERIAL NUMBER: US37039332	CAL DATE: 25 May 2017
ASSET NUMBER: 24424	CAL DUE: 25 May 2018
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

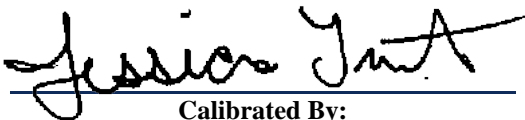
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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	-0.0009mV		21.3	Pass		
1 VDC Range						
0.000000 V	-0.000001V		13.1	Pass		
10 VDC Range						
0.00000 V	-0.00000V		2.6	Pass		
100 VDC Range						
0.0000 V	0.0000V		6.67	Pass		
300 VDC Range						
0.000 V	0.000V		1.33	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	-0.0002Ohm		0.0172	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	-0.0002Ohm		5	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	0.000023kOhm		2.25	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	-0.000000kOhm		4	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	0.00002kOhm		1.45	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	-0.00000kOhm		4	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0001kOhm		3.35	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	-0.0000kOhm		1.3	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	0.000000MOhm		0	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	0.000000MOhm		2.7	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	0.00000MOhm		0	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00000MOhm		0	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mADC Range						
0.00000 mA	0.00001mA		0.45	Pass		
100 mADC Range						
0.00000 mA	0.00005mA		1.04	Pass		
1 ADC Range						
0.000000 A	0.000001A		1.44	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	49.9999mV	6.50000000001e-006	1.52	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	100.0000mV	0.00000900V	0.178	Pass	2.3e-006V	3.00
1V Range						
0.5000000 V	0.4999979V	2.70000000001e-005	7.96	Pass	5.8e-006V	3.60
1.000000 V	0.999997V	4.69999999999e-005	6.13	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00000V	0.000225V	0.533	Pass	6.2e-005V	2.81
10.00000 V	10.00001V	0.000400000000001V	2.5	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0003V	0.00285V	10.1	Pass	8.2e-004V	2.71
100.0000 V	100.0003V	0.00510V	6.47	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	149.9977V	0.01575V	14.4	Pass	2.2e-003V	
300.0000 V	299.9990V	0.02250V	4.53	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	100.0103mV	0.00010000V	10.3	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	99.9749mV	0.00017000V	14.8	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	1.000092V	0.0010000V	9.16	Pass	1.6e-004V	
1.000000 V @ 50 kHz	1.000032V	0.0017000V	1.88	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	10.00041V	0.010000V	4.13	Pass	1.6e-003V	
10.00000 V @ 50 kHz	9.99911V	0.017000V	5.26	Pass	3.2e-003V	
10.00000 V @ 10 Hz	9.99873V	0.010000V	12.7	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	99.9999V	0.10000V	0.135	Pass	1.6e-002V	
100.0000 V @ 50 kHz	99.9708V	0.17000V	17.2	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	300.000V	0.4200V	0.0548	Pass	4.6e-002V	
300.000 V @ 50 kHz	300.003V	0.7200V	0.375	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	100.1358Ohm	1.01400Ohm	13.4	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	1.000137kOhm	1.1100Ohm	12.3	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00016kOhm	2.100Ohm	7.43	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	100.0002kOhm	12.00Ohm	1.83	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000015MOhm	111.0Ohm	14	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	10.00046MOhm	4100Ohm	11.2	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	100.1281MOhm	810000Ohm	15.8	Pass	4.1e+004Ohm	
4-WIRE OHMS: 100 Ohm Range 100.0000 Ohm	100.0004Ohm	0.01400Ohm	3.14	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	1.000003kOhm	0.1100Ohm	2.73	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	10.00004kOhm	1.100Ohm	3.55	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	100.0004kOhm	11.00Ohm	3.64	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	99.9681Hz	0.10000Hz	31.9	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0001kHz	10.00Hz	1.5	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	9.99992mA	0.000007000A	1.19	Pass	9.7e-007A	
100mA Range 100.0000 mA	99.9970mA	0.00005500A	5.53	Pass	9.7e-006A	
1A Range 1.000000 A	0.999923A	0.0011000A	7.02	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99821mA	0.000014000A	12.8	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	100.0153mA	0.00060000A	2.56	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	1.000030A	0.0014000A	2.13	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 72"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 03 April 2017
ASSET NUMBER: 100006	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

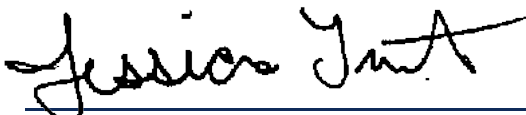
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

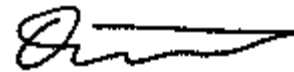
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= 100006					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.84667 Ohms						
40.4160 F	40.418F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.2375 Ohms						
65.3590 F	65.354F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.626 Ohms						
90.3710 F	90.375F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.99217 Ohms						
115.3880 F	115.387F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.3375 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.84667 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.2375 Ohms						
18.5320 c	18.530c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.626 Ohms						
32.4280 c	32.430c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.99217 Ohms						
46.3270 c	46.326c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.3375 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.02231

Alpha= 0.003849601

Delta= 1.38095627721

A= 0.00390276230666

B= -5.31613066572e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 72"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 03 April 2017
ASSET NUMBER: 300006	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

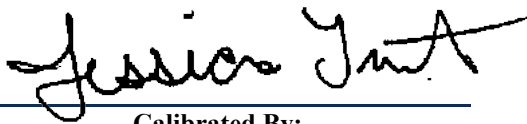
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

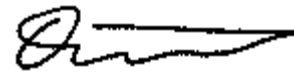
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= 300006					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.80317 Ohms						
40.4160 F	40.422F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.20733 Ohms						
65.3590 F	65.349F	0.1000F	10	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.58867 Ohms						
90.3710 F	90.365F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.9325 Ohms						
115.3880 F	115.404F	0.1000F	16	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.22283 Ohms						
140.3980 F	140.390F	0.1000F	8	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.80317 Ohms						
4.6760 c	4.679c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.20733 Ohms						
18.5320 c	18.527c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.58867 Ohms						
32.4280 c	32.425c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.9325 Ohms						
46.3270 c	46.336c	0.0560c	16.1	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.22283 Ohms						
60.2210 c	60.217c	0.0560c	7.14	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 99.96788

Alpha= 0.003819575

Delta= 2.86499326621

A= 0.00392900556655

B= -1.09430566548e-006

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 08 March 2017
ASSET NUMBER: CT006	CAL DUE: 08 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20-200 CAL UNITS: Deg F

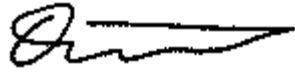
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.

 <hr style="width: 80%; margin: 0 auto;"/> Calibrated By:	 <hr style="width: 80%; margin: 0 auto;"/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT006					
Probe Calibration Range = 20 to 200 Deg F						
= -6.7 to 93.3 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.488 Ohms						
20.4240 F	20.434F	0.1000F	10	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.98083 Ohms						
50.3690 F	50.355F	0.1000F	14	Pass	3.4e-002F	2.94
Resistance Value at Temp = 110.446 Ohms						
80.3260 F	80.320F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 116.8865 Ohms						
110.3440 F	110.344F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.2905 Ohms						
140.3600 F	140.372F	0.1000F	12	Pass	3.4e-002F	2.94
Resistance Value at Temp = 129.65783 Ohms						
170.3970 F	170.403F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 135.98633 Ohms						
200.4350 F	200.427F	0.1000F	8	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 97.488 Ohms						
-6.4310 c	-6.425c	0.0560c	10.7	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.98083 Ohms						
10.2050 c	10.197c	0.0560c	14.3	Pass	1.9e-002c	2.95
Resistance Value at Temp = 110.446 Ohms						
26.8480 c	26.844c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 116.8865 Ohms						
43.5250 c	43.524c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.2905 Ohms						
60.2000 c	60.206c	0.0560c	10.7	Pass	1.9e-002c	2.95
Resistance Value at Temp = 129.65783 Ohms						
76.8870 c	76.890c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 135.98633 Ohms						
93.5750 c	93.571c	0.0560c	7.14	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}}{2 * Ro * B}$$

Ro= 100.00216

Alpha= 0.003841264

Delta= 1.7490579987

A= 0.00390844993524

B= -6.71859352432e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 08 March 2017
ASSET NUMBER: CT021	CAL DUE: 08 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20-200 CAL UNITS: Deg F

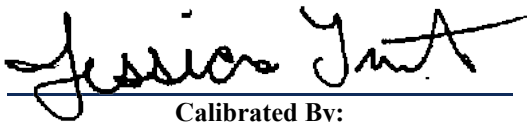
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.


Calibrated By:


Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT021					
Probe Calibration Range = 20 to 200 Deg F						
= -6.7 to 93.3 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.48583 Ohms						
20.4240 F	20.429F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.9835 Ohms						
50.3690 F	50.359F	0.1000F	10	Pass	3.4e-002F	2.94
Resistance Value at Temp = 110.4565 Ohms						
80.3260 F	80.327F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 116.90717 Ohms						
110.3440 F	110.343F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.32617 Ohms						
140.3600 F	140.365F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 129.71517 Ohms						
170.3970 F	170.400F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 136.07033 Ohms						
200.4350 F	200.432F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 97.48583 Ohms						
-6.4310 c	-6.428c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.9835 Ohms						
10.2050 c	10.200c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 110.4565 Ohms						
26.8480 c	26.848c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 116.90717 Ohms						
43.5250 c	43.524c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.32617 Ohms						
60.2000 c	60.203c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 129.71517 Ohms						
76.8870 c	76.889c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 136.07033 Ohms						
93.5750 c	93.573c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.00162

Alpha= 0.00385074

Delta= 1.53596082518

A= 0.00390988585788

B= -5.91458578796e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 03 April 2017
ASSET NUMBER: CT030	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

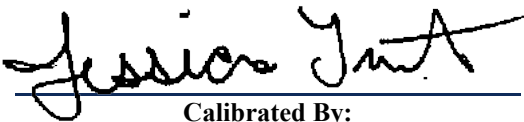
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

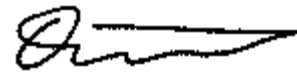
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT030					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.8345 Ohms						
40.4160 F	40.418F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.2295 Ohms						
65.3590 F	65.353F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.623 Ohms						
90.3710 F	90.376F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.993 Ohms						
115.3880 F	115.386F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.343 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.8345 Ohms						
4.6760 c	4.677c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.2295 Ohms						
18.5320 c	18.529c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.623 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.993 Ohms						
46.3270 c	46.325c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.343 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00858

Alpha= 0.003853285

Delta= 1.38167310762

A= 0.0039065248026

B= -5.32398026049e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 03 April 2017
ASSET NUMBER: CT047	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

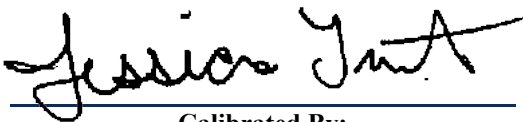
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

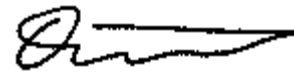
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT047					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.84283 Ohms						
40.4160 F	40.419F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.2345 Ohms						
65.3590 F	65.350F	0.1000F	9	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.62733 Ohms						
90.3710 F	90.375F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.99867 Ohms						
115.3880 F	115.390F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.349 Ohms						
140.3980 F	140.396F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.84283 Ohms						
4.6760 c	4.677c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.2345 Ohms						
18.5320 c	18.528c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.62733 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.99867 Ohms						
46.3270 c	46.328c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.349 Ohms						
60.2210 c	60.220c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.01769
 Alpha= 0.00385386
 Delta= 1.29164099689
 A= 0.00390363803572
 B= -4.97780357228e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 03 April 2017
ASSET NUMBER: R112	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

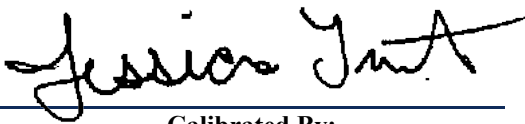
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

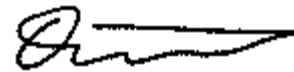
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R112					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.79183 Ohms						
40.4160 F	40.417F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.19867 Ohms						
65.3590 F	65.354F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.60033 Ohms						
90.3710 F	90.377F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.975 Ohms						
115.3880 F	115.384F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.32783 Ohms						
140.3980 F	140.399F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.79183 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.19867 Ohms						
18.5320 c	18.530c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.60033 Ohms						
32.4280 c	32.432c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.975 Ohms						
46.3270 c	46.324c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.32783 Ohms						
60.2210 c	60.222c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2A^2 - 4RoB(Ro - Rt))] / (2 * Ro * B)$

Ro= 99.96155

Alpha= 0.003857181

Delta= 1.58787412061

A= 0.00391842817888

B= -6.12471788841e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R254	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

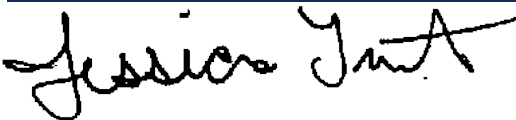
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

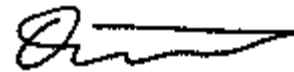
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R254					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.94733 Ohms						
40.4050 F	40.402F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.36433 Ohms						
65.3590 F	65.364F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.76483 Ohms						
90.3580 F	90.358F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.14317 Ohms						
115.3640 F	115.358F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.50333 Ohms						
140.3800 F	140.383F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.94733 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.36433 Ohms						
18.5320 c	18.536c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.76483 Ohms						
32.4210 c	32.421c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.14317 Ohms						
46.3130 c	46.310c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.50333 Ohms						
60.2110 c	60.213c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.11869

Alpha= 0.003854874

Delta= 1.57665289531

A= 0.00391565198253

B= -6.07779825316e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R381	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

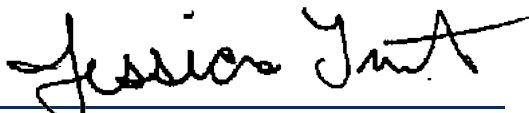
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R381					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.80967 Ohms						
40.4050 F	40.402F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.21817 Ohms						
65.3590 F	65.367F	0.1000F	8	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.60833 Ohms						
90.3580 F	90.355F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.97917 Ohms						
115.3640 F	115.360F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.33033 Ohms						
140.3800 F	140.383F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.80967 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.21817 Ohms						
18.5320 c	18.537c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.60833 Ohms						
32.4210 c	32.419c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.97917 Ohms						
46.3130 c	46.311c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.33033 Ohms						
60.2110 c	60.213c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$$

Ro= 99.98436

Alpha= 0.003853924

Delta= 1.56107372367

A= 0.00391408659489

B= -6.0162594894e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00032	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

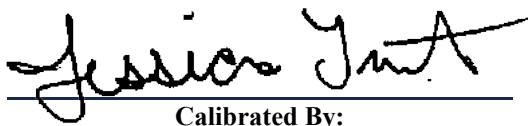
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00032					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.91717 Ohms						
40.4160 F	40.441F	0.1000F	25	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.2635 Ohms						
65.3590 F	65.302F	0.1000F	57	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.6505 Ohms						
90.3710 F	90.392F	0.1000F	21	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.0145 Ohms						
115.3880 F	115.415F	0.1000F	27	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.35783 Ohms						
140.3980 F	140.380F	0.1000F	18	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.91717 Ohms						
4.6760 c	4.689c	0.0560c	23.2	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.2635 Ohms						
18.5320 c	18.501c	0.0560c	55.4	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.6505 Ohms						
32.4280 c	32.440c	0.0560c	21.4	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.0145 Ohms						
46.3270 c	46.342c	0.0560c	26.8	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.35783 Ohms						
60.2210 c	60.211c	0.0560c	17.9	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.10017

Alpha= 0.003850088

Delta= 0.568922801489

A= 0.00387199202851

B= -2.19040285094e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00037	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

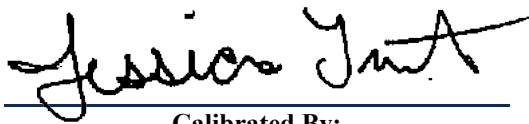
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

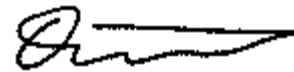
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00037					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.75917 Ohms						
40.4160 F	40.417F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.15033 Ohms						
65.3590 F	65.355F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.5365 Ohms						
90.3710 F	90.374F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.89917 Ohms						
115.3880 F	115.387F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.23917 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.75917 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.15033 Ohms						
18.5320 c	18.531c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.5365 Ohms						
32.4280 c	32.430c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.89917 Ohms						
46.3270 c	46.326c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.23917 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 99.93455
 Alpha= 0.003849376
 Delta= 1.50248022783
 A= 0.00390721211329
 B= -5.78361132949e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00039	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

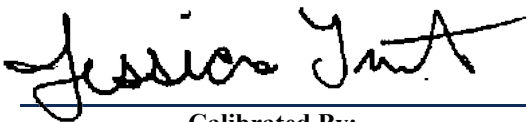
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

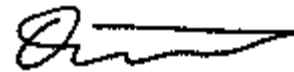
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00039					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.75333 Ohms						
40.4160 F	40.416F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.14967 Ohms						
65.3590 F	65.357F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.53933 Ohms						
90.3710 F	90.374F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.90433 Ohms						
115.3880 F	115.384F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.2475 Ohms						
140.3980 F	140.399F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.75333 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.14967 Ohms						
18.5320 c	18.532c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.53933 Ohms						
32.4280 c	32.430c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.90433 Ohms						
46.3270 c	46.324c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.2475 Ohms						
60.2210 c	60.222c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 99.92726

Alpha= 0.003851444

Delta= 1.55168274186

A= 0.00391120619186

B= -5.97621918606e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00043	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

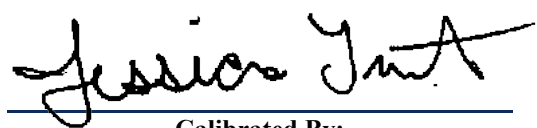
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used				
Asset #	Description	Serial #	Cal Date	Due Date
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00043					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.75433 Ohms						
40.4160 F	40.416F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.16283 Ohms						
65.3590 F	65.358F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.56467 Ohms						
90.3710 F	90.372F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.94417 Ohms						
115.3880 F	115.387F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.30033 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.75433 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.16283 Ohms						
18.5320 c	18.532c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.56467 Ohms						
32.4280 c	32.429c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.94417 Ohms						
46.3270 c	46.326c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.30033 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 99.92422

Alpha= 0.003861463

Delta= 1.51000257675

A= 0.0039197711908

B= -5.83081908002e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00045	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

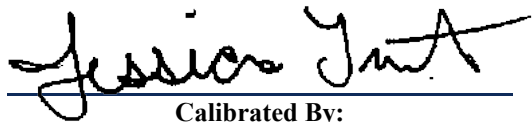
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00045					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.79567 Ohms						
40.4160 F	40.418F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.18667 Ohms						
65.3590 F	65.353F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.57433 Ohms						
90.3710 F	90.376F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.93733 Ohms						
115.3880 F	115.386F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.27817 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.79567 Ohms						
4.6760 c	4.677c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.18667 Ohms						
18.5320 c	18.530c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.57433 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.93733 Ohms						
46.3270 c	46.326c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.27817 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.97072

Alpha= 0.003848583

Delta= 1.49427792752

A= 0.00390609152629

B= -5.75085262914e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00046	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

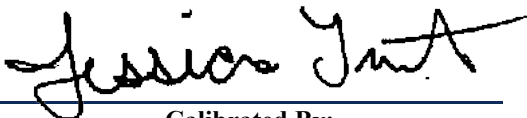
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00046					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.819 Ohms						
40.4160 F	40.416F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.23 Ohms						
65.3590 F	65.357F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.63517 Ohms						
90.3710 F	90.377F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.01367 Ohms						
115.3880 F	115.381F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.37217 Ohms						
140.3980 F	140.400F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.819 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.23 Ohms						
18.5320 c	18.531c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.63517 Ohms						
32.4280 c	32.432c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.01367 Ohms						
46.3270 c	46.323c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.37217 Ohms						
60.2210 c	60.222c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.98791

Alpha= 0.003859596

Delta= 1.55465953542

A= 0.00391959957724

B= -6.00035772427e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00052	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00052					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.8255 Ohms						
40.4160 F	40.418F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.22483 Ohms						
65.3590 F	65.352F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.62117 Ohms						
90.3710 F	90.377F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.99133 Ohms						
115.3880 F	115.386F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.33917 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.8255 Ohms						
4.6760 c	4.677c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.22483 Ohms						
18.5320 c	18.529c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.62117 Ohms						
32.4280 c	32.432c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.99133 Ohms						
46.3270 c	46.326c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.33917 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.99739

Alpha= 0.003852637

Delta= 1.53281113394

A= 0.00391169064889

B= -5.90536488865e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00055	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

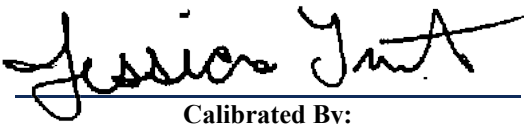
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

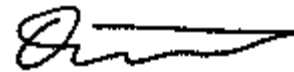
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00055					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.82117 Ohms						
40.4160 F	40.418F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.21967 Ohms						
65.3590 F	65.353F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.61533 Ohms						
90.3710 F	90.377F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.98533 Ohms						
115.3880 F	115.385F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.334 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.82117 Ohms						
4.6760 c	4.677c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.21967 Ohms						
18.5320 c	18.529c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.61533 Ohms						
32.4280 c	32.432c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.98533 Ohms						
46.3270 c	46.325c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.334 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.99363

Alpha= 0.003853101

Delta= 1.49579986719

A= 0.00391073567964

B= -5.76346796407e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00056	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

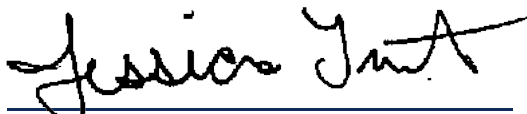
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00056					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.7795 Ohms						
40.4160 F	40.418F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.1825 Ohms						
65.3590 F	65.353F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.582 Ohms						
90.3710 F	90.376F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.956 Ohms						
115.3880 F	115.385F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.30817 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.7795 Ohms						
4.6760 c	4.677c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.1825 Ohms						
18.5320 c	18.530c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.582 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.956 Ohms						
46.3270 c	46.325c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.30817 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.95048

Alpha= 0.003857368

Delta= 1.51261683446

A= 0.00391571519774

B= -5.83471977351e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00060	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

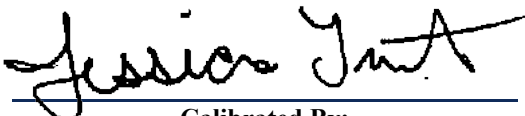
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

Asset #	Description	Serial #	Cal Date	Due Date
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00060					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.87083 Ohms						
40.4160 F	40.417F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.27433 Ohms						
65.3590 F	65.354F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.67367 Ohms						
90.3710 F	90.376F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.04783 Ohms						
115.3880 F	115.385F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.4 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.87083 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.27433 Ohms						
18.5320 c	18.530c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.67367 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.04783 Ohms						
46.3270 c	46.325c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.4 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.04178

Alpha= 0.003853833

Delta= 1.51902682195

A= 0.00391237375694

B= -5.8540756943e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00062	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.

 _____ Calibrated By:	 _____ Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00062					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.8255 Ohms						
40.4160 F	40.416F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.22667 Ohms						
65.3590 F	65.357F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.62217 Ohms						
90.3710 F	90.374F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.9935 Ohms						
115.3880 F	115.384F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.34333 Ohms						
140.3980 F	140.399F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.8255 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.22667 Ohms						
18.5320 c	18.531c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.62217 Ohms						
32.4280 c	32.430c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.9935 Ohms						
46.3270 c	46.325c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.34333 Ohms						
60.2210 c	60.222c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.99778

Alpha= 0.003853549

Delta= 1.51000817019

A= 0.00391173790474

B= -5.81889047424e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00064	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

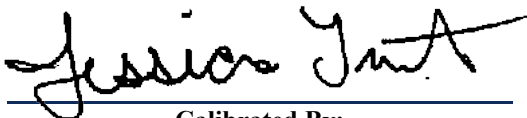
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00064					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.78033 Ohms						
40.4160 F	40.417F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.171 Ohms						
65.3590 F	65.356F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.55667 Ohms						
90.3710 F	90.374F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.91867 Ohms						
115.3880 F	115.386F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.25833 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.78033 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.171 Ohms						
18.5320 c	18.531c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.55667 Ohms						
32.4280 c	32.430c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.91867 Ohms						
46.3270 c	46.326c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.25833 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.95593

Alpha= 0.003848202

Delta= 1.50098126491

A= 0.00390596279106

B= -5.77607910557e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00070	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.

 _____ Calibrated By:	 _____ Approved By:
---	---

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00070					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.86767 Ohms						
40.4160 F	40.418F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.27367 Ohms						
65.3590 F	65.353F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.67617 Ohms						
90.3710 F	90.376F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.053 Ohms						
115.3880 F	115.386F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.40783 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.86767 Ohms						
4.6760 c	4.677c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.27367 Ohms						
18.5320 c	18.529c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.67617 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.053 Ohms						
46.3270 c	46.325c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.40783 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.03757

Alpha= 0.003855975

Delta= 1.52000763128

A= 0.00391458611426

B= -5.86111142602e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R413	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

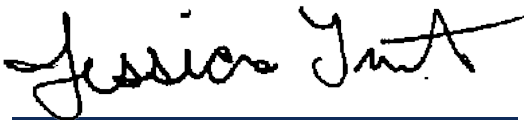
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

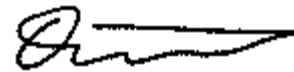
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R413					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.80767 Ohms						
40.4050 F	40.402F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.21517 Ohms						
65.3590 F	65.364F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.608 Ohms						
90.3580 F	90.361F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.97817 Ohms						
115.3640 F	115.355F	0.1000F	9	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.3335 Ohms						
140.3800 F	140.384F	0.1000F	4	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.80767 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.21517 Ohms						
18.5320 c	18.536c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.608 Ohms						
32.4210 c	32.423c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.97817 Ohms						
46.3130 c	46.308c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.3335 Ohms						
60.2110 c	60.214c	0.0560c	5.36	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 99.98257
 Alpha= 0.003855792
 Delta= 1.49313315795
 A= 0.00391336410885
 B= -5.75721088534e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R443	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

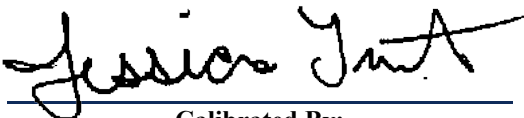
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R443					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.86917 Ohms						
40.4050 F	40.403F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.282 Ohms						
65.3590 F	65.363F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.67967 Ohms						
90.3580 F	90.358F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.056 Ohms						
115.3640 F	115.361F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.41333 Ohms						
140.3800 F	140.382F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.86917 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.282 Ohms						
18.5320 c	18.535c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.67967 Ohms						
32.4210 c	32.421c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.056 Ohms						
46.3130 c	46.311c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.41333 Ohms						
60.2110 c	60.212c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2A^2 - 4RoB(Ro - Rt)}}{2RoB}$$

Ro= 100.04165

Alpha= 0.003856249

Delta= 1.5435667981

A= 0.00391577277922

B= -5.95237792161e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R526	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

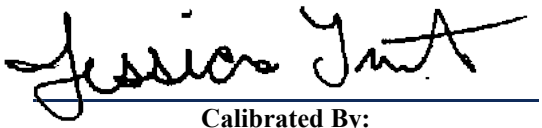
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

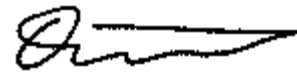
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R526					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.85617 Ohms						
40.4050 F	40.403F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.26767 Ohms						
65.3590 F	65.363F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.66383 Ohms						
90.3580 F	90.357F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.039 Ohms						
115.3640 F	115.361F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.39517 Ohms						
140.3800 F	140.382F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.85617 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.26767 Ohms						
18.5320 c	18.535c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.66383 Ohms						
32.4210 c	32.421c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.039 Ohms						
46.3130 c	46.311c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.39517 Ohms						
60.2110 c	60.212c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 100.02919

Alpha= 0.003855881

Delta= 1.53743423701

A= 0.00391516263463

B= -5.92816346322e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R616	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

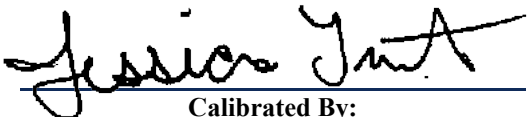
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R616					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.72 Ohms

40.4050 F	40.403F	0.1000F	2	Pass	3.4e-002F	2.94
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Resistance Value at Temp = 107.1235 Ohms

65.3590 F	65.363F	0.1000F	4	Pass	3.4e-002F	2.94
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Resistance Value at Temp = 112.51183 Ohms

90.3580 F	90.358F	0.1000F	0	Pass	3.4e-002F	2.94
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Resistance Value at Temp = 117.879 Ohms

115.3640 F	115.360F	0.1000F	4	Pass	3.4e-002F	2.94
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Resistance Value at Temp = 123.2275 Ohms

140.3800 F	140.382F	0.1000F	2	Pass	3.4e-002F	2.94
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*****Degrees C*****

Resistance Value at Temp = 101.72 Ohms

4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
----------	--------	---------	------	------	-----------	------

Resistance Value at Temp = 107.1235 Ohms

18.5320 c	18.535c	0.0560c	5.36	Pass	1.9e-002c	2.95
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Resistance Value at Temp = 112.51183 Ohms

32.4210 c	32.421c	0.0560c	0	Pass	1.9e-002c	2.95
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Resistance Value at Temp = 117.879 Ohms

46.3130 c	46.311c	0.0560c	3.57	Pass	1.9e-002c	2.95
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Resistance Value at Temp = 123.2275 Ohms

60.2110 c	60.212c	0.0560c	1.79	Pass	1.9e-002c	2.95
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As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4RoB(Ro - Rt)}}{2RoB}$$

Ro= 99.89573

Alpha= 0.00385542

Delta= 1.53446165269

A= 0.00391457994145

B= -5.91599414503e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R631	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

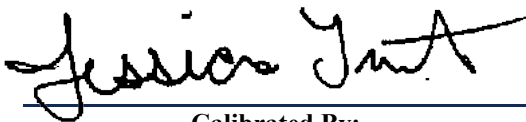
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

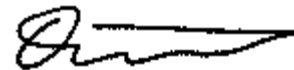
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R631					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.89067 Ohms						
40.4050 F	40.401F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.30033 Ohms						
65.3590 F	65.367F	0.1000F	8	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.6915 Ohms						
90.3580 F	90.357F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.06067 Ohms						
115.3640 F	115.357F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.4115 Ohms						
140.3800 F	140.384F	0.1000F	4	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.89067 Ohms						
4.6700 c	4.667c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.30033 Ohms						
18.5320 c	18.537c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.6915 Ohms						
32.4210 c	32.421c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.06067 Ohms						
46.3130 c	46.310c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.4115 Ohms						
60.2110 c	60.213c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.06484

Alpha= 0.003850064

Delta= 1.61586829683

A= 0.00391227596358

B= -6.22119635836e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R832	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

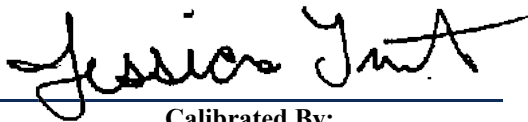
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

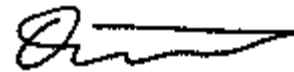
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R832					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.814 Ohms						
40.4050 F	40.403F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.222 Ohms						
65.3590 F	65.363F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.614 Ohms						
90.3580 F	90.356F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.98533 Ohms						
115.3640 F	115.362F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.3365 Ohms						
140.3800 F	140.382F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.814 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.222 Ohms						
18.5320 c	18.535c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.614 Ohms						
32.4210 c	32.420c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.98533 Ohms						
46.3130 c	46.312c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.3365 Ohms						
60.2110 c	60.212c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.98811

Alpha= 0.003854168

Delta= 1.56418275805

A= 0.00391445423132

B= -6.02862313221e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R919	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

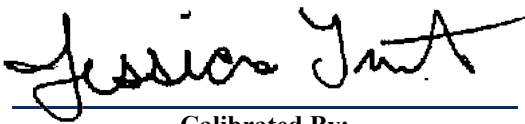
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

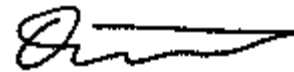
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R919					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.8265 Ohms						
40.4050 F	40.403F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.23417 Ohms						
65.3590 F	65.362F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.6265 Ohms						
90.3580 F	90.357F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.9975 Ohms						
115.3640 F	115.362F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.34867 Ohms						
140.3800 F	140.382F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.8265 Ohms						
4.6700 c	4.669c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.23417 Ohms						
18.5320 c	18.535c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.6265 Ohms						
32.4210 c	32.421c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.9975 Ohms						
46.3130 c	46.312c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.34867 Ohms						
60.2110 c	60.212c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$$

Ro= 100.00056

Alpha= 0.00385364

Delta= 1.56420393448

A= 0.0039139187885

B= -6.02787885008e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R996	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

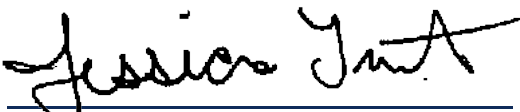
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R996					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.834 Ohms						
40.4050 F	40.403F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.24117 Ohms						
65.3590 F	65.363F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.633 Ohms						
90.3580 F	90.358F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.0035 Ohms						
115.3640 F	115.360F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.35567 Ohms						
140.3800 F	140.383F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.834 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.24117 Ohms						
18.5320 c	18.535c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.633 Ohms						
32.4210 c	32.421c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.0035 Ohms						
46.3130 c	46.311c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.35567 Ohms						
60.2110 c	60.213c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00857

Alpha= 0.003853578

Delta= 1.53523891886

A= 0.00391273962922

B= -5.91616292247e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 14 April 2017
ASSET NUMBER: R1104	CAL DUE: 14 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

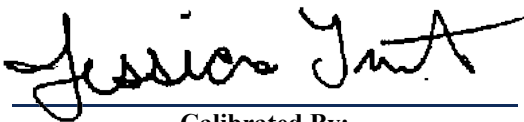
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

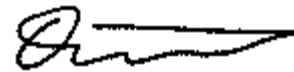
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R1104					
Probe Calibration Range = 40 to 140 Deg F						
= 4.4 to 60 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 102.07117 Ohms						
40.4050 F	40.402F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.4885 Ohms						
65.3590 F	65.365F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.8895 Ohms						
90.3580 F	90.356F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.2705 Ohms						
115.3640 F	115.360F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.63267 Ohms						
140.3800 F	140.382F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 102.07117 Ohms						
4.6700 c	4.668c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.4885 Ohms						
18.5320 c	18.536c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.8895 Ohms						
32.4210 c	32.420c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.2705 Ohms						
46.3130 c	46.311c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.63267 Ohms						
60.2110 c	60.212c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.24261

Alpha= 0.00385184

Delta= 1.5232441693

A= 0.00391051292821

B= -5.86729282109e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00028	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

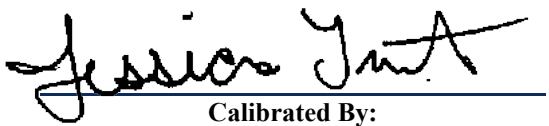
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

Asset #	Description	Serial #	Cal Date	Due Date
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00028					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.92317 Ohms						
40.4160 F	40.423F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.27333 Ohms						
65.3590 F	65.340F	0.1000F	19	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.6395 Ohms						
90.3710 F	90.384F	0.1000F	13	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.98617 Ohms						
115.3880 F	115.389F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.32167 Ohms						
140.3980 F	140.395F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.92317 Ohms						
4.6760 c	4.680c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.27333 Ohms						
18.5320 c	18.522c	0.0560c	17.9	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.6395 Ohms						
32.4280 c	32.435c	0.0560c	12.5	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.98617 Ohms						
46.3270 c	46.327c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.32167 Ohms						
60.2210 c	60.219c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 100.11197

Alpha= 0.00383826

Delta= 0.760785541671

A= 0.00386746092713

B= -2.92009271317e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00029	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

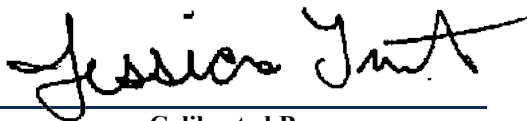
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

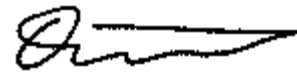
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00029					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.84633 Ohms						
40.4160 F	40.417F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.24283 Ohms						
65.3590 F	65.354F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.635 Ohms						
90.3710 F	90.375F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 118.0025 Ohms						
115.3880 F	115.386F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.348 Ohms						
140.3980 F	140.398F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.84633 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.24283 Ohms						
18.5320 c	18.530c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.635 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 118.0025 Ohms						
46.3270 c	46.325c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.348 Ohms						
60.2210 c	60.221c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.01975

Alpha= 0.003849884

Delta= 1.50931920215

A= 0.00390799103847

B= -5.81070384726e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 6"	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 April 2017
ASSET NUMBER: RTD00030	CAL DUE: 03 April 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 40~140
	CAL UNITS: Deg F

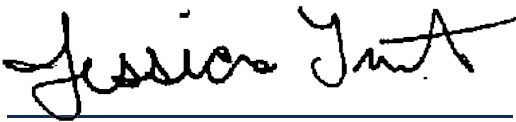
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= RTD00030					
Probe Calibration Range	= 40 to 140 Deg F					
	= 4.4 to 60 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 101.7735 Ohms						
40.4160 F	40.417F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 107.16467 Ohms						
65.3590 F	65.355F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 112.5515 Ohms						
90.3710 F	90.376F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 117.91333 Ohms						
115.3880 F	115.384F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 123.25467 Ohms						
140.3980 F	140.399F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 101.7735 Ohms						
4.6760 c	4.676c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 107.16467 Ohms						
18.5320 c	18.531c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 112.5515 Ohms						
32.4280 c	32.431c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 117.91333 Ohms						
46.3270 c	46.324c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 123.25467 Ohms						
60.2210 c	60.222c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \text{Sqrt}(Ro^2A^2 - 4RoB(Ro - Rt))] / (2 * Ro * B)$$

Ro= 99.949

Alpha= 0.003849127

Delta= 1.49113036129

A= 0.00390652250134

B= -5.73955013414e-007

***** End of Report *****



Certificate of Calibration



Certificate Number: 24297
Certificate Date: 2/7/2017

Date Received: 02/07/2017
Date of Calibration: 2/7/2017
Recommended Due Date: 2/7/2018
Temperature: 23.30 °C
Relative Humidity: 44.5 %RH

Manufacturer: Fluke
Model: 1735
Serial Number: S120714120B6
Description: Three-Phase Power Logger - Analyst w/Shield

Cal Procedure
FLUK-1735-CAL

Customer Name: McHale & Associates Inc
Customer Address: 5025 Thomas Edison Dr Waldford MD
PO Number:
CRM Order Number: End of Rental

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.

This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).

In the attached measurement results, deviation may be expressed with units, Measured Value (MV) - Nominal Value (NV) or as a proportion of the nominal value ((MV-NV)/NV), expressed without units with a scalar multiplier such as % (0.01), or as a ratio of the units (mA/A, μ V/V, etc.)

Descriptions such as μ A/A, μ V/V, and others, where used to annotate results or column headings are the preferred replacements for what was historically labeled as "ppm" or parts-per-million and described the results in that column, unless otherwise noted by units symbols.

Where applicable, the expanded uncertainty of measurement at the time of test is given in the following pages. They are calculated in accordance with the method described in the ISO Guide to the Expression of Uncertainty in Measurement (GUM). The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k, such that the confidence level approximates 95%.

This Calibration certificate may contain data that is not covered by the A2LA Scope of Accreditation. Unaccredited material, where applicable is indicated by an asterisk (*), or confined to clearly marked sections. Functional (Pass / Fail) tests are not accredited.

No statement of compliance with specifications is made or implied on this certificate. However, measurement results are reviewed, where applicable, to establish where any measurement result exceeded the manufacturer's specifications.

Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
McNair, Shane P	Technician	Javier Estrada	02/07/2017
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications



Certificate of Calibration



Certificate Number: 22844
Certificate Date: 2/7/2017

Manufacturer: Fluke
Model: 1735
Serial Number: S150635991B6
Description: Three-Phase Power Logger - Analyst w/Shield

Date Received: 10/18/2016
Date of Calibration: 10/18/2016
Recommended Due Date: 10/18/2017
Temperature: 2,333.00 °C
Relative Humidity: 40.0 %RH

Cal Procedure
FLUK-1735-CAL

Customer Name: McHale & Associates Inc
Customer Address: 5025 Thomas Edison Dr Waldford MD
PO Number:
CRM Order Number: End of Rental

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.

This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).

In the attached measurement results, deviation may be expressed with units, Measured Value (MV) - Nominal Value (NV) or as a proportion of the nominal value ((MV-NV)/NV), expressed without units with a scalar multiplier such as % (0.01), or as a ratio of the units (mA/A, μ V/V, etc.)

Descriptions such as μ A/A, μ V/V, and others, where used to annotate results or column headings are the preferred replacements for what was historically labeled as "ppm" or parts-per-million and described the results in that column, unless otherwise noted by units symbols.

Where applicable, the expanded uncertainty of measurement at the time of test is given in the following pages. They are calculated in accordance with the method described in the ISO Guide to the Expression of Uncertainty in Measurement (GUM). The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k, such that the confidence level approximates 95%.

This Calibration certificate may contain data that is not covered by the A2LA Scope of Accreditation. Unaccredited material, where applicable is indicated by an asterisk (*), or confined to clearly marked sections. Functional (Pass / Fail) tests are not accredited.

No statement of compliance with specifications is made or implied on this certificate. However, measurement results are reviewed, where applicable, to establish where any measurement result exceeded the manufacturer's specifications.

Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Standards Utilized

Asset ID.	Manufacturer	Model No.	Description	Cal. Date	Due Date
L-3132	Fluke	FLUK-5520A	Calibrators / Standards (10037)	10/28/2015	10/28/2016

Calibration Performed By:		Authorized by:	
Vancelette, John M	Technician	Javier Estrada	02/07/2017
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1113236	CAL DATE: 29 March 2017
ASSET NUMBER: 1011	CAL DUE: 29 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5 CAL UNITS: psia

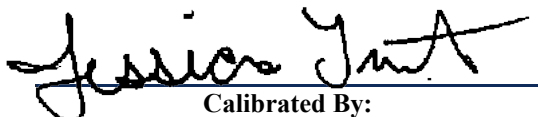
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA01011

Calibrated Span = 5 PSI

Calibration Tolerance = 0.00325 PSI

Upscale Tests

0.5000 psi	0.500psi	0.00325psi	0	Pass	6.1e-004psi
1.2500 psi	1.249psi	0.00325psi	30.8	Pass	6.1e-004psi
2.5000 psi	2.500psi	0.00325psi	0	Pass	6.1e-004psi
3.7500 psi	3.750psi	0.00325psi	0	Pass	6.5e-004psi
5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi

Downscale Tests

5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi
3.7500 psi	3.750psi	0.00325psi	0	Pass	6.5e-004psi
2.5000 psi	2.500psi	0.00325psi	0	Pass	6.1e-004psi
1.2500 psi	1.250psi	0.00325psi	0	Pass	6.1e-004psi
0.5000 psi	0.500psi	0.00325psi	0	Pass	6.1e-004psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1060094	CAL DATE: 29 March 2017
ASSET NUMBER: 1014	CAL DUE: 29 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5
	CAL UNITS: psia

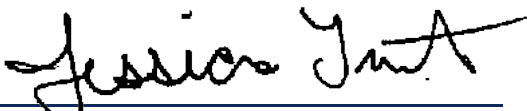
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA01014
Calibrated Span = 5 PSI
Calibration Tolerance = 0.00325 PSI

Upscale Tests

0.5000 psi	0.499psi	0.00325psi	30.8	Pass	6.1e-004psi
1.2500 psi	1.249psi	0.00325psi	30.8	Pass	6.1e-004psi
2.5000 psi	2.500psi	0.00325psi	0	Pass	6.1e-004psi
3.7500 psi	3.750psi	0.00325psi	0	Pass	6.5e-004psi
5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi

Downscale Tests

5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi
3.7500 psi	3.750psi	0.00325psi	0	Pass	6.5e-004psi
2.5000 psi	2.500psi	0.00325psi	0	Pass	6.1e-004psi
1.2500 psi	1.250psi	0.00325psi	0	Pass	6.1e-004psi
0.5000 psi	0.500psi	0.00325psi	0	Pass	6.1e-004psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 125248	CAL DATE: 03 April 2017
ASSET NUMBER: 1059	CAL DUE: 03 April 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150
	CAL UNITS: psia

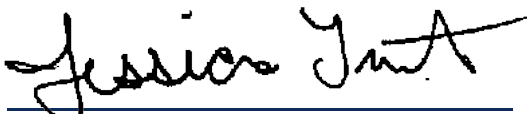
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA01059
Calibrated Span = 150 PSI
Calibration Tolerance = 0.0975 PSI

Upscale Tests

15.0000 psi	15.006psi	0.0975psi	6.15	Pass	7.3e-003psi
37.5000 psi	37.505psi	0.0975psi	5.13	Pass	7.3e-003psi
75.0000 psi	74.992psi	0.0975psi	8.21	Pass	7.3e-003psi
112.5000 psi	112.492psi	0.0975psi	8.21	Pass	9.0e-003psi
150.0000 psi	149.996psi	0.0975psi	4.1	Pass	1.2e-002psi

Downscale Tests

150.0000 psi	150.006psi	0.0975psi	6.15	Pass	1.2e-002psi
112.5000 psi	112.503psi	0.0975psi	3.08	Pass	9.0e-003psi
75.0000 psi	75.004psi	0.0975psi	4.1	Pass	7.3e-003psi
37.5000 psi	37.503psi	0.0975psi	3.08	Pass	7.3e-003psi
15.0000 psi	15.000psi	0.0975psi	0	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1543986	CAL DATE: 29 March 2017
ASSET NUMBER: 1074	CAL DUE: 29 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5 CAL UNITS: psia

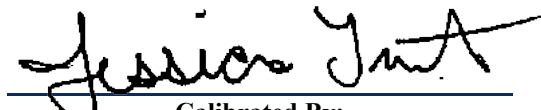
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA01074
Calibrated Span = 5 PSI
Calibration Tolerance = 0.00325 PSI

Upscale Tests

0.5000 psi	0.499psi	0.00325psi	30.8	Pass	6.1e-004psi
1.2500 psi	1.249psi	0.00325psi	30.8	Pass	6.1e-004psi
2.5000 psi	2.499psi	0.00325psi	30.8	Pass	6.1e-004psi
3.7500 psi	3.750psi	0.00325psi	0	Pass	6.5e-004psi
5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi

Downscale Tests

5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi
3.7500 psi	3.750psi	0.00325psi	0	Pass	6.5e-004psi
2.5000 psi	2.499psi	0.00325psi	30.8	Pass	6.1e-004psi
1.2500 psi	1.249psi	0.00325psi	30.8	Pass	6.1e-004psi
0.5000 psi	0.500psi	0.00325psi	0	Pass	6.1e-004psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1099228	CAL DATE: 29 March 2017
ASSET NUMBER: 1081	CAL DUE: 29 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5 CAL UNITS: psia

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA01081
Calibrated Span = 5 PSI
Calibration Tolerance = 0.00325 PSI

Upscale Tests

0.5000 psi	0.499psi	0.00325psi	30.8	Pass	6.1e-004psi
1.2500 psi	1.249psi	0.00325psi	30.8	Pass	6.1e-004psi
2.5000 psi	2.499psi	0.00325psi	30.8	Pass	6.1e-004psi
3.7500 psi	3.749psi	0.00325psi	30.8	Pass	6.5e-004psi
5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi

Downscale Tests

5.0000 psi	5.000psi	0.00325psi	0	Pass	7.0e-004psi
3.7500 psi	3.749psi	0.00325psi	30.8	Pass	6.5e-004psi
2.5000 psi	2.499psi	0.00325psi	30.8	Pass	6.1e-004psi
1.2500 psi	1.249psi	0.00325psi	30.8	Pass	6.1e-004psi
0.5000 psi	0.500psi	0.00325psi	0	Pass	6.1e-004psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1046926	CAL DATE: 29 March 2017
ASSET NUMBER: 1082	CAL DUE: 29 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5 CAL UNITS: psia

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA01082
Calibrated Span = 5 PSI
Calibration Tolerance = 0.00325 PSI

Upscale Tests

0.5000 psi	0.499psi	0.00325psi	30.8	Pass	6.1e-004psi
1.2500 psi	1.249psi	0.00325psi	30.8	Pass	6.1e-004psi
2.5000 psi	2.499psi	0.00325psi	30.8	Pass	6.1e-004psi
3.7500 psi	3.749psi	0.00325psi	30.8	Pass	6.5e-004psi
5.0000 psi	4.999psi	0.00325psi	30.8	Pass	7.0e-004psi

Downscale Tests

5.0000 psi	4.999psi	0.00325psi	30.8	Pass	7.0e-004psi
3.7500 psi	3.749psi	0.00325psi	30.8	Pass	6.5e-004psi
2.5000 psi	2.499psi	0.00325psi	30.8	Pass	6.1e-004psi
1.2500 psi	1.248psi	0.00325psi	61.5	Pass	6.1e-004psi
0.5000 psi	0.500psi	0.00325psi	0	Pass	6.1e-004psi

***** End of Report *****

UNIT UNDER TEST: Agilent 34970A Data Logger	TEST RESULT: PASS
SERIAL NUMBER: US37030138	CAL DATE: 10 May 2017
ASSET NUMBER: 2010	CAL DUE: 10 May 2018
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



 Calibrated By:



 Approved By:

Standards Used				
Asset #	Description	Serial #	Cal Date	Due Date
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	-0.0038mV		94.8	Pass		
1 VDC Range						
0.000000 V	-0.000004V		53.9	Pass		
10 VDC Range						
0.00000 V	-0.00001V		10	Pass		
100 VDC Range						
0.0000 V	-0.0000V		2.17	Pass		
300 VDC Range						
0.000 V	0.000V		0.889	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	-0.0001Ohm		0.0101	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	-0.0004Ohm		8.85	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	0.000000kOhm		0.0129	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	-0.000000kOhm		1.3	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	-0.00003kOhm		2.75	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	-0.00000kOhm		3.8	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0004kOhm		19	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	-0.0000kOhm		3.8	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	-0.000000MOhm		4.55	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	0.000000MOhm		2.5	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	-0.00001MOhm		12.4	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00001MOhm		5	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mADC Range						
0.00000 mA	-0.00001mA		0.625	Pass		
100 mADC Range						
0.00000 mA	-0.00005mA		0.98	Pass		
1 ADC Range						
0.000000 A	-0.000003A		2.77	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	49.9948mV	0.00000650V	80.7	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	99.9929mV	9.00000000001e-006	79.2	Pass	2.3e-006V	3.00
1V Range						
0.500000 V	0.4999917V	2.70000000001e-005	30.6	Pass	5.8e-006V	3.60
1.000000 V	0.999987V	4.69999999999e-005	27.1	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00000V	0.000225V	0.933	Pass	6.2e-005V	2.81
10.00000 V	9.99999V	0.000400000000001V	2.57	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0002V	0.00285V	5.4	Pass	8.2e-004V	2.71
100.0000 V	100.0000V	0.00510V	0	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	150.0004V	0.01575V	2.48	Pass	2.2e-003V	
300.0000 V	300.0003V	0.02250V	1.42	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	100.0118mV	0.00010000V	11.8	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	100.0012mV	0.00017000V	0.694	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	1.000125V	0.0010000V	12.5	Pass	1.6e-004V	
1.000000 V @ 50 kHz	1.000126V	0.0017000V	7.39	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	10.00094V	0.010000V	9.44	Pass	1.6e-003V	
10.00000 V @ 50 kHz	10.00029V	0.017000V	1.72	Pass	3.2e-003V	
10.00000 V @ 10 Hz	9.99910V	0.010000V	9	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	100.0266V	0.10000V	26.6	Pass	1.6e-002V	
100.0000 V @ 50 kHz	99.9773V	0.17000V	13.3	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	300.121V	0.4200V	28.9	Pass	4.6e-002V	
300.000 V @ 50 kHz	300.130V	0.7200V	18.1	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	100.1101Ohm	1.01400Ohm	10.9	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	1.000109kOhm	1.1100Ohm	9.83	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00009kOhm	2.100Ohm	4.19	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	99.9999kOhm	12.00Ohm	0.758	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000021MOhm	111.0Ohm	19	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	10.00039MOhm	4100Ohm	9.44	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	99.6151MOhm	810000Ohm	47.5	Pass	4.1e+004Ohm	
4-WIRE OHMS: 100 Ohm Range 100.0000 Ohm	99.9956Ohm	0.01400Ohm	31.2	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	0.999998kOhm	0.1100Ohm	2.09	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	10.00002kOhm	1.100Ohm	1.55	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	100.0003kOhm	11.00Ohm	2.82	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	99.9773Hz	0.10000Hz	22.7	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0002kHz	10.00Hz	1.7	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	9.99964mA	0.000007000A	5.18	Pass	9.7e-007A	
100mA Range 100.0000 mA	99.9958mA	0.00005500A	7.72	Pass	9.7e-006A	
1A Range 1.000000 A	0.999901A	0.0011000A	9.02	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99990mA	0.000014000A	0.748	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	100.1164mA	0.00060000A	19.4	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	1.000226A	0.0014000A	16.2	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: Data Logger	TEST RESULT: PASS
SERIAL NUMBER: MY41005806	CAL DATE: 10 May 2017
ASSET NUMBER: 2028	CAL DUE: 10 May 2018
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as left.



 Calibrated By:



 Approved By:

Standards Used				
Asset #	Description	Serial #	Cal Date	Due Date
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	-0.0005mV		12.7	Pass		
1 VDC Range						
0.000000 V	-0.000001V		11.1	Pass		
10 VDC Range						
0.00000 V	0.00000V		0	Pass		
100 VDC Range						
0.0000 V	0.0000V		2.17	Pass		
300 VDC Range						
0.000 V	0.000V		0.556	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	-0.0001Ohm		0.0141	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	-0.0002Ohm		3.88	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	0.000002kOhm		0.166	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	-0.000000kOhm		1.3	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	-0.00001kOhm		0.827	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	0.00000kOhm		1.3	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0001kOhm		4.55	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	0.0000kOhm		2.6	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	0.000000MOhm		2.36	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	0.000000MOhm		0	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	-0.00000MOhm		2.57	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00000MOhm		2.6	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mADC Range						
0.00000 mA	0.00005mA		2.47	Pass		
100 mADC Range						
0.00000 mA	0.00000mA		0	Pass		
1 ADC Range						
0.000000 A	0.000002A		2.22	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	49.9995mV	0.00000650V	7.28	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	99.9993mV	0.00000900V	7.9	Pass	2.3e-006V	3.00
1V Range						
0.5000000 V	0.5000002V	0.00002700V	0.667	Pass	5.8e-006V	3.60
1.000000 V	1.000000V	0.0000470V	0.638	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00000V	0.000225V	1.64	Pass	6.2e-005V	2.81
10.00000 V	10.00000V	0.000400000000001V	1.17	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0001V	0.00285V	3.65	Pass	8.2e-004V	2.71
100.0000 V	99.9999V	0.00510V	1.02	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	149.9994V	0.01575V	3.68	Pass	2.2e-003V	
300.0000 V	299.9971V	0.02250V	13.1	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	99.9990mV	0.00010000V	0.974	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	99.9660mV	0.00017000V	20	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	0.999997V	0.0010000V	0.262	Pass	1.6e-004V	
1.000000 V @ 50 kHz	0.999988V	0.0017000V	0.682	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	10.00014V	0.010000V	1.35	Pass	1.6e-003V	
10.00000 V @ 50 kHz	9.99893V	0.017000V	6.31	Pass	3.2e-003V	
10.00000 V @ 10 Hz	10.00010V	0.010000V	1.02	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	100.0014V	0.10000V	1.36	Pass	1.6e-002V	
100.0000 V @ 50 kHz	100.0258V	0.17000V	15.2	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	300.011V	0.4200V	2.61	Pass	4.6e-002V	
300.000 V @ 50 kHz	300.060V	0.7200V	8.32	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	100.1176Ohm	1.01400Ohm	11.6	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	1.000118kOhm	1.1100Ohm	10.6	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00013kOhm	2.100Ohm	6.14	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	100.0001kOhm	12.00Ohm	0.75	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000005MOhm	111.0Ohm	4.59	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	10.00008MOhm	4100Ohm	1.88	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	99.9416MOhm	810000Ohm	7.21	Pass	4.1e+004Ohm	
4-WIRE OHMS: 100 Ohm Range 100.0000 Ohm	100.0003Ohm	0.01400Ohm	2.14	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	1.000002kOhm	0.1100Ohm	1.45	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	10.00003kOhm	1.100Ohm	3.09	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	100.0001kOhm	11.00Ohm	0.636	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	100.0449Hz	0.10000Hz	44.9	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0002kHz	10.00Hz	1.6	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	10.00003mA	0.000007000A	0.457	Pass	9.7e-007A	
100mA Range 100.0000 mA	100.0002mA	0.00005500A	0.364	Pass	9.7e-006A	
1A Range 1.000000 A	0.999956A	0.0011000A	4.03	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99850mA	0.000014000A	10.7	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	99.9658mA	0.00060000A	5.7	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	1.000117A	0.0014000A	8.34	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: Power Meter, Digital	TEST RESULT: PASS
SERIAL NUMBER: 32-69374	CAL DATE: 11 May 2017
ASSET NUMBER: 9131	CAL DUE: 11 May 2018
PROCEDURE NAME: Nexus 1250/1252/1500: CAL VER 60Hz	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 03/28/17	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."


Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Unit is operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	3/14/2017	3/14/2018
14002	Rotek MSB100 Power and Energy Standard	173	2/25/2017	2/25/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AC VOLTAGE TESTS - 60Hz						
Phase A -						
100.000 V	100.0140V	0.08000V	17.5	Pass	1.6e-002V	3.81
120.000 V	120.0130V	0.09600V	13.5	Pass	1.9e-002V	3.87
240.000 V	240.0410V	0.19200V	21.4	Pass	3.7e-002V	
Phase B -						
100.000 V	100.0110V	0.08000V	13.7	Pass	1.6e-002V	3.81
120.000 V	120.0150V	0.09600V	15.6	Pass	1.9e-002V	3.87
240.000 V	240.0420V	0.19200V	21.9	Pass	3.7e-002V	
Phase C -						
100.000 V	100.0200V	0.08000V	25	Pass	1.6e-002V	3.81
120.000 V	120.0200V	0.09600V	20.8	Pass	1.9e-002V	3.87
240.000 V	240.0410V	0.19200V	21.4	Pass	3.7e-002V	
AC CURRENT TESTS - 60Hz						
Phase A - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase B - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase C - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase A - 2.5A Range						
2.50060 A	2.4999A	0.00200A	35	Pass	6.5e-004A	3.11
Phase B - 2.5A Range						
2.50060 A	2.5005A	0.00200A	5	Pass	6.5e-004A	3.11
Phase C - 2.5A Range						
2.50060 A	2.5008A	0.00200A	10	Pass	6.5e-004A	3.11
Phase A - 5A Range						
5.00170 A	5.0009A	0.00400A	20	Pass	1.3e-003A	3.11
Phase B - 5A Range						
5.00170 A	5.0020A	0.00400A	7.5	Pass	1.3e-003A	3.11
Phase C - 5A Range						
5.00160 A	5.0019A	0.00400A	7.5	Pass	1.3e-003A	3.11
AC WATT TESTS - 60Hz - PF 1.0						
Phase A - 1A Range						
120.03250 W	120.0229W	0.09600W	10	Pass	7.6e-003W	
Phase B - 1A Range						
120.03240 W	120.0376W	0.09600W	5.42	Pass	7.6e-003W	
Phase C - 1A Range						
120.03310 W	120.0543W	0.09600W	22.1	Pass	7.6e-003W	
Phase A - 2.5A Range						

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
300.07280 W	299.9951W	0.24000W	32.4	Pass	3.5e-002W	
Phase B - 2.5A Range						
300.07200 W	300.0721W	0.24010W	0.0416	Pass	3.5e-002W	
Phase C - 2.5A Range						
300.07330 W	300.1334W	0.24000W	25	Pass	3.5e-002W	
Phase A - 5A Range						
600.20020 W	600.0889W	0.48000W	23.2	Pass	1.4e-001W	
Phase B - 5A Range						
600.19600 W	600.2154W	0.48000W	4.04	Pass	1.4e-001W	
Phase C - 5A Range						
600.20180 W	600.2774W	0.48000W	15.7	Pass	1.4e-001W	
AC WATT TESTS - 60Hz - PF 0.75 Lead/Lag						
Phase A - 0.75 Lag						
450.27520 W	450.2192W	0.36000W	15.6	Pass	9.0e+002W	
Phase B - 0.75 Lag						
450.27480 W	450.2617W	0.36000W	3.64	Pass	8.7e-003W	
Phase C - 0.75 Lag						
450.27190 W	450.2956W	0.36000W	6.58	Pass	8.7e-003W	
Phase A - 0.75 Lead						
450.00550 W	449.7418W	0.36000W	73.2	Pass	9.0e+002W	
Phase B - 0.75 Lead						
450.00320 W	449.8639W	0.36000W	38.7	Pass	8.7e-003W	
Phase C - 0.75 Lead						
450.00480 W	449.9557W	0.36000W	13.6	Pass	8.7e-003W	

***** End of Report *****

UNIT UNDER TEST: Data Logger	TEST RESULT: PASS
SERIAL NUMBER: US37018653	CAL DATE: 11 May 2017
ASSET NUMBER: 10063	CAL DUE: 11 May 2018
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	-0.0018mV		43.9	Pass		
1 VDC Range						
0.000000 V	-0.000001V		20.6	Pass		
10 VDC Range						
0.00000 V	0.00000V		0	Pass		
100 VDC Range						
0.0000 V	-0.0000V		6.5	Pass		
300 VDC Range						
0.000 V	0.000V		0	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	0.0002Ohm		0.0198	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	0.0030Ohm		76.1	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	0.000000kOhm		0.0257	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	0.000003kOhm		34.4	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	-0.00001kOhm		1.33	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	0.00004kOhm		35.7	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0002kOhm		8.6	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	0.0003kOhm		30.4	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	0.000000MOhm		2.36	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	0.000001MOhm		7.9	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	0.00000MOhm		0	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00001MOhm		10.6	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mA DC Range						
0.00000 mA	-0.00001mA		0.4	Pass		
100 mA DC Range						
0.00000 mA	0.00003mA		0.52	Pass		
1 A DC Range						
0.000000 A	-0.000002A		2.49	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	50.0000mV	6.50000000001e-006	0.477	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	100.0009mV	9.00000000001e-006	10.1	Pass	2.3e-006V	3.00
1V Range						
0.500000 V	0.5000064V	0.00002700V	23.7	Pass	5.8e-006V	3.60
1.000000 V	1.000014V	0.0000470V	30.4	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00009V	0.000225V	41.4	Pass	6.2e-005V	2.81
10.00000 V	10.00019V	0.000400000000001V	46.5	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0004V	0.00285V	15.4	Pass	8.2e-004V	2.71
100.0000 V	100.0006V	0.00510V	12.5	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	150.0008V	0.01575V	5.27	Pass	2.2e-003V	
300.0000 V	299.9999V	0.02250V	0.622	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	99.9769mV	0.00010000V	23.1	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	99.9979mV	0.00017000V	1.22	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	0.999759V	0.0010000V	24.1	Pass	1.6e-004V	
1.000000 V @ 50 kHz	0.999650V	0.0017000V	20.6	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	9.99785V	0.010000V	21.5	Pass	1.6e-003V	
10.00000 V @ 50 kHz	10.00241V	0.017000V	14.1	Pass	3.2e-003V	
10.00000 V @ 10 Hz	9.99753V	0.010000V	24.7	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	99.9824V	0.10000V	17.6	Pass	1.6e-002V	
100.0000 V @ 50 kHz	100.0268V	0.17000V	15.7	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	299.940V	0.4200V	14.4	Pass	4.6e-002V	
300.000 V @ 50 kHz	300.046V	0.7200V	6.32	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	100.1144Ohm	1.01400Ohm	11.3	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	1.000128kOhm	1.1100Ohm	11.5	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00026kOhm	2.100Ohm	12.3	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	100.0019kOhm	12.00Ohm	15.5	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000023MOhm	111.0Ohm	20.5	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	9.99982MOhm	4100Ohm	4.42	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	99.8297MOhm	810000Ohm	21	Pass	4.1e+004Ohm	
4-WIRE OHMS: 100 Ohm Range 100.0000 Ohm	99.9994Ohm	0.01400Ohm	3.97	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	1.000015kOhm	0.1100Ohm	13.7	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	10.00019kOhm	1.100Ohm	17.4	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	100.0024kOhm	11.00Ohm	21.4	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	99.9908Hz	0.10000Hz	9.2	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0000kHz	10.00Hz	0.21	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	10.00069mA	0.000007000A	9.84	Pass	9.7e-007A	
100mA Range 100.0000 mA	100.0055mA	0.00005500A	10.1	Pass	9.7e-006A	
1A Range 1.000000 A	0.999862A	0.0011000A	12.6	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99715mA	0.000014000A	20.3	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	99.7810mA	0.00060000A	36.5	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	0.999723A	0.0014000A	19.8	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6056	CAL DATE: 26 April 2017
ASSET NUMBER: 10221	CAL DUE: 26 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT010221

Probe Calibration Range = 20 to 200 Deg F
= -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F						
Resistance Value at Temp = 97.42927 Ohms						
20.4130 F	20.407F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 103.93317 Ohms						
50.3650 F	50.370F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 110.3995 Ohms						
80.3220 F	80.330F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 116.839 Ohms						
110.3400 F	110.338F	0.2590F	0.772	Pass	3.4e-002F	
Resistance Value at Temp = 123.2445 Ohms						
140.3640 F	140.360F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 129.61817 Ohms						
170.4160 F	170.407F	0.2590F	3.47	Pass	3.4e-002F	
Resistance Value at Temp = 135.95383 Ohms						
200.4420 F	200.450F	0.2590F	3.09	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.42927 Ohms						
-6.4370 c	-6.441c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 103.93317 Ohms						
10.2030 c	10.206c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 110.3995 Ohms						
26.8460 c	26.850c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 116.839 Ohms						
43.5220 c	43.521c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 123.2445 Ohms						
60.2030 c	60.200c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 129.61817 Ohms						
76.8980 c	76.893c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 135.95383 Ohms						
93.5790 c	93.583c	0.1440c	2.78	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
where T = Deg C and Rt = Resistance at Temp
 $T = \frac{[-RoA + \sqrt{(Ro^2 \cdot A^2 - 4Ro \cdot B \cdot (Ro - Rt))}]}{2 \cdot Ro \cdot B}$
Ro= 99.95008
Alpha= 0.003844891
Delta= 1.73472031169
A= 0.00391158910514
B= -6.66981051394e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 5791	CAL DATE: 10 April 2017
ASSET NUMBER: 10224	CAL DUE: 10 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14016	Rosemount Aerospace 162CE SPRT	4211	8/19/2016	8/19/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT010224
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.24533 Ohms	125.1290 F	125.218F	0.5000F	17.8	Pass	1.2e-001F
Resistance Value at Temp = 154.433 Ohms	287.5700 F	287.441F	0.5000F	25.8	Pass	1.2e-001F
Resistance Value at Temp = 187.78083 Ohms	450.0740 F	450.017F	0.5000F	11.4	Pass	1.2e-001F
Resistance Value at Temp = 220.22317 Ohms	612.5820 F	612.643F	0.5000F	12.2	Pass	1.2e-001F
Resistance Value at Temp = 251.73767 Ohms	775.1300 F	775.207F	0.5000F	15.4	Pass	1.2e-001F
Resistance Value at Temp = 282.328 Ohms	937.7220 F	937.723F	0.5000F	0.2	Pass	1.2e-001F
Resistance Value at Temp = 311.98633 Ohms	1100.1840 F	1100.141F	0.5000F	8.6	Pass	1.2e-001F

*****Degrees C*****

Resistance Value at Temp = 120.24533 Ohms	51.7380 c	51.788c	0.2780c	18	Pass	6.4e-002c
Resistance Value at Temp = 154.433 Ohms	141.9830 c	141.912c	0.2780c	25.5	Pass	6.4e-002c
Resistance Value at Temp = 187.78083 Ohms	232.2630 c	232.232c	0.2780c	11.2	Pass	6.4e-002c
Resistance Value at Temp = 220.22317 Ohms	322.5460 c	322.580c	0.2780c	12.2	Pass	6.4e-002c
Resistance Value at Temp = 251.73767 Ohms	412.8500 c	412.893c	0.2780c	15.5	Pass	6.4e-002c
Resistance Value at Temp = 282.328 Ohms	503.1790 c	503.179c	0.2780c	0	Pass	6.4e-002c
Resistance Value at Temp = 311.98633 Ohms	593.4350 c	593.412c	0.2780c	8.27	Pass	6.4e-002c

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \sqrt{Ro^2 A^2 - 4Ro * B(Ro - Rt)}] / (2 * Ro * B)$$

 Ro= 100.18769
 Alpha= 0.003838779
 Delta= 1.45872995149
 A= 0.00389477641904
 B= -5.59974190444e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 10831	CAL DATE: 13 April 2017
ASSET NUMBER: 10502	CAL DUE: 13 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

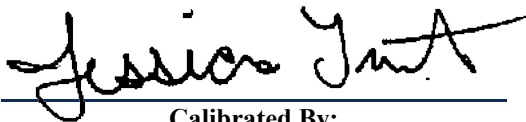
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT010502
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.3415 Ohms						
125.1020 F	125.009F	0.5000F	18.6	Pass	1.2e-001F	
Resistance Value at Temp = 154.681 Ohms						
287.4470 F	287.597F	0.5000F	30	Pass	1.2e-001F	
Resistance Value at Temp = 188.03233 Ohms						
449.8780 F	449.901F	0.5000F	4.6	Pass	1.2e-001F	
Resistance Value at Temp = 220.47967 Ohms						
612.3750 F	612.323F	0.5000F	10.4	Pass	1.2e-001F	
Resistance Value at Temp = 252.00767 Ohms						
774.8490 F	774.794F	0.5000F	11	Pass	1.2e-001F	
Resistance Value at Temp = 282.62333 Ohms						
937.3750 F	937.356F	0.5000F	3.8	Pass	1.2e-001F	
Resistance Value at Temp = 312.30617 Ohms						
1099.8570 F	1099.903F	0.5000F	9.2	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.3415 Ohms						
51.7230 c	51.671c	0.2780c	18.7	Pass	6.4e-002c	
Resistance Value at Temp = 154.681 Ohms						
141.9150 c	141.998c	0.2780c	29.9	Pass	6.4e-002c	
Resistance Value at Temp = 188.03233 Ohms						
232.1540 c	232.167c	0.2780c	4.68	Pass	6.4e-002c	
Resistance Value at Temp = 220.47967 Ohms						
322.4300 c	322.402c	0.2780c	10.1	Pass	6.4e-002c	
Resistance Value at Temp = 252.00767 Ohms						
412.6940 c	412.663c	0.2780c	11.2	Pass	6.4e-002c	
Resistance Value at Temp = 282.62333 Ohms						
502.9860 c	502.975c	0.2780c	3.96	Pass	6.4e-002c	
Resistance Value at Temp = 312.30617 Ohms						
593.2540 c	593.279c	0.2780c	8.99	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.27917

Alpha= 0.003844379

Delta= 1.47923469527

A= 0.00390124638799

B= -5.68673879856e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 10827	CAL DATE: 10 April 2017
ASSET NUMBER: 10504	CAL DUE: 10 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14016	Rosemount Aerospace 162CE SPRT	4211	8/19/2016	8/19/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT010504
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F						
Resistance Value at Temp = 120.71583 Ohms						
125.1290 F	125.062F	0.5000F	13.4	Pass	1.2e-001F	
Resistance Value at Temp = 155.13833 Ohms						
287.5700 F	287.629F	0.5000F	11.8	Pass	1.2e-001F	
Resistance Value at Temp = 188.60817 Ohms						
450.0740 F	450.145F	0.5000F	14.2	Pass	1.2e-001F	
Resistance Value at Temp = 221.12783 Ohms						
612.5820 F	612.617F	0.5000F	7	Pass	1.2e-001F	
Resistance Value at Temp = 252.70083 Ohms						
775.1300 F	775.059F	0.5000F	14.2	Pass	1.2e-001F	
Resistance Value at Temp = 283.34833 Ohms						
937.7220 F	937.583F	0.5000F	27.8	Pass	1.2e-001F	
Resistance Value at Temp = 313.08817 Ohms						
1100.1840 F	1100.296F	0.5000F	22.4	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.71583 Ohms						
51.7380 c	51.701c	0.2780c	13.3	Pass	6.4e-002c	
Resistance Value at Temp = 155.13833 Ohms						
141.9830 c	142.016c	0.2780c	11.9	Pass	6.4e-002c	
Resistance Value at Temp = 188.60817 Ohms						
232.2630 c	232.303c	0.2780c	14.4	Pass	6.4e-002c	
Resistance Value at Temp = 221.12783 Ohms						
322.5460 c	322.565c	0.2780c	6.83	Pass	6.4e-002c	
Resistance Value at Temp = 252.70083 Ohms						
412.8500 c	412.811c	0.2780c	14	Pass	6.4e-002c	
Resistance Value at Temp = 283.34833 Ohms						
503.1790 c	503.102c	0.2780c	27.7	Pass	6.4e-002c	
Resistance Value at Temp = 313.08817 Ohms						
593.4350 c	593.498c	0.2780c	22.7	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}] / (2 * Ro * B)$
 Ro= 100.58668
 Alpha= 0.003842948
 Delta= 1.49401848189
 A= 0.00390036235337
 B= -5.74143533696e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 10846	CAL DATE: 11 April 2017
ASSET NUMBER: 10507	CAL DUE: 11 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT010507
Probe Calibration Range = 125 to 1100 Deg F
= 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.399 Ohms						
125.1040 F	125.114F	0.5000F	2	Pass	1.2e-001F	
Resistance Value at Temp = 154.61917 Ohms						
287.6000 F	287.630F	0.5000F	6	Pass	1.2e-001F	
Resistance Value at Temp = 187.905 Ohms						
450.0950 F	450.022F	0.5000F	14.6	Pass	1.2e-001F	
Resistance Value at Temp = 220.31333 Ohms						
612.5950 F	612.570F	0.5000F	5	Pass	1.2e-001F	
Resistance Value at Temp = 251.81133 Ohms						
775.0680 F	775.115F	0.5000F	9.4	Pass	1.2e-001F	
Resistance Value at Temp = 282.3905 Ohms						
937.5450 F	937.610F	0.5000F	13	Pass	1.2e-001F	
Resistance Value at Temp = 312.02133 Ohms						
1099.9420 F	1099.888F	0.5000F	10.8	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.399 Ohms						
51.7240 c	51.730c	0.2780c	2.16	Pass	6.4e-002c	
Resistance Value at Temp = 154.61917 Ohms						
142.0000 c	142.017c	0.2780c	6.12	Pass	6.4e-002c	
Resistance Value at Temp = 187.905 Ohms						
232.2750 c	232.235c	0.2780c	14.4	Pass	6.4e-002c	
Resistance Value at Temp = 220.31333 Ohms						
322.5530 c	322.539c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 251.81133 Ohms						
412.8160 c	412.841c	0.2780c	8.99	Pass	6.4e-002c	
Resistance Value at Temp = 282.3905 Ohms						
503.0800 c	503.117c	0.2780c	13.3	Pass	6.4e-002c	
Resistance Value at Temp = 312.02133 Ohms						
593.3010 c	593.271c	0.2780c	10.8	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
Ro= 100.38254
Alpha= 0.003827827
Delta= 1.45168729324
A= 0.00388339507817
B= -5.55680781662e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 10851	CAL DATE: 14 April 2017
ASSET NUMBER: 10512	CAL DUE: 14 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

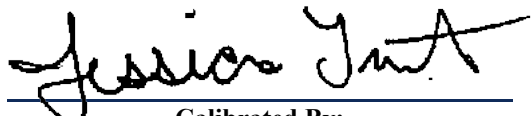
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT010512
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.25133 Ohms						
125.0950 F	125.097F	0.5000F	0.4	Pass	1.2e-001F	
Resistance Value at Temp = 154.437 Ohms						
287.4450 F	287.468F	0.5000F	4.6	Pass	1.2e-001F	
Resistance Value at Temp = 187.70383 Ohms						
449.8770 F	449.837F	0.5000F	8	Pass	1.2e-001F	
Resistance Value at Temp = 220.08167 Ohms						
612.3720 F	612.356F	0.5000F	3.2	Pass	1.2e-001F	
Resistance Value at Temp = 251.53583 Ohms						
774.8290 F	774.854F	0.5000F	5	Pass	1.2e-001F	
Resistance Value at Temp = 282.08133 Ohms						
937.3810 F	937.413F	0.5000F	6.4	Pass	1.2e-001F	
Resistance Value at Temp = 311.682 Ohms						
1099.8610 F	1099.835F	0.5000F	5.2	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.25133 Ohms						
51.7200 c	51.720c	0.2780c	0	Pass	6.4e-002c	
Resistance Value at Temp = 154.437 Ohms						
141.9140 c	141.927c	0.2780c	4.68	Pass	6.4e-002c	
Resistance Value at Temp = 187.70383 Ohms						
232.1540 c	232.132c	0.2780c	7.91	Pass	6.4e-002c	
Resistance Value at Temp = 220.08167 Ohms						
322.4290 c	322.420c	0.2780c	3.24	Pass	6.4e-002c	
Resistance Value at Temp = 251.53583 Ohms						
412.6830 c	412.697c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 282.08133 Ohms						
502.9890 c	503.007c	0.2780c	6.47	Pass	6.4e-002c	
Resistance Value at Temp = 311.682 Ohms						
593.2560 c	593.242c	0.2780c	5.04	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.23663

Alpha= 0.00383348

Delta= 1.4684386638

A= 0.00388977230249

B= -5.62923024892e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: TT16032	CAL DATE: 12 April 2017
ASSET NUMBER: 16032	CAL DUE: 12 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

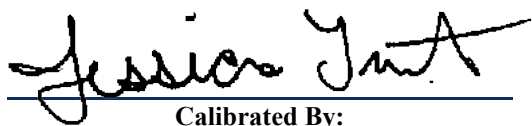
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT016032
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 119.89417 Ohms						
125.1080 F	125.083F	0.5000F	5	Pass	1.2e-001F	
Resistance Value at Temp = 154.06083 Ohms						
287.4720 F	287.559F	0.5000F	17.4	Pass	1.2e-001F	
Resistance Value at Temp = 187.27467 Ohms						
449.9220 F	449.853F	0.5000F	13.8	Pass	1.2e-001F	
Resistance Value at Temp = 219.62233 Ohms						
612.4310 F	612.391F	0.5000F	8	Pass	1.2e-001F	
Resistance Value at Temp = 251.0545 Ohms						
774.9110 F	774.936F	0.5000F	5	Pass	1.2e-001F	
Resistance Value at Temp = 281.57717 Ohms						
937.4660 F	937.521F	0.5000F	11	Pass	1.2e-001F	
Resistance Value at Temp = 311.15067 Ohms						
1099.9630 F	1099.928F	0.5000F	7	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 119.89417 Ohms						
51.7270 c	51.713c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 154.06083 Ohms						
141.9290 c	141.977c	0.2780c	17.3	Pass	6.4e-002c	
Resistance Value at Temp = 187.27467 Ohms						
232.1790 c	232.141c	0.2780c	13.7	Pass	6.4e-002c	
Resistance Value at Temp = 219.62233 Ohms						
322.4620 c	322.440c	0.2780c	7.91	Pass	6.4e-002c	
Resistance Value at Temp = 251.0545 Ohms						
412.7280 c	412.742c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 281.57717 Ohms						
503.0360 c	503.067c	0.2780c	11.2	Pass	6.4e-002c	
Resistance Value at Temp = 311.15067 Ohms						
593.3130 c	593.293c	0.2780c	7.19	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2A^2 - 4RoB(Ro - Rt)}}{2RoB}$$

Ro= 99.90727

Alpha= 0.003841402

Delta= 1.46482646332

A= 0.00389767187306

B= -5.62698730583e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2245	CAL DATE: 12 April 2017
ASSET NUMBER: 16047	CAL DUE: 12 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

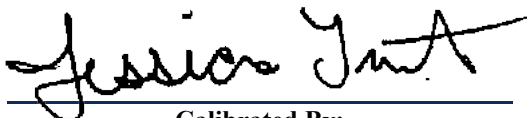
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT016047
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.362 Ohms						
125.1080 F	125.037F	0.5000F	14.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.70833 Ohms						
287.4720 F	287.605F	0.5000F	26.6	Pass	1.2e-001F	
Resistance Value at Temp = 188.0555 Ohms						
449.9220 F	449.907F	0.5000F	3	Pass	1.2e-001F	
Resistance Value at Temp = 220.494 Ohms						
612.4310 F	612.379F	0.5000F	10.4	Pass	1.2e-001F	
Resistance Value at Temp = 251.999 Ohms						
774.9110 F	774.907F	0.5000F	0.8	Pass	1.2e-001F	
Resistance Value at Temp = 282.56133 Ohms						
937.4660 F	937.446F	0.5000F	4	Pass	1.2e-001F	
Resistance Value at Temp = 312.17967 Ohms						
1099.9630 F	1099.991F	0.5000F	5.6	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.362 Ohms						
51.7270 c	51.687c	0.2780c	14.4	Pass	6.4e-002c	
Resistance Value at Temp = 154.70833 Ohms						
141.9290 c	142.003c	0.2780c	26.6	Pass	6.4e-002c	
Resistance Value at Temp = 188.0555 Ohms						
232.1790 c	232.171c	0.2780c	2.88	Pass	6.4e-002c	
Resistance Value at Temp = 220.494 Ohms						
322.4620 c	322.433c	0.2780c	10.4	Pass	6.4e-002c	
Resistance Value at Temp = 251.999 Ohms						
412.7280 c	412.726c	0.2780c	0.719	Pass	6.4e-002c	
Resistance Value at Temp = 282.56133 Ohms						
503.0360 c	503.026c	0.2780c	3.6	Pass	6.4e-002c	
Resistance Value at Temp = 312.17967 Ohms						
593.3130 c	593.328c	0.2780c	5.4	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.28058
 Alpha= 0.003846409
 Delta= 1.50213804408
 A= 0.00390418737292
 B= -5.777837292e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2394	CAL DATE: 11 April 2017
ASSET NUMBER: 16080	CAL DUE: 11 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT016080
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.43633 Ohms						
125.1040 F	125.118F	0.5000F	2.8	Pass	1.2e-001F	
Resistance Value at Temp = 154.781 Ohms						
287.6000 F	287.565F	0.5000F	7	Pass	1.2e-001F	
Resistance Value at Temp = 188.20667 Ohms						
450.0950 F	450.112F	0.5000F	3.4	Pass	1.2e-001F	
Resistance Value at Temp = 220.684 Ohms						
612.5950 F	612.617F	0.5000F	4.4	Pass	1.2e-001F	
Resistance Value at Temp = 252.208 Ohms						
775.0680 F	775.052F	0.5000F	3.2	Pass	1.2e-001F	
Resistance Value at Temp = 282.80317 Ohms						
937.5450 F	937.541F	0.5000F	0.8	Pass	1.2e-001F	
Resistance Value at Temp = 312.44367 Ohms						
1099.9420 F	1099.946F	0.5000F	0.8	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.43633 Ohms						
51.7240 c	51.732c	0.2780c	2.88	Pass	6.4e-002c	
Resistance Value at Temp = 154.781 Ohms						
142.0000 c	141.981c	0.2780c	6.83	Pass	6.4e-002c	
Resistance Value at Temp = 188.20667 Ohms						
232.2750 c	232.284c	0.2780c	3.24	Pass	6.4e-002c	
Resistance Value at Temp = 220.684 Ohms						
322.5530 c	322.565c	0.2780c	4.32	Pass	6.4e-002c	
Resistance Value at Temp = 252.208 Ohms						
412.8160 c	412.806c	0.2780c	3.6	Pass	6.4e-002c	
Resistance Value at Temp = 282.80317 Ohms						
503.0800 c	503.078c	0.2780c	0.719	Pass	6.4e-002c	
Resistance Value at Temp = 312.44367 Ohms						
593.3010 c	593.303c	0.2780c	0.719	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.32595

Alpha= 0.003847048

Delta= 1.4936750614

A= 0.00390451039658

B= -5.7462396576e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2256	CAL DATE: 26 April 2017
ASSET NUMBER: 20062	CAL DUE: 26 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

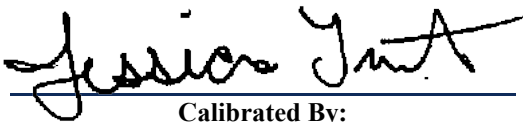
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2464	CAL DATE: 13 April 2017
ASSET NUMBER: 20072	CAL DUE: 13 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100 CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT020072
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.10283 Ohms						
125.1020 F	125.212F	0.5000F	22	Pass	1.2e-001F	
Resistance Value at Temp = 154.07433 Ohms						
287.4470 F	287.360F	0.5000F	17.4	Pass	1.2e-001F	
Resistance Value at Temp = 187.2085 Ohms						
449.8780 F	449.702F	0.5000F	35.2	Pass	1.2e-001F	
Resistance Value at Temp = 219.53383 Ohms						
612.3750 F	612.399F	0.5000F	4.8	Pass	1.2e-001F	
Resistance Value at Temp = 250.95783 Ohms						
774.8490 F	774.997F	0.5000F	29.6	Pass	1.2e-001F	
Resistance Value at Temp = 281.48083 Ohms						
937.3750 F	937.487F	0.5000F	22.4	Pass	1.2e-001F	
Resistance Value at Temp = 311.0785 Ohms						
1099.8570 F	1099.725F	0.5000F	26.4	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.10283 Ohms						
51.7230 c	51.784c	0.2780c	21.9	Pass	6.4e-002c	
Resistance Value at Temp = 154.07433 Ohms						
141.9150 c	141.867c	0.2780c	17.3	Pass	6.4e-002c	
Resistance Value at Temp = 187.2085 Ohms						
232.1540 c	232.057c	0.2780c	34.9	Pass	6.4e-002c	
Resistance Value at Temp = 219.53383 Ohms						
322.4300 c	322.444c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 250.95783 Ohms						
412.6940 c	412.776c	0.2780c	29.5	Pass	6.4e-002c	
Resistance Value at Temp = 281.48083 Ohms						
502.9860 c	503.048c	0.2780c	22.3	Pass	6.4e-002c	
Resistance Value at Temp = 311.0785 Ohms						
593.2540 c	593.181c	0.2780c	26.3	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.17751

Alpha= 0.003814951

Delta= 1.4128672766

A= 0.0038688511943

B= -5.39001942972e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2492	CAL DATE: 13 April 2017
ASSET NUMBER: 20119	CAL DUE: 13 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

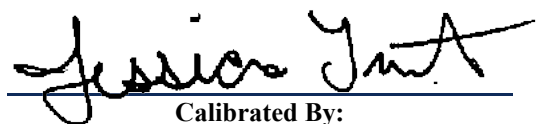
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT020119
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.15617 Ohms						
125.1020 F	125.207F	0.5000F	21	Pass	1.2e-001F	
Resistance Value at Temp = 154.17183 Ohms						
287.4470 F	287.394F	0.5000F	10.6	Pass	1.2e-001F	
Resistance Value at Temp = 187.32283 Ohms						
449.8780 F	449.667F	0.5000F	42.2	Pass	1.2e-001F	
Resistance Value at Temp = 219.674 Ohms						
612.3750 F	612.365F	0.5000F	2	Pass	1.2e-001F	
Resistance Value at Temp = 251.13217 Ohms						
774.8490 F	775.037F	0.5000F	37.6	Pass	1.2e-001F	
Resistance Value at Temp = 281.66633 Ohms						
937.3750 F	937.511F	0.5000F	27.2	Pass	1.2e-001F	
Resistance Value at Temp = 311.26433 Ohms						
1099.8570 F	1099.702F	0.5000F	31	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.15617 Ohms						
51.7230 c	51.782c	0.2780c	21.2	Pass	6.4e-002c	
Resistance Value at Temp = 154.17183 Ohms						
141.9150 c	141.885c	0.2780c	10.8	Pass	6.4e-002c	
Resistance Value at Temp = 187.32283 Ohms						
232.1540 c	232.037c	0.2780c	42.1	Pass	6.4e-002c	
Resistance Value at Temp = 219.674 Ohms						
322.4300 c	322.425c	0.2780c	1.8	Pass	6.4e-002c	
Resistance Value at Temp = 251.13217 Ohms						
412.6940 c	412.798c	0.2780c	37.4	Pass	6.4e-002c	
Resistance Value at Temp = 281.66633 Ohms						
502.9860 c	503.062c	0.2780c	27.3	Pass	6.4e-002c	
Resistance Value at Temp = 311.26433 Ohms						
593.2540 c	593.168c	0.2780c	30.9	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 100.20843

Alpha= 0.003818111

Delta= 1.42008562715

A= 0.00387233144554

B= -5.42204455396e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2427	CAL DATE: 17 April 2017
ASSET NUMBER: 20171	CAL DUE: 17 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

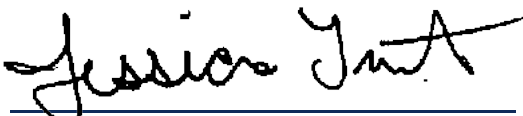
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT020171
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.26033 Ohms						
125.1000 F	125.128F	0.5000F	5.6	Pass	1.2e-001F	
Resistance Value at Temp = 154.489 Ohms						
287.4490 F	287.415F	0.5000F	6.8	Pass	1.2e-001F	
Resistance Value at Temp = 187.8225 Ohms						
449.8780 F	449.852F	0.5000F	5.2	Pass	1.2e-001F	
Resistance Value at Temp = 220.24633 Ohms						
612.3650 F	612.375F	0.5000F	2	Pass	1.2e-001F	
Resistance Value at Temp = 251.73667 Ohms						
774.8320 F	774.869F	0.5000F	7.4	Pass	1.2e-001F	
Resistance Value at Temp = 282.29967 Ohms						
937.3620 F	937.364F	0.5000F	0.4	Pass	1.2e-001F	
Resistance Value at Temp = 311.93133 Ohms						
1099.8560 F	1099.838F	0.5000F	3.6	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.26033 Ohms						
51.7220 c	51.738c	0.2780c	5.76	Pass	6.4e-002c	
Resistance Value at Temp = 154.489 Ohms						
141.9160 c	141.897c	0.2780c	6.83	Pass	6.4e-002c	
Resistance Value at Temp = 187.8225 Ohms						
232.1540 c	232.140c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 220.24633 Ohms						
322.4250 c	322.431c	0.2780c	2.16	Pass	6.4e-002c	
Resistance Value at Temp = 251.73667 Ohms						
412.6850 c	412.705c	0.2780c	7.19	Pass	6.4e-002c	
Resistance Value at Temp = 282.29967 Ohms						
502.9790 c	502.980c	0.2780c	0.36	Pass	6.4e-002c	
Resistance Value at Temp = 311.93133 Ohms						
593.2540 c	593.244c	0.2780c	3.6	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.2007

Alpha= 0.003842014

Delta= 1.47821575009

A= 0.00389880725607

B= -5.67932560688e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2589	CAL DATE: 14 April 2017
ASSET NUMBER: 20262	CAL DUE: 14 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT020262
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.52067 Ohms						
125.0950 F	125.114F	0.5000F	3.8	Pass	1.2e-001F	
Resistance Value at Temp = 154.8135 Ohms						
287.4450 F	287.434F	0.5000F	2.2	Pass	1.2e-001F	
Resistance Value at Temp = 188.19767 Ohms						
449.8770 F	449.833F	0.5000F	8.8	Pass	1.2e-001F	
Resistance Value at Temp = 220.6865 Ohms						
612.3720 F	612.387F	0.5000F	3	Pass	1.2e-001F	
Resistance Value at Temp = 252.234 Ohms						
774.8290 F	774.868F	0.5000F	7.8	Pass	1.2e-001F	
Resistance Value at Temp = 282.85983 Ohms						
937.3810 F	937.376F	0.5000F	1	Pass	1.2e-001F	
Resistance Value at Temp = 312.55217 Ohms						
1099.8610 F	1099.848F	0.5000F	2.6	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.52067 Ohms						
51.7200 c	51.730c	0.2780c	3.6	Pass	6.4e-002c	
Resistance Value at Temp = 154.8135 Ohms						
141.9140 c	141.908c	0.2780c	2.16	Pass	6.4e-002c	
Resistance Value at Temp = 188.19767 Ohms						
232.1540 c	232.130c	0.2780c	8.63	Pass	6.4e-002c	
Resistance Value at Temp = 220.6865 Ohms						
322.4290 c	322.437c	0.2780c	2.88	Pass	6.4e-002c	
Resistance Value at Temp = 252.234 Ohms						
412.6830 c	412.704c	0.2780c	7.55	Pass	6.4e-002c	
Resistance Value at Temp = 282.85983 Ohms						
502.9890 c	502.987c	0.2780c	0.719	Pass	6.4e-002c	
Resistance Value at Temp = 312.55217 Ohms						
593.2560 c	593.249c	0.2780c	2.52	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = \frac{-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}}{2 * Ro * B}$

Ro= 100.43133

Alpha= 0.00383949

Delta= 1.47461378573

A= 0.00389610764884

B= -5.66176488416e-007

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1368313	CAL DATE: 25 April 2017
ASSET NUMBER: 20274	CAL DUE: 25 April 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Dave Price	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20274
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	14.979psi	0.5200psi	4.04	Pass	7.3e-003psi
200.0000 psi	200.168psi	0.5200psi	32.3	Pass	1.6e-002psi
400.0000 psi	400.148psi	0.5200psi	28.5	Pass	3.2e-002psi
600.0000 psi	600.078psi	0.5200psi	15	Pass	4.8e-002psi
800.0000 psi	799.953psi	0.5200psi	9.04	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	799.953psi	0.5200psi	9.04	Pass	6.4e-002psi
600.0000 psi	600.078psi	0.5200psi	15	Pass	4.8e-002psi
400.0000 psi	400.148psi	0.5200psi	28.5	Pass	3.2e-002psi
200.0000 psi	200.141psi	0.5200psi	27.1	Pass	1.6e-002psi
15.0000 psi	14.979psi	0.5200psi	4.04	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1859806	CAL DATE: 08 May 2017
ASSET NUMBER: 20276	CAL DUE: 08 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~250 CAL UNITS: In-H2O

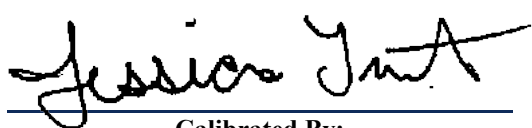
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20276
Calibrated Span = 250 inH2O
Calibration Tolerance = 0.1625 inH2O

Upscale Tests

0.0000 inH2O	0.001inH2O	0.1625inH2O	0.615	Pass	5.8e-003inH2O
62.5000 inH2O	62.507inH2O	0.1625inH2O	4.31	Pass	5.8e-003inH2O
125.0000 inH2O	125.012inH2O	0.1625inH2O	7.38	Pass	1.0e-002inH2O
187.5000 inH2O	187.488inH2O	0.1625inH2O	7.38	Pass	1.5e-002inH2O
250.0000 inH2O	250.000inH2O	0.1625inH2O	0	Pass	2.0e-002inH2O

Downscale Tests

250.0000 inH2O	250.000inH2O	0.1625inH2O	0	Pass	2.0e-002inH2O
187.5000 inH2O	187.504inH2O	0.1625inH2O	2.46	Pass	1.5e-002inH2O
125.0000 inH2O	125.031inH2O	0.1625inH2O	19.1	Pass	1.0e-002inH2O
62.5000 inH2O	62.537inH2O	0.1625inH2O	22.8	Pass	5.8e-003inH2O
0.0000 inH2O	-0.002inH2O	0.1625inH2O	1.23	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1036528	CAL DATE: 25 April 2017
ASSET NUMBER: 20298	CAL DUE: 25 April 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Dave Price	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20298
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	15.033psi	0.5200psi	6.35	Pass	7.3e-003psi
200.0000 psi	200.058psi	0.5200psi	11.2	Pass	1.6e-002psi
400.0000 psi	400.034psi	0.5200psi	6.54	Pass	3.2e-002psi
600.0000 psi	600.020psi	0.5200psi	3.85	Pass	4.8e-002psi
800.0000 psi	799.993psi	0.5200psi	1.35	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	800.000psi	0.5200psi	0	Pass	6.4e-002psi
600.0000 psi	600.012psi	0.5200psi	2.31	Pass	4.8e-002psi
400.0000 psi	400.034psi	0.5200psi	6.54	Pass	3.2e-002psi
200.0000 psi	200.058psi	0.5200psi	11.2	Pass	1.6e-002psi
15.0000 psi	15.060psi	0.5200psi	11.5	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2088	CAL DATE: 06 April 2017
ASSET NUMBER: 20432	CAL DUE: 06 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

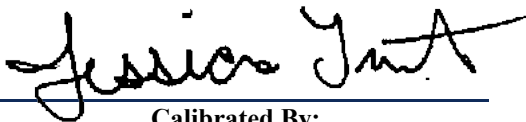
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT020432
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.24817 Ohms						
125.1110 F	125.254F	0.5000F	28.6	Pass	1.2e-001F	
Resistance Value at Temp = 154.36217 Ohms						
287.4820 F	287.288F	0.5000F	38.8	Pass	1.2e-001F	
Resistance Value at Temp = 187.66733 Ohms						
449.8520 F	449.758F	0.5000F	18.8	Pass	1.2e-001F	
Resistance Value at Temp = 220.10583 Ohms						
612.3590 F	612.410F	0.5000F	10.2	Pass	1.2e-001F	
Resistance Value at Temp = 251.619 Ohms						
774.8020 F	774.950F	0.5000F	29.6	Pass	1.2e-001F	
Resistance Value at Temp = 282.208 Ohms						
937.3360 F	937.376F	0.5000F	8	Pass	1.2e-001F	
Resistance Value at Temp = 311.8795 Ohms						
1099.8080 F	1099.714F	0.5000F	18.8	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.24817 Ohms						
51.7280 c	51.808c	0.2780c	28.8	Pass	6.4e-002c	
Resistance Value at Temp = 154.36217 Ohms						
141.9350 c	141.826c	0.2780c	39.2	Pass	6.4e-002c	
Resistance Value at Temp = 187.66733 Ohms						
232.1400 c	232.088c	0.2780c	18.7	Pass	6.4e-002c	
Resistance Value at Temp = 220.10583 Ohms						
322.4220 c	322.450c	0.2780c	10.1	Pass	6.4e-002c	
Resistance Value at Temp = 251.619 Ohms						
412.6680 c	412.750c	0.2780c	29.5	Pass	6.4e-002c	
Resistance Value at Temp = 282.208 Ohms						
502.9640 c	502.987c	0.2780c	8.27	Pass	6.4e-002c	
Resistance Value at Temp = 311.8795 Ohms						
593.2260 c	593.174c	0.2780c	18.7	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.20789

Alpha= 0.003833536

Delta= 1.44125023735

A= 0.0038887868467

B= -5.5250846699e-007

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 298573	CAL DATE: 15 May 2017
ASSET NUMBER: 20491	CAL DUE: 15 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

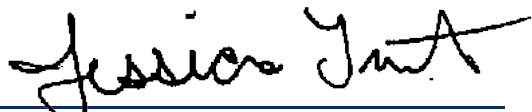
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.19PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.1900 psi	14.279psi	1.9500psi	4.56	Pass	2.2e-003psi
513.1550 psi	514.016psi	1.9500psi	44.2	Pass	7.7e-002psi
1012.6380 psi	1013.516psi	1.9500psi	45	Pass	1.5e-001psi
2011.6050 psi	2011.906psi	1.9500psi	15.4	Pass	3.0e-001psi
3010.5710 psi	3010.500psi	1.9500psi	3.64	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.5710 psi	3010.563psi	1.9500psi	0.41	Pass	4.5e-001psi
2011.6050 psi	2012.094psi	1.9500psi	25.1	Pass	3.0e-001psi
1012.6380 psi	1013.594psi	1.9500psi	49	Pass	1.5e-001psi
513.1550 psi	513.891psi	1.9500psi	37.7	Pass	7.7e-002psi
14.1900 psi	14.279psi	1.9500psi	4.56	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1016394	CAL DATE: 12 May 2017
ASSET NUMBER: 20511	CAL DUE: 12 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia

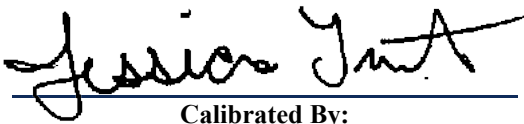
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

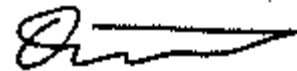
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20511
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	15.033psi	0.5200psi	6.35	Pass	7.3e-003psi
200.0000 psi	200.058psi	0.5200psi	11.2	Pass	1.6e-002psi
400.0000 psi	400.008psi	0.5200psi	1.54	Pass	3.2e-002psi
600.0000 psi	600.038psi	0.5200psi	7.31	Pass	4.8e-002psi
800.0000 psi	800.015psi	0.5200psi	2.88	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	800.015psi	0.5200psi	2.88	Pass	6.4e-002psi
600.0000 psi	600.038psi	0.5200psi	7.31	Pass	4.8e-002psi
400.0000 psi	400.034psi	0.5200psi	6.54	Pass	3.2e-002psi
200.0000 psi	200.058psi	0.5200psi	11.2	Pass	1.6e-002psi
15.0000 psi	15.033psi	0.5200psi	6.35	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1457872	CAL DATE: 16 May 2017
ASSET NUMBER: 20522	CAL DUE: 16 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

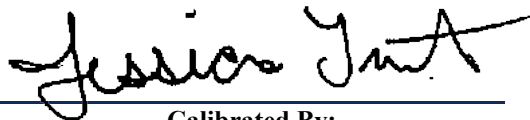
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

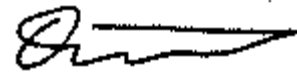
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.22PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.2200 psi	14.278psi	1.9500psi	2.97	Pass	2.2e-003psi
513.1850 psi	513.224psi	1.9500psi	2	Pass	7.7e-002psi
1012.6680 psi	1012.820psi	1.9500psi	7.79	Pass	1.5e-001psi
2011.6340 psi	2011.814psi	1.9500psi	9.23	Pass	3.0e-001psi
3010.6000 psi	3010.877psi	1.9500psi	14.2	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.6000 psi	3010.730psi	1.9500psi	6.67	Pass	4.5e-001psi
2011.6340 psi	2012.012psi	1.9500psi	19.4	Pass	3.0e-001psi
1012.6680 psi	1012.983psi	1.9500psi	16.2	Pass	1.5e-001psi
513.1850 psi	513.483psi	1.9500psi	15.3	Pass	7.7e-002psi
14.2200 psi	14.459psi	1.9500psi	12.3	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1339337	CAL DATE: 31 March 2017
ASSET NUMBER: 20536	CAL DUE: 31 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

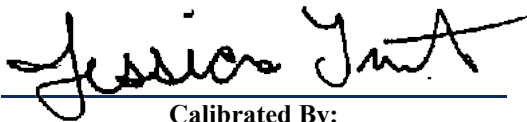
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20536
Calibrated Span = 25 inH2O
Calibration Tolerance = 0.025 inH2O

Upscale Tests

0.0000 inH2O	-0.006inH2O	0.0250inH2O	24	Pass	5.8e-003inH2O
6.2500 inH2O	6.251inH2O	0.0250inH2O	4	Pass	5.8e-003inH2O
12.5000 inH2O	12.500inH2O	0.0250inH2O	0	Pass	5.8e-003inH2O
18.7500 inH2O	18.750inH2O	0.0250inH2O	0	Pass	5.8e-003inH2O
25.0000 inH2O	25.002inH2O	0.0250inH2O	8	Pass	5.8e-003inH2O

Downscale Tests

25.0000 inH2O	24.998inH2O	0.0250inH2O	8	Pass	5.8e-003inH2O
18.7500 inH2O	18.750inH2O	0.0250inH2O	0	Pass	5.8e-003inH2O
12.5000 inH2O	12.499inH2O	0.0250inH2O	4	Pass	5.8e-003inH2O
6.2500 inH2O	6.252inH2O	0.0250inH2O	8	Pass	5.8e-003inH2O
0.0000 inH2O	0.001inH2O	0.0250inH2O	4	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1989407	CAL DATE: 31 March 2017
ASSET NUMBER: 20604	CAL DUE: 31 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.


Calibrated By: _____


Approved By: _____

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20604
Calibrated Span = 25 inH2O
Calibration Tolerance = 0.025 inH2O

Upscale Tests

0.0000 inH2O	-0.007inH2O	0.0250inH2O	28	Pass	5.8e-003inH2O
6.2500 inH2O	6.244inH2O	0.0250inH2O	24	Pass	5.8e-003inH2O
12.5000 inH2O	12.490inH2O	0.0250inH2O	40	Pass	5.8e-003inH2O
18.7500 inH2O	18.740inH2O	0.0250inH2O	40	Pass	5.8e-003inH2O
25.0000 inH2O	25.000inH2O	0.0250inH2O	0	Pass	5.8e-003inH2O

Downscale Tests

25.0000 inH2O	25.002inH2O	0.0250inH2O	8	Pass	5.8e-003inH2O
18.7500 inH2O	18.746inH2O	0.0250inH2O	16	Pass	5.8e-003inH2O
12.5000 inH2O	12.498inH2O	0.0250inH2O	8	Pass	5.8e-003inH2O
6.2500 inH2O	6.245inH2O	0.0250inH2O	20	Pass	5.8e-003inH2O
0.0000 inH2O	-0.009inH2O	0.0250inH2O	36	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 61300106	CAL DATE: 03 April 2017
ASSET NUMBER: 20690	CAL DUE: 03 April 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150
	CAL UNITS: psia

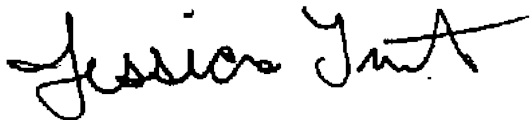
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

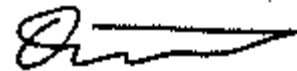
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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20690
Calibrated Span = 150 PSI
Calibration Tolerance = 0.0975 PSI

Upscale Tests

15.0000 psi	14.992psi	0.0975psi	8.21	Pass	7.3e-003psi
37.5000 psi	37.494psi	0.0975psi	6.15	Pass	7.3e-003psi
75.0000 psi	74.992psi	0.0975psi	8.21	Pass	7.3e-003psi
112.5000 psi	112.492psi	0.0975psi	8.21	Pass	9.0e-003psi
150.0000 psi	149.992psi	0.0975psi	8.21	Pass	1.2e-002psi

Downscale Tests

150.0000 psi	150.000psi	0.0975psi	0	Pass	1.2e-002psi
112.5000 psi	112.492psi	0.0975psi	8.21	Pass	9.0e-003psi
75.0000 psi	74.992psi	0.0975psi	8.21	Pass	7.3e-003psi
37.5000 psi	37.501psi	0.0975psi	1.03	Pass	7.3e-003psi
15.0000 psi	15.002psi	0.0975psi	2.05	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1852835	CAL DATE: 11 May 2017
ASSET NUMBER: 20705	CAL DUE: 11 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~350
	CAL UNITS: In-H2O

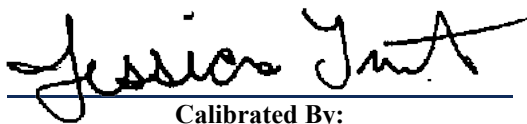
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20705
Calibrated Span = 350 inH2O
Calibration Tolerance = 0.2275 inH2O

Upscale Tests

0.0000 inH2O	0.007inH2O	0.2275inH2O	3.08	Pass	5.8e-003inH2O
87.5000 inH2O	87.461inH2O	0.2275inH2O	17.1	Pass	7.0e-003inH2O
175.0000 inH2O	174.945inH2O	0.2275inH2O	24.2	Pass	1.4e-002inH2O
262.5000 inH2O	262.484inH2O	0.2275inH2O	7.03	Pass	2.1e-002inH2O
350.0000 inH2O	350.000inH2O	0.2275inH2O	0	Pass	2.8e-002inH2O

Downscale Tests

350.0000 inH2O	350.000inH2O	0.2275inH2O	0	Pass	2.8e-002inH2O
262.5000 inH2O	262.508inH2O	0.2275inH2O	3.52	Pass	2.1e-002inH2O
175.0000 inH2O	175.008inH2O	0.2275inH2O	3.52	Pass	1.4e-002inH2O
87.5000 inH2O	87.510inH2O	0.2275inH2O	4.4	Pass	7.0e-003inH2O
0.0000 inH2O	0.016inH2O	0.2275inH2O	7.03	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 71283	CAL DATE: 10 May 2017
ASSET NUMBER: 20722	CAL DUE: 10 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150 CAL UNITS: psia

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left.

 <hr style="width: 80%; margin: 0 auto;"/> Calibrated By:	 <hr style="width: 80%; margin: 0 auto;"/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20722
Calibrated Span = 150 PSI
Calibration Tolerance = 0.0975 PSI

Upscale Tests

15.0000 psi	15.005psi	0.0975psi	5.13	Pass	7.3e-003psi
37.5000 psi	37.506psi	0.0975psi	6.15	Pass	7.3e-003psi
75.0000 psi	75.010psi	0.0975psi	10.3	Pass	7.3e-003psi
112.5000 psi	112.506psi	0.0975psi	6.15	Pass	9.0e-003psi
150.0000 psi	149.999psi	0.0975psi	1.03	Pass	1.2e-002psi

Downscale Tests

150.0000 psi	150.006psi	0.0975psi	6.15	Pass	1.2e-002psi
112.5000 psi	112.510psi	0.0975psi	10.3	Pass	9.0e-003psi
75.0000 psi	75.003psi	0.0975psi	3.08	Pass	7.3e-003psi
37.5000 psi	37.506psi	0.0975psi	6.15	Pass	7.3e-003psi
15.0000 psi	15.010psi	0.0975psi	10.3	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 71272	CAL DATE: 10 May 2017
ASSET NUMBER: 20733	CAL DUE: 10 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150 CAL UNITS: psia

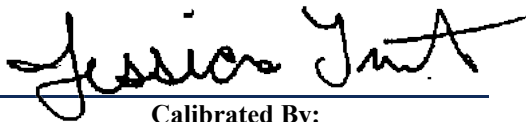
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20733
Calibrated Span = 150 PSI
Calibration Tolerance = 0.0975 PSI

Upscale Tests

15.0000 psi	15.014psi	0.0975psi	14.4	Pass	7.3e-003psi
37.5000 psi	37.511psi	0.0975psi	11.3	Pass	7.3e-003psi
75.0000 psi	75.008psi	0.0975psi	8.21	Pass	7.3e-003psi
112.5000 psi	112.511psi	0.0975psi	11.3	Pass	9.0e-003psi
150.0000 psi	150.000psi	0.0975psi	0	Pass	1.2e-002psi

Downscale Tests

150.0000 psi	150.000psi	0.0975psi	0	Pass	1.2e-002psi
112.5000 psi	112.511psi	0.0975psi	11.3	Pass	9.0e-003psi
75.0000 psi	75.019psi	0.0975psi	19.5	Pass	7.3e-003psi
37.5000 psi	37.513psi	0.0975psi	13.3	Pass	7.3e-003psi
15.0000 psi	15.001psi	0.0975psi	1.03	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 71280	CAL DATE: 10 May 2017
ASSET NUMBER: 20735	CAL DUE: 10 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150 CAL UNITS: psia

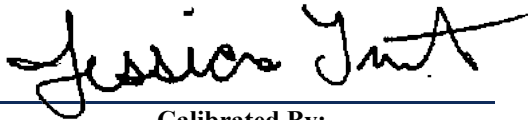
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

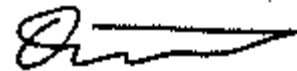
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20735
Calibrated Span = 150 PSI
Calibration Tolerance = 0.0975 PSI

Upscale Tests

15.0000 psi	15.007psi	0.0975psi	7.18	Pass	7.3e-003psi
37.5000 psi	37.506psi	0.0975psi	6.15	Pass	7.3e-003psi
75.0000 psi	75.010psi	0.0975psi	10.3	Pass	7.3e-003psi
112.5000 psi	112.506psi	0.0975psi	6.15	Pass	9.0e-003psi
150.0000 psi	150.004psi	0.0975psi	4.1	Pass	1.2e-002psi

Downscale Tests

150.0000 psi	150.002psi	0.0975psi	2.05	Pass	1.2e-002psi
112.5000 psi	112.511psi	0.0975psi	11.3	Pass	9.0e-003psi
75.0000 psi	75.000psi	0.0975psi	0	Pass	7.3e-003psi
37.5000 psi	37.500psi	0.0975psi	0	Pass	7.3e-003psi
15.0000 psi	15.008psi	0.0975psi	8.21	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 71279	CAL DATE: 10 May 2017
ASSET NUMBER: 20736	CAL DUE: 10 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150 CAL UNITS: psia

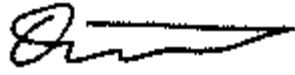
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20736
Calibrated Span = 150 PSI
Calibration Tolerance = 0.0975 PSI

Upscale Tests

15.0000 psi	15.000psi	0.0975psi	0	Pass	7.3e-003psi
37.5000 psi	37.491psi	0.0975psi	9.23	Pass	7.3e-003psi
75.0000 psi	75.005psi	0.0975psi	5.13	Pass	7.3e-003psi
112.5000 psi	112.501psi	0.0975psi	1.03	Pass	9.0e-003psi
150.0000 psi	150.010psi	0.0975psi	10.3	Pass	1.2e-002psi

Downscale Tests

150.0000 psi	150.008psi	0.0975psi	8.21	Pass	1.2e-002psi
112.5000 psi	112.507psi	0.0975psi	7.18	Pass	9.0e-003psi
75.0000 psi	74.995psi	0.0975psi	5.13	Pass	7.3e-003psi
37.5000 psi	37.494psi	0.0975psi	6.15	Pass	7.3e-003psi
15.0000 psi	14.993psi	0.0975psi	7.18	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1466932	CAL DATE: 16 May 2017
ASSET NUMBER: 20745	CAL DUE: 16 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

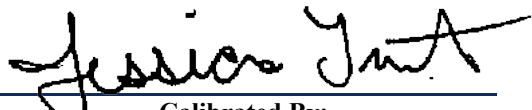
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.2274PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.2270 psi	14.548psi	1.9500psi	16.5	Pass	2.2e-003psi
513.1920 psi	513.565psi	1.9500psi	19.1	Pass	7.7e-002psi
1012.6750 psi	1013.074psi	1.9500psi	20.5	Pass	1.5e-001psi
2011.6410 psi	2011.549psi	1.9500psi	4.72	Pass	3.0e-001psi
3010.6070 psi	3010.846psi	1.9500psi	12.3	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.6070 psi	3010.788psi	1.9500psi	9.28	Pass	4.5e-001psi
2011.6410 psi	2012.347psi	1.9500psi	36.2	Pass	3.0e-001psi
1012.6750 psi	1013.471psi	1.9500psi	40.8	Pass	1.5e-001psi
513.1920 psi	514.012psi	1.9500psi	42.1	Pass	7.7e-002psi
14.2270 psi	14.683psi	1.9500psi	23.4	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1015724	CAL DATE: 25 April 2017
ASSET NUMBER: 20765	CAL DUE: 25 April 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Dave Price	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20765
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	14.979psi	0.5200psi	4.04	Pass	7.3e-003psi
200.0000 psi	199.950psi	0.5200psi	9.62	Pass	1.6e-002psi
400.0000 psi	399.981psi	0.5200psi	3.65	Pass	3.2e-002psi
600.0000 psi	599.987psi	0.5200psi	2.5	Pass	4.8e-002psi
800.0000 psi	800.000psi	0.5200psi	0	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	799.995psi	0.5200psi	0.962	Pass	6.4e-002psi
600.0000 psi	600.011psi	0.5200psi	2.12	Pass	4.8e-002psi
400.0000 psi	400.007psi	0.5200psi	1.35	Pass	3.2e-002psi
200.0000 psi	200.004psi	0.5200psi	0.769	Pass	1.6e-002psi
15.0000 psi	14.963psi	0.5200psi	7.12	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1036524	CAL DATE: 25 April 2017
ASSET NUMBER: 20777	CAL DUE: 25 April 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Dave Price	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800
	CAL UNITS: psia

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20777
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	15.033psi	0.5200psi	6.35	Pass	7.3e-003psi
200.0000 psi	200.112psi	0.5200psi	21.5	Pass	1.6e-002psi
400.0000 psi	400.142psi	0.5200psi	27.3	Pass	3.2e-002psi
600.0000 psi	600.119psi	0.5200psi	22.9	Pass	4.8e-002psi
800.0000 psi	799.988psi	0.5200psi	2.31	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	799.988psi	0.5200psi	2.31	Pass	6.4e-002psi
600.0000 psi	600.096psi	0.5200psi	18.5	Pass	4.8e-002psi
400.0000 psi	400.142psi	0.5200psi	27.3	Pass	3.2e-002psi
200.0000 psi	200.112psi	0.5200psi	21.5	Pass	1.6e-002psi
15.0000 psi	15.033psi	0.5200psi	6.35	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1015712	CAL DATE: 12 May 2017
ASSET NUMBER: 20789	CAL DUE: 12 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~400 CAL UNITS: psia

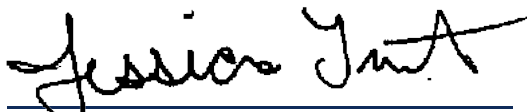
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20789
Calibrated Span = 400 PSI
Calibration Tolerance = 0.26 PSI

Upscale Tests

15.0000 psi	15.006psi	0.2600psi	2.31	Pass	7.3e-003psi
100.0000 psi	100.029psi	0.2600psi	11.2	Pass	8.0e-003psi
200.0000 psi	200.004psi	0.2600psi	1.54	Pass	1.6e-002psi
300.0000 psi	300.015psi	0.2600psi	5.77	Pass	2.4e-002psi
400.0000 psi	400.032psi	0.2600psi	12.3	Pass	3.2e-002psi

Downscale Tests

400.0000 psi	400.034psi	0.2600psi	13.1	Pass	3.2e-002psi
300.0000 psi	300.019psi	0.2600psi	7.31	Pass	2.4e-002psi
200.0000 psi	200.008psi	0.2600psi	3.08	Pass	1.6e-002psi
100.0000 psi	100.029psi	0.2600psi	11.2	Pass	8.0e-003psi
15.0000 psi	15.006psi	0.2600psi	2.31	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1924154	CAL DATE: 15 May 2017
ASSET NUMBER: 20976	CAL DUE: 15 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150
	CAL UNITS: In-H2O

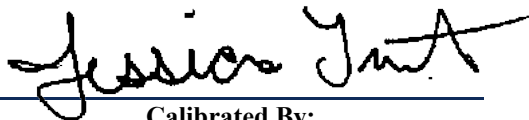
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20976
Calibrated Span = 150 inH2O
Calibration Tolerance = 0.0975 inH2O

Upscale Tests

0.0000 inH2O	0.001inH2O	0.0975inH2O	1.03	Pass	5.8e-003inH2O
37.5000 inH2O	37.490inH2O	0.0975inH2O	10.3	Pass	5.8e-003inH2O
75.0000 inH2O	74.992inH2O	0.0975inH2O	8.21	Pass	6.0e-003inH2O
112.5000 inH2O	112.496inH2O	0.0975inH2O	4.1	Pass	9.0e-003inH2O
150.0000 inH2O	149.998inH2O	0.0975inH2O	2.05	Pass	1.2e-002inH2O

Downscale Tests

150.0000 inH2O	149.999inH2O	0.0975inH2O	1.03	Pass	1.2e-002inH2O
112.5000 inH2O	112.511inH2O	0.0975inH2O	11.3	Pass	9.0e-003inH2O
75.0000 inH2O	74.994inH2O	0.0975inH2O	6.15	Pass	6.0e-003inH2O
37.5000 inH2O	37.494inH2O	0.0975inH2O	6.15	Pass	5.8e-003inH2O
0.0000 inH2O	-0.017inH2O	0.0975inH2O	17.4	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 91699105	CAL DATE: 15 May 2017
ASSET NUMBER: 20987	CAL DUE: 15 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150 CAL UNITS: In-H2O

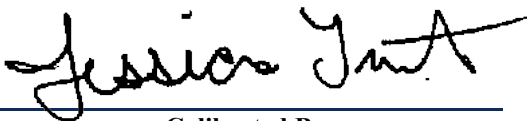
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20987
Calibrated Span = 150 inH2O
Calibration Tolerance = 0.0975 inH2O

Upscale Tests

0.0000 inH2O	-0.005inH2O	0.0975inH2O	5.13	Pass	5.8e-003inH2O
37.5000 inH2O	37.501inH2O	0.0975inH2O	1.03	Pass	5.8e-003inH2O
75.0000 inH2O	75.004inH2O	0.0975inH2O	4.1	Pass	6.0e-003inH2O
112.5000 inH2O	112.506inH2O	0.0975inH2O	6.15	Pass	9.0e-003inH2O
150.0000 inH2O	150.008inH2O	0.0975inH2O	8.21	Pass	1.2e-002inH2O

Downscale Tests

150.0000 inH2O	150.004inH2O	0.0975inH2O	4.1	Pass	1.2e-002inH2O
112.5000 inH2O	112.522inH2O	0.0975inH2O	22.6	Pass	9.0e-003inH2O
75.0000 inH2O	75.023inH2O	0.0975inH2O	23.6	Pass	6.0e-003inH2O
37.5000 inH2O	37.516inH2O	0.0975inH2O	16.4	Pass	5.8e-003inH2O
0.0000 inH2O	-0.014inH2O	0.0975inH2O	14.4	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 4270112	CAL DATE: 15 May 2017
ASSET NUMBER: 21050	CAL DUE: 15 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150
	CAL UNITS: In-H2O

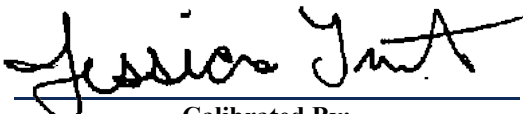
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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD21050
Calibrated Span = 150 inH2O
Calibration Tolerance = 0.0975 inH2O

Upscale Tests

0.0000 inH2O	-0.004inH2O	0.0975inH2O	4.1	Pass	5.8e-003inH2O
37.5000 inH2O	37.489inH2O	0.0975inH2O	11.3	Pass	5.8e-003inH2O
75.0000 inH2O	75.000inH2O	0.0975inH2O	0	Pass	6.0e-003inH2O
112.5000 inH2O	112.506inH2O	0.0975inH2O	6.15	Pass	9.0e-003inH2O
150.0000 inH2O	150.007inH2O	0.0975inH2O	7.18	Pass	1.2e-002inH2O

Downscale Tests

150.0000 inH2O	150.006inH2O	0.0975inH2O	6.15	Pass	1.2e-002inH2O
112.5000 inH2O	112.518inH2O	0.0975inH2O	18.5	Pass	9.0e-003inH2O
75.0000 inH2O	75.009inH2O	0.0975inH2O	9.23	Pass	6.0e-003inH2O
37.5000 inH2O	37.507inH2O	0.0975inH2O	7.18	Pass	5.8e-003inH2O
0.0000 inH2O	-0.012inH2O	0.0975inH2O	12.3	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1024700	CAL DATE: 15 May 2017
ASSET NUMBER: 21067	CAL DUE: 15 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150 CAL UNITS: In-H2O

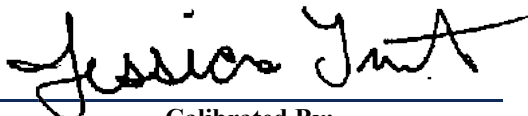
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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD21067
Calibrated Span = 150 inH2O
Calibration Tolerance = 0.0975 inH2O

Upscale Tests

0.0000 inH2O	0.000inH2O	0.0975inH2O	0	Pass	5.8e-003inH2O
37.5000 inH2O	37.498inH2O	0.0975inH2O	2.05	Pass	5.8e-003inH2O
75.0000 inH2O	75.004inH2O	0.0975inH2O	4.1	Pass	6.0e-003inH2O
112.5000 inH2O	112.502inH2O	0.0975inH2O	2.05	Pass	9.0e-003inH2O
150.0000 inH2O	150.002inH2O	0.0975inH2O	2.05	Pass	1.2e-002inH2O

Downscale Tests

150.0000 inH2O	150.000inH2O	0.0975inH2O	0	Pass	1.2e-002inH2O
112.5000 inH2O	112.519inH2O	0.0975inH2O	19.5	Pass	9.0e-003inH2O
75.0000 inH2O	75.021inH2O	0.0975inH2O	21.5	Pass	6.0e-003inH2O
37.5000 inH2O	37.515inH2O	0.0975inH2O	15.4	Pass	5.8e-003inH2O
0.0000 inH2O	0.000inH2O	0.0975inH2O	0	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1024701	CAL DATE: 15 May 2017
ASSET NUMBER: 21108	CAL DUE: 15 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150
	CAL UNITS: In-H2O

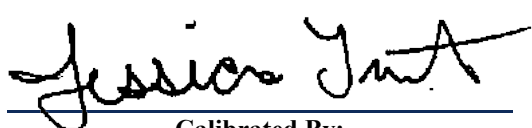
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD21108
Calibrated Span = 150 inH2O
Calibration Tolerance = 0.0975 inH2O

Upscale Tests

0.0000 inH2O	0.000inH2O	0.0975inH2O	0	Pass	5.8e-003inH2O
37.5000 inH2O	37.483inH2O	0.0975inH2O	17.4	Pass	5.8e-003inH2O
75.0000 inH2O	74.996inH2O	0.0975inH2O	4.1	Pass	6.0e-003inH2O
112.5000 inH2O	112.502inH2O	0.0975inH2O	2.05	Pass	9.0e-003inH2O
150.0000 inH2O	150.006inH2O	0.0975inH2O	6.15	Pass	1.2e-002inH2O

Downscale Tests

150.0000 inH2O	150.016inH2O	0.0975inH2O	16.4	Pass	1.2e-002inH2O
112.5000 inH2O	112.513inH2O	0.0975inH2O	13.3	Pass	9.0e-003inH2O
75.0000 inH2O	74.996inH2O	0.0975inH2O	4.1	Pass	6.0e-003inH2O
37.5000 inH2O	37.498inH2O	0.0975inH2O	2.05	Pass	5.8e-003inH2O
0.0000 inH2O	0.015inH2O	0.0975inH2O	15.4	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1344511	CAL DATE: 15 May 2017
ASSET NUMBER: 21122	CAL DUE: 15 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~150
	CAL UNITS: In-H2O

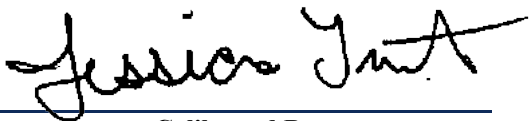
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Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD21122
Calibrated Span = 150 inH2O
Calibration Tolerance = 0.0975 inH2O

Upscale Tests

0.0000 inH2O	-0.008inH2O	0.0975inH2O	8.21	Pass	5.8e-003inH2O
37.5000 inH2O	37.489inH2O	0.0975inH2O	11.3	Pass	5.8e-003inH2O
75.0000 inH2O	74.985inH2O	0.0975inH2O	15.4	Pass	6.0e-003inH2O
112.5000 inH2O	112.492inH2O	0.0975inH2O	8.21	Pass	9.0e-003inH2O
150.0000 inH2O	150.001inH2O	0.0975inH2O	1.03	Pass	1.2e-002inH2O

Downscale Tests

150.0000 inH2O	150.001inH2O	0.0975inH2O	1.03	Pass	1.2e-002inH2O
112.5000 inH2O	112.510inH2O	0.0975inH2O	10.3	Pass	9.0e-003inH2O
75.0000 inH2O	75.000inH2O	0.0975inH2O	0	Pass	6.0e-003inH2O
37.5000 inH2O	37.489inH2O	0.0975inH2O	11.3	Pass	5.8e-003inH2O
0.0000 inH2O	-0.026inH2O	0.0975inH2O	26.7	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1764571	CAL DATE: 16 May 2017
ASSET NUMBER: 21128	CAL DUE: 16 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

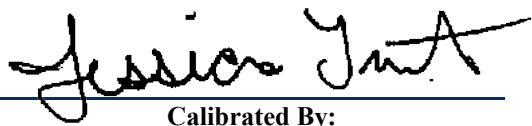
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

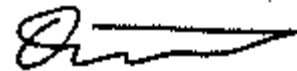
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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.22PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.2200 psi	14.279psi	1.9500psi	3.03	Pass	2.2e-003psi
513.1850 psi	513.222psi	1.9500psi	1.9	Pass	7.7e-002psi
1012.6680 psi	1012.740psi	1.9500psi	3.69	Pass	1.5e-001psi
2011.6340 psi	2011.904psi	1.9500psi	13.8	Pass	3.0e-001psi
3010.6000 psi	3010.801psi	1.9500psi	10.3	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.6000 psi	3010.778psi	1.9500psi	9.13	Pass	4.5e-001psi
2011.6340 psi	2011.979psi	1.9500psi	17.7	Pass	3.0e-001psi
1012.6680 psi	1012.973psi	1.9500psi	15.6	Pass	1.5e-001psi
513.1850 psi	513.431psi	1.9500psi	12.6	Pass	7.7e-002psi
14.2200 psi	14.279psi	1.9500psi	3.03	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 69293	CAL DATE: 11 May 2017
ASSET NUMBER: 21289	CAL DUE: 11 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~350 CAL UNITS: In-H2O

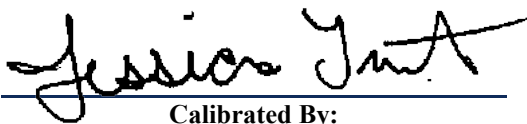
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD21289
Calibrated Span = 350 inH2O
Calibration Tolerance = 0.2275 inH2O

Upscale Tests

0.0000 inH2O	-0.003inH2O	0.2275inH2O	1.32	Pass	5.8e-003inH2O
87.5000 inH2O	87.492inH2O	0.2275inH2O	3.52	Pass	7.0e-003inH2O
175.0000 inH2O	174.993inH2O	0.2275inH2O	3.08	Pass	1.4e-002inH2O
262.5000 inH2O	262.499inH2O	0.2275inH2O	0.44	Pass	2.1e-002inH2O
350.0000 inH2O	350.009inH2O	0.2275inH2O	3.96	Pass	2.8e-002inH2O

Downscale Tests

350.0000 inH2O	350.011inH2O	0.2275inH2O	4.84	Pass	2.8e-002inH2O
262.5000 inH2O	262.491inH2O	0.2275inH2O	3.96	Pass	2.1e-002inH2O
175.0000 inH2O	174.982inH2O	0.2275inH2O	7.91	Pass	1.4e-002inH2O
87.5000 inH2O	87.490inH2O	0.2275inH2O	4.4	Pass	7.0e-003inH2O
0.0000 inH2O	-0.002inH2O	0.2275inH2O	0.879	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4161	CAL DATE: 12 April 2017
ASSET NUMBER: 21349	CAL DUE: 12 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

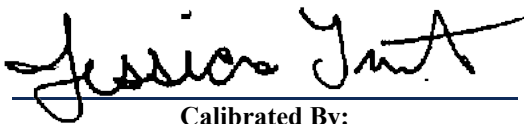
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT021349
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.1385 Ohms						
125.1080 F	125.022F	0.5000F	17.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.37333 Ohms						
287.4720 F	287.555F	0.5000F	16.6	Pass	1.2e-001F	
Resistance Value at Temp = 187.67017 Ohms						
449.9220 F	450.039F	0.5000F	23.4	Pass	1.2e-001F	
Resistance Value at Temp = 220.01583 Ohms						
612.4310 F	612.403F	0.5000F	5.6	Pass	1.2e-001F	
Resistance Value at Temp = 251.4395 Ohms						
774.9110 F	774.787F	0.5000F	24.8	Pass	1.2e-001F	
Resistance Value at Temp = 281.98367 Ohms						
937.4660 F	937.426F	0.5000F	8	Pass	1.2e-001F	
Resistance Value at Temp = 311.5945 Ohms						
1099.9630 F	1100.041F	0.5000F	15.6	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.1385 Ohms						
51.7270 c	51.679c	0.2780c	17.3	Pass	6.4e-002c	
Resistance Value at Temp = 154.37333 Ohms						
141.9290 c	141.975c	0.2780c	16.5	Pass	6.4e-002c	
Resistance Value at Temp = 187.67017 Ohms						
232.1790 c	232.244c	0.2780c	23.4	Pass	6.4e-002c	
Resistance Value at Temp = 220.01583 Ohms						
322.4620 c	322.446c	0.2780c	5.76	Pass	6.4e-002c	
Resistance Value at Temp = 251.4395 Ohms						
412.7280 c	412.660c	0.2780c	24.5	Pass	6.4e-002c	
Resistance Value at Temp = 281.98367 Ohms						
503.0360 c	503.014c	0.2780c	7.91	Pass	6.4e-002c	
Resistance Value at Temp = 311.5945 Ohms						
593.3130 c	593.356c	0.2780c	15.5	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.12746
 Alpha= 0.003839796
 Delta= 1.48025902381
 A= 0.00389663492679
 B= -5.68389267857e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4137	CAL DATE: 10 April 2017
ASSET NUMBER: 21414	CAL DUE: 10 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14016	Rosemount Aerospace 162CE SPRT	4211	8/19/2016	8/19/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT021414
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.227 Ohms						
125.1290 F	125.155F	0.5000F	5.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.35733 Ohms						
287.5700 F	287.565F	0.5000F	1	Pass	1.2e-001F	
Resistance Value at Temp = 187.59883 Ohms						
450.0740 F	450.034F	0.5000F	8	Pass	1.2e-001F	
Resistance Value at Temp = 219.942 Ohms						
612.5820 F	612.519F	0.5000F	12.6	Pass	1.2e-001F	
Resistance Value at Temp = 251.41833 Ohms						
775.1300 F	775.185F	0.5000F	11	Pass	1.2e-001F	
Resistance Value at Temp = 281.9865 Ohms						
937.7220 F	937.826F	0.5000F	20.8	Pass	1.2e-001F	
Resistance Value at Temp = 311.58633 Ohms						
1100.1840 F	1100.105F	0.5000F	15.8	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.227 Ohms						
51.7380 c	51.753c	0.2780c	5.4	Pass	6.4e-002c	
Resistance Value at Temp = 154.35733 Ohms						
141.9830 c	141.981c	0.2780c	0.719	Pass	6.4e-002c	
Resistance Value at Temp = 187.59883 Ohms						
232.2630 c	232.241c	0.2780c	7.91	Pass	6.4e-002c	
Resistance Value at Temp = 219.942 Ohms						
322.5460 c	322.510c	0.2780c	12.9	Pass	6.4e-002c	
Resistance Value at Temp = 251.41833 Ohms						
412.8500 c	412.881c	0.2780c	11.2	Pass	6.4e-002c	
Resistance Value at Temp = 281.9865 Ohms						
503.1790 c	503.237c	0.2780c	20.9	Pass	6.4e-002c	
Resistance Value at Temp = 311.58633 Ohms						
593.4350 c	593.392c	0.2780c	15.5	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.24408
 Alpha= 0.003825194
 Delta= 1.44262104341
 A= 0.0038803770536
 B= -5.51830535952e-007

***** End of Report *****

UNIT UNDER TEST: Power Meter, Digital	TEST RESULT: PASS
SERIAL NUMBER: 399850	CAL DATE: 11 May 2017
ASSET NUMBER: 21461	CAL DUE: 11 May 2018
PROCEDURE NAME: Nexus 1250/1252/1500: CAL VER 60Hz	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 03/28/17	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A


McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Unit is operating within tolerance as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	3/14/2017	3/14/2018
14002	Rotek MSB100 Power and Energy Standard	173	2/25/2017	2/25/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AC VOLTAGE TESTS - 60Hz						
Phase A -						
100.000 V	100.0080V	0.08000V	10	Pass	1.6e-002V	3.81
120.000 V	120.0070V	0.09600V	7.29	Pass	1.9e-002V	3.87
240.000 V	240.0110V	0.19200V	5.73	Pass	3.7e-002V	
Phase B -						
100.000 V	99.9920V	0.08000V	10	Pass	1.6e-002V	3.81
120.000 V	119.9870V	0.09600V	13.5	Pass	1.9e-002V	3.87
240.000 V	240.0040V	0.19200V	2.08	Pass	3.7e-002V	
Phase C -						
100.000 V	99.9910V	0.08000V	11.3	Pass	1.6e-002V	3.81
120.000 V	119.9890V	0.09600V	11.5	Pass	1.9e-002V	3.87
240.000 V	239.9940V	0.19200V	3.13	Pass	3.7e-002V	
AC CURRENT TESTS - 60Hz						
Phase A - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase B - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase C - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase A - 2.5A Range						
2.50060 A	2.5004A	0.00200A	10	Pass	6.5e-004A	3.11
Phase B - 2.5A Range						
2.50060 A	2.5004A	0.00200A	10	Pass	6.5e-004A	3.11
Phase C - 2.5A Range						
2.50060 A	2.5004A	0.00200A	10	Pass	6.5e-004A	3.11
Phase A - 5A Range						
5.00180 A	5.0017A	0.00400A	2.5	Pass	1.3e-003A	3.11
Phase B - 5A Range						
5.00180 A	5.0017A	0.00400A	2.5	Pass	1.3e-003A	3.11
Phase C - 5A Range						
5.00190 A	5.0017A	0.00400A	5	Pass	1.3e-003A	3.11
AC WATT TESTS - 60Hz - PF 1.0						
Phase A - 1A Range						
120.03090 W	120.0330W	0.09600W	2.19	Pass	7.6e-003W	
Phase B - 1A Range						
120.03060 W	120.0077W	0.09600W	23.9	Pass	7.6e-003W	
Phase C - 1A Range						
120.03080 W	120.0152W	0.09600W	16.3	Pass	7.6e-003W	
Phase A - 2.5A Range						

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
300.07220 W	300.0566W	0.24000W	6.5	Pass	3.5e-002W	
Phase B - 2.5A Range						
300.07260 W	300.0303W	0.24010W	17.6	Pass	3.5e-002W	
Phase C - 2.5A Range						
300.07280 W	300.0247W	0.24000W	20	Pass	3.5e-002W	
Phase A - 5A Range						
600.22640 W	600.1278W	0.48000W	20.5	Pass	1.4e-001W	
Phase B - 5A Range						
600.22310 W	600.0789W	0.48000W	30	Pass	1.4e-001W	
Phase C - 5A Range						
600.22440 W	600.0768W	0.48000W	30.7	Pass	1.4e-001W	
AC WATT TESTS - 60Hz - PF 0.75 Lead/Lag						
Phase A - 0.75 Lag						
450.32880 W	450.2323W	0.36000W	26.8	Pass	9.0e+002W	
Phase B - 0.75 Lag						
450.32560 W	450.1639W	0.36000W	44.9	Pass	8.7e-003W	
Phase C - 0.75 Lag						
450.33070 W	450.2446W	0.36000W	23.9	Pass	8.7e-003W	
Phase A - 0.75 Lead						
450.03200 W	449.9171W	0.36000W	31.9	Pass	9.0e+002W	
Phase B - 0.75 Lead						
450.03130 W	449.8398W	0.36000W	53.2	Pass	8.7e-003W	
Phase C - 0.75 Lead						
450.03160 W	449.7627W	0.36000W	74.7	Pass	8.7e-003W	

***** End of Report *****

UNIT UNDER TEST: Power Meter, Digital	TEST RESULT: PASS
SERIAL NUMBER: 399854	CAL DATE: 12 May 2017
ASSET NUMBER: 21466	CAL DUE: 12 May 2018
PROCEDURE NAME: Nexus 1250/1252/1500: CAL VER 60Hz	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 03/28/17	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Unit is operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	3/14/2017	3/14/2018
14002	Rotek MSB100 Power and Energy Standard	173	2/25/2017	2/25/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AC VOLTAGE TESTS - 60Hz						
Phase A -						
100.000 V	99.9940V	0.08000V	7.5	Pass	1.6e-002V	3.81
120.000 V	119.9900V	0.09600V	10.4	Pass	1.9e-002V	3.87
240.000 V	239.9920V	0.19200V	4.17	Pass	3.7e-002V	
Phase B -						
100.000 V	99.9970V	0.08000V	3.75	Pass	1.6e-002V	3.81
120.000 V	119.9900V	0.09600V	10.4	Pass	1.9e-002V	3.87
240.000 V	239.9950V	0.19200V	2.6	Pass	3.7e-002V	
Phase C -						
100.000 V	99.9770V	0.08000V	28.7	Pass	1.6e-002V	3.81
120.000 V	119.9640V	0.09600V	37.5	Pass	1.9e-002V	3.87
240.000 V	239.9770V	0.19200V	12	Pass	3.7e-002V	
AC CURRENT TESTS - 60Hz						
Phase A - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase B - 1A Range						
1.00030 A	1.0002A	0.00100A	10	Pass	2.6e-004A	3.89
Phase C - 1A Range						
1.00030 A	1.0007A	0.00100A	40	Pass	2.6e-004A	3.89
Phase A - 2.5A Range						
2.50060 A	2.5012A	0.00200A	30	Pass	6.5e-004A	3.11
Phase B - 2.5A Range						
2.50060 A	2.5012A	0.00200A	30	Pass	6.5e-004A	3.11
Phase C - 2.5A Range						
2.50060 A	2.5020A	0.00200A	70	Pass	6.5e-004A	3.11
Phase A - 5A Range						
5.00190 A	5.0024A	0.00400A	12.5	Pass	1.3e-003A	3.11
Phase B - 5A Range						
5.00200 A	5.0028A	0.00400A	20	Pass	1.3e-003A	3.11
Phase C - 5A Range						
5.00200 A	5.0055A	0.00400A	87.5	Pass	1.3e-003A	3.11
AC WATT TESTS - 60Hz - PF 1.0						
Phase A - 1A Range						
120.03240 W	120.0225W	0.09600W	10.3	Pass	7.6e-003W	
Phase B - 1A Range						
120.03140 W	120.0408W	0.09600W	9.79	Pass	7.6e-003W	
Phase C - 1A Range						
120.03200 W	120.0320W	0.09600W	0	Pass	7.6e-003W	
Phase A - 2.5A Range						

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
300.07300 W	300.0741W	0.24000W	0.458	Pass	3.5e-002W	
Phase B - 2.5A Range						
300.07470 W	300.1107W	0.24010W	15	Pass	3.5e-002W	
Phase C - 2.5A Range						
300.07490 W	300.1400W	0.24000W	27.1	Pass	3.5e-002W	
Phase A - 5A Range						
600.20660 W	600.1381W	0.48000W	14.3	Pass	1.4e-001W	
Phase B - 5A Range						
600.21250 W	600.2002W	0.48000W	2.56	Pass	1.4e-001W	
Phase C - 5A Range						
600.21390 W	600.3634W	0.48000W	31.1	Pass	1.4e-001W	
AC WATT TESTS - 60Hz - PF 0.75 Lead/Lag						
Phase A - 0.75 Lag						
450.34160 W	450.1850W	0.36000W	43.5	Pass	9.0e+002W	
Phase B - 0.75 Lag						
450.33830 W	450.3588W	0.36000W	5.69	Pass	8.7e-003W	
Phase C - 0.75 Lag						
450.34160 W	450.5301W	0.36000W	52.4	Pass	8.7e-003W	
Phase A - 0.75 Lead						
450.03400 W	450.0212W	0.36000W	3.56	Pass	9.0e+002W	
Phase B - 0.75 Lead						
450.03270 W	449.9375W	0.36000W	26.4	Pass	8.7e-003W	
Phase C - 0.75 Lead						
450.03710 W	450.0108W	0.36000W	7.31	Pass	8.7e-003W	

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6744	CAL DATE: 12 April 2017
ASSET NUMBER: 21481	CAL DUE: 12 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

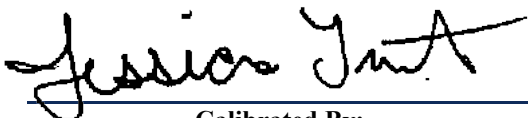
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT021481
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.05 Ohms						
125.1080 F	125.007F	0.5000F	20.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.36267 Ohms						
287.4720 F	287.566F	0.5000F	18.8	Pass	1.2e-001F	
Resistance Value at Temp = 187.7125 Ohms						
449.9220 F	450.058F	0.5000F	27.2	Pass	1.2e-001F	
Resistance Value at Temp = 220.08533 Ohms						
612.4310 F	612.404F	0.5000F	5.4	Pass	1.2e-001F	
Resistance Value at Temp = 251.51867 Ohms						
774.9110 F	774.789F	0.5000F	24.4	Pass	1.2e-001F	
Resistance Value at Temp = 282.042 Ohms						
937.4660 F	937.374F	0.5000F	18.4	Pass	1.2e-001F	
Resistance Value at Temp = 311.63633 Ohms						
1099.9630 F	1100.074F	0.5000F	22.2	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.05 Ohms						
51.7270 c	51.671c	0.2780c	20.1	Pass	6.4e-002c	
Resistance Value at Temp = 154.36267 Ohms						
141.9290 c	141.981c	0.2780c	18.7	Pass	6.4e-002c	
Resistance Value at Temp = 187.7125 Ohms						
232.1790 c	232.254c	0.2780c	27	Pass	6.4e-002c	
Resistance Value at Temp = 220.08533 Ohms						
322.4620 c	322.447c	0.2780c	5.4	Pass	6.4e-002c	
Resistance Value at Temp = 251.51867 Ohms						
412.7280 c	412.660c	0.2780c	24.5	Pass	6.4e-002c	
Resistance Value at Temp = 282.042 Ohms						
503.0360 c	502.986c	0.2780c	18	Pass	6.4e-002c	
Resistance Value at Temp = 311.63633 Ohms						
593.3130 c	593.375c	0.2780c	22.3	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$
 Ro= 99.99129
 Alpha= 0.00385424
 Delta= 1.50993046414
 A= 0.00391243634392
 B= -5.81963439211e-007

***** End of Report *****

UNIT UNDER TEST: Input Card, 20 Channel, Type K	TEST RESULT: PASS
SERIAL NUMBER: US37236738	CAL DATE: 13 December 2016
ASSET NUMBER: 21565	CAL DUE: 13 December 2017
PROCEDURE NAME: Agilent 34901A TYPE K T/C (1 year)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 01/30/14	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as found and as left.



 Calibrated By:



 Approved By:

Standards Used				
Asset #	Description	Serial #	Cal Date	Due Date
10219	Agilent 34970A Data Logger	US37042760	11/22/2016	2/22/2017
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
Type K T/C						
32 °F	32°F	1.8°F	22.1	Pass	6.2e-001°F	
150.0 °F	150.5°F	1.80°F	28.4	Pass	2.3e-001°F	
1050.0 °F	1050.6°F	1.80°F	31.1	Pass	3.7e-001°F	3.85
Channel 201 Test						
100.0 °F	100.7°F	1.80°F	40.6	Pass	2.3e-001°F	
Channel 202 Test						
100.0 °F	100.7°F	1.80°F	40.2	Pass	2.3e-001°F	
Channel 203 Test						
100.0 °F	100.7°F	1.80°F	36.4	Pass	2.3e-001°F	
Channel 204 Test						
100.0 °F	100.6°F	1.80°F	33.7	Pass	2.3e-001°F	
Channel 205 Test						
100.0 °F	100.6°F	1.80°F	32.6	Pass	2.3e-001°F	
Channel 206 Test						
100.0 °F	100.5°F	1.80°F	28.6	Pass	2.3e-001°F	
Channel 207 Test						
100.0 °F	100.6°F	1.80°F	31.2	Pass	2.3e-001°F	
Channel 208 Test						
100.0 °F	100.6°F	1.80°F	32.3	Pass	2.3e-001°F	
Channel 209 Test						
100.0 °F	100.6°F	1.80°F	33.8	Pass	2.3e-001°F	
Channel 210 Test						
100.0 °F	100.6°F	1.80°F	32.6	Pass	2.3e-001°F	
Channel 211 Test						
100.0 °F	100.5°F	1.80°F	29.8	Pass	2.3e-001°F	
Channel 212 Test						
100.0 °F	100.5°F	1.80°F	26.6	Pass	2.3e-001°F	
Channel 213 Test						
100.0 °F	100.5°F	1.80°F	29.7	Pass	2.3e-001°F	
Channel 214 Test						
100.0 °F	100.5°F	1.80°F	28.2	Pass	2.3e-001°F	
Channel 215 Test						
100.0 °F	100.5°F	1.80°F	26.4	Pass	2.3e-001°F	
Channel 216 Test						
100.0 °F	100.4°F	1.80°F	24.7	Pass	2.3e-001°F	
Channel 217 Test						
100.0 °F	100.4°F	1.80°F	22.7	Pass	2.3e-001°F	
Channel 218 Test						
100.0 °F	100.5°F	1.80°F	25.1	Pass	2.3e-001°F	
Channel 219 Test						
100.0 °F	100.5°F	1.80°F	25.3	Pass	2.3e-001°F	
Channel 220 Test						
100.0 °F	100.5°F	1.80°F	25.2	Pass	2.3e-001°F	

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 7235	CAL DATE: 14 April 2017
ASSET NUMBER: 21615	CAL DUE: 14 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

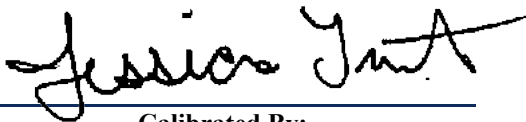
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

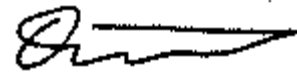
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT021615
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.33767 Ohms						
125.0950 F	125.046F	0.5000F	9.8	Pass	1.2e-001F	
Resistance Value at Temp = 154.56317 Ohms						
287.4450 F	287.549F	0.5000F	20.8	Pass	1.2e-001F	
Resistance Value at Temp = 187.84033 Ohms						
449.8770 F	449.850F	0.5000F	5.4	Pass	1.2e-001F	
Resistance Value at Temp = 220.24783 Ohms						
612.3720 F	612.334F	0.5000F	7.6	Pass	1.2e-001F	
Resistance Value at Temp = 251.74767 Ohms						
774.8290 F	774.817F	0.5000F	2.4	Pass	1.2e-001F	
Resistance Value at Temp = 282.35967 Ohms						
937.3810 F	937.405F	0.5000F	4.8	Pass	1.2e-001F	
Resistance Value at Temp = 312.03883 Ohms						
1099.8610 F	1099.860F	0.5000F	0.2	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.33767 Ohms						
51.7200 c	51.692c	0.2780c	10.1	Pass	6.4e-002c	
Resistance Value at Temp = 154.56317 Ohms						
141.9140 c	141.971c	0.2780c	20.5	Pass	6.4e-002c	
Resistance Value at Temp = 187.84033 Ohms						
232.1540 c	232.139c	0.2780c	5.4	Pass	6.4e-002c	
Resistance Value at Temp = 220.24783 Ohms						
322.4290 c	322.408c	0.2780c	7.55	Pass	6.4e-002c	
Resistance Value at Temp = 251.74767 Ohms						
412.6830 c	412.676c	0.2780c	2.52	Pass	6.4e-002c	
Resistance Value at Temp = 282.35967 Ohms						
502.9890 c	503.003c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 312.03883 Ohms						
593.2560 c	593.256c	0.2780c	0	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.33204

Alpha= 0.003830516

Delta= 1.44893939824

A= 0.00388601785548

B= -5.550185548e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire, 24"	TEST RESULT: PASS
SERIAL NUMBER: 07260	CAL DATE: 17 April 2017
ASSET NUMBER: 21653	CAL DUE: 17 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number	= TT021653					
Probe Calibration Range	= 125 to 1100 Deg F					
	= 51.7 to 593.3 Deg C					

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.39033 Ohms						
125.1000 F	125.074F	0.5000F	5.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.71633 Ohms						
287.4490 F	287.424F	0.5000F	5	Pass	1.2e-001F	
Resistance Value at Temp = 188.133 Ohms						
449.8780 F	449.987F	0.5000F	21.8	Pass	1.2e-001F	
Resistance Value at Temp = 220.5635 Ohms						
612.3650 F	612.392F	0.5000F	5.4	Pass	1.2e-001F	
Resistance Value at Temp = 252.03517 Ohms						
774.8320 F	774.768F	0.5000F	12.8	Pass	1.2e-001F	
Resistance Value at Temp = 282.574 Ohms						
937.3620 F	937.253F	0.5000F	21.8	Pass	1.2e-001F	
Resistance Value at Temp = 312.1955 Ohms						
1099.8560 F	1099.944F	0.5000F	17.6	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.39033 Ohms						
51.7220 c	51.708c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 154.71633 Ohms						
141.9160 c	141.902c	0.2780c	5.04	Pass	6.4e-002c	
Resistance Value at Temp = 188.133 Ohms						
232.1540 c	232.215c	0.2780c	21.9	Pass	6.4e-002c	
Resistance Value at Temp = 220.5635 Ohms						
322.4250 c	322.440c	0.2780c	5.4	Pass	6.4e-002c	
Resistance Value at Temp = 252.03517 Ohms						
412.6850 c	412.649c	0.2780c	12.9	Pass	6.4e-002c	
Resistance Value at Temp = 282.574 Ohms						
502.9790 c	502.919c	0.2780c	21.6	Pass	6.4e-002c	
Resistance Value at Temp = 312.1955 Ohms						
593.2540 c	593.302c	0.2780c	17.3	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.28179

Alpha= 0.003849752

Delta= 1.51663379498

A= 0.00390813863986

B= -5.8386639855e-007

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 21 April 2017
ASSET NUMBER: 21735	CAL DUE: 21 April 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
11.5000 %RH	12.658%RH	2.0000%RH	57.9	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	33.295%RH	2.0000%RH	14.7	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
75.0000 %RH	74.907%RH	2.0000%RH	4.63	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 18 April 2017
ASSET NUMBER: 21740	CAL DUE: 18 April 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

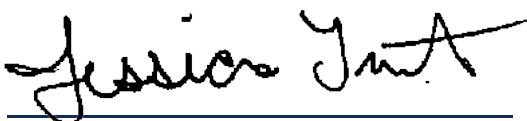
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
12.0000 %RH	11.766%RH	2.0000%RH	11.7	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	32.978%RH	2.0000%RH	1.1	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
76.0000 %RH	75.363%RH	2.0000%RH	31.9	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 21 April 2017
ASSET NUMBER: 21741	CAL DUE: 21 April 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
11.5000 %RH	11.299%RH	2.0000%RH	10.1	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	33.399%RH	2.0000%RH	19.9	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
75.0000 %RH	74.715%RH	2.0000%RH	14.2	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 21 April 2017
ASSET NUMBER: 21742	CAL DUE: 21 April 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:

Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
12.0000 %RH	12.101%RH	2.0000%RH	5.04	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	33.515%RH	2.0000%RH	25.7	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
76.0000 %RH	75.112%RH	2.0000%RH	44.4	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 21 April 2017
ASSET NUMBER: 21746	CAL DUE: 21 April 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
12.0000 %RH	11.463%RH	2.0000%RH	26.9	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	33.023%RH	2.0000%RH	1.14	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
76.0000 %RH	75.884%RH	2.0000%RH	5.82	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER: DAVE-010916-012	CAL DATE: 18 April 2017
ASSET NUMBER: 21749	CAL DUE: 18 April 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0-99 CAL UNITS: %

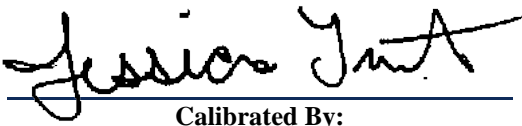
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Operating within tolerance as found and as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
12.0000 %RH	11.548%RH	2.0000%RH	22.6	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	32.440%RH	2.0000%RH	28	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
76.0000 %RH	75.243%RH	2.0000%RH	37.9	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1469714	CAL DATE: 15 May 2017
ASSET NUMBER: 21897	CAL DUE: 15 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~1500
	CAL UNITS: psia

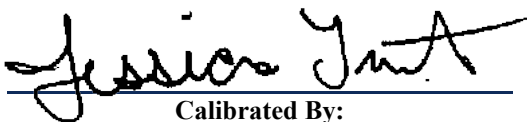
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.196PSIA

Transmitter Calibration Range= 1500 psia

Transmitter Accuracy= 0.975 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.1960 psi	14.144psi	0.9750psi	5.33	Pass	2.2e-003psi
313.3670 psi	313.321psi	0.9750psi	4.72	Pass	4.7e-002psi
812.8510 psi	812.952psi	0.9750psi	10.4	Pass	1.2e-001psi
1212.4370 psi	1212.631psi	0.9750psi	19.9	Pass	1.8e-001psi
1512.1270 psi	1512.433psi	0.9750psi	31.4	Pass	2.3e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

1512.1270 psi	1512.455psi	0.9750psi	33.6	Pass	2.3e-001psi
1212.4370 psi	1212.620psi	0.9750psi	18.8	Pass	1.8e-001psi
812.8510 psi	812.938psi	0.9750psi	8.92	Pass	1.2e-001psi
313.3670 psi	313.456psi	0.9750psi	9.13	Pass	4.7e-002psi
14.1960 psi	14.144psi	0.9750psi	5.33	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1879144	CAL DATE: 16 May 2017
ASSET NUMBER: 21900	CAL DUE: 16 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

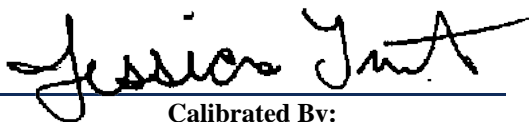
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

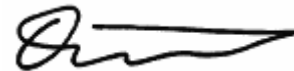
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.23PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.2300 psi	14.278psi	1.9500psi	2.46	Pass	2.2e-003psi
513.1950 psi	512.833psi	1.9500psi	18.6	Pass	7.7e-002psi
1012.6780 psi	1012.554psi	1.9500psi	6.36	Pass	1.5e-001psi
2011.6440 psi	2011.455psi	1.9500psi	9.69	Pass	3.0e-001psi
3010.6100 psi	3010.537psi	1.9500psi	3.74	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.6100 psi	3010.493psi	1.9500psi	6	Pass	4.5e-001psi
2011.6440 psi	2011.755psi	1.9500psi	5.69	Pass	3.0e-001psi
1012.6780 psi	1012.897psi	1.9500psi	11.2	Pass	1.5e-001psi
513.1950 psi	513.080psi	1.9500psi	5.9	Pass	7.7e-002psi
14.2300 psi	14.278psi	1.9500psi	2.46	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1164345	CAL DATE: 16 May 2017
ASSET NUMBER: 22102	CAL DUE: 16 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

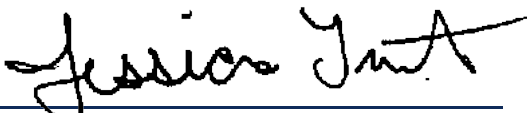
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.23PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.2300 psi	14.278psi	1.9500psi	2.46	Pass	2.2e-003psi
513.1950 psi	513.484psi	1.9500psi	14.8	Pass	7.7e-002psi
1012.6780 psi	1012.958psi	1.9500psi	14.4	Pass	1.5e-001psi
2011.6440 psi	2011.804psi	1.9500psi	8.21	Pass	3.0e-001psi
3010.6100 psi	3010.586psi	1.9500psi	1.23	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.6100 psi	3010.631psi	1.9500psi	1.08	Pass	4.5e-001psi
2011.6440 psi	2012.172psi	1.9500psi	27.1	Pass	3.0e-001psi
1012.6780 psi	1013.084psi	1.9500psi	20.8	Pass	1.5e-001psi
513.1950 psi	513.589psi	1.9500psi	20.2	Pass	7.7e-002psi
14.2300 psi	14.278psi	1.9500psi	2.46	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1701576	CAL DATE: 16 May 2017
ASSET NUMBER: 22105	CAL DUE: 16 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

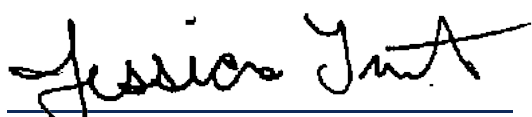
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.22PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.2200 psi	14.404psi	1.9500psi	9.44	Pass	2.2e-003psi
513.1850 psi	513.618psi	1.9500psi	22.2	Pass	7.7e-002psi
1012.6680 psi	1013.052psi	1.9500psi	19.7	Pass	1.5e-001psi
2011.6340 psi	2011.855psi	1.9500psi	11.3	Pass	3.0e-001psi
3010.6000 psi	3010.853psi	1.9500psi	13	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.6000 psi	3010.831psi	1.9500psi	11.8	Pass	4.5e-001psi
2011.6340 psi	2011.994psi	1.9500psi	18.5	Pass	3.0e-001psi
1012.6680 psi	1013.714psi	1.9500psi	53.6	Pass	1.5e-001psi
513.1850 psi	513.618psi	1.9500psi	22.2	Pass	7.7e-002psi
14.2200 psi	14.278psi	1.9500psi	2.97	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1332066	CAL DATE: 12 May 2017
ASSET NUMBER: 22122	CAL DUE: 12 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia

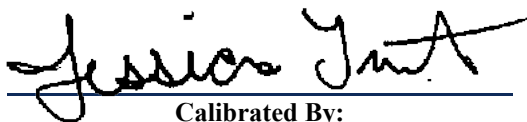
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA22122
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	15.060psi	0.5200psi	11.5	Pass	7.3e-003psi
200.0000 psi	200.032psi	0.5200psi	6.15	Pass	1.6e-002psi
400.0000 psi	400.011psi	0.5200psi	2.12	Pass	3.2e-002psi
600.0000 psi	600.016psi	0.5200psi	3.08	Pass	4.8e-002psi
800.0000 psi	800.021psi	0.5200psi	4.04	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	800.021psi	0.5200psi	4.04	Pass	6.4e-002psi
600.0000 psi	600.016psi	0.5200psi	3.08	Pass	4.8e-002psi
400.0000 psi	400.011psi	0.5200psi	2.12	Pass	3.2e-002psi
200.0000 psi	200.032psi	0.5200psi	6.15	Pass	1.6e-002psi
15.0000 psi	15.006psi	0.5200psi	1.15	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1824521	CAL DATE: 31 March 2017
ASSET NUMBER: 23082	CAL DUE: 31 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

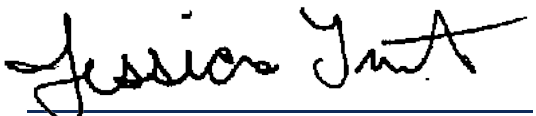
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD23082
Calibrated Span = 25 inH2O
Calibration Tolerance = 0.025 inH2O

Upscale Tests

0.0000 inH2O	-0.006inH2O	0.0250inH2O	24	Pass	5.8e-003inH2O
6.2500 inH2O	6.250inH2O	0.0250inH2O	0	Pass	5.8e-003inH2O
12.5000 inH2O	12.498inH2O	0.0250inH2O	8	Pass	5.8e-003inH2O
18.7500 inH2O	18.746inH2O	0.0250inH2O	16	Pass	5.8e-003inH2O
25.0000 inH2O	25.000inH2O	0.0250inH2O	0	Pass	5.8e-003inH2O

Downscale Tests

25.0000 inH2O	25.001inH2O	0.0250inH2O	4	Pass	5.8e-003inH2O
18.7500 inH2O	18.745inH2O	0.0250inH2O	20	Pass	5.8e-003inH2O
12.5000 inH2O	12.495inH2O	0.0250inH2O	20	Pass	5.8e-003inH2O
6.2500 inH2O	6.246inH2O	0.0250inH2O	16	Pass	5.8e-003inH2O
0.0000 inH2O	-0.006inH2O	0.0250inH2O	24	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Input Card, 20 Channel, Type K	TEST RESULT: PASS
SERIAL NUMBER: US37238146	CAL DATE: 16 May 2017
ASSET NUMBER: 23858	CAL DUE: 16 May 2018
PROCEDURE NAME: Agilent 34901A TYPE K T/C (1 year)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 01/30/14	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

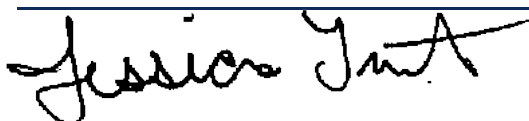
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

Asset #	Description	Serial #	Cal Date	Due Date
10133	Agilent 34970A Data Logger	US37028610	5/4/2017	8/2/2017
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
Type K T/C						
32 °F	32°F	1.8°F	24.9	Pass	6.2e-001°F	
150.0 °F	150.5°F	1.80°F	30.3	Pass	2.3e-001°F	
1050.0 °F	1050.6°F	1.80°F	32.1	Pass	3.7e-001°F	3.85
Channel 101 Test						
100.0 °F	99.9°F	1.80°F	5.33	Pass	2.3e-001°F	
Channel 102 Test						
100.0 °F	100.1°F	1.80°F	3.17	Pass	2.3e-001°F	
Channel 103 Test						
100.0 °F	100.2°F	1.80°F	8.33	Pass	2.3e-001°F	
Channel 104 Test						
100.0 °F	100.3°F	1.80°F	14.8	Pass	2.3e-001°F	
Channel 105 Test						
100.0 °F	100.4°F	1.80°F	22.7	Pass	2.3e-001°F	
Channel 106 Test						
100.0 °F	100.5°F	1.80°F	25.7	Pass	2.3e-001°F	
Channel 107 Test						
100.0 °F	100.5°F	1.80°F	26.2	Pass	2.3e-001°F	
Channel 108 Test						
100.0 °F	100.5°F	1.80°F	28.9	Pass	2.3e-001°F	
Channel 109 Test						
100.0 °F	100.6°F	1.80°F	30.7	Pass	2.3e-001°F	
Channel 110 Test						
100.0 °F	100.6°F	1.80°F	32.4	Pass	2.3e-001°F	
Channel 111 Test						
100.0 °F	100.6°F	1.80°F	34.7	Pass	2.3e-001°F	
Channel 112 Test						
100.0 °F	100.7°F	1.80°F	36.6	Pass	2.3e-001°F	
Channel 113 Test						
100.0 °F	100.6°F	1.80°F	36.1	Pass	2.3e-001°F	
Channel 114 Test						
100.0 °F	100.6°F	1.80°F	35.1	Pass	2.3e-001°F	
Channel 115 Test						
100.0 °F	100.6°F	1.80°F	34.6	Pass	2.3e-001°F	
Channel 116 Test						
100.0 °F	100.6°F	1.80°F	32.2	Pass	2.3e-001°F	
Channel 117 Test						
100.0 °F	100.5°F	1.80°F	30.1	Pass	2.3e-001°F	
Channel 118 Test						
100.0 °F	100.6°F	1.80°F	31.8	Pass	2.3e-001°F	
Channel 119 Test						
100.0 °F	100.6°F	1.80°F	35.2	Pass	2.3e-001°F	
Channel 120 Test						
100.0 °F	100.6°F	1.80°F	33.9	Pass	2.3e-001°F	

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4373	CAL DATE: 26 April 2017
ASSET NUMBER: 23897	CAL DUE: 26 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

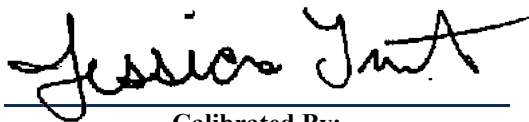
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT023897
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.47653 Ohms						
20.4130 F	20.403F	0.2590F	3.86	Pass	3.4e-002F	
Resistance Value at Temp = 103.94833 Ohms						
50.3650 F	50.376F	0.2590F	4.25	Pass	3.4e-002F	
Resistance Value at Temp = 110.38767 Ohms						
80.3220 F	80.336F	0.2590F	5.41	Pass	3.4e-002F	
Resistance Value at Temp = 116.80633 Ohms						
110.3400 F	110.336F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 123.19383 Ohms						
140.3640 F	140.329F	0.2590F	13.5	Pass	3.4e-002F	
Resistance Value at Temp = 129.578 Ohms						
170.4160 F	170.446F	0.2590F	11.6	Pass	3.4e-002F	
Resistance Value at Temp = 135.90583 Ohms						
200.4420 F	200.436F	0.2590F	2.32	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.47653 Ohms						
-6.4370 c	-6.443c	0.1440c	4.17	Pass	1.9e-002c	
Resistance Value at Temp = 103.94833 Ohms						
10.2030 c	10.209c	0.1440c	4.17	Pass	1.9e-002c	
Resistance Value at Temp = 110.38767 Ohms						
26.8460 c	26.853c	0.1440c	4.86	Pass	1.9e-002c	
Resistance Value at Temp = 116.80633 Ohms						
43.5220 c	43.520c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 123.19383 Ohms						
60.2030 c	60.183c	0.1440c	13.9	Pass	1.9e-002c	
Resistance Value at Temp = 129.578 Ohms						
76.8980 c	76.914c	0.1440c	11.1	Pass	1.9e-002c	
Resistance Value at Temp = 135.90583 Ohms						
93.5790 c	93.576c	0.1440c	2.08	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 99.98402
 Alpha= 0.003835997
 Delta= 1.38628573318
 A= 0.00388917487914
 B= -5.31778791363e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 9383	CAL DATE: 13 April 2017
ASSET NUMBER: 23899	CAL DUE: 13 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

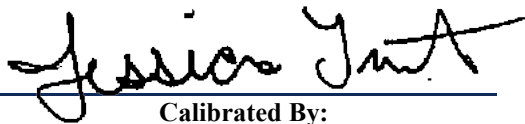
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT023899
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.2415 Ohms						
125.1020 F	125.036F	0.5000F	13.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.5075 Ohms						
287.4470 F	287.572F	0.5000F	25	Pass	1.2e-001F	
Resistance Value at Temp = 187.799 Ohms						
449.8780 F	449.872F	0.5000F	1.2	Pass	1.2e-001F	
Resistance Value at Temp = 220.19317 Ohms						
612.3750 F	612.306F	0.5000F	13.8	Pass	1.2e-001F	
Resistance Value at Temp = 251.68167 Ohms						
774.8490 F	774.844F	0.5000F	1	Pass	1.2e-001F	
Resistance Value at Temp = 282.24433 Ohms						
937.3750 F	937.385F	0.5000F	2	Pass	1.2e-001F	
Resistance Value at Temp = 311.87017 Ohms						
1099.8570 F	1099.868F	0.5000F	2.2	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.2415 Ohms						
51.7230 c	51.687c	0.2780c	12.9	Pass	6.4e-002c	
Resistance Value at Temp = 154.5075 Ohms						
141.9150 c	141.985c	0.2780c	25.2	Pass	6.4e-002c	
Resistance Value at Temp = 187.799 Ohms						
232.1540 c	232.151c	0.2780c	1.08	Pass	6.4e-002c	
Resistance Value at Temp = 220.19317 Ohms						
322.4300 c	322.392c	0.2780c	13.7	Pass	6.4e-002c	
Resistance Value at Temp = 251.68167 Ohms						
412.6940 c	412.691c	0.2780c	1.08	Pass	6.4e-002c	
Resistance Value at Temp = 282.24433 Ohms						
502.9860 c	502.991c	0.2780c	1.8	Pass	6.4e-002c	
Resistance Value at Temp = 311.87017 Ohms						
593.2540 c	593.260c	0.2780c	2.16	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$$

Ro= 100.21076

Alpha= 0.003839887

Delta= 1.47649419571

A= 0.00389658270868

B= -5.66957086768e-007

***** End of Report *****

UNIT UNDER TEST: Input Card, 20 Channel, Type K	TEST RESULT: PASS
SERIAL NUMBER: US37002262	CAL DATE: 16 May 2017
ASSET NUMBER: 23970	CAL DUE: 16 May 2018
PROCEDURE NAME: Agilent 34901A TYPE K T/C (1 year)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 01/30/14	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

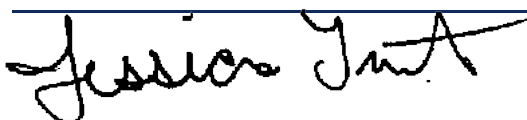
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

Asset #	Description	Serial #	Cal Date	Due Date
10133	Agilent 34970A Data Logger	US37028610	5/4/2017	8/2/2017
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
Type K T/C						
32 °F	32°F	1.8°F	3.83	Pass	6.2e-001°F	
150.0 °F	150.2°F	1.80°F	9.67	Pass	2.3e-001°F	
1050.0 °F	1050.2°F	1.80°F	10.2	Pass	3.7e-001°F	3.85
Channel 301 Test						
100.0 °F	99.0°F	1.80°F	56.7	Pass	2.3e-001°F	
Channel 302 Test						
100.0 °F	99.2°F	1.80°F	43.7	Pass	2.3e-001°F	
Channel 303 Test						
100.0 °F	99.4°F	1.80°F	31.4	Pass	2.3e-001°F	
Channel 304 Test						
100.0 °F	99.6°F	1.80°F	22.4	Pass	2.3e-001°F	
Channel 305 Test						
100.0 °F	99.9°F	1.80°F	7.67	Pass	2.3e-001°F	
Channel 306 Test						
100.0 °F	100.0°F	1.80°F	2.72	Pass	2.3e-001°F	
Channel 307 Test						
100.0 °F	100.2°F	1.80°F	9.22	Pass	2.3e-001°F	
Channel 308 Test						
100.0 °F	100.1°F	1.80°F	5.72	Pass	2.3e-001°F	
Channel 309 Test						
100.0 °F	100.2°F	1.80°F	10.2	Pass	2.3e-001°F	
Channel 310 Test						
100.0 °F	100.2°F	1.80°F	12.2	Pass	2.3e-001°F	
Channel 311 Test						
100.0 °F	100.0°F	1.80°F	1.83	Pass	2.3e-001°F	
Channel 312 Test						
100.0 °F	100.0°F	1.80°F	1.33	Pass	2.3e-001°F	
Channel 313 Test						
100.0 °F	99.9°F	1.80°F	5.56	Pass	2.3e-001°F	
Channel 314 Test						
100.0 °F	99.8°F	1.80°F	11.9	Pass	2.3e-001°F	
Channel 315 Test						
100.0 °F	99.7°F	1.80°F	16.3	Pass	2.3e-001°F	
Channel 316 Test						
100.0 °F	99.6°F	1.80°F	22.4	Pass	2.3e-001°F	
Channel 317 Test						
100.0 °F	99.6°F	1.80°F	23.3	Pass	2.3e-001°F	
Channel 318 Test						
100.0 °F	99.6°F	1.80°F	23.7	Pass	2.3e-001°F	
Channel 319 Test						
100.0 °F	99.6°F	1.80°F	23.8	Pass	2.3e-001°F	
Channel 320 Test						
100.0 °F	99.6°F	1.80°F	23.9	Pass	2.3e-001°F	

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 5627	CAL DATE: 17 April 2017
ASSET NUMBER: 23986	CAL DUE: 17 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

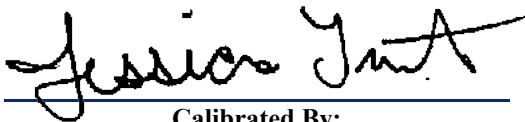
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Probe ID Number = TT023986
Probe Calibration Range = 125 to 1100 Deg F
= 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Standard Reading	UUT Reading	Test Tol	% Tol Error	PASS/FAIL	Expanded Unc.	TUR
Resistance Value at Temp = 120.4555 Ohms 125.1000 F	125.014F	0.5000F	17.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.76383 Ohms 287.4490 F	287.581F	0.5000F	26.4	Pass	1.2e-001F	
Resistance Value at Temp = 188.0955 Ohms 449.8780 F	449.901F	0.5000F	4.6	Pass	1.2e-001F	
Resistance Value at Temp = 220.526 Ohms 612.3650 F	612.337F	0.5000F	5.6	Pass	1.2e-001F	
Resistance Value at Temp = 252.02983 Ohms 774.8320 F	774.764F	0.5000F	13.6	Pass	1.2e-001F	
Resistance Value at Temp = 282.636 Ohms 937.3620 F	937.339F	0.5000F	4.6	Pass	1.2e-001F	
Resistance Value at Temp = 312.31383 Ohms 1099.8560 F	1099.906F	0.5000F	10	Pass	1.2e-001F	

*****Degrees C*****

Standard Reading	UUT Reading	Test Tol	% Tol Error	PASS/FAIL	Expanded Unc.	TUR
Resistance Value at Temp = 120.4555 Ohms 51.7220 c	51.675c	0.2780c	16.9	Pass	6.4e-002c	
Resistance Value at Temp = 154.76383 Ohms 141.9160 c	141.990c	0.2780c	26.6	Pass	6.4e-002c	
Resistance Value at Temp = 188.0955 Ohms 232.1540 c	232.167c	0.2780c	4.68	Pass	6.4e-002c	
Resistance Value at Temp = 220.526 Ohms 322.4250 c	322.409c	0.2780c	5.76	Pass	6.4e-002c	
Resistance Value at Temp = 252.02983 Ohms 412.6850 c	412.647c	0.2780c	13.7	Pass	6.4e-002c	
Resistance Value at Temp = 282.636 Ohms 502.9790 c	502.966c	0.2780c	4.68	Pass	6.4e-002c	
Resistance Value at Temp = 312.31383 Ohms 593.2540 c	593.281c	0.2780c	9.71	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}] / (2 * Ro * B)$
Ro= 100.40882
Alpha= 0.003836265
Delta= 1.47466389578
A= 0.0038928370149
B= -5.65720149015e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6434	CAL DATE: 14 April 2017
ASSET NUMBER: 24022	CAL DUE: 14 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

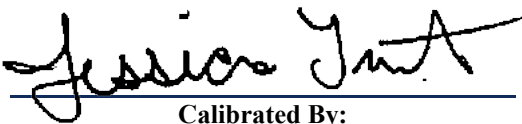
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT024022
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.3175 Ohms						
125.0950 F	125.168F	0.5000F	14.6	Pass	1.2e-001F	
Resistance Value at Temp = 154.57083 Ohms						
287.4450 F	287.337F	0.5000F	21.6	Pass	1.2e-001F	
Resistance Value at Temp = 187.97133 Ohms						
449.8770 F	449.849F	0.5000F	5.6	Pass	1.2e-001F	
Resistance Value at Temp = 220.45317 Ohms						
612.3720 F	612.399F	0.5000F	5.4	Pass	1.2e-001F	
Resistance Value at Temp = 251.994 Ohms						
774.8290 F	774.874F	0.5000F	9	Pass	1.2e-001F	
Resistance Value at Temp = 282.62267 Ohms						
937.3810 F	937.423F	0.5000F	8.4	Pass	1.2e-001F	
Resistance Value at Temp = 312.29533 Ohms						
1099.8610 F	1099.809F	0.5000F	10.4	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.3175 Ohms						
51.7200 c	51.760c	0.2780c	14.4	Pass	6.4e-002c	
Resistance Value at Temp = 154.57083 Ohms						
141.9140 c	141.854c	0.2780c	21.6	Pass	6.4e-002c	
Resistance Value at Temp = 187.97133 Ohms						
232.1540 c	232.138c	0.2780c	5.76	Pass	6.4e-002c	
Resistance Value at Temp = 220.45317 Ohms						
322.4290 c	322.444c	0.2780c	5.4	Pass	6.4e-002c	
Resistance Value at Temp = 251.994 Ohms						
412.6830 c	412.708c	0.2780c	8.99	Pass	6.4e-002c	
Resistance Value at Temp = 282.62267 Ohms						
502.9890 c	503.013c	0.2780c	8.63	Pass	6.4e-002c	
Resistance Value at Temp = 312.29533 Ohms						
593.2560 c	593.227c	0.2780c	10.4	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.22137
 Alpha= 0.003846631
 Delta= 1.47373473852
 A= 0.00390332013731
 B= -5.66891373099e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6521	CAL DATE: 13 April 2017
ASSET NUMBER: 24272	CAL DUE: 13 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

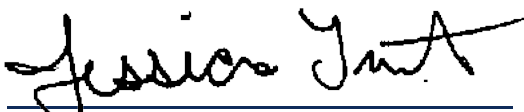
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number	= TT024272					
Probe Calibration Range	= 125 to 1100 Deg F					
	= 51.7 to 593.3 Deg C					

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.33783 Ohms						
125.1020 F	124.969F	0.5000F	26.6	Pass	1.2e-001F	
Resistance Value at Temp = 154.7915 Ohms						
287.4470 F	287.653F	0.5000F	41.2	Pass	1.2e-001F	
Resistance Value at Temp = 188.19117 Ohms						
449.8780 F	449.910F	0.5000F	6.4	Pass	1.2e-001F	
Resistance Value at Temp = 220.663 Ohms						
612.3750 F	612.339F	0.5000F	7.2	Pass	1.2e-001F	
Resistance Value at Temp = 252.166 Ohms						
774.8490 F	774.744F	0.5000F	21	Pass	1.2e-001F	
Resistance Value at Temp = 282.73817 Ohms						
937.3750 F	937.327F	0.5000F	9.6	Pass	1.2e-001F	
Resistance Value at Temp = 312.34967 Ohms						
1099.8570 F	1099.940F	0.5000F	16.6	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.33783 Ohms						
51.7230 c	51.649c	0.2780c	26.6	Pass	6.4e-002c	
Resistance Value at Temp = 154.7915 Ohms						
141.9150 c	142.030c	0.2780c	41.4	Pass	6.4e-002c	
Resistance Value at Temp = 188.19117 Ohms						
232.1540 c	232.172c	0.2780c	6.47	Pass	6.4e-002c	
Resistance Value at Temp = 220.663 Ohms						
322.4300 c	322.411c	0.2780c	6.83	Pass	6.4e-002c	
Resistance Value at Temp = 252.166 Ohms						
412.6940 c	412.636c	0.2780c	20.9	Pass	6.4e-002c	
Resistance Value at Temp = 282.73817 Ohms						
502.9860 c	502.960c	0.2780c	9.35	Pass	6.4e-002c	
Resistance Value at Temp = 312.34967 Ohms						
593.2540 c	593.300c	0.2780c	16.5	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))]}{(2 * Ro * B)}$$

Ro= 100.21442

Alpha= 0.00385926

Delta= 1.53062248644

A= 0.00391833070137

B= -5.90707013703e-007

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 70223	CAL DATE: 11 May 2017
ASSET NUMBER: 24360	CAL DUE: 11 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: MCHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~350 CAL UNITS: In-H2O

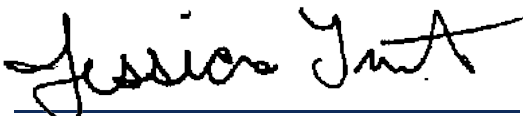
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Transmitter Tag = PTD24360						
Calibrated Span = 350 inH2O						
Calibration Tolerance = 0.2275 inH2O						
Upscale Tests						
0.0000 inH2O	-0.002inH2O	0.2275inH2O	0.879	Pass	5.8e-003inH2O	
87.5000 inH2O	87.494inH2O	0.2275inH2O	2.64	Pass	7.0e-003inH2O	
175.0000 inH2O	175.000inH2O	0.2275inH2O	0	Pass	1.4e-002inH2O	
262.5000 inH2O	262.501inH2O	0.2275inH2O	0.44	Pass	2.1e-002inH2O	
350.0000 inH2O	349.996inH2O	0.2275inH2O	1.76	Pass	2.8e-002inH2O	
Downscale Tests						
350.0000 inH2O	350.003inH2O	0.2275inH2O	1.32	Pass	2.8e-002inH2O	
262.5000 inH2O	262.493inH2O	0.2275inH2O	3.08	Pass	2.1e-002inH2O	
175.0000 inH2O	174.992inH2O	0.2275inH2O	3.52	Pass	1.4e-002inH2O	
87.5000 inH2O	87.494inH2O	0.2275inH2O	2.64	Pass	7.0e-003inH2O	
0.0000 inH2O	-0.008inH2O	0.2275inH2O	3.52	Pass	5.8e-003inH2O	

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 70245	CAL DATE: 11 May 2017
ASSET NUMBER: 24363	CAL DUE: 11 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~350
	CAL UNITS: In-H2O

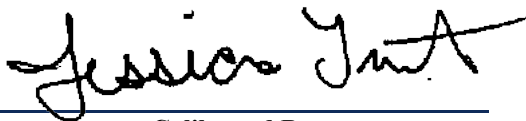
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."


Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD24363
Calibrated Span = 350 inH2O
Calibration Tolerance = 0.2275 inH2O

Upscale Tests

0.0000 inH2O	-0.001inH2O	0.2275inH2O	0.44	Pass	5.8e-003inH2O
87.5000 inH2O	87.510inH2O	0.2275inH2O	4.4	Pass	7.0e-003inH2O
175.0000 inH2O	175.015inH2O	0.2275inH2O	6.59	Pass	1.4e-002inH2O
262.5000 inH2O	262.510inH2O	0.2275inH2O	4.4	Pass	2.1e-002inH2O
350.0000 inH2O	350.005inH2O	0.2275inH2O	2.2	Pass	2.8e-002inH2O

Downscale Tests

350.0000 inH2O	349.999inH2O	0.2275inH2O	0.44	Pass	2.8e-002inH2O
262.5000 inH2O	262.493inH2O	0.2275inH2O	3.08	Pass	2.1e-002inH2O
175.0000 inH2O	174.990inH2O	0.2275inH2O	4.4	Pass	1.4e-002inH2O
87.5000 inH2O	87.491inH2O	0.2275inH2O	3.96	Pass	7.0e-003inH2O
0.0000 inH2O	0.000inH2O	0.2275inH2O	0	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 70231	CAL DATE: 11 May 2017
ASSET NUMBER: 24365	CAL DUE: 11 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~350 CAL UNITS: In-H2O

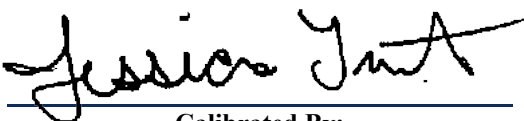
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD24365
Calibrated Span = 350 inH2O
Calibration Tolerance = 0.2275 inH2O

Upscale Tests

0.0000 inH2O	-0.003inH2O	0.2275inH2O	1.32	Pass	5.8e-003inH2O
87.5000 inH2O	87.510inH2O	0.2275inH2O	4.4	Pass	7.0e-003inH2O
175.0000 inH2O	175.021inH2O	0.2275inH2O	9.23	Pass	1.4e-002inH2O
262.5000 inH2O	262.512inH2O	0.2275inH2O	5.27	Pass	2.1e-002inH2O
350.0000 inH2O	350.002inH2O	0.2275inH2O	0.879	Pass	2.8e-002inH2O

Downscale Tests

350.0000 inH2O	349.995inH2O	0.2275inH2O	2.2	Pass	2.8e-002inH2O
262.5000 inH2O	262.499inH2O	0.2275inH2O	0.44	Pass	2.1e-002inH2O
175.0000 inH2O	174.982inH2O	0.2275inH2O	7.91	Pass	1.4e-002inH2O
87.5000 inH2O	87.488inH2O	0.2275inH2O	5.27	Pass	7.0e-003inH2O
0.0000 inH2O	-0.005inH2O	0.2275inH2O	2.2	Pass	5.8e-003inH2O

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1449288	CAL DATE: 16 May 2017
ASSET NUMBER: 24563	CAL DUE: 16 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

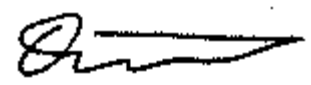
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.

 _____ Calibrated By:	 _____ Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.22PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.2200 psi	14.258psi	1.9500psi	1.95	Pass	2.2e-003psi
513.1850 psi	513.625psi	1.9500psi	22.6	Pass	7.7e-002psi
1012.6680 psi	1013.094psi	1.9500psi	21.8	Pass	1.5e-001psi
2011.6340 psi	2011.875psi	1.9500psi	12.4	Pass	3.0e-001psi
3010.6000 psi	3010.500psi	1.9500psi	5.13	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.6000 psi	3010.500psi	1.9500psi	5.13	Pass	4.5e-001psi
2011.6340 psi	2012.313psi	1.9500psi	34.8	Pass	3.0e-001psi
1012.6680 psi	1013.063psi	1.9500psi	20.3	Pass	1.5e-001psi
513.1850 psi	513.641psi	1.9500psi	23.4	Pass	7.7e-002psi
14.2200 psi	14.279psi	1.9500psi	3.03	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1996930	CAL DATE: 12 May 2017
ASSET NUMBER: 24574	CAL DUE: 12 May 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia

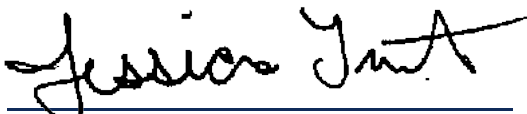
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA24574
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	14.979psi	0.5200psi	4.04	Pass	7.3e-003psi
200.0000 psi	200.113psi	0.5200psi	21.7	Pass	1.6e-002psi
400.0000 psi	400.094psi	0.5200psi	18.1	Pass	3.2e-002psi
600.0000 psi	600.078psi	0.5200psi	15	Pass	4.8e-002psi
800.0000 psi	800.016psi	0.5200psi	3.08	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	800.016psi	0.5200psi	3.08	Pass	6.4e-002psi
600.0000 psi	600.078psi	0.5200psi	15	Pass	4.8e-002psi
400.0000 psi	400.070psi	0.5200psi	13.5	Pass	3.2e-002psi
200.0000 psi	200.109psi	0.5200psi	21	Pass	1.6e-002psi
15.0000 psi	14.979psi	0.5200psi	4.04	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1201630	CAL DATE: 15 May 2017
ASSET NUMBER: 24623	CAL DUE: 15 May 2018
PROCEDURE NAME: Pressure Transmitter - PSIA/DW M2000	DATA TYPE: AS-LEFT
PROCEDURE REV.: 3 - 10/11/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~3000
	CAL UNITS: psia

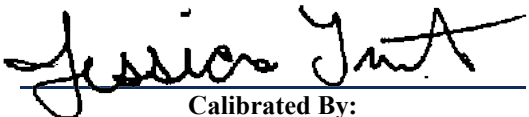
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
7214	Pressurements M2000/3 Hydraulic Dead Weight Tester	13715-1	5/24/2016	5/24/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Environmental Conditions

Temperature: 22C, Humidity: 45%Rh, Barometric Pressure: 14.18PSIA

Transmitter Calibration Range= 3000 psia

Transmitter Accuracy= 1.95 psia

***** AS FOUND/AS LEFT *****

--- Upscale Pressure Tests (DIGITAL) ---

14.1800 psi	14.144psi	1.9500psi	1.85	Pass	2.2e-003psi
513.1450 psi	513.259psi	1.9500psi	5.85	Pass	7.7e-002psi
1012.6280 psi	1013.071psi	1.9500psi	22.7	Pass	1.5e-001psi
2011.5950 psi	2012.008psi	1.9500psi	21.2	Pass	3.0e-001psi
3010.5620 psi	3011.211psi	1.9500psi	33.3	Pass	4.5e-001psi

--- Downscale Pressure Tests (DIGITAL) ---

3010.5620 psi	3011.110psi	1.9500psi	28.1	Pass	4.5e-001psi
2011.5950 psi	2012.437psi	1.9500psi	43.2	Pass	3.0e-001psi
1012.6280 psi	1013.252psi	1.9500psi	32	Pass	1.5e-001psi
513.1450 psi	513.455psi	1.9500psi	15.9	Pass	7.7e-002psi
14.1800 psi	14.144psi	1.9500psi	1.85	Pass	2.2e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1393320	CAL DATE: 25 April 2017
ASSET NUMBER: 24635	CAL DUE: 25 April 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Dave Price	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA24635
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	15.006psi	0.5200psi	1.15	Pass	7.3e-003psi
200.0000 psi	200.116psi	0.5200psi	22.3	Pass	1.6e-002psi
400.0000 psi	400.124psi	0.5200psi	23.8	Pass	3.2e-002psi
600.0000 psi	600.121psi	0.5200psi	23.3	Pass	4.8e-002psi
800.0000 psi	800.109psi	0.5200psi	21	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	800.114psi	0.5200psi	21.9	Pass	6.4e-002psi
600.0000 psi	600.113psi	0.5200psi	21.7	Pass	4.8e-002psi
400.0000 psi	400.097psi	0.5200psi	18.7	Pass	3.2e-002psi
200.0000 psi	200.116psi	0.5200psi	22.3	Pass	1.6e-002psi
15.0000 psi	14.979psi	0.5200psi	4.04	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Input Card, 20 Channel, Type K	TEST RESULT: PASS
SERIAL NUMBER: US37259960	CAL DATE: 16 May 2017
ASSET NUMBER: 24663	CAL DUE: 16 May 2018
PROCEDURE NAME: Agilent 34901A TYPE K T/C (1 year)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 01/30/14	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 45 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

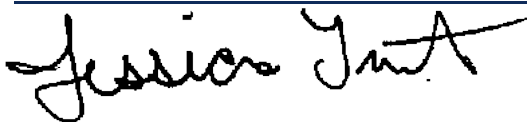
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

Asset #	Description	Serial #	Cal Date	Due Date
10133	Agilent 34970A Data Logger	US37028610	5/4/2017	8/2/2017
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/5/2016	10/5/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
Type K T/C						
32 °F	32°F	1.8°F	4.56	Pass	6.2e-001°F	
150.0 °F	150.1°F	1.80°F	2.78	Pass	2.3e-001°F	
1050.0 °F	1050.1°F	1.80°F	3.89	Pass	3.7e-001°F	3.85
Channel 201 Test						
100.0 °F	99.7°F	1.80°F	15.2	Pass	2.3e-001°F	
Channel 202 Test						
100.0 °F	99.8°F	1.80°F	10.6	Pass	2.3e-001°F	
Channel 203 Test						
100.0 °F	99.8°F	1.80°F	8.33	Pass	2.3e-001°F	
Channel 204 Test						
100.0 °F	99.9°F	1.80°F	4.17	Pass	2.3e-001°F	
Channel 205 Test						
100.0 °F	100.0°F	1.80°F	2.17	Pass	2.3e-001°F	
Channel 206 Test						
100.0 °F	100.1°F	1.80°F	5.56	Pass	2.3e-001°F	
Channel 207 Test						
100.0 °F	100.0°F	1.80°F	2.28	Pass	2.3e-001°F	
Channel 208 Test						
100.0 °F	100.0°F	1.80°F	1.72	Pass	2.3e-001°F	
Channel 209 Test						
100.0 °F	100.1°F	1.80°F	6.33	Pass	2.3e-001°F	
Channel 210 Test						
100.0 °F	100.1°F	1.80°F	4.44	Pass	2.3e-001°F	
Channel 211 Test						
100.0 °F	100.0°F	1.80°F	0.0556	Pass	2.3e-001°F	
Channel 212 Test						
100.0 °F	100.1°F	1.80°F	3.17	Pass	2.3e-001°F	
Channel 213 Test						
100.0 °F	100.0°F	1.80°F	0.556	Pass	2.3e-001°F	
Channel 214 Test						
100.0 °F	100.0°F	1.80°F	2.78	Pass	2.3e-001°F	
Channel 215 Test						
100.0 °F	99.9°F	1.80°F	3.33	Pass	2.3e-001°F	
Channel 216 Test						
100.0 °F	99.9°F	1.80°F	3.83	Pass	2.3e-001°F	
Channel 217 Test						
100.0 °F	99.9°F	1.80°F	6.28	Pass	2.3e-001°F	
Channel 218 Test						
100.0 °F	100.0°F	1.80°F	0.667	Pass	2.3e-001°F	
Channel 219 Test						
100.0 °F	100.1°F	1.80°F	4.44	Pass	2.3e-001°F	
Channel 220 Test						
100.0 °F	100.1°F	1.80°F	5.06	Pass	2.3e-001°F	

***** End of Report *****

UNIT UNDER TEST: Power Meter, Digital	TEST RESULT: PASS
SERIAL NUMBER: 00400006	CAL DATE: 12 May 2017
ASSET NUMBER: 25055	CAL DUE: 12 May 2018
PROCEDURE NAME: Nexus 1250/1252/1500: CAL VER 60Hz	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 03/28/17	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Unit is operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	3/14/2017	3/14/2018
14002	Rotek MSB100 Power and Energy Standard	173	2/25/2017	2/25/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AC VOLTAGE TESTS - 60Hz						
Phase A -						
100.000 V	100.0220V	0.08000V	27.5	Pass	1.6e-002V	3.81
120.000 V	120.0220V	0.09600V	22.9	Pass	1.9e-002V	3.87
240.000 V	240.0280V	0.19200V	14.6	Pass	3.7e-002V	
Phase B -						
100.000 V	100.0420V	0.08000V	52.5	Pass	1.6e-002V	3.81
120.000 V	120.0460V	0.09600V	47.9	Pass	1.9e-002V	3.87
240.000 V	240.0300V	0.19200V	15.6	Pass	3.7e-002V	
Phase C -						
100.000 V	100.0230V	0.08000V	28.7	Pass	1.6e-002V	3.81
120.000 V	120.0280V	0.09600V	29.2	Pass	1.9e-002V	3.87
240.000 V	239.9850V	0.19200V	7.81	Pass	3.7e-002V	
AC CURRENT TESTS - 60Hz						
Phase A - 1A Range						
1.00030 A	1.0004A	0.00100A	10	Pass	2.6e-004A	3.89
Phase B - 1A Range						
1.00030 A	1.0006A	0.00100A	30	Pass	2.6e-004A	3.89
Phase C - 1A Range						
1.00030 A	1.0003A	0.00100A	0	Pass	2.6e-004A	3.89
Phase A - 2.5A Range						
2.50060 A	2.5008A	0.00200A	10	Pass	6.5e-004A	3.11
Phase B - 2.5A Range						
2.50060 A	2.5011A	0.00200A	25	Pass	6.5e-004A	3.11
Phase C - 2.5A Range						
2.50060 A	2.5011A	0.00200A	25	Pass	6.5e-004A	3.11
Phase A - 5A Range						
5.00180 A	5.0026A	0.00400A	20	Pass	1.3e-003A	3.11
Phase B - 5A Range						
5.00180 A	5.0025A	0.00400A	17.5	Pass	1.3e-003A	3.11
Phase C - 5A Range						
5.00190 A	5.0024A	0.00400A	12.5	Pass	1.3e-003A	3.11
AC WATT TESTS - 60Hz - PF 1.0						
Phase A - 1A Range						
120.03190 W	120.0549W	0.09600W	24	Pass	7.6e-003W	
Phase B - 1A Range						
120.03290 W	120.1089W	0.09600W	79.2	Pass	7.6e-003W	
Phase C - 1A Range						
120.03290 W	120.0730W	0.09600W	41.8	Pass	7.6e-003W	
Phase A - 2.5A Range						

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
300.07500 W	300.1086W	0.24000W	14	Pass	3.5e-002W	
Phase B - 2.5A Range						
300.07590 W	300.2050W	0.24010W	53.8	Pass	3.5e-002W	
Phase C - 2.5A Range						
300.07500 W	300.1456W	0.24000W	29.4	Pass	3.5e-002W	
Phase A - 5A Range						
600.22260 W	600.3083W	0.48000W	17.9	Pass	1.4e-001W	
Phase B - 5A Range						
600.22260 W	600.4502W	0.48000W	47.4	Pass	1.4e-001W	
Phase C - 5A Range						
600.22190 W	600.3589W	0.48000W	28.5	Pass	1.4e-001W	
AC WATT TESTS - 60Hz - PF 0.75 Lead/Lag						
Phase A - 0.75 Lag						
450.32500 W	450.4598W	0.36000W	37.4	Pass	9.0e+002W	
Phase B - 0.75 Lag						
450.32600 W	450.5408W	0.36000W	59.7	Pass	8.7e-003W	
Phase C - 0.75 Lag						
450.32900 W	450.4090W	0.36000W	22.2	Pass	8.7e-003W	
Phase A - 0.75 Lead						
450.10930 W	450.1018W	0.36000W	2.08	Pass	9.0e+002W	
Phase B - 0.75 Lead						
450.11110 W	450.2727W	0.36000W	44.9	Pass	8.7e-003W	
Phase C - 0.75 Lead						
450.10680 W	450.1933W	0.36000W	24	Pass	8.7e-003W	

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 11 April 2017
ASSET NUMBER: SR317	CAL DUE: 11 April 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 21.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

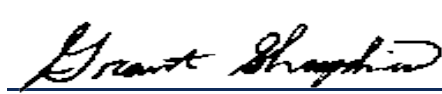
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14045	Rosemount Aerospace 162CE SPRT	4025	1/3/2017	1/3/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT0SR317
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.02417 Ohms						
125.1040 F	125.126F	0.5000F	4.4	Pass	1.2e-001F	
Resistance Value at Temp = 154.10733 Ohms						
287.6000 F	287.615F	0.5000F	3	Pass	1.2e-001F	
Resistance Value at Temp = 187.27683 Ohms						
450.0950 F	450.025F	0.5000F	14	Pass	1.2e-001F	
Resistance Value at Temp = 219.57067 Ohms						
612.5950 F	612.544F	0.5000F	10.2	Pass	1.2e-001F	
Resistance Value at Temp = 250.98067 Ohms						
775.0680 F	775.137F	0.5000F	13.8	Pass	1.2e-001F	
Resistance Value at Temp = 281.4745 Ohms						
937.5450 F	937.636F	0.5000F	18.2	Pass	1.2e-001F	
Resistance Value at Temp = 311.02233 Ohms						
1099.9420 F	1099.867F	0.5000F	15	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.02417 Ohms						
51.7240 c	51.737c	0.2780c	4.68	Pass	6.4e-002c	
Resistance Value at Temp = 154.10733 Ohms						
142.0000 c	142.009c	0.2780c	3.24	Pass	6.4e-002c	
Resistance Value at Temp = 187.27683 Ohms						
232.2750 c	232.236c	0.2780c	14	Pass	6.4e-002c	
Resistance Value at Temp = 219.57067 Ohms						
322.5530 c	322.524c	0.2780c	10.4	Pass	6.4e-002c	
Resistance Value at Temp = 250.98067 Ohms						
412.8160 c	412.854c	0.2780c	13.7	Pass	6.4e-002c	
Resistance Value at Temp = 281.4745 Ohms						
503.0800 c	503.131c	0.2780c	18.3	Pass	6.4e-002c	
Resistance Value at Temp = 311.02233 Ohms						
593.3010 c	593.259c	0.2780c	15.1	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.0856

Alpha= 0.003823984

Delta= 1.43922277424

A= 0.00387901964861

B= -5.50356486113e-007

***** End of Report *****

UNIT UNDER TEST: Agilent 34970A Data Logger	TEST RESULT: PASS
SERIAL NUMBER: US37030228	CAL DATE: 24 May 2016
ASSET NUMBER: 2018	CAL DUE: 24 May 2017
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 0.23 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 40 %
CUSTOMER: MCHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

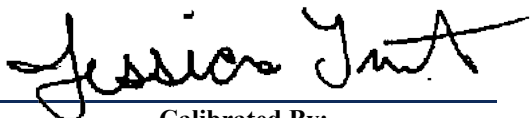
McHale & Associates certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as found and as left.

 <hr/> Calibrated By:	 <hr/> Approved By:
--	--

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/1/2015	10/1/2016

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	-0.0025mV		62.6	Pass		
1 VDC Range						
0.000000 V	-0.000002V		28.7	Pass		
10 VDC Range						
0.00000 V	-0.00000V		7.6	Pass		
100 VDC Range						
0.0000 V	-0.0001V		10.5	Pass		
300 VDC Range						
0.000 V	-0.000V		0.444	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	-0.0002Ohm		0.0237	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	0.0000Ohm		0.625	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	0.000038kOhm		3.74	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	0.000000kOhm		3.8	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	0.00002kOhm		1.82	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	0.00000kOhm		2.5	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0002kOhm		9.4	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	-0.0001kOhm		5	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	0.000000MOhm		4.55	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	-0.000000MOhm		2.5	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	-0.00000MOhm		2.48	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00001MOhm		5	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mADC Range						
0.00000 mA	-0.00005mA		2.31	Pass		
100 mADC Range						
0.00000 mA	-0.00012mA		2.46	Pass		
1 ADC Range						
0.000000 A	-0.000002A		1.75	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	49.9988mV	0.00000650V	18.3	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	99.9990mV	9.00000000001e-006	10.8	Pass	2.3e-006V	3.00
1V Range						
0.5000000 V	0.5000050V	0.00002700V	18.4	Pass	5.8e-006V	3.60
1.000000 V	1.000013V	0.0000470V	27	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00007V	0.000225V	31.6	Pass	6.2e-005V	2.81
10.00000 V	10.00015V	0.000400000000001V	36.5	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0006V	0.00285V	21.5	Pass	8.2e-004V	2.71
100.0000 V	100.0010V	0.00510V	19.4	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	149.9975V	0.01575V	15.9	Pass	2.2e-003V	
300.0000 V	299.9983V	0.02250V	7.69	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	100.0076mV	0.00010000V	7.61	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	100.0682mV	0.00017000V	40.1	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	1.000058V	0.0010000V	5.82	Pass	1.6e-004V	
1.000000 V @ 50 kHz	1.000726V	0.0017000V	42.7	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	10.00021V	0.010000V	2.14	Pass	1.6e-003V	
10.00000 V @ 50 kHz	10.00381V	0.017000V	22.4	Pass	3.2e-003V	
10.00000 V @ 10 Hz	9.99839V	0.010000V	16.1	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	100.0198V	0.10000V	19.8	Pass	1.6e-002V	
100.0000 V @ 50 kHz	100.0011V	0.17000V	0.653	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	300.077V	0.4200V	18.4	Pass	4.6e-002V	
300.000 V @ 50 kHz	300.134V	0.7200V	18.6	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	100.1226Ohm	1.01400Ohm	12.1	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	1.000138kOhm	1.1100Ohm	12.4	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00024kOhm	2.100Ohm	11.5	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	100.0024kOhm	12.00Ohm	20.2	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000039MOhm	111.00Ohm	34.7	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	10.00061MOhm	41000Ohm	14.8	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	99.5444MOhm	810000Ohm	56.2	Pass	4.1e+004Ohm	
4-WIRE OHMS: 100 Ohm Range 100.0000 Ohm	100.0000Ohm	0.01400Ohm	0.179	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	1.000014kOhm	0.1100Ohm	12.5	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	10.00013kOhm	1.100Ohm	11.9	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	100.0026kOhm	11.00Ohm	23.4	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	100.0089Hz	0.10000Hz	8.9	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0001kHz	10.00Hz	1.4	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	10.00043mA	0.000007000A	6.09	Pass	9.7e-007A	
100mA Range 100.0000 mA	100.0022mA	0.00005500A	3.95	Pass	9.7e-006A	
1A Range 1.000000 A	0.999909A	0.0011000A	8.28	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99954mA	0.000014000A	3.32	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	100.0507mA	0.00060000A	8.45	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	1.000086A	0.0014000A	6.16	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: Nexus 1500 Power Meter	TEST RESULT: PASS
SERIAL NUMBER: 180266730	CAL DATE: 10 February 2017
ASSET NUMBER: 10387	CAL DUE: 10 February 2018
PROCEDURE NAME: Nexus 1250: CAL VER 1	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 06/25/07	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

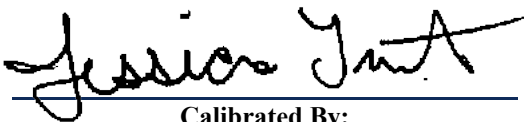
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Unit is operating within tolerance as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14001	Fluke 5520A Multi-Function Calibrator	8635015	2/24/2016	2/23/2017
14002	Rotek MSB100 Power and Energy Standard	173	3/4/2016	3/4/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
AC VOLTAGE TESTS - 60Hz						
Phase A -						
100.000 V	99.9920V	0.08000V	10	Pass	1.6e-002V	3.81
120.000 V	119.9880V	0.09600V	12.5	Pass	1.9e-002V	3.87
240.000 V	239.9770V	0.19200V	12	Pass	3.7e-002V	
Phase B -						
100.000 V	99.9810V	0.08000V	23.8	Pass	1.6e-002V	3.81
120.000 V	119.9850V	0.09600V	15.6	Pass	1.9e-002V	3.87
240.000 V	239.9650V	0.19200V	18.2	Pass	3.7e-002V	
Phase C -						
100.000 V	99.9900V	0.08000V	12.5	Pass	1.6e-002V	3.81
120.000 V	119.9850V	0.09600V	15.6	Pass	1.9e-002V	3.87
240.000 V	239.9790V	0.19200V	10.9	Pass	3.7e-002V	
AC CURRENT TESTS - 60Hz						
Phase A - 1A Range						
1.00020 A	1.0002A	0.00100A	0	Pass	2.6e-004A	3.89
Phase B - 1A Range						
1.00020 A	1.0001A	0.00100A	10	Pass	2.6e-004A	3.89
Phase C - 1A Range						
1.00020 A	1.0001A	0.00100A	10	Pass	2.6e-004A	3.89
Phase A - 2.5A Range						
2.50050 A	2.5004A	0.00200A	5	Pass	6.5e-004A	3.11
Phase B - 2.5A Range						
2.50050 A	2.5004A	0.00200A	5	Pass	6.5e-004A	3.11
Phase C - 2.5A Range						
2.50050 A	2.5004A	0.00200A	5	Pass	6.5e-004A	3.11
Phase A - 5A Range						
5.00130 A	5.0010A	0.00400A	7.5	Pass	1.3e-003A	3.11
Phase B - 5A Range						
5.00130 A	5.0009A	0.00400A	10	Pass	1.3e-003A	3.11
Phase C - 5A Range						
5.00130 A	5.0011A	0.00400A	5	Pass	1.3e-003A	3.11
AC WATT TESTS - 60Hz - PF 1.0						
Phase A - 1A Range						
120.02500 W	120.0065W	0.09600W	19.3	Pass	7.6e-003W	
Phase B - 1A Range						
120.02510 W	120.0054W	0.09600W	20.5	Pass	7.6e-003W	
Phase C - 1A Range						
120.02490 W	119.9995W	0.09600W	26.5	Pass	7.6e-003W	
Phase A - 2.5A Range						

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
300.05720 W	300.0178W	0.24000W	16.4	Pass	3.5e-002W	
Phase B - 2.5A Range						
300.05940 W	300.0005W	0.24000W	24.5	Pass	3.5e-002W	
Phase C - 2.5A Range						
300.06130 W	300.0107W	0.24000W	21.1	Pass	3.5e-002W	
Phase A - 5A Range						
600.16840 W	600.0420W	0.48000W	26.3	Pass	1.4e-001W	
Phase B - 5A Range						
600.17960 W	600.0800W	0.48000W	20.8	Pass	1.4e-001W	
Phase C - 5A Range						
600.17700 W	600.0553W	0.48000W	25.4	Pass	1.4e-001W	
AC WATT TESTS - 60Hz - PF 0.75 Lead/Lag						
Phase A - 0.75 Lag						
450.25490 W	450.1898W	0.36000W	18.1	Pass	9.0e+002W	
Phase A - 0.75 Lead						
450.08880 W	449.9913W	0.36000W	27.1	Pass	9.0e+002W	
Phase B - 0.75 Lag						
450.22170 W	450.1490W	0.36000W	20.2	Pass	8.7e-003W	
Phase B - 0.75 Lead						
450.11140 W	450.0308W	0.36000W	22.4	Pass	8.7e-003W	
Phase C - 0.75 Lag						
450.21300 W	450.1389W	0.36000W	20.6	Pass	8.7e-003W	
Phase C - 0.75 Lead						
450.16030 W	450.0790W	0.36000W	22.6	Pass	8.7e-003W	

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 5577	CAL DATE: 09 February 2017
ASSET NUMBER: 15047	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

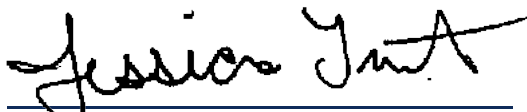
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT015047
Probe Calibration Range = 20 to 200 Deg F
= -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.78033 Ohms						
20.4060 F	20.411F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 104.32033 Ohms						
50.3570 F	50.351F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 110.82233 Ohms						
80.3200 F	80.307F	0.2590F	5.02	Pass	3.4e-002F	
Resistance Value at Temp = 117.30267 Ohms						
110.3350 F	110.357F	0.2590F	8.49	Pass	3.4e-002F	
Resistance Value at Temp = 123.7305 Ohms						
140.3530 F	140.356F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 130.11867 Ohms						
170.3830 F	170.365F	0.2590F	6.95	Pass	3.4e-002F	
Resistance Value at Temp = 136.475 Ohms						
200.4150 F	200.422F	0.2590F	2.7	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.78033 Ohms						
-6.4410 c	-6.438c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 104.32033 Ohms						
10.1980 c	10.195c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 110.82233 Ohms						
26.8440 c	26.837c	0.1440c	4.86	Pass	1.9e-002c	
Resistance Value at Temp = 117.30267 Ohms						
43.5200 c	43.531c	0.1440c	7.64	Pass	1.9e-002c	
Resistance Value at Temp = 123.7305 Ohms						
60.1960 c	60.198c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 130.11867 Ohms						
76.8790 c	76.870c	0.1440c	6.25	Pass	1.9e-002c	
Resistance Value at Temp = 136.475 Ohms						
93.5640 c	93.568c	0.1440c	2.78	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}] / (2*Ro*B)$
Ro= 100.31678
Alpha= 0.003847372
Delta= 1.94647903101
A= 0.00392226028923
B= -7.48882892251e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2261	CAL DATE: 09 February 2017
ASSET NUMBER: 16055	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

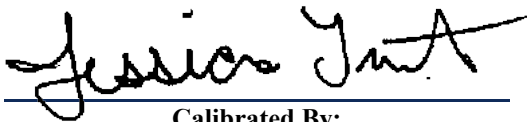
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

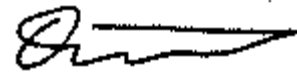
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT016055
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.61817 Ohms						
20.4060 F	20.413F	0.2590F	2.7	Pass	3.4e-002F	
Resistance Value at Temp = 104.13283 Ohms						
50.3570 F	50.350F	0.2590F	2.7	Pass	3.4e-002F	
Resistance Value at Temp = 110.617 Ohms						
80.3200 F	80.318F	0.2590F	0.772	Pass	3.4e-002F	
Resistance Value at Temp = 117.073 Ohms						
110.3350 F	110.329F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 123.4935 Ohms						
140.3530 F	140.350F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 129.88483 Ohms						
170.3830 F	170.409F	0.2590F	10	Pass	3.4e-002F	
Resistance Value at Temp = 136.224 Ohms						
200.4150 F	200.400F	0.2590F	5.79	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.61817 Ohms						
-6.4410 c	-6.437c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 104.13283 Ohms						
10.1980 c	10.194c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 110.617 Ohms						
26.8440 c	26.843c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 117.073 Ohms						
43.5200 c	43.516c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 123.4935 Ohms						
60.1960 c	60.194c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 129.88483 Ohms						
76.8790 c	76.894c	0.1440c	10.4	Pass	1.9e-002c	
Resistance Value at Temp = 136.224 Ohms						
93.5640 c	93.556c	0.1440c	5.56	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$$

Ro= 100.14408

Alpha= 0.003846639

Delta= 1.74977530987

A= 0.00391394653948

B= -6.73075394819e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2508	CAL DATE: 09 February 2017
ASSET NUMBER: 20128	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

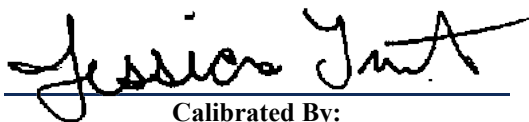
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT020128
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.32567 Ohms						
20.4060 F	20.407F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 103.83383 Ohms						
50.3570 F	50.360F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 110.3035 Ohms						
80.3200 F	80.314F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 116.748 Ohms						
110.3350 F	110.330F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 123.15517 Ohms						
140.3530 F	140.353F	0.2590F	0	Pass	3.4e-002F	
Resistance Value at Temp = 129.5285 Ohms						
170.3830 F	170.399F	0.2590F	6.18	Pass	3.4e-002F	
Resistance Value at Temp = 135.85483 Ohms						
200.4150 F	200.406F	0.2590F	3.47	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.32567 Ohms						
-6.4410 c	-6.440c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 103.83383 Ohms						
10.1980 c	10.200c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 110.3035 Ohms						
26.8440 c	26.841c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 116.748 Ohms						
43.5200 c	43.517c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 123.15517 Ohms						
60.1960 c	60.196c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 129.5285 Ohms						
76.8790 c	76.888c	0.1440c	6.25	Pass	1.9e-002c	
Resistance Value at Temp = 135.85483 Ohms						
93.5640 c	93.559c	0.1440c	3.47	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}}{2 * Ro * B}$$

Ro= 99.84909

Alpha= 0.003849784

Delta= 1.81202991077

A= 0.00391954323758

B= -6.97592375799e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4050	CAL DATE: 09 February 2017
ASSET NUMBER: 20148	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

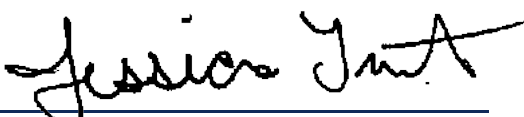
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT020148
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.27517 Ohms						
20.4060 F	20.407F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 103.74833 Ohms						
50.3570 F	50.350F	0.2590F	2.7	Pass	3.4e-002F	
Resistance Value at Temp = 110.19533 Ohms						
80.3200 F	80.329F	0.2590F	3.47	Pass	3.4e-002F	
Resistance Value at Temp = 116.6145 Ohms						
110.3350 F	110.336F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 123.00117 Ohms						
140.3530 F	140.352F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 129.3555 Ohms						
170.3830 F	170.375F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 135.68 Ohms						
200.4150 F	200.420F	0.2590F	1.93	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.27517 Ohms						
-6.4410 c	-6.440c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 103.74833 Ohms						
10.1980 c	10.194c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 110.19533 Ohms						
26.8440 c	26.849c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 116.6145 Ohms						
43.5200 c	43.520c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 123.00117 Ohms						
60.1960 c	60.195c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 129.3555 Ohms						
76.8790 c	76.875c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 135.68 Ohms						
93.5640 c	93.566c	0.1440c	1.39	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}] / (2 * Ro * B)$

Ro= 99.78539

Alpha= 0.003840568

Delta= 1.60016089415

A= 0.00390202326725

B= -6.14552672491e-007

***** End of Report *****

UNIT UNDER TEST: Data Logger	TEST RESULT: PASS
SERIAL NUMBER: MY44058010	CAL DATE: 20 May 2016
ASSET NUMBER: 20365	CAL DUE: 20 May 2017
PROCEDURE NAME: Agilent 34970A: RS-232/5520A (1 year) (Auto)	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 0 - 05/26/04	TEMPERATURE: 23.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 40 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: N/A
	CAL UNITS: N/A

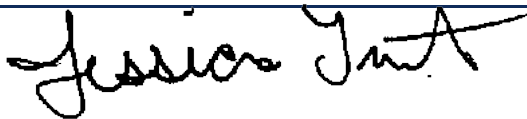
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

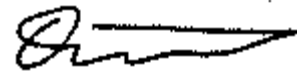
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as found and as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14023	Fluke 5520A Multi-Function Calibrator	7825010	10/1/2015	10/1/2016

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
SELF TEST						
0.00 status	0.0status		0	Pass		
ZERO TESTS						
100 mVDC Range						
0.0000 mV	-0.0004mV		10	Pass		
1 VDC Range						
0.000000 V	-0.000000V		1.86	Pass		
10 VDC Range						
0.00000 V	0.00000V		2.6	Pass		
100 VDC Range						
0.0000 V	0.0000V		4.5	Pass		
300 VDC Range						
0.000 V	0.000V		1.44	Pass		
100 Ohm Range, 2-Wire						
0.0000 Ohm	-0.0003Ohm		0.0253	Pass		
100 Ohm Range, 4-Wire						
0.0000 Ohm	-0.0002Ohm		5.02	Pass		
1 kOhm Range, 2-Wire						
0.000000 kOhm	-0.000024kOhm		2.4	Pass		
1 kOhm Range, 4-Wire						
0.000000 kOhm	0.000000kOhm		1.3	Pass		
10 kOhm Range, 2-Wire						
0.00000 kOhm	-0.00003kOhm		2.44	Pass		
10 kOhm Range, 4-Wire						
0.00000 kOhm	0.00000kOhm		2.7	Pass		
100 kOhm Range, 2-Wire						
0.0000 kOhm	-0.0000kOhm		2	Pass		
100 kOhm Range, 4-Wire						
0.0000 kOhm	0.0000kOhm		2.7	Pass		
1 MOhm Range, 2-Wire						
0.000000 MOhm	-0.000000MOhm		2.45	Pass		
1 MOhm Range, 4-Wire						
0.000000 MOhm	-0.000000MOhm		2.7	Pass		
10 MOhm Range, 2-Wire						
0.00000 MOhm	-0.00000MOhm		2.67	Pass		
10 MOhm Range, 4-Wire						
0.00000 MOhm	0.00001MOhm		5.3	Pass		
100 MOhm Range, 2-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
100 MOhm Range, 4-Wire						
0.0000 MOhm	0.0000MOhm		0	Pass		
10 mADC Range						
0.00000 mA	0.00001mA		0.405	Pass		
100 mADC Range						
0.00000 mA	0.00000mA		0	Pass		
1 ADC Range						
0.000000 A	-0.000000A		0.13	Pass		
DC VOLTAGE:						
100mV Range						
50.0000 mV	49.9981mV	0.00000650V	29.3	Pass	1.6e-006V	3.25

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
100.0000 mV	99.9957mV	0.00000900V	48.3	Pass	2.3e-006V	3.00
1V Range						
0.500000 V	0.4999986V	0.00002700V	5.07	Pass	5.8e-006V	3.60
1.000000 V	0.999998V	0.0000470V	4.32	Pass	1.0e-005V	3.62
10V Range						
5.00000 V	5.00002V	0.000225V	10.3	Pass	6.2e-005V	2.81
10.00000 V	10.00005V	0.000400000000001V	12.3	Pass	1.1e-004V	2.86
100V Range						
50.0000 V	50.0004V	0.00285V	14	Pass	8.2e-004V	2.71
100.0000 V	100.0006V	0.00510V	12.2	Pass	1.5e-003V	2.62
300V Range						
150.0000 V	149.9994V	0.01575V	3.68	Pass	2.2e-003V	
300.0000 V	299.9997V	0.02250V	1.38	Pass	4.3e-003V	
AC VOLTAGE:						
100mV Range						
100.0000 mV @ 1 kHz	100.0028mV	0.00010000V	2.83	Pass	1.7e-005V	
100.0000 mV @ 50 kHz	100.0371mV	0.00017000V	21.8	Pass	3.3e-005V	3.95
1V Range						
1.000000 V @ 1 kHz	0.999976V	0.0010000V	2.41	Pass	1.6e-004V	
1.000000 V @ 50 kHz	1.000035V	0.0017000V	2.06	Pass	2.7e-004V	
10V Range						
10.00000 V @ 1 kHz	9.99920V	0.010000V	8.03	Pass	1.6e-003V	
10.00000 V @ 50 kHz	10.00165V	0.017000V	9.69	Pass	3.2e-003V	
10.00000 V @ 10 Hz	9.99808V	0.010000V	19.2	Pass	2.8e-003V	2.74
100V Range						
100.0000 V @ 1 kHz	99.9998V	0.10000V	0.159	Pass	1.6e-002V	
100.0000 V @ 50 kHz	99.9754V	0.17000V	14.5	Pass	2.8e-002V	
300V Range						
300.000 V @ 1 kHz	299.982V	0.4200V	4.4	Pass	4.6e-002V	
300.000 V @ 50 kHz	299.934V	0.7200V	9.22	Pass	7.4e-002V	
2-WIRE OHMS:						
100 Ohm Range						
100.0000 Ohm	100.1344Ohm	1.01400Ohm	13.3	Pass	3.3e-003Ohm	
1 kOhm Range						
1.000000 kOhm	1.000129kOhm	1.1100Ohm	11.6	Pass	2.3e-002Ohm	
10 kOhm Range						
10.00000 kOhm	10.00002kOhm	2.100Ohm	1.05	Pass	2.3e-001Ohm	
100 kOhm Range						
100.0000 kOhm	99.9996kOhm	12.00Ohm	3.45	Pass	2.3e+000Ohm	4.00
1 MOhm Range						
1.000000 MOhm	1.000010MOhm	111.00Ohm	9.01	Pass	2.6e+001Ohm	3.26

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
10 MOhm Range 10.00000 MOhm	10.00012MOhm	41000Ohm	2.98	Pass	1.0e+003Ohm	3.04
100 MOhm Range 100.0000 MOhm	99.8952MOhm	810000Ohm	12.9	Pass	4.1e+004Ohm	
4-WIRE OHMS: 100 Ohm Range 100.0000 Ohm	99.9962Ohm	0.01400Ohm	27.1	Pass	3.3e-003Ohm	3.33
1 kOhm Range 1.000000 kOhm	0.999992kOhm	0.1100Ohm	7.38	Pass	2.3e-002Ohm	3.67
10 kOhm Range 10.00000 kOhm	9.99991kOhm	1.100Ohm	8.16	Pass	2.3e-001Ohm	3.67
100 kOhm Range 100.0000 kOhm	99.9995kOhm	11.00Ohm	4.37	Pass	2.3e+000Ohm	3.67
FREQUENCY - Gain Verification						
100mV Range 100.0000 Hz @ 10 mV	100.0573Hz	0.10000Hz	57.3	Pass	2.1e-004Hz	
1V Range 100.0000 kHz @ 1 V	100.0002kHz	10.00Hz	2.3	Pass	2.0e-001Hz	
DC CURRENT:						
10mA Range 10.00000 mA	10.00016mA	0.000007000A	2.24	Pass	9.7e-007A	
100mA Range 100.0000 mA	99.9986mA	0.00005500A	2.61	Pass	9.7e-006A	
1A Range 1.000000 A	0.999784A	0.0011000A	19.6	Pass	1.9e-004A	
AC CURRENT:						
10mA Range 10.00000 mA @ 1 kHz	9.99943mA	0.000014000A	4.1	Pass	4.7e-006A	2.33
100mA Range 100.0000 mA @ 1 kHz	99.9967mA	0.00060000A	0.551	Pass	4.7e-005A	
1A Range 1.000000 A @ 1 kHz	1.000202A	0.0014000A	14.5	Pass	4.7e-004A	2.33

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 53787	CAL DATE: 07 February 2017
ASSET NUMBER: 20385	CAL DUE: 07 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 35 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 10~15 CAL UNITS: psia

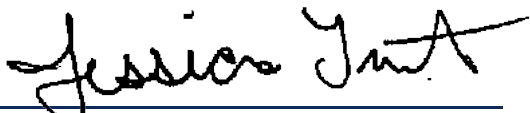
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20385

Calibrated Span = 5 PSI

Calibration Tolerance = 0.00325 PSI

Upscale Tests

10.0000 psi	10.000psi	0.00325psi	0	Pass	9.9e-004psi	
11.2500 psi	11.249psi	0.00325psi	30.8	Pass	1.1e-003psi	3.61
12.5000 psi	12.498psi	0.00325psi	61.5	Pass	1.2e-003psi	3.25
13.7500 psi	13.749psi	0.00325psi	30.8	Pass	1.2e-003psi	2.95
15.0000 psi	14.999psi	0.00325psi	30.8	Pass	1.3e-003psi	2.71

Downscale Tests

15.0000 psi	14.998psi	0.00325psi	61.5	Pass	1.3e-003psi	2.71
13.7500 psi	13.749psi	0.00325psi	30.8	Pass	1.2e-003psi	2.95
12.5000 psi	12.499psi	0.00325psi	30.8	Pass	1.2e-003psi	3.25
11.2500 psi	11.250psi	0.00325psi	0	Pass	1.1e-003psi	3.61
10.0000 psi	10.000psi	0.00325psi	0	Pass	9.9e-004psi	

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1332074	CAL DATE: 02 February 2017
ASSET NUMBER: 20508	CAL DUE: 02 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Dave Price	HUMIDITY: 39 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800
	CAL UNITS: psia

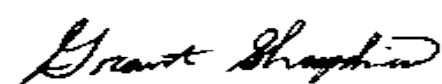
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20508
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	15.114psi	0.5200psi	21.9	Pass	7.3e-003psi
200.0000 psi	200.005psi	0.5200psi	0.962	Pass	1.6e-002psi
400.0000 psi	400.092psi	0.5200psi	17.7	Pass	3.2e-002psi
600.0000 psi	600.178psi	0.5200psi	34.2	Pass	4.8e-002psi
800.0000 psi	800.318psi	0.5200psi	61.2	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	800.337psi	0.5200psi	64.8	Pass	6.4e-002psi
600.0000 psi	600.172psi	0.5200psi	33.1	Pass	4.8e-002psi
400.0000 psi	400.092psi	0.5200psi	17.7	Pass	3.2e-002psi
200.0000 psi	199.978psi	0.5200psi	4.23	Pass	1.6e-002psi
15.0000 psi	14.949psi	0.5200psi	9.81	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1146882	CAL DATE: 22 February 2017
ASSET NUMBER: 20538	CAL DUE: 22 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 38 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5 CAL UNITS: In-H2O

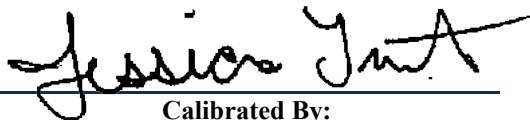
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
20282	Pressurements Limited V1600/3D Dead Weight Tester	N455/2013611	1/7/2016	1/6/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20538
Calibrated Span = 5 inH2O
Calibration Tolerance = 0.005 inH2O

Upscale Tests

0.0000 inH2O	0.000inH2O	0.0050inH2O	0	Pass	7.6e-004inH2O	
2.0000 inH2O	1.999inH2O	0.0050inH2O	20	Pass	1.6e-003inH2O	3.29
3.0000 inH2O	3.000inH2O	0.0050inH2O	0	Pass	1.9e-003inH2O	2.73
4.0000 inH2O	3.999inH2O	0.0050inH2O	20	Pass	2.1e-003inH2O	2.45
5.0000 inH2O	5.000inH2O	0.0050inH2O	0	Pass	2.3e-003inH2O	2.27

Downscale Tests

5.0000 inH2O	5.000inH2O	0.0050inH2O	0	Pass	2.3e-003inH2O	2.27
4.0000 inH2O	3.999inH2O	0.0050inH2O	20	Pass	2.1e-003inH2O	2.45
3.0000 inH2O	2.999inH2O	0.0050inH2O	20	Pass	1.9e-003inH2O	2.73
2.0000 inH2O	1.999inH2O	0.0050inH2O	20	Pass	1.6e-003inH2O	3.29
0.0000 inH2O	-0.001inH2O	0.0050inH2O	20	Pass	7.6e-004inH2O	

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1339325	CAL DATE: 22 February 2017
ASSET NUMBER: 20606	CAL DUE: 22 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 38 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5 CAL UNITS: In-H2O

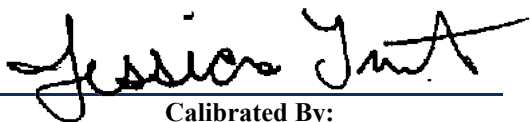
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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
20282	Pressurements Limited V1600/3D Dead Weight Tester	N455/2013611	1/7/2016	1/6/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20606
Calibrated Span = 5 inH2O
Calibration Tolerance = 0.005 inH2O

Upscale Tests

0.0000 inH2O	0.000inH2O	0.0050inH2O	0	Pass	7.6e-004inH2O	
2.0000 inH2O	1.999inH2O	0.0050inH2O	20	Pass	1.6e-003inH2O	3.29
3.0000 inH2O	3.000inH2O	0.0050inH2O	0	Pass	1.9e-003inH2O	2.73
4.0000 inH2O	3.999inH2O	0.0050inH2O	20	Pass	2.1e-003inH2O	2.45
5.0000 inH2O	4.999inH2O	0.0050inH2O	20	Pass	2.3e-003inH2O	2.27

Downscale Tests

5.0000 inH2O	4.999inH2O	0.0050inH2O	20	Pass	2.3e-003inH2O	2.27
4.0000 inH2O	4.000inH2O	0.0050inH2O	0	Pass	2.1e-003inH2O	2.45
3.0000 inH2O	3.000inH2O	0.0050inH2O	0	Pass	1.9e-003inH2O	2.73
2.0000 inH2O	2.000inH2O	0.0050inH2O	0	Pass	1.6e-003inH2O	3.29
0.0000 inH2O	0.000inH2O	0.0050inH2O	0	Pass	7.6e-004inH2O	

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1015711	CAL DATE: 02 February 2017
ASSET NUMBER: 20783	CAL DUE: 02 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 22.00 °C
CALIBRATED BY: Dave Price	HUMIDITY: 39 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~800 CAL UNITS: psia


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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA20783
Calibrated Span = 800 PSI
Calibration Tolerance = 0.52 PSI

Upscale Tests

15.0000 psi	15.033psi	0.5200psi	6.35	Pass	7.3e-003psi
200.0000 psi	200.015psi	0.5200psi	2.88	Pass	1.6e-002psi
400.0000 psi	400.034psi	0.5200psi	6.54	Pass	3.2e-002psi
600.0000 psi	600.011psi	0.5200psi	2.12	Pass	4.8e-002psi
800.0000 psi	800.015psi	0.5200psi	2.88	Pass	6.4e-002psi

Downscale Tests

800.0000 psi	800.015psi	0.5200psi	2.88	Pass	6.4e-002psi
600.0000 psi	600.011psi	0.5200psi	2.12	Pass	4.8e-002psi
400.0000 psi	400.015psi	0.5200psi	2.88	Pass	3.2e-002psi
200.0000 psi	200.031psi	0.5200psi	5.96	Pass	1.6e-002psi
15.0000 psi	15.044psi	0.5200psi	8.46	Pass	7.3e-003psi

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1024081	CAL DATE: 14 February 2017
ASSET NUMBER: 20875	CAL DUE: 14 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

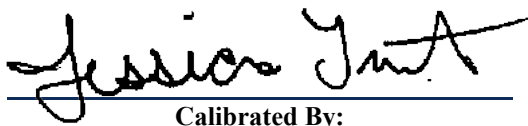
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left.


Calibrated By:


Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20875
Calibrated Span = 25 inH2O
Calibration Tolerance = 0.01625 inH2O

Upscale Tests

0.0000 inH2O	-0.010inH2O	0.01625inH2O	61.5	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.254inH2O	0.01625inH2O	24.6	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.504inH2O	0.01625inH2O	24.6	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.758inH2O	0.01625inH2O	49.2	Pass	5.8e-003inH2O	2.81
25.0000 inH2O	25.007inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81

Downscale Tests

25.0000 inH2O	25.002inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.759inH2O	0.01625inH2O	55.4	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.508inH2O	0.01625inH2O	49.2	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.249inH2O	0.01625inH2O	6.15	Pass	5.8e-003inH2O	2.81
0.0000 inH2O	-0.007inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1894777	CAL DATE: 22 February 2017
ASSET NUMBER: 20895	CAL DUE: 22 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 38 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~5 CAL UNITS: In-H2O

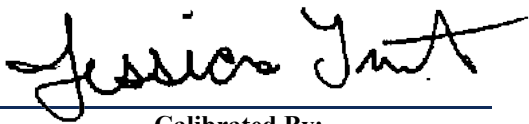
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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017
20282	Pressurements Limited V1600/3D Dead Weight Tester	N455/2013611	1/7/2016	1/6/2018

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20895
Calibrated Span = 5 inH2O
Calibration Tolerance = 0.005 inH2O

Upscale Tests

0.0000 inH2O	0.000inH2O	0.0050inH2O	0	Pass	7.6e-004inH2O	
2.0000 inH2O	1.999inH2O	0.0050inH2O	20	Pass	1.6e-003inH2O	3.29
3.0000 inH2O	2.999inH2O	0.0050inH2O	20	Pass	1.9e-003inH2O	2.73
4.0000 inH2O	3.999inH2O	0.0050inH2O	20	Pass	2.1e-003inH2O	2.45
5.0000 inH2O	4.999inH2O	0.0050inH2O	20	Pass	2.3e-003inH2O	2.27

Downscale Tests

5.0000 inH2O	4.999inH2O	0.0050inH2O	20	Pass	2.3e-003inH2O	2.27
4.0000 inH2O	3.999inH2O	0.0050inH2O	20	Pass	2.1e-003inH2O	2.45
3.0000 inH2O	2.998inH2O	0.0050inH2O	40	Pass	1.9e-003inH2O	2.73
2.0000 inH2O	1.999inH2O	0.0050inH2O	20	Pass	1.6e-003inH2O	3.29
0.0000 inH2O	0.000inH2O	0.0050inH2O	0	Pass	7.6e-004inH2O	

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1473856	CAL DATE: 14 February 2017
ASSET NUMBER: 20896	CAL DUE: 14 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

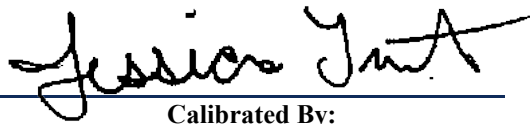
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

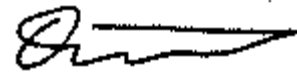
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Transmitter Tag = PTD20896
 Calibrated Span = 25 inH2O
 Calibration Tolerance = 0.01625 inH2O

Upscale Tests

0.0000 inH2O	-0.008inH2O	0.01625inH2O	49.2	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.246inH2O	0.01625inH2O	24.6	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.493inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.747inH2O	0.01625inH2O	18.5	Pass	5.8e-003inH2O	2.81
25.0000 inH2O	24.999inH2O	0.01625inH2O	6.15	Pass	5.8e-003inH2O	2.81

Downscale Tests

25.0000 inH2O	24.997inH2O	0.01625inH2O	18.5	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.748inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.498inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.243inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81
0.0000 inH2O	-0.007inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1339339	CAL DATE: 14 February 2017
ASSET NUMBER: 20904	CAL DUE: 14 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

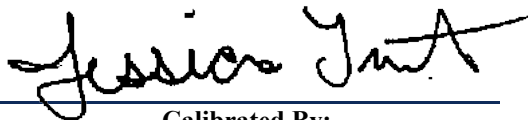
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Transmitter Tag = PTD20904						
Calibrated Span = 25 inH2O						
Calibration Tolerance = 0.01625 inH2O						
Upscale Tests						
0.0000 inH2O	-0.008inH2O	0.01625inH2O	49.2	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.248inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.494inH2O	0.01625inH2O	36.9	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.750inH2O	0.01625inH2O	0	Pass	5.8e-003inH2O	2.81
25.0000 inH2O	25.009inH2O	0.01625inH2O	55.4	Pass	5.8e-003inH2O	2.81
Downscale Tests						
25.0000 inH2O	25.003inH2O	0.01625inH2O	18.5	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.750inH2O	0.01625inH2O	0	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.497inH2O	0.01625inH2O	18.5	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.241inH2O	0.01625inH2O	55.4	Pass	5.8e-003inH2O	2.81
0.0000 inH2O	-0.005inH2O	0.01625inH2O	30.8	Pass	5.8e-003inH2O	2.81

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1877017	CAL DATE: 14 February 2017
ASSET NUMBER: 20921	CAL DUE: 14 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

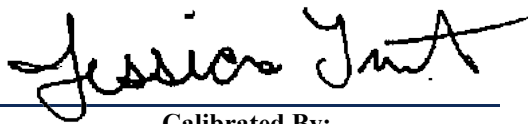
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

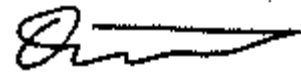
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTD20921
Calibrated Span = 25 inH2O
Calibration Tolerance = 0.01625 inH2O

Upscale Tests

0.0000 inH2O	-0.008inH2O	0.01625inH2O	49.2	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.247inH2O	0.01625inH2O	18.5	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.498inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.750inH2O	0.01625inH2O	0	Pass	5.8e-003inH2O	2.81
25.0000 inH2O	24.995inH2O	0.01625inH2O	30.8	Pass	5.8e-003inH2O	2.81

Downscale Tests

25.0000 inH2O	24.996inH2O	0.01625inH2O	24.6	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.748inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.499inH2O	0.01625inH2O	6.15	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.243inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81
0.0000 inH2O	-0.007inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Diff.	TEST RESULT: PASS
SERIAL NUMBER: 1812059	CAL DATE: 14 February 2017
ASSET NUMBER: 20923	CAL DUE: 14 February 2018
PROCEDURE NAME: Digital Pressure Transmitter (inH2O@20c)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 06/21/12	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~25 CAL UNITS: In-H2O

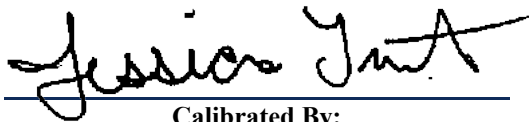
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

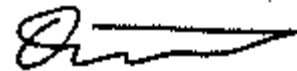
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Transmitter Tag = PTD20923						
Calibrated Span = 25 inH2O						
Calibration Tolerance = 0.01625 inH2O						
Upscale Tests						
0.0000 inH2O	-0.007inH2O	0.01625inH2O	43.1	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.253inH2O	0.01625inH2O	18.5	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.501inH2O	0.01625inH2O	6.15	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.750inH2O	0.01625inH2O	0	Pass	5.8e-003inH2O	2.81
25.0000 inH2O	25.008inH2O	0.01625inH2O	49.2	Pass	5.8e-003inH2O	2.81
Downscale Tests						
25.0000 inH2O	25.002inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
18.7500 inH2O	18.751inH2O	0.01625inH2O	6.15	Pass	5.8e-003inH2O	2.81
12.5000 inH2O	12.504inH2O	0.01625inH2O	24.6	Pass	5.8e-003inH2O	2.81
6.2500 inH2O	6.248inH2O	0.01625inH2O	12.3	Pass	5.8e-003inH2O	2.81
0.0000 inH2O	-0.005inH2O	0.01625inH2O	30.8	Pass	5.8e-003inH2O	2.81

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER: A1530001	CAL DATE: 08 February 2017
ASSET NUMBER: 21013	CAL DUE: 08 February 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 35 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

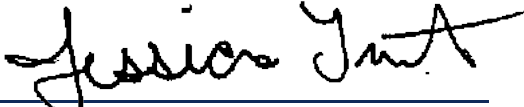
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-found and as-left.

 <hr style="width: 80%; margin: 0 auto;"/> <p>Calibrated By:</p>	 <hr style="width: 80%; margin: 0 auto;"/> <p>Approved By:</p>
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
12.0000 %RH	12.163%RH	2.0000%RH	8.15	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	32.728%RH	2.0000%RH	13.6	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
76.0000 %RH	76.431%RH	2.0000%RH	21.5	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6819	CAL DATE: 09 February 2017
ASSET NUMBER: 21179	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

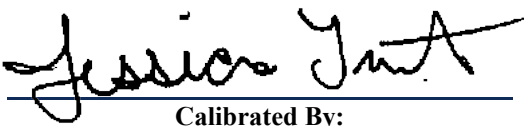
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT021179
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.5435 Ohms						
20.4060 F	20.414F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 104.03317 Ohms						
50.3570 F	50.344F	0.2590F	5.02	Pass	3.4e-002F	
Resistance Value at Temp = 110.49983 Ohms						
80.3200 F	80.322F	0.2590F	0.772	Pass	3.4e-002F	
Resistance Value at Temp = 116.94017 Ohms						
110.3350 F	110.335F	0.2590F	0	Pass	3.4e-002F	
Resistance Value at Temp = 123.34883 Ohms						
140.3530 F	140.356F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 129.72617 Ohms						
170.3830 F	170.388F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 136.06783 Ohms						
200.4150 F	200.410F	0.2590F	1.93	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.5435 Ohms						
-6.4410 c	-6.437c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 104.03317 Ohms						
10.1980 c	10.191c	0.1440c	4.86	Pass	1.9e-002c	
Resistance Value at Temp = 110.49983 Ohms						
26.8440 c	26.846c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 116.94017 Ohms						
43.5200 c	43.519c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 123.34883 Ohms						
60.1960 c	60.198c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 129.72617 Ohms						
76.8790 c	76.882c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 136.06783 Ohms						
93.5640 c	93.561c	0.1440c	2.08	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$$

Ro= 100.05969

Alpha= 0.003842433

Delta= 1.57145046111

A= 0.0039028149311

B= -6.03819310964e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4058	CAL DATE: 09 February 2017
ASSET NUMBER: 21309	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

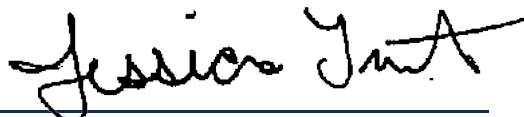
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number	= TT021309					
Probe Calibration Range	= 20 to 200 Deg F					
	= -6.7 to 93.3 Deg C					

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.3745 Ohms						
20.4060 F	20.410F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 103.90683 Ohms						
50.3570 F	50.358F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 110.39483 Ohms						
80.3200 F	80.300F	0.2590F	7.72	Pass	3.4e-002F	
Resistance Value at Temp = 116.86367 Ohms						
110.3350 F	110.351F	0.2590F	6.18	Pass	3.4e-002F	
Resistance Value at Temp = 123.28 Ohms						
140.3530 F	140.357F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 129.657 Ohms						
170.3830 F	170.380F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 135.99333 Ohms						
200.4150 F	200.414F	0.2590F	0.386	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.3745 Ohms						
-6.4410 c	-6.439c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 103.90683 Ohms						
10.1980 c	10.199c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 110.39483 Ohms						
26.8440 c	26.833c	0.1440c	7.64	Pass	1.9e-002c	
Resistance Value at Temp = 116.86367 Ohms						
43.5200 c	43.528c	0.1440c	5.56	Pass	1.9e-002c	
Resistance Value at Temp = 123.28 Ohms						
60.1960 c	60.198c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 129.657 Ohms						
76.8790 c	76.878c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 135.99333 Ohms						
93.5640 c	93.563c	0.1440c	0.694	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))]}{(2 * Ro * B)}$$

Ro= 99.90759

Alpha= 0.003855431

Delta= 2.0028845986

A= 0.00393265083371

B= -7.72198337085e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4041	CAL DATE: 13 February 2017
ASSET NUMBER: 21317	CAL DUE: 13 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number	= TT021317					
Probe Calibration Range	= 20 to 200 Deg F					
	= -6.7 to 93.3 Deg C					

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.41917 Ohms						
20.4160 F	20.423F	0.2590F	2.7	Pass	3.4e-002F	
Resistance Value at Temp = 103.92933 Ohms						
50.3710 F	50.366F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 110.41433 Ohms						
80.3640 F	80.356F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 116.8655 Ohms						
110.3520 F	110.353F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 123.284 Ohms						
140.3560 F	140.364F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 129.67317 Ohms						
170.3990 F	170.404F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 136.0225 Ohms						
200.4280 F	200.423F	0.2590F	1.93	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.41917 Ohms						
-6.4350 c	-6.432c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 103.92933 Ohms						
10.2060 c	10.203c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 110.41433 Ohms						
26.8690 c	26.864c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 116.8655 Ohms						
43.5290 c	43.530c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 123.284 Ohms						
60.1980 c	60.202c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 129.67317 Ohms						
76.8890 c	76.891c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 136.0225 Ohms						
93.5710 c	93.568c	0.1440c	2.08	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$$

Ro= 99.9405

Alpha= 0.003854412

Delta= 1.65678427143

A= 0.00391827129177

B= -6.3859291772e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6751	CAL DATE: 09 February 2017
ASSET NUMBER: 21475	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

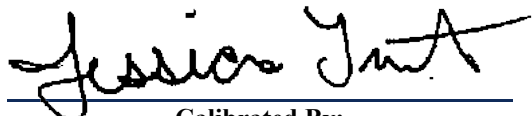
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number = TT021475						
Probe Calibration Range = 20 to 200 Deg F						
= -6.7 to 93.3 Deg C						

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.51617 Ohms						
20.4060 F	20.402F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 103.99617 Ohms						
50.3570 F	50.361F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 110.44683 Ohms						
80.3200 F	80.325F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 116.8775 Ohms						
110.3350 F	110.338F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 123.27583 Ohms						
140.3530 F	140.343F	0.2590F	3.86	Pass	3.4e-002F	
Resistance Value at Temp = 129.651 Ohms						
170.3830 F	170.382F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 135.99517 Ohms						
200.4150 F	200.419F	0.2590F	1.54	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.51617 Ohms						
-6.4410 c	-6.444c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 103.99617 Ohms						
10.1980 c	10.200c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 110.44683 Ohms						
26.8440 c	26.847c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 116.8775 Ohms						
43.5200 c	43.521c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 123.27583 Ohms						
60.1960 c	60.190c	0.1440c	4.17	Pass	1.9e-002c	
Resistance Value at Temp = 129.651 Ohms						
76.8790 c	76.879c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 135.99517 Ohms						
93.5640 c	93.566c	0.1440c	1.39	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}}{2 * Ro * B}$$

Ro= 100.02844

Alpha= 0.003839369

Delta= 1.42933528857

A= 0.00389424645598

B= -5.48774559753e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 07268	CAL DATE: 09 February 2017
ASSET NUMBER: 21631	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

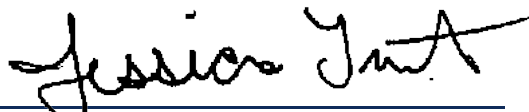
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 07262	CAL DATE: 14 February 2017
ASSET NUMBER: 21635	CAL DUE: 14 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100 CAL UNITS: Deg F

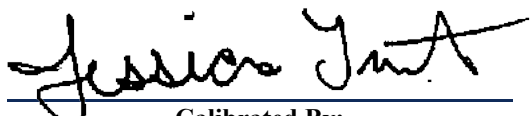
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14016	Rosemount Aerospace 162CE SPRT	4211	8/19/2016	8/19/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT021635
 Probe Calibration Range = 125 to 1100 Deg F
 = 51.7 to 593.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 119.98717 Ohms						
125.1070 F	125.046F	0.5000F	12.2	Pass	1.2e-001F	
Resistance Value at Temp = 154.176 Ohms						
287.4490 F	287.508F	0.5000F	11.8	Pass	1.2e-001F	
Resistance Value at Temp = 187.44217 Ohms						
449.8480 F	449.936F	0.5000F	17.6	Pass	1.2e-001F	
Resistance Value at Temp = 219.76433 Ohms						
612.2640 F	612.220F	0.5000F	8.8	Pass	1.2e-001F	
Resistance Value at Temp = 251.20883 Ohms						
774.7370 F	774.694F	0.5000F	8.6	Pass	1.2e-001F	
Resistance Value at Temp = 281.73667 Ohms						
937.2310 F	937.164F	0.5000F	13.4	Pass	1.2e-001F	
Resistance Value at Temp = 311.3725 Ohms						
1099.7020 F	1099.769F	0.5000F	13.4	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 119.98717 Ohms						
51.7260 c	51.692c	0.2780c	12.2	Pass	6.4e-002c	
Resistance Value at Temp = 154.176 Ohms						
141.9160 c	141.949c	0.2780c	11.9	Pass	6.4e-002c	
Resistance Value at Temp = 187.44217 Ohms						
232.1370 c	232.187c	0.2780c	18	Pass	6.4e-002c	
Resistance Value at Temp = 219.76433 Ohms						
322.3690 c	322.344c	0.2780c	8.99	Pass	6.4e-002c	
Resistance Value at Temp = 251.20883 Ohms						
412.6320 c	412.608c	0.2780c	8.63	Pass	6.4e-002c	
Resistance Value at Temp = 281.73667 Ohms						
502.9060 c	502.869c	0.2780c	13.3	Pass	6.4e-002c	
Resistance Value at Temp = 311.3725 Ohms						
593.1680 c	593.205c	0.2780c	13.3	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 \cdot A^2 - 4Ro \cdot B(Ro - Rt))] / (2 \cdot Ro \cdot B)$
 Ro= 99.99387
 Alpha= 0.003840838
 Delta= 1.46378152426
 A= 0.00389705947702
 B= -5.62214770206e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 07246	CAL DATE: 09 February 2017
ASSET NUMBER: 21655	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

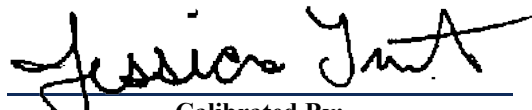
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT021655
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.39533 Ohms						
20.4060 F	20.405F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 103.89333 Ohms						
50.3570 F	50.356F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 110.3605 Ohms						
80.3200 F	80.327F	0.2590F	2.7	Pass	3.4e-002F	
Resistance Value at Temp = 116.7995 Ohms						
110.3350 F	110.331F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 123.20733 Ohms						
140.3530 F	140.353F	0.2590F	0	Pass	3.4e-002F	
Resistance Value at Temp = 129.58117 Ohms						
170.3830 F	170.380F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 135.92183 Ohms						
200.4150 F	200.417F	0.2590F	0.772	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.39533 Ohms						
-6.4410 c	-6.442c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 103.89333 Ohms						
10.1980 c	10.198c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 110.3605 Ohms						
26.8440 c	26.849c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 116.7995 Ohms						
43.5200 c	43.517c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 123.20733 Ohms						
60.1960 c	60.196c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 129.58117 Ohms						
76.8790 c	76.878c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 135.92183 Ohms						
93.5640 c	93.565c	0.1440c	0.694	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 99.91511
 Alpha= 0.003847502
 Delta= 1.64481403329
 A= 0.00391078625283
 B= -6.32842528271e-007

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER: C1230032	CAL DATE: 09 February 2017
ASSET NUMBER: 22677	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

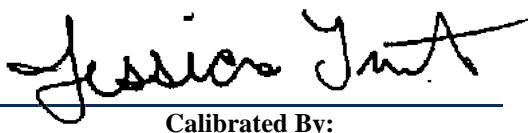
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-found and as-left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
12.0000 %RH	11.912%RH	2.0000%RH	4.4	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	33.421%RH	2.0000%RH	21	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
76.0000 %RH	76.590%RH	2.0000%RH	29.5	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER: D4150049	CAL DATE: 08 February 2017
ASSET NUMBER: 22690	CAL DUE: 08 February 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 35 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

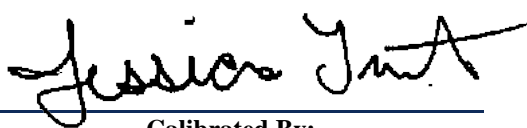
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-left.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
11.5000 %RH	11.710%RH	2.0000%RH	10.5	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	32.990%RH	2.0000%RH	0.5	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
75.0000 %RH	75.013%RH	2.0000%RH	0.65	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: Humidity Sensor, Digital	TEST RESULT: PASS
SERIAL NUMBER: C2820115	CAL DATE: 08 February 2017
ASSET NUMBER: 23830	CAL DUE: 08 February 2018
PROCEDURE NAME: Digital RH Cal 3 pt	DATA TYPE: FOUND-LEFT
PROCEDURE REV.: 1 - 09/08/2016	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 35 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 0~99
	CAL UNITS: %

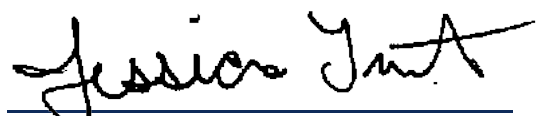
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as-found and as-left.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
20000	McHale LiCl - 11.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20001	McHale MgCl2 - 33.0% Saturated Salt Solution	N/A	1/6/2017	7/6/2017
20003	McHale NaCl - 75.3% Saturated Salt Solution	N/A	1/6/2017	7/6/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Relative Humidity Test						
Test Point: 11.3% RH						
12.0000 %RH	11.235%RH	2.0000%RH	38.3	Pass	1.0e+000%RH	2.00
Test Point: 33.0% RH						
33.0000 %RH	32.735%RH	2.0000%RH	13.3	Pass	1.0e+000%RH	2.00
Test Point: 75.3.0% RH						
76.0000 %RH	76.566%RH	2.0000%RH	28.3	Pass	1.0e+000%RH	2.00

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4390	CAL DATE: 09 February 2017
ASSET NUMBER: 23964	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

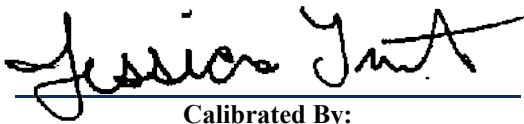
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

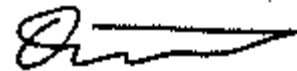
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT023964
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.6855 Ohms						
20.4060 F	20.426F	0.2590F	7.72	Pass	3.4e-002F	
Resistance Value at Temp = 104.251 Ohms						
50.3570 F	50.328F	0.2590F	11.2	Pass	3.4e-002F	
Resistance Value at Temp = 110.7865 Ohms						
80.3200 F	80.312F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 117.28383 Ohms						
110.3350 F	110.343F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 123.7315 Ohms						
140.3530 F	140.367F	0.2590F	5.41	Pass	3.4e-002F	
Resistance Value at Temp = 130.13033 Ohms						
170.3830 F	170.389F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 136.4795 Ohms						
200.4150 F	200.404F	0.2590F	4.25	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.6855 Ohms						
-6.4410 c	-6.430c	0.1440c	7.64	Pass	1.9e-002c	
Resistance Value at Temp = 104.251 Ohms						
10.1980 c	10.182c	0.1440c	11.1	Pass	1.9e-002c	
Resistance Value at Temp = 110.7865 Ohms						
26.8440 c	26.840c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 117.28383 Ohms						
43.5200 c	43.524c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 123.7315 Ohms						
60.1960 c	60.204c	0.1440c	5.56	Pass	1.9e-002c	
Resistance Value at Temp = 130.13033 Ohms						
76.8790 c	76.883c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 136.4795 Ohms						
93.5640 c	93.558c	0.1440c	4.17	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4RoB(Ro - Rt)}}{2RoB}$

Ro= 100.23245

Alpha= 0.003859728

Delta= 2.24356029955

A= 0.00394632332508

B= -8.65953250788e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4417	CAL DATE: 09 February 2017
ASSET NUMBER: 23967	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

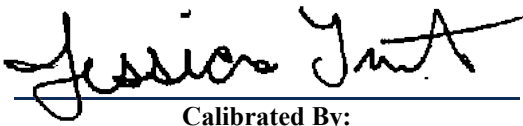
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

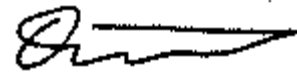
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number	= TT023967					
Probe Calibration Range = 20 to 200 Deg F						
	= -6.7 to 93.3 Deg C					

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.38617 Ohms						
20.4060 F	20.398F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 103.89583 Ohms						
50.3570 F	50.372F	0.2590F	5.79	Pass	3.4e-002F	
Resistance Value at Temp = 110.36033 Ohms						
80.3200 F	80.302F	0.2590F	6.95	Pass	3.4e-002F	
Resistance Value at Temp = 116.8165 Ohms						
110.3350 F	110.360F	0.2590F	9.65	Pass	3.4e-002F	
Resistance Value at Temp = 123.22333 Ohms						
140.3530 F	140.356F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 129.593 Ohms						
170.3830 F	170.346F	0.2590F	14.3	Pass	3.4e-002F	
Resistance Value at Temp = 135.9475 Ohms						
200.4150 F	200.434F	0.2590F	7.34	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.38617 Ohms						
-6.4410 c	-6.445c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 103.89583 Ohms						
10.1980 c	10.207c	0.1440c	6.25	Pass	1.9e-002c	
Resistance Value at Temp = 110.36033 Ohms						
26.8440 c	26.834c	0.1440c	6.94	Pass	1.9e-002c	
Resistance Value at Temp = 116.8165 Ohms						
43.5200 c	43.533c	0.1440c	9.03	Pass	1.9e-002c	
Resistance Value at Temp = 123.22333 Ohms						
60.1960 c	60.198c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 129.593 Ohms						
76.8790 c	76.859c	0.1440c	13.9	Pass	1.9e-002c	
Resistance Value at Temp = 135.9475 Ohms						
93.5640 c	93.575c	0.1440c	7.64	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2 * A^2 - 4Ro * B * (Ro - Rt)}}{2 * Ro * B}$$

Ro= 99.91009

Alpha= 0.0038505

Delta= 1.68049763866

A= 0.00391520756158

B= -6.47075615768e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 5641	CAL DATE: 09 February 2017
ASSET NUMBER: 24008	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

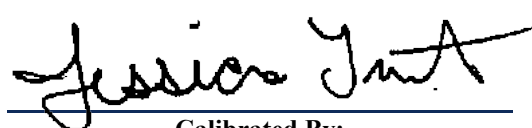
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT024008
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.58933 Ohms						
20.4060 F	20.404F	0.2590F	0.772	Pass	3.4e-002F	
Resistance Value at Temp = 104.10967 Ohms						
50.3570 F	50.364F	0.2590F	2.7	Pass	3.4e-002F	
Resistance Value at Temp = 110.58967 Ohms						
80.3200 F	80.311F	0.2590F	3.47	Pass	3.4e-002F	
Resistance Value at Temp = 117.04967 Ohms						
110.3350 F	110.340F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 123.46717 Ohms						
140.3530 F	140.346F	0.2590F	2.7	Pass	3.4e-002F	
Resistance Value at Temp = 129.85583 Ohms						
170.3830 F	170.394F	0.2590F	4.25	Pass	3.4e-002F	
Resistance Value at Temp = 136.20017 Ohms						
200.4150 F	200.410F	0.2590F	1.93	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.58933 Ohms						
-6.4410 c	-6.442c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 104.10967 Ohms						
10.1980 c	10.202c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 110.58967 Ohms						
26.8440 c	26.839c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 117.04967 Ohms						
43.5200 c	43.522c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 123.46717 Ohms						
60.1960 c	60.192c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 129.85583 Ohms						
76.8790 c	76.885c	0.1440c	4.17	Pass	1.9e-002c	
Resistance Value at Temp = 136.20017 Ohms						
93.5640 c	93.561c	0.1440c	2.08	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = [-RoA + \sqrt{Ro^2 \cdot A^2 - 4Ro \cdot B(Ro - Rt)}] / (2 \cdot Ro \cdot B)$$

Ro= 100.1174

Alpha= 0.003847708

Delta= 1.75974048162

A= 0.00391541767529

B= -6.77096752906e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 5616	CAL DATE: 13 February 2017
ASSET NUMBER: 24018	CAL DUE: 13 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Grant Shropshire	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT024018
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.37867 Ohms						
20.4160 F	20.422F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 103.88133 Ohms						
50.3710 F	50.360F	0.2590F	4.25	Pass	3.4e-002F	
Resistance Value at Temp = 110.36267 Ohms						
80.3640 F	80.369F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 116.801 Ohms						
110.3520 F	110.349F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 123.20833 Ohms						
140.3560 F	140.355F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 129.589 Ohms						
170.3990 F	170.408F	0.2590F	3.47	Pass	3.4e-002F	
Resistance Value at Temp = 135.92467 Ohms						
200.4280 F	200.423F	0.2590F	1.93	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.37867 Ohms						
-6.4350 c	-6.432c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 103.88133 Ohms						
10.2060 c	10.200c	0.1440c	4.17	Pass	1.9e-002c	
Resistance Value at Temp = 110.36267 Ohms						
26.8690 c	26.872c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 116.801 Ohms						
43.5290 c	43.527c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 123.20833 Ohms						
60.1980 c	60.197c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 129.589 Ohms						
76.8890 c	76.894c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 135.92467 Ohms						
93.5710 c	93.568c	0.1440c	2.08	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2 A^2 - 4Ro * B (Ro - Rt)}}{2 * Ro * B}$$

Ro= 99.89776

Alpha= 0.003850022

Delta= 1.71670308917

A= 0.00391611544661

B= -6.60934466078e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 5616	CAL DATE: 09 February 2017
ASSET NUMBER: 24030	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

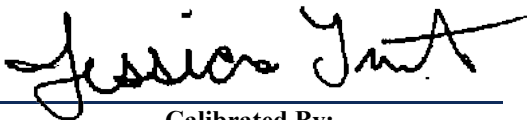
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

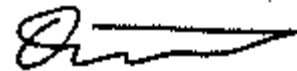
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT024030
Probe Calibration Range = 20 to 200 Deg F
= -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.11333 Ohms						
20.4060 F	20.411F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 103.54533 Ohms						
50.3570 F	50.341F	0.2590F	6.18	Pass	3.4e-002F	
Resistance Value at Temp = 109.961 Ohms						
80.3200 F	80.337F	0.2590F	6.56	Pass	3.4e-002F	
Resistance Value at Temp = 116.34533 Ohms						
110.3350 F	110.331F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 122.70367 Ohms						
140.3530 F	140.347F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 129.03683 Ohms						
170.3830 F	170.389F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 135.33517 Ohms						
200.4150 F	200.413F	0.2590F	0.772	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.11333 Ohms						
-6.4410 c	-6.438c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 103.54533 Ohms						
10.1980 c	10.189c	0.1440c	6.25	Pass	1.9e-002c	
Resistance Value at Temp = 109.961 Ohms						
26.8440 c	26.854c	0.1440c	6.94	Pass	1.9e-002c	
Resistance Value at Temp = 116.34533 Ohms						
43.5200 c	43.517c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 122.70367 Ohms						
60.1960 c	60.193c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 129.03683 Ohms						
76.8790 c	76.883c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 135.33517 Ohms						
93.5640 c	93.563c	0.1440c	0.694	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
Ro= 99.60743
Alpha= 0.00383006
Delta= 1.45062820618
A= 0.00388561993067
B= -5.55599306738e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 4350	CAL DATE: 09 February 2017
ASSET NUMBER: 24047	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

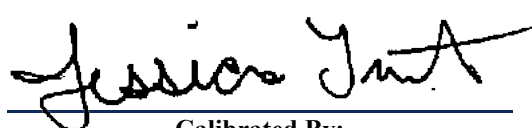
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
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Probe ID Number = TT024047
Probe Calibration Range = 20 to 200 Deg F
= -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.413 Ohms						
20.4060 F	20.402F	0.2590F	1.54	Pass	3.4e-002F	
Resistance Value at Temp = 103.841 Ohms						
50.3570 F	50.365F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 110.24167 Ohms						
80.3200 F	80.319F	0.2590F	0.386	Pass	3.4e-002F	
Resistance Value at Temp = 116.63033 Ohms						
110.3350 F	110.337F	0.2590F	0.772	Pass	3.4e-002F	
Resistance Value at Temp = 122.99033 Ohms						
140.3530 F	140.341F	0.2590F	4.63	Pass	3.4e-002F	
Resistance Value at Temp = 129.335 Ohms						
170.3830 F	170.393F	0.2590F	3.86	Pass	3.4e-002F	
Resistance Value at Temp = 135.64717 Ohms						
200.4150 F	200.413F	0.2590F	0.772	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.413 Ohms						
-6.4410 c	-6.443c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 103.841 Ohms						
10.1980 c	10.203c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 110.24167 Ohms						
26.8440 c	26.844c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 116.63033 Ohms						
43.5200 c	43.521c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 122.99033 Ohms						
60.1960 c	60.189c	0.1440c	4.86	Pass	1.9e-002c	
Resistance Value at Temp = 129.335 Ohms						
76.8790 c	76.885c	0.1440c	4.17	Pass	1.9e-002c	
Resistance Value at Temp = 135.64717 Ohms						
93.5640 c	93.563c	0.1440c	0.694	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
where T = Deg C and Rt = Resistance at Temp
 $T = \frac{-RoA + \text{Sqrt}(Ro^2*A^2 - 4Ro*B*(Ro - Rt))}{2*Ro*B}$
Ro= 99.90421
Alpha= 0.003820908
Delta= 1.20693916633
A= 0.00386702403516
B= -4.61160351615e-007

***** End of Report *****

Calibration Certificate No.37132

Instrument: Sound Level Meter
Model: SC310
Manufacturer: Cesva
Serial number: T229771_24125
Tested with: Microphone C-130 s/n 10467
Preamplifier PA13 s/n 2391
Type (class): 1
Customer: McHale Performance
Tel/Fax: 865-588-2654 x119 /

Date Calibrated: 10/11/2016 **Cal Due:** 10/11/2017
Status:

	Received	Sent
In tolerance:	X	X
Out of tolerance:		

See comments:
Contains non-accredited tests: ___ Yes No
Calibration service: ___ Basic Standard
Address: 4700 Coster Rd
Knoxville, TN 37912

Tested in accordance with the following procedures and standards:
Calibration of Sound Level Meters, Scantek Inc., Rev. 6/22/2012
SLM & Dosimeters – Acoustical Tests, Scantek Inc., Rev. 7/6/2011

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence	Cal. Due
				Cal. Lab / Accreditation	
483B-Norsonic	SME Cal Unit	31061	Jul 27, 2016	Scantek, Inc./ NVLAP	Jul 27, 2017
DS-360-SRS	Function Generator	88077	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2018
34401A-Agilent Technologies	Digital Voltmeter	MY47011118	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2017
HM30-Thommen	Meteo Station	1040170/39633	Oct 23, 2015	ACR Env./ A2LA	Oct 23, 2016
PC Program 1019 Norsonic	Calibration software	v.6.1T	Validated Nov 2014	Scantek, Inc.	-
1251-Norsonic	Calibrator	30878	Nov 10, 2015	Scantek, Inc./ NVLAP	Nov 10, 2016
4226-Brüel&Kjær	Multifunction calibrator	2305103	Jul 25, 2016	Scantek, Inc./ NVLAP	Jul 25, 2017

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
21.4	101.20	41.6

Calibrated by:	Signature	Date	Authorized signatory:	Signature	Date
	Jeremy Gotwalt	10/12/16		Valentin Buzduga	10/12/2016

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.

Results summary: Device complies with following clauses of mentioned specifications:

CLAUSES ¹ FROM IEC/ANSI STANDARDS REFERENCED IN PROCEDURES:	RESULT ^{2,3}	EXPANDED UNCERTAINTY (coverage factor 2) [dB]
INDICATION AT THE CALIBRATION CHECK FREQUENCY - IEC61672-3 ED.2 CLAUSE 10	Passed	0.15
SELF-GENERATED NOISE - IEC 61672-3 ED.2 CLAUSE 11	Passed	0.3
ACOUSTICAL TEST OF A FREQUENCY WEIGHTING - IEC 61672-3 ED.2.0 CLAUSE 12	Passed	0.3
FREQUENCY WEIGHTINGS: A NETWORK - IEC 61672-3 ED.2.0 CLAUSE 13	Passed	0.2
FREQUENCY WEIGHTINGS: C NETWORK - IEC 61672-3 ED.2.0 CLAUSE 13	Passed	0.2
FREQUENCY WEIGHTINGS: Z NETWORK - IEC 61672-3 ED.2.0 CLAUSE 13	Passed	0.2
FREQUENCY AND TIME WEIGHTINGS AT 1 KHZ IEC 61672-3 ED.2.0 CLAUSE 14	Passed	0.2
LEVEL LINEARITY ON THE REFERENCE LEVEL RANGE - IEC 61672-3 ED.2 CLAUSE 16	Passed	0.25
TOURBURST RESPONSE - IEC 61672-3 ED.2.0 CLAUSE 18	Passed	0.3
PEAK C SOUND LEVEL - IEC 61672-3 ED.2.0 CLAUSE 19	Passed	0.35
OVERLOAD INDICATION - IEC 61672-3 ED.2.0 CLAUSE 20	Passed	0.25
HIGH LEVEL STABILITY TEST - IEC 61672-3 ED.2.0 CLAUSE 21	Passed	0.1
LONG TERM STABILITY TEST - IEC 61672-3 ED.2.0 CLAUSE 15	Passed	0.1
FILTER TEST 1/OCTAVE: RELATIVE ATTENUATION - IEC 61260, CLAUSE 4.4 & #5.3	Passed	0.25
FILTER TEST 1/3OCTAVE: RELATIVE ATTENUATION - IEC 61260, CLAUSE 4.4 & #5.3	Passed	0.25

¹ The results of this calibration apply only to the instrument type with serial number identified in this report.

² Parameters are certified at actual environmental conditions.

³ The tests marked with (*) are not covered by the current NVLAP accreditation.

Comments: The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organization responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2, to demonstrate that the model of sound level meter fully conforms to the requirements in the IEC 61672-2, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1.

Note: The instrument was tested for the parameters listed in the table above, using the test methods described in the listed standards. All tests were performed around the reference conditions. The test results were compared with the manufacturer's or with the standard's specifications, whichever are larger.

Compliance with any standard cannot be claimed based solely on the periodic tests.

Tests made with the following attachments to the instrument:

Microphone: Cesva C-130 s/n 10467 for acoustical test
Preamplifier: Cesva PA13 s/n 2391 for all tests
Other: line adaptor ADP005 (18pF) for electrical tests
Accompanying acoustical calibrator: Cesva C8006 s/n 48461_24356
Windscreen: Cesva PVM-05

Measured Data: in Test Report # 37132 of two sections totaling 11 pages.

Place of Calibration: Scantek, Inc.
6430 Dobbin Road, Suite C
Columbia, MD 21045 USA

Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.
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Document stored Z:\Calibration Lab\SLM 2016\SC310_T229771_24125_M1.doc

Page 2 of 2

Summary of Test Report No.:37132

Cesva Type: SC310 Serial no: T229771_24125

Customer: McHale Performance
Address: 4700 Coster Rd, Knoxville, TN 37912
Contact Person: Jessica Trent
Phone No.: 865-588-2654 x119
eMail: jessica.trent@mchaleperformance.com

Microphone:	Cesva	Type: C-130	Serial no: 10467	Sens:dB
Preamplifier	Cesva	Type: PA13	Serial no: 2391	
Calibrator:	Cesva	Type: CB006	Serial no: 48461_24356	Level:93.76dB
Wind screen	Cesva	Type: PVM-05		

Measurement Results:

Indication at the calibration check frequency - IEC61672-3 Ed.2 Clause 10	Passed
Self-generated noise - IEC 61672-3 Ed.2 Clause 11	Passed
Acoustical test of a frequency weighting - IEC 61672-3 Ed.2.0 Clause 12	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.2.0 Clause 13	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.2.0 Clause 13	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.2.0 Clause 13	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.2.0 Clause 14	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.2 Clause 16	Passed
Toneburst response - IEC 61672-3 Ed.2.0 Clause 18	Passed
Peak C sound level - IEC 61672-3 Ed.2.0 Clause 19	Passed
Overload indication - IEC 61672-3 Ed.2.0 Clause 20	Passed
High level stability test - IEC 61672-3 Ed.2.0 Clause 21	Passed
Long term stability test - IEC 61672-3 Ed.2.0 Clause 15	Passed
Filter Test 1/1octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3	Passed
Filter Test 1/3octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3	Passed

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
101.20	21.4	41.6

Date of calibration: 10/11/2016

Date of issue: 10/12/2016

Supervisor: Valentin Buzduga

Measurements performed by:


Jeremy Gotwall

Software version:

Scantek, Inc.

6430 Dobbin Rd., Suite C, Columbia, MD 21045
Ph: 410-290-7726 eMail: callab@scantekinc.com

Test Report No.:37132

Manufacturer: Cesva
Instrument type: SC310
Serial no: T229771_24125
Customer: McHale Performance
Department:
Order No:
Contact Person: Jessica Trent
Address: 4700 Coster Rd, Knoxville, TN 37912

Environmental conditions:

Pressure: 101.20
Temperature: 21.4
Relative humidity: 41.6

Supervisor Valentin Buzduga
Engineer Jeremy Gotwalt
Date: 10/11/2016

Measurement Results:

Indication at the calibration check frequency - IEC61672-3 Ed.2 Clause 10

Reference Calibrator: WSC4 - NOR1251-30878
Reference calibrator level: 114.06
Before calibration:
Environmental corrections: 0.00
Other corrections: -0.1
Notional level: 113.96
Reference calibrator level before calibration: 114.0
After calibration:
Environmental corrections: 0.00
Other corrections: -0.1
Notional level: 113.96
Reference calibrator level after calibration: 114.0
Associated Calibrator: Cesva - CB006 - 48461_24356
Associated calibrator level: 93.76
Initial level check:
Environmental corrections: 0.00
Other corrections: -0.1
Notional level: 93.66
Indicated level: 93.7
Final level statement:
Environmental corrections after calibration: 0.00
Other corrections: -0.1
Notional level: 93.66
Indicated level after calibration: 93.7
This value shall be used for adjusting the sound level meter in the future.
Test Passed

Self-generated noise - IEC 61672-3 Ed.2 Clause 11

Network	Level (dB)	Max (dB)	Uncert. (dB)	Result	Comment
A	13.7	14.4	0.3	P	Equivalent capacity
C	17.8	16.8	0.3	N	Equivalent capacity

Test Passed

Acoustical test of a frequency weighting - IEC 61672-3 Ed.2.0 Clause 12

A-Weighted results: free field response

Frequency	Response (dB)	Tol. (dB)	Uncert. (dB)	Result	
125 Hz	0.0	1.0	-1.0	0.2	P
1 kHz	0.0	0.7	-0.7	0.1	P
4 kHz	0.0	1.0	-1.0	0.2	P
8 kHz	-0.4	1.5	-2.5	0.4	P

Test Passed

The overall frequency response of the sound level meter, typical wind

Test Passed

The overall frequency response of the sound level meter, typical wind screen response and microphone response has shown to conform with the requirements in IEC 61672-3 for a class 1 sound level meter.

Frequency response test using multi frequency calibrator.

Sources for correction data:

Calibrator levels and uncertainty: Scantek - SCL

Microphone field corrections and uncertainty:

Case reflections and uncertainty:

Wind screen corrections and uncertainty:

Tabular information

Calibrator = WSC4 at 94dB

txtMFCL125 = 94.07

txtMFCLU125 = 0.11

txtSU125 = 0.20

txtM125_1 = 78.3

txtM125_2 = 78.2

txtM125_3 = 78.2

txtMFCL1k = 94.07

txtMFCLU1k = 0.11

txtSU1k = 0.15

txtM1k_1 = 94.2

txtM1k_2 = 94.2

txtM1k_3 = 94.2

txtMFCL4k = 94.02

txtMFCLU4k = 0.11

txtSU4k = 0.40

txtM4k_1 = 94.1

txtM4k_2 = 94.1

txtM4k_3 = 94.1

txtMFCL8k = 93.88

txtMFCLU8k = 0.14

txtSU8k = 0.50

txtM8k_1 = 89.4

txtM8k_2 = 89.4

txtM8k_3 = 89.4

txtSLM125 = 78.23

txtNC125 = 16.1

txtSLMU125 = 0.2

txtMic125 = 0.0

txtMicU125 = 0.05

txtCR125 =

txtCRU125 =

txtWS125 =

txtWSU125 =

txtSLM1k = 94.2

txtNC1k = 0

txtSLMU1k = 0.1

txtMFCL1k = 94.07

txtMFCLU1k = 0.11

txtMic1k = 0.1

txtMicU1k = 0.1

txtCR1k =

txtCRU1k =

txtWS1k =

txtWSU1k =

txtSLM4k = 94.1

txtNC4k = -1.0

txtSLMU4k = 0.1

Acoustical test of a frequency weighting - IEC 61672-3 Ed.2.0 Clause 12

txtMFCL4k = 94.02
 txtMFCLU4k = 0.11
 txtMic4k = 1.2
 txtMicU4k = 0.2
 txtCR4k =
 txtCRU4k =
 txtWS4k =
 txtWSU4k =
 txtSLM8k = 89.4
 txtNC8k = 1.1
 txtSLMU8k = 0.1
 txtMFCL8k = 93.88
 txtMFCLU8k = 0.14
 txtMic8k = 3.2
 txtMicU8k = 0.4
 txtCR8k =
 txtCRU8k =
 txtWS8k =
 txtWSU8k =

Frequency weightings: A Network - IEC 61672-3 Ed.2.0 Clause 13

Freq (Hz)	Ref. (dB)	Meas. (dB)	Tol. (dB)		Uncert. (dB)	Dev. (dB)	Result
63.1	85.0	85.0	1.0	-1.0	0.2	0.0	P
125.9	85.0	85.0	1.0	-1.0	0.2	0.0	P
251.2	85.0	85.0	1.0	-1.0	0.2	0.0	P
501.2	85.0	85.0	1.0	-1.0	0.2	0.0	P
1000.0	85.0	85.0	0.7	-0.7	0.2	0.0	P
1995.3	85.0	85.0	1.0	-1.0	0.2	0.0	P
3981.1	85.0	85.0	1.0	-1.0	0.2	0.0	P
7943.3	85.0	84.9	1.5	-2.5	0.2	-0.1	P
15848.9	85.0	80.0	2.5	-16.0	0.2	-5.0	P

Test Passed

Frequency weightings: C Network - IEC 61672-3 Ed.2.0 Clause 13

Freq (Hz)	Ref. Level (dB)	Meas. Value (dB)	Tol. (dB)		Uncert. (dB)	Dev. (dB)	Result
63.1	85.0	84.9	1.0	-1.0	0.2	-0.1	P
125.9	85.0	85.0	1.0	-1.0	0.2	0.0	P
251.2	85.0	85.0	1.0	-1.0	0.2	0.0	P
501.2	85.0	85.1	1.0	-1.0	0.2	0.1	P
1000.0	85.0	85.0	0.7	-0.7	0.2	0.0	P
1995.3	85.0	85.1	1.0	-1.0	0.2	0.1	P
3981.1	85.0	85.1	1.0	-1.0	0.2	0.1	P
7943.3	85.0	85.0	1.5	-2.5	0.2	0.0	P
15848.9	85.0	80.0	2.5	-16.0	0.2	-5.0	P

Test Passed

Frequency weightings: Z Network - IEC 61672-3 Ed.2.0 Clause 13

Freq (Hz)	Ref. Level (dB)	Meas. Value (dB)	Tol. (dB)		Uncert. (dB)	Dev. (dB)	Result
63.1	85.0	85.0	1.0	-1.0	0.2	0.0	P
125.9	85.0	85.0	1.0	-1.0	0.2	0.0	P
251.2	85.0	85.0	1.0	-1.0	0.2	0.0	P
501.2	85.0	85.1	1.0	-1.0	0.2	0.1	P
1000.0	85.0	85.1	0.7	-0.7	0.2	0.1	P
1995.3	85.0	85.0	1.0	-1.0	0.2	0.0	P
3981.1	85.0	85.0	1.0	-1.0	0.2	0.0	P
7943.3	85.0	85.0	1.5	-2.5	0.2	0.0	P
15848.9	85.0	84.9	2.5	-16.0	0.2	-0.1	P

Test Passed

Frequency and time weightings at 1 kHz IEC 61672-3 Ed.2.0 Clause 14

Weightings Time Netw	Ref. (dB)	Measured (dB)	Tol. (dB)		Uncert. (dB)	Dev. (dB)	Result
Fast A	94.0	94.0	0.1	-0.1	0.2	0.0	P
Fast C	94.0	94.1	0.1	-0.1	0.2	0.1	P
Fast Z	94.0	94.1	0.1	-0.1	0.2	0.1	P
Fast Flat	94.0	94.1	0.1	-0.1	0.2	0.1	P
Slow A	94.0	94.0	0.1	-0.1	0.2	0.0	P
Leq A	94.0	94.0	0.1	-0.1	0.2	0.0	P
SEL A	104.0	104.0	0.1	-0.1	0.2	0.0	P

Test Passed

Level linearity on the reference level range - IEC 61672-3 Ed.2 Clause 16

Ref. (dB)	Measured (dB)	Tol. (dB)		Uncert. (dB)	Dev. (dB)	Result
Full scale setting: 130dB						
The following measurements are SPL measurements						
Measured at 31.5 Hz						
84.0	84.0	0.8	-0.8	0.25	0.0	P
89.0	89.0	0.8	-0.8	0.25	0.0	P
90.6	90.6	0.8	-0.8	0.25	0.0	P
91.6	91.6	0.8	-0.8	0.25	0.0	P
92.6	92.6	0.8	-0.8	0.25	0.0	P
93.6	93.6	0.8	-0.8	0.25	0.0	P
94.6	94.6	0.8	-0.8	0.25	0.0	P
84.0	84.0	0.8	-0.8	0.25	0.0	P
79.0	79.0	0.8	-0.8	0.25	0.0	P
74.0	74.1	0.8	-0.8	0.25	0.1	P
69.0	69.1	0.8	-0.8	0.25	0.1	P
64.0	64.1	0.8	-0.8	0.25	0.1	P
59.0	59.1	0.8	-0.8	0.25	0.1	P
54.0	54.1	0.8	-0.8	0.25	0.1	P
49.0	49.1	0.8	-0.8	0.25	0.1	P
44.0	44.1	0.8	-0.8	0.25	0.1	P
38.0	38.1	0.8	-0.8	0.25	0.1	P

Level linearity on the reference level range - IEC 61672-3 Ed.2 Clause 16

Ref. (dB)	Measured (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result	
37.0	37.1	0.8	-0.8	0.25	0.1	P
36.0	36.1	0.8	-0.8	0.25	0.1	P
35.0	35.1	0.8	-0.8	0.25	0.1	P
34.0	34.1	0.8	-0.8	0.25	0.1	P
Measured at 1 kHz						
94.0	94.0	0.8	-0.8	0.25	0.0	P
99.0	99.0	0.8	-0.8	0.25	0.0	P
104.0	104.1	0.8	-0.8	0.25	0.1	P
109.0	109.1	0.8	-0.8	0.25	0.1	P
114.0	114.1	0.8	-0.8	0.25	0.1	P
119.0	119.0	0.8	-0.8	0.25	0.0	P
124.0	124.0	0.8	-0.8	0.25	0.0	P
130.0	130.0	0.8	-0.8	0.25	0.0	P
131.0	131.0	0.8	-0.8	0.25	0.0	P
132.0	132.0	0.8	-0.8	0.25	0.0	P
133.0	133.0	0.8	-0.8	0.25	0.0	P
134.0	134.0	0.8	-0.8	0.25	0.0	P
94.0	94.0	0.8	-0.8	0.25	0.0	P
89.0	89.0	0.8	-0.8	0.25	0.0	P
84.0	84.0	0.8	-0.8	0.25	0.0	P
79.0	79.0	0.8	-0.8	0.25	0.0	P
74.0	74.0	0.8	-0.8	0.25	0.0	P
69.0	69.0	0.8	-0.8	0.25	0.0	P
64.0	64.0	0.8	-0.8	0.25	0.0	P
59.0	59.0	0.8	-0.8	0.25	0.0	P
54.0	54.0	0.8	-0.8	0.25	0.0	P
49.0	49.0	0.8	-0.8	0.25	0.0	P
44.0	44.0	0.8	-0.8	0.25	0.0	P
38.0	38.0	0.8	-0.8	0.25	0.0	P
37.0	37.0	0.8	-0.8	0.25	0.0	P
36.0	36.0	0.8	-0.8	0.25	0.0	P
35.0	35.1	0.8	-0.8	0.25	0.1	P
34.0	34.1	0.8	-0.8	0.25	0.1	P
Measured at 8 kHz						
94.0	94.0	0.8	-0.8	0.25	0.0	P
99.0	99.0	0.8	-0.8	0.25	0.0	P
104.0	104.0	0.8	-0.8	0.25	0.0	P
109.0	109.0	0.8	-0.8	0.25	0.0	P
114.0	114.0	0.8	-0.8	0.25	0.0	P
119.0	118.9	0.8	-0.8	0.25	-0.1	P
124.0	124.0	0.8	-0.8	0.25	0.0	P
128.9	128.8	0.8	-0.8	0.25	-0.1	P
129.9	129.8	0.8	-0.8	0.25	-0.1	P
130.9	130.8	0.8	-0.8	0.25	-0.1	P
131.9	131.8	0.8	-0.8	0.25	-0.1	P
132.9	132.8	0.8	-0.8	0.25	-0.1	P
94.0	94.0	0.8	-0.8	0.25	0.0	P
89.0	89.0	0.8	-0.8	0.25	0.0	P
84.0	84.0	0.8	-0.8	0.25	0.0	P
79.0	78.9	0.8	-0.8	0.25	-0.1	P
74.0	73.9	0.8	-0.8	0.25	-0.1	P
69.0	68.9	0.8	-0.8	0.25	-0.1	P
64.0	64.0	0.8	-0.8	0.25	0.0	P
59.0	58.9	0.8	-0.8	0.25	-0.1	P
54.0	53.9	0.8	-0.8	0.25	-0.1	P
49.0	48.9	0.8	-0.8	0.25	-0.1	P
44.0	44.0	0.8	-0.8	0.25	0.0	P

Level linearity on the reference level range - IEC 61672-3 Ed.2 Clause 16

Ref. (dB)	Measured (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result	
38.0	38.0	0.8	-0.8	0.25	0.0	P
37.0	37.0	0.8	-0.8	0.25	0.0	P
36.0	36.0	0.8	-0.8	0.25	0.0	P
35.0	35.0	0.8	-0.8	0.25	0.0	P
34.0	34.0	0.8	-0.8	0.25	0.0	P

Test Passed

Toneburst response - IEC 61672-3 Ed.2.0 Clause 18

Burst type	Ref. (dB)	Measured (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result	
Fast 200 mSec	127.0	127.0	0.5	-0.5	0.3	0.0	P
Fast 2.0 mSec	110.0	110.0	1.0	-1.5	0.3	0.0	P
Fast 0.25 mSec	101.0	100.9	1.0	-3.0	0.3	-0.1	P
Slow 200 mSec	120.6	120.6	0.5	-0.5	0.3	0.0	P
Slow 2.0 mSec	101.0	101.0	1.0	-3.0	0.3	0.0	P
SEL 200 mSec	121.0	121.0	0.5	-0.5	0.3	0.0	P
SEL 2.0 mSec	101.0	101.0	1.0	-1.5	0.3	0.0	P
SEL 0.25 mSec	92.0	91.9	1.0	-3.0	0.3	-0.1	P

Test Passed

Peak C sound level - IEC 61672-3 Ed.2.0 Clause 19

Pulse Type	Pulse Freq. (Hz)	Ref. RMS (dB)	Ref. Peak (dB)	Measured Value (dB)	Tol. (+/-dB)	Uncert. (dB)	Dev. (dB)	Result
1 cycle	8k	119.0	122.4	121.5	2.0	0.35	-0.9	P
Pos 1/2 cycle	500	122.0	124.4	124.3	1.0	0.35	-0.1	P
Neg 1/2 cycle	500	122.0	124.4	124.3	1.0	0.35	-0.1	P

Test Passed

Overload indication - IEC 61672-3 Ed.2.0 Clause 20

Level difference of positive and negative pulses:	Measured (dB)	Tol. (+/-dB)	Uncert. (dB)	Result
Positive 1/2 cycle 4 kHz. Overload occurred at:	0.1	1.5	0.25	P
Negative 1/2 cycle 4 kHz. Overload occurred at:	139.7			
	139.8			

Test Passed

High level stability test - IEC 61672-3 Ed.2.0 Clause 21

Test signal: Sine wave at 1 kHz

Initial level (dB)	Final level (dB)	Diff. (dB)	Tol. value (dB)	Uncert. (dB)	Result
129.0	129.0	0.0	0.1	0.1	P

Test Passed

Long term stability test - IEC 61672-3 Ed.2.0 Clause 15

Test signal: Sine wave at 1 kHz

Time interval (mm:SS)	StartLevel (dB)	StopLevel (dB)	Difference (dB)	Tolerance (dB)	Result
42:31	94.0	94.0	0.0	0.1	P

Test Passed

Filter Test 1/1octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3

Test 1/1 octave filter X= 3 fexact=7943.282Hz class 1

Nominal f [Hz]	Measured L [dB]	LoLim [dB]	HiLim [dB]	Result [P/F]
501.187	38.6	0.0	58.0	P
1000.00	48.2	0.0	67.0	P
1995.26	73.1	0.0	86.0	P
3981.07	103.9	0.0	110.5	P
5623.41	125.1	123.0	126.0	P
6130.56	127.5	126.7	128.3	P
6683.44	128.0	127.4	128.3	P
7286.18	128.0	127.6	128.3	P
7943.28	128.0	127.7	128.3	P
8659.64	128.0	127.6	128.3	P
9440.61	128.0	127.4	128.3	P
10292.0	127.8	126.7	128.3	P
11220.2	125.1	123.0	126.0	P
15848.9	91.5	0.0	110.5	P
31622.8	14.9	0.0	86.0	P
63095.7	16.0	0.0	67.0	P
125893	24.5	0.0	58.0	P

Test 1/1 octave filter X= 4 fexact=15848.932Hz class 1

Nominal f [Hz]	Measured L [dB]	LoLim [dB]	HiLim [dB]	Result [P/F]
1000.00	42.2	0.0	58.0	P
1995.26	57.8	0.0	67.0	P
3981.07	82.0	0.0	86.0	P
7943.28	110.1	0.0	110.5	P
11220.2	125.1	123.0	126.0	P
12232.1	127.0	126.7	128.3	P
13335.2	127.8	127.4	128.3	P
14537.8	128.0	127.6	128.3	P
15848.9	128.0	127.7	128.3	P
17278.3	128.0	127.6	128.3	P
18836.5	128.0	127.4	128.3	P

Filter Test 1/octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3

Nominal f [Hz]	Measured L [dB]	LoLim [dB]	HiLim [dB]	Result [P/F]
20535.3	128.0	126.7	128.3	P
22387.2	125.3	123.0	126.0	P
31622.8	33.1	0.0	110.5	P
63095.7	18.3	0.0	86.0	P
125893	26.1	0.0	67.0	P
200000	24.7	0.0	58.0	P

Test Passed

Filter Test 1/3octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3

Test 1/3 octave filter X= 12 fexact=15848.932Hz class 1

Nominal f [Hz]	Measured L [dB]	LoLim [dB]	HiLim [dB]	Result [P/F]
2939.37	38.5	0.0	58.0	P
5190.16	54.2	0.0	67.0	P
8422.54	76.5	0.0	86.0	P
12244.5	104.7	0.0	110.5	P
14125.4	125.0	123.0	126.0	P
14574.3	127.5	126.7	128.3	P
15012.0	127.9	127.4	128.3	P
15437.2	128.0	127.6	128.3	P
15848.9	128.0	127.7	128.3	P
16271.7	128.0	127.6	128.3	P
16732.6	128.0	127.4	128.3	P
17235.0	127.9	126.7	128.3	P
17782.8	125.0	123.0	126.0	P
20514.4	83.5	0.0	110.5	P
29823.4	18.6	0.0	86.0	P
48397.1	11.7	0.0	67.0	P
85456.6	12.5	0.0	58.0	P

Test 1/3 octave filter X= 13 fexact=19952.623Hz class 1

Nominal f [Hz]	Measured L [dB]	LoLim [dB]	HiLim [dB]	Result [P/F]
3700.45	43.2	0.0	58.0	P
6534.02	62.0	0.0	67.0	P
10603.4	83.7	0.0	86.0	P
15414.9	109.2	0.0	110.5	P
17782.8	126.0	123.0	126.0	P
18348.0	127.1	126.7	128.3	P
18898.9	127.9	127.4	128.3	P
19434.2	128.0	127.6	128.3	P
19952.6	128.0	127.7	128.3	P
20484.8	128.0	127.6	128.3	P
21065.1	128.0	127.4	128.3	P
21697.6	128.0	126.7	128.3	P
22387.2	125.0	123.0	126.0	P
25826.2	59.7	0.0	110.5	P
37545.4	14.2	0.0	86.0	P
60928.4	15.7	0.0	67.0	P
107584	15.2	0.0	58.0	P

Test Passed

SC310.ini

JDG

Test Report No.: 37132

Part 2

Instrument: Sound Level Meter
Manufacturer: Cesva
Model: SC310
Serial no: T229771
ID no: 24125
Tested with: Microphone C-130 sn: 10467
Customer: McHale Performance
Date: 10/11/2016

Type: 1

Input level: 94 dB

Frequency [Hz]	A weighting network				Tolerances [dB]				Expanded uncertainty (cov. fact. 2) [dB]
	Measured pressure response [dB re 20µPa]	Estimated Free Field response [dB re 20µPa]	Reference level [dB re 20µPa]	Result	Type 1		Type 2		
31.5	55.7	55.7	54.8	Passed	1.5	-1.5	3.0	-3.0	0.17
63	68.1	68.1	68.0	Passed	1.0	-1.0	2.0	-2.0	0.16
125	78.0	78.0	78.1	Passed	1.0	-1.0	1.5	-1.5	0.16
250	85.5	85.5	85.6	Passed	1.0	-1.0	1.5	-1.5	0.16
500	90.9	90.9	91.0	Passed	1.0	-1.0	1.5	-1.5	0.16
1000	94.2	94.2	94.2	Passed	1.0	-1.0	1.5	-1.5	0.16
2000	95.5	95.5	95.4	Passed	1.0	-1.0	2.0	-2.0	0.16
4000	95.2	95.2	95.2	Passed	1.0	-1.0	3.0	-3.0	0.30
8000	93.5	93.5	93.1	Passed	1.5	-3.0	5.0	-5.0	0.91
12500	88.4	88.4	89.9	Passed	3.0	-6.0	5.0	-99.0	2.4
16000	82.7	82.7	87.6	Passed	3.0	-99.0	5.0	-99.0	1.2

Tested by: JG _____

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6425	CAL DATE: 14 February 2017
ASSET NUMBER: 24223	CAL DUE: 14 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 125~1100
	CAL UNITS: Deg F

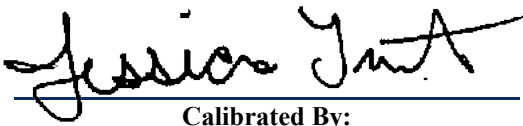
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10290	Fluke 9173 Metrology Well w/ built-in Ref. Readout	B54045	4/1/2015	3/29/2025
14016	Rosemount Aerospace 162CE SPRT	4211	8/19/2016	8/19/2017

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number	= TT024223					
Probe Calibration Range = 125 to 1100 Deg F						
	= 51.7 to 593.3 Deg C					

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 120.012 Ohms						
125.1070 F	124.947F	0.5000F	32	Pass	1.2e-001F	
Resistance Value at Temp = 154.23783 Ohms						
287.4490 F	287.646F	0.5000F	39.4	Pass	1.2e-001F	
Resistance Value at Temp = 187.47917 Ohms						
449.8480 F	450.027F	0.5000F	35.8	Pass	1.2e-001F	
Resistance Value at Temp = 219.74583 Ohms						
612.2640 F	612.113F	0.5000F	30.2	Pass	1.2e-001F	
Resistance Value at Temp = 251.17467 Ohms						
774.7370 F	774.597F	0.5000F	28	Pass	1.2e-001F	
Resistance Value at Temp = 281.71017 Ohms						
937.2310 F	937.215F	0.5000F	3.2	Pass	1.2e-001F	
Resistance Value at Temp = 311.319 Ohms						
1099.7020 F	1099.792F	0.5000F	18	Pass	1.2e-001F	

*****Degrees C*****

Resistance Value at Temp = 120.012 Ohms						
51.7260 c	51.637c	0.2780c	32	Pass	6.4e-002c	
Resistance Value at Temp = 154.23783 Ohms						
141.9160 c	142.025c	0.2780c	39.2	Pass	6.4e-002c	
Resistance Value at Temp = 187.47917 Ohms						
232.1370 c	232.237c	0.2780c	36	Pass	6.4e-002c	
Resistance Value at Temp = 219.74583 Ohms						
322.3690 c	322.285c	0.2780c	30.2	Pass	6.4e-002c	
Resistance Value at Temp = 251.17467 Ohms						
412.6320 c	412.554c	0.2780c	28.1	Pass	6.4e-002c	
Resistance Value at Temp = 281.71017 Ohms						
502.9060 c	502.897c	0.2780c	3.24	Pass	6.4e-002c	
Resistance Value at Temp = 311.319 Ohms						
593.1680 c	593.218c	0.2780c	18	Pass	6.4e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4Ro*B(Ro - Rt)}}{2*Ro*B}$$

Ro= 100.04609

Alpha= 0.003837541

Delta= 1.46722909063

A= 0.00389384651792

B= -5.63055179168e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 6528	CAL DATE: 09 February 2017
ASSET NUMBER: 24279	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200 CAL UNITS: Deg F

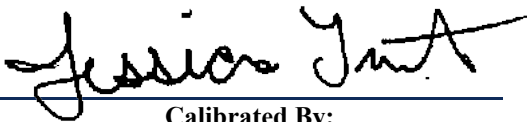
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
-------------------------	--------------------	-----------------	--------------------	------------------	----------------------	------------

Probe ID Number = TT024279
 Probe Calibration Range = 20 to 200 Deg F
 = -6.7 to 93.3 Deg C

AS FOUND/AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 97.79017 Ohms						
20.4060 F	20.415F	0.2590F	3.47	Pass	3.4e-002F	
Resistance Value at Temp = 104.288 Ohms						
50.3570 F	50.344F	0.2590F	5.02	Pass	3.4e-002F	
Resistance Value at Temp = 110.76233 Ohms						
80.3200 F	80.315F	0.2590F	1.93	Pass	3.4e-002F	
Resistance Value at Temp = 117.2155 Ohms						
110.3350 F	110.341F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 123.63317 Ohms						
140.3530 F	140.356F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 130.02183 Ohms						
170.3830 F	170.389F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 136.37467 Ohms						
200.4150 F	200.409F	0.2590F	2.32	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.79017 Ohms						
-6.4410 c	-6.436c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 104.288 Ohms						
10.1980 c	10.191c	0.1440c	4.86	Pass	1.9e-002c	
Resistance Value at Temp = 110.76233 Ohms						
26.8440 c	26.842c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 117.2155 Ohms						
43.5200 c	43.523c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 123.63317 Ohms						
60.1960 c	60.198c	0.1440c	1.39	Pass	1.9e-002c	
Resistance Value at Temp = 130.02183 Ohms						
76.8790 c	76.883c	0.1440c	2.78	Pass	1.9e-002c	
Resistance Value at Temp = 136.37467 Ohms						
93.5640 c	93.561c	0.1440c	2.08	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp

$$T = \frac{[-RoA + \sqrt{Ro^2 \cdot A^2 - 4Ro \cdot B(Ro - Rt)}}{2 \cdot Ro \cdot B}$$
 Ro= 100.30922
 Alpha= 0.003839081
 Delta= 1.54063891255
 A= 0.00389822737577
 B= -5.91463757704e-007

***** End of Report *****

Scantek, Inc.

CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCCL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)



NVLAP Lab Code: 200625-0

Calibration Certificate No.37131

Instrument: Acoustical Calibrator
Model: CB006
Manufacturer: Cesva
Serial number: 48461
Class (IEC 60942): 1
Barometer type:
Barometer s/n:
ID number: 24356
Customer: McHale Performance
Tel/Fax: 865-588-2654 x119 /

Date Calibrated: 10/7/2016 **Cal Due:** 10/7/2017
Status:

Received	Sent
	X
X	
X	

In tolerance:
Out of tolerance:
See comments:
Contains non-accredited tests: Yes X No

Address: 4700 Coster Rd
Knoxville, TN 37912

Tested in accordance with the following procedures and standards:
Calibration of Acoustical Calibrators, Scantek Inc., Rev. 10/1/2010

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence	
				Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31061	Jul 27, 2016	Scantek, Inc. / NVLAP	Jul 27, 2017
DS-360-SRS	Function Generator	88077	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2018
34401A-Agilent Technologies	Digital Voltmeter	MY47011118	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2017
HM30-Thommen	Meteo Station	1040170/39633	Oct 23, 2015	ACR Env./ A2LA	Oct 23, 2016
140-Norsonic	Real Time Analyzer	1403978	Mar 17, 2016	Scantek, Inc. / NVLAP	Mar 17, 2017
PC Program 1018 Norsonic	Calibration software	v.6.1T	Validated Nov 2014	Scantek, Inc.	-
4192-Brüel&Kjær	Microphone	2854675	Nov 11, 2015	Scantek, Inc. / NVLAP	Nov 11, 2016
1203-Norsonic	Preamplifier	92268	Oct 14, 2015	Scantek, Inc. / NVLAP	Oct 14, 2016

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK)

Calibrated by:	Jeremy Gotwalt	Authorized signatory:	Valentin Buzduga
Signature		Signature	
Date	10/7/16	Date	10/12/2016

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory. This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.

Document stored as: Z:\Calibration Lab\Cal 2016\CesvaCB006_48461_M2.doc

Page 1 of 2

Results summary: Device was tested and complies with following clauses of mentioned specifications:

CLAUSES ¹ FROM STANDARDS REFERENCED IN PROCEDURES:	MET ²	NOT MET	COMMENTS
Manufacturer specifications			
Manufacturer specifications: Sound pressure level	X		
Manufacturer specifications: Frequency	X		
Manufacturer specifications: Total harmonic distortion	X		
Current standards			
ANSI S1.40:2006 B.3 / IEC 60942: 2003 B.2 - Preliminary inspection	X		
ANSI S1.40:2006 B.4.4 / IEC 60942: 2003 B.3.4 - Sound pressure level	X		
ANSI S1.40:2006 A.5.4 / IEC 60942: 2003 A.4.4 - Sound pressure level stability	X		
ANSI S1.40:2006 B.4.5 / IEC 60942: 2003 B.3.5 - Frequency	X		
ANSI S1.40:2006 B.4.6 / IEC 60942: 2003 B.3.6 - Total harmonic distortion	X		

¹ The results of this calibration apply only to the instrument type with serial number identified in this report.

² The tests marked with (*) are not covered by the current NVLAP accreditation.

Main measured parameters ³:

Measured ⁴ /Acceptable ⁵ Tone frequency (Hz):	Measured ⁴ /Acceptable ⁵ Total Harmonic Distortion (%):	Measured ⁴ /Acceptable Level ⁵ (dB):
1000.03 ± 1.0/1000.0 ± 10.0	0.20 ± 0.10/ < 3	93.76 ± 0.12/94.0 ± 0.4

³ The stated level is valid at measurement conditions.

⁴ The above expanded uncertainties for frequency and distortion are calculated with a coverage factor k=2; for level k=2.00

⁵ Acceptable parameters values are from the current standards

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
21.7 ± 1.0	100.76 ± 0.000	58.6 ± 2.0

Tests made with following attachments to instrument:

Calibrator 1/2" Adaptor Type:
Other:

Adjustments: Unit was adjusted for level.

Comments: As received, the instrument produced sound pressure level below the lower limit of the admissible range. The level was adjusted to the maximum value possible. After adjustment, the instrument was tested and met all specifications found in the referenced procedures.

Note: The instrument was tested for the parameters listed in the table above, using the test methods described in the listed standards. All tests were performed around the reference conditions. The test results were compared with the manufacturer's or with the standard's specifications, whichever are larger.

Compliance with any standard cannot be claimed based solely on the periodic tests.

Measured Data: in Acoustical Calibrator Test Report # 37131 of two pages.

Place of Calibration: Scantek, Inc.

6430 Dobbin Road, Suite C
Columbia, MD 21045 USA

Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

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This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.

Document stored as: Z:\Calibration Lab\Cal 2016\CesvaCB006_48461_M2.doc

Test Report No.:37131

Manufacturer: Cesva
Type: CB006
Serial no: 48461

Customer: McHale Performance
Department:
Address: 4700 Coster Rd, Knoxville, TN 37912
Order No:
Contact Person: Jessica Trent
Phone No.: 865-588-2654 x119
eMail: jessica.trent@mchaleperformance.com

Measurement Results:

	Level: (dB)	P. Stab : (dB)	Frequency: (Hz)	F. Stab : (%)	Distortion: (% TD)
1:	93.62	0.02	1000.03	0.00	0.20

Result (Average):

0.00

0.00

Expanded Uncertainty:

Degree of Freedom:

Coverage Factor:

0.00

The stated levels are relative to 20 μ Pa.

The stated level is valid at measurement conditions.

Reference microphone: 4134-982459. Volume correction: 0.000 dB

Records:Z:\Calibration Lab\Cal 2016\CesvaCB006_48461_M1.nmf

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k = 2$, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

As received data.

Environmental conditions:

Pressure: 100.760 \pm 0.020 kPa Temperature: 21.7 \pm 1.0 $^{\circ}$ C Relative humidity: 58.6 \pm 2.0 %RH

Date of calibration: 10/7/2016

Date of issue: 10/7/2016

Supervisor : Valentin Buzduga

Measurements performed by:



Jeremy Gorwalt
Software version: 6.1T**Scantek, Inc.**6430 Dobbin Rd., Suite C, Columbia, MD 21045
Ph: 410-290-7726 eMail: callab@scantekinc.com

Test Report No.:37131

Manufacturer: Cesva
Type: CB006
Serial no: 48461

Customer: McHale Performance
Department:
Address: 4700 Coster Rd, Knoxville, TN 37912
Order No:
Contact Person: Jessica Trent
Phone No.: 865-588-2654 x119
eMail: jessica.trent@mchaleperformance.com

Measurement Results:

	Level:	P. Stab :	Frequency:	F. Stab :	Distortion:
	(dB)	(dB)	(Hz)	(%)	(% TD)
1:	93.76	0.01	1000.03	0.00	0.20
2:	93.75	0.01	1000.04	0.00	0.20
3:	93.77	0.02	1000.03	0.00	0.20
Result (Average):	93.76	0.01	1000.03	0.00	0.20
Expanded Uncertainty:	0.12	0.02	1.00	0.01	0.10
Degree of Freedom:	>100	>100	>100	>100	>100
Coverage Factor:	2.00	2.00	2.00	2.00	2.00

The stated levels are relative to 20 μ Pa.

The stated level is valid at measurement conditions.
Reference microphone: 4134-982459. Volume correction: 0.000 dB
Records:Z:\Calibration Lab\Cal 2016\CesvaCB006_48461_M2.nmf

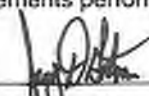
The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k = 2$, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

After adjustment data.

Environmental conditions:
Pressure: 100.760 \pm 0.020 kPa
Temperature: 21.7 \pm 1.0 $^{\circ}$ C
Relative humidity: 58.6 \pm 2.0 %RH

Date of calibration: 10/7/2016
Date of issue: 10/7/2016

Supervisor : Valentin Buzduga
Measurements performed by:



Jeremy Gotwalt
Software version: 6.1T

Scantek, Inc.
6430 Dobbin Rd., Suite C, Columbia, MD 21045
Ph: 410-290-7726 eMail: callab@scantekinc.com

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER: 1317188	CAL DATE: 03 March 2017
ASSET NUMBER: 51593	CAL DUE: 03 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 10~15 CAL UNITS: psia

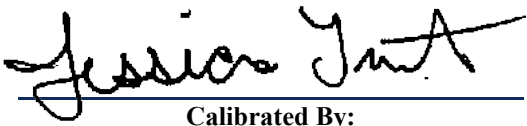
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."


Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA51593
Calibrated Span = 5 PSI
Calibration Tolerance = 0.00325 PSI

Upscale Tests

10.0000 psi	10.000psi	0.00325psi	0	Pass	9.9e-004psi	
11.2500 psi	11.249psi	0.00325psi	30.8	Pass	1.1e-003psi	3.61
12.5000 psi	12.500psi	0.00325psi	0	Pass	1.2e-003psi	3.25
13.7500 psi	13.751psi	0.00325psi	30.8	Pass	1.2e-003psi	2.95
15.0000 psi	15.000psi	0.00325psi	0	Pass	1.3e-003psi	2.71

Downscale Tests

15.0000 psi	15.000psi	0.00325psi	0	Pass	1.3e-003psi	2.71
13.7500 psi	13.750psi	0.00325psi	0	Pass	1.2e-003psi	2.95
12.5000 psi	12.500psi	0.00325psi	0	Pass	1.2e-003psi	3.25
11.2500 psi	11.249psi	0.00325psi	30.8	Pass	1.1e-003psi	3.61
10.0000 psi	10.000psi	0.00325psi	0	Pass	9.9e-004psi	

***** End of Report *****

UNIT UNDER TEST: Press. Transmitter, Abs.	TEST RESULT: PASS
SERIAL NUMBER:	CAL DATE: 03 March 2017
ASSET NUMBER: 51604	CAL DUE: 03 March 2018
PROCEDURE NAME: Digital Pressure Transmitter (PSI)	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 08/25/09	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
	CAL RANGE: 10~15
	CAL UNITS: psia

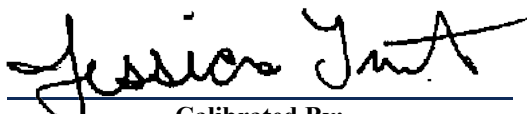
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
14025	DH Instruments PPC4 Pressure Controller/Calibrator	217	7/11/2016	7/11/2017
14052	DH Instruments RPM4 Pressure Controller/Calibrator	1067	7/9/2016	7/9/2017

Test Results

Standard Reading **UUT Reading** **Test Tol** **% Tol Error** **PASS/FAIL** **Expanded Unc.** **TUR**

Transmitter Tag = PTA51604
Calibrated Span = 5 PSI
Calibration Tolerance = 0.00325 PSI

Upscale Tests

10.0000 psi	9.999psi	0.00325psi	30.8	Pass	9.9e-004psi	
11.2500 psi	11.249psi	0.00325psi	30.8	Pass	1.1e-003psi	3.61
12.5000 psi	12.500psi	0.00325psi	0	Pass	1.2e-003psi	3.25
13.7500 psi	13.750psi	0.00325psi	0	Pass	1.2e-003psi	2.95
15.0000 psi	15.001psi	0.00325psi	30.8	Pass	1.3e-003psi	2.71

Downscale Tests

15.0000 psi	15.001psi	0.00325psi	30.8	Pass	1.3e-003psi	2.71
13.7500 psi	13.751psi	0.00325psi	30.8	Pass	1.2e-003psi	2.95
12.5000 psi	12.501psi	0.00325psi	30.8	Pass	1.2e-003psi	3.25
11.2500 psi	11.250psi	0.00325psi	0	Pass	1.1e-003psi	3.61
10.0000 psi	9.999psi	0.00325psi	30.8	Pass	9.9e-004psi	

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: 100013	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

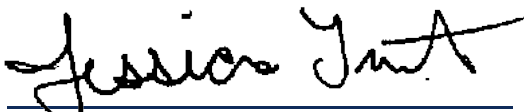
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:


Approved By:

Standards Used				
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<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= 100013					
Probe Calibration Range	= -20 to 120 Deg F					
	= -28.9 to 48.9 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.8145 Ohms						
-19.4830 F	-19.488F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.46017 Ohms						
15.4290 F	15.439F	0.1000F	10	Pass	3.4e-002F	2.94
Resistance Value at Temp = 104.06217 Ohms						
50.3790 F	50.376F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.62483 Ohms						
85.3510 F	85.344F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.15117 Ohms						
120.3530 F	120.357F	0.1000F	4	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.8145 Ohms						
-28.6020 c	-28.604c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.46017 Ohms						
-9.2060 c	-9.201c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 104.06217 Ohms						
10.2100 c	10.209c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.62483 Ohms						
29.6390 c	29.635c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.15117 Ohms						
49.0850 c	49.087c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 100.06943

Alpha= 0.003853598

Delta= 1.58120634568

A= 0.00391453133611

B= -6.09333361131e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Digital, 4-Wire	TEST RESULT: PASS
SERIAL NUMBER: 2241	CAL DATE: 09 February 2017
ASSET NUMBER: 160025	CAL DUE: 09 February 2018
PROCEDURE NAME: Digital RTD	DATA TYPE: AS-LEFT
PROCEDURE REV.: 1 - 01/05/06	TEMPERATURE: 22.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 31 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: 20~200
	CAL UNITS: Deg F

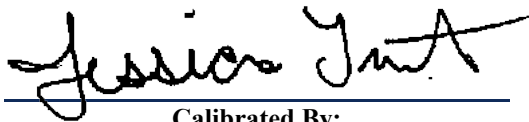
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
Probe ID Number	= TT160025					
Probe Calibration Range	= 20 to 200 Deg F					
	= -6.7 to 93.3 Deg C					

AS FOUND/AS LEFT RESULTS

Degrees F						
Resistance Value at Temp = 97.443 Ohms						
20.4060 F	20.404F	0.2590F	0.772	Pass	3.4e-002F	
Resistance Value at Temp = 104.07383 Ohms						
50.3570 F	50.357F	0.2590F	0	Pass	3.4e-002F	
Resistance Value at Temp = 110.6755 Ohms						
80.3200 F	80.328F	0.2590F	3.09	Pass	3.4e-002F	
Resistance Value at Temp = 117.25167 Ohms						
110.3350 F	110.335F	0.2590F	0	Pass	3.4e-002F	
Resistance Value at Temp = 123.7955 Ohms						
140.3530 F	140.347F	0.2590F	2.32	Pass	3.4e-002F	
Resistance Value at Temp = 130.3105 Ohms						
170.3830 F	170.380F	0.2590F	1.16	Pass	3.4e-002F	
Resistance Value at Temp = 136.79333 Ohms						
200.4150 F	200.419F	0.2590F	1.54	Pass	3.4e-002F	

*****Degrees C*****

Resistance Value at Temp = 97.443 Ohms						
-6.4410 c	-6.442c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 104.07383 Ohms						
10.1980 c	10.198c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 110.6755 Ohms						
26.8440 c	26.849c	0.1440c	3.47	Pass	1.9e-002c	
Resistance Value at Temp = 117.25167 Ohms						
43.5200 c	43.520c	0.1440c	0	Pass	1.9e-002c	
Resistance Value at Temp = 123.7955 Ohms						
60.1960 c	60.193c	0.1440c	2.08	Pass	1.9e-002c	
Resistance Value at Temp = 130.3105 Ohms						
76.8790 c	76.878c	0.1440c	0.694	Pass	1.9e-002c	
Resistance Value at Temp = 136.79333 Ohms						
93.5640 c	93.566c	0.1440c	1.39	Pass	1.9e-002c	

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.01409
 Alpha= 0.003926417
 Delta= 1.52911931646
 A= 0.00398645660079
 B= -6.00396007917e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: 300012	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

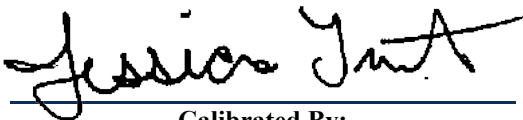
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."


Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= 300012					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.75483 Ohms						
-19.4830 F	-19.489F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.39817 Ohms						
15.4290 F	15.440F	0.1000F	11	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.9965 Ohms						
50.3790 F	50.381F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.55 Ohms						
85.3510 F	85.336F	0.1000F	15	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.07067 Ohms						
120.3530 F	120.360F	0.1000F	7	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.75483 Ohms						
-28.6020 c	-28.605c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.39817 Ohms						
-9.2060 c	-9.200c	0.0560c	10.7	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.9965 Ohms						
10.2100 c	10.212c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.55 Ohms						
29.6390 c	29.631c	0.0560c	14.3	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.07067 Ohms						
49.0850 c	49.089c	0.0560c	7.14	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B(Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00526

Alpha= 0.003851438

Delta= 1.64274680159

A= 0.00391470737456

B= -6.32693745602e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: 300018	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

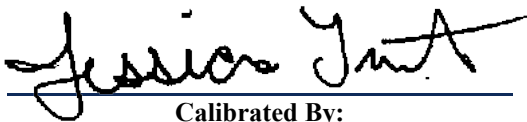
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= 300018					
Probe Calibration Range	= -20 to 120 Deg F					
	= -28.9 to 48.9 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.755 Ohms						
-19.4830 F	-19.486F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.39433 Ohms						
15.4290 F	15.436F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.99183 Ohms						
50.3790 F	50.377F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.54917 Ohms						
85.3510 F	85.346F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.06933 Ohms						
120.3530 F	120.356F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.755 Ohms						
-28.6020 c	-28.604c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.39433 Ohms						
-9.2060 c	-9.202c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.99183 Ohms						
10.2100 c	10.209c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.54917 Ohms						
29.6390 c	29.636c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.06933 Ohms						
49.0850 c	49.087c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00173

Alpha= 0.00385333

Delta= 1.58470234123

A= 0.00391439381073

B= -6.10638107254e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT007	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT007					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.7645 Ohms						
-19.4830 F	-19.485F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.39467 Ohms						
15.4290 F	15.432F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.9865 Ohms						
50.3790 F	50.378F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.539 Ohms						
85.3510 F	85.348F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.0545 Ohms						
120.3530 F	120.354F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.7645 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.39467 Ohms						
-9.2060 c	-9.204c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.9865 Ohms						
10.2100 c	10.210c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.539 Ohms						
29.6390 c	29.638c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.0545 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.99953

Alpha= 0.003851854

Delta= 1.53684936379

A= 0.00391105119369

B= -5.91971936933e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT012	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



 Calibrated By: 

 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT012					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.772 Ohms						
-19.4830 F	-19.486F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.40167 Ohms						
15.4290 F	15.434F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.99167 Ohms						
50.3790 F	50.382F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.53767 Ohms						
85.3510 F	85.341F	0.1000F	10	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.05 Ohms						
120.3530 F	120.357F	0.1000F	4	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.772 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.40167 Ohms						
-9.2060 c	-9.204c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.99167 Ohms						
10.2100 c	10.212c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.53767 Ohms						
29.6390 c	29.634c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.05 Ohms						
49.0850 c	49.087c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00522

Alpha= 0.003848467

Delta= 1.58720200769

A= 0.00390954994549

B= -6.10829454892e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT016	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

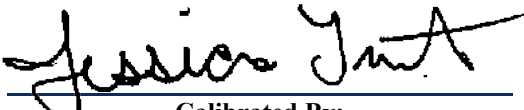
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Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT016					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.77033 Ohms						
-19.4830 F	-19.484F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.39683 Ohms						
15.4290 F	15.429F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.98667 Ohms						
50.3790 F	50.379F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.53617 Ohms						
85.3510 F	85.349F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.04817 Ohms						
120.3530 F	120.354F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.77033 Ohms						
-28.6020 c	-28.602c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.39683 Ohms						
-9.2060 c	-9.206c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.98667 Ohms						
10.2100 c	10.211c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.53617 Ohms						
29.6390 c	29.639c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.04817 Ohms						
49.0850 c	49.085c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00095

Alpha= 0.00385019

Delta= 1.54069777005

A= 0.00390950979147

B= -5.93197914725e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT018	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

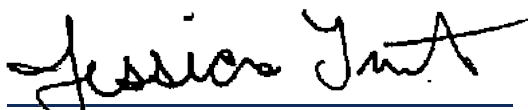
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT018					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.77467 Ohms						
-19.4830 F	-19.484F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.40417 Ohms						
15.4290 F	15.430F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.99633 Ohms						
50.3790 F	50.379F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.54783 Ohms						
85.3510 F	85.349F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.062 Ohms						
120.3530 F	120.354F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.77467 Ohms						
-28.6020 c	-28.602c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.40417 Ohms						
-9.2060 c	-9.205c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.99633 Ohms						
10.2100 c	10.211c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.54783 Ohms						
29.6390 c	29.638c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.062 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00934

Alpha= 0.003850766

Delta= 1.55023512035

A= 0.00391046192693

B= -5.96959269344e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT027	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

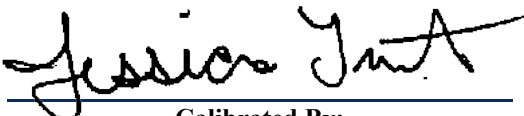
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT027					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.74033 Ohms						
-19.4830 F	-19.485F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.37417 Ohms						
15.4290 F	15.432F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.96917 Ohms						
50.3790 F	50.378F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.52483 Ohms						
85.3510 F	85.348F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.043 Ohms						
120.3530 F	120.354F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.74033 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.37417 Ohms						
-9.2060 c	-9.204c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.96917 Ohms						
10.2100 c	10.210c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.52483 Ohms						
29.6390 c	29.638c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.043 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.98057

Alpha= 0.003853911

Delta= 1.54623969482

A= 0.00391350170169

B= -5.95907016852e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT040	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

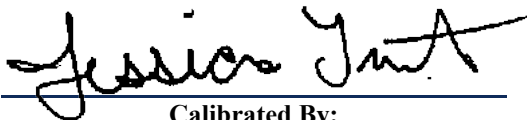
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT040					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.74767 Ohms						
-19.4830 F	-19.487F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.385 Ohms						
15.4290 F	15.438F	0.1000F	9	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.9785 Ohms						
50.3790 F	50.375F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.53233 Ohms						
85.3510 F	85.346F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.04783 Ohms						
120.3530 F	120.356F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.74767 Ohms						
-28.6020 c	-28.604c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.385 Ohms						
-9.2060 c	-9.201c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.9785 Ohms						
10.2100 c	10.209c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.53233 Ohms						
29.6390 c	29.637c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.04783 Ohms						
49.0850 c	49.087c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.99054

Alpha= 0.003851191

Delta= 1.60942129691

A= 0.00391317288814

B= -6.19818881385e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT044	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

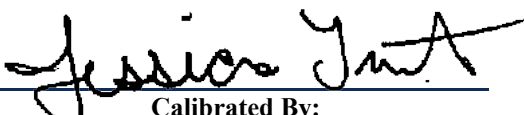
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT044					
Probe Calibration Range	= -20 to 120 Deg F					
	= -28.9 to 48.9 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.767 Ohms						
-19.4830 F	-19.488F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.40533 Ohms						
15.4290 F	15.441F	0.1000F	12	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.99717 Ohms						
50.3790 F	50.373F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.55117 Ohms						
85.3510 F	85.346F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.06617 Ohms						
120.3530 F	120.356F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.767 Ohms						
-28.6020 c	-28.605c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.40533 Ohms						
-9.2060 c	-9.199c	0.0560c	12.5	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.99717 Ohms						
10.2100 c	10.207c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.55117 Ohms						
29.6390 c	29.637c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.06617 Ohms						
49.0850 c	49.087c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.00996

Alpha= 0.003850088

Delta= 1.6152869236

A= 0.00391227796801

B= -6.21899680112e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 8"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: CT049	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 _____ Calibrated By:	 _____ Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= CT049					
Probe Calibration Range	= -20 to 120 Deg F					
	= -28.9 to 48.9 Deg C					

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.74133 Ohms						
-19.4830 F	-19.487F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.38183 Ohms						
15.4290 F	15.437F	0.1000F	8	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.9795 Ohms						
50.3790 F	50.376F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.53767 Ohms						
85.3510 F	85.345F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.05867 Ohms						
120.3530 F	120.356F	0.1000F	3	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.74133 Ohms						
-28.6020 c	-28.604c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.38183 Ohms						
-9.2060 c	-9.201c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.9795 Ohms						
10.2100 c	10.209c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.53767 Ohms						
29.6390 c	29.636c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.05867 Ohms						
49.0850 c	49.087c	0.0560c	3.57	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4RoB(Ro - Rt)}}{2RoB}$

Ro= 99.98922

Alpha= 0.003854172

Delta= 1.58456906748

A= 0.00391524401732

B= -6.10720173195e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R05	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

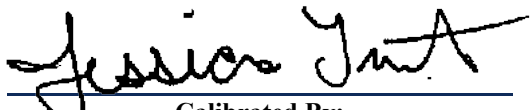
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R05					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.78733 Ohms						
-19.4830 F	-19.490F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.43967 Ohms						
15.4290 F	15.444F	0.1000F	15	Pass	3.4e-002F	2.94
Resistance Value at Temp = 104.04483 Ohms						
50.3790 F	50.374F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.61117 Ohms						
85.3510 F	85.341F	0.1000F	10	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.1415 Ohms						
120.3530 F	120.358F	0.1000F	5	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.78733 Ohms						
-28.6020 c	-28.605c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.43967 Ohms						
-9.2060 c	-9.198c	0.0560c	14.3	Pass	1.9e-002c	2.95
Resistance Value at Temp = 104.04483 Ohms						
10.2100 c	10.208c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.61117 Ohms						
29.6390 c	29.634c	0.0560c	8.93	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.1415 Ohms						
49.0850 c	49.088c	0.0560c	5.36	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.05016

Alpha= 0.003855762

Delta= 1.60444847857

A= 0.00391762571475

B= -6.18637147461e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: R119	CAL DATE: 06 March 2017
ASSET NUMBER: R119	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

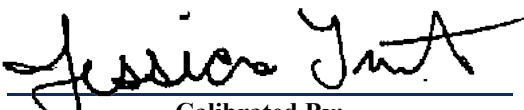
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R119					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.86833 Ohms						
-19.4830 F	-19.485F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.51567 Ohms						
15.4290 F	15.433F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 104.12367 Ohms						
50.3790 F	50.377F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.69267 Ohms						
85.3510 F	85.349F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.2235 Ohms						
120.3530 F	120.354F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.86833 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.51567 Ohms						
-9.2060 c	-9.204c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 104.12367 Ohms						
10.2100 c	10.209c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.69267 Ohms						
29.6390 c	29.638c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.2235 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.1283

Alpha= 0.003854766

Delta= 1.55053204554

A= 0.00391453538211

B= -5.97693821107e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R273	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

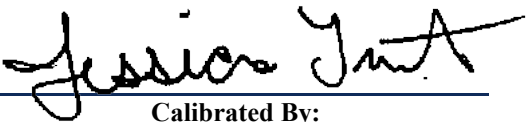
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



 Calibrated By:



 Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R273					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.76383 Ohms						
-19.4830 F	-19.485F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.40133 Ohms						
15.4290 F	15.433F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 104.0005 Ohms						
50.3790 F	50.378F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.561 Ohms						
85.3510 F	85.348F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.08483 Ohms						
120.3530 F	120.354F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.76383 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.40133 Ohms						
-9.2060 c	-9.204c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 104.0005 Ohms						
10.2100 c	10.210c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.561 Ohms						
29.6390 c	29.638c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.08483 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.0096

Alpha= 0.003855842

Delta= 1.522228516

A= 0.00391453672646

B= -5.86947264559e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R321	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 <hr style="width: 80%; margin: 0 auto;"/> Calibrated By:	 <hr style="width: 80%; margin: 0 auto;"/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R321					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.77283 Ohms						
-19.4830 F	-19.490F	0.1000F	7	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.42233 Ohms						
15.4290 F	15.444F	0.1000F	15	Pass	3.4e-002F	2.94
Resistance Value at Temp = 104.024 Ohms						
50.3790 F	50.374F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.58717 Ohms						
85.3510 F	85.342F	0.1000F	9	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.1135 Ohms						
120.3530 F	120.358F	0.1000F	5	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.77283 Ohms						
-28.6020 c	-28.606c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.42233 Ohms						
-9.2060 c	-9.198c	0.0560c	14.3	Pass	1.9e-002c	2.95
Resistance Value at Temp = 104.024 Ohms						
10.2100 c	10.208c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.58717 Ohms						
29.6390 c	29.635c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.1135 Ohms						
49.0850 c	49.088c	0.0560c	5.36	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 100.03124

Alpha= 0.00385446

Delta= 1.61502148794

A= 0.00391671035724

B= -6.2250357244e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R397A	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

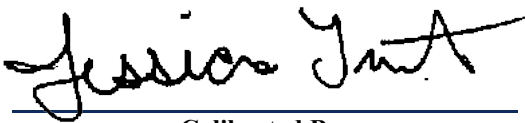
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

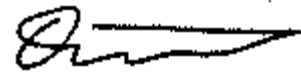
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R397A					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.72583 Ohms						
-19.4830 F	-19.485F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.35667 Ohms						
15.4290 F	15.435F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.949 Ohms						
50.3790 F	50.374F	0.1000F	5	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.507 Ohms						
85.3510 F	85.352F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.02733 Ohms						
120.3530 F	120.353F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.72583 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.35667 Ohms						
-9.2060 c	-9.203c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.949 Ohms						
10.2100 c	10.208c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.507 Ohms						
29.6390 c	29.640c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.02733 Ohms						
49.0850 c	49.085c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.96169

Alpha= 0.003856811

Delta= 1.47004840642

A= 0.00391350798864

B= -5.6696988644e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R652	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 <hr style="width: 80%; margin: 0 auto;"/> Calibrated By:	 <hr style="width: 80%; margin: 0 auto;"/> Approved By:
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Standards Used				
Asset #	Description	Serial #	Cal Date	Due Date
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R652					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.964 Ohms						
-19.4830 F	-19.484F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.61633 Ohms						
15.4290 F	15.430F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 104.23167 Ohms						
50.3790 F	50.382F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.80467 Ohms						
85.3510 F	85.345F	0.1000F	6	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.3425 Ohms						
120.3530 F	120.355F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.964 Ohms						
-28.6020 c	-28.602c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.61633 Ohms						
-9.2060 c	-9.205c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 104.23167 Ohms						
10.2100 c	10.212c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.80467 Ohms						
29.6390 c	29.636c	0.0560c	5.36	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.3425 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.23224
 Alpha= 0.003853843
 Delta= 1.54618914984
 A= 0.00391343070232
 B= -5.95877023177e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R785	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120 CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 <hr style="width: 80%; margin: 0 auto;"/> <p>Calibrated By:</p>	 <hr style="width: 80%; margin: 0 auto;"/> <p>Approved By:</p>
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Standards Used				
Asset #	Description	Serial #	Cal Date	Due Date
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R785					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.743 Ohms						
-19.4830 F	-19.487F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.382 Ohms						
15.4290 F	15.437F	0.1000F	8	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.97917 Ohms						
50.3790 F	50.376F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.53783 Ohms						
85.3510 F	85.347F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.05917 Ohms						
120.3530 F	120.355F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.743 Ohms						
-28.6020 c	-28.604c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.382 Ohms						
-9.2060 c	-9.202c	0.0560c	7.14	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.97917 Ohms						
10.2100 c	10.209c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.53783 Ohms						
29.6390 c	29.637c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.05917 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.98921

Alpha= 0.003854755

Delta= 1.56140099214

A= 0.00391494318281

B= -6.01881828146e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R886	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 _____ Calibrated By:	 _____ Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R886					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.74867 Ohms						
-19.4830 F	-19.485F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.384 Ohms						
15.4290 F	15.433F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.98067 Ohms						
50.3790 F	50.378F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.53783 Ohms						
85.3510 F	85.347F	0.1000F	4	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.05867 Ohms						
120.3530 F	120.355F	0.1000F	2	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.74867 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.384 Ohms						
-9.2060 c	-9.204c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.98067 Ohms						
10.2100 c	10.210c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.53783 Ohms						
29.6390 c	29.637c	0.0560c	3.57	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.05867 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = \frac{-RoA + \sqrt{Ro^2A^2 - 4RoB(Ro - Rt)}}{2RoB}$

Ro= 99.99104

Alpha= 0.00385475

Delta= 1.53514205097

A= 0.00391392588821

B= -5.91758882099e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R961	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120
	CAL UNITS: Deg F

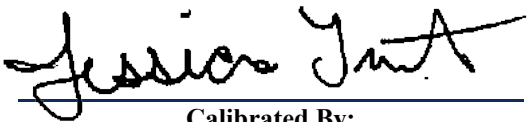
McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NC SL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

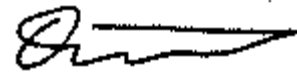
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.



Calibrated By:



Approved By:

Standards Used

<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R961					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.75067 Ohms						
-19.4830 F	-19.483F	0.1000F	0	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.384 Ohms						
15.4290 F	15.428F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 103.98117 Ohms						
50.3790 F	50.380F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.5375 Ohms						
85.3510 F	85.350F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.05567 Ohms						
120.3530 F	120.353F	0.1000F	0	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.75067 Ohms						
-28.6020 c	-28.602c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.384 Ohms						
-9.2060 c	-9.207c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 103.98117 Ohms						
10.2100 c	10.211c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.5375 Ohms						
29.6390 c	29.639c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.05567 Ohms						
49.0850 c	49.085c	0.0560c	0	Pass	1.9e-002c	2.95

As Left Coefficients:

Equation Used= Callendar-Van Dusen

where T = Deg C and Rt = Resistance at Temp

$T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$

Ro= 99.99174

Alpha= 0.00385379

Delta= 1.54861111703

A= 0.00391347022037

B= -5.96802203671e-007

***** End of Report *****

UNIT UNDER TEST: RTD, Analog, 4-Wire, 16"	TEST RESULT: PASS
SERIAL NUMBER: N/A	CAL DATE: 06 March 2017
ASSET NUMBER: R1108	CAL DUE: 06 March 2018
PROCEDURE NAME: Analog RTD Cal	DATA TYPE: AS-LEFT
PROCEDURE REV.: 0 - 09/30/04	TEMPERATURE: 21.00 °C
CALIBRATED BY: Jessica Trent	HUMIDITY: 30 %
CUSTOMER: McHale & Associates 4700 Coster Rd. Knoxville, TN 37912	CAL RANGE: -20~120 CAL UNITS: Deg F

McHale Performance certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ANSI/NCSL Z540.1-1994 (R2002) and ISO/IEC 17025:2005.

Measurement uncertainties are calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement."

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k = 2. Any Test Uncertainty Ratio (TUR) that is less than four to one will appear under the "TUR" heading on the data record. If the TUR meets or exceeds four to one, the field is left blank.

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REMARKS: Instrument passed calibration as left with new coefficients.

 <hr/> Calibrated By:	 <hr/> Approved By:
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Standards Used				
<u>Asset #</u>	<u>Description</u>	<u>Serial #</u>	<u>Cal Date</u>	<u>Due Date</u>
10219	Agilent 34970A Data Logger	US37042760	3/2/2017	6/2/2017
10261	Hart Scientific 1529 Thermometer Chub-E4	23202	1/20/2017	1/20/2018
10328	Hart Scientific 5699 Standard Platinum Resistance Thermometer	1021	1/9/2017	1/9/2018

Test Results

<u>Standard Reading</u>	<u>UUT Reading</u>	<u>Test Tol</u>	<u>% Tol Error</u>	<u>PASS/FAIL</u>	<u>Expanded Unc.</u>	<u>TUR</u>
DAS Asset	= 10219					
Probe ID Number	= R1108					
Probe Calibration Range = -20 to 120 Deg F						
= -28.9 to 48.9 Deg C						

AS LEFT RESULTS

Degrees F

Resistance Value at Temp = 88.82767 Ohms						
-19.4830 F	-19.485F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 96.46517 Ohms						
15.4290 F	15.431F	0.1000F	2	Pass	3.4e-002F	2.94
Resistance Value at Temp = 104.06533 Ohms						
50.3790 F	50.378F	0.1000F	1	Pass	3.4e-002F	2.94
Resistance Value at Temp = 111.62633 Ohms						
85.3510 F	85.348F	0.1000F	3	Pass	3.4e-002F	2.94
Resistance Value at Temp = 119.15083 Ohms						
120.3530 F	120.354F	0.1000F	1	Pass	3.4e-002F	2.94

*****Degrees C*****

Resistance Value at Temp = 88.82767 Ohms						
-28.6020 c	-28.603c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 96.46517 Ohms						
-9.2060 c	-9.205c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 104.06533 Ohms						
10.2100 c	10.210c	0.0560c	0	Pass	1.9e-002c	2.95
Resistance Value at Temp = 111.62633 Ohms						
29.6390 c	29.638c	0.0560c	1.79	Pass	1.9e-002c	2.95
Resistance Value at Temp = 119.15083 Ohms						
49.0850 c	49.086c	0.0560c	1.79	Pass	1.9e-002c	2.95

As Left Coefficients:

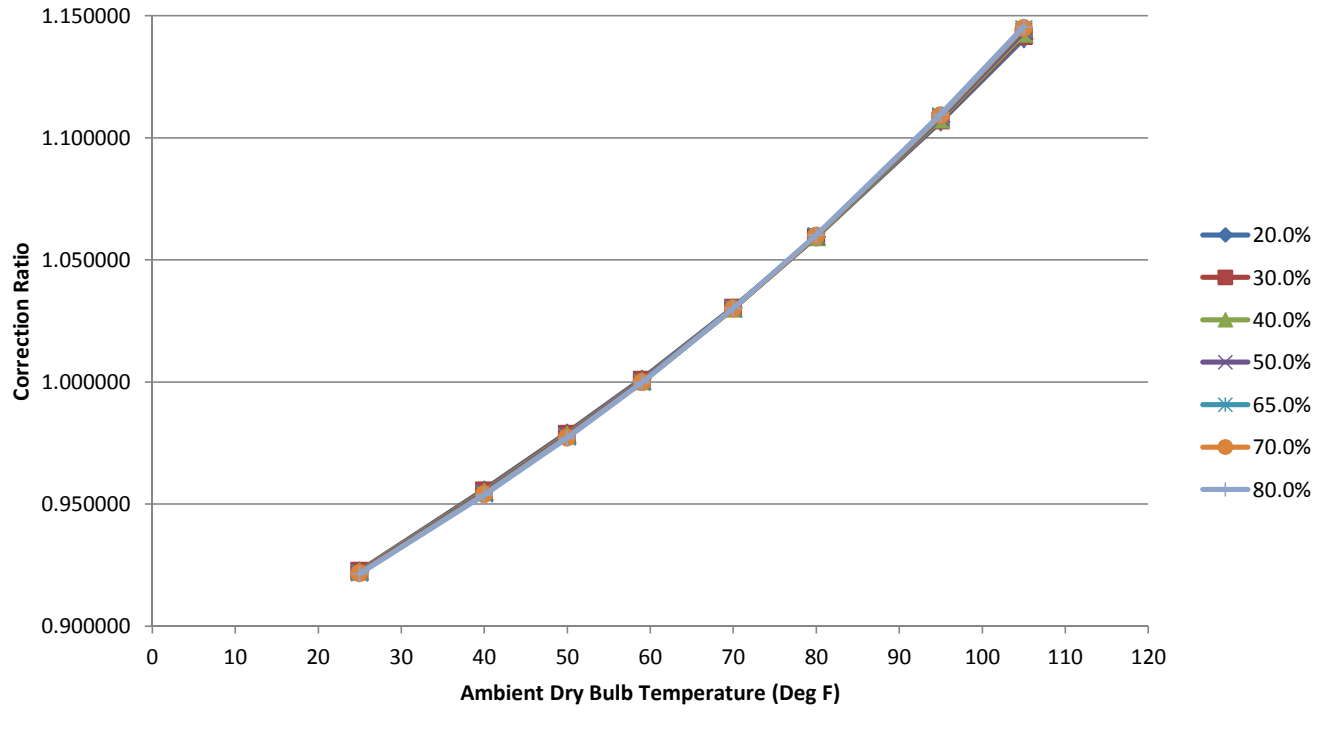
Equation Used= Callendar-Van Dusen
 where T = Deg C and Rt = Resistance at Temp
 $T = [-RoA + \text{Sqrt}(Ro^2 * A^2 - 4Ro * B * (Ro - Rt))] / (2 * Ro * B)$
 Ro= 100.07396
 Alpha= 0.003853787
 Delta= 1.5179898633
 A= 0.00391228709601
 B= -5.85000960133e-007

***** End of Report *****

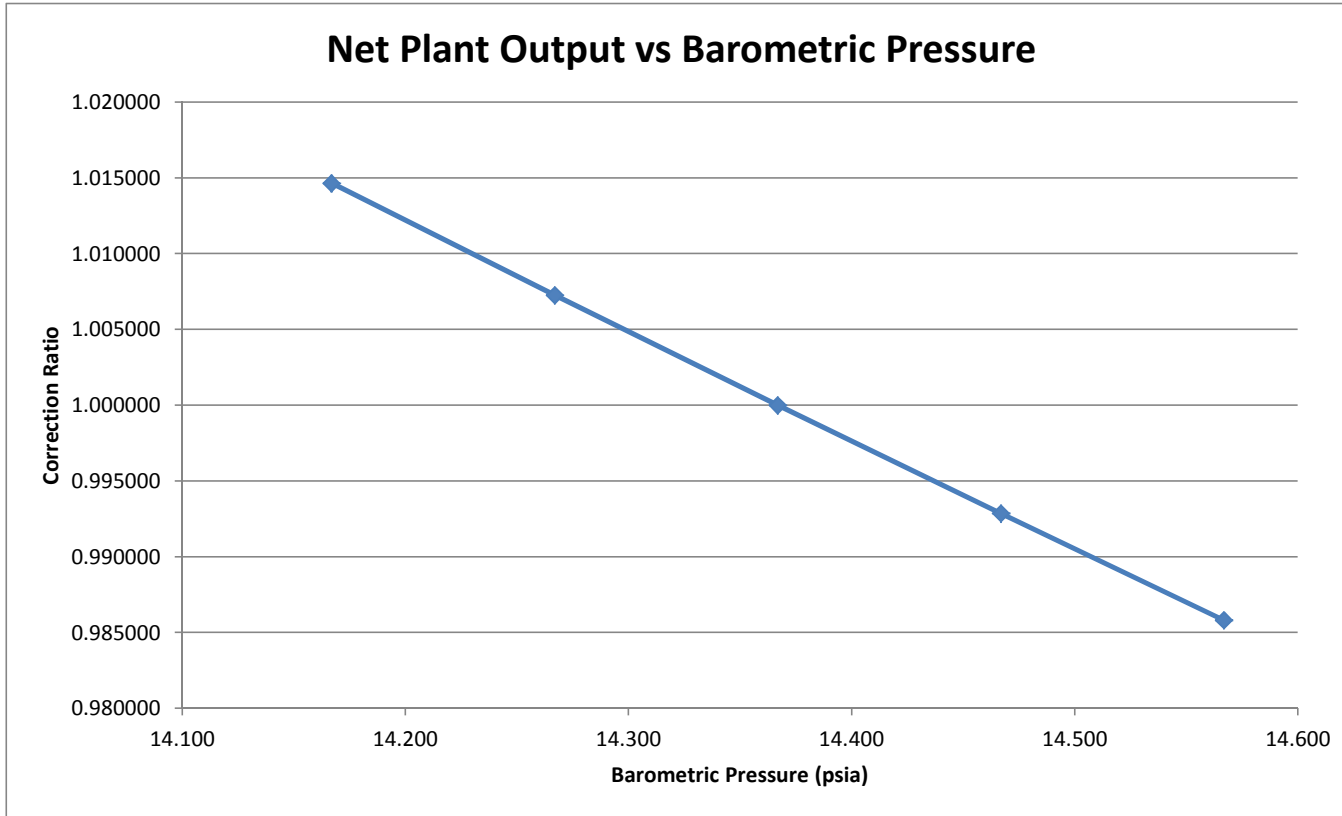
APPENDIX F

CORRECTION CURVES

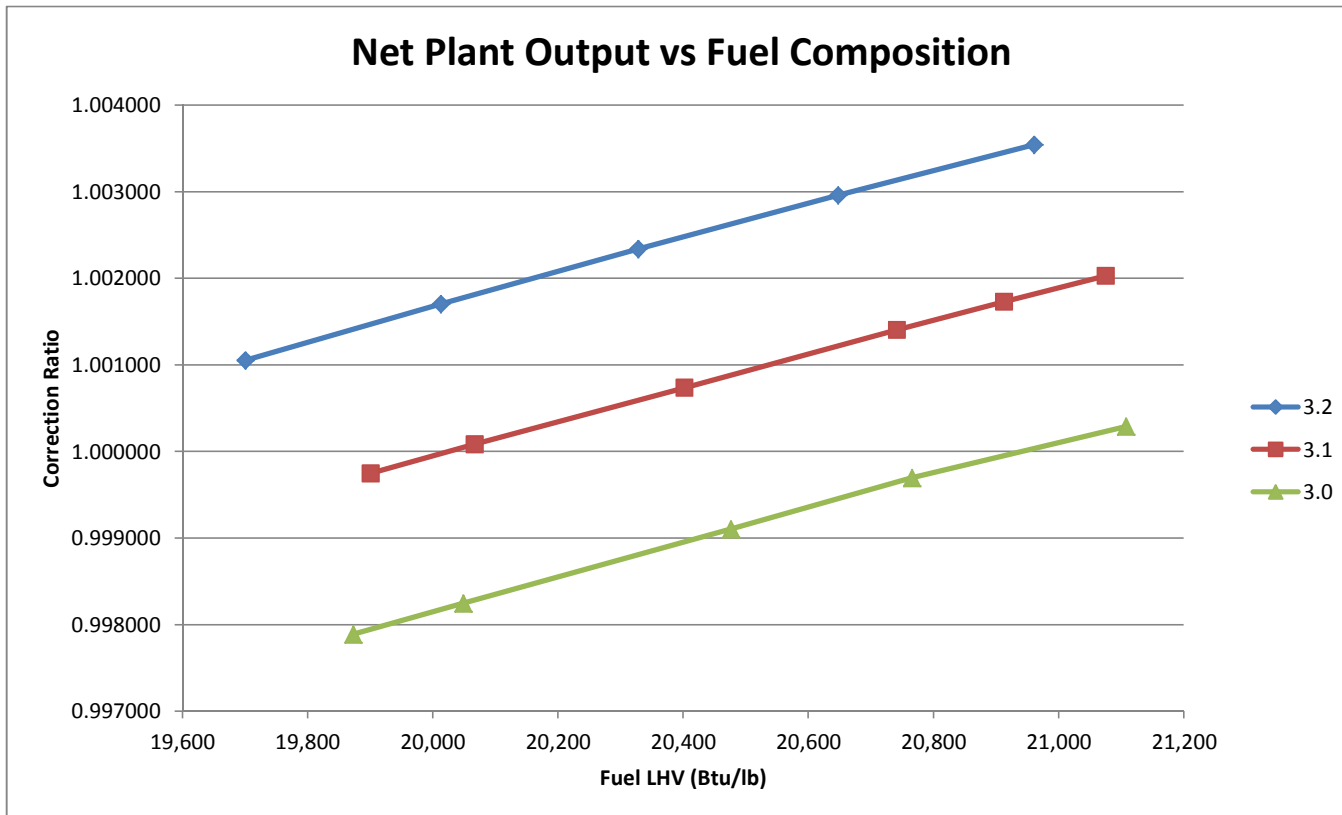
Net Plant Output vs Ambient Temperature and Humidity



		Ambient Dry Bulb Temperature (Deg F)							
		25	40	50	59	70	80	95	105
Relative Humidity (%)	20.0%	0.922805	0.955999	0.979224	1.001267	1.030532	1.059359	1.106500	1.140663
	30.0%	0.922642	0.955590	0.978773	1.000818	1.030319	1.059388	1.107059	1.141685
	40.0%	0.922431	0.955211	0.978394	1.000525	1.030163	1.059449	1.107625	1.142646
	50.0%	0.922185	0.954838	0.978031	1.000253	1.030101	1.059591	1.108194	1.143559
	65.0%	0.921869	0.954295	0.977516	1.000000	1.030082	1.059882	1.108943	1.144668
	70.0%	0.921766	0.954122	0.977362	0.999943	1.030082	1.059978	1.109189	1.144950
	80.0%	0.921575	0.953781	0.977054	0.999801	1.030169	1.060167	1.109622	1.145420



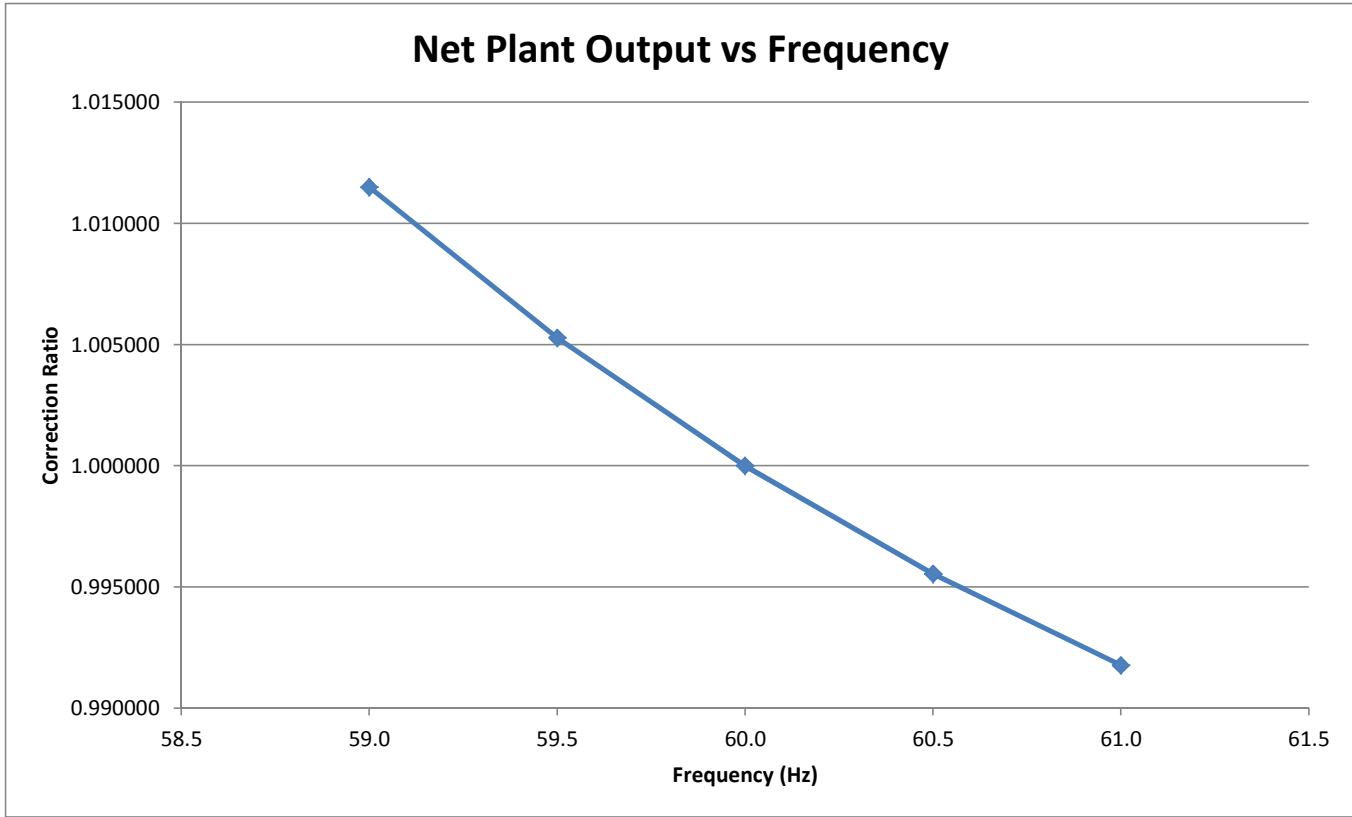
Barometric Pressure (psia)				
14.167	14.267	14.367	14.467	14.567
1.014641	1.007260	1.000000	0.992851	0.985809



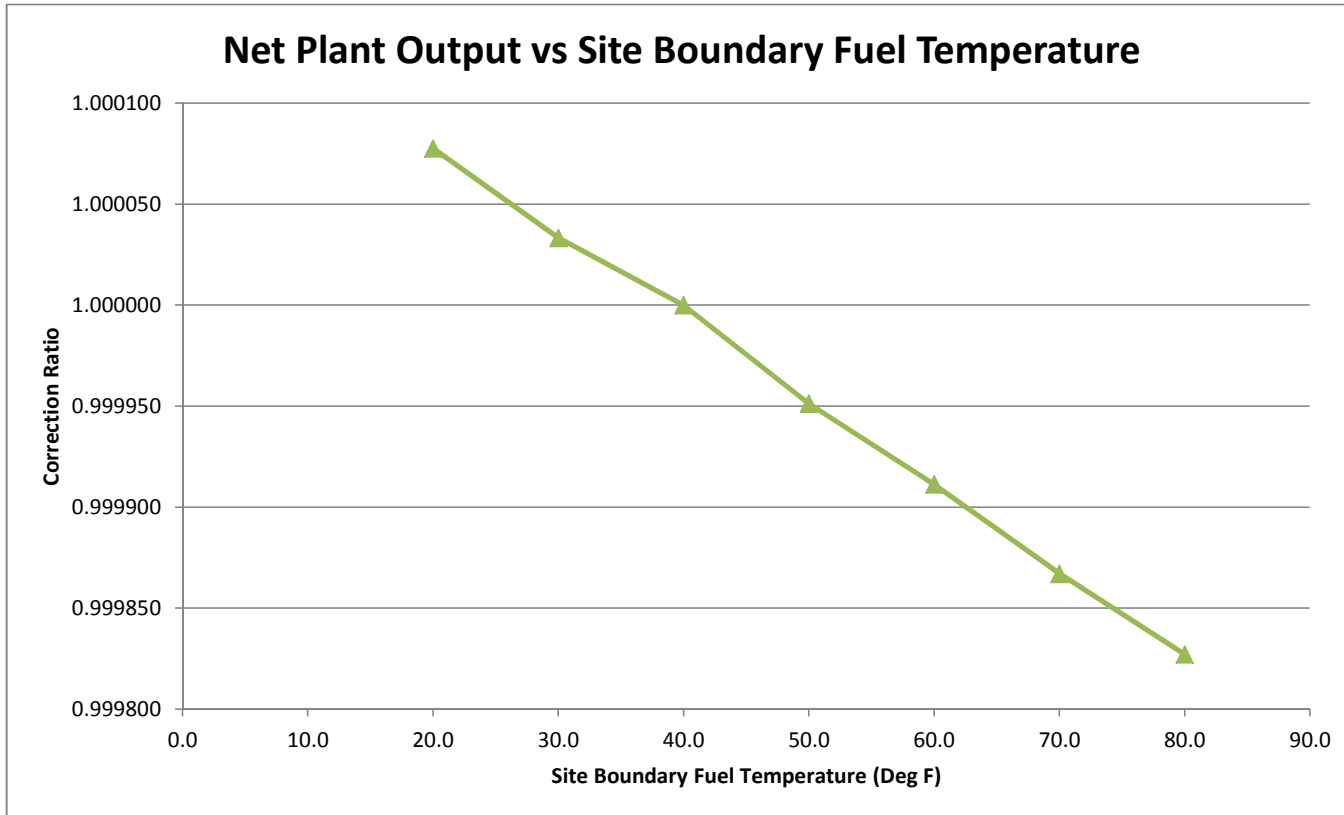
		Fuel H/C	
			3.0
Fuel LHV (BTU/lb)	19,873	0.997888	
	20,049	0.998246	
	20,477	0.999103	
	20,766	0.999695	
	21,108	1.000288	

		Fuel H/C	
			3.1
19,901	0.999747		
20,067	1.000083		
20,403	1.000735		
20,742	1.001404		
20,913	1.001728		
21,075	1.002030		

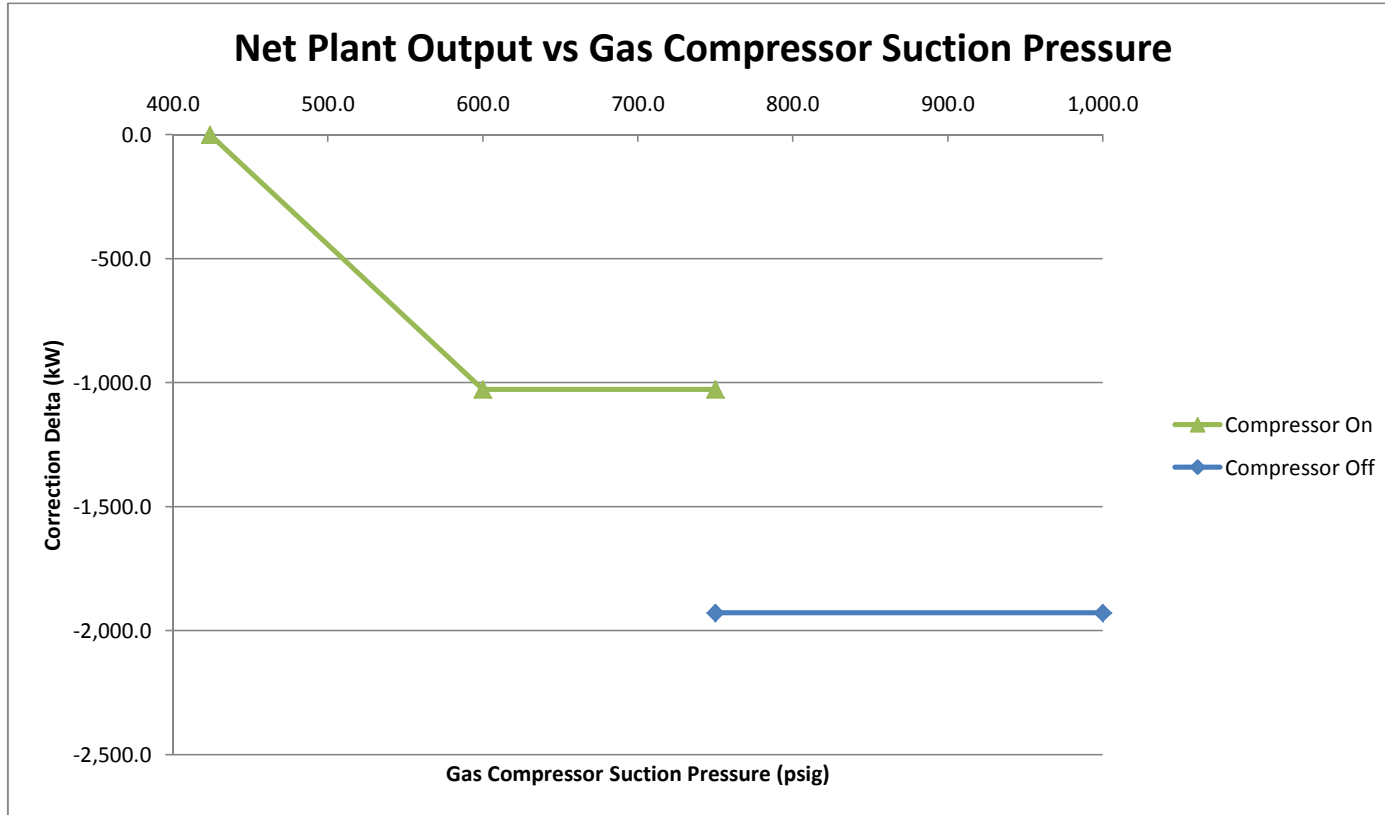
		Fuel H/C	
			3.2
19,701	1.001054		
20,013	1.001703		
20,329	1.002337		
20,648	1.002958		
20,961	1.003545		



Frequency (Hz)				
59.0	59.5	60.0	60.5	61.0
1.011491	1.005282	1.000000	0.995539	0.991773



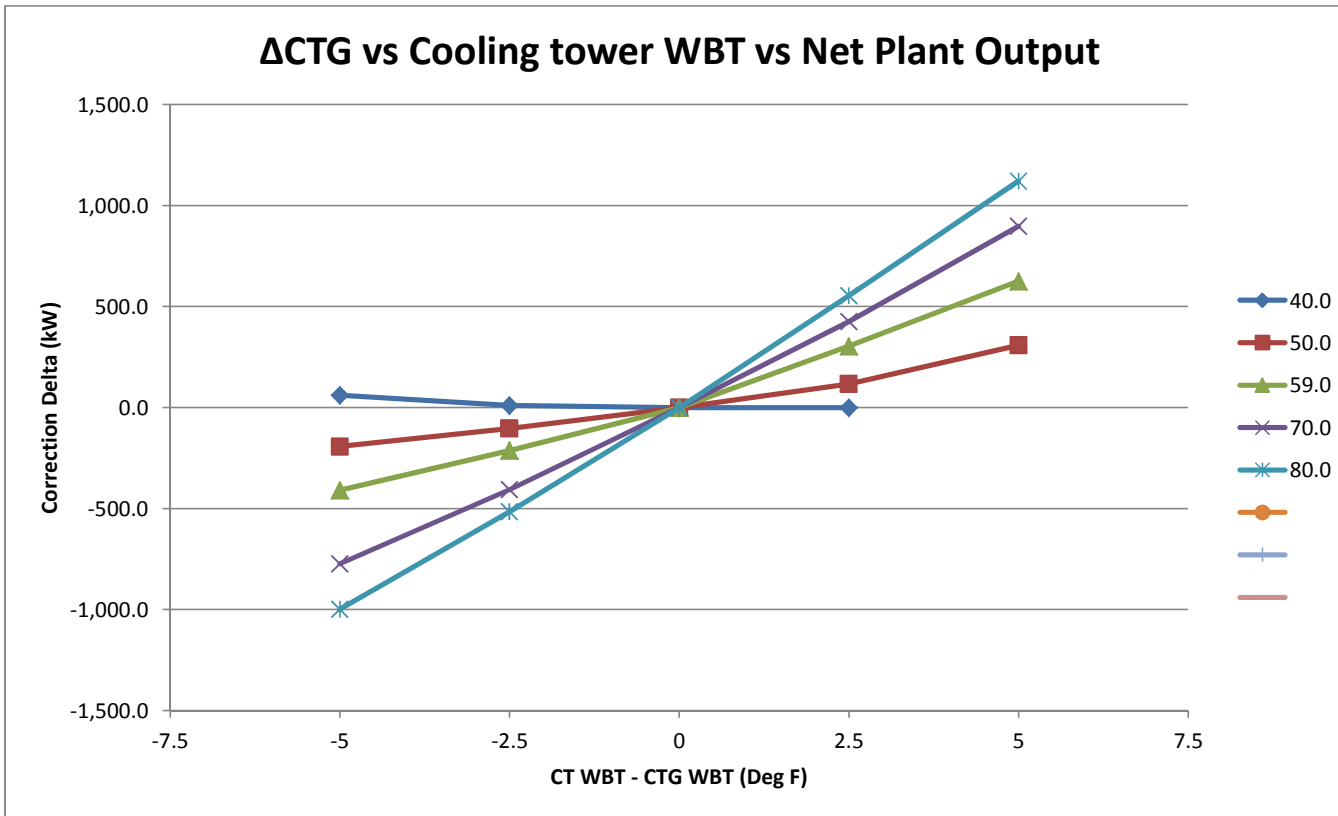
Site Boundary Fuel Temperature (Deg F)						
20.0	30.0	40.0	50.0	60.0	70.0	80.0
1.000078	1.000033	1.000000	0.999951	0.999911	0.999867	0.999827



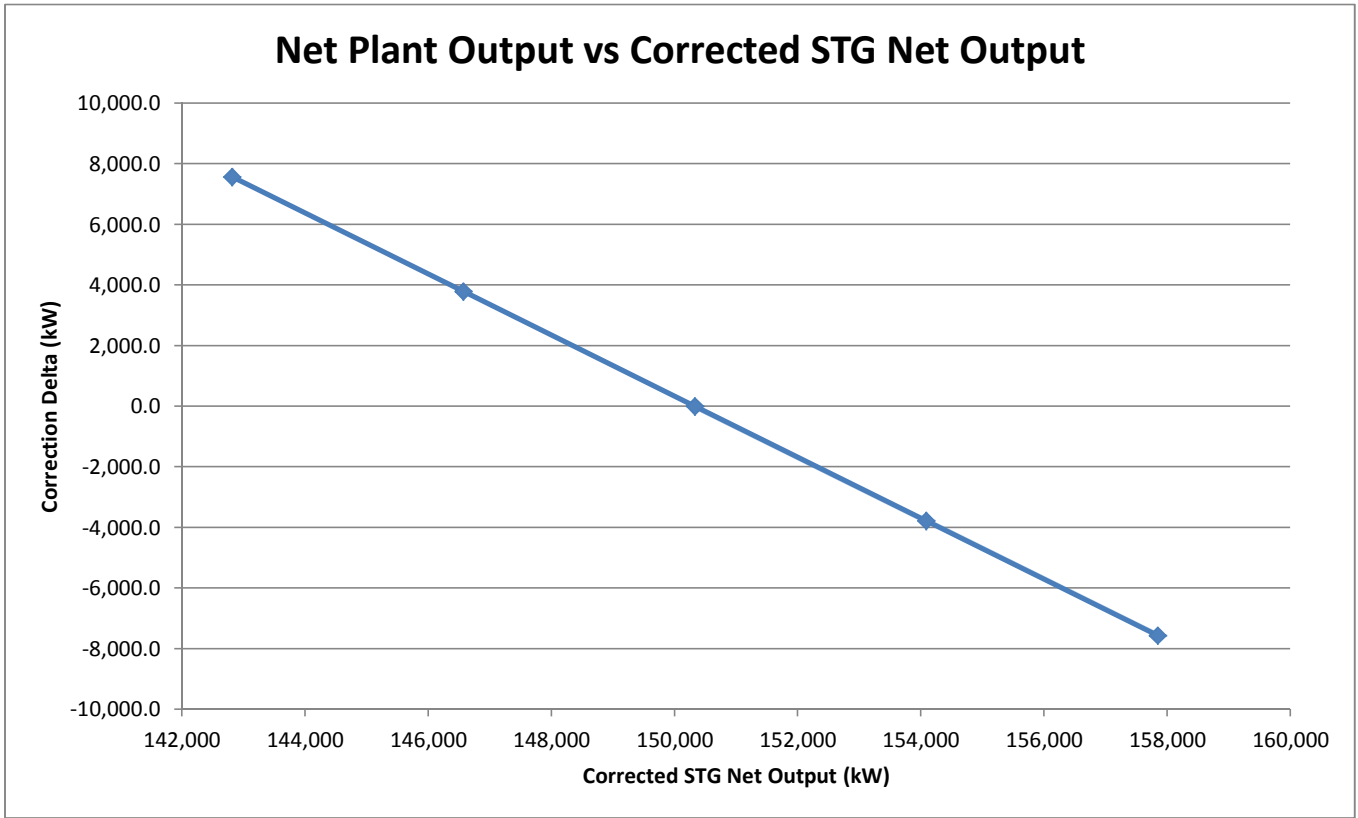
Compressors are in operation until site inlet pressure exceeds 750 psig

		Gas Compressor Suction Pressure (psig)*				
		400	424.0	600.0	750.0	1000
Compressor On	No plant operation	0.0	-1,027.0	-1,027.0	-	-
Compressor Off	-	-	-	-1,928.0	-1,928.0	-

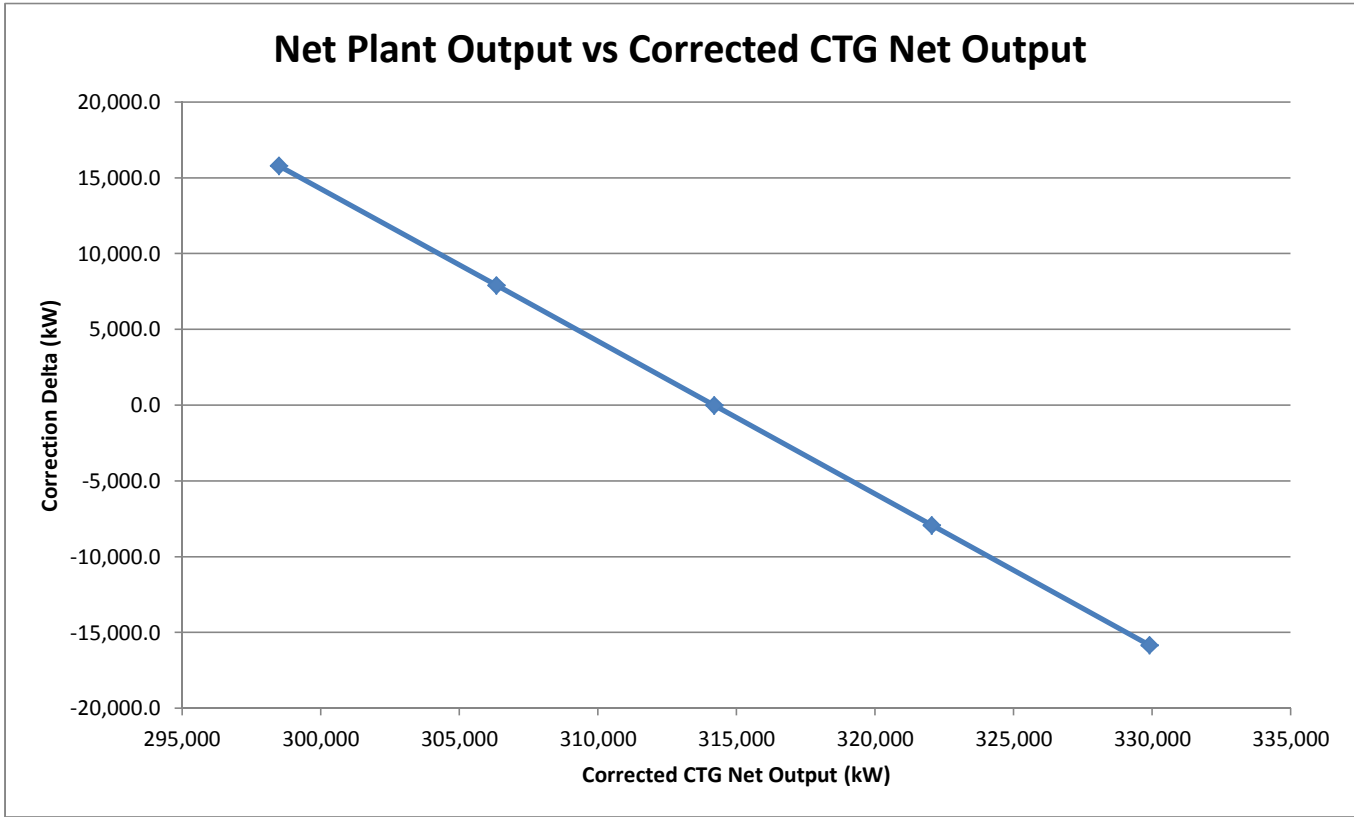
*Pressure upstream regulating valve



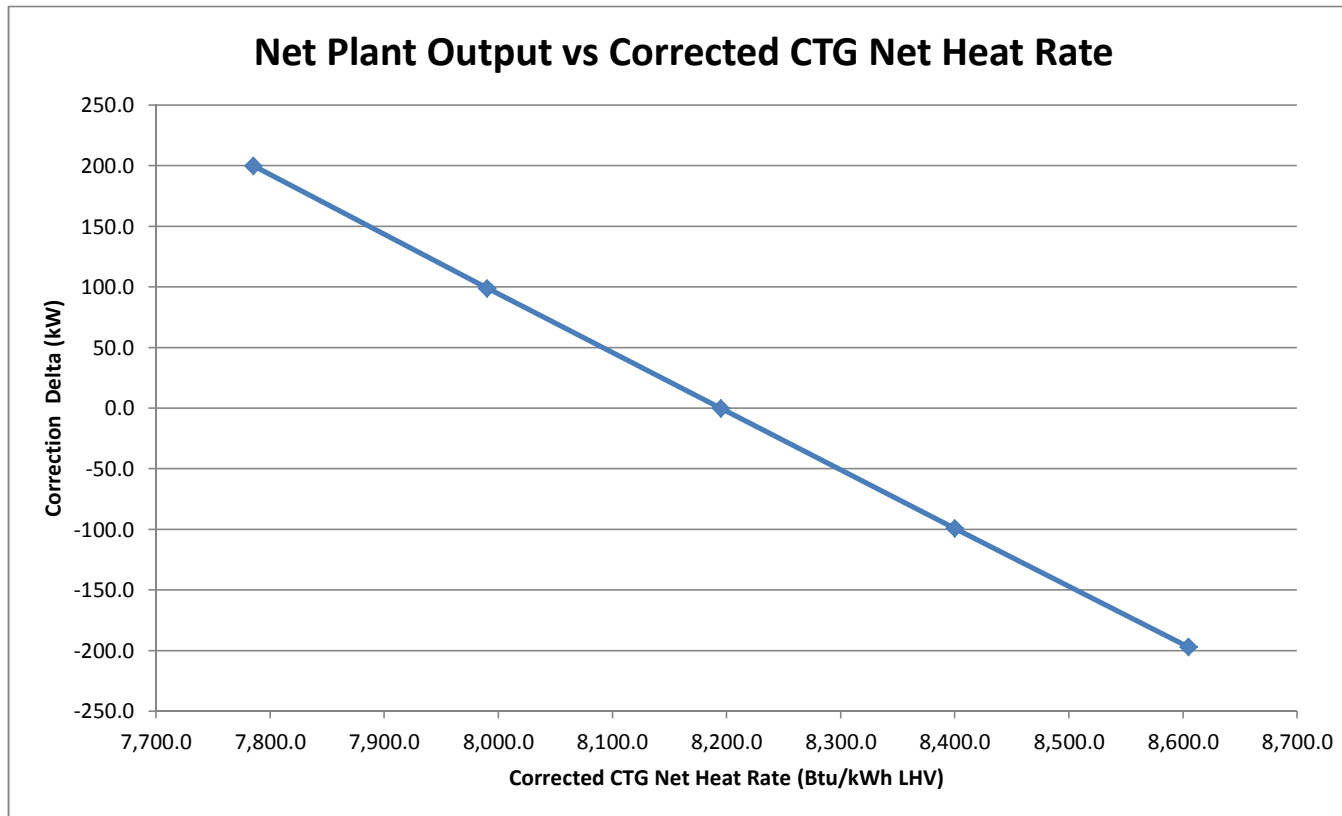
		CT WBT - CTG WBT (Deg F)				
		-5	-2.5	0	2.5	5
Ambient DB Temperat ure (Deg F)	40.0	61.0	11.0	0.0	0.0	
	50.0	-193.0	-104.0	0.0	117.0	308.0
	59.0	-409.0	-213.0	0.0	303.0	625.0
	70.0	-773.0	-406.0	0.0	426.0	897.0
	80.0	-998.0	-515.0	0.0	554.0	1,121.0



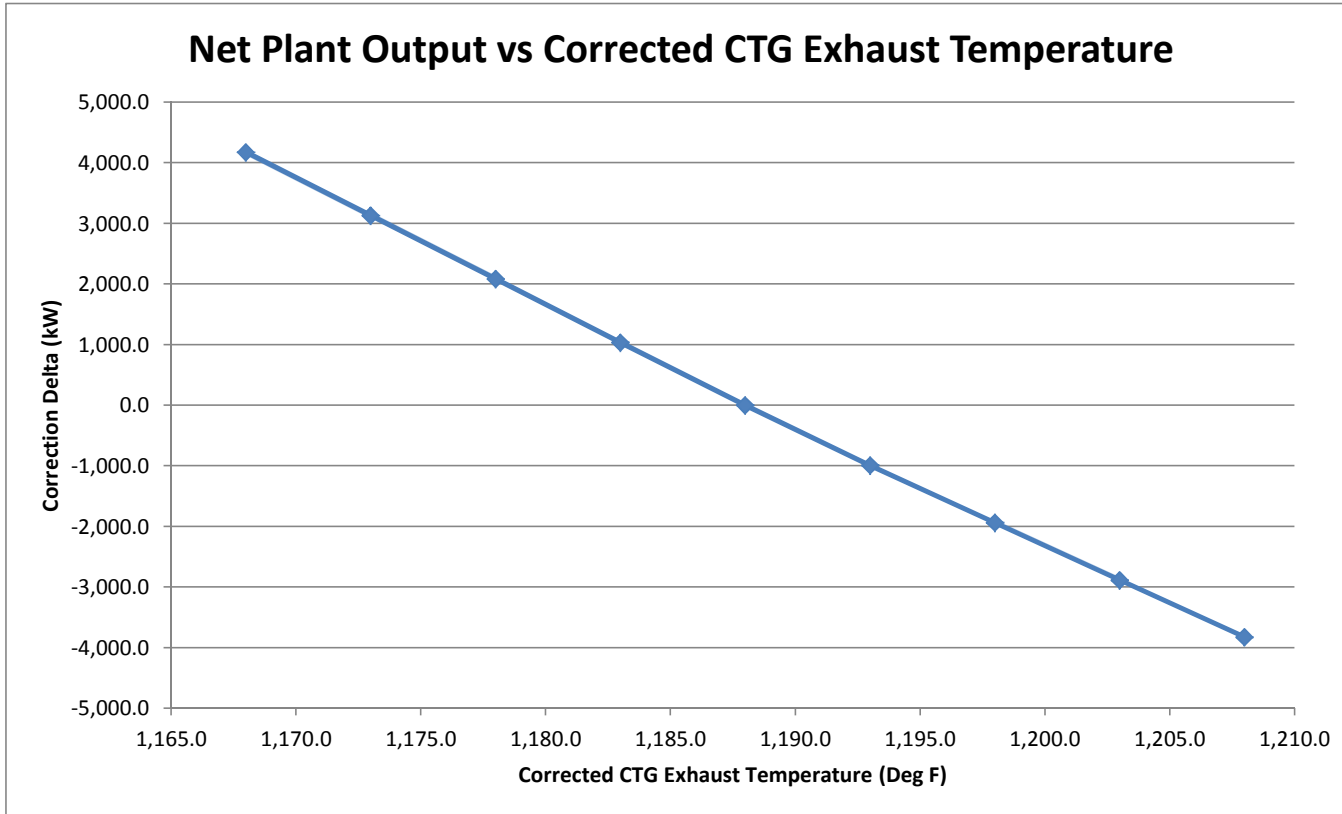
Corrected STG Net Output (kW)				
142,814	146,572	150,330	154,088	157,847
7,569.0	3,784.0	0.0	-3,784.0	-7,569.0



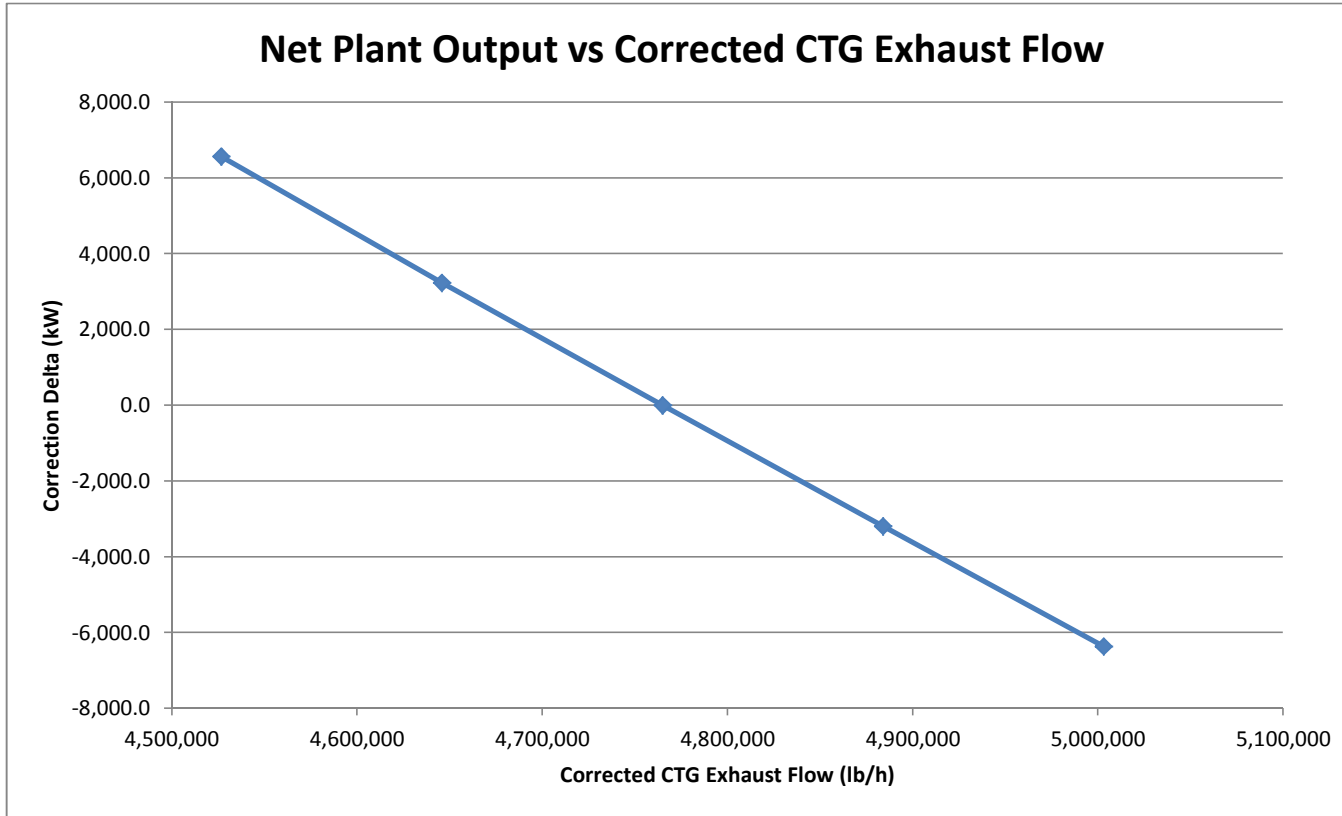
Corrected CTG Net Output (kW)				
298,490	306,345	314,200	322,055	329,910
15,796.0	7,913.5	0.0	-7,920.5	-15,838.0



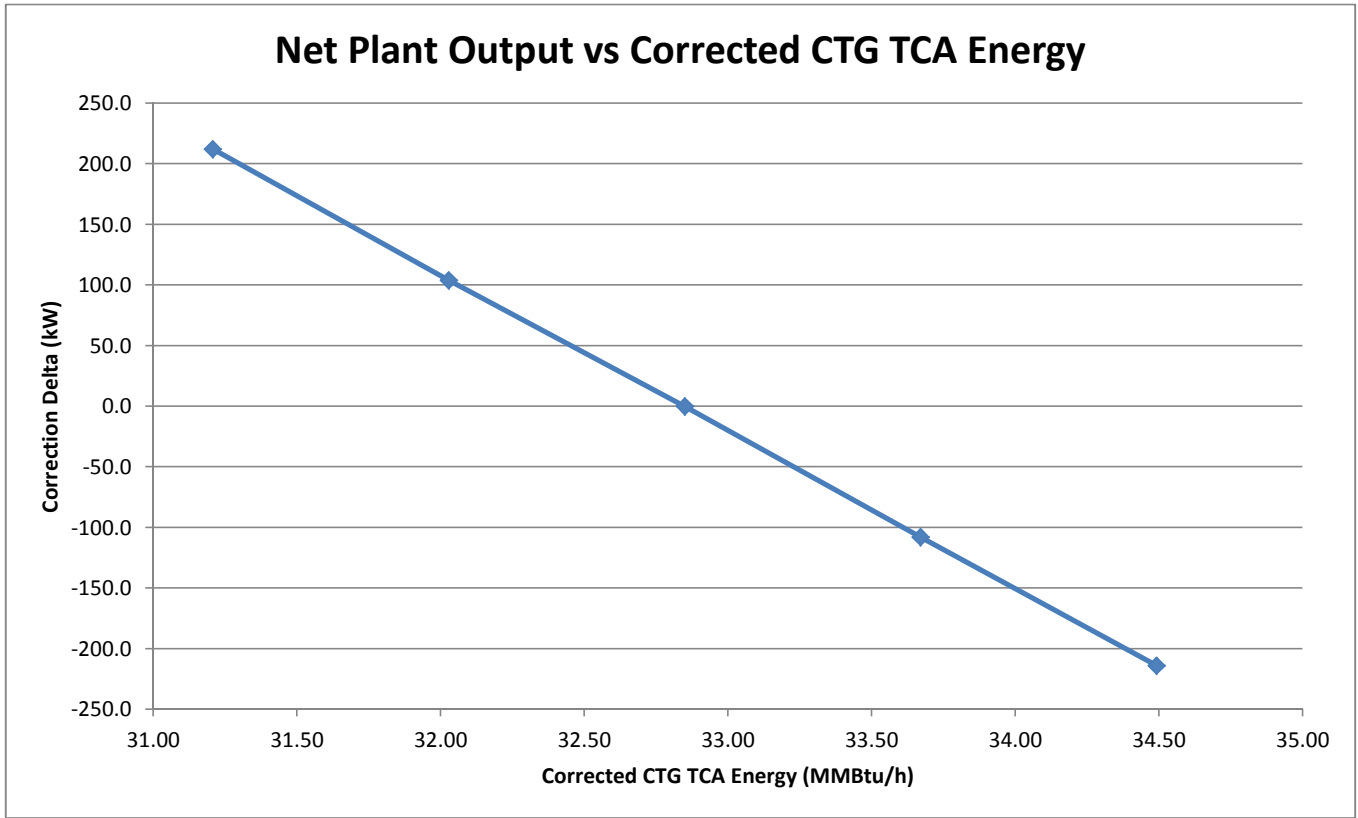
Corrected CTG Net Heat Rate (Btu/kWh)				
7,785.3	7,990.1	8,195.0	8,399.9	8,604.8
200.0	99.0	0.0	-99.0	-197.0



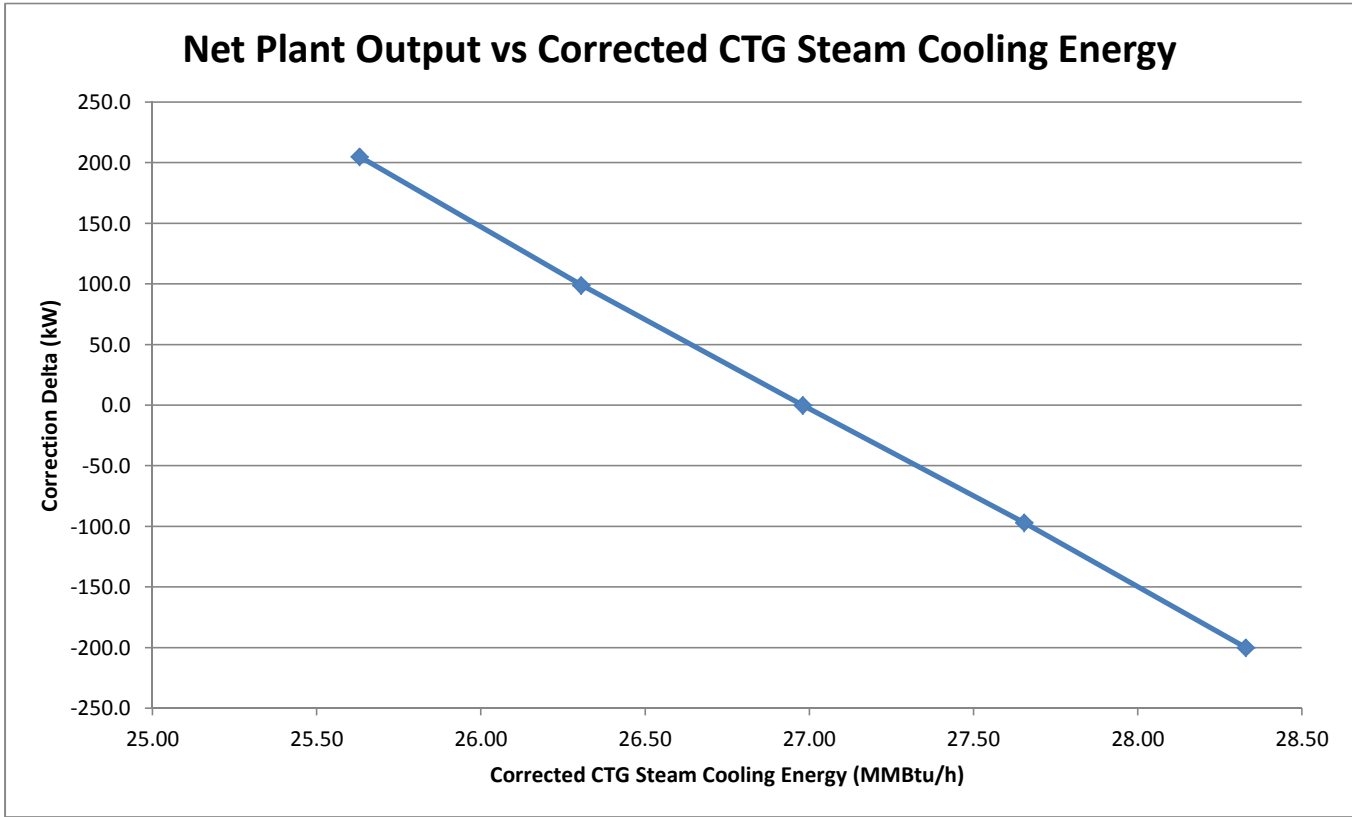
Corrected CTG Exhaust Temperature (Deg F)								
1,168.0	1,173.0	1,178.0	1,183.0	1,188.0	1,193.0	1,198.0	1,203.0	1,208.0
4,171.0	3,127.0	2,081.0	1,032.0	0.0	-995.0	-1,940.0	-2,887.0	-3,827.0



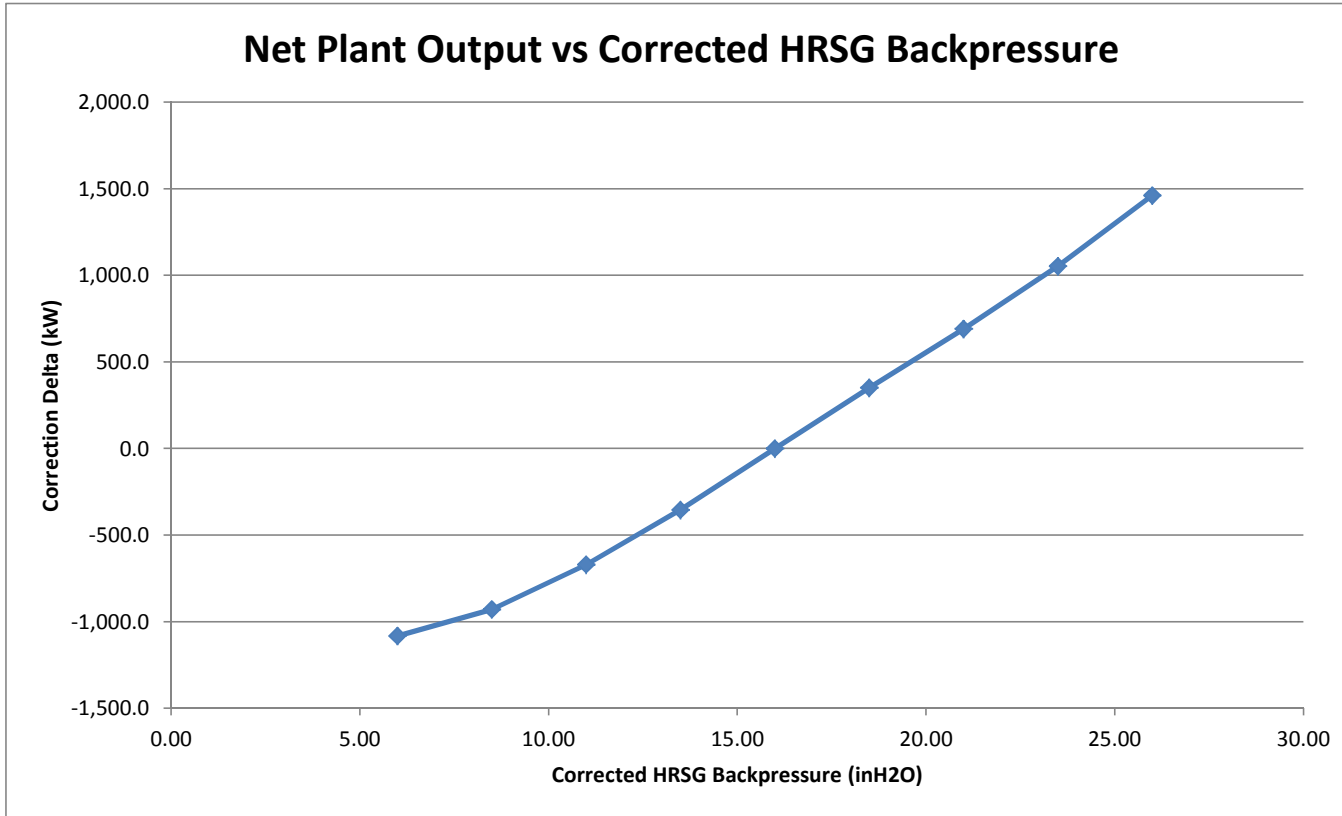
Corrected CTG Exhaust Flow (lb/h)				
4,526,750	4,645,875	4,765,000	4,884,125	5,003,250
6,563.0	3,235.0	0.0	-3,196.0	-6,369.0



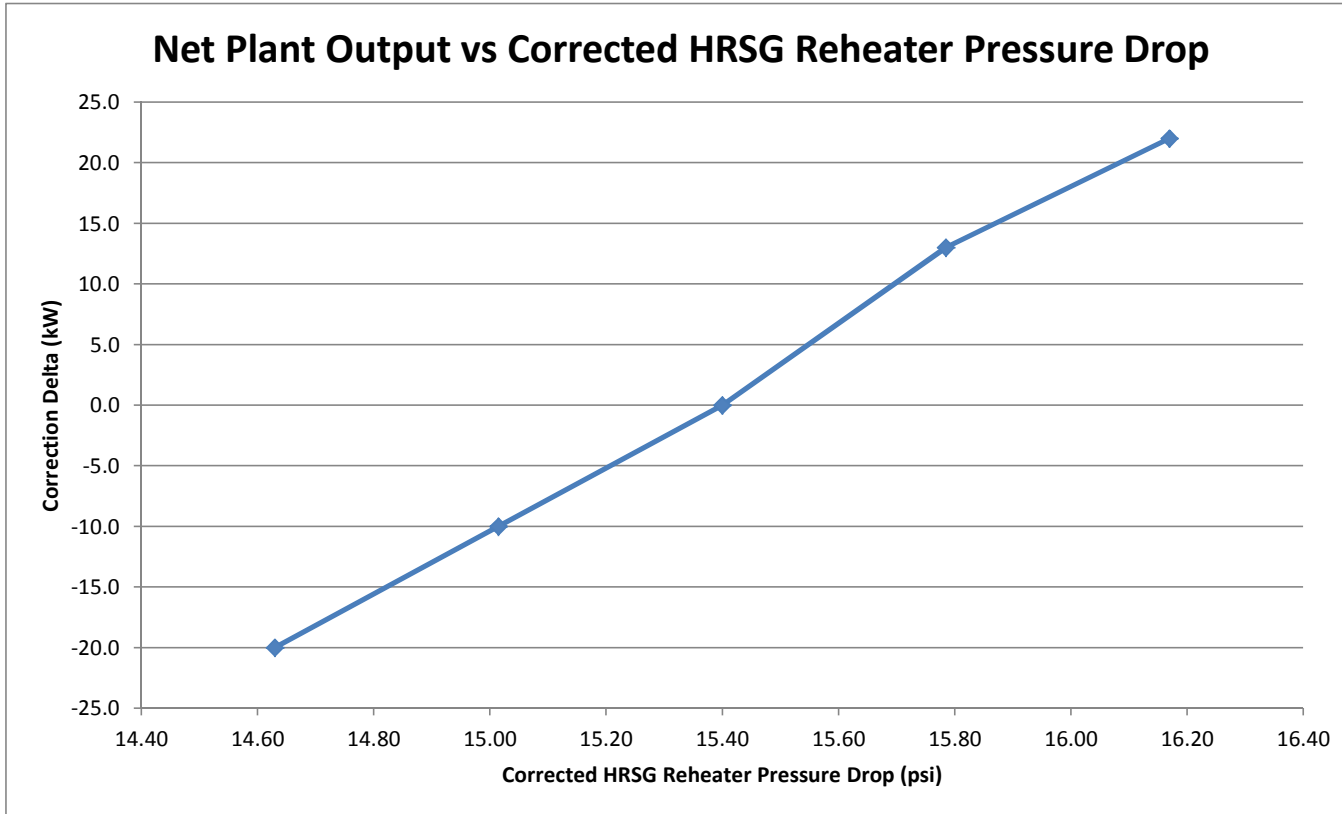
Corrected CTG TCA Energy (MMBtu/h)				
31.21	32.03	32.85	33.67	34.49
212.0	104.0	0.0	-108.0	-214.0



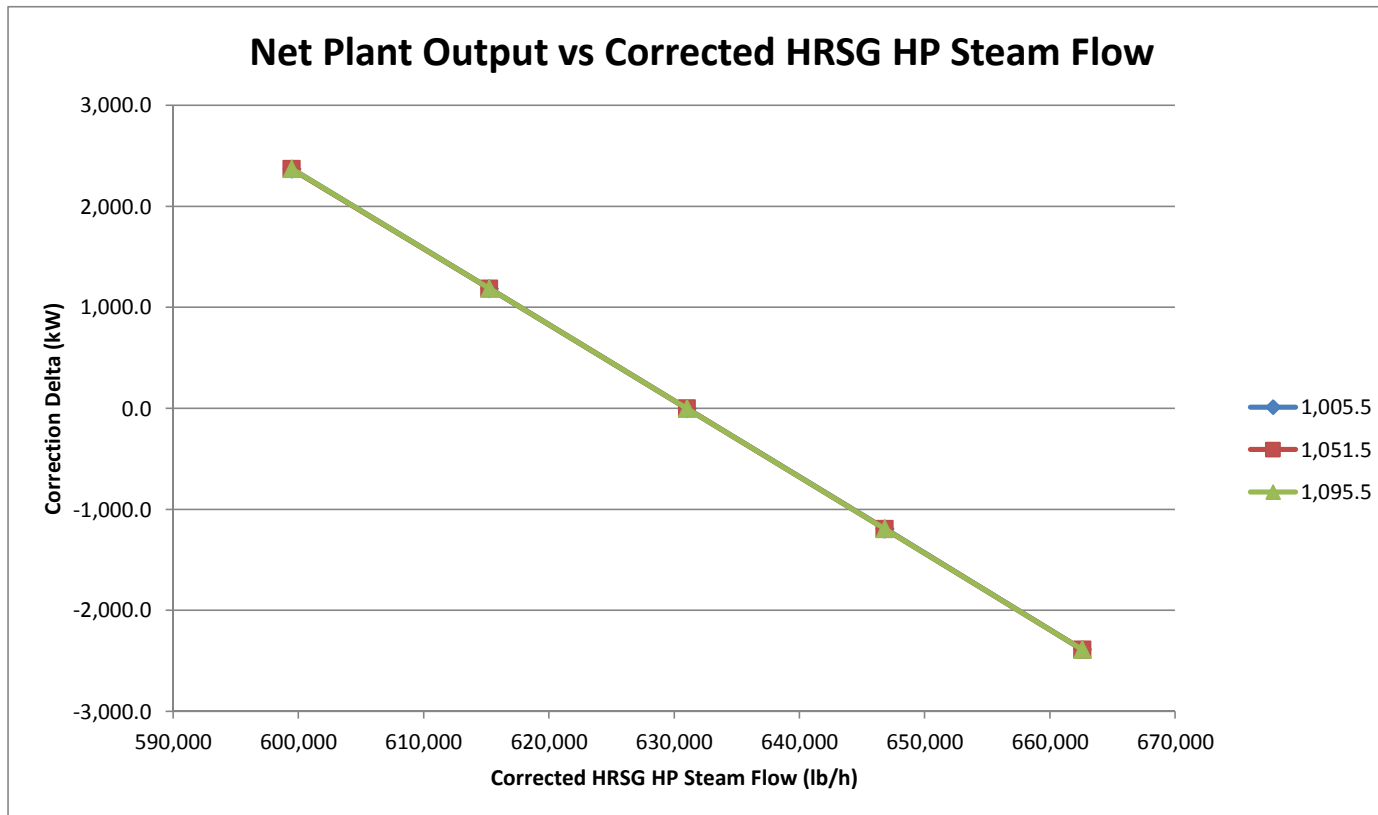
Corrected CTG Steam Cooling Energy (MMBtu/h)				
25.63	26.31	26.98	27.65	28.33
205.0	99.0	0.0	-97.0	-200.0



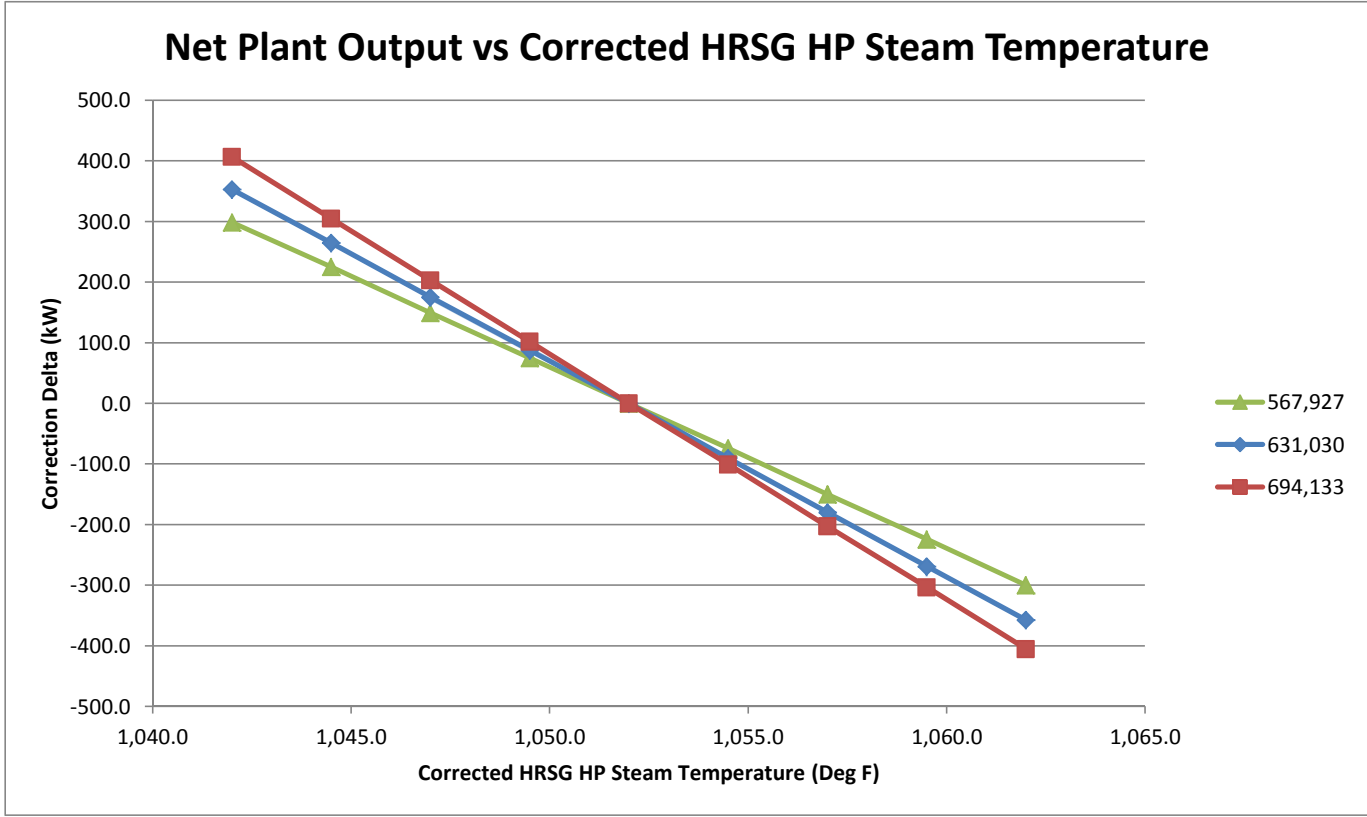
Corrected HRSG Backpressure (inH2O)								
6.00	8.50	11.00	13.50	16.00	18.50	21.00	23.50	26.00
-1,082.4	-929.2	-670.4	-353.7	0.0	351.3	691.6	1,052.7	1,460.4



Corrected HRSG Reheater Pressure Drop (psi)				
14.63	15.02	15.40	15.79	16.17
-20.0	-10.0	0.0	13.0	22.0

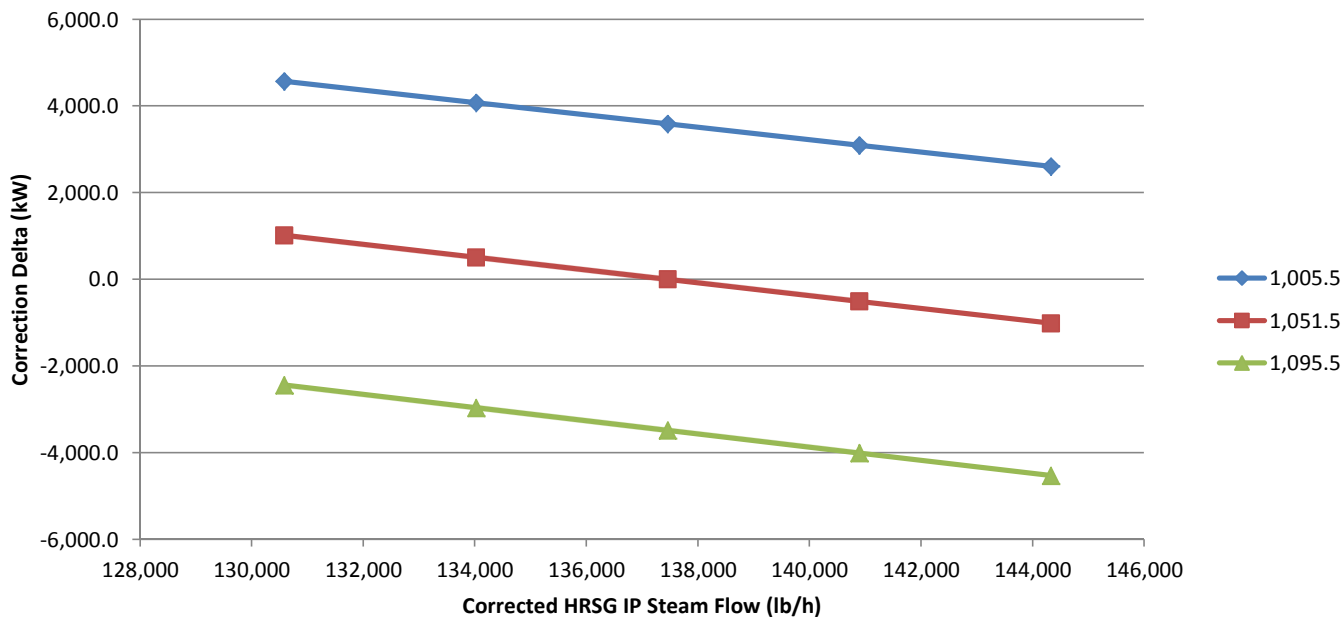


		Corrected HRSG HP Steam Flow (lb/h)				
		599,479	615,254	631,030	646,806	662,582
Reheat Steam Temp (Deg F)	1,005.5	2,370.8	1,187.6	0.0	-1,190.1	-2,385.3
	1,051.5	2,369.2	1,185.4	0.0	-1,192.9	-2,387.4
	1,095.5	2,371.4	1,187.8	0.0	-1,191.9	-2,386.2

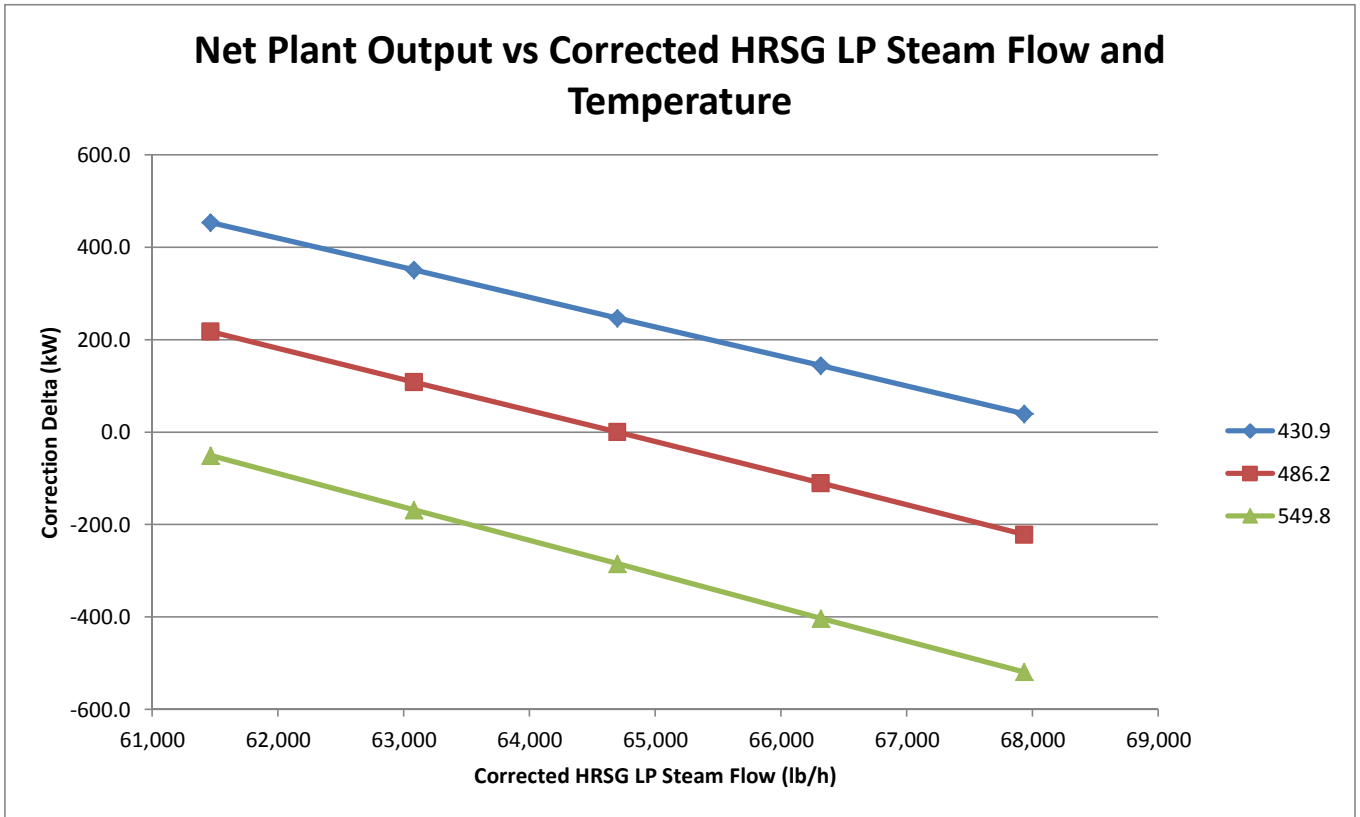


		Corrected HRSG HP Steam Temperature (Deg F)								
		1,042.0	1,044.5	1,047.0	1,049.5	1,052.0	1,054.5	1,057.0	1,059.5	1,062.0
HP Steam Flow (lb/h)	567,927	298.8	225.4	149.1	74.8	0.0	-74.0	-150.1	-224.2	-300.1
	631,030	352.7	265.0	175.2	87.4	0.0	-90.3	-179.8	-269.0	-357.6
	694,133	406.7	304.7	202.9	101.6	0.0	-100.8	-202.8	-303.5	-405.2

Net Plant Output vs Corrected HRSG IP Added Steam Flow and Reheat Steam Temperature
(HRH flow - CRH flow)

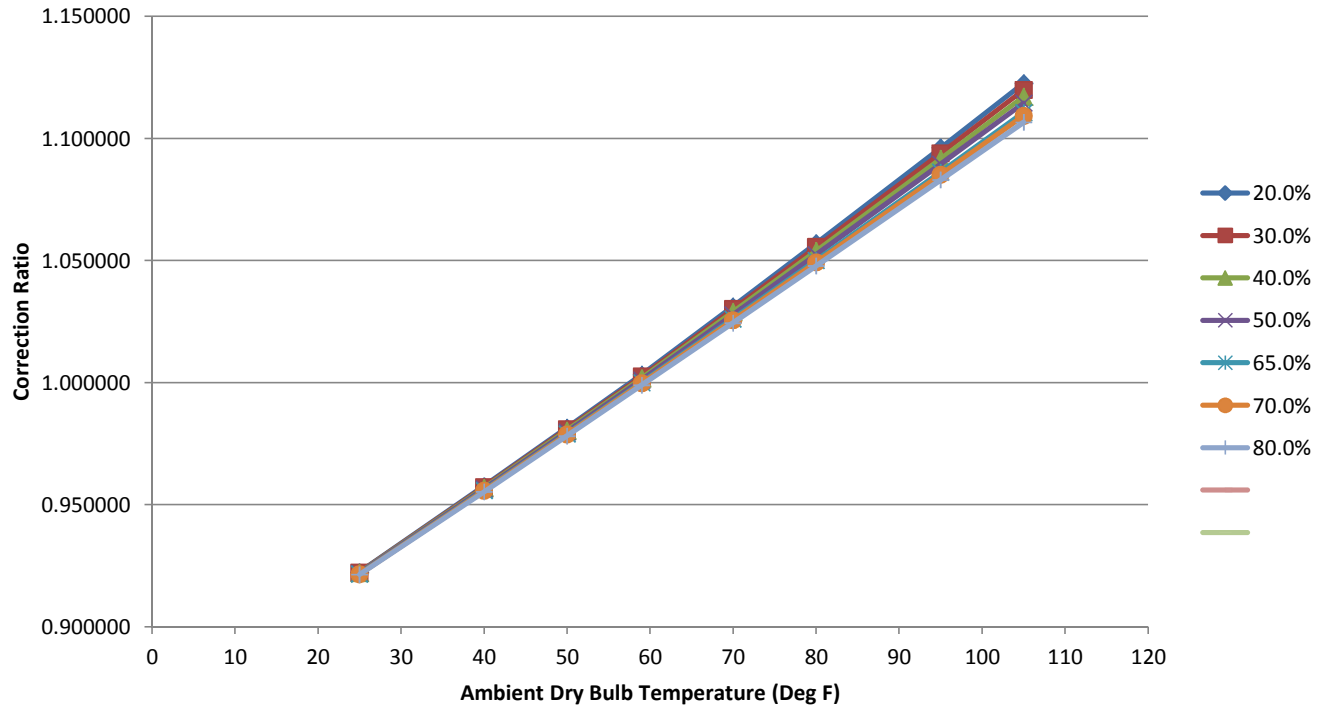


		Corrected HRSG IP Steam Flow (lb/h)				
		130,587	134,024	137,460	140,897	144,333
Reheat Steam Temp (Deg F)	1,005.5	4,567.5	4,076.8	3,584.7	3,094.7	2,603.0
	1,051.5	1,013.8	505.4	0.0	-508.3	-1,015.5
	1,095.5	-2,439.6	-2,962.1	-3,485.1	-4,006.3	-4,529.3

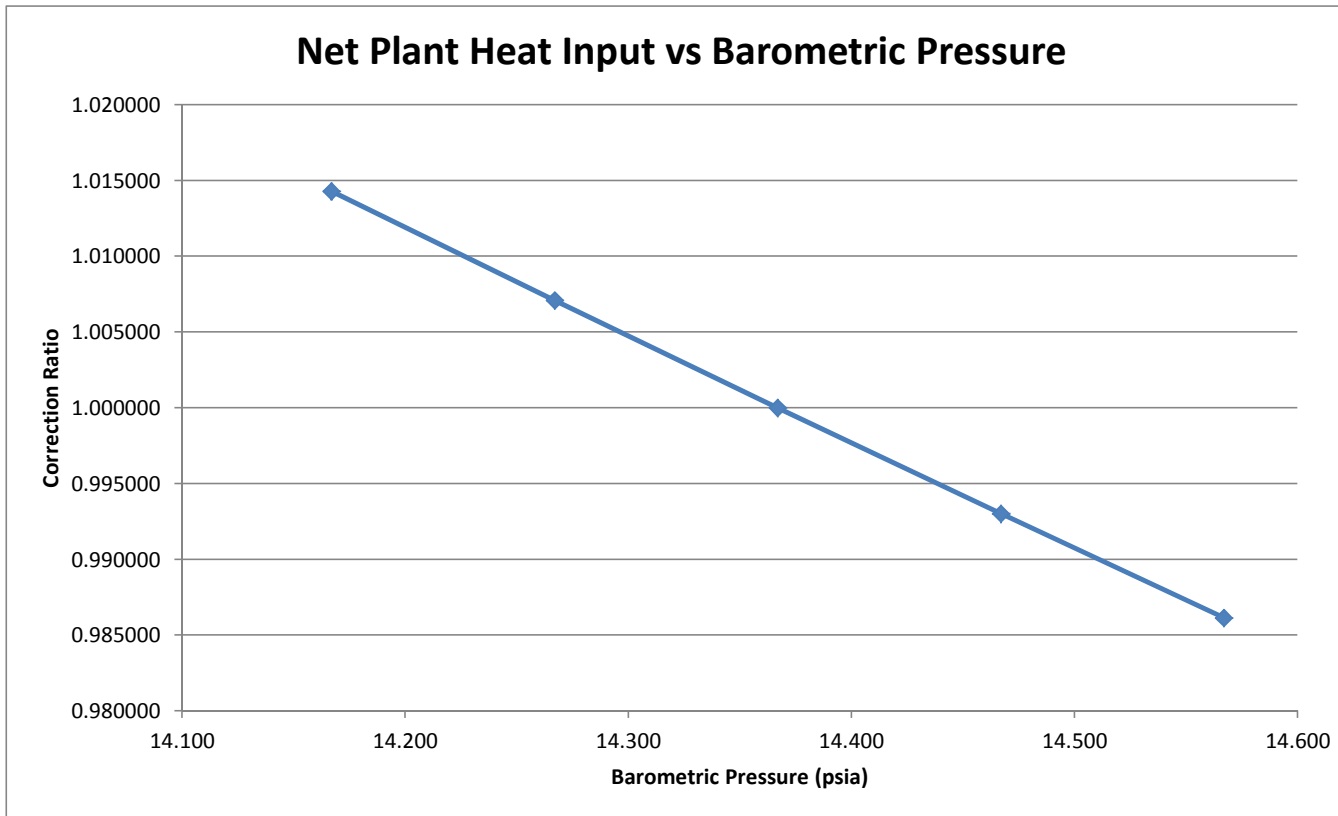


		Corrected HRSG LP Steam Flow (lb/h)				
		61,465	63,083	64,700	66,318	67,935
LP Temp (Deg F)	430.9	453.5	351.0	246.8	143.9	39.7
	486.2	217.6	107.9	0.0	-110.3	-221.7
	549.8	-50.7	-168.3	-284.6	-403.0	-518.9

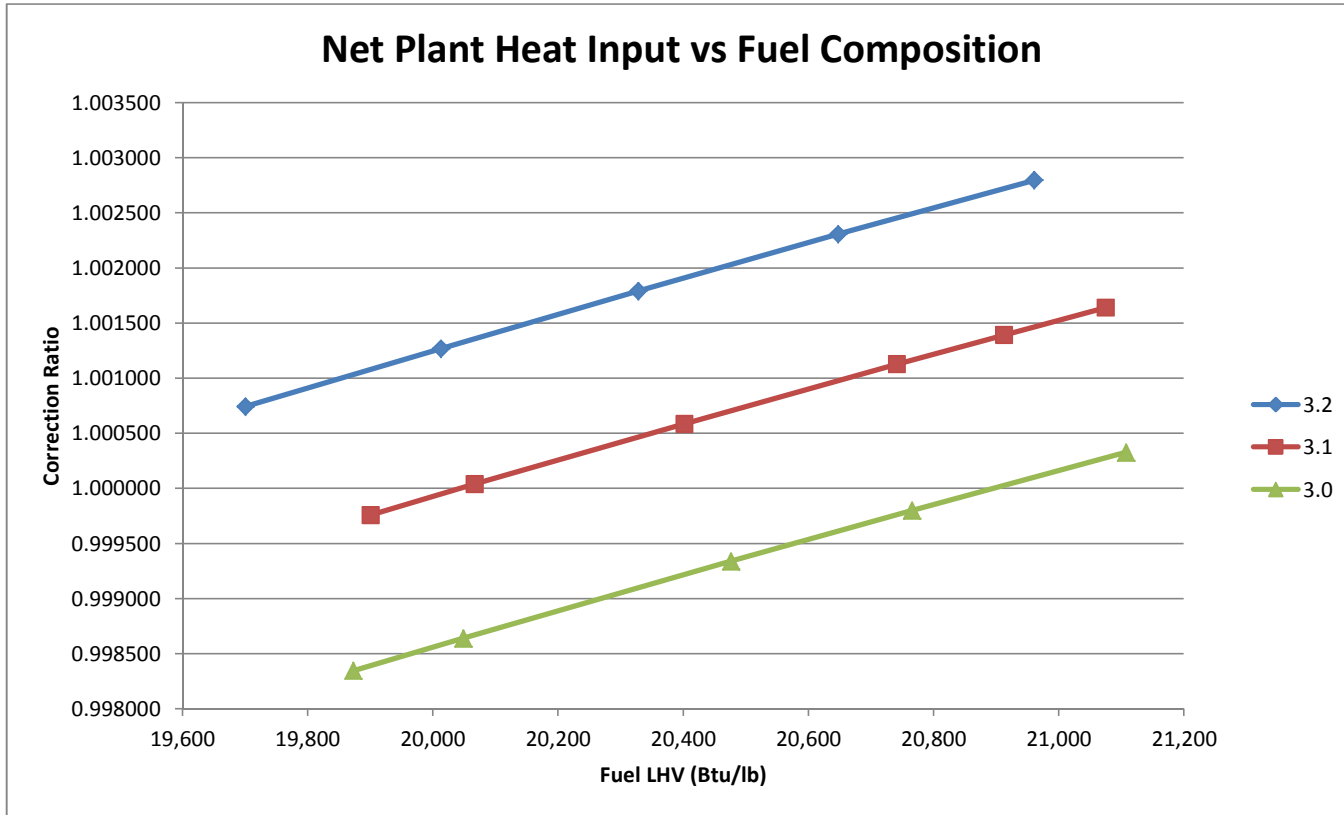
Net Plant Heat Input vs Ambient Temperature and Humidity



		Ambient Dry Bulb Temperature (Deg F)							
		25	40	50	59	70	80	95	105
Relative Humidity (%)	20.0%	0.922355	0.957583	0.981439	1.003170	1.031182	1.057004	1.096142	1.122501
	30.0%	0.922208	0.957198	0.980886	1.002459	1.030028	1.055427	1.093893	1.119778
	40.0%	0.922055	0.956812	0.980334	1.001752	1.028884	1.053866	1.091669	1.117088
	50.0%	0.921895	0.956423	0.979784	1.001049	1.027747	1.052313	1.089459	1.114416
	65.0%	0.921652	0.955840	0.978960	1.000000	1.026051	1.050000	1.086170	1.110441
	70.0%	0.921574	0.955648	0.978687	0.999651	1.025488	1.049235	1.085083	1.109129
	80.0%	0.921428	0.955268	0.978142	0.998952	1.024366	1.047712	1.082926	1.106528



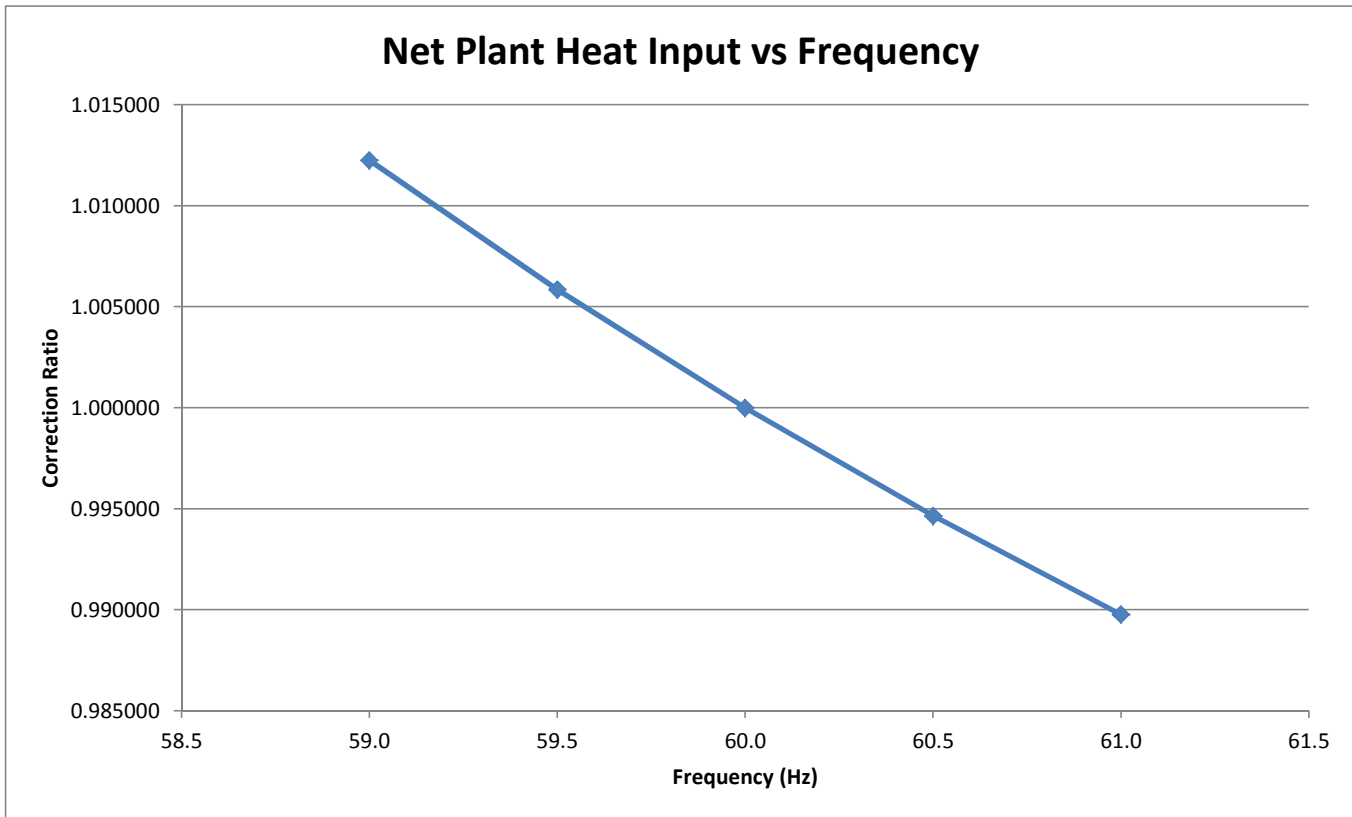
Barometric Pressure (psia)				
14.167	14.267	14.367	14.467	14.567
1.014282	1.007085	1.000000	0.993019	0.986130



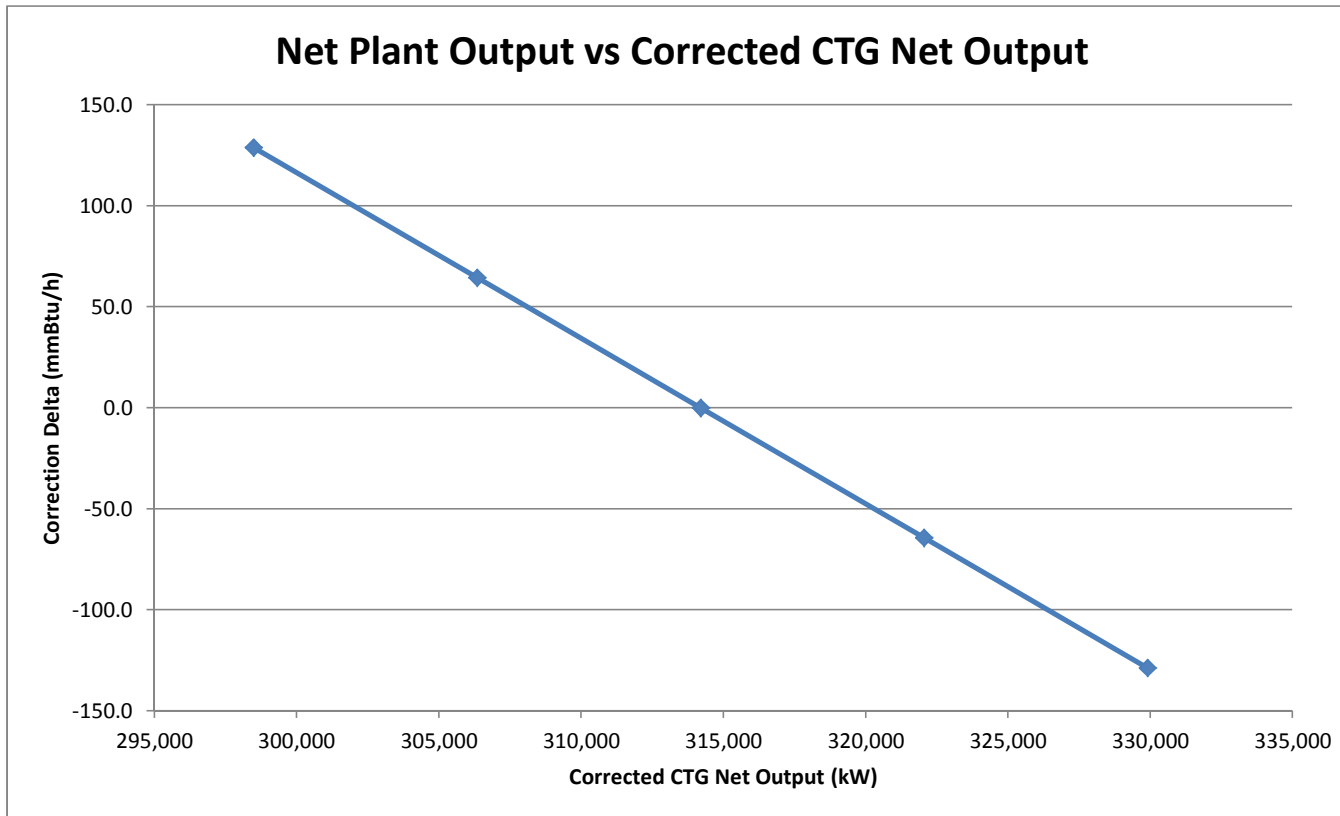
		Fuel H/C	
			3.0
Fuel LHV (BTU/lb)	19,873	0.998345	
	20,049	0.998640	
	20,477	0.999340	
	20,766	0.999799	
	21,108	1.000327	

		Fuel H/C	
			3.1
19,901	0.999758		
20,067	1.000039		
20,403	1.000585		
20,742	1.001127		
20,913	1.001391		
21,075	1.001639		

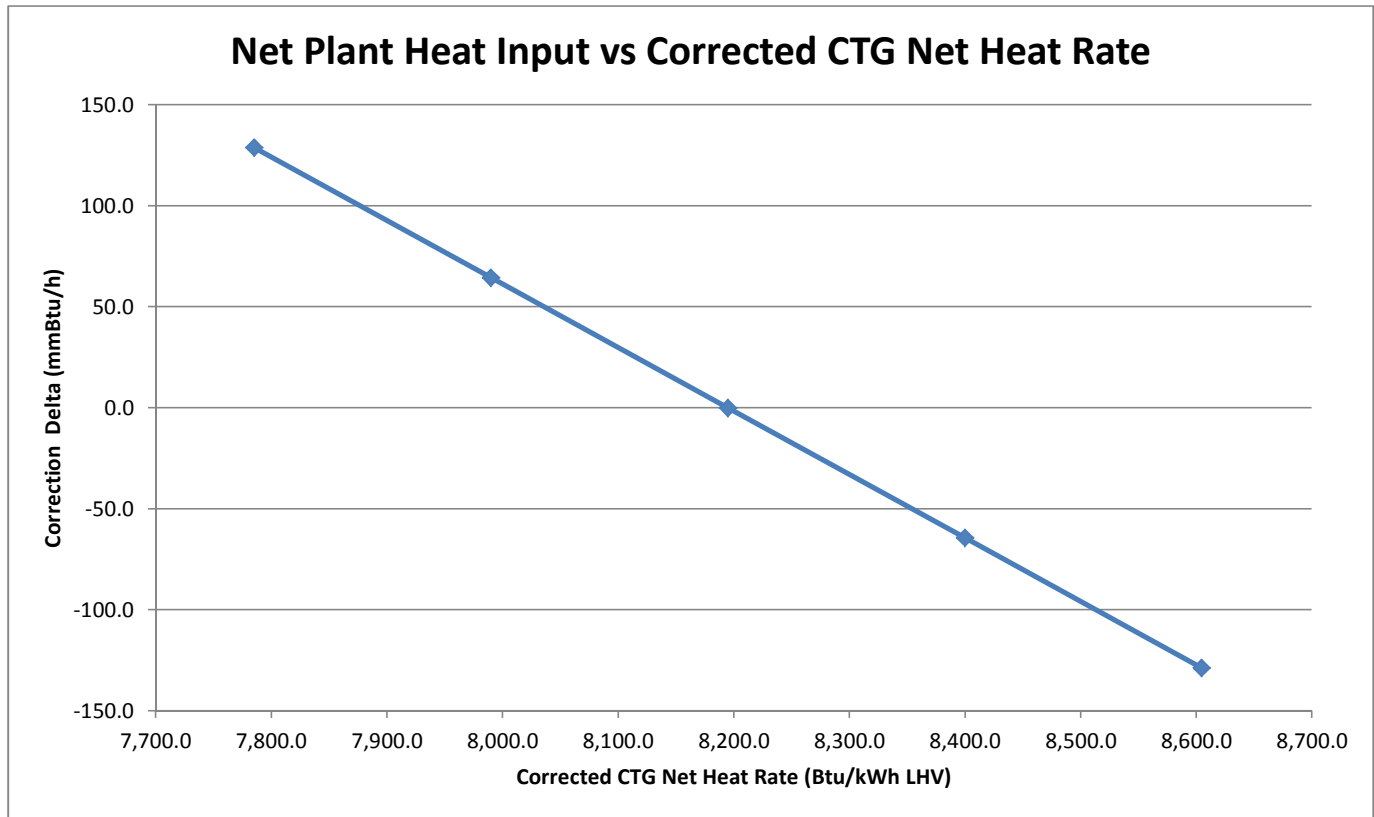
		Fuel H/C	
			3.2
19,701	1.000743		
20,013	1.001268		
20,329	1.001792		
20,648	1.002309		
20,961	1.002797		



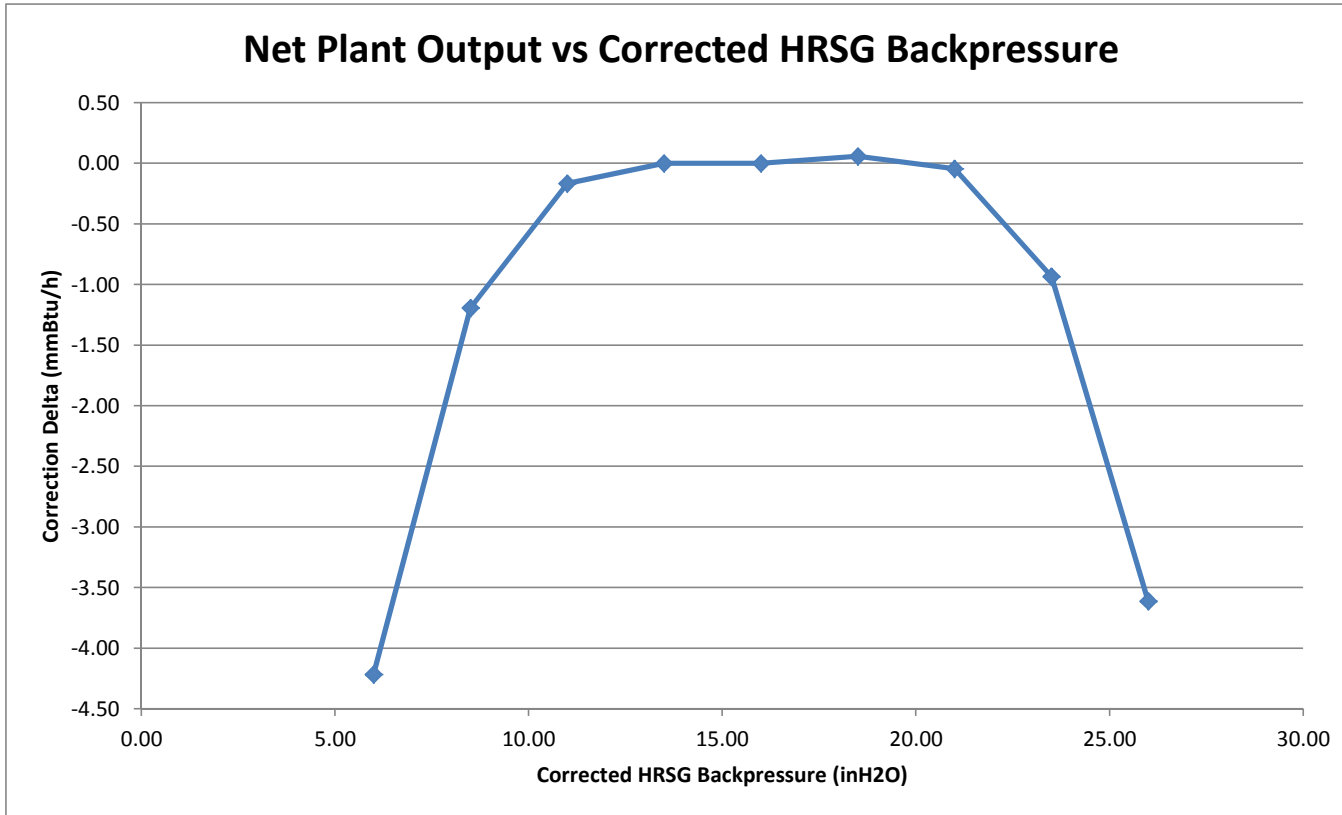
Frequency (Hz)				
59.0	59.5	60.0	60.5	61.0
1.012254	1.005860	1.000000	0.994648	0.989767



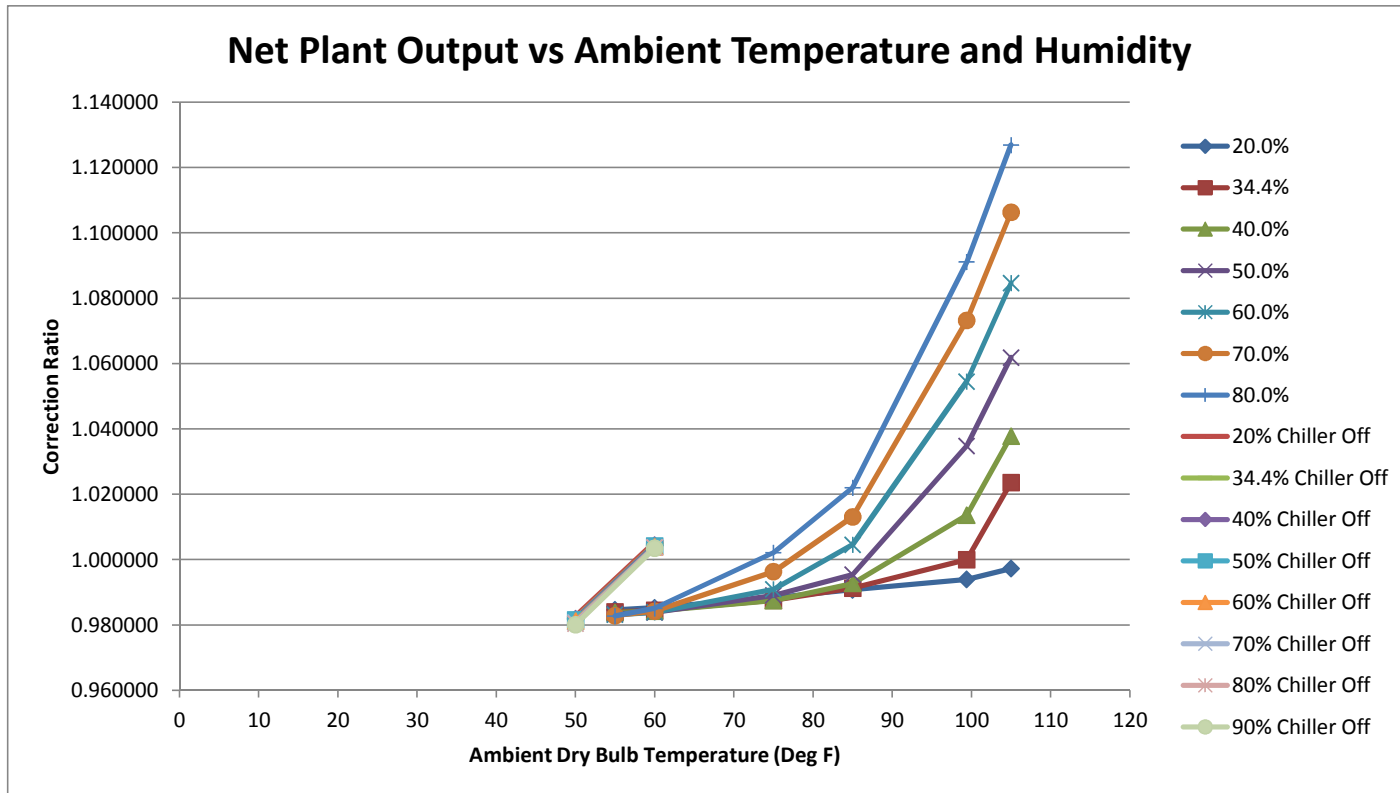
Corrected CTG Net Output (kW)				
298,490	306,345	314,200	322,055	329,910
128.8	64.4	0.0	-64.4	-128.8



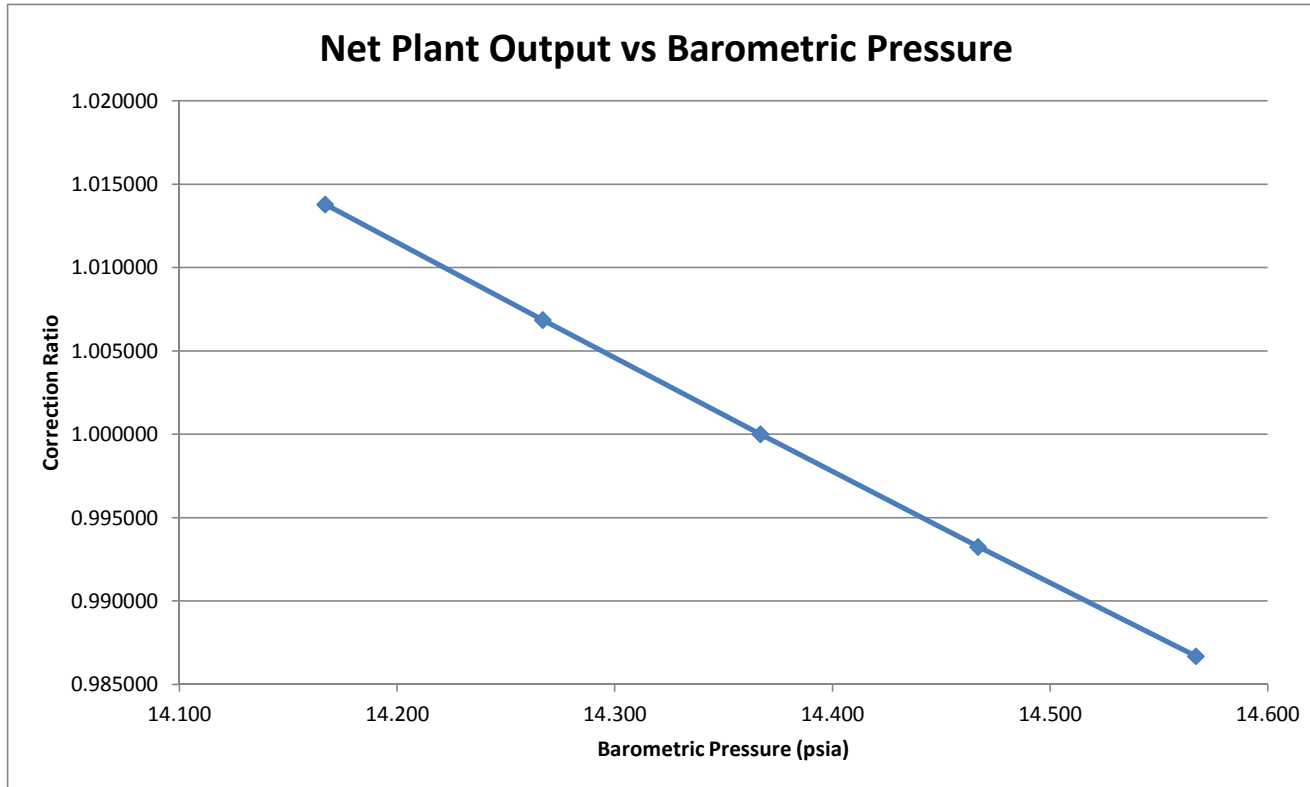
Corrected CTG Net Heat Rate (Btu/kWh)				
7,785.3	7,990.1	8,195.0	8,399.9	8,604.8
128.8	64.4	0.0	-64.4	-128.8



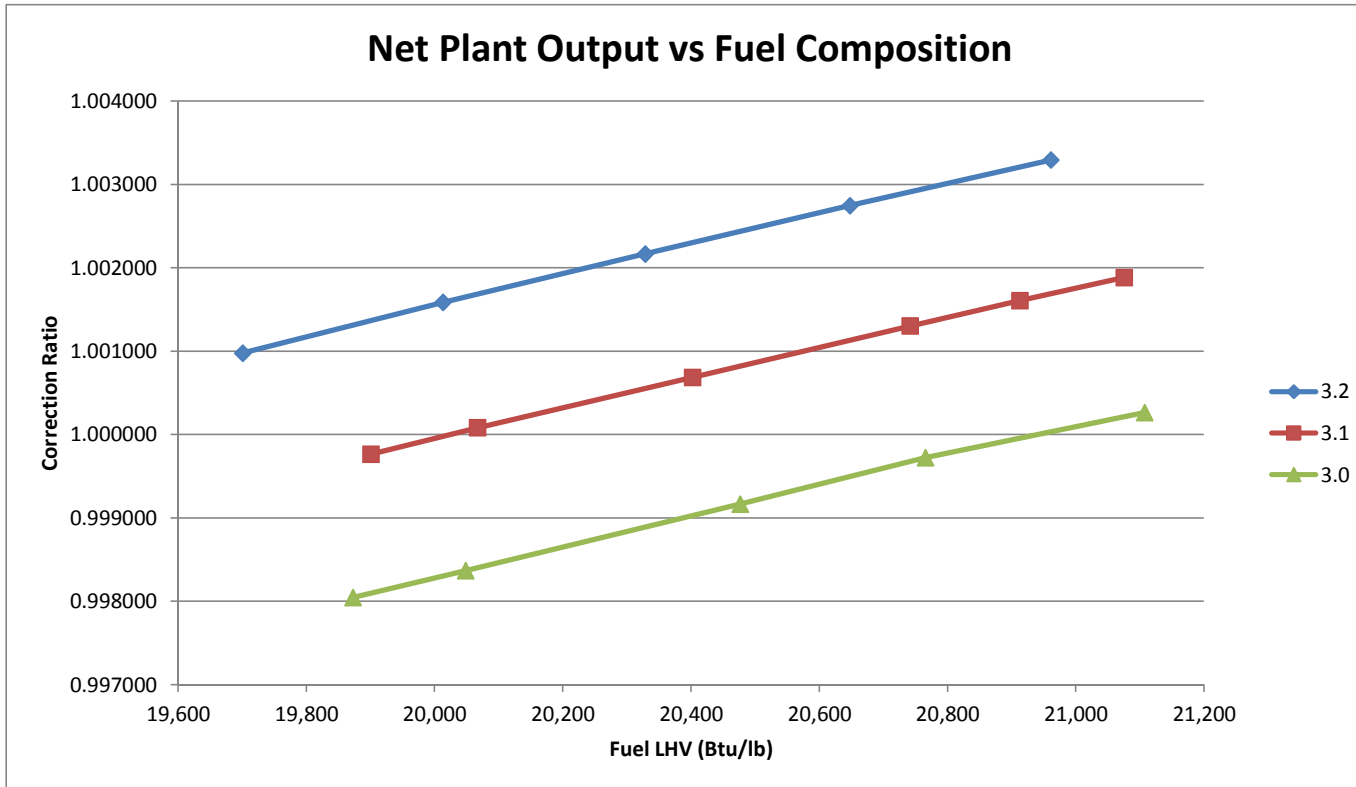
Corrected HRSG Backpressure (inH2O)								
6.00	8.50	11.00	13.50	16.00	18.50	21.00	23.50	26.00
-4.22	-1.19	-0.17	0.00	0.00	0.06	-0.04	-0.93	-3.61



		Ambient Dry Bulb Temperature (Deg F)							
		Chiller Off		Chiller On					
		50	60	55	60	75	85	99.4	105
Relative Humidity (%)	20.0%	0.982733	1.005377	0.984649	0.985287	0.988371	0.990784	0.993954	0.997263
	34.4%	0.982116	1.004690	0.984030	0.984445	0.987564	0.991256	1.000000	1.023586
	40.0%	0.981900	1.004484	0.983806	0.984179	0.987441	0.992674	1.013614	1.037808
	50.0%	0.981512	1.004137	0.983398	0.983820	0.989038	0.995438	1.034853	1.061890
	60.0%	0.981134	1.003857	0.983082	0.983856	0.990911	1.004595	1.054526	1.084664
	70.0%	0.980769	1.003812	0.982862	0.984201	0.996287	1.013094	1.073213	1.106270
	80.0%	0.980411	1.003749	0.982715	0.985069	1.002104	1.022026	1.091097	1.126923
	90.0%	0.980092	1.003495	0.982877	0.985687	1.007875	1.030990	1.107755	1.146133



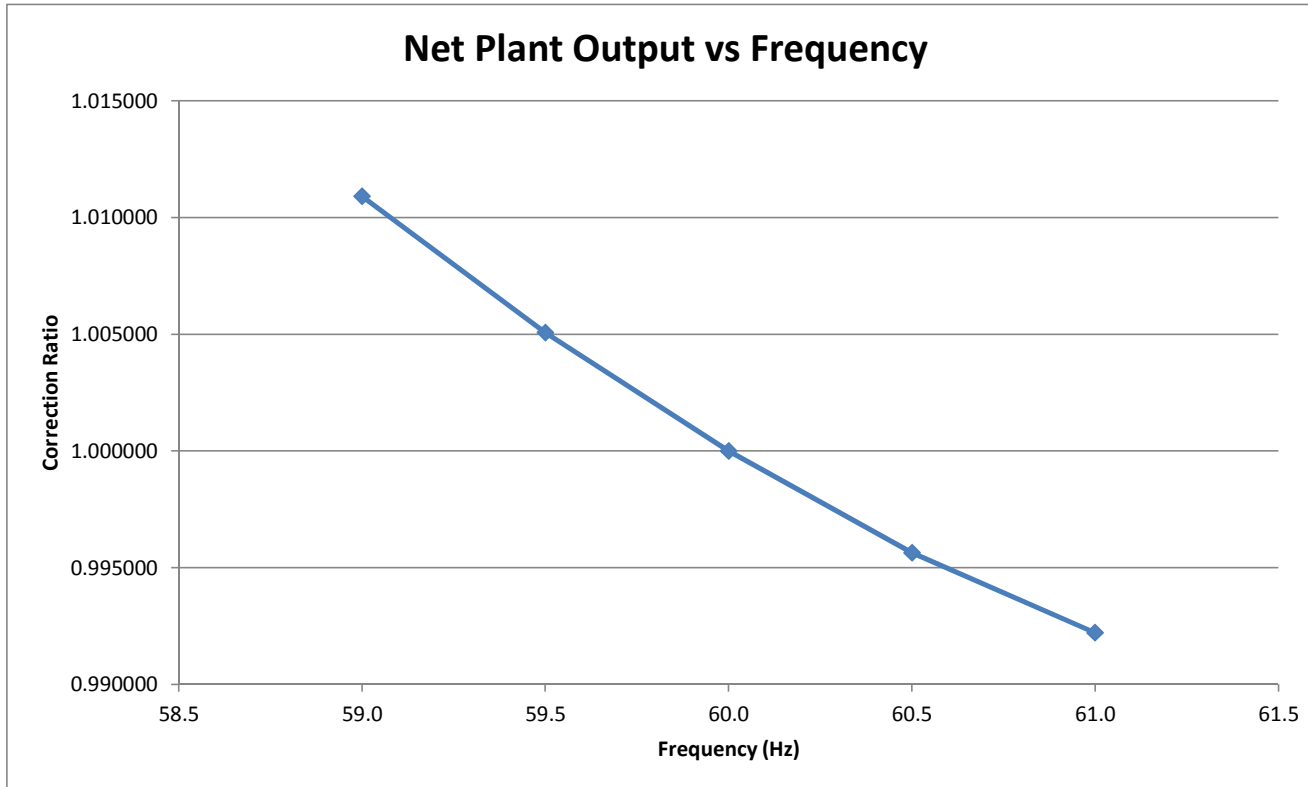
Barometric Pressure (psia)				
14.167	14.267	14.367	14.467	14.567
1.013792	1.006848	1.000000	0.993259	0.986690



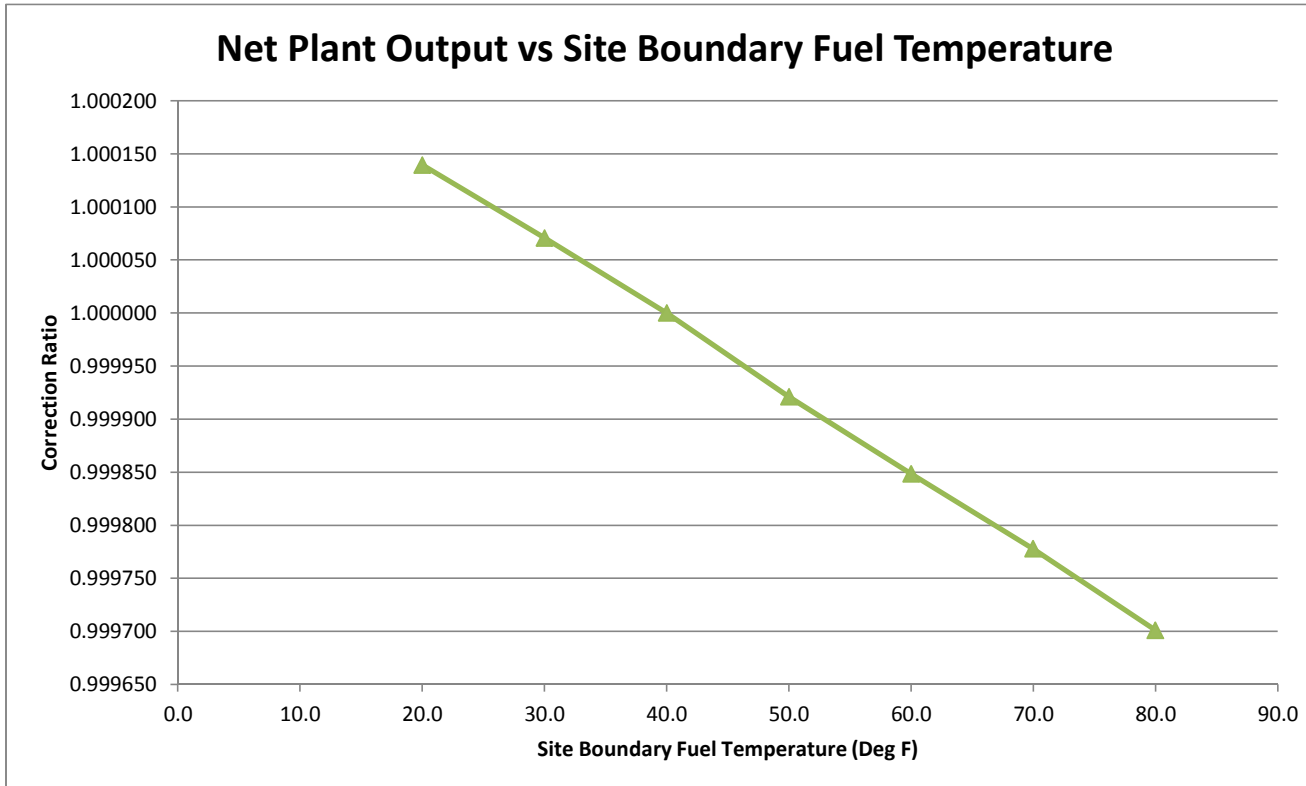
		Fuel H/C	
		3.0	
Fuel LHV (BTU/lb)	19,873	0.998046	
	20,049	0.998367	
	20,477	0.999167	
	20,766	0.999721	
	21,108	1.000263	

		Fuel H/C	
		3.1	
Fuel LHV (BTU/lb)	19,901	0.999765	
	20,067	1.000080	
	20,403	1.000686	
	20,742	1.001301	
	20,913	1.001606	
	21,075	1.001882	

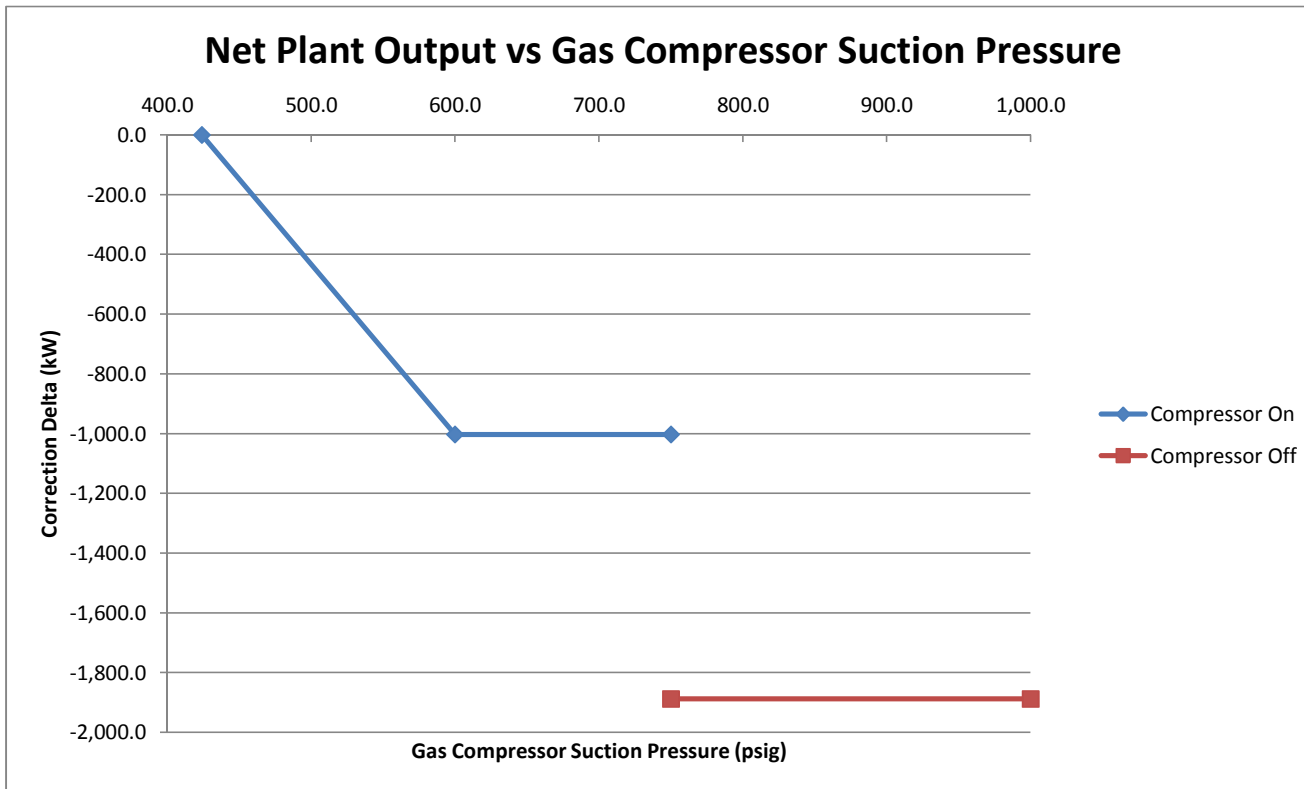
		Fuel H/C	
		3.2	
Fuel LHV (BTU/lb)	19,701	1.000977	
	20,013	1.001586	
	20,329	1.002166	
	20,648	1.002747	
	20,961	1.003293	



Frequency (Hz)				
59.0	59.5	60.0	60.5	61.0
1.010912	1.005077	1.000000	0.995644	0.992218



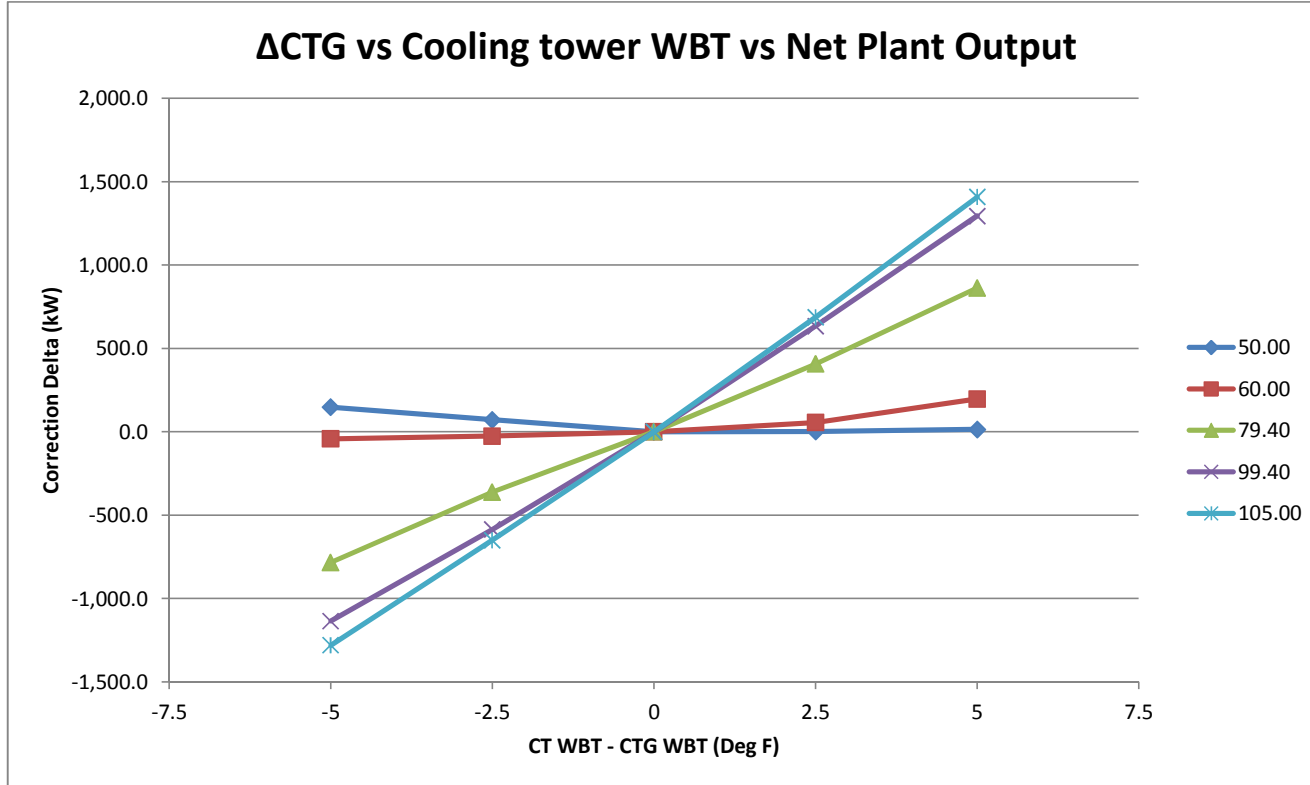
Site Boundary Fuel Temperature (Deg F)						
20.0	30.0	40.0	50.0	60.0	70.0	80.0
1.000139	1.000071	1.000000	0.999921	0.999848	0.999778	0.999701



Compressors are in operation until site inlet pressure exceeds 750 psig

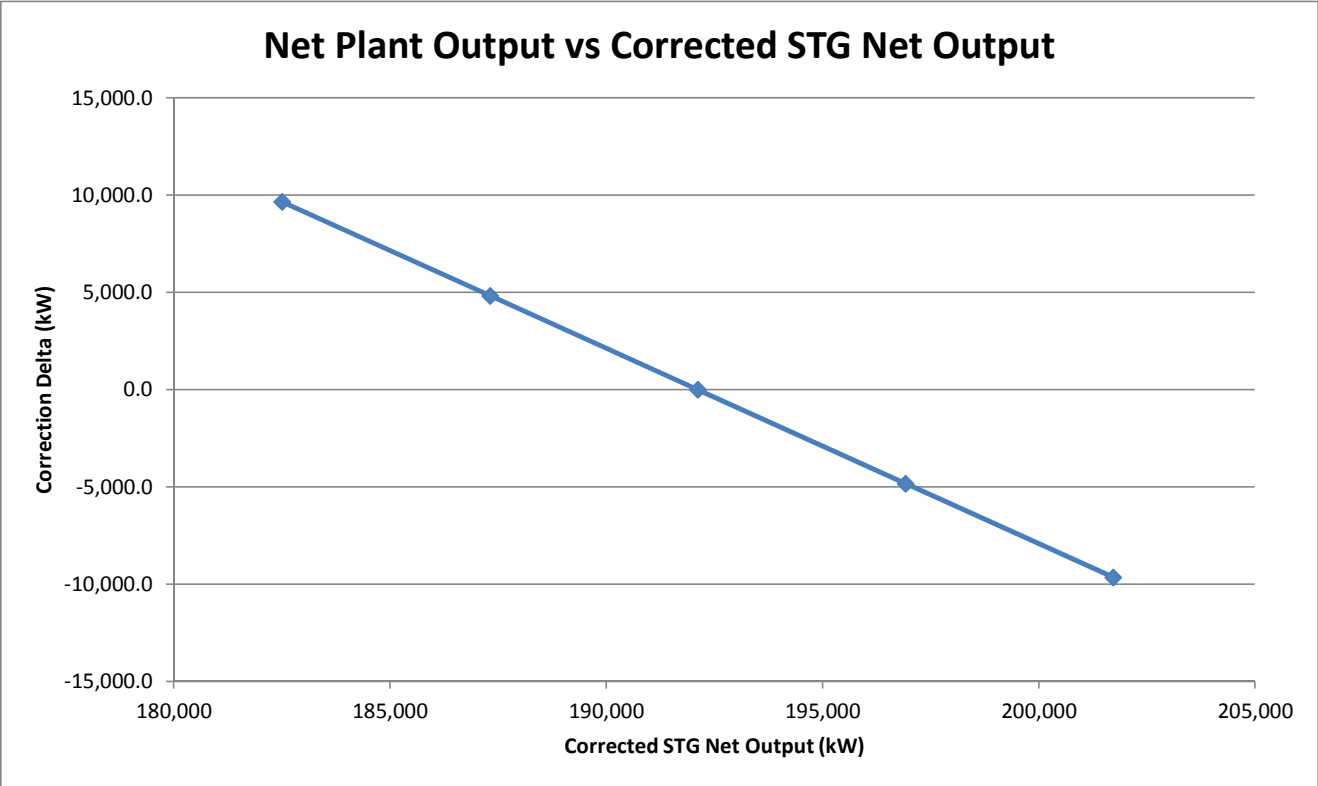
		Gas Compressor Suction Pressure (psig)*				
		400	424.0	600.0	750.0	1000
Compressor On	No plant	0.0	-	-1,003.0	-1,003.0	-
Compressor Off	operation	-	-	-	-1,888.0	-1,888.0

*Pressure upstream regulating valve

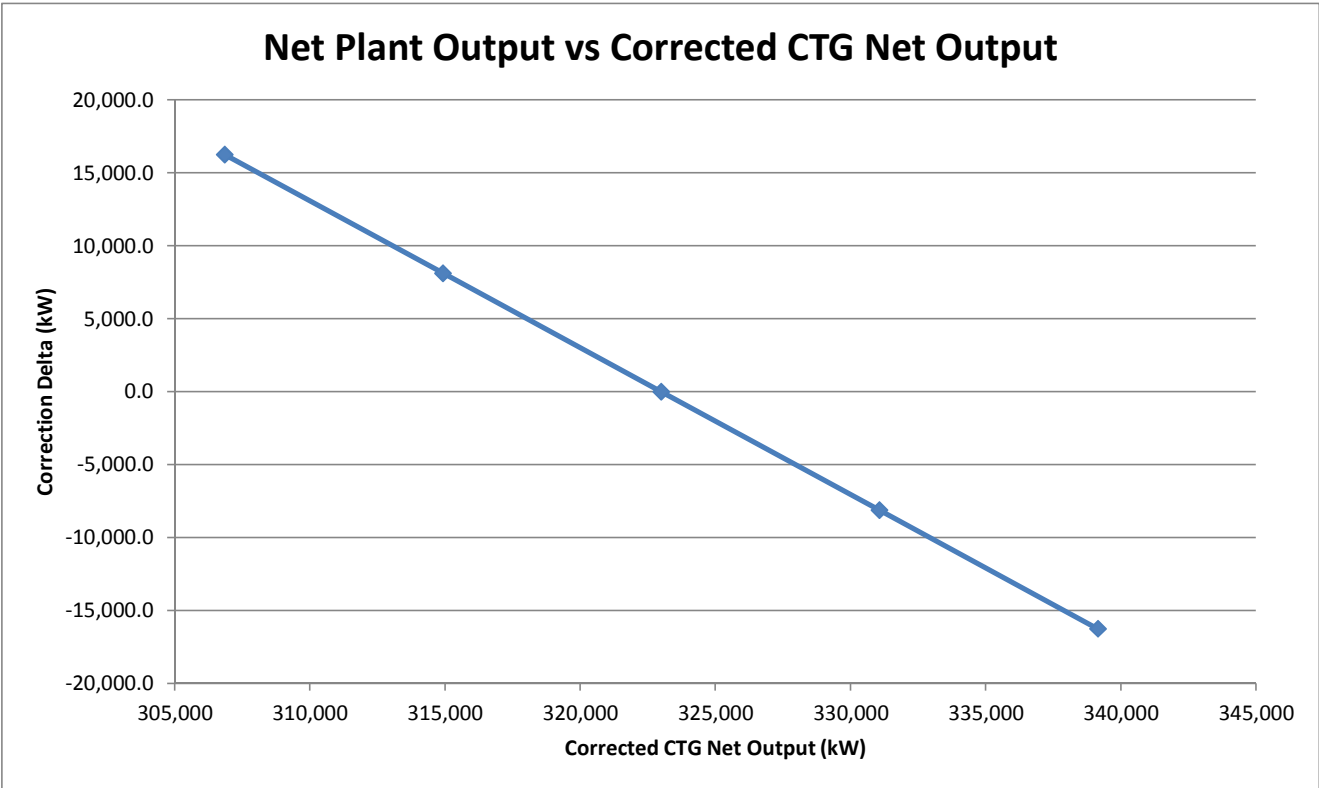


		CT WBT - CTG WBT (Deg F)				
		-5	-2.5	0	2.5	5
Ambient DB Temperat ure (Deg F)	50.00	148.0	72.0	0.0	2.0	15.0
	60.00	-42.0	-26.0	0.0	56.0	197.0
	79.40	-784.0	-361.0	0.0	407.0	863.0
	99.40	-1,135.0	-585.0	0.0	634.0	1,294.0
	105.00	-1,280.0	-649.0	0.0	687.0	1,409.0

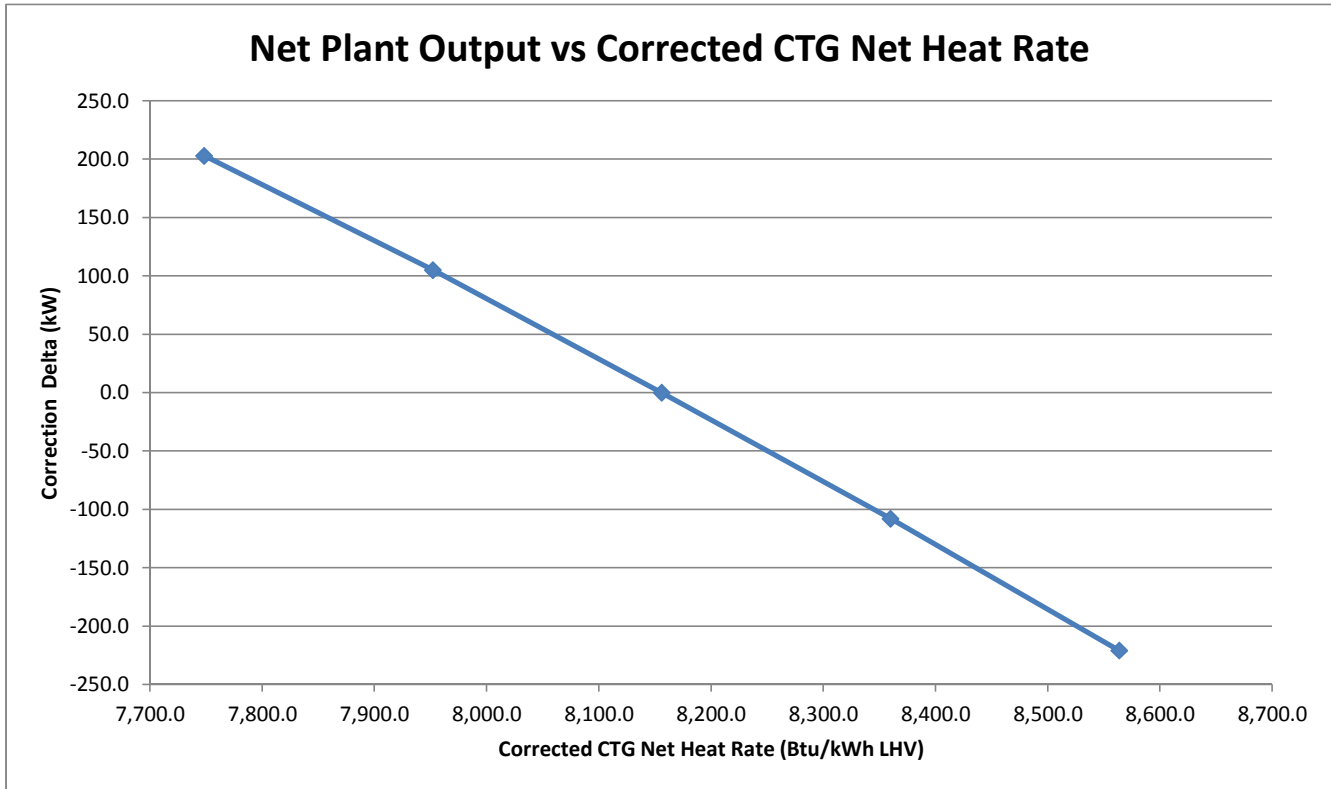
Valid for chiller on operation only



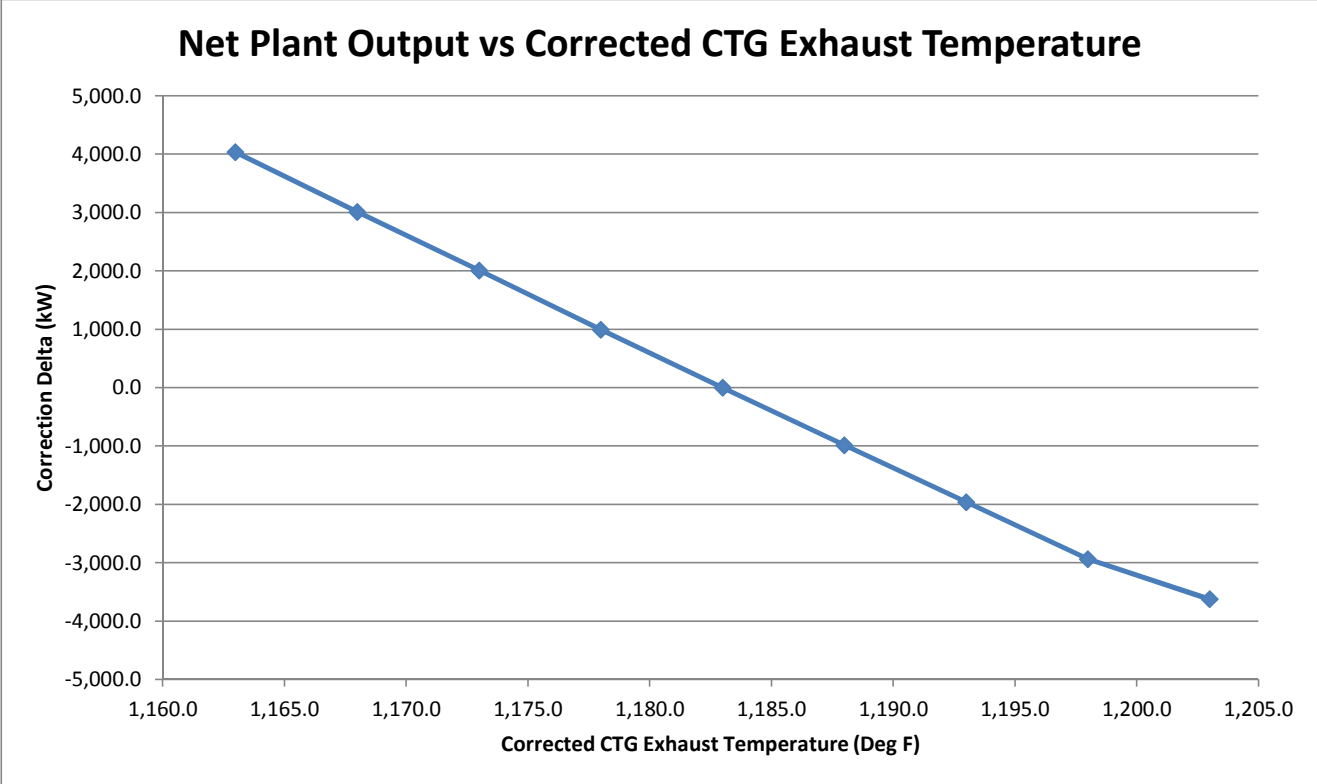
Corrected STG Net Output (kW)				
182,514	187,317	192,120	196,923	201,726
9,654.0	4,827.0	0.0	-4,828.0	-9,654.0



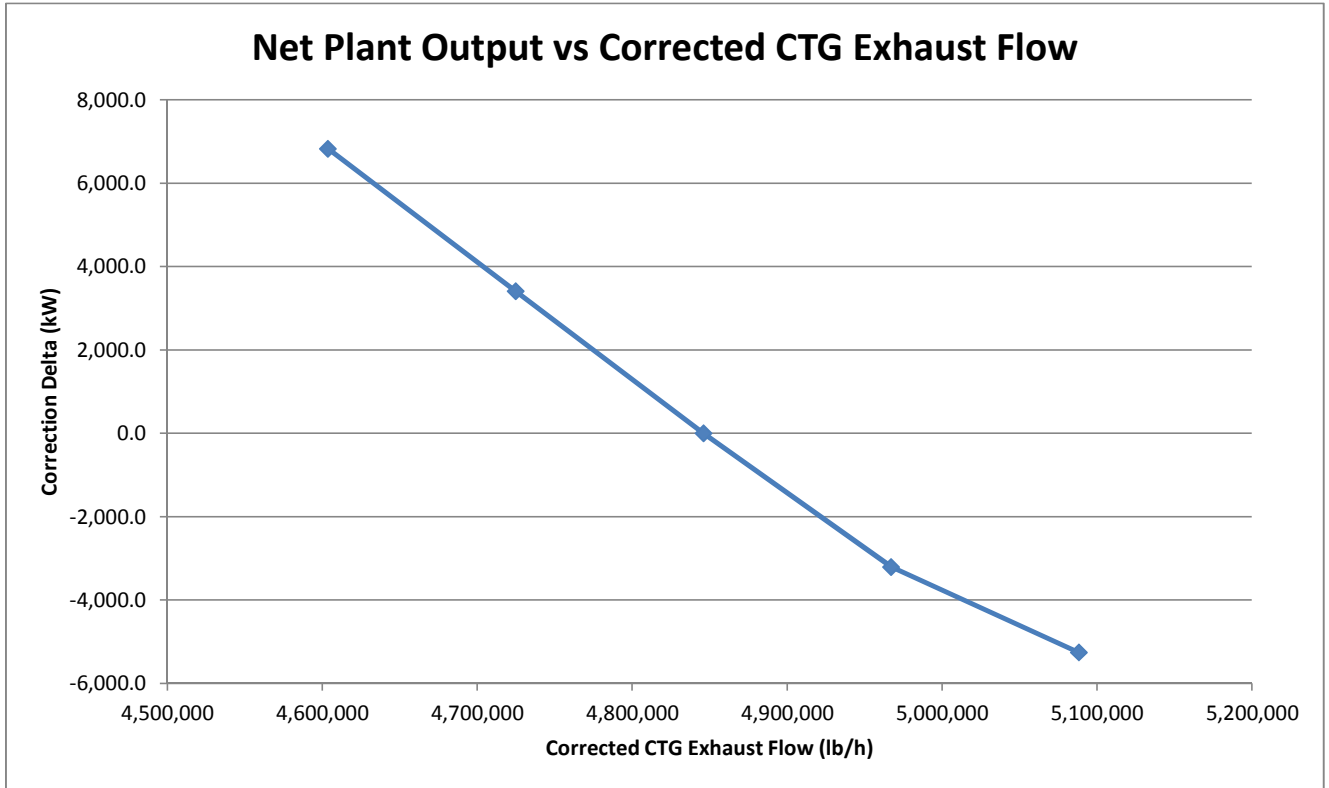
Corrected CTG Net Output (kW)				
306,850	314,925	323,000	331,075	339,150
16,245.0	8,126.6	0.0	-8,121.2	-16,256.7



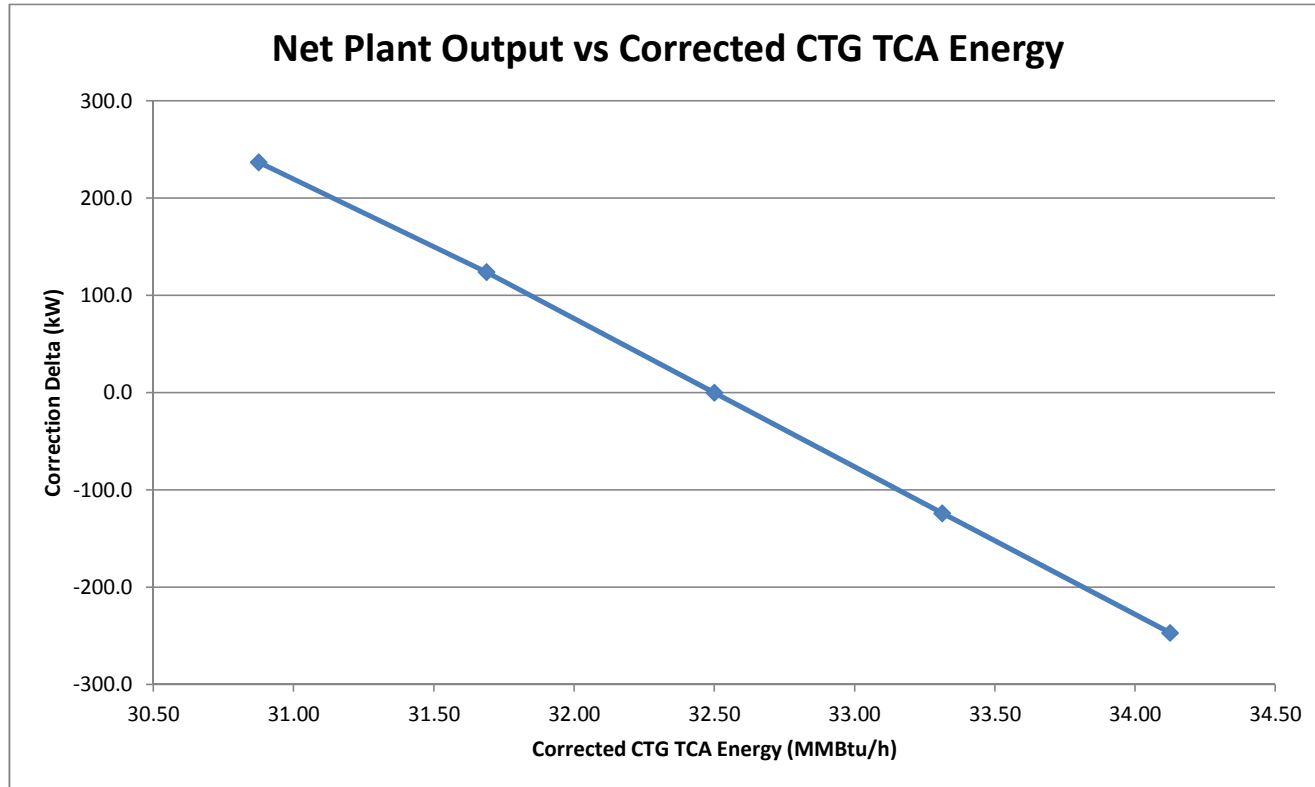
Corrected CTG Net Heat Rate (Btu/kWh)				
7,748.2	7,952.1	8,156.0	8,359.9	8,563.8
203.0	105.0	0.0	-108.0	-221.0



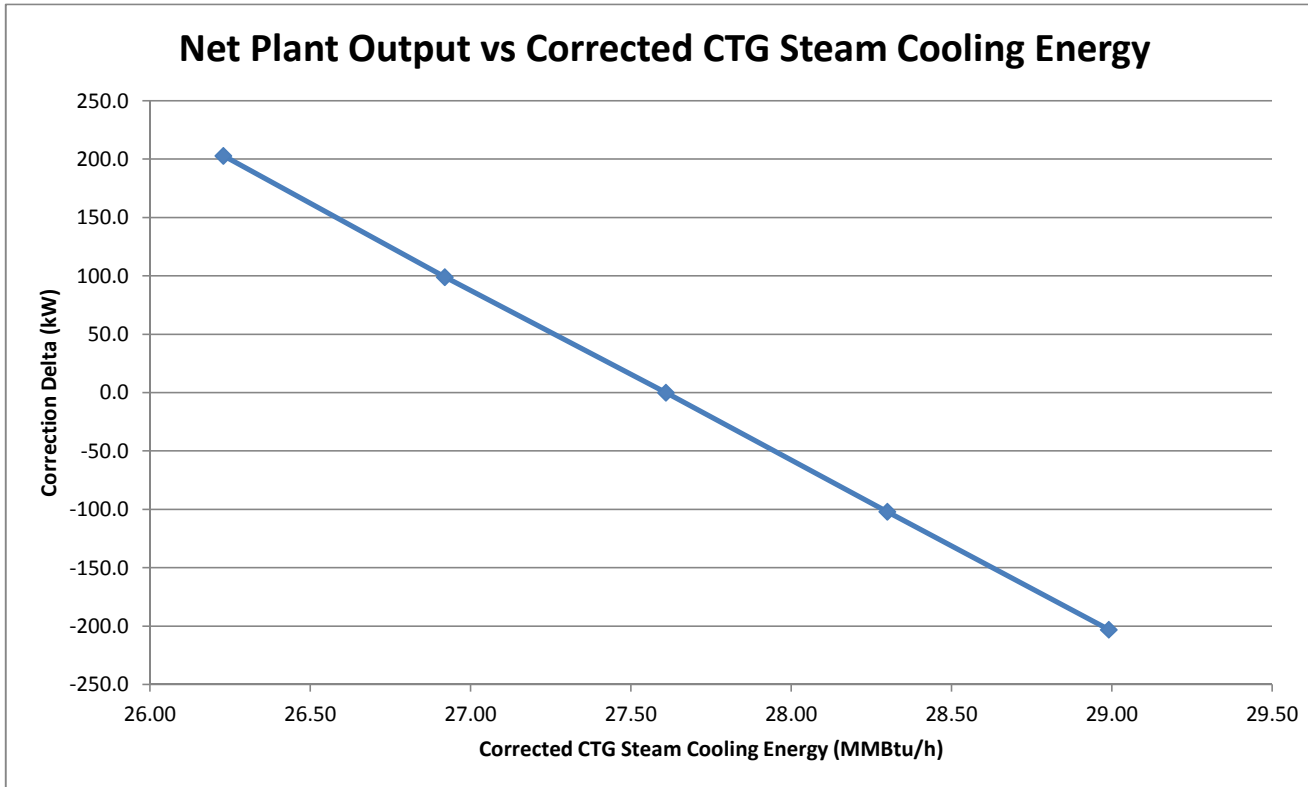
Corrected CTG Exhaust Temperature (Deg F)								
1,163.0	1,168.0	1,173.0	1,178.0	1,183.0	1,188.0	1,193.0	1,198.0	1,203.0
4,035.0	3,012.0	2,007.0	995.0	0.0	-986.0	-1,960.0	-2,937.0	-3,626.0



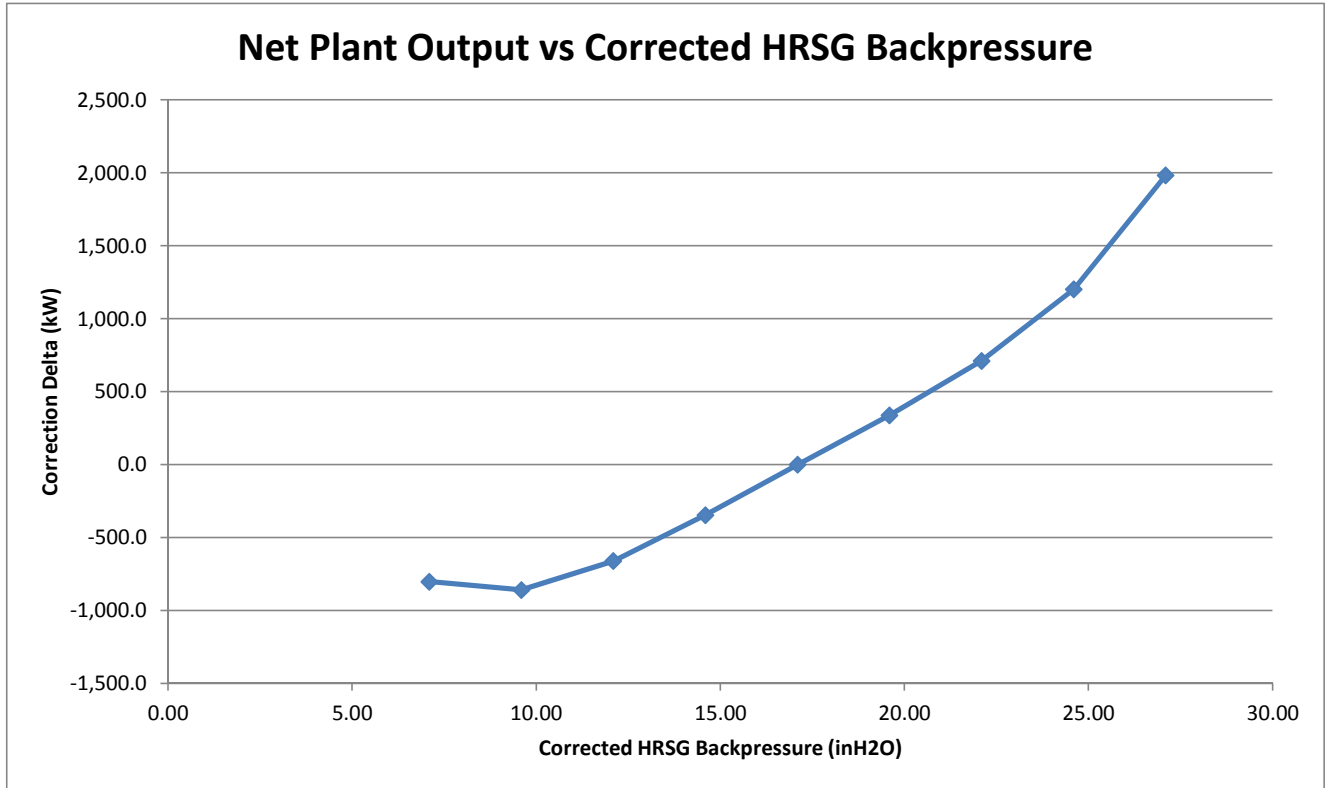
Corrected CTG Exhaust Flow (lb/h)				
4,603,700	4,724,850	4,846,000	4,967,150	5,088,300
6,830.0	3,407.0	0.0	-3,202.0	-5,258.0



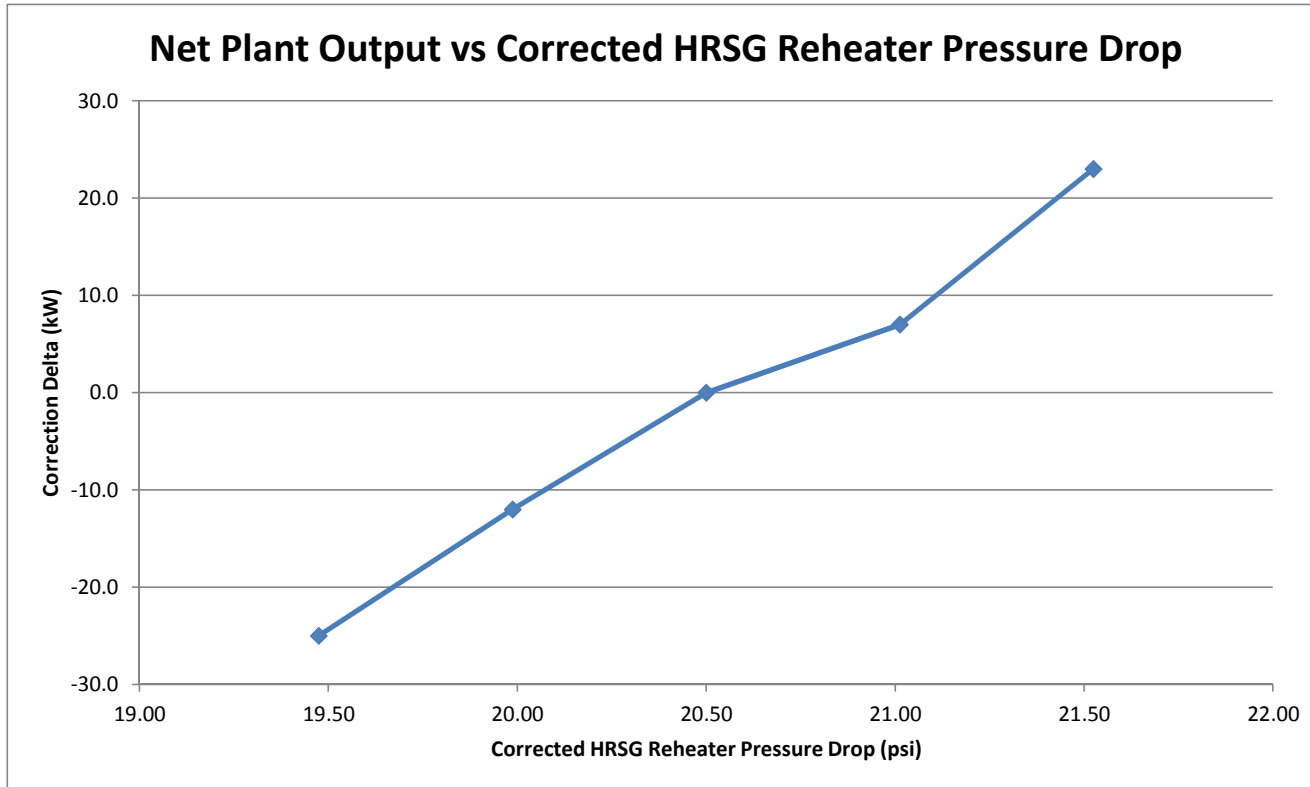
Corrected CTG TCA Energy (MMBtu/h)				
30.88	31.69	32.50	33.31	34.13
237.0	124.0	0.0	-124.0	-247.0



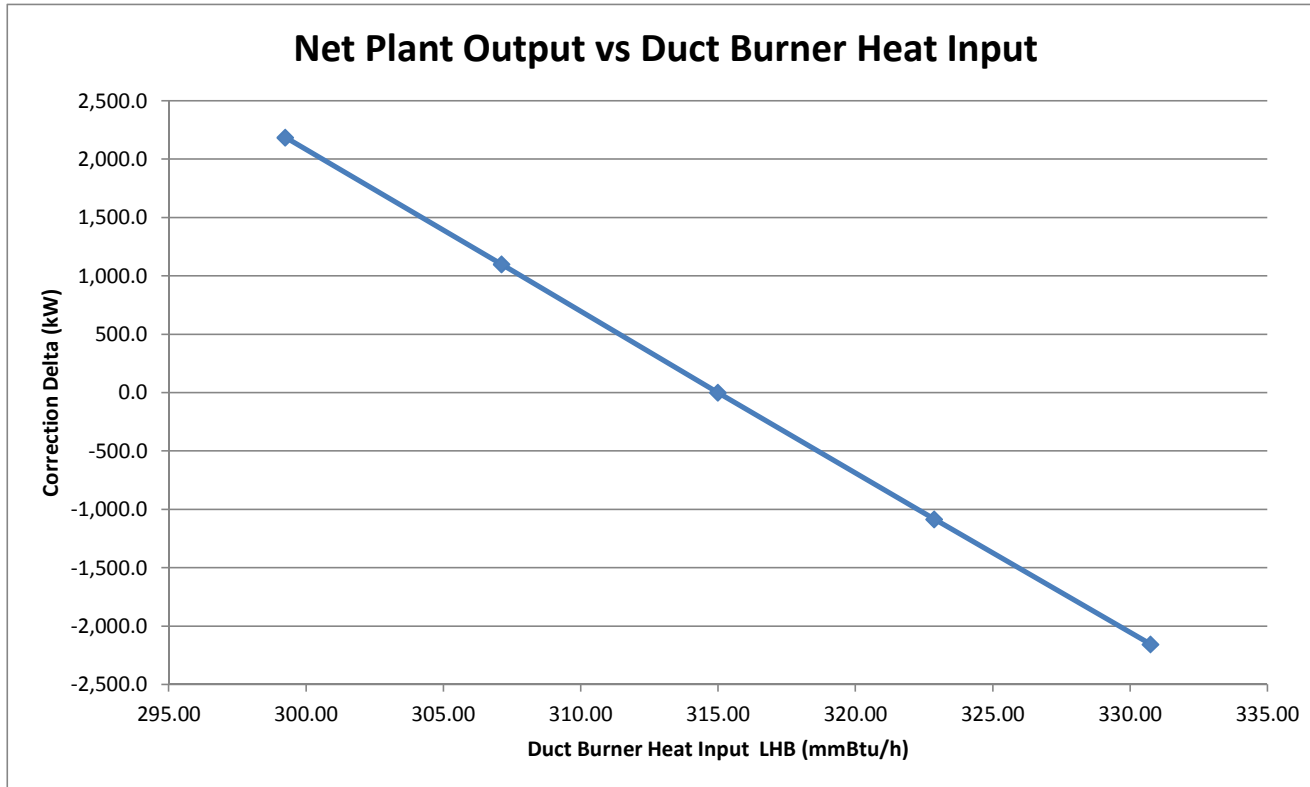
Corrected CTG Steam Cooling Energy (MMBtu/h)				
26.23	26.92	27.61	28.30	28.99
203.0	99.0	0.0	-102.0	-203.0



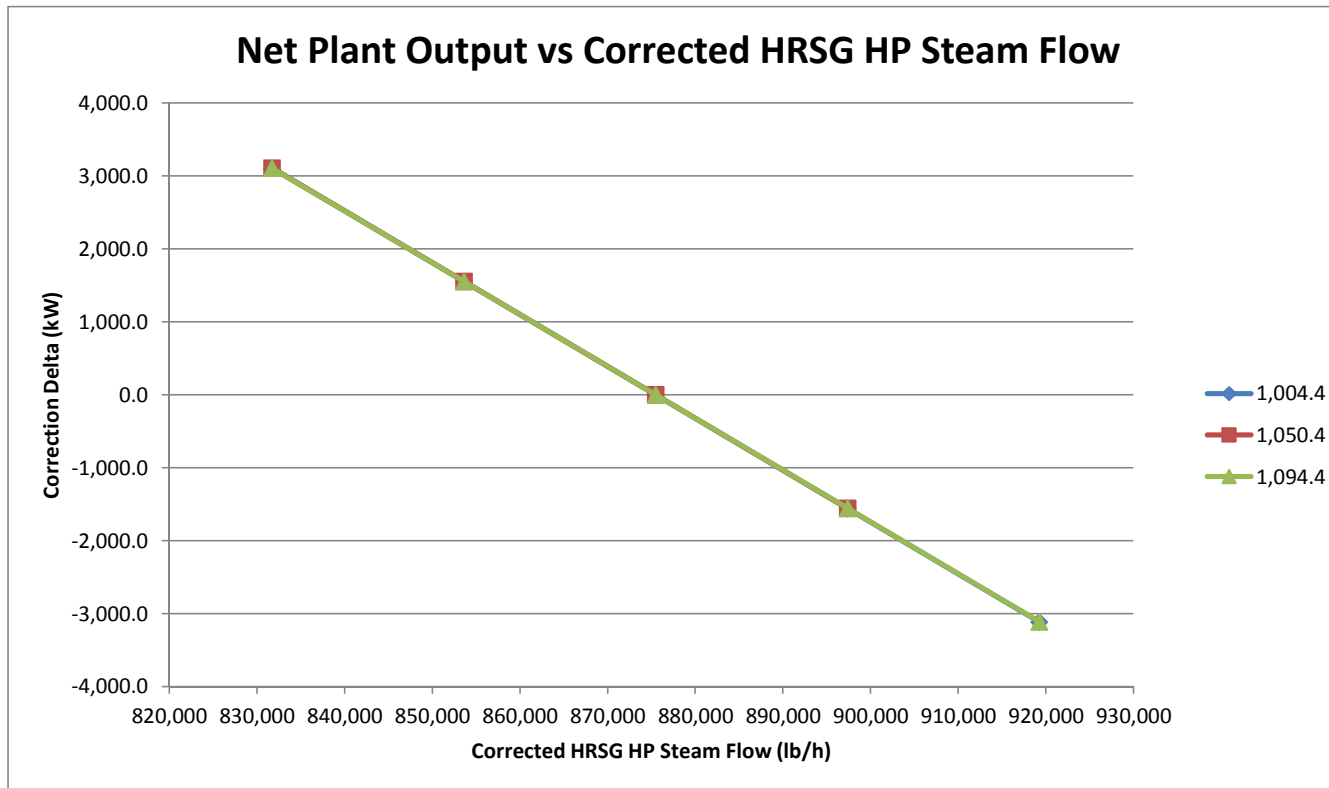
Corrected HRSG Backpressure (inH2O)								
7.10	9.60	12.10	14.60	17.10	19.60	22.10	24.60	27.10
-802.2	-859.4	-660.8	-346.3	0.0	337.9	711.2	1,201.7	1,983.1



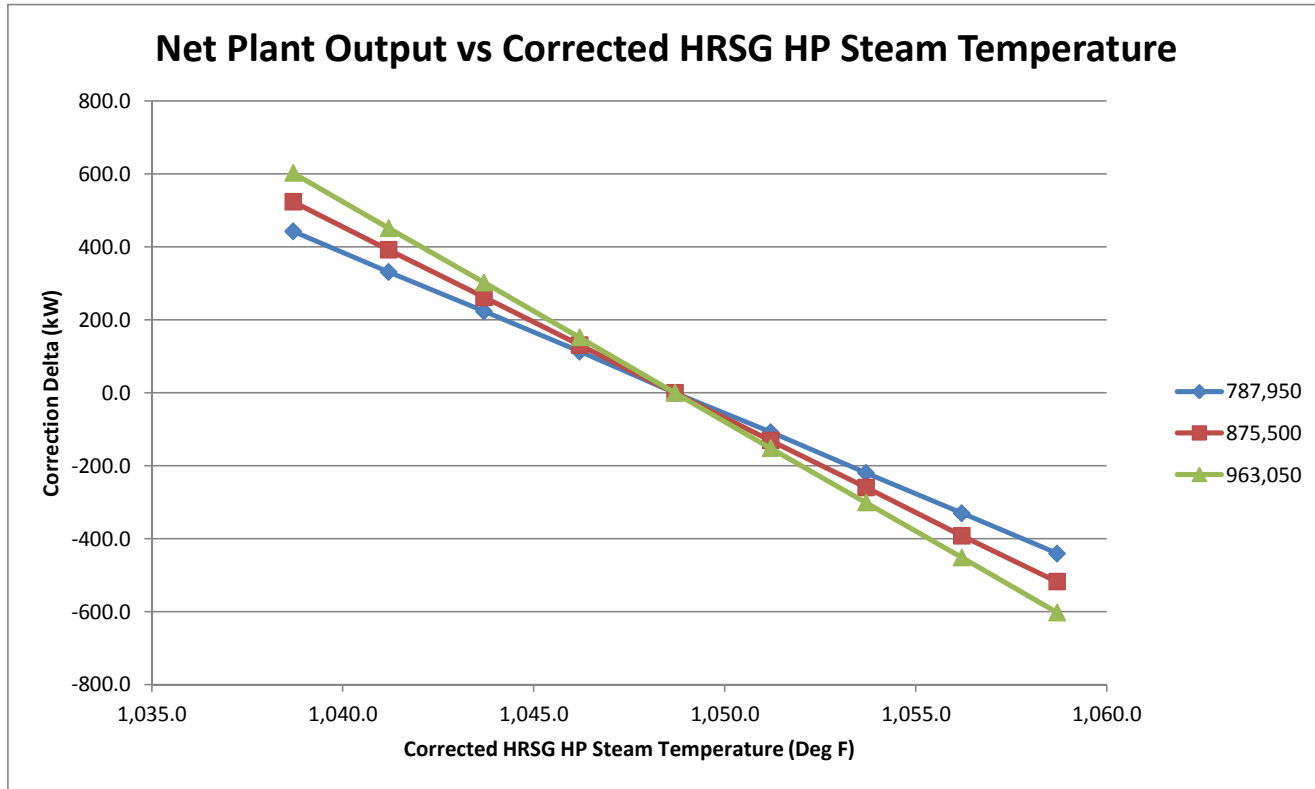
Corrected HRSG Reheater Pressure Drop (psi)				
19.48	19.99	20.50	21.01	21.53
-25.0	-12.0	0.0	7.0	23.0



Duct Burner Heat Input LHV (mmBtu/h)				
299.25	307.13	315.00	322.88	330.75
2,186.0	1,099.0	0.0	-1,084.0	-2,156.0

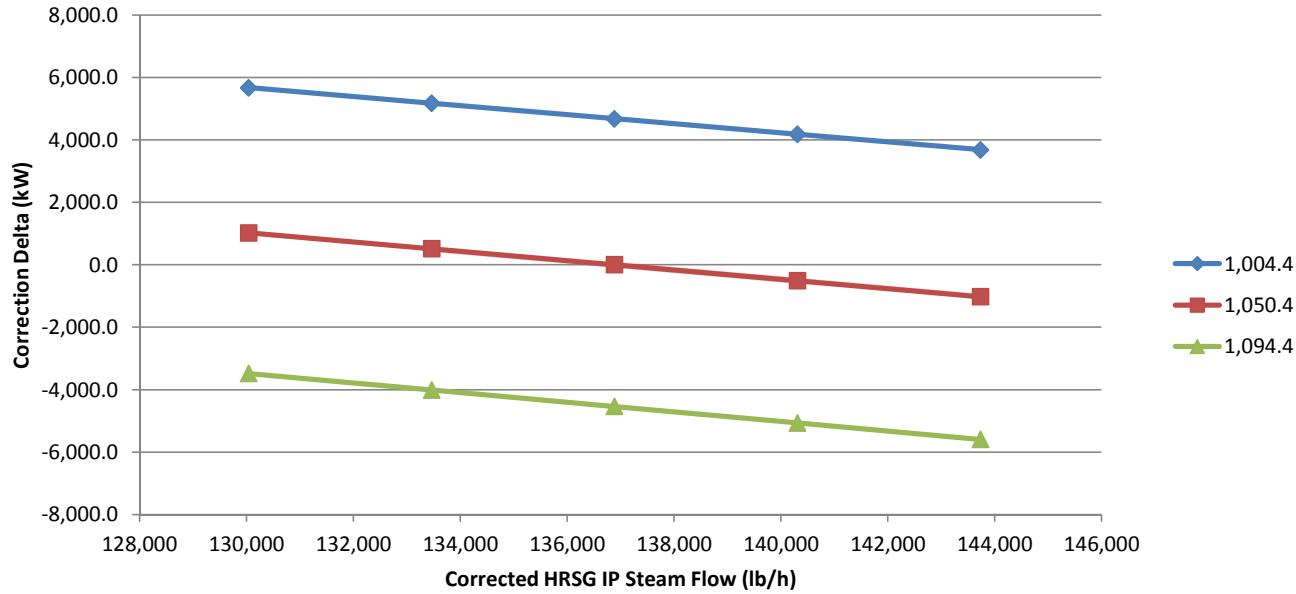


		Corrected HRSG HP Steam Flow (lb/h)				
		831,725	853,613	875,500	897,388	919,275
Reheat Steam Temp (Deg F)	1,004.4	3,106.4	1,554.9	0.0	-1,557.9	-3,115.5
	1,050.4	3,106.5	1,554.7	0.0	-1,557.2	-3,116.2
	1,094.4	3,105.3	1,553.8	0.0	-1,555.9	-3,114.0

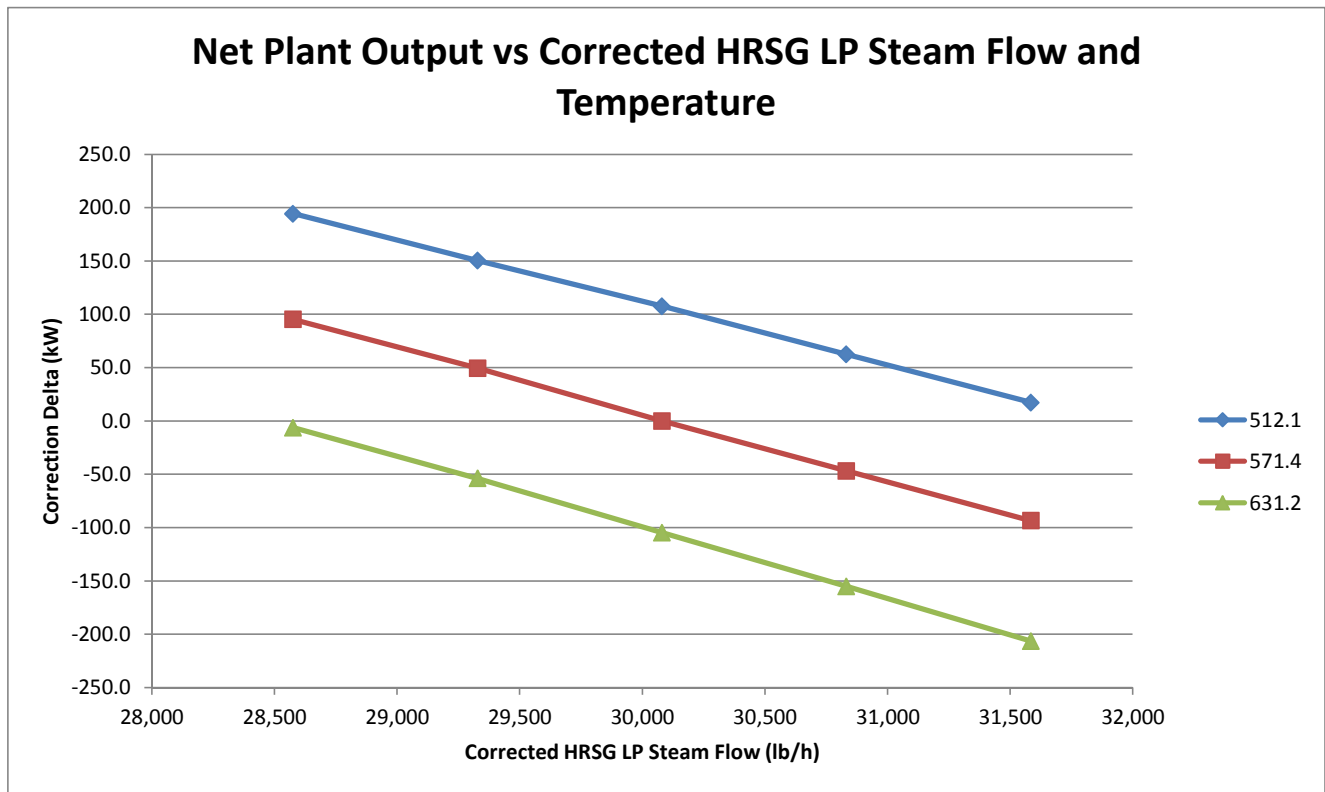


		Corrected HRSG HP Steam Temperature (Deg F)								
		1,038.7	1,041.2	1,043.7	1,046.2	1,048.7	1,051.2	1,053.7	1,056.2	1,058.7
HP Steam Flow (lb/h)	787,950	442.9	331.5	223.5	113.3	0.0	-107.6	-219.4	-329.4	-439.9
	875,500	523.4	392.1	261.8	131.2	0.0	-131.0	-259.4	-391.6	-517.8
	963,050	602.6	451.2	302.0	151.4	0.0	-152.0	-300.9	-451.7	-602.2

Net Plant Output vs Corrected HRSG IP Added Steam Flow and Reheat Steam Temperature (HRH flow - CRH flow)

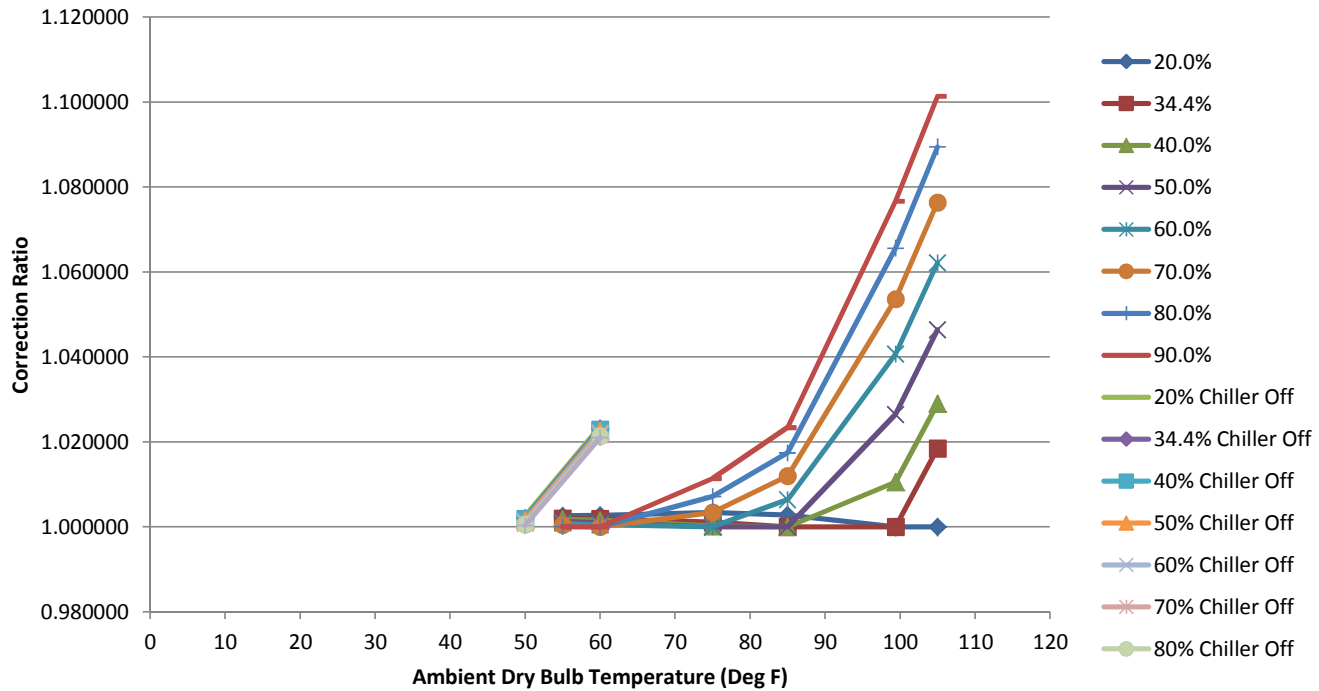


		Corrected HRSG IP Steam Flow (lb/h)				
		130,046	133,468	136,890	140,312	143,735
Reheat Steam Temp (Deg F)	1,004.4	5,672.2	5,173.6	4,675.7	4,179.6	3,684.7
	1,050.4	1,022.3	513.2	0.0	-511.7	-1,022.6
	1,094.4	-3,484.7	-4,012.9	-4,539.5	-5,066.5	-5,593.6

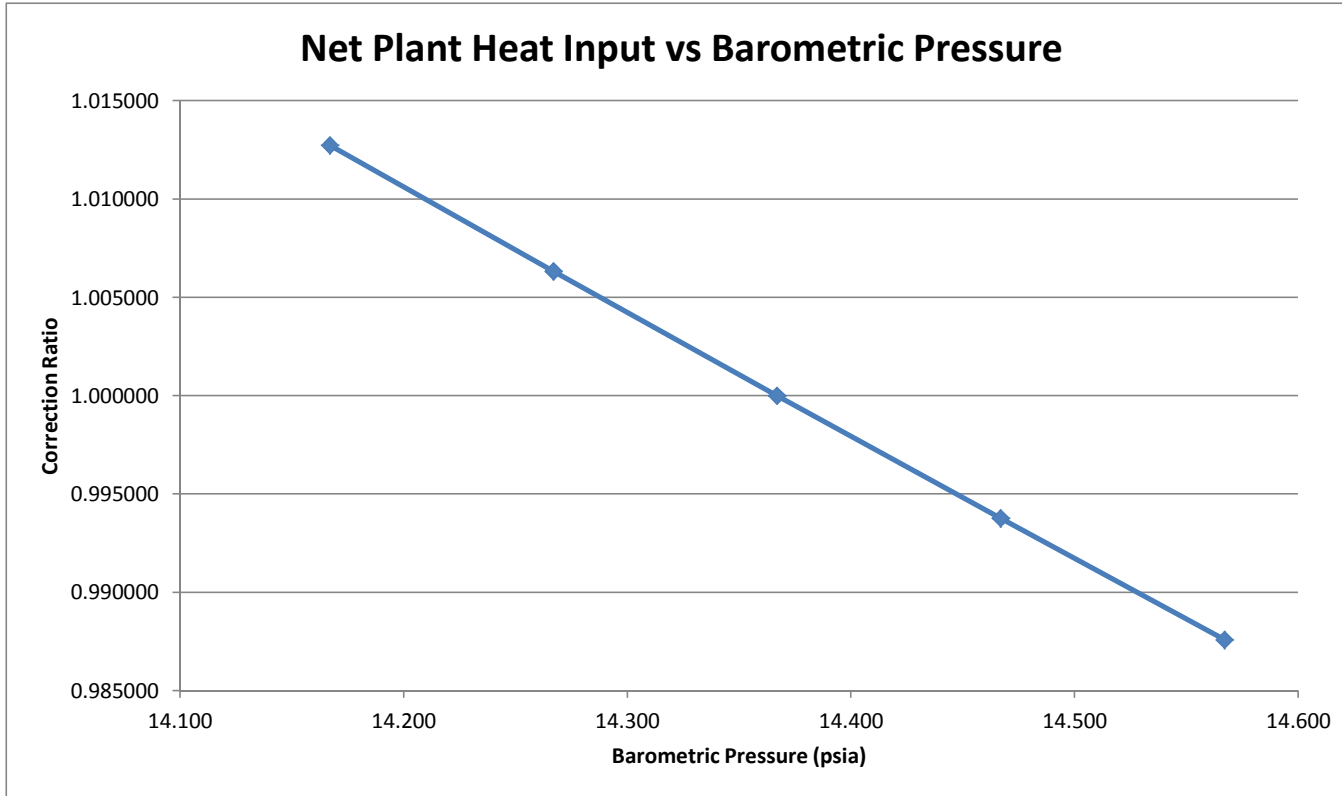


		Corrected HRSG LP Steam Flow (lb/h)				
		28,576	29,328	30,080	30,832	31,584
LP Temp (Deg F)	512.1	194.5	150.5	107.7	62.6	17.4
	571.4	95.3	49.5	0.0	-46.8	-93.4
	631.2	-6.3	-53.9	-104.7	-155.1	-206.5

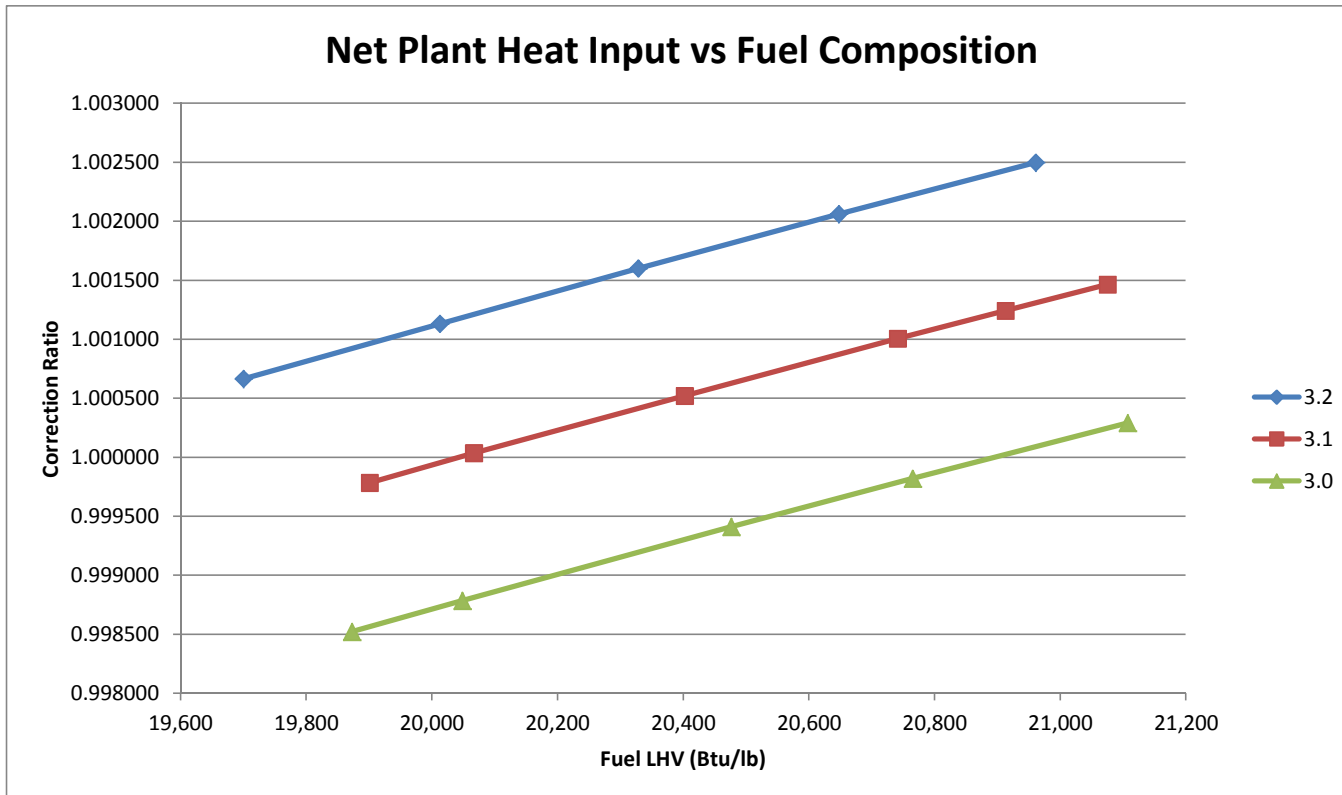
Net Plant Heat Input vs Ambient Temperature and Humidity



		Ambient Dry Bulb Temperature (Deg F)							
		Chiller Off		Chiller On					
		50	60	55	60	75	85	99.4	105
Relative Humidity (%)	20.0%	1.002529	1.023746	1.002600	1.002721	1.003393	1.002797	0.999993	0.999993
	34.4%	1.002072	1.023175	1.001993	1.001883	1.001094	0.999993	1.000000	1.018437
	40.0%	1.001886	1.022944	1.001745	1.001555	1.000204	0.999993	1.010547	1.029033
	50.0%	1.001547	1.022526	1.001306	1.001003	0.999993	0.999993	1.026482	1.046425
	60.0%	1.001210	1.022116	1.000893	1.000495	0.999993	1.006422	1.040651	1.062137
	70.0%	1.000889	1.021727	1.000511	0.999993	1.003401	1.011965	1.053645	1.076416
	80.0%	1.000588	1.021364	1.000129	0.999993	1.007143	1.017456	1.065622	1.089443
	90.0%	1.000300	1.021013	0.999993	0.999993	1.011366	1.023394	1.076705	1.101342



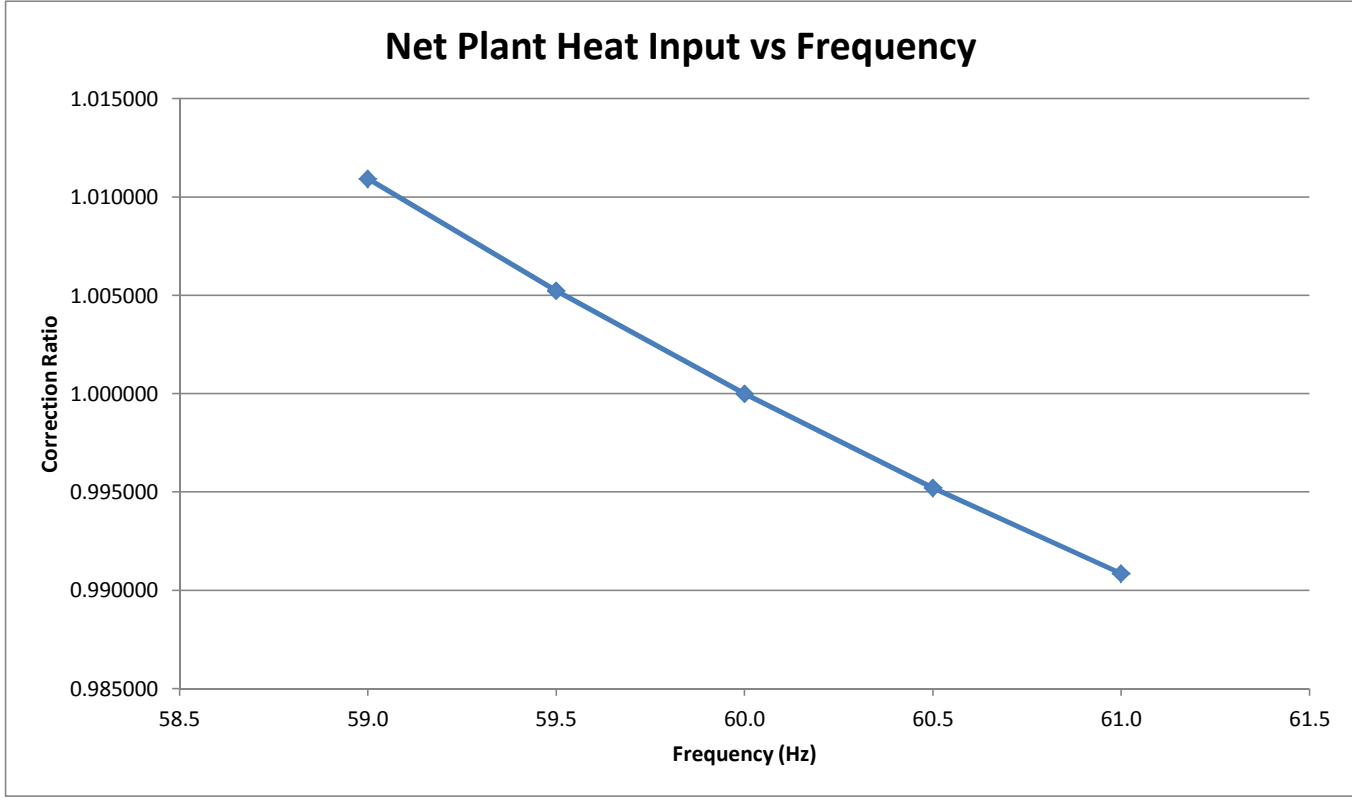
Barometric Pressure (psia)				
14.167	14.267	14.367	14.467	14.567
1.012737	1.006323	1.000000	0.993760	0.987593



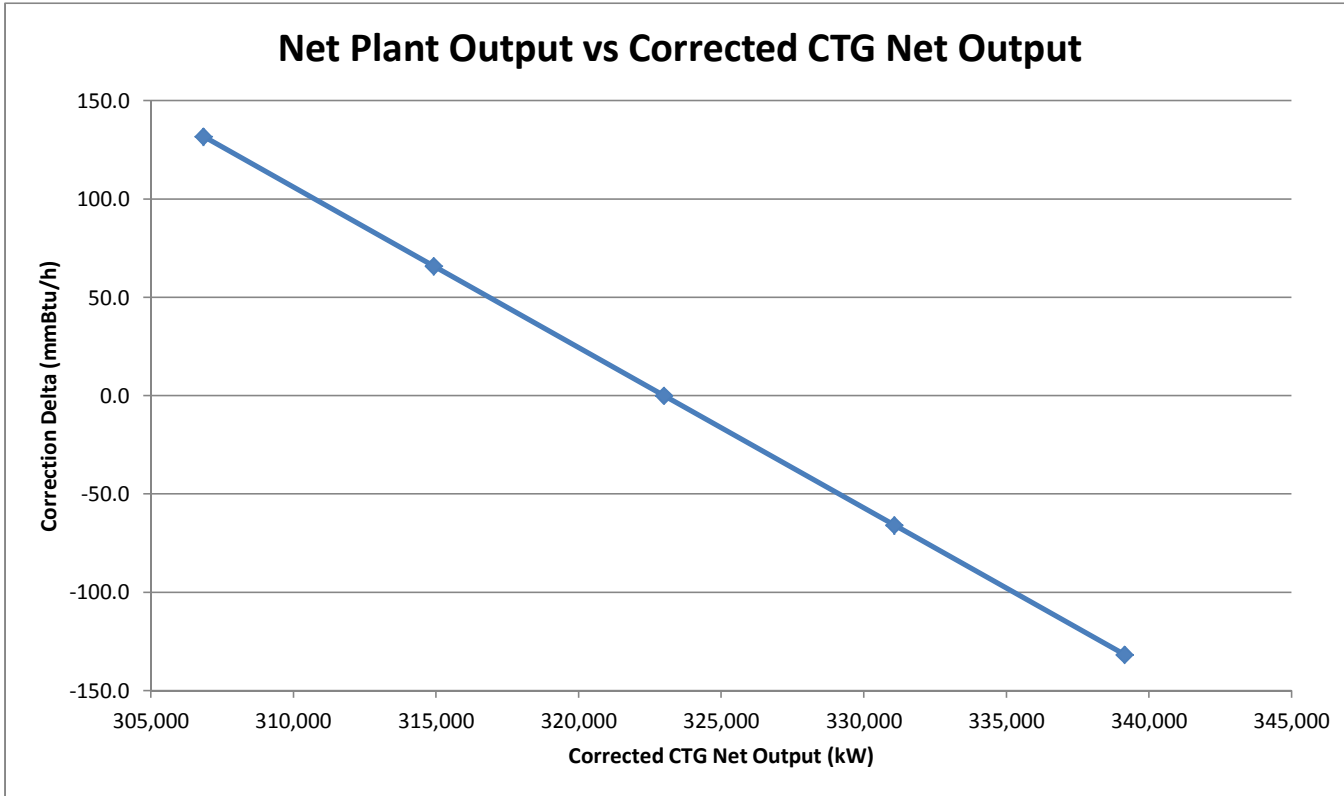
		Fuel H/C	
		3.0	
Fuel LHV (BTU/lb)	19,873	0.998522	
	20,049	0.998785	
	20,477	0.999410	
	20,766	0.999820	
	21,108	1.000292	

		Fuel H/C	
		3.1	
	19,901	0.999783	
	20,067	1.000035	
	20,403	1.000522	
	20,742	1.001006	
	20,913	1.001243	
	21,075	1.001464	

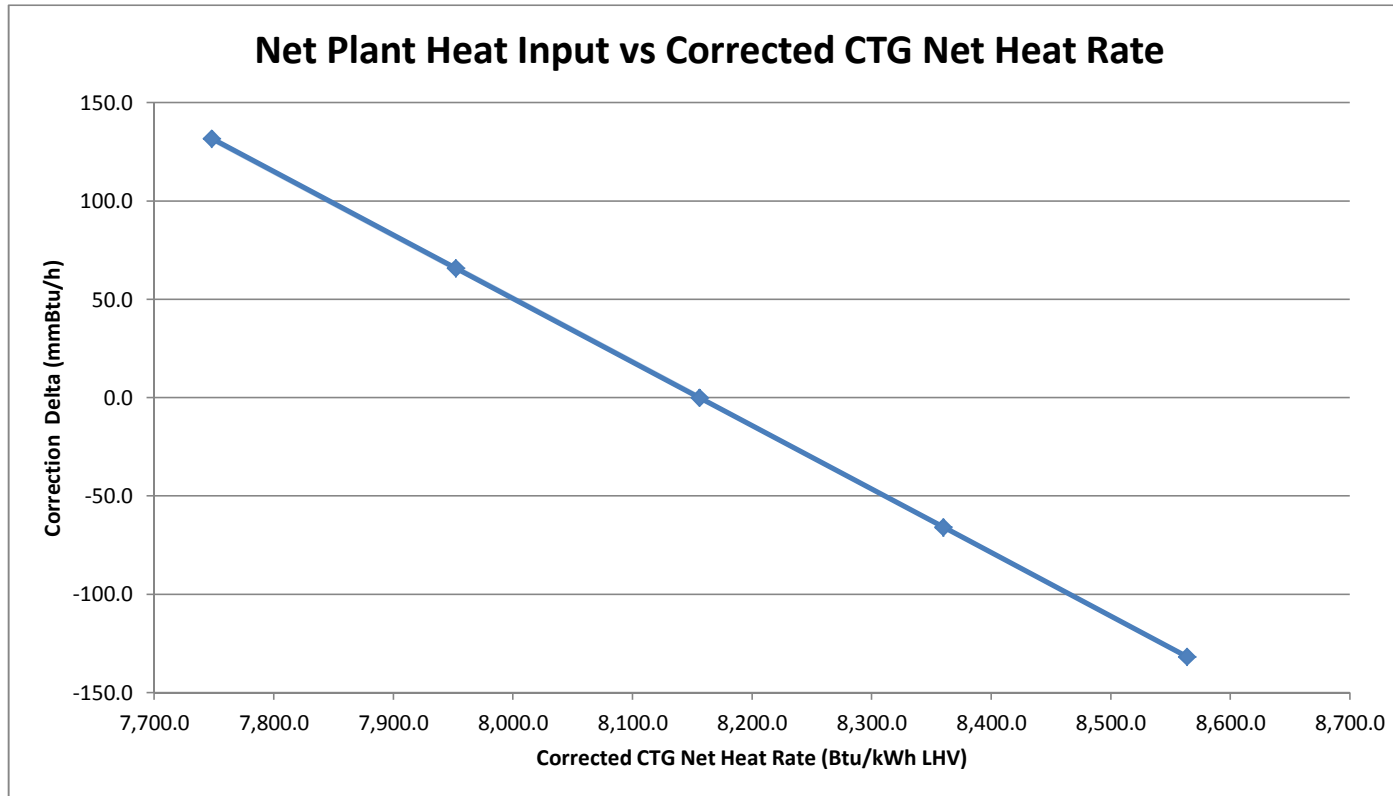
		Fuel H/C	
		3.2	
	19,701	1.000664	
	20,013	1.001132	
	20,329	1.001600	
	20,648	1.002062	
	20,961	1.002497	



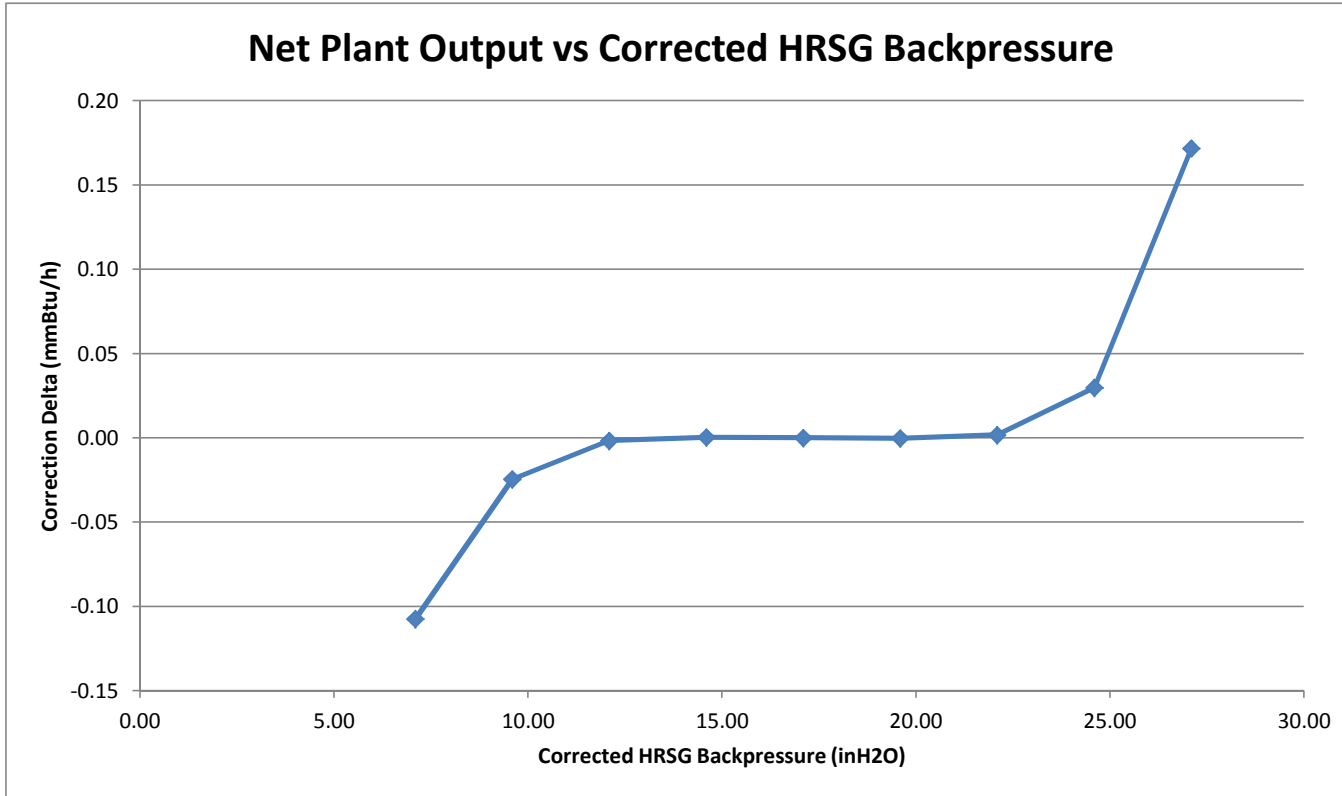
Frequency (Hz)				
59.0	59.5	60.0	60.5	61.0
1.010931	1.005231	1.000000	0.995216	0.990850



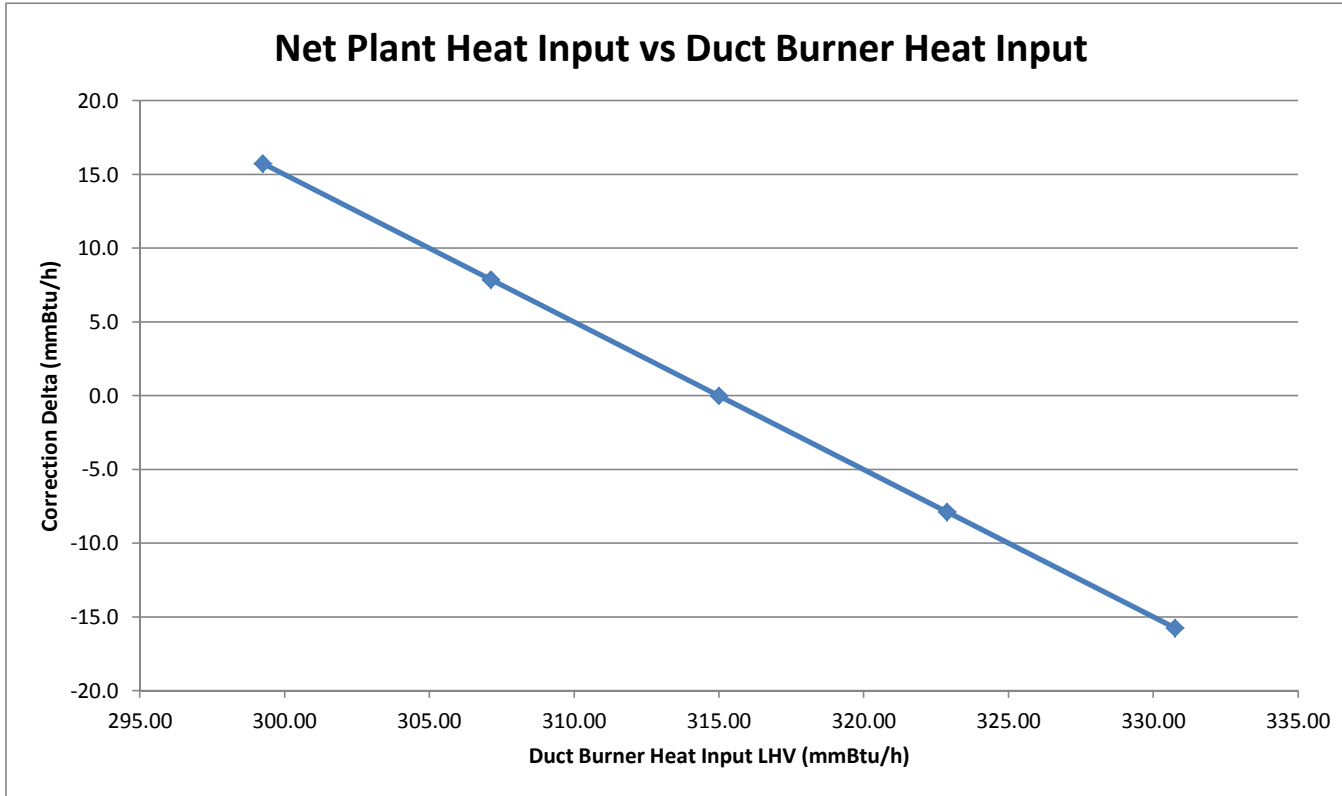
Corrected CTG Net Output (kW)				
306,850	314,925	323,000	331,075	339,150
131.8	65.9	0.0	-65.8	-131.7



Corrected CTG Net Heat Rate (Btu/kWh)				
7,748.2	7,952.1	8,156.0	8,359.9	8,563.8
131.7	65.9	0.0	-65.9	-131.7



Corrected HRSG Backpressure (inH2O)								
7.10	9.60	12.10	14.60	17.10	19.60	22.10	24.60	27.10
-0.11	-0.02	0.00	0.00	0.00	0.00	0.00	0.03	0.17



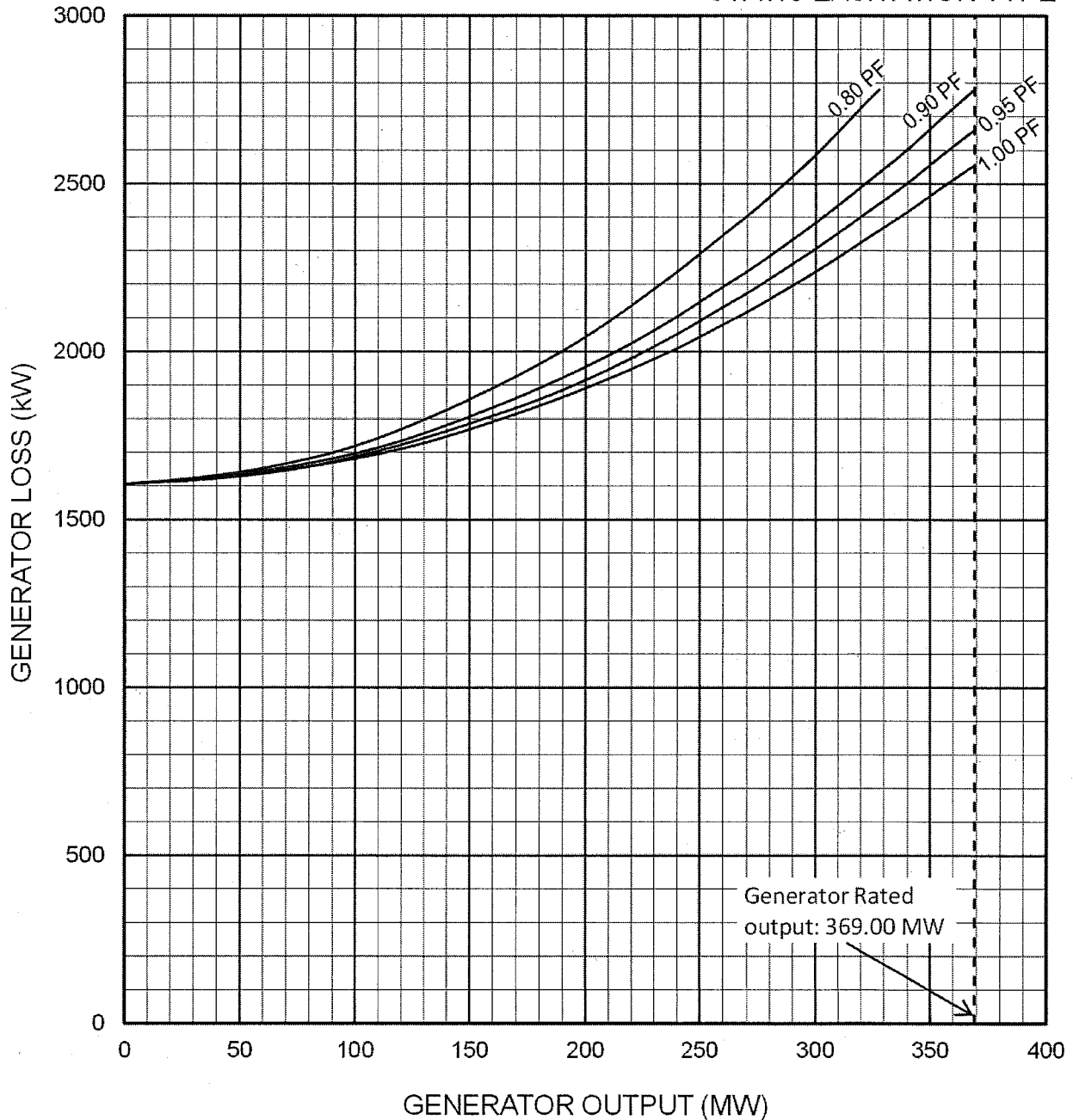
Duct Burner Heat Input LHV (mmBtu/h)				
299.25	307.13	315.00	322.88	330.75
15.8	7.9	0.0	-7.9	-15.8

USA / GRDA
Grand River Energy Center Unit 3
Gas Turbine Generator

HYDROGEN INDIRECTLY COOLED TURBINE GENERATOR
GENERATOR LOSS CURVE

410,000 kVA, 369,000 kW, 90 %PF, 60 Hz, 3,600 min⁻¹,
20.0 kV, 11,836 A, 0.45 MPa-g, 390 VEXC.

STATIC EXCITATION TYPE



(Note) Exciter loss and field winding loss are not included in the calculation.

APPROVED	<i>K. Tanaka</i>
CHECKED	<i>K. Tanaka</i>
DESIGNED	'16-5/30 <i>m. Hayashi</i>

COMPANY PROPRIETARY INFORMATION
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WITHOUT SPECIFIC WRITTEN PERMISSION OF
MITSUBISHI ELECTRIC CORPORATION



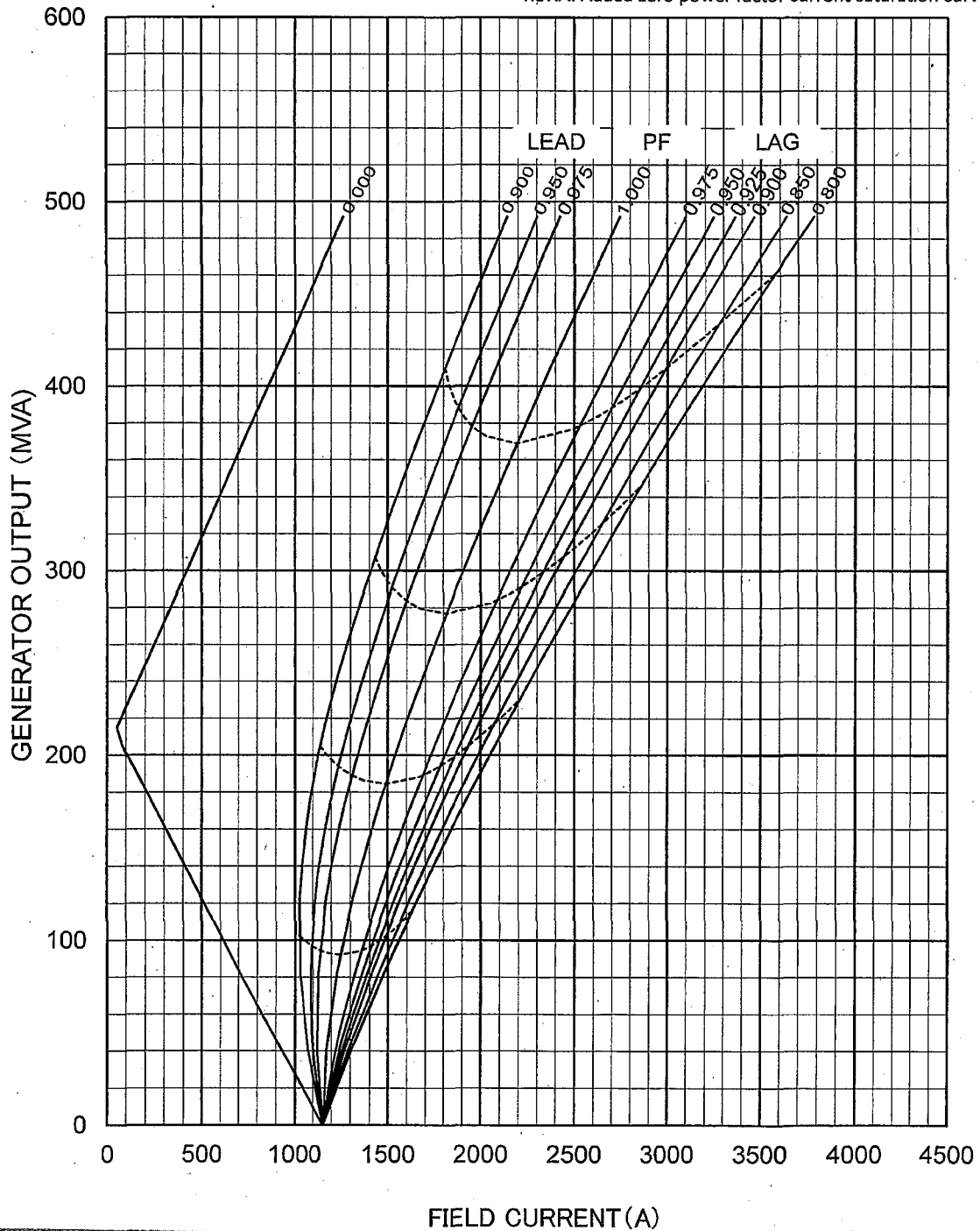
Turbine-Generators for Combined Cycle Unit 3 (GTG)

410000 kVA, 369000 kW, 90 %PF, 60 Hz, 3600 min-1,
20 kV, 11836 A, 0.45 MPa-g, 390 VEXC

HYDROGEN INDIRECTLY COOLED GENERATOR

V-CURVE VOLTAGE 20 kV

Rev.A: Added zero power factor current saturation curve.



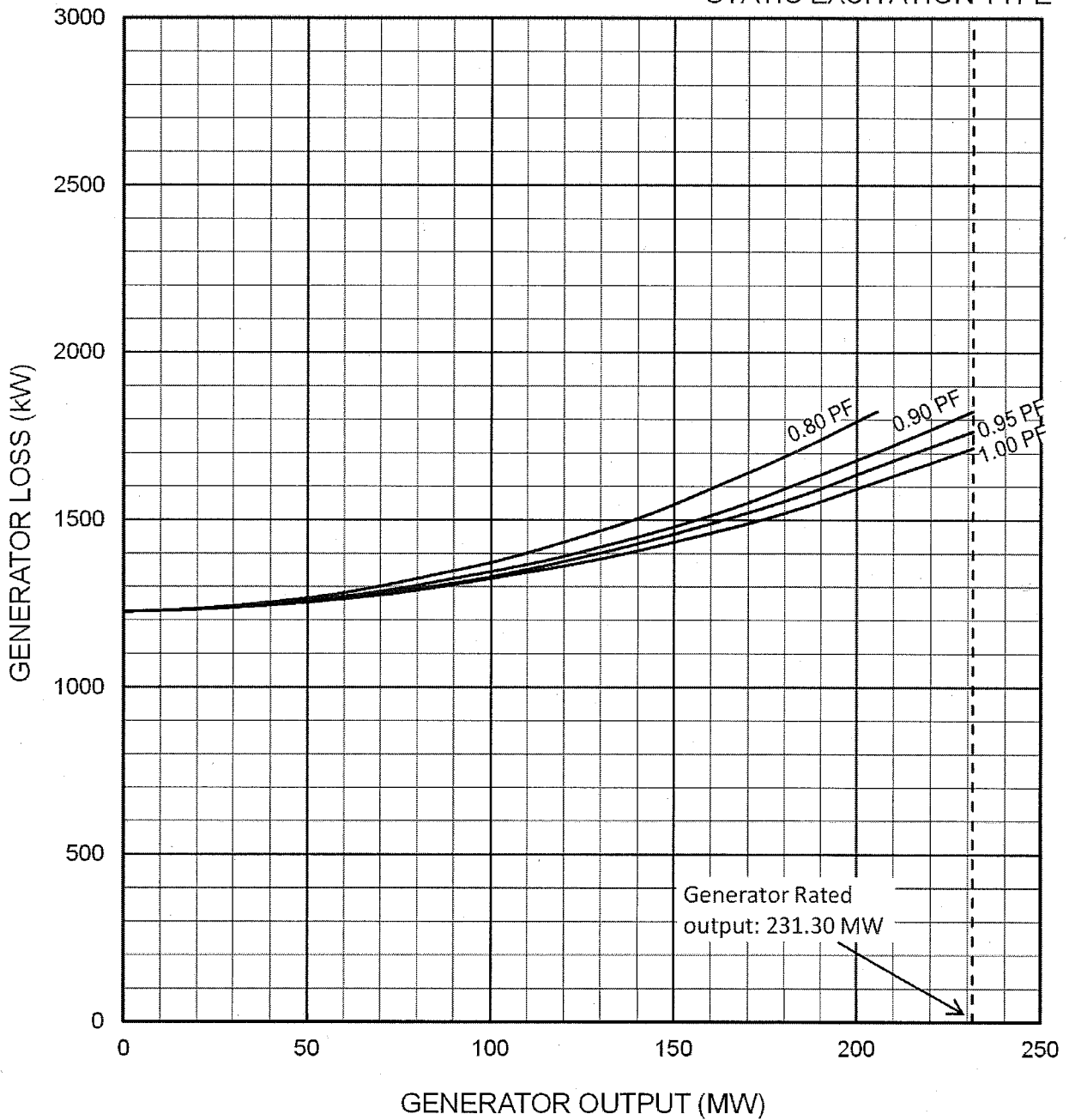
APPROVED	<i>K. Imada</i>
CHECKED	<i>T. Kajiwara</i>
DESIGNED	2014-4/15 <i>Y. Saito</i>

USA / GRDA
Grand River Energy Center Unit 3
Steam Turbine Generator

HYDROGEN INDIRECTLY COOLED TURBINE GENERATOR
GENERATOR LOSS CURVE

257,000 kVA, 231,300 kW, 90 %PF, 60 Hz, 3,600 min⁻¹,
21.0 kV, 7,066 A, 0.30 MPa-g, 335 VEXC.

STATIC EXCITATION TYPE



(Note) Exciter loss and field winding loss are not included in the calculation.

APPROVED	<i>K. Tanaka</i>
CHECKED	<i>K. Tanaka</i>
DESIGNED	7/16-5/90 <i>M. Hayashi</i>

COMPANY PROPRIETARY INFORMATION
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KC921154A

USA / GRDA



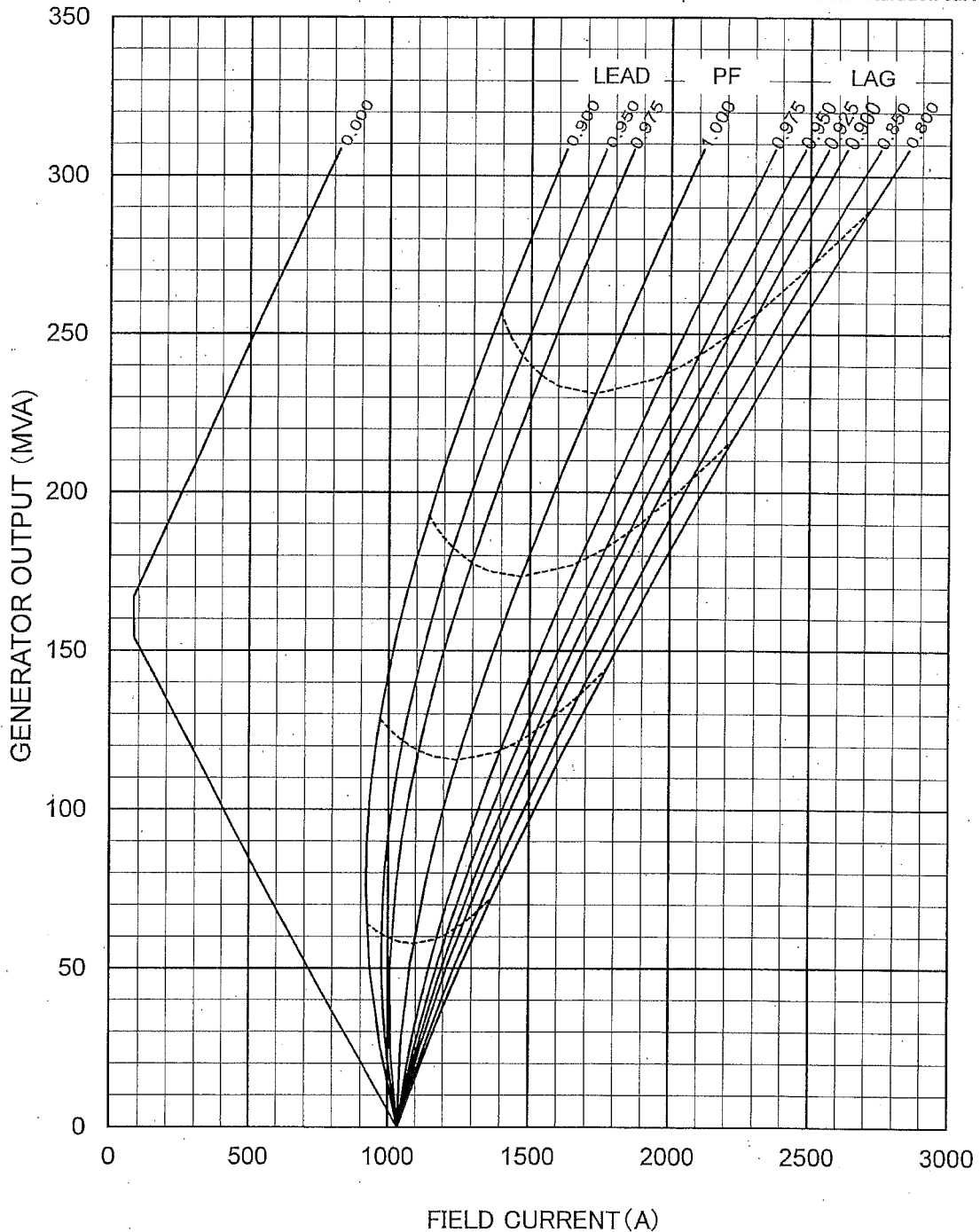
Turbine-Generators for Combined Cycle Unit 3 (STG)

257000 kVA, 231300 kW, 90 %PF, 60 Hz, 3600 min⁻¹,
21 kV, 7066 A, 0.3 MPa-g, 335 VEXC

HYDROGEN INDIRECTLY COOLED GENERATOR

V-CURVE VOLTAGE 21 kV

Rev.A: Added zero power factor current saturation curve.



APPROVED	<i>K. Maki</i>
CHECKED	<i>G. Kogawa</i>
DESIGNED	2014-4/15 <i>Y. Saito</i>

KC921154A

GAE-MP-EXO1STG

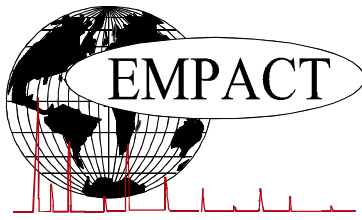
APPENDIX G

PERFORMANCE TEST DATA

Previously provided electronically

APPENDIX H

FUEL ANALYSIS



EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #: NAME/DESCRIP : **GREC - KIEWIT
U3, SAMPLE A-01**

PROJECT NO. : **201707030** ANALYSIS NO. : **01**

COMPANY NAME : **MCHALE & ASSOCIATES** ANALYSIS DATE: **JULY 13, 2017 10:56**

OFFICE / BRANCH: **KNOXVILLE, TN** SAMPLE DATE : **JULY 6, 2017 23:05**

CUSTOMER REF: **PRJ 17041.0** TO:

PRODUCER : EFFECTIVE DATE:

*****FIELD DATA*****

SAMPLE CYCLE: SAMPLE TYPE:

SAMPLE PRES. : psig CYLINDER NO. : M-12298

LAB PRES: psig SAMPLED BY : HF GROTKOPF

SAMPLE TEMP. : °f SAMPLING COMPANY: MCHALE

AMBIENT TEMP.: °f H2S BY STAIN TUBE: - ppm

H2O BY STAIN TUBE: - #/mmcf CO2 BY STAIN TUBE: - Mol %

FIELD COMMENTS:

LAB COMMENTS:

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.7300	2.7800	---	---
CARBON DIOXIDE	0.61	1.54	---	---
METHANE	90.58110	83.20820	---	---
ETHANE	6.6807	11.5026	1.7902	1.7861
PROPANE	0.3023	0.7633	0.0834	0.0832
I-BUTANE	0.0110	0.0366	0.0040	0.0040
N-BUTANE	0.0200	0.0665	0.0060	0.0060
I-PENTANE	0.0033	0.0136	0.0010	0.0010
N-PENTANE	0.0030	0.0124	0.0010	0.0010
HEXANES PLUS	0.0086	0.0468	0.0010	0.0010
TOTALS	100.00000	100.00000	1.8866	1.8823

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	944.4 /scf	942.2 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	928.0 /scf	925.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1046.9 /scf	1044.5 /scf
XYLENES	0.0001	0.0006	GROSS WET REAL :	1028.7 /scf	1026.3 /scf
TOTAL BTEX	0.0006	0.0031	NET DRY REAL :	20529.2 /lb	20481.8 /lb
			GROSS DRY REAL :	22755.4 /lb	22702.8 /lb

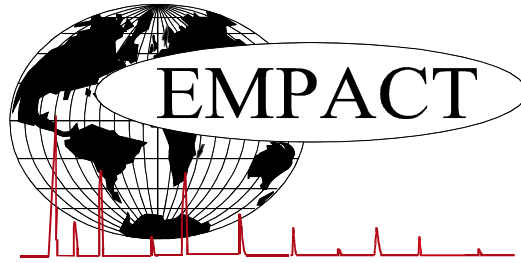
(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6027

COMPRESSIBILITY FACTOR : 0.99773

The data presented herein has been acquired by means of current analytical techniques and represents the judicious conclusion EMPACT Analytical Systems, Inc. Results of the analysis can be affected by the sampling conditions, therefore, are only warranted through proper lab protocol. EMPACT assumes no responsibility for interpretation or any consequences from application of the reported information and is the sole liability of the user. The reproduction in any media of this reported information may not be made, in portion or as a whole, without the written permission of EMPACT Analytical Systems, Inc.



EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	01
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 10:56
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 6, 2017 23:05
PRODUCER :		CYLINDER NO. :	M-12298
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE A-01		

FIELD DATA
 SAMPLE PRES. :
 COMMENTS :

SAMPLE TEMP. :
 AMBIENT TEMP.:

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.73	2.78	---	---
Carbon Dioxide	---	0.61	1.54	---	---
Methane	P1	90.58110	83.20820	---	---
Ethane	P2	6.6807	11.5026	1.790	1.786
Propane	P3	0.3023	0.7633	0.083	0.083
i-Butane	I4	0.0110	0.0366	0.004	0.004
n-Butane	P4	0.0200	0.0665	0.006	0.006
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0030	0.0124	0.001	0.001
n-Pentane	P5	0.0030	0.0124	0.001	0.001
2,2-Dimethylbutane	I6	0.0001	0.0005	0.000	0.000
Cyclopentane	N5	0.0001	0.0004	0.000	0.000
2,3-Dimethylbutane	I6	0.0001	0.0005	0.000	0.000
2-Methylpentane	I6	0.0009	0.0045	0.000	0.000
3-Methylpentane	I6	0.0006	0.0030	0.000	0.000
n-Hexane	P6	0.0013	0.0064	0.001	0.001
Methylcyclopentane	N6	0.0004	0.0019	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0004	0.0019	0.000	0.000
2-Methylhexane	I7	0.0003	0.0017	0.000	0.000
2,3-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0003	0.0017	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
UnknownC6s	U6	0.0001	0.0005	0.000	0.000
n-Heptane	P7	0.0006	0.0034	0.000	0.000
Methylcyclohexane	N7	0.0007	0.0039	0.000	0.000
2,2,3-Trimethylpentane	I8	0.0001	0.0006	0.000	0.000
2,4-Dimethylhexane	I8	0.0001	0.0006	0.000	0.000
Toluene	A7	0.0003	0.0016	0.000	0.000
2-Methylheptane	I8	0.0002	0.0013	0.000	0.000
4-Methylheptane	I8	0.0001	0.0006	0.000	0.000

1c,2t,3-Trimethylcyclopentane	N8	0.0003	0.0019	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0004	0.0026	0.000	0.000
1,1,4-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0001	0.0006	0.000	0.000
3-Methyloctane	I9	0.0001	0.0007	0.000	0.000
n-Nonane	P9	0.0001	0.0007	0.000	0.000
TOTAL		100.00000	100.00000	1.8866	1.8823

BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	944.4 /scf	942.2 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	928.0 /scf	925.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1046.9 /scf	1044.5 /scf
XYLENES	0.0001	0.0006	GROSS WET REAL :	1028.7 /scf	1026.3 /scf
TOTAL BTEX	0.0006	0.0031	NET DRY REAL :	20529.2 /lb	20481.8 /lb
			GROSS DRY REAL :	22755.4 /lb	22702.8 /lb

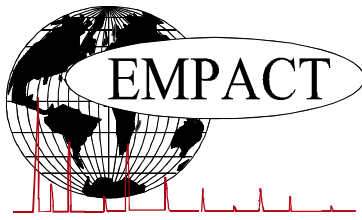
RELATIVE DENSITY (AIR=1): 0.6027
 COMPRESSIBILITY FACTOR : 0.99773

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #: NAME/DESCRIP : **GREC - KIEWIT
U3, SAMPLE A-03**

PROJECT NO. : **201707030** ANALYSIS NO. : **02**

COMPANY NAME : **MCHALE & ASSOCIATES** ANALYSIS DATE: **JULY 13, 2017 13:24**

OFFICE / BRANCH: **KNOXVILLE, TN** SAMPLE DATE : **JULY 6, 2017 23:20**

CUSTOMER REF: **PRJ 17041.0** TO:

PRODUCER : EFFECTIVE DATE:

*****FIELD DATA*****

SAMPLE CYCLE: SAMPLE TYPE:

SAMPLE PRES. : psig CYLINDER NO. : **M-23773**

LAB PRES: psig SAMPLED BY : **HF GROTKOPF**

SAMPLE TEMP. : °f SAMPLING COMPANY: **MCHALE**

AMBIENT TEMP.: °f H2S BY STAIN TUBE: - ppm

H2O BY STAIN TUBE: - #/mmcf CO2 BY STAIN TUBE: - Mol %

FIELD COMMENTS:

LAB COMMENTS:

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.8000	2.8900	---	---
CARBON DIOXIDE	0.60	1.51	---	---
METHANE	90.57370	83.21960	---	---
ETHANE	6.6372	11.4301	1.7781	1.7740
PROPANE	0.2943	0.7432	0.0814	0.0812
I-BUTANE	0.0100	0.0333	0.0030	0.0030
N-BUTANE	0.0180	0.0599	0.0060	0.0060
I-PENTANE	0.0034	0.0140	0.0010	0.0010
N-PENTANE	0.0030	0.0124	0.0010	0.0010
HEXANES PLUS	0.0104	0.0575	0.0010	0.0010
TOTALS	100.00000	100.00000	1.8715	1.8672

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	943.4 /scf	941.2 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	927.0 /scf	924.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1045.7 /scf	1043.3 /scf
XYLENES	0.0004	0.0024	GROSS WET REAL :	1027.5 /scf	1025.1 /scf
TOTAL BTEX	0.0009	0.0049	NET DRY REAL :	20512.9 /lb	20465.6 /lb
			GROSS DRY REAL :	22737.4 /lb	22684.9 /lb

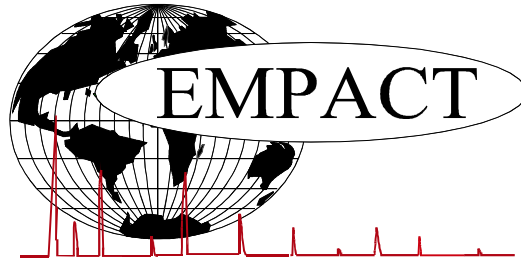
(CALC: GPA STD 2145 & TP-17 @14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6026

COMPRESSIBILITY FACTOR : 0.99773

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	02
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 13:24
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 6, 2017 23:20
PRODUCER :		CYLINDER NO. :	M-23773
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE A-03		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.80	2.89	---	---
Carbon Dioxide	---	0.60	1.51	---	---
Methane	P1	90.57370	83.21960	---	---
Ethane	P2	6.6372	11.4301	1.778	1.774
Propane	P3	0.2943	0.7432	0.081	0.081
i-Butane	I4	0.0100	0.0333	0.003	0.003
n-Butane	P4	0.0180	0.0599	0.006	0.006
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0030	0.0124	0.001	0.001
n-Pentane	P5	0.0030	0.0124	0.001	0.001
2,2-Dimethylbutane	I6	0.0001	0.0005	0.000	0.000
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
2-Methylpentane	I6	0.0010	0.0049	0.000	0.000
3-Methylpentane	I6	0.0006	0.0030	0.000	0.000
n-Hexane	P6	0.0014	0.0069	0.001	0.001
Methylcyclopentane	N6	0.0004	0.0019	0.000	0.000
2,4-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0005	0.0024	0.000	0.000
2-Methylhexane	I7	0.0003	0.0017	0.000	0.000
2,3-Dimethylpentane	I7	0.0002	0.0011	0.000	0.000
1,1-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0004	0.0023	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
UnknownC6s	U6	0.0001	0.0005	0.000	0.000
n-Heptane	P7	0.0007	0.0040	0.000	0.000
Methylcyclohexane	N7	0.0008	0.0045	0.000	0.000
Toluene	A7	0.0003	0.0016	0.000	0.000
2-Methylheptane	I8	0.0003	0.0019	0.000	0.000
4-Methylheptane	I8	0.0001	0.0006	0.000	0.000

1c,2t,3-Trimethylcyclopentane	N8	0.0003	0.0019	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0003	0.0019	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,1,4-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
Ethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0002	0.0012	0.000	0.000
1,4-Dimethylbenzene (p-Xylene)	A8	0.0001	0.0006	0.000	0.000
4-Methyloctane	I9	0.0001	0.0007	0.000	0.000
2-Methyloctane	I9	0.0001	0.0007	0.000	0.000
3-Methyloctane	I9	0.0001	0.0007	0.000	0.000
1,2-Dimethylbenzene (o-Xylene)	A8	0.0001	0.0006	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
TOTAL		100.00000	100.00000	1.8715	1.8672

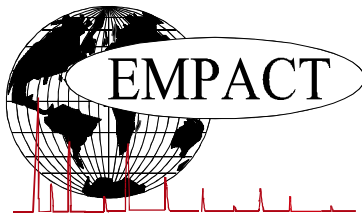
BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	943.4 /scf	941.2 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	927.0 /scf	924.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1045.7 /scf	1043.3 /scf
XYLENES	0.0004	0.0024	GROSS WET REAL :	1027.5 /scf	1025.1 /scf
TOTAL BTEX	0.0009	0.0049	NET DRY REAL :	20512.9 /lb	20465.6 /lb
			GROSS DRY REAL :	22737.4 /lb	22684.9 /lb

RELATIVE DENSITY (AIR=1): 0.6026
 COMPRESSIBILITY FACTOR : 0.99773

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #:		NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE A-05
PROJECT NO. :	201707030	ANALYSIS NO. :	03
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 15:06
OFFICE / BRANCH:	KNOXVILLE, TN	SAMPLE DATE :	JULY 6, 2017 23:35
CUSTOMER REF:	PRJ 17041.0	TO:	
PRODUCER :		EFFECTIVE DATE:	

*****FIELD DATA*****

SAMPLE CYCLE:		SAMPLE TYPE:	
SAMPLE PRES. :	psig	CYLINDER NO. :	M-23779
LAB PRES:	psig	SAMPLED BY :	HF GROTKOPF
SAMPLE TEMP. :	°f	SAMPLING COMPANY:	MCHALE
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE:	- ppm
H2O BY STAIN TUBE:	- #/mmcf	CO2 BY STAIN TUBE:	- Mol %
FIELD COMMENTS:			
LAB COMMENTS:			

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.8300	2.9200	---	---
CARBON DIOXIDE	0.64	1.61	---	---
METHANE	90.18210	82.54420	---	---
ETHANE	6.9122	11.8585	1.8525	1.8482
PROPANE	0.3355	0.8441	0.0924	0.0922
I-BUTANE	0.0110	0.0365	0.0040	0.0040
N-BUTANE	0.0220	0.0730	0.0070	0.0070
I-PENTANE	0.0034	0.0139	0.0010	0.0010
N-PENTANE	0.0040	0.0165	0.0010	0.0010
HEXANES PLUS	0.0098	0.0533	0.0010	0.0010
TOTALS	100.00000	100.00000	1.9589	1.9544

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	945.4 /scf	943.3 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	929.0 /scf	926.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1047.9 /scf	1045.5 /scf
<u>XYLENES</u>	<u>0.0003</u>	<u>0.0018</u>	GROSS WET REAL :	1029.7 /scf	1027.3 /scf
TOTAL BTEX	0.0008	0.0043	NET DRY REAL :	20478.6 /lb	20431.3 /lb
			GROSS DRY REAL :	22697.2 /lb	22644.8 /lb

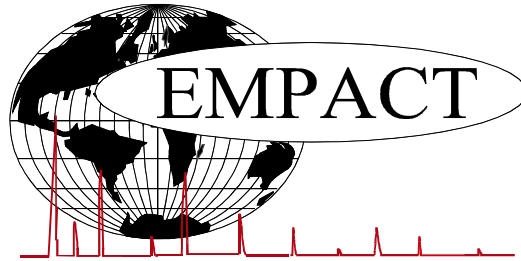
(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6048

COMPRESSIBILITY FACTOR : 0.99772

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	03
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 15:06
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 6, 2017 23:35
PRODUCER :		CYLINDER NO. :	M-23779
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE A-05		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.83	2.92	---	---
Carbon Dioxide	---	0.64	1.61	---	---
Methane	P1	90.18210	82.54420	---	---
Ethane	P2	6.9122	11.8585	1.853	1.848
Propane	P3	0.3355	0.8441	0.092	0.092
i-Butane	I4	0.0110	0.0365	0.004	0.004
n-Butane	P4	0.0220	0.0730	0.007	0.007
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0030	0.0123	0.001	0.001
n-Pentane	P5	0.0040	0.0165	0.001	0.001
2,2-Dimethylbutane	I6	0.0001	0.0005	0.000	0.000
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
2-Methylpentane	I6	0.0011	0.0054	0.000	0.000
3-Methylpentane	I6	0.0006	0.0030	0.000	0.000
n-Hexane	P6	0.0015	0.0074	0.001	0.001
Methylcyclopentane	N6	0.0004	0.0019	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0005	0.0024	0.000	0.000
2-Methylhexane	I7	0.0004	0.0023	0.000	0.000
2,3-Dimethylpentane	I7	0.0002	0.0011	0.000	0.000
3-Methylhexane	I7	0.0004	0.0023	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
UnknownC6s	U6	0.0001	0.0005	0.000	0.000
n-Heptane	P7	0.0008	0.0046	0.000	0.000
Methylcyclohexane	N7	0.0008	0.0045	0.000	0.000
Toluene	A7	0.0003	0.0016	0.000	0.000
2-Methylheptane	I8	0.0003	0.0019	0.000	0.000
4-Methylheptane	I8	0.0001	0.0006	0.000	0.000
1c,2t,3-Trimethylcyclopentane	N8	0.0003	0.0019	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000

1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0003	0.0019	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,1,4-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0002	0.0012	0.000	0.000
1,4-Dimethylbenzene (p-Xylene)	A8	0.0001	0.0006	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
TOTAL		<u>100.00000</u>	<u>100.00000</u>	<u>1.9589</u>	<u>1.9544</u>

BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	945.4 /scf	943.3 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	929.0 /scf	926.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1047.9 /scf	1045.5 /scf
XYLENES	0.0003	0.0018	GROSS WET REAL :	1029.7 /scf	1027.3 /scf
TOTAL BTEX	0.0008	0.0043	NET DRY REAL :	20478.6 /lb	20431.3 /lb
			GROSS DRY REAL :	22697.2 /lb	22644.8 /lb

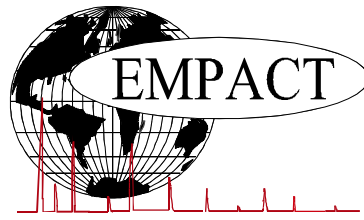
RELATIVE DENSITY (AIR=1): 0.6048

COMPRESSIBILITY FACTOR : 0.99772

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #:		NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE A-07
PROJECT NO. :	201707030	ANALYSIS NO. :	04
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 16:43
OFFICE / BRANCH:	KNOXVILLE, TN	SAMPLE DATE :	JULY 7, 2017 00:00
CUSTOMER REF:	PRJ 17041.0	TO:	
PRODUCER :		EFFECTIVE DATE:	

*****FIELD DATA*****

SAMPLE CYCLE:		SAMPLE TYPE:	
SAMPLE PRES. :	psig	CYLINDER NO. :	M-23822
LAB PRES:	psig	SAMPLED BY :	HF GROTKOPF
SAMPLE TEMP. :	°f	SAMPLING COMPANY:	MCHALE
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE:	- ppm
H2O BY STAIN TUBE:	- #/mmcf	CO2 BY STAIN TUBE:	- Mol %
FIELD COMMENTS:			
LAB COMMENTS:			

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.8400	2.9400	---	---
CARBON DIOXIDE	0.64	1.61	---	---
METHANE	90.12050	82.41510	---	---
ETHANE	6.9499	11.9128	1.8625	1.8582
PROPANE	0.3397	0.8539	0.0934	0.0932
I-BUTANE	0.0120	0.0397	0.0040	0.0040
N-BUTANE	0.0230	0.0762	0.0070	0.0070
I-PENTANE	0.0054	0.0222	0.0020	0.0020
N-PENTANE	0.0050	0.0206	0.0020	0.0020
HEXANES PLUS	0.0145	0.0795	0.0030	0.0030
TOTALS	100.00000	100.00000	1.9739	1.9694

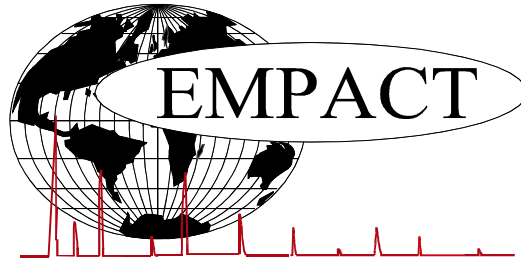
<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.1 /scf	944.0 /scf
TOLUENE	0.0005	0.0026	NET WET REAL :	929.7 /scf	927.5 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.5 /scf	1046.1 /scf
<u>XYLENES</u>	<u>0.0003</u>	<u>0.0018</u>	GROSS WET REAL :	1030.3 /scf	1027.9 /scf
TOTAL BTEX	0.0010	0.0053	NET DRY REAL :	20472.6 /lb	20425.4 /lb
			GROSS DRY REAL :	22690.0 /lb	22637.6 /lb

(CALC: GPA STD 2145 & TP-17 @14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6053
COMPRESSIBILITY FACTOR : 0.99772

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	04
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 16:43
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 00:00
PRODUCER :		CYLINDER NO. :	M-23822
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE A-07		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.84	2.94	---	---
Carbon Dioxide	---	0.64	1.61	---	---
Methane	P1	90.12050	82.41510	---	---
Ethane	P2	6.9499	11.9128	1.863	1.858
Propane	P3	0.3397	0.8539	0.093	0.093
i-Butane	I4	0.0120	0.0397	0.004	0.004
n-Butane	P4	0.0230	0.0762	0.007	0.007
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0050	0.0206	0.002	0.002
n-Pentane	P5	0.0050	0.0206	0.002	0.002
2,2-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
2-Methylpentane	I6	0.0016	0.0079	0.001	0.001
3-Methylpentane	I6	0.0008	0.0039	0.000	0.000
n-Hexane	P6	0.0021	0.0103	0.001	0.001
Methylcyclopentane	N6	0.0006	0.0028	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0007	0.0034	0.000	0.000
2-Methylhexane	I7	0.0005	0.0028	0.000	0.000
2,3-Dimethylpentane	I7	0.0003	0.0017	0.000	0.000
1,1-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0006	0.0034	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
UnknownC6s	U6	0.0002	0.0010	0.000	0.000
n-Heptane	P7	0.0011	0.0063	0.001	0.001
Methylcyclohexane	N7	0.0011	0.0062	0.000	0.000
2,2,3-Trimethylpentane	I8	0.0001	0.0006	0.000	0.000
Toluene	A7	0.0005	0.0026	0.000	0.000
2-Methylheptane	I8	0.0004	0.0026	0.000	0.000
4-Methylheptane	I8	0.0001	0.0006	0.000	0.000

1c,2t,3-Trimethylcyclopentane	N8	0.0004	0.0026	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0002	0.0012	0.000	0.000
1t,2-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0006	0.0039	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,1,4-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
Ethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Propylcyclopentane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0002	0.0012	0.000	0.000
1,4-Dimethylbenzene (p-Xylene)	A8	0.0001	0.0006	0.000	0.000
4-Methyloctane	I9	0.0001	0.0007	0.000	0.000
2-Methyloctane	I9	0.0001	0.0007	0.000	0.000
3-Methyloctane	I9	0.0001	0.0007	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
TOTAL		100.00000	100.00000	1.9739	1.9694

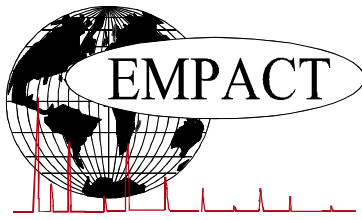
BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.1 /scf	944.0 /scf
TOLUENE	0.0005	0.0026	NET WET REAL :	929.7 /scf	927.5 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.5 /scf	1046.1 /scf
XYLENES	0.0003	0.0018	GROSS WET REAL :	1030.3 /scf	1027.9 /scf
TOTAL BTEX	0.0010	0.0053	NET DRY REAL :	20472.6 /lb	20425.4 /lb
			GROSS DRY REAL :	22690.0 /lb	22637.6 /lb

RELATIVE DENSITY (AIR=1): 0.6053
 COMPRESSIBILITY FACTOR : 0.99772

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #:		NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE B-01
PROJECT NO. :	201707030	ANALYSIS NO. :	05
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 06:27
OFFICE / BRANCH:	KNOXVILLE, TN	SAMPLE DATE :	JULY 7, 2017 03:23
CUSTOMER REF:	PRJ 17041.0	TO:	
PRODUCER :		EFFECTIVE DATE:	

*****FIELD DATA*****

SAMPLE CYCLE:		SAMPLE TYPE:	
SAMPLE PRES. :	psig	CYLINDER NO. :	M-13031
LAB PRES:	psig	SAMPLED BY :	HF GROTKOPF
SAMPLE TEMP. :	°f	SAMPLING COMPANY:	MCHALE
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE:	- ppm
H2O BY STAIN TUBE:	- #/mmcf	CO2 BY STAIN TUBE:	- Mol %
FIELD COMMENTS:			
LAB COMMENTS:			

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.8600	2.9700	---	---
CARBON DIOXIDE	0.65	1.63	---	---
METHANE	89.99610	82.20790	---	---
ETHANE	7.0276	12.0321	1.8837	1.8793
PROPANE	0.3544	0.8898	0.0974	0.0972
I-BUTANE	0.0130	0.0430	0.0040	0.0040
N-BUTANE	0.0260	0.0860	0.0080	0.0080
I-PENTANE	0.0054	0.0222	0.0020	0.0020
N-PENTANE	0.0050	0.0206	0.0020	0.0020
HEXANES PLUS	0.0125	0.0684	0.0020	0.0020
TOTALS	100.00000	100.00000	1.9991	1.9945

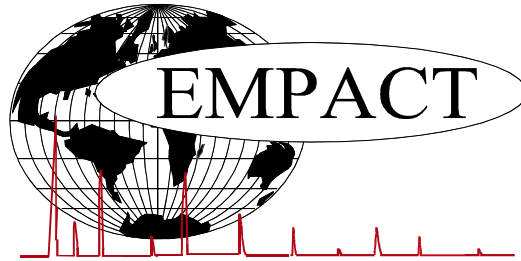
<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.5 /scf	944.4 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	930.0 /scf	927.9 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.9 /scf	1046.5 /scf
<u>XYLENES</u>	<u>0.0003</u>	<u>0.0018</u>	GROSS WET REAL :	1030.7 /scf	1028.3 /scf
TOTAL BTEX	0.0009	0.0048	NET DRY REAL :	20460.1 /lb	20412.8 /lb
			GROSS DRY REAL :	22675.4 /lb	22623.1 /lb

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6061
COMPRESSIBILITY FACTOR : 0.99771

The data presented herein has been acquired by means of current analytical techniques and represents the judicious conclusion EMPACT Analytical Systems, Inc. Results of the analysis can be affected by the sampling conditions, therefore, are only warranted through proper lab protocol. EMPACT assumes no responsibility for interpretation or any consequences from application of the reported information and is the sole liability of the user. The reproduction in any media of this reported information may not be made, in portion or as a whole, without the written permission of EMPACT Analytical Systems, Inc.



EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	05
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 06:27
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 03:23
PRODUCER :		CYLINDER NO. :	M-13031
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE B-01		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

COMPONENT	PIANO #	MOLE %	MASS %	GPM @ 14.730	GPM @ 14.696
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.86	2.97	---	---
Carbon Dioxide	---	0.65	1.63	---	---
Methane	P1	89.99610	82.20790	---	---
Ethane	P2	7.0276	12.0321	1.884	1.879
Propane	P3	0.3544	0.8898	0.097	0.097
i-Butane	I4	0.0130	0.0430	0.004	0.004
n-Butane	P4	0.0260	0.0860	0.008	0.008
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0050	0.0206	0.002	0.002
n-Pentane	P5	0.0050	0.0206	0.002	0.002
2,2-Dimethylbutane	I6	0.0001	0.0005	0.000	0.000
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
2-Methylpentane	I6	0.0014	0.0069	0.001	0.001
3-Methylpentane	I6	0.0008	0.0039	0.000	0.000
n-Hexane	P6	0.0018	0.0088	0.001	0.001
Methylcyclopentane	N6	0.0005	0.0024	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0006	0.0028	0.000	0.000
2-Methylhexane	I7	0.0005	0.0028	0.000	0.000
2,3-Dimethylpentane	I7	0.0002	0.0011	0.000	0.000
1,1-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0005	0.0028	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
UnknownC6s	U6	0.0001	0.0005	0.000	0.000
n-Heptane	P7	0.0009	0.0051	0.000	0.000
Methylcyclohexane	N7	0.0009	0.0050	0.000	0.000
Toluene	A7	0.0004	0.0021	0.000	0.000
2-Methylheptane	I8	0.0003	0.0019	0.000	0.000
4-Methylheptane	I8	0.0001	0.0006	0.000	0.000
1c,2t,3-Trimethylcyclopentane	N8	0.0003	0.0019	0.000	0.000

3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0005	0.0032	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,1,4-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
Ethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Propylcyclopentane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0001	0.0006	0.000	0.000
1,4-Dimethylbenzene (p-Xylene)	A8	0.0001	0.0006	0.000	0.000
4-Methyloctane	I9	0.0001	0.0007	0.000	0.000
2-Methyloctane	I9	0.0001	0.0007	0.000	0.000
3,3-Diethylpentane	I9	0.0001	0.0007	0.000	0.000
1,2-Dimethylbenzene (o-Xylene)	A8	0.0001	0.0006	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
3-Methyl-5-ethylheptane	I10	0.0001	0.0008	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
TOTAL		100.00000	100.00000	1.9991	1.9945

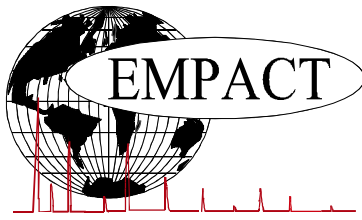
BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.5 /scf	944.4 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	930.0 /scf	927.9 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.9 /scf	1046.5 /scf
XYLENES	0.0003	0.0018	GROSS WET REAL :	1030.7 /scf	1028.3 /scf
TOTAL BTEX	0.0009	0.0048	NET DRY REAL :	20460.1 /lb	20412.8 /lb
			GROSS DRY REAL :	22675.4 /lb	22623.1 /lb

RELATIVE DENSITY (AIR=1): 0.6061
 COMPRESSIBILITY FACTOR : 0.99771

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #:		NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE B-03
PROJECT NO. :	201707030	ANALYSIS NO. :	06
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 08:42
OFFICE / BRANCH:	KNOXVILLE, TN	SAMPLE DATE :	JULY 7, 2017 03:34
CUSTOMER REF:	PRJ 17041.0	TO:	
PRODUCER :		EFFECTIVE DATE:	

*****FIELD DATA*****

SAMPLE CYCLE:		SAMPLE TYPE:	
SAMPLE PRES. :	psig	CYLINDER NO. :	M-23144
LAB PRES:	psig	SAMPLED BY :	HF GROTKOPF
SAMPLE TEMP. :	°f	SAMPLING COMPANY:	MCHALE
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE:	- ppm
H2O BY STAIN TUBE:	- #/mmcf	CO2 BY STAIN TUBE:	- Mol %
FIELD COMMENTS:			
LAB COMMENTS:			

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.9100	3.0500	---	---
CARBON DIOXIDE	0.64	1.60	---	---
METHANE	89.92600	82.10180	---	---
ETHANE	7.0603	12.0818	1.8917	1.8873
PROPANE	0.3476	0.8723	0.0964	0.0962
I-BUTANE	0.0130	0.0430	0.0040	0.0040
N-BUTANE	0.0260	0.0860	0.0080	0.0080
I-PENTANE	0.0055	0.0225	0.0020	0.0020
N-PENTANE	0.0060	0.0246	0.0020	0.0020
HEXANES PLUS	0.0156	0.0880	0.0020	0.0020
TOTALS	100.00000	100.00000	2.0061	2.0015

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.4 /scf	944.3 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	929.9 /scf	927.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.7 /scf	1046.3 /scf
XYLENES	0.0004	0.0024	GROSS WET REAL :	1030.5 /scf	1028.1 /scf
TOTAL BTEX	0.0010	0.0054	NET DRY REAL :	20448.4 /lb	20401.2 /lb
			GROSS DRY REAL :	22662.3 /lb	22610.0 /lb

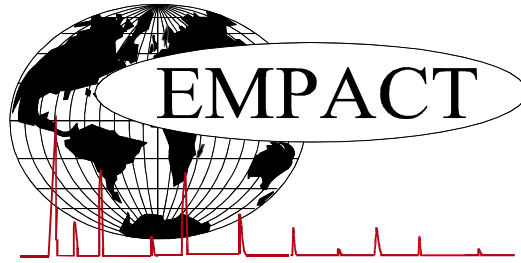
(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6062

COMPRESSIBILITY FACTOR : 0.99771

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	06
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 08:42
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 03:34
PRODUCER :		CYLINDER NO. :	M-23144
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE B-03		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.91	3.05	---	---
Carbon Dioxide	---	0.64	1.60	---	---
Methane	P1	89.92600	82.10180	---	---
Ethane	P2	7.0603	12.0818	1.892	1.887
Propane	P3	0.3476	0.8723	0.096	0.096
i-Butane	I4	0.0130	0.0430	0.004	0.004
n-Butane	P4	0.0260	0.0860	0.008	0.008
2,2-Dimethylpropane	I5	0.0003	0.0012	0.000	0.000
i-Pentane	I5	0.0050	0.0205	0.002	0.002
n-Pentane	P5	0.0060	0.0246	0.002	0.002
2,2-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0003	0.0015	0.000	0.000
2-Methylpentane	I6	0.0016	0.0078	0.001	0.001
3-Methylpentane	I6	0.0009	0.0044	0.000	0.000
n-Hexane	P6	0.0021	0.0103	0.001	0.001
Methylcyclopentane	N6	0.0006	0.0028	0.000	0.000
2,4-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0006	0.0028	0.000	0.000
2-Methylhexane	I7	0.0005	0.0028	0.000	0.000
2,3-Dimethylpentane	I7	0.0002	0.0011	0.000	0.000
1,1-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0006	0.0034	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
2,2,4-Trimethylpentane	I8	0.0001	0.0006	0.000	0.000
UnknownC6s	U6	0.0001	0.0005	0.000	0.000
n-Heptane	P7	0.0010	0.0057	0.000	0.000
1c,2-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
Methylcyclohexane	N7	0.0011	0.0061	0.000	0.000
Ethylcyclopentane	N7	0.0001	0.0006	0.000	0.000

2,4-Dimethylhexane	I8	0.0001	0.0006	0.000	0.000
Toluene	A7	0.0004	0.0021	0.000	0.000
2-Methylheptane	I8	0.0004	0.0026	0.000	0.000
4-Methylheptane	I8	0.0002	0.0013	0.000	0.000
3-Methyl-3-ethylpentane	I8	0.0001	0.0006	0.000	0.000
1c,2t,3-Trimethylcyclopentane	N8	0.0004	0.0026	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0005	0.0032	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,1,4-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
Ethylcyclohexane	N8	0.0002	0.0012	0.000	0.000
n-Propylcyclopentane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0002	0.0012	0.000	0.000
1,4-Dimethylbenzene (p-Xylene)	A8	0.0001	0.0006	0.000	0.000
4-Methyloctane	I9	0.0001	0.0007	0.000	0.000
2-Methyloctane	I9	0.0002	0.0015	0.000	0.000
3,3-Diethylpentane	I9	0.0001	0.0007	0.000	0.000
1,2-Dimethylbenzene (o-Xylene)	A8	0.0001	0.0006	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
5-Methylnonane	I10	0.0001	0.0008	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
n-Undecane	P11	0.0001	0.0009	0.000	0.000
UnknownC11s	U11	0.0001	0.0009	0.000	0.000
n-Dodecane	P12	0.0001	0.0010	0.000	0.000
UnknownC12s	U12	0.0001	0.0009	0.000	0.000
n-Tridecane	P13	0.0001	0.0010	0.000	0.000
TOTAL		100.00000	100.00000	2.0061	2.0015

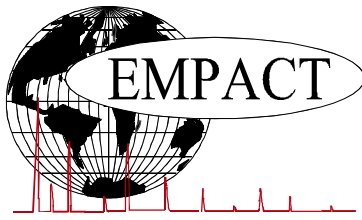
BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.4 /scf	944.3 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	929.9 /scf	927.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.7 /scf	1046.3 /scf
XYLENES	0.0004	0.0024	GROSS WET REAL :	1030.5 /scf	1028.1 /scf
TOTAL BTEX	0.0010	0.0054	NET DRY REAL :	20448.4 /lb	20401.2 /lb
			GROSS DRY REAL :	22662.3 /lb	22610.0 /lb

RELATIVE DENSITY (AIR=1): 0.6062
 COMPRESSIBILITY FACTOR : 0.99771

(CALC: GPA STD 2145 & TP-17 @14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #: NAME/DESCRIP : **GREC - KIEWIT
U3, SAMPLE B-05**

PROJECT NO. : **201707030** ANALYSIS NO. : **07**

COMPANY NAME : **MCHALE & ASSOCIATES** ANALYSIS DATE: **JULY 14, 2017 10:43**

OFFICE / BRANCH: **KNOXVILLE, TN** SAMPLE DATE : **JULY 7, 2017 03:51**

CUSTOMER REF: **PRJ 17041.0** TO:

PRODUCER : EFFECTIVE DATE:

*****FIELD DATA*****

SAMPLE CYCLE: SAMPLE TYPE:

SAMPLE PRES. : psig CYLINDER NO. : **M-10469**

LAB PRES: psig SAMPLED BY : **HF GROTKOPF**

SAMPLE TEMP. : °f SAMPLING COMPANY: **MCHALE**

AMBIENT TEMP.: °f H2S BY STAIN TUBE: - ppm

H2O BY STAIN TUBE: - #/mmcf CO2 BY STAIN TUBE: - Mol %

FIELD COMMENTS:

LAB COMMENTS:

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.8200	2.9000	---	---
CARBON DIOXIDE	0.65	1.63	---	---
METHANE	90.06860	82.32520	---	---
ETHANE	6.9926	11.9797	1.8736	1.8693
PROPANE	0.3576	0.8984	0.0985	0.0982
I-BUTANE	0.0140	0.0464	0.0050	0.0050
N-BUTANE	0.0260	0.0861	0.0080	0.0080
I-PENTANE	0.0054	0.0222	0.0020	0.0020
N-PENTANE	0.0040	0.0165	0.0010	0.0010
HEXANES PLUS	0.0118	0.0655	0.0020	0.0020
TOTALS	100.00000	100.00000	1.9901	1.9855

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.6 /scf	944.5 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	930.1 /scf	928.0 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1049.1 /scf	1046.7 /scf
XYLENES	0.0003	0.0018	GROSS WET REAL :	1030.9 /scf	1028.5 /scf
TOTAL BTEX	0.0008	0.0043	NET DRY REAL :	20475.8 /lb	20428.6 /lb
			GROSS DRY REAL :	22693.0 /lb	22640.6 /lb

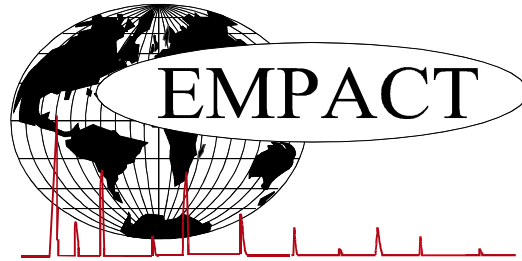
(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6057

COMPRESSIBILITY FACTOR : 0.99771

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	07
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 10:43
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 03:51
PRODUCER :		CYLINDER NO. :	M-10469
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE B-05		

FIELD DATA
 SAMPLE PRES. :
 COMMENTS :

SAMPLE TEMP. :
 AMBIENT TEMP.:

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.82	2.90	---	---
Carbon Dioxide	---	0.65	1.63	---	---
Methane	P1	90.06860	82.32520	---	---
Ethane	P2	6.9926	11.9797	1.874	1.869
Propane	P3	0.3576	0.8984	0.099	0.098
i-Butane	I4	0.0140	0.0464	0.005	0.005
n-Butane	P4	0.0260	0.0861	0.008	0.008
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0050	0.0206	0.002	0.002
n-Pentane	P5	0.0040	0.0165	0.001	0.001
2,2-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
2-Methylpentane	I6	0.0014	0.0069	0.001	0.001
3-Methylpentane	I6	0.0008	0.0039	0.000	0.000
n-Hexane	P6	0.0017	0.0083	0.001	0.001
Methylcyclopentane	N6	0.0005	0.0024	0.000	0.000
2,4-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0005	0.0024	0.000	0.000
2-Methylhexane	I7	0.0004	0.0023	0.000	0.000
2,3-Dimethylpentane	I7	0.0002	0.0011	0.000	0.000
1,1-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0005	0.0029	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
n-Heptane	P7	0.0008	0.0046	0.000	0.000
Methylcyclohexane	N7	0.0008	0.0045	0.000	0.000
2,4-Dimethylhexane	I8	0.0001	0.0006	0.000	0.000
Toluene	A7	0.0003	0.0016	0.000	0.000
2-Methylheptane	I8	0.0002	0.0013	0.000	0.000
4-Methylheptane	I8	0.0002	0.0013	0.000	0.000

1c,2t,3-Trimethylcyclopentane	N8	0.0003	0.0019	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0004	0.0026	0.000	0.000
1,1,4-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
Ethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Propylcyclopentane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0002	0.0012	0.000	0.000
1,4-Dimethylbenzene (p-Xylene)	A8	0.0001	0.0006	0.000	0.000
4-Methyloctane	I9	0.0001	0.0007	0.000	0.000
2-Methyloctane	I9	0.0001	0.0007	0.000	0.000
3,3-Diethylpentane	I9	0.0001	0.0007	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
5-Methylnonane	I10	0.0001	0.0008	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
UnknownC11s	U11	0.0001	0.0009	0.000	0.000
TOTAL		100.00000	100.00000	1.9901	1.9855

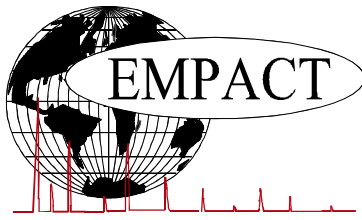
BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.6 /scf	944.5 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	930.1 /scf	928.0 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1049.1 /scf	1046.7 /scf
XYLENES	0.0003	0.0018	GROSS WET REAL :	1030.9 /scf	1028.5 /scf
TOTAL BTEX	0.0008	0.0043	NET DRY REAL :	20475.8 /lb	20428.6 /lb
			GROSS DRY REAL :	22693.0 /lb	22640.6 /lb

RELATIVE DENSITY (AIR=1): 0.6057
 COMPRESSIBILITY FACTOR : 0.99771

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

The data presented herein has been acquired by means of current analytical techniques and represents the judicious conclusion EMPACT Analytical Systems, Inc. Results of the analysis can be affected by the sampling conditions, therefore, are only warranted through proper lab protocol. EMPACT assumes no responsibility for interpretation or any consequences from application of the reported information and is the sole liability of the user. The reproduction in any media of this reported information may not be made, in portion or as a whole, without the written permission of EMPACT Analytical Systems, Inc.



EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #: NAME/DESCRIP : **GREC - KIEWIT
U3, SAMPLE B-07**

PROJECT NO. : **201707030** ANALYSIS NO. : **08**

COMPANY NAME : **MCHALE & ASSOCIATES** ANALYSIS DATE: **JULY 14, 2017 10:30**

OFFICE / BRANCH: **KNOXVILLE, TN** SAMPLE DATE : **JULY 7, 2017 04:14**

CUSTOMER REF: **PRJ 17041.0** TO:

PRODUCER : EFFECTIVE DATE:

*****FIELD DATA*****

SAMPLE CYCLE: SAMPLE TYPE:

SAMPLE PRES. : psig CYLINDER NO. : **M-13131**

LAB PRES: psig SAMPLED BY : **HF GROTKOPF**

SAMPLE TEMP. : °f SAMPLING COMPANY: **MCHALE**

AMBIENT TEMP.: °f H2S BY STAIN TUBE: - ppm

H2O BY STAIN TUBE: - #/mmcf CO2 BY STAIN TUBE: - Mol %

FIELD COMMENTS:

LAB COMMENTS:

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.9000	3.0300	---	---
CARBON DIOXIDE	0.65	1.63	---	---
METHANE	89.94300	82.11530	---	---
ETHANE	7.0259	12.0229	1.8826	1.8783
PROPANE	0.3616	0.9074	0.0995	0.0992
I-BUTANE	0.0150	0.0496	0.0050	0.0050
N-BUTANE	0.0300	0.0993	0.0090	0.0090
I-PENTANE	0.0064	0.0262	0.0020	0.0020
N-PENTANE	0.0060	0.0246	0.0020	0.0020
HEXANES PLUS	0.0121	0.0647	0.0020	0.0020
TOTALS	100.00000	100.00000	2.0021	1.9975

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0003	0.0013	LOW NET DRY REAL :	946.4 /scf	944.3 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	929.9 /scf	927.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.8 /scf	1046.4 /scf
XYLENES	0.0000	0.0000	GROSS WET REAL :	1030.6 /scf	1028.2 /scf
TOTAL BTEX	0.0007	0.0034	NET DRY REAL :	20446.7 /lb	20399.5 /lb
			GROSS DRY REAL :	22660.8 /lb	22608.5 /lb

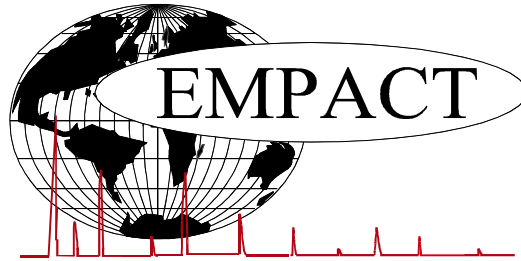
(CALC: GPA STD 2145 & TP-17 @14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6064

COMPRESSIBILITY FACTOR : 0.99771

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	08
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 10:30
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 04:14
PRODUCER :		CYLINDER NO. :	M-13131
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE B-07		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.90	3.03	---	---
Carbon Dioxide	---	0.65	1.63	---	---
Methane	P1	89.94300	82.11530	---	---
Ethane	P2	7.0259	12.0229	1.883	1.878
Propane	P3	0.3616	0.9074	0.100	0.099
i-Butane	I4	0.0150	0.0496	0.005	0.005
n-Butane	P4	0.0300	0.0993	0.009	0.009
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0060	0.0246	0.002	0.002
n-Pentane	P5	0.0060	0.0246	0.002	0.002
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0005	0.0024	0.000	0.000
2-Methylpentane	I6	0.0008	0.0039	0.000	0.000
3-Methylpentane	I6	0.0017	0.0084	0.001	0.001
n-Hexane	P6	0.0022	0.0108	0.001	0.001
Methylcyclopentane	N6	0.0005	0.0024	0.000	0.000
Benzene	A6	0.0003	0.0013	0.000	0.000
Cyclohexane	N6	0.0006	0.0028	0.000	0.000
2-Methylhexane	I7	0.0003	0.0017	0.000	0.000
2,3-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0007	0.0040	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
n-Heptane	P7	0.0010	0.0057	0.000	0.000
Methylcyclohexane	N7	0.0009	0.0050	0.000	0.000
Toluene	A7	0.0004	0.0021	0.000	0.000
2-Methylheptane	I8	0.0003	0.0019	0.000	0.000
3-Methylheptane	I8	0.0002	0.0013	0.000	0.000
1c,2t,3-Trimethylcyclopentane	N8	0.0002	0.0012	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0005	0.0032	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000

n-Nonane	P9	0.0003	0.0022	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
<u>TOTAL</u>		<u>100.00000</u>	<u>100.00000</u>	<u>2.0021</u>	<u>1.9975</u>

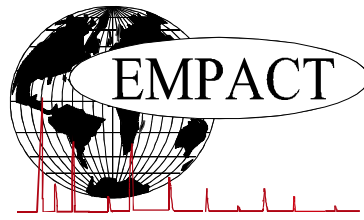
BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0003	0.0013	LOW NET DRY REAL :	946.4 /scf	944.3 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	929.9 /scf	927.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1048.8 /scf	1046.4 /scf
XYLENES	0.0000	0.0000	GROSS WET REAL :	1030.6 /scf	1028.2 /scf
<u>TOTAL BTEX</u>	<u>0.0007</u>	<u>0.0034</u>	NET DRY REAL :	20446.7 /lb	20399.5 /lb
			GROSS DRY REAL :	22660.8 /lb	22608.5 /lb

RELATIVE DENSITY (AIR=1): 0.6064
 COMPRESSIBILITY FACTOR : 0.99771

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #:		NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE B-09
PROJECT NO. :	201707030	ANALYSIS NO. :	09
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 08:18
OFFICE / BRANCH:	KNOXVILLE, TN	SAMPLE DATE :	JULY 7, 2017 04:30
CUSTOMER REF:	PRJ 17041.0	TO:	
PRODUCER :		EFFECTIVE DATE:	

*****FIELD DATA*****

SAMPLE CYCLE:		SAMPLE TYPE:	
SAMPLE PRES. :	psig	CYLINDER NO. :	M-21838
LAB PRES:	psig	SAMPLED BY :	HF GROTKOPF
SAMPLE TEMP. :	°f	SAMPLING COMPANY:	MCHALE
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE:	- ppm
H2O BY STAIN TUBE:	- #/mmcf	CO2 BY STAIN TUBE:	- Mol %
FIELD COMMENTS:			
LAB COMMENTS:			

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.8500	2.9500	---	---
CARBON DIOXIDE	0.65	1.63	---	---
METHANE	90.03350	82.25520	---	---
ETHANE	6.9944	11.9773	1.8746	1.8703
PROPANE	0.3518	0.8835	0.0974	0.0972
I-BUTANE	0.0140	0.0464	0.0050	0.0050
N-BUTANE	0.0291	0.0963	0.0090	0.0090
I-PENTANE	0.0065	0.0267	0.0020	0.0020
N-PENTANE	0.0070	0.0288	0.0030	0.0030
HEXANES PLUS	0.0137	0.0758	0.0020	0.0020
TOTALS	100.00000	100.00000	1.9930	1.9885

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.6 /scf	944.5 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	930.1 /scf	928.0 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1049.1 /scf	1046.7 /scf
<u>XYLENES</u>	<u>0.0003</u>	<u>0.0018</u>	GROSS WET REAL :	1030.9 /scf	1028.5 /scf
TOTAL BTEX	0.0009	0.0048	NET DRY REAL :	20464.6 /lb	20417.4 /lb
			GROSS DRY REAL :	22680.8 /lb	22628.4 /lb

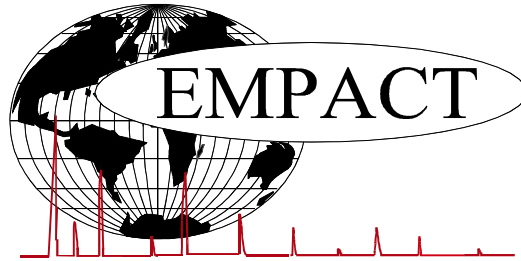
(CALC: GPA STD 2145 & TP-17 @14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6060

COMPRESSIBILITY FACTOR : 0.99771

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	09
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 14, 2017 08:18
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 04:30
PRODUCER :		CYLINDER NO. :	M-21838
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE B-09		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

<u>COMPONENT</u>	<u>PIANO #</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.85	2.95	---	---
Carbon Dioxide	---	0.65	1.63	---	---
Methane	P1	90.03350	82.25520	---	---
Ethane	P2	6.9944	11.9773	1.875	1.870
Propane	P3	0.3518	0.8835	0.097	0.097
i-Butane	I4	0.0140	0.0464	0.005	0.005
n-Butane	P4	0.0291	0.0963	0.009	0.009
2,2-Dimethylpropane	I5	0.0003	0.0012	0.000	0.000
i-Pentane	I5	0.0060	0.0247	0.002	0.002
n-Pentane	P5	0.0070	0.0288	0.003	0.003
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0004	0.0019	0.000	0.000
2-Methylpentane	I6	0.0009	0.0044	0.000	0.000
3-Methylpentane	I6	0.0015	0.0073	0.001	0.001
n-Hexane	P6	0.0022	0.0108	0.001	0.001
Methylcyclopentane	N6	0.0006	0.0028	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0007	0.0034	0.000	0.000
2-Methylhexane	I7	0.0004	0.0023	0.000	0.000
2,3-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0006	0.0034	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
n-Heptane	P7	0.0010	0.0057	0.000	0.000
Methylcyclohexane	N7	0.0012	0.0067	0.000	0.000
Toluene	A7	0.0004	0.0021	0.000	0.000
2-Methylheptane	I8	0.0004	0.0026	0.000	0.000
4-Methylheptane	I8	0.0002	0.0013	0.000	0.000
3-Methylheptane	I8	0.0002	0.0013	0.000	0.000
1c,2t,3-Trimethylcyclopentane	N8	0.0003	0.0019	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0006	0.0039	0.000	0.000

1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0002	0.0012	0.000	0.000
4-Methyloctane	I9	0.0002	0.0015	0.000	0.000
2-Methyloctane	I9	0.0001	0.0007	0.000	0.000
1c,2t,3-Trimethylcyclohexane	N9	0.0001	0.0007	0.000	0.000
1,2-Dimethylbenzene (o-Xylene)	A8	0.0001	0.0006	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
n-Undecane	P11	0.0001	0.0009	0.000	0.000
UnknownC14s	U14	0.0001	0.0011	0.000	0.000
TOTAL		100.00000	100.00000	1.9930	1.9885

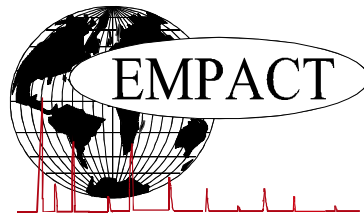
BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.6 /scf	944.5 /scf
TOLUENE	0.0004	0.0021	NET WET REAL :	930.1 /scf	928.0 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1049.1 /scf	1046.7 /scf
XYLENES	0.0003	0.0018	GROSS WET REAL :	1030.9 /scf	1028.5 /scf
TOTAL BTEX	0.0009	0.0048	NET DRY REAL :	20464.6 /lb	20417.4 /lb
			GROSS DRY REAL :	22680.8 /lb	22628.4 /lb

RELATIVE DENSITY (AIR=1): 0.6060
 COMPRESSIBILITY FACTOR : 0.99771

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #:		NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE B-11
PROJECT NO. :	201707030	ANALYSIS NO. :	10
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 16:49
OFFICE / BRANCH:	KNOXVILLE, TN	SAMPLE DATE :	JULY 7, 2017 04:45
CUSTOMER REF:	PRJ 17041.0	TO:	
PRODUCER :		EFFECTIVE DATE:	

*****FIELD DATA*****

SAMPLE CYCLE:		SAMPLE TYPE:	
SAMPLE PRES. :	psig	CYLINDER NO. :	M-24723
LAB PRES:	psig	SAMPLED BY :	HF GROTKOPF
SAMPLE TEMP. :	°f	SAMPLING COMPANY:	MCHALE
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE:	- ppm
H2O BY STAIN TUBE:	- #/mmcf	CO2 BY STAIN TUBE:	- Mol %
FIELD COMMENTS:			
LAB COMMENTS:			

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.02	0.04	---	---
NITROGEN	1.9600	3.1200	---	---
CARBON DIOXIDE	0.65	1.63	---	---
METHANE	89.87990	82.03930	---	---
ETHANE	7.0389	12.0424	1.8867	1.8823
PROPANE	0.3465	0.8693	0.0954	0.0952
I-BUTANE	0.0130	0.0430	0.0040	0.0040
N-BUTANE	0.0270	0.0893	0.0080	0.0080
I-PENTANE	0.0064	0.0262	0.0020	0.0020
N-PENTANE	0.0060	0.0246	0.0020	0.0020
HEXANES PLUS	0.0123	0.0659	0.0020	0.0020
TOTALS	100.00000	100.00000	2.0001	1.9955

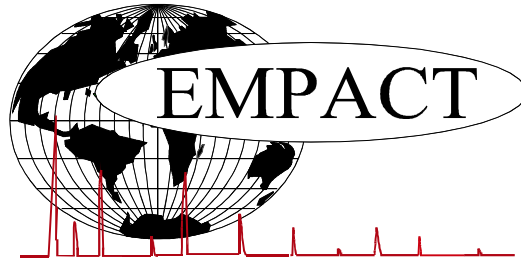
<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0003	0.0013	LOW NET DRY REAL :	945.5 /scf	943.4 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	929.1 /scf	926.9 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1047.8 /scf	1045.4 /scf
XYLENES	0.0001	0.0006	GROSS WET REAL :	1029.6 /scf	1027.2 /scf
TOTAL BTEX	0.0007	0.0035	NET DRY REAL :	20423.4 /lb	20376.3 /lb
			GROSS DRY REAL :	22635.1 /lb	22582.8 /lb

(CALC: GPA STD 2145 & TP-17 @14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6066
COMPRESSIBILITY FACTOR : 0.99771

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	10
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 16:49
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 04:45
PRODUCER :		CYLINDER NO. :	M-24723
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT		
	U3, SAMPLE B-11		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

COMPONENT	PIANO #	MOLE %	MASS %	GPM @ 14.730	GPM @ 14.696
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.02	0.04	---	---
Nitrogen	---	1.96	3.12	---	---
Carbon Dioxide	---	0.65	1.63	---	---
Methane	P1	89.87990	82.03930	---	---
Ethane	P2	7.0389	12.0424	1.887	1.882
Propane	P3	0.3465	0.8693	0.095	0.095
i-Butane	I4	0.0130	0.0430	0.004	0.004
n-Butane	P4	0.0270	0.0893	0.008	0.008
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0060	0.0246	0.002	0.002
n-Pentane	P5	0.0060	0.0246	0.002	0.002
2,2-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
Cyclopentane	N5	0.0002	0.0008	0.000	0.000
2,3-Dimethylbutane	I6	0.0002	0.0010	0.000	0.000
2-Methylpentane	I6	0.0010	0.0049	0.000	0.000
3-Methylpentane	I6	0.0017	0.0084	0.001	0.001
n-Hexane	P6	0.0020	0.0098	0.001	0.001
Methylcyclopentane	N6	0.0006	0.0028	0.000	0.000
Benzene	A6	0.0003	0.0013	0.000	0.000
Cyclohexane	N6	0.0006	0.0028	0.000	0.000
2-Methylhexane	I7	0.0004	0.0023	0.000	0.000
2,3-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
1,1-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0005	0.0028	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
n-Heptane	P7	0.0009	0.0051	0.000	0.000
Methylcyclohexane	N7	0.0009	0.0050	0.000	0.000
Toluene	A7	0.0003	0.0016	0.000	0.000
2-Methylheptane	I8	0.0003	0.0019	0.000	0.000
4-Methylheptane	I8	0.0002	0.0013	0.000	0.000
3-Methylheptane	I8	0.0002	0.0013	0.000	0.000
1c,2t,3-Trimethylcyclopentane	N8	0.0003	0.0019	0.000	0.000

3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000
1t,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
UnknownC7s	U7	0.0001	0.0006	0.000	0.000
n-Octane	P8	0.0003	0.0019	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0001	0.0006	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
TOTAL		<u>100.00000</u>	<u>100.00000</u>	<u>2.0001</u>	<u>1.9955</u>

BTEX COMPONENTS	MOLE%	WT%	BTU @	<u>14.730</u>	<u>14.696</u>
BENZENE	0.0003	0.0013	LOW NET DRY REAL :	945.5 /scf	943.4 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	929.1 /scf	926.9 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1047.8 /scf	1045.4 /scf
XYLENES	0.0001	0.0006	GROSS WET REAL :	1029.6 /scf	1027.2 /scf
TOTAL BTEX	<u>0.0007</u>	<u>0.0035</u>	NET DRY REAL :	20423.4 /lb	20376.3 /lb
			GROSS DRY REAL :	22635.1 /lb	22582.8 /lb

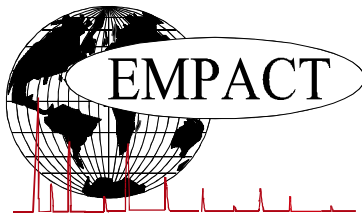
RELATIVE DENSITY (AIR=1): 0.6066
 COMPRESSIBILITY FACTOR : 0.99771

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

MAIN PAGE

LEASE #:		NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE B-13
PROJECT NO. :	201707030	ANALYSIS NO. :	11
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 15:08
OFFICE / BRANCH:	KNOXVILLE, TN	SAMPLE DATE :	JULY 7, 2017 05:14
CUSTOMER REF:	PRJ 17041.0	TO:	
PRODUCER :		EFFECTIVE DATE:	

*****FIELD DATA*****

SAMPLE CYCLE:		SAMPLE TYPE:	
SAMPLE PRES. :	psig	CYLINDER NO. :	M-30404
LAB PRES:	psig	SAMPLED BY :	HF GROTKOPF
SAMPLE TEMP. :	°f	SAMPLING COMPANY:	MCHALE
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE:	- ppm
H2O BY STAIN TUBE:	- #/mmcf	CO2 BY STAIN TUBE:	- Mol %
FIELD COMMENTS:			
LAB COMMENTS:			

<u>COMPONENT</u>	<u>MOLE %</u>	<u>MASS %</u>	<u>GPM @ 14.730</u>	<u>GPM @ 14.696</u>
HELIUM	0.04	0.01	---	---
HYDROGEN	0.00	0.00	---	---
OXYGEN/ARGON	0.01	0.02	---	---
NITROGEN	1.8500	2.9500	---	---
CARBON DIOXIDE	0.67	1.68	---	---
METHANE	89.98180	82.17350	---	---
ETHANE	7.0340	12.0399	1.8847	1.8803
PROPANE	0.3497	0.8778	0.0964	0.0962
I-BUTANE	0.0130	0.0430	0.0040	0.0040
N-BUTANE	0.0270	0.0893	0.0080	0.0080
I-PENTANE	0.0055	0.0225	0.0020	0.0020
N-PENTANE	0.0060	0.0246	0.0020	0.0020
HEXANES PLUS	0.0130	0.0694	0.0020	0.0020
TOTALS	100.00000	100.00000	1.9991	1.9945

<u>BTEX COMPONENTS</u>	<u>MOLE%</u>	<u>WT%</u>	<u>BTU @ 14.730</u>	<u>14.696</u>	
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.4 /scf	944.3 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	929.9 /scf	927.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1049.0 /scf	1046.6 /scf
<u>XYLENES</u>	<u>0.0002</u>	<u>0.0012</u>	GROSS WET REAL :	1030.8 /scf	1028.4 /scf
TOTAL BTEX	0.0007	0.0037	NET DRY REAL :	20453.6 /lb	20406.4 /lb
			GROSS DRY REAL :	22668.4 /lb	22616.1 /lb

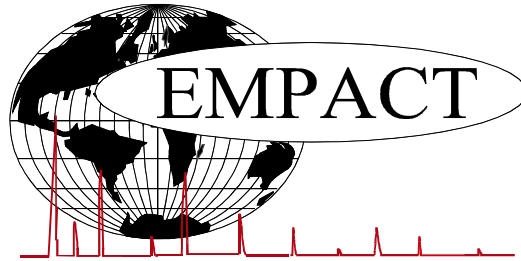
(CALC: GPA STD 2145 & TP-17 @14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

RELATIVE DENSITY (AIR=1): 0.6062

COMPRESSIBILITY FACTOR : 0.99771

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EXTENDED NATURAL GAS ANALYSIS (*DHA)

DHA COMPONENT LIST

PROJECT NO. :	201707030	ANALYSIS NO. :	11
COMPANY NAME :	MCHALE & ASSOCIATES	ANALYSIS DATE:	JULY 13, 2017 15:08
ACCOUNT NO. :	PRJ 17041.0	SAMPLE DATE :	JULY 7, 2017 05:14
PRODUCER :		CYLINDER NO. :	M-30404
LEASE NO. :		SAMPLED BY :	HF GROTKOPF
NAME/DESCRIP :	GREC - KIEWIT U3, SAMPLE B-13		

FIELD DATA

SAMPLE PRES. :		SAMPLE TEMP. :	
COMMENTS :		AMBIENT TEMP.:	

COMPONENT	PIANO #	MOLE %	MASS %	GPM @ 14.730	GPM @ 14.696
Helium	---	0.04	0.01	---	---
Oxygen/Argon	---	0.01	0.02	---	---
Nitrogen	---	1.85	2.95	---	---
Carbon Dioxide	---	0.67	1.68	---	---
Methane	P1	89.98180	82.17350	---	---
Ethane	P2	7.0340	12.0399	1.885	1.880
Propane	P3	0.3497	0.8778	0.096	0.096
i-Butane	I4	0.0130	0.0430	0.004	0.004
n-Butane	P4	0.0270	0.0893	0.008	0.008
2,2-Dimethylpropane	I5	0.0002	0.0008	0.000	0.000
i-Pentane	I5	0.0050	0.0205	0.002	0.002
n-Pentane	P5	0.0060	0.0246	0.002	0.002
2,2-Dimethylbutane	I6	0.0001	0.0005	0.000	0.000
Cyclopentane	N5	0.0003	0.0012	0.000	0.000
2,3-Dimethylbutane	I6	0.0003	0.0015	0.000	0.000
2-Methylpentane	I6	0.0011	0.0054	0.000	0.000
3-Methylpentane	I6	0.0018	0.0088	0.001	0.001
n-Hexane	P6	0.0025	0.0122	0.001	0.001
Methylcyclopentane	N6	0.0007	0.0034	0.000	0.000
Benzene	A6	0.0002	0.0009	0.000	0.000
Cyclohexane	N6	0.0006	0.0028	0.000	0.000
2-Methylhexane	I7	0.0004	0.0023	0.000	0.000
2,3-Dimethylpentane	I7	0.0001	0.0006	0.000	0.000
1,1-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
3-Methylhexane	I7	0.0005	0.0028	0.000	0.000
1c,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,3-Dimethylcyclopentane	N7	0.0001	0.0006	0.000	0.000
1t,2-Dimethylcyclopentane	N7	0.0002	0.0011	0.000	0.000
n-Heptane	P7	0.0009	0.0051	0.000	0.000
Methylcyclohexane	N7	0.0010	0.0056	0.000	0.000
Toluene	A7	0.0003	0.0016	0.000	0.000
2-Methylheptane	I8	0.0003	0.0019	0.000	0.000
3-Methylheptane	I8	0.0002	0.0013	0.000	0.000
1c,2t,3-Trimethylcyclopentane	N8	0.0002	0.0012	0.000	0.000
3-Ethylhexane	I8	0.0001	0.0006	0.000	0.000

n-Octane	P8	0.0006	0.0039	0.000	0.000
1c,4-Dimethylcyclohexane	N8	0.0001	0.0006	0.000	0.000
1,3-Dimethylbenzene (m-Xylene)	A8	0.0001	0.0006	0.000	0.000
1,2-Dimethylbenzene (o-Xylene)	A8	0.0001	0.0006	0.000	0.000
n-Nonane	P9	0.0002	0.0015	0.000	0.000
n-Decane	P10	0.0001	0.0008	0.000	0.000
TOTAL		100.00000	100.00000	1.9991	1.9945

BTEX COMPONENTS	MOLE%	WT%	BTU @	14.730	14.696
BENZENE	0.0002	0.0009	LOW NET DRY REAL :	946.4 /scf	944.3 /scf
TOLUENE	0.0003	0.0016	NET WET REAL :	929.9 /scf	927.8 /scf
ETHYLBENZENE	0.0000	0.0000	HIGH GROSS DRY REAL :	1049.0 /scf	1046.6 /scf
XYLENES	0.0002	0.0012	GROSS WET REAL :	1030.8 /scf	1028.4 /scf
TOTAL BTEX	0.0007	0.0037	NET DRY REAL :	20453.6 /lb	20406.4 /lb
			GROSS DRY REAL :	22668.4 /lb	22616.1 /lb

RELATIVE DENSITY (AIR=1): 0.6062
 COMPRESSIBILITY FACTOR : 0.99771

(CALC: GPA STD 2145 & TP-17 @ 14.696 & 60 F)

*(DETAILED HYDROCARBON ANALYSIS/NJ 1993) ; ASTM D6730

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201707030

CHAIN OF CUSTODY FORM FOR NATURAL GAS



Please analyze the enclosed fuel samples by the methods indicated below.

Project Name GREC-Kiewit

Project Number 17041.0

TEST CODE SECTIONS (REFERENCE ONLY)

ASME PTC 22-1997	4.12.5	4.12.6
ASME PTC 22-2005	4-4.4.1	4-4.4
ASME PTC 46-1996	-	4.5.3

Other (Write-In Below)

Description	LHV / HHV	Composition						
	ASTM D 3588	ASTM D 1945						

SAMPLES TO BE ANALYZED

A-01-12248								
A-03-23773								
A-05-23799								
A-07-23822								
B-01-13031								
B-03-23144								
B-05-10469								
B-07-13131								
B-09-21838								
B-11-24723								
B-13-30404								

If extended analysis check here _____

Turn Around Time: _____ Business Days

Retention Time: _____ Business Days

Unless otherwise specified, sample analyses should be completed within 5 business days of receipt of the samples by the laboratory. Additionally, any unused or referee samples should be retained for 30 business days after issuance of certificates of analysis, unless otherwise specified.

Requested/Sent By: Cory Smith
NAME

Cory.Smith@mchaleperformance.com
E-MAIL

865-282-0855
PHONE

Please email the lab analysis results to the following parties
Party 1 _____

Party 2 _____

Party 3 _____

FOR LAB USE ONLY

Received By: Eric Hoffman
PRINT

[Signature]
SIGN

7/10/17 16:54
DATE

Proj. Name/No.: _____

P.O. Number: _____

Notes: _____

REMARKS:	SAMPLE #	REMARKS
(Please place additional notes on the back of this sheet)		

McHale - Redmond, WA
425-883-2058

McHale - Knoxville, TN
865-588-2654

McHale - Arvada, CO
303-800-3739

APPENDIX I

SIGNED DEVIATION LETTER



July 6, 2017

Subject: GREC U3 EPC Performance Test Deviations

The following are a list of the test deviations/clarifications from the current performance test procedure (73.09.02.010_TP_EPC – PERFORMANCE TEST PROCEDURE) Revision 1, Dated 5/17/2017:

Deviations:

- Section 2.3 and Appendix C of the procedure state that the auxiliary power will be measured using a temporary instrument at five-minute time intervals. All parties to the test agree to use the station instruments (which have been validated using temporary instruments) for the HRSG Aux Power measurement and to use the STG Aux Power measurements taken using a temporary instrument one time after the performance test.
- All parties to the test agree two closed cooling water heat exchangers will be in service during testing as one heat exchanger is insufficient to support plant operation.
- All parties to the test agreed the fuel gas heater 3 way gas bypass valve will not be closed during the testing. This is inconsistent with the thermal design of the plant, but required by MHPSA to support CTG operation.
- All parties to the test agree that an IGV inspection shall not be performed within 24 fired hours of the start of testing.
- All parties to the test agree that a separate pretest need not be performed.
- All parties to the test agree that in order to accurately measure the cooling steam going to the gas turbine, the HP backup steam warming line and the associated DSH (03-V035635 and 03-TV-035636) shall be closed for the duration of the testing.
- All parties to the test agree that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in "high power" mode after a load change.

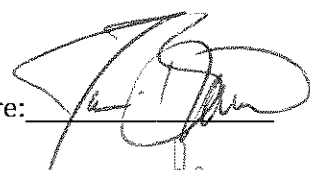
Clarifications:

- At this time, testing will only be conducted for the unfired conditions.
- The vacuum pump heat exchangers will be run on service water in between test runs, and switched to circulating water for the test runs to minimize fouling of the strainers and heat exchangers.
- The most recent fuel gas analysis available will be used for calculation of preliminary results instead of the station gas chromatograph.

Approval Signatures:

GRDA Representative

Print Name: Jammita Burrow

Signature:  7/11/17

Kiewit Representative

Print Name: PARAG PATHAK

Signature:  07/10/17



July 6, 2017

Subject: GREC U3 CTG Performance Test Deviations

The following are a list of the test deviations/clarifications from the current performance test procedure (73.09.02.010_TP_CTG – PERFORMANCE TEST PROCEDURE) Revision 2, Dated 6/21/2017:

Deviations:

- All parties to the test agreed the fuel gas heater 3 way gas bypass valve will not be closed during the testing. This is inconsistent with the thermal design of the plant, but required by MHPSA to support CTG operation.
- All parties to the test agree that an IGV inspection shall not be performed within 24 fired hours of the start of testing.
- All parties to the test agree that a separate pretest need not be performed.
- All parties to the test agree that in order to accurately measure the cooling steam going to the gas turbine, the HP backup steam warming line and the associated DSH (03-V035635 and 03-TV-035636) shall be closed for the duration of the testing.
- All parties to the test agree that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in "high power" mode after a load change.
- All parties to the test agree that the CTG is not required to operate only in exhaust temperature control mode, but rather operation on either blade path temperature control or exhaust temperature control is acceptable.

Clarifications:

- At this time, testing will only be conducted for the unfired conditions.
- There are 9 RH transmitters measuring ambient RH. 3 were provided by MHI and 6 were provided by Kiewit.
- The most recent fuel gas analysis available will be used for calculation of preliminary results instead of the station gas chromatograph.

Approval Signatures:

GRDA Representative

Print Name:

James Burrow

Signature:

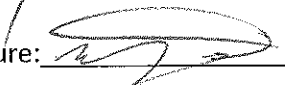
 7/9/17

MHPS Representative

Print Name:

Marc Fujinaka

Signature:

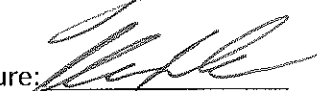
 7/7/17

Kiewit Representative

Print Name:

Adam Decker

Signature:

 7/7/17



July 6, 2017

Subject: GREC U3 HRSG Performance Test Deviations

The following are a list of the test deviations/clarifications from the current performance test procedure (73.09.02.010_TP_HRSG – PERFORMANCE TEST PROCEDURE) Revision 2, Dated 6/2/2017:

Deviations:

- o Appendix C of the procedure states the auxiliary power will be measured using a temporary instrument. All parties to the test agree to use the station instruments (which have been validated using temporary instruments) for this measurement.
- o All parties to the test agree that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in "high power" mode after a load change.

Clarifications:

- o *Testing was only conducted for the unfired conditions.* BHP 7/10/17 PSP 07/10/17
~~At this time, testing will only be conducted for the unfired conditions.~~ 7/11/17
- o The most recent fuel gas analysis available will be used for calculation of preliminary results instead of the station gas chromatograph.

Approval Signatures:

GRDA Representative

Print Name: Jaminto Burrow

Signature: [Signature] 7/11/17

NE Representative

Print Name: Brendan H. Phillips

Signature: [Signature]

Kiewit Representative

Print Name: PARAG PATHAK

Signature: [Signature]



July 6, 2017

Subject: GREC U3 STG Performance Test Deviations

The following are a list of the test deviations/clarifications from the current performance test procedure (73.09.02.010_TP_STG – PERFORMANCE TEST PROCEDURE) Revision 2, Dated 6/9/2017:

Deviations:

- Section 3.5.2.7 of the procedure states the unfired f_{Design} is 0.0693. All parties to the test agree to the correct value is 0.0369.
- Section 2.3 and Appendix C of the procedure state that the auxiliary power will be measured using a temporary instrument at five-minute time intervals. All parties to the test agree to use the STG Aux Power measurements taken using a temporary instrument one time after the performance test.
- One of the steam turbine balance pipe sensing lines on DP1 is plugged and cannot be cleared. All parties to the test agree to use the design value for the flows through the balance piping.
- All parties to the test agree that there shall be no load change between test runs 2 and 3 due to the length of time required to get the CTG back in “high power” mode after a load change.


Clarifications:

- At this time, testing will only be conducted for the unfired conditions.

Approval Signatures:

GRDA Representative

Print Name: Jamie Burrow

Signature:  7/11/17

MHI Representative

Print Name: YUKI SUMI

Signature: Y. Sumi

Kiewit Representative

Print Name: PARAG PATHAK

Signature:  07/10/17