

IOWA WASTEWATER FACILITIES DESIGN STANDARDS

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CHAPTER 13

WASTEWATER PUMPING STATIONS AND FORCE MAINS

13.1 GENERAL

13.1.1 Applicability

This chapter is applicable to construction, installation or modifications of any wastewater disposal system required to obtain a permit to construct from this Department under the Iowa Code, Section 455B.183, and Subrule 567 IAC 64.2(1).

13.1.2 Variances [Paragraph 567 IAC 64.2(9)"c"]

A variation from these design standards shall meet the requirements of Section 14.1.2 of these standards.

13.1.3 Explanation of Terms

The terms "shall" or "must" are used in these standards when it is required that the standard be used. Other terms such as "should" and "recommended" indicate desirable procedures or methods which should be considered but will not be required.

13.1.4 Scope of Standard

This chapter shall apply to all raw wastewater pumping stations, whether located in the collection system or at the wastewater treatment works.

13.2 GENERAL REQUIREMENTS

The design for wastewater pumping stations and force mains shall meet all applicable requirements in Chapter 14 of these standards.

13.2.1 Flood Protection

The design for flood protection shall meet the requirements in Section 14.2.4 of these standards. In the absence of official records to establish 100 year and 25 year flood elevations, the best available local information shall be used.

13.2.2 Accessibility

Access to all wastewater pumping stations by maintenance vehicles shall be provided in accordance with Section 14.2.4 of these standards.

13.2.3 Siting

The engineering report or facilities plan required by Chapter 11 of these standards shall address site selection. The design for pumping stations shall comply with the separation requirements in Section 14.2.3 of these standards.

Pumping stations should be located as far as practical from present or proposed built-up residential areas. Ultimate land use, noise control, odor control, geotechnical investigations, station architectural design, and other aesthetic items shall be taken into consideration. Sites for stations should be of sufficient size for maintenance, future expansion, or addition, if applicable.

13.2.4 Safety

Adequate provision shall be made to effectively protect maintenance personnel from hazards. Provisions for confined space entry shall be provided for all wastewater pumping stations as necessary to comply with Occupational Safety and Health Administration requirements.

13.2.5 Security and Fencing

Pumping stations shall be designed to discourage vandalism and the entrance of animals or unauthorized personnel. Fencing should be provided when appropriate. All access gates, control panels and access hatches should be lockable.

13.3 **DESIGN**

13.3.1 Type

Wastewater pumping stations are generally of four types; wet well/dry well, suction lift, submersible, and screw pumps.

13.3.2 Structures

13.3.2.1 Separation

Dry wells, including their superstructures, shall be separated from wet wells. Where common wall construction is proposed, all penetrations shall be water and gas tight.

13.3.2.2 Equipment Removal

Provisions shall be made to facilitate removal of pumps, motors, and other mechanical and electrical equipment.

13.3.2.3 Access

Suitable and safe means of access shall be provided to dry wells and to wet wells containing screens, bar racks, or other mechanical equipment requiring inspection or maintenance.

13.3.2.4 Construction Materials

Materials shall be selected that are appropriate under conditions of exposure to hydrogen sulfide and other corrosive gases, as well as fats, oils, greases, and other constituents frequently present in wastewater.

13.3.2.5 Grit Protection

The wet well and pumping station piping should be designed to avoid operational problems from the accumulation of grit.

13.3.3 Odor Control

Design of the pumping station and force main should minimize odor potential. Where the pumping station is expected to operate at a rate less than ½ the ADW flow for longer than 12 hours at a time, handle high organic strength wastewater or pump wastewater with excessive sulfate, the design should include measures necessary to minimize or prevent septicity due to holding times in the wet well and/or retention times in the force main.

13.4 PUMPS

13.4.1 Pumping Rate and Number of Units

Multiple pumps shall be installed. Units shall have capacity such that with any unit out of service, the remaining unit or units will have the capacity to handle the expected PHWW flow.

All pumps should be tested by the manufacturer. These tests should include a hydrostatic test and an operating test.

Consideration shall be given to the use of variable-speed pumps, particularly when the pumping station delivers flow directly to a treatment plant, so that wastewater will be delivered at approximately the same rate as it is received at the pumping station.

13.4.2 Provisions for Screening

Trash baskets constructed of a corrosion resistant material and easily removable for cleaning should be considered for small pumping stations.

Where the size of the installation warrants, mechanically cleaned and/or duplicate bar racks should be considered. The design for screening devices, if used, shall meet the applicable provisions in Section 15.2 of these standards.

Where screenings removal is provided, the design shall address storage and disposal. Hoists shall be provided for removing screenings containers from facilities located below ground. Where disposal of screenings at a landfill is recommended, the design shall be in accordance with Subrule 567 IAC 109.11(3).

13.4.3 Pump Openings

Pumps shall be capable of passing solid spheres at least 3 inches in diameter. Pump suction and discharge openings shall be at least 4 inches in diameter. An exception to the requirement for passing solid spheres of at least 3 inches in diameter may be made on a case by case basis when the design includes equivalent protection from clogging.

13.4.4 Priming

Pumps shall be placed so that they will operate under a positive suction head under all operating conditions (except for suction lift pumps).

13.4.5 Intakes

Each pump shall have individual intake piping. The wet well shall be designed to avoid turbulence, such as vortexing, near the intake and to minimize air entrainment resulting from proximity of the flow entering the wet well and the pump intakes. Intake piping shall be as straight and short as practical and designed to avoid air entrapment.

13.4.6 Reverse Rotation Protection

Consideration should be given to protect against runaway pumps on installations with high flows, high discharge heads, long force mains or combinations of these which could contribute to excessive backflows in the event of check valve failure.

13.4.7 Electrical Equipment and Controls

Electrical systems and components (e.g., motors, lights, cables, conduits, switchboxes, control circuits, etc.) in raw wastewater wet wells, or in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or

vapors may be present, shall comply with NFPA 70 (National Electrical Code) requirements for Class I, Division 1, Group D locations (except for submersible pump motors). Electrical classification may be downgraded to Class I, Division 2, Group D if the space is continuously ventilated with at least 12 fresh air changes per hour. If the pump room is above grade and physically separated from the raw wastewater wet well by a gas tight partition, it may be unclassified. The extent of all classified areas shall be based on the NFPA 820 (Standard for Fire Protection in Wastewater Treatment and Collection Facilities).

Equipment located in the wet well shall be suitable for use under corrosive conditions. Each flexible cable shall be provided with a watertight seal and separate strain relief. A fused disconnect switch located above ground shall be provided for the main power feed for all pumping stations. When such equipment is exposed to weather, it shall meet the requirements of weatherproof equipment NEMA 3R or 4, at a minimum. Lightning and surge protection systems shall be considered. Pumping station control panels located outdoors shall be provided with a 110 volt power receptacle inside the control panel to facilitate maintenance. Ground Fault Circuit Interrupter (GFCI) protection shall be provided for all outdoor power receptacles.

Sensing devices for level controls in wet wells shall be located to minimize the effects of turbulence from entering flows or pump suction. Provisions shall be made to alternate the pumps in use.

13.4.8 Dry Well Dewatering

A separate sump pump shall be provided in the dry well to remove leakage or drainage, with the discharge equipped with dual check valves and located above the maximum liquid level in the wet well. All floor and walkway surfaces shall have an adequate slope to a point of drainage. Pump seal water shall not be permitted to discharge on the floor of the pumping station. Sump pumps shall be placed to allow access for removal and maintenance.

13.5 SUCTION AND DISCHARGE PIPING AND VALVES

13.5.1 Pipe Size

Pump suction and discharge piping shall not be less than four inches in diameter except where design of specialized equipment allows. Maximum recommended velocities are six feet per second in the suction line and eight feet per second in the discharge line. Minimum velocity shall not be less than two feet per second in the discharge line.

13.5.2 Valves

13.5.2.1 Suction Line

Suitable shutoff valves shall be placed on the suction line of each dry well pump.

13.5.2.2 Discharge Line

Suitable shutoff and check valves shall be placed on the discharge line of each pump (except on screw pumps). The check valve shall be located between the shutoff valve and the pump. Check valves shall be suitable for the material being handled and shall be placed on the horizontal portion of discharge piping. Ball checks may be placed in the vertical run for very small installations or where a wastewater pumping station is upgraded and no horizontal option exists. Valves shall be capable of withstanding normal pressure and water hammer.

All shutoff and check valves shall be operable from the floor level and accessible for maintenance. Outside levers are recommended on swing check valves.

Where limited pump backspin will not damage the pump and low discharge head conditions exist, short individual force mains for each pump may be considered in lieu of discharge valves.

Suitable provisions shall be made on installations using screw pumps to prevent backflow down the trough of a pump that is out of service.

13.6 WET WELLS

13.6.1 Wet Well Size

The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting. Manufacturers should be consulted to determine allowable cycle times. The effective volume of the wet well based on filling time should be 30 minutes or less. For constant speed pumps the minimum wet well volume shall be based on the following formula:

$$V = \frac{TQ}{4}$$

Where:

- V = Storage Volume, Gallons
- T = Required Time between Starts, Minutes
- Q = Pump Discharge Capacity, gpm

Detention times for initial and ultimate flow conditions shall be evaluated.

13.6.2 Floor Slope

The wet well fillets shall have a minimum slope of one to one to the hopper bottom. The horizontal area of the hopper bottom shall be kept as small as possible while providing for proper installation and function of the inlet.

13.7 VENTILATION

Adequate ventilation shall be provided for all pumping stations. Where the dry well is below the ground surface, mechanical ventilation is required. The wet well shall be independently ventilated if screens or mechanical equipment requiring maintenance or inspection are located in the wet well. There shall be no interconnection between the wet well and dry well ventilation systems. Multiple inlets and outlets for ventilation are desirable for large installations. Fine screens or other obstructions in air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment shall be marked and conveniently located. All intermittently operated ventilating equipment shall be interconnected with the respective wet well or dry well lighting system. Consideration shall be given to automatic controls where intermittent operation is used. The fan wheel shall be fabricated from non-sparking material. Consideration should be given to installation of automatic heating and/or dehumidification equipment.

CAUTION: The ventilation practices under the NFPA 820 standard are intended to minimize fire and explosion hazards; therefore, the NFPA 820 criteria may not be adequate to protect personnel from exposure to toxic and biological hazards.

13.7.1 Wet Wells

Ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least 12 complete air changes per hour; if intermittent, at least 30 complete air changes per hour. Air shall be forced into the wet well by mechanical means rather than solely exhausted from the wet well. The air change requirements shall be based on 100 percent fresh air. Submersible pump wet wells shall be provided with static vents if mechanical ventilation is not provided.

13.7.2 Dry Wells

Ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least 6 complete fresh air changes per hour; if intermittent, at least 30 complete fresh air changes per hour. This requirement applies to an above grade pump room that is physically separated from the raw wastewater wet well by a gas tight partition.

13.8 SPECIAL DETAILS

13.8.1 Flow Measurement

Pumping stations with a PHWW flow capacity more than 0.5 mgd shall be equipped with flow metering equipment in addition to elapsed time meters. All flow meters should be capable of recording the maximum hourly flow during any 24 hour period. Elapsed time meters shall be installed on all pumps unless otherwise approved by the Department. Where flow meters are not installed, additional elapsed time meters shall be installed for every combination of simultaneous pump operation to measure total flow rate.

13.8.2 Water Supply

There shall be no physical connection between any potable water supply and a wastewater pumping station which under any conditions might cause contamination of the potable water supply. If a potable water supply is brought to the station, it shall comply with conditions stipulated in Section 14.7.1 of these standards.

13.8.3 Alarm Systems

Alarm systems shall be provided for pumping stations. The alarm shall be activated in cases of power failure, pump failure, high water level or any cause of pumping station malfunction. Pumping station alarms shall be transmitted to a municipal facility that is manned 24 hours a day. If such a facility is not available, the alarm shall be transmitted to city offices during normal working hours and to the homes and mobile phones of the person(s) in responsible charge of the pumping station during off-duty hours. Audio-visual alarm systems with a self-contained power supply may be acceptable in some cases in lieu of the transmitting system outlined above, depending upon location, station holding capacity and inspection frequency.

13.8.4 Lighting

Adequate lighting shall be provided for the pumping station. Where the wet well is lighted, electrical luminaires shall be rated for the classified area in accordance with Section 13.4.7 of these standards.

13.9 SUCTION LIFT PUMPS

Suction lift pumps shall be of the vacuum-priming or self-priming type. All suction lift pumps shall meet the applicable requirements set forth in Sections 13.3 and 13.4 of these standards. The maximum lift for suction lift pumps shall not exceed 15 feet. Higher lifts may be permitted if detailed calculations are submitted indicating satisfactory pump performance under the proposed operating conditions. Such detailed calculations must include static suction lift as measured from the "lead pump off" elevation to the center line of pump suction, friction and other hydraulic losses of the suction piping, vapor pressure of the liquid, altitude correction, required net positive suction head, and a safety

factor of at least 6 feet. Under no conditions shall the combined total of dynamic suction lift at the "lead pump off" elevation and required net positive suction head (NPSH) at design operating conditions exceed 22 feet.

The pump equipment compartment shall be above grade or offset and shall be effectively isolated from the wet well to prevent the humid and corrosive sewer atmosphere from entering the equipment compartment. Wet well access shall not be through the equipment compartment. Valves shall not be located in the wet well.

13.9.1 Self-Priming Pumps

Self-priming pumps shall be capable of rapid priming and repriming at the "lead pump on" elevation. Such self-priming and repriming shall be accomplished automatically under design operating conditions. Suction piping shall not exceed the size of the pump suction and shall not exceed 25 feet in total length.

13.9.2 Vacuum-Priming Pumps

Vacuum-priming pumping stations shall be equipped with dual vacuum pumps capable of automatically and completely removing air from the suction lift pump. The vacuum pumps shall be adequately protected from damage due to wastewater.

13.10 SUBMERSIBLE PUMPS

Submersible pumping stations shall meet all applicable requirements under Sections 13.3 and 13.4 of these standards.

13.10.1 Construction

Submersible pumps and motors shall be designed specifically for wastewater use, including totally submerged operation during a portion of each pumping cycle. An effective method to detect shaft seal failure or potential seal failure shall be provided, and the motor shall be of the type without brushes or other arc-producing mechanisms.

13.10.2 Pump Removal

Submersible pumps shall be readily removable and replaceable without dewatering the wet well or disconnecting any piping in the wet well.

13.10.3 Electrical

13.10.3.1 Power Supply and Control

Electrical supply, control and alarm circuits shall be designed to provide strain relief and to allow disconnection from outside the wet well. Terminals and connectors shall be located outside the wet well or protected from corrosion through use of watertight seals. If located outside, weatherproof equipment shall be used.

13.10.3.2 Control Center

The motor control center shall be located outside the wet well and be protected by a conduit seal or other appropriate measures meeting the requirements of the National Electrical Code to prevent the atmosphere of the wet well from gaining access to the control center. The conduit seal shall be located such that the motor may be removed and electrically disconnected without disturbing the seal.

13.10.3.3 Power Cord

Pump motor power cords shall be designed for flexibility and serviceability under conditions of heavy usage. Ground fault interruption (GFI) protection shall be used to de-energize the circuit in the event of any failure in the electrical integrity of the cable.

13.10.4 Valves

Valves for submersible pumps required under Section 13.5 of these standards shall be located in a separate valve chamber. Accumulated water shall be drained to the wet well. An effective method shall be provided to prevent wastewater and gas from entering the valve chamber.

13.11 EMERGENCY OPERATION

Pumping stations and collection systems shall be designed to prevent or minimize bypassing of wastewater and sanitary sewer overflows. An emergency means of operation shall be provided for use during possible periods of extensive power outages, mandatory power reductions, or uncontrolled storm events; such as a second, independent power source connected to the station, an engine-driven generator, engine-driven standby pumps, or portable pumps or portable generator. Portable standby units must be capable of being placed in operation at the site within 30 minutes of the onset of the emergency condition.

Where the specified portable standby units may be used at multiple locations (i.e., other pumping stations, municipal offices, etc.), the design shall evaluate for adequacy the total number and size of required portable standby units necessary to prevent backup of wastewater into basements and/or other prohibited discharges during a power outage.

Engine-driven pumps must meet all applicable requirements in Section 13.4 of these standards. Provisions for backup power sources must comply with the requirements of Section 14.5.3 of these standards.

In addition to the required emergency means of operation, where overflows affect public water supplies, a high level wet well overflow and a storage/detention basin, or tank, shall be provided having 2-hour detention capacity at the anticipated overflow rate. Storage/detention tanks, or basins, shall be designed to drain by gravity or by pumping to the station wet well.

13.11.1 In-Place Equipment

Where in-place internal combustion equipment is utilized, the following guidelines must be followed.

13.11.1.1 Placement

The unit shall be bolted in place. Facilities shall be provided for unit removal for purposes of major repair or routine maintenance.

13.11.1.2 Controls

Consideration shall be given to provisions for automatic and manual startup and cut-in. The transfer switch shall be in accordance with the National Electric Code, Article 700.

13.11.1.3 Size

Unit size shall be adequate to provide power for lighting and ventilating systems in addition to pumping requirements.

13.11.1.4 Engine Location

The unit internal combustion engine shall be located at or above grade, with suitable and adequate provisions for heat dissipation and ventilation of exhaust gases.

13.11.1.5 Air Emissions

Provisions shall be included to comply with federal, state and local air emission requirements.

13.11.2 Portable Equipment

Where portable equipment is utilized, the following guidelines shall be followed in addition to all applicable provisions in Section 13.11.1 of these standards:

Pumping units shall have capability to operate between the wet well and the discharge side of the station and the station shall be provided with permanent fixtures that will facilitate rapid and easy connection of lines. Electrical energy generating units shall be protected against burnout when normal utility services are restored, and shall have sufficient capacity to provide power for lighting and ventilating systems in addition to the pumping units.

13.12 FORCE MAINS

13.12.1 Size

Minimum size force mains shall be not less than 4 inches in diameter, except for grinder pumps or other specialized applications.

13.12.2 Velocity

The minimum self-scouring velocity shall not be less than two feet per second. Recommended maximum velocity is eight feet per second.

13.12.3 Air Relief and Vacuum Valves

An air relief valve or air vacuum valve shall be placed at high points in the force main to relieve air locking.

13.12.4 Termination

The force main shall enter the receiving manhole with an invert elevation that will ensure a smooth flow transition to the gravity flow section; but in no case shall the force main enter the gravity sewer system at a point more than 1 foot above the flow line of the receiving manhole. The design shall minimize turbulence and scouring at the point of discharge.

Consideration shall be given to the use of inert materials or protective coatings for the receiving manhole to prevent deterioration as a result of exposure to hydrogen sulfide or other chemicals where such chemicals are present or suspected to be present because of industrial discharges or long force mains.

13.12.5 Materials of Construction

Pipe and joints shall be equal to the water main strength materials described in Section 12.4 of these standards and shall be suitable for local conditions, such as character of industrial wastes, soil characteristics, exceptionally heavy external loadings, internal erosion, corrosion, and similar problems.

Installation specifications shall contain appropriate requirements based on the criteria, standards, and requirements established by the industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and backfilling thereof so as not to damage the pipe or its joints nor impede cleaning operations, nor to create excessive side fill pressures, nor to seriously impair flow capacity.

All pipes shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the pipe shall be made because of the width and depth of trench.

13.12.6 Pressure Tests

All force mains shall be tested at a minimum pressure of at least 50 percent above the design operating pressure for at least 30 minutes at the low point in the line. Leakage shall not exceed the amount given by the following formula:

$$L = \frac{SD\sqrt{P}}{133,200}$$

Where L = is allowable leakage in gallons per hour,
 S = is the length of pipe in feet,
 D = is the pipe diameter in inches, and
 P = is the test pressure in pounds per square inch.

13.12.7 Special Construction

Force main construction near streams or used for aerial crossings shall meet the requirements in Sections 12.5.11 and 12.5.12 of these standards.

13.12.8 Protection of Water Supplies

Force main construction shall comply with all applicable requirements in Section 12.5.8 of these standards for the protection of public and private water supplies.

13.12.9 Anchoring

Force mains shall be sufficiently anchored within the pumping station and throughout the line length. The number of bends shall be as few as possible. Thrust blocks, restrained joints, and/or tie rods shall be provided where restraint is needed.

13.12.10 Surge Protection

Consideration shall be given to the use of surge anticipation valves, surge tanks, or other suitable means to protect the force main against severe pressure changes

due to the starting or stopping of large capacity pumps, particularly when such pumps are required to run against high discharge heads.

13.12.11 Design Friction Losses

Friction losses through force mains shall be based on the Hazen and Williams formula or other acceptable method. When the Hazen and Williams formula is used, the following values for “C” shall be used for design.

Unlined iron or steel - 100

All other materials - 120

When initially installed, force mains will have a significantly higher “C” factor than shown. The effect of the higher “C” factor shall be used in designing for the discharge forces at receiving or splitting structures at the discharge end of force mains, in calculating maximum power requirements, and in evaluating the initial operating conditions of the pumps.

13.12.12 Identification

Where force mains are constructed of material which might cause the force main to be confused with potable water mains, the force mains shall be appropriately identified. Generally, tracer wire is desirable, but it should not be the sole means of piping identification.

13.12.13 Cleaning

Provisions should be provided to facilitate cleaning of the force main, such as making provisions for pigging and/or periodically operating at a resuspension velocity of 3 to 5 feet per second.