Oregon DEQ Wastewater Pump Station Design Standards

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DEQ

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Oregon DEQ Wastewater Pump Station Design Standards

1. General

1.1 Purpose

This DEQ document provides recommendations and requirements regarding wastewater pump station design – which components should be considered by design engineers, and which must be provided for approval by DEQ. The objective of these standards is to benefit the design and construction of wastewater pump stations so that failures that cause spills or backups of sewage occur only under the most extreme circumstances. These guidelines supplement, but do not supercede, Oregon Administrative Rules 340-052 Appendix B.

There are many textbooks and standards to guide design of pump stations so as to achieve the functionality and reliability described herein; DEQ reviews each pump station design on a case-by-case basis which enables a customized approach toward achieving these objectives. These standards apply to rotodynamic pumps, such as centrifugal pumps and axial flow pumps. They do not apply to positive displacement pumps.

Wastewater utilities are encouraged to develop supplemental standards as necessary to address local needs. Conflicts between the utility's established standards and the information herein should be discussed with DEQ and resolved at the preliminary design phase, or earlier. In general, the more conservative approach is encouraged.

1.2 Applicability

These guidelines apply to the design of sewage pump stations where DEQ has review responsibility under state law. Thus they apply to all pump stations serving two or more homes on two or more tax lots, which is considered a common sewer system.

These guidelines also apply to private facilities, even if on a single tax lot, from which sewage flows cannot readily be halted in cases of equipment breakdown or overload, potentially causing a raw sewage overflow. Otherwise, private facilities are regulated by the plumbing code. These guidelines do not apply to pump stations at individual homes or factories, where sewage can readily be halted and the station can be removed from service without risk of a sewage overflow. This document does not apply to onsite sewage disposal systems, which follow state standards established in OAR 340-071 and OAR 340-073.

1.3 Fee for DEQ Plan Review

Technical activities fees are applicable for station reviews as set forth in OAR 340-045-0075 Table 70F. The fees can be found at the following link below, or by contacting the applicable regional plan review engineer. Alternatively DEQ can invoice the utility. Fee payment covers DEQ review of both report and plans for a given project.
https://www.oregon.gov/deq/Rulemaking%20Docs/340-045-0075WQFeeTables.pdf

1.4 General Design Criteria Requirements

General system requirements are presented below; requirements for specific components are described in Section 2 and Section 3.

A. A pumping system consisting of multiple pumps, with one spare pump to provide for system redundancy. Firm capacity is defined as pump station capacity with the largest pump out of service. Sewage overflows are prohibited as defined in the applicable NPDES permit.

B. Reliability: design consistent with EPA Class I reliability standards for mechanical and electrical components and alarms.

C. Solids handling: pumps must pass at least 2 ½-inch spheres, but should be capable of handling 3-inch spheres. Piping and valves must pass 3-inch spheres. Also, design so as to minimize pump clogging due to rags, disposable wipes, or other fibrous materials.

D. For variable-speed pumping systems, provide measurement of flow rate and run time.

E. Design for proper handling of grease and grit.

F. Provide sound attenuation for noise as appropriate for the facility's location.

G. Provide structures of adequate size and interior/exterior clearances for ease of operation and maintenance of all systems and to meet applicable codes.

H. Provide corrosion control equipment as needed to adequately protect pump station piping and force mains. Materials of construction must be appropriate for exposure to corrosive constituents frequently present in wastewater.

I. Flood protection: set the elevation of the wet well rim and of the finished floor of associated buildings at least one foot above the 100-year flood plain, or any distance above the 500-year flood plain, whichever is higher; in addition, it's necessary to meet local code requirements if they're more stringent. NEMA ratings for electrical equipment must meet applicable electrical code requirements for proposed installation heights and environments.

J. Adequate provision for prevention of uplift of structures due to buoyancy.

K. Mechanical systems for heating and ventilating as required for station equipment and by applicable codes.

L. Plumbing systems for potable water, wet-well washdown, and drainage. Provide potable water cross-connection protection in accordance with Oregon Health Authority regulations.

M. Provide systems for lighting, security, and control.

N. Provide an independent second source of electrical power.

O. Provide complete system of alarms and telemetry to facilitate operation and maintenance, and notification of emergency conditions at the station at all hours.

P. Provide a dedicated alarm for sewage overflow, which must be designed with a separate connection to alarm telemetry, independent from main control power supply, and designed to operate during failure of main control system, i.e. the overflow alarm must function even if the primary power and control systems are lost.

Q. Separate dry wells from wet wells completely. Common walls must be gas-tight.

1.5 General Recommendations

Consider incorporating the following into design of the pump station:

A. A galvanic corrosion controls system which is designed, inspected, and tested by a corrosion control engineer.

B. Odor control equipment as recommended by an odor control evaluation of the upstream collection system, wet well, and discharge system.

C. For variable-frequency drive (VFD) systems, consider use of control algorithms in order to improve system performance parameters such as efficiency or clogging frequency.

D. When feasible, provide shelter for operator protection against the elements, particularly while working on electrical equipment.

E. At locations where severe property damage could result from sewage backups caused by a pump station failure, it is recommended that the design include a manhole with a low elevation lid or an overflow pipe in the sewage collection system that drains to a less damage-prone area.

1.6 Design Report

DEQ recommends that the design engineer prepare a design report. At a minimum, the report should contain the information below. The length and complexity of the report should correspond to the complexity of the proposed pump station including ancillary facilities.

A. Headloss calculations or spreadsheet; system head curve plotted against performance curve of selected pump. The curves should reflect both new and old pipe conditions.

B. Wet well buoyancy calculations.

C. Wet well and force main detention time calculations, based on initial conditions at station start-up and at buildout.

D. Description of sewage overflow point and predicted path of overflow.

E. Description of standby power and type of alarm telemetry proposed to assure EPA Reliability Class I with respect to sewage overflows.

F. A preliminary list of alarm elevations in the wet well.

G. Description: provide a general description of the new facilities. Also briefly define the parameters below:

   1. Pump
      - type
      - drive type
      - capacity
      - motor HP

   2. Level Monitoring
      - primary level control
      - secondary level control

   3. Influent Sewer
      - time to overflow @ PIF once overflow alarm triggered

4. Electrical Power
    - main service size
    - auxiliary power type
    - auxiliary power output and fuel tank capacity
    - type of transfer switch
5. Control and Monitoring
    - type of alarm telemetry
    - EPA reliability class
6. Force Main
    - length, type
    - profile
    - discharge manhole location
    - number of air release valves
    - number of vacuum release valves
    - maximum detention time (for evaluation of need for sulfide control system = minimum month inflow/total volume within force main)
    - type of sulfide control system (if required)

1.7 Temporary Pumping Plan

A temporary pumping plan must be provided by the contractor and approved by the Owner in order to facilitate ongoing wastewater system operations during construction.

1.8 Equipment Removal and Replacement

The sewage pump station design, including doors, vaults, and roof access panels, should include the capability to remove or replace all mechanical and electrical equipment. Permanent monorails and hoists with a lift rating at least equal to the largest piece of equipment are recommended for sewage pump stations with large pumps and motors. For smaller pump stations, portable gantry-style hoists or truck-mounted hoists can be sufficient.

1.9 Site Selection and Improvements

Site access is required for maintenance personnel and equipment, and for visitors. Provisions must be made for adequate turning radius for vehicles such as a dump truck, backhoe, and crane truck which are required for removal of equipment; grade of access road must not be excessively steep. Access is recommended around the entire perimeter of the pump station for maintenance vehicles where feasible. For completely-buried stations, room must be provided to access hatches and vents with equipment, including adequate clearance from overhead power lines, to allow for safe operation of a crane. Parking space should be provided for at least two maintenance vehicles.

Above-grade equipment and piping should be protected by bollards. A concrete pad must be placed around vaults which is suitable for confined-space personnel-retrieval equipment. Vaults must be designed for expected vehicle loading (minimum H-20).

Note that for most projects, for DEQ plan approval a signed Land Use Compatibility Statement will be required, and the owner will need to gain an off-site wetland determination from the Oregon Department of State Lands prior to earth moving.

1.10 Applicable Oregon Codes

The pump station must conform to the most current version (at the time of project advertisement) of the Oregon codes below:

- Oregon Electrical Specialty Code (OESC)
  Based on NFPA 70, National Electrical Code
- Oregon Plumbing Specialty Code (OPSC)
  Based on Uniform Plumbing Code (UPC)
- Oregon Structural Specialty Code (OSSC)
  Based on International Building Code (IBC)
- Oregon Energy Efficiency Specialty Code (OEESC)
  Based on International Energy Conservation Code (IECC)
- Oregon Mechanical Specialty Code (OMSC)
  Based on International Mechanical Code (IMC) and
- International Fuel Gas Code (IFGC)

In addition, standards of the Oregon Occupational Health and Safety Administration (OR-OSHA) must be met during construction and operation of pump stations, force mains, and gravity collection systems.

2. Pump Station Design Components

2.1 Capacity

The firm capacity of a pump station must be at least equal to the peak hourly flow rate associated with the five-year, 24-hour storm in its tributary area. However it must be expandable to meet the projected peak hourly flow rate associated with full buildout of the tributary or service area. DEQ recommends that the initial installation have a firm capacity corresponding to the projected peak hourly flow 20 years beyond the date of startup. However if flowrate associated with ultimate buildout is lower, that value should be considered the future design capacity. Note that it may be acceptable to reduce the design firm capacity to as low as peak day flow and surcharge the collection system during peak hourly flow, rather than sizing it for peak hourly flow. Calculations demonstrating sufficient available storage must be submitted to DEQ for review and approval.

2.2 Common Pump Station Types

Wet well/dry well pump stations house the pumps below grade in a dry well adjacent to the wet well. The dry well should be provided with a sump pump and a float switch alarm.

Suction lift pump stations incorporate self-priming or vacuum-priming pumps which are located typically above-grade; a dry well is not required. Maximum suction lift must not exceed the pump manufacturer’s recommendations and must be based on a net positive suction head calculation with an adequate factor of safety (minimum 6 feet). Proper air release is also required. Any buried structure housing equipment or personnel must be physically separated from the wet well.

Submersible pump stations provide submersible pumps in the wet well with the electrical and control systems mounted above grade. Guide-rail assemblies must be provided to set and remove the pumps without entering the wet well. Check valves, isolation valves, meters, and auxiliary instrumentation must be located outside the wet well.

2.3 Wet Well

A. All pumps, fixtures, and miscellaneous metals in the wet well shall be explosion-proof and corrosion-proof, for use in Class 1, Division 1 environments. If the wet well is constructed of concrete, consider coating it for corrosion protection.

B. Design of inlet discharge location must provide for proper flow patterns to pumps' suctions. Refer to Hydraulic Institute standards. Design should provide a self-cleaning floor and/or a pumped floor scour valve or a recycle pump and pipe. For larger stations consider modeling the station using computational fluid dynamics.

C. Minimize the free fall of sewage into the wet well.

2.4 Motors

A. Motors installed below an elevation of 1 foot above the 100-year flood elevation must be submersible.

B. Motors shall be either Factory Mutual (FM) or Underwriter's Laboratories (UL) approved.

C. High efficiency motors are recommended (i.e. NEMA premium efficiency, or IEC IE3).

2.5 Piping

A. The standard for pump station wastewater piping is cement-mortar lined ductile iron pipe and fittings.

B. Discharge piping for stations containing three or more pumps should connect to the FM discharge manifold with wyes.

C. Piping less than two inches in diameter connected to wastewater piping must be 316 stainless steel or PVC. Screwed pipe must be minimum Schedule 80. Galvanized steel piping is not allowed except for seal water, tap water, and potable applications.

2.6 Valves

A. Discharge piping from each pump must contain an:

- Isolation valve. - Additional isolation valves may be required at piping manifolds, depending on design.
- Check valve - Locate check valve horizontally between pump and isolation valve. Ball check valves should not be used on sewage pumps.

B. Suction piping for dry pit pumps must contain an isolation valve.

C. Air and/or vacuum release valves may be required, as discussed under Item 3.7.3.

D. A surge analysis is required as discussed under Item 3.7.4. Results of this analysis will influence selection of many valve types listed above, and may require additional facilities to provide protection of the force main.

E. A system of pipes and valves for launching and retrieving pigs should be provided when pumps discharge into force mains which may accumulate solids or grease over time as discussed under Item 3.7.5.

2.7 Design Velocities

A. Piping and valves shall be in accordance with AWWA standards. Design fluid velocities shall be:

- Pump discharge lines including force mains: 3.5 – 8 fps
- Pump vertical discharge lines: 6 – 10 fps
- Pump suction lines: 3 – 5 fps

B. VFD pump systems must be designed to provide a flushing velocity in the force main of at least 3.5 fps during each pumping cycle and to maintain a fluid velocity of at least 2 fps in the force main.

2.8 Pipe Supports

A. Supports and restraints must be provided, adequately anchored for vertical and lateral support during hydraulic surges and earthquakes. Dead loads must not be transmitted to pump flanges.

B. Base supports should have a grouted base of at least 1-1/2 inches.

C. Base elbows should be installed on pedestals at vertical elbows, and should not be required to provide horizontal thrust restraint.

D. Use of rubber expansion joints to make up for poor workmanship can lead to increased vibration levels in pumping systems. Meeting ANSI/HI 9.6.4 vibration criteria should be a condition of equipment acceptance for all facilities.

2.9 Flow Meters

A. For stations driven with VFDs, DEQ requires a flow meter or a system which monitors pump operation and calculates flow rate. DEQ recommends a minimum full-scale accuracy of +/- 5%.

B. If provided, meters must be installed on the pump station force main inside the station, or in a shallow vault located in the yard. A drainable bypass around the meter is recommended.

2.10 Vents and Drains

A. Manual vents and drains must be provided at all high and low points, respectively, in a piping system and at all locations required to facilitate draining and filling equipment or piping.

B. A ¼-inch gauge cock must be installed on the top of the volute of dry-pit pumps to allow removal of air after servicing and prior to placing pumps back into service. The associated vent line should be plumbed to discharge to the wet well or sump pump.

C. Vaults containing valves and meters may drain by gravity to the wet well, however this would cause the vault to be a Class 1, Division 1 space.

2.11 Pressure Gauges

A pressure gauge or pressure transducer must be installed on the suction and discharge side of each pump that is installed in a dry well, and in the valve vault on the discharge side of each submersible pump. Discharge gauge range must be adequate to measure the pump shutoff head.

2.12 Water Supply

A. Water supply to the pump station is recommended. A reduced pressure backflow prevention device must be provided on the water service as required by OAR 333-061-070. If the backflow preventer is located outside of a structure, it must be insulated and heat traced. If water supply is not provided, then adequate parking space must be provided for a water truck.

B. Safety showers and eyewash stations must be provided wherever chemicals are used requiring such safety equipment.

3. Auxiliary Design Components

3.1 Alarms

Below is a list of wastewater pump station alarms which are required or recommended by DEQ; alarms **required** by DEQ are shown in **bold**.

In addition to a primary level measurement system, a secondary level measurement system is required for pump control and alarms for redundancy. The two systems should be independent, which will increase reliability of level measurement. Common instruments for the primary system are pressure transducers and ultrasonic devices; secondary systems commonly utilize float switches or a probe.

Pumping station alarms should be transmitted to a municipal facility that is staffed 24 hours a day, and should also identify the alarm condition. If such a facility is not available, the alarm must be transmitted to municipal offices during normal working hours and to the home of responsible persons in charge of the lift station during off-duty hours. A battery-powered backup power source must be provided for the alarm system.

Pump Wet Well Water Level Alarms

	Primary Level Measurement System	Secondary Level Measurement System
Overflow	**Required**	**Required**
HWL	**Required**	**Required**
Lag Pump On	Optional	Optional
LWL	Optional	Optional

A. Power Alarms
- power failure
- VFD fault
- emergency generator failure to start

B. Pump Operation Alarms
   - vibration
   - temperature (pump and motor bearings, motor windings)
   - seal water pressure failure
   - pump failure (via check valve fail to open, low amperage, etc.)
   - surge control system failure
   - fire
   - intrusion
   - loss of communication with pump station
   - toxic gas detection

3.2 Electrical

A. Provide fail-safe design features. In general, development of fail-safe design features should consider the criticality of the pump station (while meeting EPA Class I reliability standards).

B. HOA: provide a separate motor starter control circuit for manual operation of pumps, and redundancy in case the circuit for automated control (primary circuit) fails, with wiring independent from the (primary) circuit, which typically utilizes a programmable logic controller.

C. Provide backup level measurement system for automated operation of alarms and control. (All alarms on primary system should be on backup system, however not all control points need alarms, as discussed above.)

D. Alarm circuits shall be normally energized (i.e., relays normally closed)

E. Control circuits shall be normally de-energized (i.e. relays normally open / energize to initiate control functions)

F. Standby generators must be of sufficient size to start and run the firm pumping capacity of the station, along with other electrical loads necessary to keep the station operational.

G. Pump station control systems should be kept operational with uninterruptible power supplies until a generator is brought on-line.

H. Permanent standby generators also require automatic transfer switches to transfer the electrical feed from the primary system to the standby generator when a power failure is detected.

I. If portable secondary power is proposed:

   - The utility must attest to DEQ that it is feasible for the proposed facility and operations staff to respond to a power outage in time to prevent a sewerage overflow from the collection system or wet well.
   - Generators should be trailer-mounted and a suitable towing vehicle should be available at all times.
   - The pump station needs a proper electrical connection point for the generator.
   - The utility should evaluate its sewage pump stations to determine the number and size of portable engine generators needed during a major regional power failure.
   - Emergency sewage storage should be considered.

J. DEQ may accept a fuel-powered backup pump system as a means of satisfying DEQ requirements for a standby generator and a duplicate (largest) pump.

K. Fuel storage for both portable and permanent generators must be adequate to operate the pump station for a minimum of 24 hours at full load. Provide secondary containment as required by applicable codes.

L. Consultant should evaluate which fuel type is best considering reliability, cost of fuel and storage, maintenance requirements, fuel degradation, environmental impacts, and complexity of system design.

3.3 HVAC

- Ensure that electrical and instrumentation equipment is rated for expected extremes of temperature and humidity of the room (or enclosure) which will house it.
- Heating and/or insulation must be provided to prevent pipes and other water-containing equipment from freezing.
- Design must conform to the Oregon Energy Efficiency Specialty Code.
- Ventilation openings must be screened with mesh to prevent entry by animals and bugs.

3.4 Fire Protection

- Conform to the requirements of NFPA 820, "Standards for Fire Protection in Wastewater Treatment and Collection Facilities", including installation of fire suppression systems, smoke detectors, fire extinguishers, and safety warning signs.
- Contact the local fire jurisdiction for its requirements, and contact the local water provider to determine fire flow availability.

3.5 Hydrogen Sulfide Control

3.5.1 Overview

Sewage collection design must seek to prevent corrosion, safety hazards, and odor associated with hydrogen sulfide and other gases. This discussion is limited to hydrogen sulfide. The hydrogen sulfide concentration of pumped sewage discharged from force mains into gravity sewers should not exceed 0.1 mg/l. The vapor phase equilibrium concentration at this level is extremely foul and may eventually corrode steel and concrete, and it can be a health hazard.

OR-OSHA regulations for entering confined spaces during construction and operation of sewage collection systems must be met, including OAR 437-002-0146, so field testing of atmospheric hydrogen sulfide concentration is needed. In general, it's necessary to test the atmosphere for concentrations of gases in this order: 1. oxygen, 2. flammable gases, 3. toxic gases; refer to OR-OSHA. Note that a potential for elevated concentrations of flammable gases gives rise to more stringent requirements for electrical equipment, per electrical codes.

3.5.2 Testing

A hand-held multi-gas instrument could be used for testing and/or for monitoring in order to evaluate if a manhole is being subjected to elevated levels of hydrogen sulfide and thus at risk of excessive corrosion; if used for monitoring, the instrument would need to be mounted near the top of the manhole for the duration of the test, while logging data during this period.

Field testing may be required by DEQ as a condition of approval of plans, in order to evaluate if a manhole is being subjected to elevated levels of hydrogen sulfide and is at risk of excessive corrosion or of harboring hazardous conditions. DEQ's standard testing requirements are:

A. Pre-construction testing
    1. Testing for hydrogen sulfide concentration is not required
    2. Inspect discharge manhole for deterioration; DEQ recommends an assessment using a rating system like NASSCO's MACP (https://www.nassco.org/manhole-assessment-macp). If the level 1 assessment indicates a satisfactory condition (or the need for replacement) then a level 2 assessment isn't needed.
    3. DEQ also recommends inspecting the existing wet well for deterioration, if applicable

B. Post-construction testing

   Testing will be required unless:
    1. Detention time at ADWF is less than15 minutes, or
    2. Receiving manhole is armored, the next manhole downstream is armored, and the pipe in-between is armored (unless it's constructed of plastic).

C. Testing needs to be done using either a currently-available Hach kit for testing hydrogen sulfide concentration in liquids (Model HS-WR or HS-C) or by a hand-held monitor as mentioned above. Samples should be taken at the discharge manhole. Each sample should be dipped approximately one minute after the pump starts its normal pumping cycle. (Samples should be poured into the test bottle with a minimum of agitation to prevent low readings.) Each sample must be tested immediately at the site. A duplicate should be tested for confirmation. Samples must be taken weekly during June through August (12 tests). Test results must be reported to DEQ no later than September 15.
    1. For liquid-phase testing, if the average hydrogen sulfide concentration of the samples exceeds 0.1 mg/l, then the report shall include a proposal for effective control of hydrogen sulfide below 0.1 mg/l and an implementation schedule. For gas-phase testing the threshold which triggers the need for control is a concentration of 25 ppm.
    2. Testing again must be done following construction of a system for controlling sulfide, in order to confirm that concentrations are below the threshold values stated above.

3.5.3 Control of Hydrogen Sulfide

Hydrogen sulfide in wastewater force mains can be controlled by a variety of methods, as listed below. These methods involve liquid-phase treatment and they all rely on addition of a chemical to the wet well, with the exception of injection of air/oxygen into a force main:

- Chemical oxidation via addition of chlorine, hydrogen peroxide, or permanganate.
- Addition of nitrate, usually calcium nitrate or a proprietary product.
- Sulfur precipitation via addition of iron salts.
- Injection of air or oxygen into force main.
- Adjustment of pH to drive sulfide to nonvolatile ionic forms, or severe pH increase to deactivate sulfur-reducing bacteria.
- Biological approach such as bioaugmentation or enzyme blockers.

Each technique has financial and technical advantages and disadvantages, thus DEQ recommends that the design engineer evaluate options for each specific application. Wastewater characteristics and sewer configuration determine which option is most beneficial. The parameters to be considered include: wastewater flow rate, temperature, pH, oxidation reduction potential, biochemical oxygen demand, sewer detention time, wet well flushing, location of odor-releasing points (manholes, pump stations), and constraints imposed by downstream treatment processes.

3.5.4 Miscellaneous Considerations

A. If the utility believes that a hydrogen sulfide treatment system is not required, then justification must be provided to DEQ. If a treatment system is not installed as part of pump station construction, then future installation should be accommodated by providing piping and electrical connections, instrumentation I/O, space for chemical storage, and any other auxiliary components; and also the wet well should be protected by applying a corrosion-proof armoring (e.g. Raven 405 epoxy coating or equal) or a plastic liner, unless the wet well is fabricated of plastic.

B. Headworks: introduction of hydrogen sulfide into headworks can cause an unacceptable intensity of odor, and in extreme instances it can cause an unsafe condition for operators, and premature deterioration of equipment. The potential for these effects should be evaluated to determine if it’s necessary to either reduce sulfide concentration upstream, or to ventilate and treat it.

C. Although DEQ recommends chemical addition systems, air injection systems are approvable however they should only be used on pipelines which are continuously ascending. Air systems must be designed for continuous injection, and must be installed without timers. A detailed evaluation of air delivery requirements should be made.

D. Another possible approach is to construct an inexpensive back drainage system to drain the entire force main automatically on a daily basis. This is only feasible on continuously-ascending force mains of moderate diameter and length, as the design of the wet well must be sized to contain force main volume in addition to incoming sewage.

3.6 Variable Frequency Drives

Variable frequency drives (VFDs) can provide numerous advantages to a pumping system. The primary potential advantage is lower energy use per unit volume of wastewater pumped. (This parameter is commonly termed “Specific Energy”.) Note that this energy savings does not apply to static lift. It applies to losses due to friction (i.e. dynamic head); this is due to the affinity laws for rotodynamic pumps which relate flow rate, head and power to pump speed as follows: changes to flow rate vary linearly with changes to speed; changes to head vary proportionately to the square of changes to speed; and changes to shaft power are proportional to the cube of speed changes. For example, if the speed (and flowrate) of a pump operating with no static lift is reduced by 50 percent but operated twice as long, then only 25% of the energy is required. $[(0.5)^3 \times 2 = 0.25]$

Note that affinity laws generally apply to radial-flow pumps but may deviate from the relationships above for axial-flow and mixed-flow pumps. VFDs can provide additional advantages including: reduce hydraulic surges; “soft starting” of motor; change rotation of impeller to facilitate unclogging; change motor torque in response to monitored parameters.

3.7 Force Mains

3.7.1 Pipe

A. The standard for force main (FM) piping and fittings is cement-mortar lined ductile iron (DI), heavy-wall polyvinyl chloride (PVC) plastic, or high-density polyethylene (HDPE) although for air-injected FM piping the standard is plastic-lined DI, PVC, or HDPE. The required minimum diameter for force mains is 3 inches; a minimum diameter of 4 inches is recommended.

B. Force mains should be designed to facilitate temporary bypass via a connection with an isolation valve(s).

C. Isolation valves for buried service must be provided with a standard AWWA operating nut and protected from vehicular traffic.

D. Force mains should discharge into a separate manhole rather than into the receiving gravity sewer.

3.7.2 Trenches

Pipe trenches must meet the requirements of Oregon Standard Drawing RD300, current version. Provide adequate cover to prevent freezing.

It is necessary to meet OR-OSHA regulations when constructing trenches; the applicable regulation is OAR 437-003 (29 CFR 1926), Subdivision P (Excavations).

3.7.3 Air/Vacuum Valves and Vaults

Air release, air-vacuum release, or combination air release and vacuum valves must be of a type and brand manufactured for the specific purpose in sewage service and must be provided at critical locations in the pump station and force main. The valves must release air captured inside the piping system, and/or prevent collapse of the piping system because of vacuum conditions. Each valve must be provided with an isolation valve. The air release valve discharge piping in pump stations should be piped to the wet well.

3.7.4 Surge Analysis and Prevention

Pump and pipeline systems must be protected against damage from transient pressures. If it is not possible to ensure that the system is safe from excessive water hammer conditions with simple manual calculations, the system must be computer modeled. Include some method of checking model results before construction.

Reliability of surge protection facilities is critical. Routine inspection and maintenance must be incorporated into the utility's standard operations. Where appropriate, redundancy must be provided for essential pieces of equipment. Adequate alarms must be provided.

3.7.5 Pig Launch Stations

Force mains less than 300 feet in length can be cleaned by conventional methods provided there is access from both the discharge manhole and the pump station. Otherwise, pig launch and retrieval systems must be provided. The pig launch system must utilize the station's installed pumps and piping, unless otherwise approved by DEQ.

3.7.6 Thrust Restraint

Thrust forces in pressurized pipelines must be restrained as needed to prevent excessive movement or joint separation under all expected conditions.

3.7.7 Drainage

Blow-off drain valves should be installed at low points in force mains.

3.8 Field Testing

3.8.1 Pump Testing

Acceptability of factory test results are dependent on which Hydraulic Institute tolerance and acceptance grades are specified in the contract documents. It's difficult to apply these requirements to pump field testing, however field testing during startup is necessary. Test requirements will be specified in contract documents; standard tests are noted below. A copy of startup test data should be provided to DEQ within 30 days of startup, and should be included in the O&M manual. DEQ recommends these tests also be performed annually after startup in order to monitor reductions in performance due to impeller wear or misalignment.

Test Point	Measurement
Shutoff	Discharge pressure at zero flow
Design condition	Flow and pressure at design rating point
Secondary condition (optional)	Flow and pressure

DEQ also recommends these additional tests where applicable:

A. Test capacity while operating every possible combination of pumps consistent with design criteria.

B. Test at full speed. For VFD systems DEQ recommends also testing the design rating point at lower speeds, down to the minimum recommended speed.

C. Measure and record current draw for later operation comparison.

D. Measure and record vibration for later comparison. Verify that vibration meets requirements of contract documents and manufacturer's standard.

E. Test functionality of all alarm and control setpoints for both primary and secondary level measurement systems. DEQ recommends these tests be performed at least annually, to facilitate correct operation.

3.8.2 Force Main Testing

Hydrostatic Pressure Testing: Test all sewer force main pipe in sections of convenient length under a hydrostatic pressure equal to one and one-half times the working pressure, but at least 150 psi, measured at the highest point of the test section. Provide certifications of accuracy to the design engineer for gauges used in the test, from a testing laboratory approved by the design engineer.

A. Flushing – Flush prior to conducting hydrostatic tests and prior to installation of air release valves, pressure sustaining valves, and other appurtenances.

B. Backfill - Backfill the pipeline sufficiently to prevent movement of the pipe under pressure. Place all thrust blocks and allow time for the concrete to cure before testing. Where permanent blocking is not required, furnish and install temporary blocking and remove it after testing.

C. Filling Pipe - Fill the mains with water and allow to stand under pressure a sufficient length of time to allow the escape of air, and to allow the lining of the pipe to absorb water if applicable.

D. Time Test - Test by pumping the main up to the required pressure for at least 2 hours. Provide additional pumping during the test period to continuously maintain pressure within 5 psi of that required. There shall be no abrupt loss in pressure during the test period. During the test observe the section being tested to detect any visible leakage. Use a clean container to hold water for pumping up pressure on the main being tested.

E. Measure Quantity - Accurately determine the quantity of water required to maintain and restore the required pressure at the end of the test period by pumping through a positive displacement water meter approved by the design engineer.

F. Loss Formula - The quantity of water lost from the main must not exceed the number of gallons per hour determined by the formula:

$$L = \frac{SD(P)^{1/2}}{148{,}000}$$

Where:

L = allowable leakage in gallons per hour

S = length of pipeline tested in feet

D = nominal diameter of the pipe in inches

P = average test pressure during the leakage test in psi

G. Leakage - Correct all visible leakage regardless of the allowable leakage specified above. If the measured leakage exceeds the allowable amount specified above, or if pressure cannot be maintained as specified above, locate and repair the leaks and retest the pipeline until test requirements are met.

4. O&M Manual

The utility must not accept or allow operation of the pump station without an approved operations and maintenance manual per OAR 340-052. The manual must conform to DEQ guidelines, which are summarized below for pump stations. DEQ recommends submittal of a complete draft manual no later than the 50-percent construction point, but not less than 45 days prior to startup. DEQ expects submittal of a revised manual that conforms to DEQ comments prior to start up.

A. General

An operations and maintenance manual should provide guidance to operators for day-to-day operation of the station and also facilitate their responses to unexpected events.

B. Format

Use labelled tabs to separate various sections of the manual, and bind it in a 3-ring binder to accommodate future revisions. Provide a spine label. Enclose one copy into a large plastic envelope or baggie for storage at the pump station. All of the manufacturers' literature should be bound separately.

C. Contents

1. Table of Contents
2. Introduction and Use of Manual: Provide a brief narrative on the background of the facility and the intended use of the manual.
3. Description: see section 1.6.G.
4. Record Drawings: Include record drawings in the appendix. Also consider marking up record drawing(s) so as to denote locations of the discharge manhole, the wet well overflow point, the backflow preventer, and auxiliary equipment; and to show how the station is served with water and electricity.
5. Troubleshooting: Provide a troubleshooting guide for the electrical and mechanical components of the pump station.
6. Pump Operation and Control: Describe operation and control of the pump station including the level control system and alarm system. Include the following items:
   - General description
   - Setpoints for control and alarms for both primary and secondary level measurement systems
   - Screens (if applicable): include screenshot of main screen for operator interfacing and at least one shot of a screen for alarms, for setpoints, and for sensor ranges
7. Startup Data: Include forms with recorded startup test data (defined above). Plot startup data onto a graph which contains the pump performance curve and the engineer's calculated system curve.
8. Operation and Control of Other Mechanical Systems: Describe other significant systems at the pump station, such as emergency power, telemetry, irrigation, sulfide controls, HVAC, and seal water, as applicable. Describe how these systems work, and their operation and maintenance requirements. Supplement with appropriate diagrams as necessary.
9. Safety Requirements: Although the manual should make reference to hazards and safe practices throughout, it is necessary to provide a separate section on safety. As a minimum the safety section should include information on specific hazards with electrical switchgear and confined spaces at the station and should refer to the safety training program and the standard safety procedures handbook followed by the sewer utility.
10. Emergencies: This is a separate section listing emergency phone numbers.
11. Maintenance of Equipment: Provide schedules that list periodic maintenance requirements for each equipment item. Include maintenance of force main, e.g. maintenance of air/vacuum valves.
12. Spare Parts Inventory: Include a list of critical replacement parts that may have long delivery times associated with them, and thus should be stored on-site. For critical parts which degrade in storage, identify supplier which can deliver items within necessary timeframes instead of storing them on-site.
13. Manufacturer's O&M Literature: In the manual, provide only a list of manufacturers / suppliers and phone contacts for ordering equipment and parts. Other cut-sheets and manufacturer's literature should be contained in a separate binder. (Do not send these to DEQ for review.)