CERAMIC FILTRATION UNIT GLASS WOOL FIBER EMISSIONS ANALYSIS

HOLLINGSWORTH & VOSE FIBER COMPANY

Prepared for

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The material and data in this report were prepared under the supervision and direction of the undersigned.

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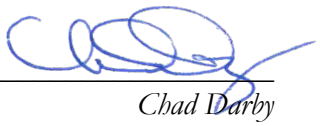

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ACRONYMS AND ABBREVIATIONS

Bison	Bison Engineering
CAO	Cleaner Air Oregon
CFU	Ceramic Filtration Unit
Chemoptix	Chemoptix Microanalysis, LLC
DEQ	Oregon Department of Environmental Quality
the facility	specialty glass fiber manufacturing facility
FB	flameblown
H&V	Hollingsworth & Vose Fiber Company
MFA	Maul Foster & Alongi, Inc.
PM	particulate matter
PTFE	Polytetrafluoroethylene
RC	rotary coarse
RF	rotary fine
URC	ultra rotary coarse

SUMMARY

Hollingsworth & Vose Fiber Company (H&V), in Corvallis, Oregon, has completed a study of process emissions to determine whether glass wool fiber is being emitted from any of the ceramic filtration units (CFUs) employed on-site for particulate matter (PM) emissions control. On November 2-5, 2022, Bison Engineering (Bison) conducted EPA Method 5 sampling on the discharge points of four CFUs, representing exhaust from the four primary fiber sizes/types manufactured by the facility. Samples were collected over three-hour test runs on both glass fiber filters (for gravimetric analysis) and polytetrafluoroethylene (PTFE) filters (for microscopy) concurrently. The gravimetric analysis confirmed that all tested emission points had measurable filterable PM emissions in one or more test runs. The microscopy analysis was conducted by Chemoptix Microanalysis, LLC (Chemoptix) on the PTFE filters for each test run of each CFU sampled. One filter from each CFU test was examined under greater magnification (500 times) to evaluate individual fiber dimensions. Fibers potentially meeting the glass wool fiber definition were found on only three of the four PTFE filters. No glass wool fibers were found on the ultra-rotary coarse (URC) test filter. Out of 400 total fields of view (100 fields of view on each PTFE filter) at 500 times magnification, only four potential glass wool fibers were found in total. While these fibers may or may not be glass wool, if they were to be treated as such, Chemoptix estimated that the fibers would account for less than 1 percent of the total mass of PM collected.

1 INTRODUCTION

H&V owns and operates a specialty glass fiber manufacturing facility (the "facility") that is regulated under Standard Air Contaminant Discharge Permit Number 02-2173-ST-01. The facility is located at 1115 SE Crystal Lake Drive in Corvallis, Oregon 97339. The facility consists of two buildings where manufacturing occurs, which are referred to as Glass Plant 1 and Glass Plant 2. Additional buildings are used for storage, maintenance, and administration.

The first stage of specialty glass fiber manufacturing at the facility involves melting solid raw materials in an electrically heated melting furnace. The molten glass is then delivered via natural gas-fired forehearths to stations that produce the fiber by either a rotary or flameblown fiberizer. Natural gas is combusted to maintain molten glass temperature as it passes through the forehearths. The fiber types produced by the facility are classified as rotary fine (RF), rotary coarse (RC), ultra-rotary coarse (URC), or flameblown (FB) based on fiber size and manufacturing method. Emission factors are based on these classifications. In all cases, the glass fibers are typically hundreds of microns in length, which is what allows the fibers to form mats for collection and for use in final products.

Exhaust from the glass melting furnaces, forehearths and all fiberizer positions installed at the facility is routed to CFUs for control of PM emissions. The CFUs, eighteen in total, each include hundreds of low-density ceramic filters arranged in parallel within an enclosure that functions similar to bags in a baghouse. CFU technology was chosen for its extremely high control efficiency and ability to collect and clear PM that might otherwise plug a traditional fabric-filter baghouse.

While numerous PM source tests over the last several years have demonstrated that the CFUs have an extremely low emissions rate, these tests do not identify the composition of the emitted material. For the purposes of the Cleaner Air Oregon (CAO) air toxics program, knowing the composition of the emissions can be important. The potential sources of process-related PM emissions from the CFUs include natural gas combustion products, bulking agent material used to help remove material from the CFUs during the cleaning cycle, glass wool fibers, and glass fragments or particles.

Glass wool fibers are synthetic vitreous fibers that are "at least 5 micrometers long and have an aspect ratio of at least 3 to 1 or sometimes 5 to 1 (the aspect ratio is the ratio of a fiber's length to its diameter)." [1] Glass wool fibers are a listed toxic air contaminant under the CAO program (ID 352). However, due to the length of the fibers in this classification it is believed that fibers are unable to pass through the ceramic filters in the CFUs.

In a letter dated September 22, 2022 from the Oregon Department of Environmental Quality (DEQ) to Anita Ragan at H&V, the DEQ stated it "recognizes that particles larger than 5 micrometers in length are not likely to travel through the CFU filtration media; however, potential emissions from these TEUs include leakage from ceramic filter seals and voids." Based on this, the DEQ

[1] Agency for Toxic Substances and Disease Registry. 2004. Toxicological Profile for Synthetic Vitreous Fibers (Update). U.S. Department of Health and Human Services. Public Health Service, Atlanta, GA.

recommended that H&V assume 100% of the filterable PM emissions (based on previous source tests) are glass wool fibers for purposes of the CAO emissions inventory.

H&V continuously monitors pressure drop and performs extensive dye testing on their CFUs to ensure the integrity of seals. There are also no "voids" in the CFUs leading to atmosphere. Based on this it was believed that the filterable PM is most likely not glass fiber, but the result of natural gas combustion products, bulking agent, or glass shot (small rounded glass particles formed from the fiberizers).

To test this hypothesis, H&V studied the CFU emissions with the intent of answering two questions:

1. Are the filterable PM emissions from the CFUs glass wool fibers?
2. If there are glass wool fibers present in the exhaust of the CFUs, how much of the filterable PM emission rate do they likely represent?

2 CFU FIBER EMISSIONS STUDY

To better understand the nature of the filterable PM emissions, H&V, Maul Foster & Alongi (MFA), and Bison collaborated and discussed several test methods or techniques that could be used. Ultimately it was decided that microscopy would be needed because glass wool fibers have specific dimensions (length and aspect ratio) that, if detected, would need to be measured. Chemical composition alone would not answer the question of whether glass particles were glass wool fibers. MFA and Bison consulted Chemoptix, owned by Stan Cassell and located in West Linn, Oregon, to help design a test program that would evaluate the presence of glass wool fibers.

2.1 Sampling Method

To conduct microscopy two requirements are critical: a sampling technique is needed that is recognized by regulatory agencies as capturing total filterable PM, and the sampling substrate must be a material that allows a microscopist to distinguish captured material from the substrate. It was decided that EPA Method 5 would be used to capture filterable material as this is the widely accepted method for capturing total PM.

2.2 Sampling Media

Chemoptix was instrumental in helping determine the optimal sampling media for Method 5. Choices included glass, quartz, and PTFE (commonly referred to as Teflon®) filters. Each of these has unique potential challenges for the purpose of this study. Both glass and quartz filters are made from materials that are similar in composition to the glass fiber manufactured at H&V. As a result, light reflection and refraction could make it difficult to get an accurate visual evaluation of the filters. PTFE filters do not have this issue as they are made from a completely different material. However, MFA learned from Chemoptix that PTFE filters have another issue that may affect microscopy but will not affect Method 5 sampling. In the manufacturing process the filter surface can develop a corrugated pattern

of ridges and troughs that are imperceptible to the naked eye but are problematic under a microscope when looking at lengths measured in microns. These ridges and troughs create shadows and lines that can result in inaccurate or difficult observations of the filter surface. Chemoptix indicated to MFA that they have seen this manufacturing issue in about 50 percent of PTFE filters.

To determine the appropriate sample media, Bison provided Chemoptix with glass, quartz, and PTFE filters and H&V provided Chemoptix with samples of fiber from their process. After placing some of the glass fiber material on each of these filter types, Chemoptix determined that PTFE filters would work best for this study. Moreover, Chemoptix determined that the PTFE filters provided by Bison did not have any corrugation from the manufacturing process.

It should be noted that even blemish-free PTFE filters have a top and bottom surface that is nearly identical and does not affect sampling for gravimetric analysis. However, the bottom surfaces of the filters have intentional ribs that most likely are present for structural support.

2.3 CFU Testing

Bison conducted emission testing of four CFUs from November 2-5, 2022.

Testing at each CFU involved operating a Method 5 sampling train for three, 3-hour test runs using a PTFE filter to collect total PM. Simultaneously, Bison operated a Method 5 sampling train with standard glass filters to collect total PM for gravimetric analysis. The purpose of the gravimetric analysis was to demonstrate that PM emissions, during the collection of material for microscopy, were consistent with emission rates typically expected. The Bison source test report is provided as Attachment A.

PTFE filters from the H&V testing were shipped to Chemoptix for analysis by microscopy. Glass fiber filters were analyzed by gravimetric analysis at Bison's lab in Helena, Montana. The Chemoptix report can be found as Attachment B.

Testing resulted in three filters for gravimetric analysis and three filters for microscopic analysis for each CFU. The microscopy was conducted at two magnifications: 100 times and 500 times. One filter for each fiber type was analyzed by 500 times magnification to resolve the specific dimensions of fibers captured on filters and to determine whether they met the length and aspect rations that define "glass wool fiber." Each of these four filters analyzed at 500 times magnification were examined at 100 transect locations on the filter's surface for a total of 400 transects examined. These filters are listed in Table 1.

Table 1. PTFE Sample Filters Examined at 500 Times Magnification

CFU	Sample Run Filter Examined	Chemoptix ID	Sample Media	H&V Fiber Type	Sample Date
CFU-112	1	G-MIC-12305	PTFE Membrane	Ultra Rotary Coarse	11/2/22
CFU-108	1	G-MIC-12308	PTFE Membrane	Rotary Coarse	11/3/22
CFU-118	1	G-MIC12311	PTFE Membrane	Rotary Fine	11/4/22
CFU-115*	2	G-MIC12315	PTFE Membrane	Flameblown	11/5/22

* In some cases, PTFE filters were sampled with the ribbed side up, resulting in nearly imperceptible ridges that restrict how closely a microscope lens can approach the surface. For instance, the PTFE filter from Run 1 of CFU-115 testing was oriented with the ribbed side up, so sample Run 2 was used for scanning for specific fibers at 500x magnification.

The remaining eight PTFE filters were examined at 100 times magnification for two reasons:

1. 500 times magnification transects are extremely labor intensive to conduct.
2. 100 times magnification provides better resolution of overall surface coverage of PM for estimating the portion of the filterable mass that is glass wool fiber.

3 STUDY FINDINGS

Source testing conducted by Bison using Method 5 with gravimetric analysis confirmed that PM emission rates from the CFUs during testing were as expected compared to previous compliance testing. This confirmed that microscopy should be able to see and identify PM normally present in CFU emissions. Some sample runs resulted in no mass detected after blank corrections were applied. However, as we learned from the microscopy there are extremely low levels of various non-fiber materials collected on all filters, regardless of the gravimetric results, and much of it looks like background PM (insect molts, skin cells, clothing and paper fibers, rust, and flooring abrasion particles). It is possible that the filter blanks acquired equal or more background PM during handling.

Due to the labor intensity of viewing filters in an extensive number of locations at distances measuring in microns, Chemoptix selected one PTFE filter for each CFU for examination at 500 times magnification to quantify the dimensions of any fibers found. All other PTFE filters were examined at 100 times magnification to get a better idea of overall deposition and composition of filterable PM.

The following findings from the 500 times magnification filter examinations suggest that little, and perhaps no, glass wool fiber is emitted from the CFUs:

- No glass wool fiber was found on the filter from Run 1 of CFU-112 (URC).
- Two glass wool fibers were found on the PTFE filter from Run 1 of CFU-108 (RC).
- One glass wool fiber was found on each of the PTFE filters from Run 1 of CFU-118 (RF) and Run 2 of CFU-115 (FB).

While the microscopy identified what appear to be glass wool fibers on three of the four filters examined, the number of fibers suggest that they could easily be from contamination during sample handling. The samples did contain epithelial slough (skin fragments) and fiber that appeared to be from textiles and paper, suggesting that during the transfer of filters to the sample containers dust may have settled onto the filters from clothing or skin, which could also explain the transfer of glass fiber to the filter surface. One glass fiber was identified as being greater than 100 micrometers in length (CFU-118), which seems far too large to pass through the ceramic filter media. Given the care with which the facility tests the CFUs for leakage it is unlikely that this was the source of the fiber. H&V conducts both external and internal (dye testing) inspections to ensure leakage is not an issue with the CFUs. Additionally, if the observed fibers had been due to leakage around a seal, far more fiber would likely have been found on the filter. Chemoptix made the following selected conclusions from their analysis:

- "Glass wool appears to be present only at trace levels to other particles contributing mass to these membranes. Their total mass is below quantitation. Glass wool fibers thus represent considerably less than <1% of the mass balance on these membranes.
- The accumulated mass on these filters appears to be related to the facility and ambient air, and not directly to manufacturing processes."

4 CONCLUSIONS

Based on both the quantitative and qualitative analyses conducted by Bison and Chemoptix, it appears that little, if any, glass wool fiber, having a length of greater than 5 micrometers and an aspect ratio of at least 3 to 1, is present in the emissions from the CFUs employed by H&V. To conservatively quantify glass fiber emissions from the CFUs for the CAO program, a value of 1% of the filterable particulate emission rate will be estimated.

LIMITATIONS

The services undertaken in completing this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

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APPENDIX A

CERAMIC FILTRATION UNITS PARTICULATE MATTER TESTING- BISON ENGINEERING, INC.

APPENDIX B

ANALYSIS OF PARTICLES DEPOSITED ON PTFE MEMBRANES- CHEMOPTIX MICROANALYSIS, LLC