IOWA WASTEWATER FACILITIES DESIGN STANDARDS

CHAPTER 13

WASTEWATER PUMPING STATIONS AND FORCE MAINS

13.1 GENERAL

13.1.1 Applicability

13.1.2 Variances

13.1.3 Explanation of Terms

13.1.4 Scope of Standard

13.2 GENERAL REQUIREMENTS

13.2.1 Flood Protection

13.2.2 Accessibility

13.2.3 Siting

13.2.4 Safety

13.3 DESIGN

13.3.1 Type

13.3.2 Structures

13.3.2.1 Separation
13.3.2.2 Equipment Removal
13.3.2.3 Access and Fencing
13.3.2.4 Construction Materials
13.3.2.5 Grit Protection

13.4 PUMPS AND PNEUMATIC EJECTORS

13.4.1 Pumping Rate and Number of Units

13.4.2 Protection Against Clogging

13.4.3 Pump Openings

13.4.4 Priming

13.4.5 Intakes

13.4.6 Reverse Rotation Protection

13.4.7 Electrical Equipment and Controls

13.4.8 Dry Well Dewatering

13.5 PIPING AND VALVES

13.5.1 Pipe Size

13.5.2 Valves

13.5.2.1 Suction Line
13.5.2.2 Discharge Line

13.6 WET WELLS

13.6.1 Wet Well Size

13.6.2 Floor Slope

13.7 VENTILATION

13.7.1 Wet Wells

13.7.2 Dry Wells

13.8 SPECIAL DETAILS

13.8.1 Flow Measurement

13.8.2 Water Supply

13.8.3 Alarm Systems

13.8.4 Lighting

13.9 SUCTION LIFT PUMPS

13.9.1 Self-Priming Pumps

13.9.2 Vacuum-Priming Pumps

13.10 SUBMERSIBLE PUMPS

13.10.1 Construction

13.10.2 Pump Removal

13.10.3 Electrical

13.10.3.1 Power Supply and Control
13.10.3.2 Control Center
13.10.3.3 Power Cord

13.10.4 Valves

13.11 EMERGENCY OPERATION

13.11.1 In-Place Equipment

13.11.1.1 Placement
13.11.1.2 Controls
13.11.1.3 Size
13.11.1.4 Engine Location

13.11.2 Portable Equipment

13.12 FORCE MAINS

13.12.1 Size

13.12.2 Velocity

13.12.3 Air Relief Valve

13.12.4 Termination

13.12.5 Materials of Construction

13.12.6 Pressure Tests

13.12.7 Special Construction

13.12.8 Protection of Water Supplies

13.12.9 Anchoring

13.12.10 Surge Protection

13.12.11 Design Friction Losses

13.12.12 Identification

IOWA WASTEWATER FACILITIES DESIGN STANDARDS

CHAPTER 13

WASTEWATER PUMPING STATIONS AND FORCE MAINS

13.1 GENERAL

13.1.1 Applicability

This chapter is applicable to construction, installation or modification of any disposal system reuqired to obtain a construction permit from this Department under the Iowa Code, Section 455B.45, and 900--64.2 of the Iowa Administrative Code (I.A.C.).

13.1.2 Variances [900--64.2(9)"c", I.A.C.]

When engineering justification satisfactory to the executive director is provided substantially demonstrating that variation from the design standards or siting criteria will result in either: at least equivalent effectiveness while significantly reducing costs, or improved effectiveness, such a variation from design stndards or siting criteria may be accepted by the executive director.

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 out in the collection system or at the wastewater treatment works.

13.2 GENERAL REQUIREMENTS

13.2.1 Flood Protection

The station's electrical and mechanical equipment which would be permanently damaged by flooding shall be located at an elevation that is not subject to the 100-year flood or shall otherwise be adequately protected against damage from the 100-year flood. The station shall be designed to remain fully operational and accessible during the 25-year flood. 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

Wastewater pumping stations shall be readily accessible by maintenance vehicles during all weather conditions.

13.2.3 Siting

Pumping statiosn shall be located as far as practical from present or proposed built-up residential areas and off the traffic way of streets and alleys. Noise control, odor control, station architectural design and other aesthetic items shall be taken into consideration. Sites for stations shall be of sufficient size for future expansion or addition, if applicable.

13.2.4 Safety

It is the facility owner's responsibility to ensure that the Occupational Safety and Health Administration (OSHA), the National Electrical Code and other applicable building and construction codes and requirements are met during construction and subsequent operation. During construction this requirement may be met by including references to OSHA, NEC and other applicable building and construction codes in the contract documents.

13.3 DESIGN

13.3.1 Type

Wastewater pumping stations may be of the wet well/dry well type, or may be of the type with suction lift pumps (Section 13.9) or submersible pumps (Section 13.10) as appropriate for the circumstances. Screw type pumps for low lift applications are also acceptable where appropriate.

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, both the liquid and gaseous contents of the wet well shall be completely sealed off from the dry well and any penetrations through the common wall shall be sealed.

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 and Fencing

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.

Pumping stations shall be designed to discourage vandalism and the entrance of animals or unauthorized personnel. Fencing should be provided when appropriate.

13.3.2.4 Construction Materials

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

13.3.2.5 Grit Protection

Where it may be necesary to pump wastewater prior to grit removal, the wet well and pumping station piping shall be designed to avoid operational problems from the accumulation of grit.

13.4 PUMPS AND PNEUMATIC EJECTORS

13.4.1 Pumping Rate and Number of Units

At least two pumps or pneumatic ejector pots (receivers) and compressors shall be provided, each capable of handling the expected PHWW flow.

When three or more units are provided, they must be of such capacity that with any one unit out of service, the remaining units will have capacity to handle the expected PHWW flow.

When the station is expected to operate at a flow rate less than 0.5 times the ADW flow for longer than 12 hours at a time, the design shall address measures taken to prevent septicity due to long holding times in the wet well.

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 Protection Against Clogging

All pumping stations handling raw wastewater shall have provisions for screening to protect the pumps from clogging or damage.

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

Bar racks with clear openings not exceeding 2 1/2 inches shall be provided for larger stations.

Mechanically cleaned bar screens with manually cleaned bar rack bypasses shall be considered for very large installations.

Unless screenings can be collected at ground level, hoists shall be provided for removing screenings containers from facilities located below ground.

13.4.3 Pump Openings

Unless grinder pumps are used, pumps shall be capable of passing spheres at least 3 inches in diameter. Pump suction and discharge openings shall be at least 4 inches in diameter.

13.4.4 Priming

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

13.4.5 Intakes

Each pump shall have individual intake piping. Wet well design shall be such as to avoid turbulence 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 possible and designed so as not to entrap air.

13.4.6 Reverse Rotation Protection

Consideration should be given to providing anti-reverse rotation ratchets 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 the National Electrical Code requirements for Class 1 Group D, Division 1 locations (except for submersible pump motors). In addition, equipment located in the wet well shall be suitable for use under corrosive conditions. Each flexible cable (except for submersible pumps) 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. Ground fault interruption (GFI) protection shall be provided for all outdoor outlets.

Sensing devices for level controls in wet wells shall be located to minimize the effects of turbulence from entering flows or pump suctions. 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 or 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.

13.5 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

13.5.1 Suction Line

Suitable shutoff valves shall be placed on the suction line of each pump except on submersible, suction lift and screw pumps.

13.5.2 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 except for ball checks, which may be placed in the vertical run. 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. To avoid septic conditions due to excessive detention time, the effective capacity of the wet well should provide a holding period not to exceed ten minutes for the MWW flow.

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. Thottling dampers shall not be used on exhaust or fresh air ducts and fine screens or other obstructions in air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment shall be marked and located conveniently. 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 shall be given to installation of automatic heating and/or dehumidification equipment.

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 rather than exhausted from it. 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 intermittnet. Ventilation, if continuous, shall provide at least 6 complete air changes per hour; if intermittent, at least 30 complete air changes per hour. This requirement does not apply to the upper or grade level operating room of a wet well/dry well type pumping station.

13.8 SPECIAL DETAILS

13.8.1 Flow Measurement

Elapsed time meters shall be installed on all pumps unless otherwise approved by the Department. Pumping stations with an AWW flow capacity of 1.0 million gallons per day or more shall be equipped with flow metering equipment or event recorders in addition to elapsed time meters.

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 under 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 home 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. If the wet well is lighted, explosion proof fixtures shall be provided.

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 reuirements 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 "lead pump off" elevation to center line of pump section, 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. Valving 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.

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 protected from corrosion by location outside the wet well or 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 seal shall be so located 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 extra hard 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 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. For use during possible periods of extensive power outages, mandatory power reductions, or uncontrolled storm events, an emergency means of operation shall be provided, 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. The standby facilities must be capable of being placed in operation at the site within 30 minutes of the onset of the emergency condition (preferably before the liquid level in the wet well rises to the overflow level).

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 pumping to the station wet well.

Consideration should be given to providing a high level wet well overflow to suppplement alarm systems and required standby facilities in order to prevent backup of wastewater into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage.

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.

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.

13.11.2 Portable Equipment

Where portable equipment is utilized, the following guidelines must be followed:

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 Valve

An air relief 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

The pipe material shall be adapted to 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 of 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 of 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, which should be used in designing for the discharge forces at receiving or splitting structures at the discharge end of force mains and in calculating maximum power requirements.

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.