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F 730 PUMPING PLANT EQUIPMENT

As indicated in Section F 710, the City's pumping plants are equipped with a variety of different types of pumps. Some of these have been in service for a long time. As pump technology develops, the Design Engineer should investigate the application of state-of-the-art equipment. Different alternatives should be evaluated each time a pumping plant is rehabilitated, expanded or a new design is required. The recommended alternative should have the features which provide the best economic return, overall plant efficiency, reliability and maintainability.

F 731 PUMPS

Due to the large variety of solids found in municipal type wastewaters, each pump selected should be non-clogging. The presence of stringy materials shall be taken into consideration. Pumping capacity and head generally influence the selection of the type of pump suitable for the project.

The following types of pumps are commonly used for wastewater collection systems:

a. Non-clog (dry pit) Submersible Pumps
b. Non-clog (dry pit) Centrifugal Pumps
c. Screw (Archimedes) Pumps
d. Recessed Impeller Centrifugal Pumps

F 731.1 NON-CLOG SUBMERSIBLE CENTRIFUGAL PUMPS

The non-clog submersible centrifugal pump shown in Figure F731.1A has identical impellers and is the same as the dry pit type shown in Figure F731.1B except that the pump shown in Figure F731.1A is equipped with quick connect discharge elbow and slide rails suitable for underwater installation. The submersible pump was originally developed as a dewatering pump commonly used to pump basements and deep excavations in construction sites. Later it became popular for wastewater applications. With advanced design and manufacturing techniques of submersible motors, submersible pumps are becoming popular in both dewatering and deep well applications.
Non-clog submersible centrifugal pumps are also available for dry pit installation (see Figure F730.1C) where the dry pit is subject to flooding. The type of motor used for this application is an air filled motor with a cooling jacket around the motor casing. This type of installation is preferred by plant operators for convenience of inspection and maintenance. The construction cost for a dry pit submersible pumping plant is more expensive compared to a submersible pumping plant because of added cost of constructing a dry pit and added accessories. Figure F731.1D shows a typical non-clog (submersible) centrifugal pump for wet well installation.

Because the pump motor and cable are in a submersible application, the Design Engineer should use care in selecting the pump manufacturer and model. Previous successful installations should be verified and the design and construction of the pumps, seals and motors used should influence the new designs.

The recommended minimum design criteria in the selection of the submersible non-clog pumps are as follows:

a. Pump impeller efficiency should be selected with the best possible efficiency at design point or at the operating range of the pump.

b. Maximum speeds - 1750 rpm for pumps with discharge nozzle diameter up to 12-inch,
   - 1175 rpm for pumps with discharge nozzle diameter from 14 to 16-inch diameter,
   - 886 rpm for pumps with discharge nozzle diameter from 18 to 30-inch.
   - or should not exceed the rotative speed limitation as recommended by the Hydraulic Institute Standards for Centrifugal Pump applications.
c. Materials of Construction -
   - Cast iron impeller and casing with stainless steel replaceable wear rings.
   - Carbon or stainless steel shaft.
   - Tandem mechanical shaft seals system with two totally independent seal assemblies and tungsten-carbide seal rings.

d. Motor Bearings -
   Permanently lubricated single row upper roller bearing and two row angular contact lower bearing to compensate for axial thrust and radial forces. Bearings should be designed for a minimum B-10 life of 60,000 hours.

e. Electric Motor -
   Motors should be designed for NEMA B Type, Class F insulation rated for 155° C,
   - For dry pit installation and ventilated, the motor should be designed for Class I, Division 2, Groups C and D,
   - For wet well installation, motors should be designed for Class I, Division 1, Groups C and D,

f. Painting and Coating -
   All wetted surfaces in contact with wastewater should be coated with coal tar epoxy enamel. Surface preparation should be in accordance with SSPC-SP5, white metal blast cleaning. Prime coat to DFT=1.5 mils, Amercoat 71, Engard 422 or equal. Two or more coats, DFT=16
mils, Amercoat 78HB, Engard 464 or equal. Total system DFT=17.5 mils.

External surface exposed to corrosive environment should be coated and painted by amine-cured epoxy. Surface preparation should be in accordance with alkaline cleaned, SSPC-SP1. Prime coat and finish coat shall be three or more, DFT=16 mils. Amercoat 395, Engard 480 or equal.

Where the submersible pump is to be installed in the wet well, the pump should be furnished with stainless steel, Type 316 slide rails and a set of stainless steel lifting chain with hook. Removal of the pump shall be through access hatches provided directly above the pump. Submersible power and control cables should be imbedded in one cable and properly terminated in explosion-proof terminal boxes mounted above the wet well.

All equipment installed in the wet well should be designed and manufactured to conform to the National Electrical Code (NEC) Class I, Division I, hazardous locations, requiring all electric motors to be for explosion proof locations. The pumps and motors should carry a Factory Mutual (FM) and Underwriters Laboratory (UL) label rated for Class I, Division 1, explosion proof.

F 731.2 NON-CLOG (DRY PIT) CENTRIFUGAL PUMPS

Non-clog centrifugal pumps are normally available with two and three vane impellers capable of passing 3-inch spheres or larger solids depending on the pump size. Typical layouts of non-clog (dry pit) centrifugal pumps are shown in Figure F 731.2A and Figure F 731.2B. They do not, however, have the capability of passing long or stringy materials, such as rags or wood particles. Where non-clog centrifugal pumps are used, comminutor or bar screens are normally provided ahead of the pumps to remove solids that may clog the pumps. The Bureau of Sanitation should be consulted regarding the use of comminutor or bar screens.
The recommended minimum design criteria in the selection of the non-clog dry pit pump are as follows:

a. Pump impeller efficiency should be selected with the best possible efficiency at design point or at the operating range of the pump.

b. Maximum Speed
   - 1750 rpm for pumps with discharge nozzle diameter up to 12-inch,
   - 1175 rpm for pumps with discharge nozzle diameter from 14 to 16-inch,
   - 886 rpm for pumps with discharge nozzle diameter from 18 to 30-inch.
   - or should not exceed the rotative speed limitation as recommended by the Hydraulic Institute Standards for Centrifugal Pump applications.

c. Materials of Construction
   - Cast iron impeller and casing with stainless steel wear rings.
   - Alloy carbon steel shafts with stainless steel sleeves.
   - Oil lubricated packing type seals.
   - Combination Radial and thrust bearings for upper and lower bearings, grease lubricated with minimum B-10 life of 60,000 hours when operating at design point.

d. Upper and lower bearings
   - Radial and thrust bearing, grease lubricated with minimum
e. Seals
   - Packing type seals.

f. Electric Motor
   - Motors should be NEMA Design B, heavy-duty, high efficiency with Class B or F insulation. Motors located in a damp environment and in a dry pit should have 2 cycles of solid baked epoxy vacuum impregnation. Bearings should be grease lubricated radial type ball bearings with a minimum B-10 life of 60,000 hours.

f. Painting and Coating
   - All wetted surfaces in contact with wastewater should be coated with coal tar epoxy enamel. Surface preparation should be in accordance with SSPC-SP5, white metal blast cleaning. Prime coat to DFT=1.5 mils, Amercoat 71, Engard 422 or equal. Two or more coats, DFT=16 mils, Amercoat 78HB, Engard 464 or equal. Total system DFT=17.5 mils.

External surface exposed to corrosive environment should be coated and painted by amine-cured epoxy. Surface preparation shall be in accordance with alkaline cleaned, SSPC-SP1. Prime coat and finish coat should be three
or more, DFT=16 mils. Amercoat 395, Engard 480 or equal.

Non-clog centrifugal pumps are normally available in the horizontal, vertical close coupled, and vertical with extended shaft configurations as shown in Figure F 731.2A and F 731.2B. Where the dry pit is subject to flooding, the vertical configuration with extended shaft and flexible couplings should be used. The motor should be mounted at an elevation above the flood level. Because pumps furnished with extended shafts are normally sensitive to vibration, the shaft bearing spacings and the natural frequency of the pump motor and supporting structure must be investigated and the design conditions must be specified. Vertical pumps close coupled to a magnetic drive and motor are also sensitive to vibration. The Design Engineer must consult the pump manufacturer to determine the vibration limits. Pumps should be specified so that the peak-to-peak vibration will not exceed the limits specified by the Hydraulic Institute Standard throughout their operating range.

F 731.3 SCREW (ARCHIMEDES) PUMPS

Open and enclosed types of screw pumps are available in various sizes and can be used for low lift pumping applications. A typical screw pump layout is shown in Figure F731.3A. Screw pumps are available with single, double or triple flights. A cover can be provided to contain the odor inside the pump channel.

Although the screw pump has been proven to be reliable because of fewer moving parts that can fail, design of bearings, drive shaft and selection of the gear reducer become important items of Design Engineer's concern. There were reported problems of early failure of the shafts, bearings and gear reducers in some enclosed screw pump installations, however this may be associated with poor design on the part of the manufacturer. The open type screw pump has been proven successful in the United States and in Europe. Pumping system requirements shall be carefully investigated prior to choosing an open or enclosed type screw pump, including screening the qualified manufacturer. In order to be assured of reliable installations, the construction specification should include strict
design criteria, testing procedures and manufacturer's qualifications and experience requirements. A manufacturer's design should be scrutinized before it is selected or approved. Furthermore, a manufacturer's reference list of successful installations using the same size pump should be verified.

Screw pumps normally have higher overall pumping plant efficiency than centrifugal pumps because of the greater head loss through the suction and discharge piping associated with centrifugal pumps. Most screw pumps are ideal for hydraulic lifts up to 30 feet at a maximum incline of 38 degrees. Higher lifts would require multiple stage pumps and head tanks which would be more expensive than a comparable size centrifugal pump installation.

By design, the screw pump has large spaces between screw flights which makes it non-clogging. Solids and stringy materials can be pumped with ease.

Design and selection of screw pumps require a thorough study. The type of bearing arrangement, lubrication and alignment method must be evaluated. The gear reducer should be selected and specified to have a service factor of at least 2.5 times the rated non-overloading horsepower of the pump. The gears should be cut with AGMA quality of at least 12, with durability ratio of at least 1.5 times the maximum dynamic loading. All babbitt bearing type journals should be designed with bearing pressures not to exceed 250 psi when the gears transmit the maximum load. Screw pumps larger than 7.5 horsepower should be provided with reduced voltage or other type of "soft" motor starting system. Soft starting will minimize shock load imparted to the drive train mechanism.

A screw pump, by virtue of its construction, is variable capacity pump corresponding to the rise and fall of the water level in the wet well while the pump speed is held constant. This precludes a requirement for a variable speed drive.

F 731.4 RECESSED IMPELLER CENTRIFUGAL PUMPS

Recessed impeller centrifugal pumps are designed to handle stringy materials and up to 25 times the amount of solids of conventional
non-clog pumps. Some recessed impellers are labeled by pump manufacturers as torque-flow, bladeless and sphere flow. However, all of these pump models follow the general design of placing the impeller away from the fluid stream in order to pass stringy material without clogging the hydraulic passages as shown in Figure F 731.4A. Most recessed impeller pumps are available in horizontal and vertical close-coupled configurations with up to 6-inch diameter nozzles.

The recommended minimum design criteria in the selection of recessed impeller centrifugal pumps are as follows:

a. Pump impeller efficiency should be selected with the best possible efficiency at design point or at the operating range of the pump.

b. Maximum speed - 1750 rpm or should not exceed the rotative speed limitation as recommended by the Hydraulic Institute Standards for Centrifugal Pump applications.

c. Materials of construction - Cast iron impeller and casing, NiHard or NiResist impeller and casing for pumps handling grit materials.

d. Upper and lower bearings - Radial and thrust bearing, grease lubricated with minimum B-10 bearing life of 60,000 hours.

e. Seals - Packing type seals.
f. Electric motors

- NEMA Design B, or F insulation, heavy duty, high efficiency motors. Motors located in dry pit or damp environment should have 2 cycles of solid baked epoxy vacuum impregnation. Bearings should be grease lubricated, radial ball bearings with minimum B-10 life of 60,000 hours when operating at design point.

g. Painting and coating

- All wetted surfaces in contact with wastewater should be coated with coal tar epoxy enamel. Surface preparation should be in accordance with SSPC-SP5, white metal blast cleaning. Prime coat to DFT=1.5 mils, Amercoat 71, Engard 422 or equal. Two or more coats, DFT=16 mils, Amercoat 78HB, Engard 464 or equal. Total system DFT=17.5 mils.

External surface exposed to corrosive environment should be coated and painted by amine-cured epoxy. Surface preparation shall be in accordance with alkaline cleaned, SSPC-SP1. Prime coat and finish coat
should be three or more, DFT=16 mils. Amercoat 395, Engard 480 or equal.

F 731.5 PUMP DRIVES

The types of drives required for certain pumping plants depend on various factors. For small capacity pumping plants where surges of flow into a large capacity treatment plant will not upset the process, the constant speed pumps can be used. Single or multiple units, constant speed pumps are normally controlled by a "fill and draw" type control system. For large pumping plants, a "matched flow" type (matching the discharge to the flow entering the wet well) variable speed drives may be the more appropriate system in order not to upset the treatment process resulting from fluctuating influent flows. Providing a combination of constant and variable speed drives or two speed motors may be appropriate in some applications.

F 731.6 CONSTANT SPEED PUMPS

Constant speed pumps are normally driven by constant speed electric motors. Electric motors that are operated by a 60 hertz power supply are available in synchronous speeds of 3600, 1800, 1200, and 900 720, 600, 514 and 450 rpm depending on the number of motor poles. The formula for calculating the number of motor poles can be derived from the following equation:

\[ f = N \times \frac{rpm}{120} \]

where:

- \( f \) - line frequency (60 hertz)
- \( N \) - number of electric motor poles
- \( rpm \) - motor speed in revolutions per minute

When a load is applied to the electric motor, the speed will decrease 2 to 3 percent of the synchronous speed. These respective speeds are 3500, 1750, 1150, and 870 rpm.
Constant speed pumps are normally used for fill and draw type pumping systems and may require multiple pump units to deliver flow to minimize excessive surges into a treatment plant. Constant speed single and 2-speed motors normally have higher efficiencies than variable (stepless) speed drives. High efficiency type motors, 15 hp and larger, usually have 90 to 95 percent efficiency at maximum load. Pumping plants equipped with constant speed pumps usually require a large wet well storage capacity, and a large dry pit to accommodate multiple pumps.

F 731.7 VARIABLE SPEED DRIVES

Although the Bureau of Sanitation prefers the variable frequency drive for new pumping plant replacement, several types of variable speed drives are available for pumping applications: variable frequency drives (VFD), wound rotor with slip recovery, magnetic coupling (eddy current) drives, direct current drives and hydraulic drives. Each type of drive has its advantages and disadvantages. Overall drive efficiency, reliability, maintenance, availability of local manufacturer's authorized service representatives, and cost are the primary considerations when selecting the type of variable speed drive to be used for a specific application.

F 731.71 VARIABLE FREQUENCY DRIVES (VFD)

VFDs consist of a power supply, converter and inverter that control the speed of an induction electric motor coupled to the pump. The speed of an induction motor can be controlled by varying the line frequency. The speed of the motor varies directly proportional to the frequency. When the VFD unit is under repair or out of order, the VFD could be designed capable of being by-passed and the motor could be operated as a standard constant speed motor. Although VFDs are inherently expensive and sensitive to temperature, humidity, corrosive atmosphere, harmonics, they offer the highest overall drive efficiency compared to the other types of variable speed drives.

VFD drive manufacturers are Robicon, Westinghouse General Electric, Eaton Dynamatic, and Rosehill Controls Corporation.
F 731.72 WOUND ROTOR DRIVES AND LIQUID RHEOSTAT VARIABLE SPEED DRIVES

The speed and torque of this type of pump drive is adjusted by varying the resistance of the motor rotor winding. The 3-phase winding of the motor is connected to slip rings attached to the rotor comminutor bars. The stationary carbon brush which comes in contact with the slip rings is attached to an adjustable resistor which is either a resistor bank or a series of submerged resistors in a liquid rheostat. For 1500 horsepower and larger, a large amount of the energy that would otherwise be lost in the resistor bank can be economically recovered by an electronic and transformer system which feeds back to the incoming power supply line at the same voltage and frequency.

F 731.73 MAGNETIC COUPLINGS

The magnetic (eddy current) drive is a magnetic coupling which connects the motor to the pump shaft. Pump speed is controlled by varying the slip in the magnetic coupling while the motor operates at constant speed.

Magnetic couplings are manufactured by E-M Company, Eaton Dynamatic or equal.

F 731.74 DIRECT CURRENT (DC) DRIVES

The DC drive is a DC electric motor coupled to the pump shaft. The pump speed is controlled by varying the armature current and terminal voltage to maintain torque and speed.

F 731.75 FLUID DRIVES

The fluid drive is a hydraulic transmission which connects the electric motor to the pump shaft. The speed of the pump is controlled by varying the flow of hydraulic fluid in the coupling. Fluid drives are normally used for applications that are sensitive to corrosion or hazardous conditions and where plant maintenance personnel do not have expertise in electronic type of equipment.
Fluid drive manufacturers are Flomatcher, Carter, or Force Control Industries.

F 732 VALVES

Pumping plants are equipped with various types of valves to prevent backflow, to isolate the equipment from the system, to control hydraulic surges and to drain the piping system during scheduled repair and maintenance. Each valve type differs in construction, materials, and operation depending on the service and application. All valves should be suitable for wastewater service.

All interior surfaces of valves in contact with wastewater should be epoxy coated. All valves 10-inch diameter and larger should be provided with motor operators. Manually operated valves located more than seven feet above the operating floor should be equipped with chain wheel operators, with the chain extended 36 inches above finish floor. Motor operated valves should be provided with a manual handwheel and manual push button station conveniently located below the valve, 5 feet above finished floor.

F 732.1 GATE VALVES AND SLUICE GATES

Gate valves (see Figure F732.1A) should be used to isolate equipment from the system. Isolation valves should be installed at each pump suction and discharge, at inlet and outlet of each flow meter, in the by-pass line around the flow meter, and in drain lines.

Double seated type bronze trim gate valves for water service should conform to ANSI/AWWA C 500 with non-rising stem, opening counterclockwise, and provided with handwheel except where electric operators are required. Unless higher system pressure is required, all valves shall have 125-pound flange to match the pipe.

Resilient-seated gate valves conforming to ANSI/AWWA C509 may be provided subject to approval of the Bureau of Sanitation, in lieu of the metal-seated double-disc type gate valves. Resilient seated gate valves should have cast iron bodies with 125-pound cast iron flanges, rubber coated cast iron disc, flange bonnets, bronze stem,
O-ring seals and operators with handwheel, except where motor operators are required.

Metal-seated and resilient-seated gate valve manufacturers are Mueller Company and Crane Valve Company.

Sluice gates (see Figure F732.1B) should be furnished with cast iron frames and slides with embedded bronze seats, Type 316 or 304 stainless steel stem, and adjustable bronze bushed stem guides. Sluice gate manual operator should have AWWA square nut; manual crank operator with floor stand and 2-speed gear reducer designed for opening time of not to exceed six minutes. Motor operator should be provided when required by the Bureau of Sanitation. Motor operated gates should be designed for opening and closing times of one foot per minute.

All sluice gates should be specified to be furnished with "F" pattern cast iron wall thimbles to match the concrete wall thickness where the gate is to be installed.

Sluice gate manufacturers are Rodney Hunt, Hydro Gate Corporation, and Waterman.

F 732.2 ECCENTRIC AND LUBRICATED PLUG VALVES

Eccentric plug valves (see Figure F732.2A) may be used in lieu of gate valves as described in Section F732.1A. Eccentric plug valves are non-clogging and easier to operate compared to gate valves. Lubricated plug valves may be used for buried service application subject to approval by the Bureau of Sanitation.

Eccentric plug valves may be used as pump control valves to alleviate hydraulic surges during normal starting and stopping of the pumps and as surge anticipators when required. The valves should be provided with hydraulic cylinder type operators with adjustable opening and closing times. Where the valve is used as a surge relief valve, emergency (upon failure of power supply) opening and closing times should be specified.
Where space permits, all eccentric plug valves should be installed with the shaft in the horizontal position. The orientation of the plug with respect to the fluid flow direction should be as per the manufacturer's recommendation. For each type of application, the valve manufacturer normally has a recommended installation instruction to prevent clogging of the valves during extended shutdown periods.

Eccentric plug valves are non-lubricated eccentric plug type with cast iron bodies, resilient faced plugs, or a replaceable, resilient seat in the body. Valves up to 20-inch in diameter should have unobstructed port area of not less than 100-percent.

Eccentric plug valve manufacturers are DeZurik Corporation, Keystone, and Drum-Owens (Homestead).

Lubricated type plug valves should have cast iron bodies and plugs. Surface in contact with wastewater shall be constructed of material suitable for wastewater service. All surfaces of plugs should be coated with a dry film lubricant, such as polyfluoride, or equal, permanently bonded to the metal surfaces. All valves 6 inches and larger should be equipped with worm-gear operators.

Lubricated plug valve manufacturers are Rockwell Manufacturing Company and Walworth Company.

F 732.3 BALL VALVES

Ball valves are usually used as pump control valves or for surge relief where flow characteristics requires the valve trim that would match that of the ball valves. Ball valves are more expensive compared to the eccentric plug valves. In some cases, spherical or cone valves or roto valves could be used in lieu of ball valves. Cross-sectional drawing of the valve is shown in Figure F 732.3A.

Small diameter ball valves can be used as isolation shut off valves for potable or plant water system. Normally these valves would be in the range of 3/4 to 2-1/2-inch diameter. For large piping, use butterfly valves or gate valves.
All ball valves should be in accordance with ANSI/AWWA C 507, with cast iron, ductile iron, or cast steel bodies, support legs or pads, flange ends, suitable for velocities up to 35 fps, temperatures up to 125 degrees F, and design pressures to 150, or 250 psi depending on the pressure range required by the system. The balls should be cast iron, ductile iron, or cast steel, shaft or trunion-mounted, with tight shut-off, single or double seat, and full bore. The valves should be rubber or metal-seated, with stainless steel or monel shafts, and at least one thrust bearing. Ferrous surfaces of valves in contact with wastewater should be epoxy-coated.

Ball valve manufacturers are Jamesbury Corporation and Wm. Powell Company.

F 732.4 CHECK VALVES

Check valves should be installed at each pump discharge piping to prevent backflow of wastewater which can cause severe damage to the pump impeller and shaft. A typical cross section of a swing type check valve is shown in Figure F732.4A. For pumping plants with multiple pump units, check valves should be provided to prevent recirculation of flows back to the suction well when the pump units are not operating.

For large pumping plants with pump discharge piping 24-inch and larger, and for pumping plants with a critical surge problem, eccentric or ball pump control valves should be used. The pump control valves should be hydraulically operated with standby nitrogen filled accumulators for emergency operation as discussed in Section F732.8 Pump Control Valves.

The most commonly used check valves in wastewater service are the swing check and the ball check valves. The swing check valves shall be installed in the horizontal position to prevent accumulation of solids downstream of the valve which can cause clogging of the valves.

Swing check valves for wastewater and sludge service should be of the outside lever and spring or weight type with oil cushion, in
accordance with AWWA C 508, full-opening, and designed for a minimum working pressure of 150 psi. Swing check valves should have a flange cover piece to provide access to the disc. The valve body should be cast iron conforming to ASTM A 126, and the valve disc should be cast iron, ductile iron, or bronze conforming to ASTM B 62 or B 148. Ferrous surfaces of valves in contact with wastewater should be epoxy coated.

Swing check valve manufacturers are APCO (Valve and Primer Corp.) and Crane Company.

F 732.5 SEWAGE SURGE RELIEF VALVES

Although surge tanks are the most reliable means to alleviate damaging surges in the force mains, sewage surge relief valve may be required by the system. Where surge relief valves are required, the valve should be installed in the discharge piping manifold and connected to the wet well. The valve should be designed to open immediately when the system pressure exceeds the load setting of the counterweights and should close slowly at an adjustable speed upon return of system pressure to normal. Figure F732.5A is a cutout section of a sewage surge relief valve showing its components.

The surge relief valve body should be constructed of a heavy cast-iron or cast steel disc having rubber seating face; and corrosion resistant shaft and cushion chamber.

Sewage surge relief valve manufacturers are APCO (Valve and Primer Corporation) and Empire Specialty Co., Inc.

F 732.6 SEWAGE AIR RELEASE VALVES

Where absolutely necessary, sewage air release valves should be provided to vent accumulating air or gas during pumping operation or entrapped during initial operation. Air release valve should be installed at high points of the piping systems. Entrapped air or gases can reduce pumping capacity of the pumping system or cause corrosion of the piping system with gases containing hydrogen sulfide. The air or gas vent located at the pumping plant should
be discharged to the wet well. Figure F 732.6A shows a sewage air release valve.

The valves should have long float stems and bodies to minimize clogging. Each valve should be furnished with backwashing accessories to remove solids accumulation inside the valve. Utility water supply and connection should be provided near the valve for backwashing.

Sewage air release valve manufacturers are APCO (Valve and Primer Corporation) and Val-Matic (Valve Manufacturing Corporation).

F 732.7 BACKFLOW PREVENTER VALVES

Where permitted by local Codes, backflow preventers should be installed where utility water or plant water is connected to the potable water supply to prevent contamination of the potable water. The valves should be designed to operate on the reduced pressure principle. The valve assembly should consist of two spring loaded check valves, automatic differential pressure relief valve, drain valves and shut-off valves. The body materials should be bronze or cast iron for working pressure of not less than 150 psi, with bronze and stainless steel trim. Drain lines and air gaps shall be provided. All backflow preventers shall be registered with County Health Department and must be approved for use in the City of Los Angeles.

Backflow prevention valve manufacturers are Cla-Val Company and Febco.

F 732.8 PUMP CONTROL VALVES

The pump control valve is normally installed in the pump discharge pipe to minimize hydraulic surges during normal starting, stopping and emergency stopping of the pump during power failure or emergency stopping caused by system failures.

The pump control valve is normally operated by hydraulic (oil) or pneumatic operator with a reserve accumulator system as back-up energy source to operate the valve during power failure. The pump
control system should be designed to start the pump against a closed valve. A typical Control Diagram is shown in Figure F 732.8A. Once the pump has developed pressure, the pump control valve should start to open until it reaches the maximum open position. Stopping sequence should cause the pump control valve to close. Complete closure of the valve should signal the pump to stop. Emergency power failure should cause the pump control valve to close.

The normal opening, closing, and emergency closing times of the pump control valve should be independently adjustable. Range of adjustment should be determined based upon the results of the surge analysis. Final settings of closing and opening times should be verified during pumping plant start-up. Settings should be included in the Operation and Maintenance Manual.

F 733 METERS - GENERAL

Each pumping plant should be equipped with metering equipment to measure outlet flow from a pumping plant, provide flow signal for recording, totalizing or control of other equipment. In addition, the flow meter should be used for pump field performance test to measure capacity and efficiency. The meter should be non-clogging, and compatible with solids bearing fluid, grease, petroleum products commonly found in municipal type wastewater. The meter should be magnetic type suitable for wastewater service.

F 733.1 MAGNETIC TYPE FLOWMETER

Magnetic meters should be provided at the pumping plant discharge manifold capable of metering the full range of flow with an accuracy of flow meter system of ± 1 percent of flow rate from 10 to 100 percent of scale. At a velocity below 1 fps, the accuracy should be ± 0.1 percent of the full scale. The meter should be installed in the piping manifold with minimum straight approach of 4 and 2 diameters upstream and downstream respectively.

The size of the flow meter should be selected from the recommended velocity range of 3 fps to 10 fps. For velocities outside of the range, consult the meter manufacturer.
The magnetic flowmeter should utilize characterized electromagnetic induction to produce a voltage linearly proportional to the average flow rate. The metering system should consist of a sensor with field coils, transmitter and interconnecting cables to make a complete operating flow metering system. The meter should be bipolar pulsed dc type with continuous automatic zeroing.

The sensor should be flange tube with non-conductive liner. The tube should be constructed of Type 304 stainless steel with carbon steel flanges AWWA Class D if the coils are external to the tube. If the coils are encapsulated inside the tube, the tube and flanges may be carbon steel. The sensor rating should be either NEMA 4 or capable of withstanding accidental submergence in water to a depth of 30 feet for 48 hours. The meter should include a positive zero feature for periods when the metering portion of the process pipe is not full.

Liner material should be neoprene, except for liquids which may deposit non-conductive coatings, which should have Teflon linings. The specific conductivity of the liquid should not preclude meter operation.

Grounding electrodes should be of the same material as the sensing electrodes and should be furnished mounted on each end of all flanges.

Transmitters should be provided for either local or remote indication as required for each particular project. Remote transmitters should be NEMA-4X enclosures suitable for wall mounting. Transmitters should produce a 4-20 ma-dc output signal into a minimum load of 800 ohms linear flow, and a scaled pulse when totalization is required. All electrical equipment furnished with the magnetic flowmeter should carry a UL label.

Magnetic meter manufacturers are Fischer and Porter Co. and Sparling Instrument Co., Inc.
F 734  PIPING AND SUPPORTS SYSTEM - GENERAL

The pumping plant piping and supports system consists of the gravity sewer, pump suction and discharge piping, plant water or utility water piping, potable water piping, air piping, sanitary drainage piping, fire protection, and sprinkler piping systems. Most of these piping systems are adequately specified by the applicable City of Los Angeles Uniform Plumbing Code, Fire Codes and the Standard Specifications for Public Works Construction (SSPWC) as amended by Standard Plan S-610.

This Section includes special requirements and recommended practices involving the design of piping and the support system.

F 734.1  PIPING SYSTEM

F 734.1.1 DUCTILE IRON PIPE

Ductile iron pipe shall be used in pumping plant main piping, consisting of suction and discharge piping, discharge manifolds force mains, and water piping 2-1/2 inch and larger. Ductile iron pipe shall be in accordance with SSPWCS, and ANSI A21.51 (AWWA C151). All internal surfaces of ductile iron pipe and fittings shall be cement mortar lined sealed with bituminous coating in conformance with AWWA C104. Outside surface of exposed ductile iron pipe and fittings shall be coated in accordance with Sub-Section F726.211.

Unless otherwise specified, all joints of ductile iron pipe should be 125-lb flange in conformance with ANSI B16.1, B16.2 and A21.10 (AWWA C110). Sleeve or mechanical grooved type coupling should be provided at the suction and discharge piping of the pump, and between the magnetic meter and the isolation valves, to allow removal of the equipment for maintenance.

All standard service bolts (not submerged or buried), unless otherwise specified should be steel in accordance with ASTM A 307 Grade A or B, galvanized after fabrication.
All buried or submerged bolts, bolts below the top of wall inside the hydraulic structure or below the wall inside any hydraulic structure should be of Type 316 stainless steel with bronze nuts or cap screws of copper-copper silicon alloy, conforming to ASTM B 98, alloy C 65100, designation H04, or alloy C 65500, designation H04. Where anaerobic conditions are anticipated, Type 304 stainless steel should be used.

Mechanical-type couplings (grooved) should be used between the valves, pumps, meters and the piping system for the above ground installation. Groove type couplings should not be used for underground installation. Mechanical-type couplings should be cast as manufactured by Victaulic, Gustin Bacon or equal.

Sleeve-type couplings should be of fabricated steel with steel bolts and with sizes to fit outside diameter of the ductile iron pipe. The middle ring should not be less than 1/4-inch in thickness and minimum of 5 to 7-inches long. The follower should be single piece contoured mill section welded and cold-expanded as required for the middle rings. The coupling should be equipped with a gasket to make the joint water-tight. The coupling should be factory epoxy coated suitable for sewer service.

Sleeve couplings should be installed in the piping systems subject to differential settlement as in the force main that connects the pump house and the yard piping. Two sets of sleeve coupling should be installed with spacing as recommended by the coupling manufacturer. Mechanical type joint should be used in lieu of sleeve couplings.

Where sleeve couplings are installed in the piping system subject to thrust loads, the coupling should be provided with restraining bolts. The bolts should be designed in conformance with AWWA Design Manual M-11.

Sleeve-type coupling manufacturers are Rockwell (Smith-Blair), and Dresser.
F 734.1.2 REINFORCED CONCRETE PIPE (RCP)

Gravity sewer mains piping located inside the pumping plant site should be PVC lined reinforced concrete pipe (RCP) in accordance with the SSPWCS and AWWA C300. Thrust blocks should be provided as required.

F 734.2 PIPE SUPPORT SYSTEMS

All piping systems, including connections to equipment, should be designed with proper support to prevent undue deflection, vibration, and stresses on piping, equipment, and structures. Seismic support should be provided and designed based on the criteria as specified in the City of Los Angeles Building Code. All supports and parts thereof should conform to the requirements of ANSI/ASME B 31.1 except as specified herein. Plumbing piping should be in accordance with the latest edition of the City of Los Angeles Plumbing Code and the requirements of the City of Los Angeles Department of Building and Safety.

Ductile iron pipe of any size should have a minimum of 2 supports per straight length not to exceed 10 feet of unsupported span. One of the supports should be located at the joint.

Where the piping system is subject to thrust as a result of hydraulic surge or actuation of a surge relief valve, a thrust support or a hydraulic shock suppressor should be provided.

All pipe supports should be galvanized after fabrication.

F 735 ANCILLARY EQUIPMENT - GENERAL

Each pumping plant should be designed to provide the necessary ancillary equipment to support the operation and maintenance of the pumping system. This equipment is essential to the operation and maintenance of the system. Ancillary equipment or systems that will be discussed herein are commonly required equipment or systems in a major pumping plant.
F 735.1 HOISTING EQUIPMENT

Most pumping plants are located underground to provide adequate submergence for the pump units. Therefore, the substructure and superstructure need to be designed to allow for installation and removal of equipment. The provisions for access hatches, lifting hooks, hoisting systems, roll-up doors and other means to provide ease of maintenance should be carefully investigated and designed as required.

For small submersible type pumping plants with pump units weighing from 50 to 500 pounds, a portable hoisting unit should be provided. The hoisting unit should be a jib crane type (Figure F731.1D) complete with a winch, lifting hook and cable, and support socket or platform socket support mounted on the wet pit wall designed to accept a jib crane post. Lifting accessories should be provided complete with a Type 316 stainless steel cable chains with end shackles, and a grip eye system for positive recovery operation. Where the access hatch is not subject to traffic loads, aluminum access hatches should be provided with a spring assist and shock absorber mechanism sized according to the pump manufacturer's recommendation. For traffic type hatch, a reinforced galvanized steel hatch with spring assist should be provided.

For dry pit type pumping plants equipped with either vertical non-clog dry pit pumps or submersible pumps mounted in the dry pit, a traveling bridge crane should be provided. See Figure F731.1C. The bridge crane should be designed to have a travel and span capable of reaching the pumps, meters and valves. Where the valves are located in areas which are inaccessible to the crane, lifting eyes attached to the ceiling should be provided directly above the valve or equipment. A floor access hatch should be provided when required.

Bridge cranes should have a manually or electrically operated hoist, trolley and end trucks, all designed to conform to all applicable codes, OSHA and the City of Los Angeles Building and Safety requirements. Where possible, monorail hoists may be used in lieu of the traveling bridge cranes.
Where space permits, a hoisting system should be designed to allow direct transfer of equipment from the dry well to a flat bed truck. Traffic into the pumping plant building should be given special consideration and necessary turning radius should be provided.

F 735.2 HVAC AND ODOR CONTROL SYSTEMS

A typical pumping plant consists of the wet well, dry pit or the pump room, motor room, electrical and control room, and ancillary equipment rooms. Each of these rooms require different methods and degrees of heating, air conditioning and ventilation to provide the following conditions:

a. To provide a safe and comfortable working environment for plant personnel;

b. To facilitate proper operation of equipment;

c. To minimize corrosion of equipment and building materials; and

d. To prevent accumulation of explosive and hazardous gases.

The heating, ventilating and air conditioning (HVAC) system and odor control systems, should be designed and controlled as one integrated system. Air distribution, building enclosures, wall penetrations, wind directions, building occupancies, and area classifications should be carefully investigated. HVAC Systems shall be designed in accordance with the American Society of Refrigeration and Air Conditioning Engineers (ASHRAE), State of California Energy conservation Standards Title 24 and the NFPA 820 Fire Protection in Wastewater Treatment Plants.

F 735.21 WET WELL VENTILATION

The pumping plant wet well receives and stores wastewater before it is being pumped to the force main. Corrosive and hazardous gases are normally present in the wet well. These gases can become a safety hazard to operating personnel or can cause corrosion of building materials and equipment in the wet well. In order to
minimize accumulation of gases inside the wet well, the wet well should be flushed with fresh air by an adequately sized ventilation system.

Ventilation rates should be in accordance with:

   a. NFPA 820 Fire Protection In Wastewater Treatment Plants

   b. Occupational Health and Safety Act (OSHA)

Pumping plant wet wells are classified into two types depending on their use:

   a. Accessible Wet Well.

   b. Sealed Wet Well.

F 735.211 ACCESSIBLE WET WELLS

An accessible type wet well is usually designed to house bar screens, barminutors, or comminutors to remove or grind solids that could clog the pumps and piping system. This equipment requires routine maintenance by plant personnel. In order to provide a safe environment for plant personnel, to prevent accumulation of explosive gases, and to minimize corrosion of equipment installed in the wet well, the wet well should be provided with adequate fresh air ventilation.

Unless otherwise required by the City's Department of Building and Safety and the Fire Department, the following minimum ventilation criteria should be used:

   a. All accessible wet wells should be provided with continuous ventilation of a minimum of 15 air changes per hour.

   b. Where intermittent ventilation is required, the ventilation rate should be at least 30 air changes per hour subject to approval by CSED.
All electrical equipment and fans inside the accessible wet well shall be explosion-proof designed and manufactured for Class I, Division I, Group D. All other design criteria shall be in accordance with NFPA 820 Fire Protection in Wastewater Treatment Plants.

F 735.22 SEALED WET WELL

Sealed wet wells are designed to be low maintenance and usually contains suction pipes or submersible pumps with slide rails. The submersible pumps can be removed by the use of hoisting mechanism mounted above ground with the slide rails. The internal surfaces of the wet well should be lined with PVC liners for corrosion protection.

Sealed wet wells should be provided with static vents to accommodate air displacement due to the rise and fall of the water level in the wet well. The vent should have a minimum diameter of one-half the diameter of the incoming sewer. The vent pipe should be connected to the nearest sewer maintenance hole where possible. Where the pumping plant is located away from any sensitive area, vent pipe could be extended above the roof line with a minimum of 15 feet from any window or fresh air inlet. Refer to subsection F735.23 for additional requirement.

All electrical equipment inside the sealed wet well should be classified in accordance with NFPA 820 Fire Protection in Wastewater Treatment and Collection System Facilities.

F 735.23 ODOR CONTROL

Where required by the regulatory agency, or where the plant is located near residential areas, or other sensitive areas, an odor control system may be provided. The odor control system should be evaluated based on a life cycle cost of 20 years with major consideration of the power and chemical consumption, first cost, maintenance cost, reliability and efficiency of the system. For a maintenance hole type pumping plant, activated carbon type scrubbers may be used. For larger plants, chemical type scrubbers are commonly used.
Chemical scrubbers utilize a chemical absorption process for removal of odors. Foul air from the plant process facility is introduced into the scrubber vessel with an atomized mist of chemical solution containing sodium hypochlorite. Oxidation of odorous compounds occur upon contact with the scrubbing mist and are removed in the condensate. The scrubber should be designed to remove a minimum of 99 percent of hydrogen sulfide in the foul air stream. Chemical scrubber manufacturers are Calvert Environmental Co., San Diego, CA, and Quad Environmental Technologies, Corp., Highland Park, IL.

All odor control and ventilation equipment should be suitable for continuous exposure to saturated hydrogen sulfide gas, sodium hypochlorite mist, sodium hydroxide mist and sulfuric acid. All electrical equipment should have explosion type enclosure design for hazardous condition for Class 1, Division 1, Locations.

For air pollution permits, consult South Coast Air Quality Management.

F 735.24 DRY WELL VENTILATION

The pumping plant dry pit is normally located adjacent to the wet well to house the pumps, valves, meters and other ancillary equipment.

The dry pit and equipment rooms should be designed for a ventilation rate of at least 15 air changes per hour or ventilation rate equivalent to cool internal heat load from the equipment which ever is greater or not greater than 60 air changes per hour. The sensible cooling ventilation rate should be calculated as follows:

\[ H = \text{cfm} \times 1.09 \times \text{t} \]

where:
- \( H \) - Internal heat gain from equipment, Btu per hr
- \( \text{cfm} \) - Air flow, cu ft per min
- \( t \) - Change in internal temperature, degree F. Use 10 degrees F for change in internal temperature as adequate for sensible cooling.
Where a pumping plant is equipped with Variable Frequency Drives (VFD), the VFD should be installed in an air conditioned room with 90 percent efficient outside air filters. VFD units are inherently sensitive to temperature, dust, moisture and other corrosive elements in the air. For constant speed pumping plant, the MCC and control rooms should be equipped with a ventilation fan and 90 percent efficient outside air filters. Pump and equipment room air inlets should be provided with 30 percent efficient outside air filters. All air filters should be provided with differential pressure gages to indicate when the filters are clogged, and flow detection devices connected to alarm signaling systems to indicate ventilation system failure.

F 735.3 FIRE PROTECTION SYSTEM

Where required by NFPA or by the Fire Department, necessary fire protection systems should be provided in required areas. For areas housing electrical equipment such as the motor control centers (MCC), computer rooms and control rooms, an approved type fire protection systems should be provided.

F 735.4 GAS DETECTION SYSTEM

When required by NFPA 820 or by the Department of Building and Safety, gas detection equipment should be provided in the wet well and dry pit or other areas where hazardous gas may be present, to record, activate alarms and/or to operate the ventilation system. The stationary gas detection system should be capable of measuring concentration of hydrogen sulfide, methane gas and/or petroleum vapor in the air. Gas detection equipment is manufactured by Mining Safety (MSA) or equal.

F 735.5 COMPRESSED AIR SYSTEM

For large pumping plants using surge tanks, air operated valves, pneumatic tools for maintenance purposes, and instrument air, a compressed air system should be provided. The air system for pneumatic tools should consist of a lubricated type air compressor, air receivers, air dryers and necessary piping system. For an instrument air system, a dedicated non-lubricated type air
compressor, receiver, dryer and necessary piping system should be provided. Where the valve operators are designed as pump control valves with the option to have controlled closing during power failure, the air receivers should be sized to store compressed air capable of stroking the air cylinders three (3) complete cycles between the specified operating pressures during power outages.

F 735.6 HYDRAULIC SYSTEM

Pumping plants equipped with hydraulic operated valves should be provided with hydraulic systems. The hydraulic system should be either a package system supplied with each valve, or one complete package to operate multiple valves. The system should consist of an oil reservoir, hydraulic pumps, control valves, hydraulic cylinders, limit switches and nitrogen gas-filled accumulators where the valves are required to operate during power outages. The valve opening and closing range should be specified. Final field adjustments should be made during pumping plant start-up. See Figure F732.8A - Hydraulic Valve Operator System.

F 735.7 STANDBY POWER GENERATION SYSTEM

The pumping plant should be provided with a standby power generation system to operate the equipment in the event of power outages. The standby power supply should be sized to operate the number of equipment necessary to deliver the maximum design capacity of the pumping plant, including its associated accessories essential to the operation of the plant, with voltage dip not to exceed 16% when starting any motor. Where secondary power supply is available, the need for a standby generator should be investigated, when both supply grids are out of service. A standby generator is more reliable than the dual power grid supply especially in the event of an earthquake. For pumping plants with a single power supply grid, and no sewer-to-sewer bypass, a standby power generator should be provided.

Generators for new pumping plants should be skid mounted, permanently anchored to the foundation, and should be housed in an acoustically equipped enclosure. Exhaust muffler designed for noise
level not to exceed the noise level allowed within each particular area should be provided.

Load banks sized for 80% of the generator capacity should be provided. Load banks should be mounted in the vicinity of the generator and protected with adequate enclosure suitable for the location as required by NEMA Standards.

Portable trailer mounted generators are only acceptable for locations where installation of a permanent skid-mounted generator is not feasible. When a portable trailer mounted generator is furnished, a power receptacle should be permanently installed for quick connection. An automatic transfer switch (ATS) should be provided in the pump station.

The standby generator should be a diesel, powered generator with an automatic transfer switch. The generator should be equipped with a fuel tank sized for a minimum of 8 hours of continuous full load operation.

In the future when the Clean Fuel Policy by AQMD will take effect, diesel standby generators may not be permitted for use in the City pumping plants. Clean burning fuel such as natural gas or propane should be investigated. For air pollution permit requirement, the Design Engineer should contact SCAQMD.

F 735.8 NOISE CONTROL

The pumping plant facility should be designed to meet the minimum noise level requirement of the City of Los Angeles Municipal Code (The Code) and the Occupational Safety and Health Administration (CAL/OSHA). All mechanical equipment and enclosures should be acoustically treated to bring the noise level down to an acceptable limit. These attenuation devices may consist of exhaust mufflers, sound isolators or acoustical panels.

The pumping plant facility should be designed with noise levels not more than 5 dBA above the ambient noise level as measured at the property line of the nearest recipient (neighbor). A 24 hour noise
level reading should be measured at the pumping plant site as basis of the design.

In the absence of actual field measurements, the presumed ambient noise level shall be deemed to be the minimum ambient noise level for each zone as follows:

Sound Level "A" Decibels
(In this chart, daytime levels are to be used from 7:00 A.M. to 10:00 P.M. and nighttime levels from 10:00 P.M. to 7:00 A.M.)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Presumed Ambient Noise Level (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1, A2, RA, RE, R5, RD, RW1, RW2, R1, R2, R3, R4, AND R5</td>
<td>Day: 50 Night: 40</td>
</tr>
<tr>
<td>P, PB, CR, C1, C1.5, C2, C4, C5, AND CM</td>
<td>Day: 60 Night: 55</td>
</tr>
<tr>
<td>M1, MR1, AND MR2</td>
<td>Day: 65 Night: 65</td>
</tr>
<tr>
<td>M2 AND M3</td>
<td>Day: 70 Night: 70</td>
</tr>
</tbody>
</table>

At the boundary line between two zones, the presumed ambient noise level of the quieter zone shall be used.

The above reference criteria were extracted from the City of Los Angeles Municipal Code, Chapter XI, Article 1, Section 111.03, as amended effective 3/29/82. The design engineer is advised to check the latest revision of the Code.

There are several ways to design a pumping plant to meet the noise level requirement. The location of the pumping plant is the major contributing factor. If the pumping plant is located in a residential area, the equipment may have to be located inside an acoustically treated building because architectural sensitivity and sound attenuation can easily be integrated in the building design for optimum noise reduction. When the pumping plant is located in an industrial or commercial area, package equipment with an acoustical enclosure may meet the requirement.
Each noise-producing mechanical equipment and/or system should be evaluated on the basis of the required sound level criteria. For example, engines, blowers, compressors, turbines and other high speed machines are inherently noisier than low speed pumps and electric motors. On the other hand, some similar equipment with higher tip speeds, high velocity ductwork, or as simple as a sewer pipe or water pipe located inside a stud wall partition can be a source of noise if not designed properly. The following procedures give some steps in designing a noise control system in a pumping plant.

Design Approach.

a. Determine zone classification of the project site and allowable noise requirement.

b. Take 24-hour ambient readings at the project site.

c. Determine the maximum allowable design noise level. The acceptable noise level should not exceed 5 dBA above the minimum ambient noise level. Also check if the plant can be exempted from these requirements if the equipment, such as a standby generator, will not be operated continuously or on a regular basis.

d. Select the type, and size of the commercially available equipment with reasonable noise levels. Do not specify the maximum noise rating of the equipment without consulting the manufacturer. The engineer should determine if the specification can be met by at least two manufacturers. As a guide, the following equipment with no acoustical treatment have the corresponding sound level requirements:

1. Pumps and electric motors 60 - 70 dBA
2. Engine generators 70 - 110 dBA
3. Compressors and blowers 70 - 110 dBA

e. Prior to the preparation of the facility layout, group the equipment according to the noise level they generate.
Usually engine generators, compressors, and blowers turbines should be located in a separate room.

f. Study the acoustical system of the equipment and its accessories normally supplied with it. For example:

1. Rotary compressors are usually furnished with suction and discharge silencers and an acoustical enclosure to reduce the noise level to 60 or 70 dBA.

2. Engine generators can be specified with critical-hospital type mufflers to have noise reduction of 40 to 50 dB measured at 50 feet from the engine as in the Maxim Model M-51. In addition, engine generators may be fitted with an inline heat exchanger in lieu of the noise generating fan cooled radiator. The use of inline heat exchanger should be subject to approval by the Bureau of Sanitation.

3. Pumps and motors can be selected and specified with speeds that would not produce noise levels in excess of 60 to 70 dB.

4. Ventilation fans can be selected and specified with propeller tip speeds not to exceed a certain speed. This data can be checked in the manufacturer's catalog. Further reduction in noise level can be achieved by the use of duct silencers.

g. Once the equipment has been selected, the engineer should determine if the equipment will be installed indoors or outdoors. The following criteria may be of help during this process:

1. If the equipment can be provided with acoustical enclosure to meet the noise requirement, the unit may be installed
outdoors. If the available standard enclosure is not adequate to reduce the noise level below the maximum required, then the equipment should be installed inside the building. The equipment may still be enclosed by an acoustical enclosure or the building should be provided with wall sound panels and/or air inlet silencers in all wall louvers or baffled ducts.

2. For equipment furnished with an acoustical enclosure, the engineer should check maintenance access, ventilation, and any possible reduction in the rated capacity, such as with electric motors.

3. When the equipment is to be installed inside the building, all outside louvers, exhaust ducts and exhaust fans that serve as direct conductors of noise should be acoustically treated as follows:

Approximate Noise Reductions

- Wall acoustical louvers  - 10 - 12 dBA
- Air Inlet Silencers (Sound Trapping)  - 20 - 25 dBA
- Acoustical wall panels  - 10 - 15 dBA
- Acoustical Enclosures  - 35 - 45 dBA

F 735.9  DEWATERING SUMP PUMPS

A dewatering sump pit should be provided in all underground structures such as dry pits (pump rooms), valve and electrical vaults. The sump pit is to be equipped with an adequately sized pump plus a standby unit, each having a minimum capacity of 50 gpm. Submersible sump pumps should be used and controlled by a duplex type control, an automatic alternator and a float switch level control. The control system should be designed to start the
standby pump when the lead pump fails to start or when the water level continues to rise while the lead pump is operating. Both pumps are to stop at low water level.

Sump pump discharge pipe, fittings and valves should be ductile iron pipe, with minimum diameter of 3-inches. Each sump pump discharge pipe should be provided with a swing valve and isolation gate valve mounted above, both in the vertical position. A common discharge manifold should terminate inside the wet well with the wall penetration above the highest surcharge elevation of the wet well. This is to prevent backflow into the dry pit in the event of failure of the check valve. See Figure F 735.9A.

F 736 SPARE PARTS

Electro-mechanical pumping plant equipment should be provided with spare parts necessary to ensure continuous operation. The recommended spare parts should be determined by the project design engineer with assistance from the Bureau of Sanitation. Unless otherwise required by the Bureau of Sanitation, the following should be the minimum list of spare parts:

a. One set of pump and motor bearings for each size and model of pump unit.

b. One set of pump seals for each size and model of pump unit.

c. One set of pump and casing wear rings for each size and model of pump unit.

d. (Optional) One set of pump and motor for each size and model of pumping unit where the pumps are located in critical pumping plants.

e. One dozen fuses for each size of fuse.

f. A printed circuit board for each size and model of the variable frequency drives.
The spare parts should be delivered to the project sites no later than two (2) months prior to plant start up. Spare parts required during testing and start-up should be provided by the contractor.

F 737  ELECTRICAL SYSTEMS

Electrical systems in the pumping plant consist of the power supply, power transformers, motor control centers, electric motors, electric variable speed drives, electrical wires and conduits, lighting fixtures, and other associated interface with the instrumentation and control systems.

F 737.1  POWER SUPPLY

The standard power supplies to the pumping plant are 34.5 KV, 16.6 KV, 12 KV, 4160 V, 480V and 240/120 volts depending on the size of electrical loads required by the pumping equipment. The range of electric motor size corresponding to line voltage are as follows:

<table>
<thead>
<tr>
<th>Power Range</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 1/2 hp</td>
<td>120 or 240 volts</td>
</tr>
<tr>
<td>1/2 to 500 hp</td>
<td>480 volts</td>
</tr>
<tr>
<td>500 to 2500 hp</td>
<td>4160 volts</td>
</tr>
</tbody>
</table>

Normally, power is supplied by the City of Los Angeles Department of Water and Power (DWP). Some pumping plants are connected to a single power grid and very few are connected to a dual grid.

F 737.2  MOTOR CONTROL CENTERS (MCC)

All motor starters and disconnect switches should be installed in Motor Control Centers (MCC). MCC rooms should be located away from hazardous gas or other corrosive environments. Mechanical ventilation equipment should be provided to maintain air circulation. All fresh air inlets to the MCC rooms should be provided with 90 percent efficiency inlet filters.

Where environmental problems exist in the pumping plant location, such as the presence of dust, moisture from sea water, or corrosive gas, the MCC room should be designed to have adequate ventilation and provided with air cleaning equipment such as de-humidifiers,
filters or carbon absorbers. HVAC should be designed in accordance with Section F735.2 HVAC and Odor Control Systems.

The MCC circuit breaker handles must be provided with safety interlocks.

F 737.3 AREA CLASSIFICATION

The locations for the pumping plant facilities vary from one pumping plant to the other. The relative location and configuration of the wet well, dry pit, electrical rooms also differ in each pumping plant. Therefore it is not possible to standardize layouts and requirement.

This manual recommends that the project engineer define the pump station layout and submit it to the Building and Safety Department to secure area classification for each part of the plant. The area classification will be used to base all the electrical equipment designs. The NFPA 820, Fire Protection in the Wastewater Treatment and Collection Facilities can be used as a reference especially in differing layout conditions.

F 737.4 ELECTRICAL CABLES AND CONDUITS

All electrical cables and conduits should be designed in accordance with the NEMA Area Classification as required by the service area. All electrical conduits should be galvanized rigid metallic conduits. Conduits installed in the wet pit and dry pit should be PVC coated galvanized rigid metallic conduit or schedule 80 PVC. All conduits should be sized for ultimate service (100 years). Spare conduits may be provided.
F 738 INSTRUMENTATION AND CONTROLS

The instrumentation and control system should be designed to operate the plant to match the flow characteristics of the service area. The control system generally consists of the wet well level control, flow metering equipment, pressure gages and switches, fire alarms and gas detection instruments.

F 738.1 PUMP CONTROL SYSTEM

F 738.11 GENERAL

The pumps are generally controlled by the level in the wet well. The level sensor should be an ultrasonic level type. The wet well should be provided with a redundant float switch type low-low level cut-off switch and a high-high level alarm switch. Each pump should be provided with a high discharge pressure switch to activate failure alarm during accidental closure of the discharge valve, failure of the pump control valve to open, or failure of the check valve to open. All failure alarm switches should be provided with alarm lights located in the Local Control Panel (LCP) or Main Control Board (MCB). LCPs are normally located near the pump units, while the MCB may be located in another building or in a remote location. An example is the Venice Pumping Plant where all the outlaying pumping plants are monitored and controlled.

Unless otherwise waived by the Bureau of Sanitation, the pump control system should consist of both "hard wired" controls and a Programmable Logic Controller (PLC). During normal operation, the PLC will be controlled by the ultrasonic level control. Loss of ultrasonic level signal or failure of the PLC, the control system will automatically switch from the PLC to the "hard wired" system. The "hard wired" system will then be controlled by the float switch for which the pumping plant will operate in a "fill-and-draw" mode.
F 738.12 CONSTANT SPEED PUMP CONTROL SYSTEM

There are two types of operating sequences to control the constant speed in a "fill and draw" pumping system.

The first operating sequence is normally applicable for multiple pump units installed in a smaller wet well. The pumping station will start in sequence, pumps start and stop in the reverse order. This operating sequence will normally provide more uniform flow to the receiving system or to the wastewater treatment plant.

The second operating sequence is normally applicable to dewatering of drainage sump pits. In this sequence, each pump would start one after the other successively. Then all pumps will continue to operate down to the low water level where all pumps are signaled to stop. This type of operating sequence is commonly used for dewatering construction sites or drainage sump in a building basement. The first sequence is recommended for the wastewater pumping plant for the following reasons:

a. To maintain uniform flow into the wastewater treatment plant, minimizing hydraulic shock loading and process upset;

b. To provide smaller wet well storage volume and less number of motor starts per hour;

c. To reduce sewer gas emission to the atmosphere by maintaining a constant water level in the wet well.

F 738.13 VARIABLE SPEED DRIVES.

Variable speed (matched-flow) pumps are normally used for the following conditions;

a. Where more uniform discharge to the wastewater treatment plant is required;
b. Where there is not enough space in the pumping plant to accommodate installation of multiple smaller unit constant speed pumps;

c. Where the wet well volume is limited to satisfy a maximum 10 starts per hour;

d. Where sewer gas emissions to the atmosphere should be limited;

The variable speed drive pumps should be controlled as follows:

a. When the wet well level reaches the first set level, the lead pump will start and ramps to a minimum preset speed. As the flow increases, the pump speed will increase in proportion to the increase in flow in order to maintain the level in the wet well until the pump has reached its maximum speed.

b. When the inflow to the wet well exceeds the maximum capacity of the lead pump, the control system will then start the lag pump. The lag pump will increase its speed while the lead pump decreases its speed up to the point where the two pumps share the flow, both at the same speed. As the inflow increases, the two pumps will increase their speeds in proportion to the inflow until the pumps have reached the maximum pumping plant design flow, in the case of two pump combination.

c. A drop in wet well level equivalent to a decrease in pumping plant inflow will signal the pumps to slow down until a preset speed is reached. Then the lag pump will stop, and the lead pump will increase its speed in proportion to the inflow.

d. Further drop in wet well level will signal the lead pump to slow down until the minimum level is reached, at which level, the lead pump will stop.
e. In the event that either the lead pump or the lag pump fails, the wet well level will rise and the standby pump will be started at the same time the failure alarm is activated. The standby pump will be provided with a variable speed drive.

For pumping plants equipped with more than two variable speed pumps, the same operating sequence will be followed.

**F 738.14 COMBINATION CONSTANT SPEED AND VARIABLE SPEED DRIVE PUMPS**

Where a combination of constant speed and variable speed drives are required by the pumping system, the variable speed pump shall be used as a jockey pump. This design, however, is often discouraged due to the complexity of the control system. The jockey pump with variable speed drive shall be sized to serve as a lead pump and to trim the flow in excess of what the constant speed pump can not deliver. The sequence of operation should be as follows:

a. At a preset level in the wet well, the lead pump with variable speed drive shall start and increase its speed to a minimum preset speed. As the inflow into the wet well increases, the pump speed shall increase to match the incoming flow.

b. When the pump speed has reached the maximum speed and the inflow is increasing, the constant speed pump shall start.

c. Due to the increase in capacity of the constant speed pump, the wet well level will drop and this shall cause the variable speed pump to slow down and maintain the level in the wet well.

d. Further increase in the incoming inflow will increase the speed of the variable speed pump until the maximum capacity of the pumping plant is reached. Decrease in wet well inflow shall reverse the sequence until the lead pump has reached its minimum speed. When the inflow is
less than the capacity of the pump at its minimum speed, the lead pump shall stop after a preset time delay.

The cost of transfer switch gear and the reliability of the whole system shall be taken into consideration when evaluating the different types of drives.

F 738.2 BUBBLER LEVEL CONTROL SYSTEM

The bubbler tube level control system operates on the principle of measuring the height of the liquid above the bottom of the bubbler tube. Air is bubbled into the wet well. As the depth of the liquid increases, the pressure required to force a constant flow of air through the liquid increases, thereby increasing the backpressure. This pressure is converted to an electrical signal by a linear variable differential transformer and then used to control the speed of the motor in the case of a VFD or control the magnetic couple in the case of a magnetic drive.

The bubbler control system shall be provided with air compressors (1+1 standby) with manual alternator and priority switch.

F 738.3 FLOAT LEVEL SWITCH

The float level switches should be used to detect the low-low level cut-off and the high-high water level alarm, as an auxiliary switch, in the event of failure of the sonic level control system. The level switch should be a float type designed and manufactured for Class 1 Division 1, Hazardous Conditions.

Submersible dewatering sump pumps located in dry pits and valve structures should be controlled by float switches. Float switches should be designed and manufactured suitable for the area classification of the sump pit.

F 738.4 SONIC LEVEL CONTROL

The pumping plant primary level control should be the sonic level sensor. The sonic level sensor should be mounted inside the wet well at a distance recommended by the manufacturer above the high
water level. The selection of the level controller should be checked for its maximum range and control span. The sonic level switch has a limited range for the sound to travel, and should therefore, be installed at a certain distance from the wet well wall in order not to obscure the sonic wave pattern. The mounting should be designed to allow cleaning of the sensor. Where a sonic device is used, the wet well shall be provided with a float type level switch to activate the low-low level pump cut-off and the high-high level alarm in the event of failure.

F 738.5 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

Where the pumping plant operation is required to be monitored or controlled remotely at a central station (Venice Pumping Plant), SCADA system equipment needs to be provided. The system should consist of the Remote Terminal Unit (RTU) located in the pumping plant connected to a computer at a designated central station. The signal to the central station is transmitted over the telephone lines.

The pump operation is normally initiated by a motor starter mounted in the Motor Control Center (MCC) Room. The starter is controlled by a local switch or push buttons or by local control automation, such as the PLC, RTU or the Process Control Module (PCM). The PCM is an intelligent RTU.

The local control panel normally houses the Programmable Logic Controller (PLC) which is designed to perform the pump station control commands, receive and send commands between the RTU and the Central Station. Other signals, such as wet well levels, flow, pressure, etc., may send signals directly to the RTU.

The RTU's are classified as "smart" (intelligent) or "dummy" RTU's. The smart RTUs are capable of providing local control and data gathering, while the dummy RTUs take information and monitor data and execute commands from the Central Station.

The Central Computer System function may consist of display information such as graphics and tables. It can also gather historical data such as trends of pumping cycles, measurement of
flows and pressures, equipment running time, number of pump starts per hour, and many more features if designed with these features.

The whole telemetering system is also called Supervisory Control And Data Acquisition (SCADA). The SCADA System shall be designed in consultation with WCSD. The SCADA equipment should be furnished and installed compatible with the existing City's standardized SCADA System.

F 738.6 PRESSURE GAUGES AND SWITCHES

Pressure gauges should be installed at the suction and discharge sides of each pump to measure the pump total dynamic head. The pressure gauge should be at least 4-1/2 inches in diameter. Where seal flushing water is required, a pressure gauge and low pressure switch should be provided to activate an alarm in case of loss of flushing water. A low flow alarm switch may be used in lieu of the pressure switch.

A pressure switch may be provided between the pump and the check valve or pump control valve to activate alarm in the event of failure of the valve to open or accidental closure of any isolation valve located at the pump discharge piping. A micro switch attached to the valve shaft may be provided in lieu of the pressure switch.

All pressure gauges and switches installed in a piping system carrying solids bearing fluids such as wastewater, sump pump discharge or chemical lines should be provided with diaphragm seals and snubbers where pulsating flow is expected. The assembly should be provided with an isolation valve for maintenance. Diaphragm seal material should be compatible with the pressure and fluid being handled. See Figure F 738.6A for Pressure Gauge and Switch with Diaphragm Seal.

F 739 PUMPING PLANT FACILITY

The pumping plant facility includes the pumping plant structure, buildings, electrical substation, access roads and other appurtenant equipment inside the plant property. The facility
design should incorporate access road and security. The architectural treatment should blend with the surrounding area.

F 739.1  BUILDING DESIGN AND MATERIALS OF CONSTRUCTION

The pumping plant usually consists of an underground concrete structure to house the wet pit and the dry pit. Where the pumping plant requires an above ground structure to house the electrical room, generator room, office area and maintenance shop, the above ground building should be designed in accordance with the requirements of the City of Los Angeles Building Commission. In general, all buildings should be cast-in-place concrete or block wall construction.

Wet Well and Dry Pit. The size and configuration of the wet well shall be designed in accordance with Section F725. The wet well and dry well should be reinforced cast-in-place concrete with wall thickness to withstand the earth loads, and should be heavy enough to resist floatation without earth skin friction resisting the outside surfaces when the wet well is empty. The bottom of the wet well should be sloped to at least 15 degrees and corners grouted to prevent accumulation of solids during operation. The dry pit shall be designed to provide the following:

a. Minimum of 36-inch working clearance between pumps and piping;

b. Access doors, stairways and landing;

c. Access opening for equipment installation, maintenance and removal;

d. Hoisting equipment or lifting hooks;

e. Adequate ventilation in accordance with Section F735.21; and

f. Fire protection equipment where required.
F 739.2 ACCESS ROADS

Pumping plants should be designed with access roads for construction, operation and maintenance of the equipment. The roads should have turning radius suitable for the size of vehicle, or heavy hoisting equipment necessary for installation, removal or delivery of equipment or supplies into the plant. Pavement sections should be able to support the load of the heaviest anticipated equipment to be used in the plant. Where monorail hoists or traveling cranes are required, adequate headroom clearance should be provided or loading docks can be used to limit the height of the building.

F 739.3 FLOOD CONTROL

When the plant is located in a flood plain or flood-prone area, it should be designed based on a 100 year flood. Flood elevations should be verified from the Flood Rate Maps as published by the Federal Emergency Management Agency, available from the Stormwater Management Division. The maps show the extent of 100 year flood. All electrical equipment should be located above the highest anticipated flood level. An alternative is to extend the wet/dry pit walls above flood level.

F 739.4 GRADING AND AREA DRAINAGE

The site drainage should be designed to prevent standing water or the erosive effects of storm runoff. Pavement areas should have a positive drain of up to 3%. Flow lines should have a minimum of 1% slope. Underground structures should not be constructed in half cut and half fill. Where this condition exists, the site should be over-excavated and restabilized. The pumping plant should be designed not to float where high groundwater exists.

F 739.5 SOILS REPORT

A geotechnical investigation should be conducted to determine the underground soils conditions. The Soils Report should show the foundation design criteria, corrosiveness of soils and groundwater, groundwater elevations if it exists, and possible hazardous materials underground, cleaning of such materials should be
addressed in the construction contract, or can be awarded to a separate hazardous materials contractor.

F 739.6 SURVEYING

The control bench marks should be referenced from the City of Los Angeles Datum. Where existing survey is available, field check existing data with the new datum and the existing building or structure. The location of the pumping plant should be tied to a nearby street and to an existing property line. Basis of survey bearings and control should be given if the local coordinate are established.

F 739.7 SECURITY

The pumping plant site should be provided with chain link fence as a minimum. In areas where security is a problem, a block wall may be required. The fence or wall should be designed in accordance with applicable building codes and local ordinances. The entrance gate should be secured with a padlock. Where required in certain areas, the pumping plant should be equipped with an intrusion or burglar alarm. The alarm should be connected to a horn mounted in the building and remoted via telemetry to the main control system if required.

F 739.8 WATER SUPPLY SYSTEM

The plant water supply system should be provided for pump seal water system, irrigation system, rest rooms and housekeeping hose downs. A backflow preventer should be installed in the pipeline connecting the hose bibbs, seal water and irrigation system. Where required, air gap tanks should be installed in lieu of the back pressure valve. All piping should be designed in conformance with the City of Los Angeles plumbing Code.

F 739.9 LANDSCAPING AND IRRIGATION SYSTEM

Where required by the Architectural Committee, landscaping should be provided. Plants should be drought resistant and irrigation system equipment should utilize water saving kits controlled by
automatic timers. Reclaimed water should be used for the irrigation system, if available and permitted.

F 739.10 PROCEDURES FOR PLAN CHECK BY THE DEPARTMENT OF BUILDING AND SAFETY

Prior to design, Design Engineer should check all necessary applicable Codes including disability (ADA) requirements. Pumping plant design plans should be submitted to the Department of Building and Safety for plan checking. This should be done prior to the Division Design Engineer's signature.

Plan check procedures are as follows:

a. Project Design Engineer prepares an Inter-Departmental Order (IDO) Form Gen.33, for approval by Division Design Engineer. The IDO is then forwarded to WPMD for a funding appropriation request, then submitted to the Bureau of Accounting, Sewer Construction and Maintenance Fund Financial Accounting Division. After approval by Accounting, a copy is retained by the Originator (Project Design Engineer). Copies of the approved IDO are given to the various disciplines involved in the design. These copies are presented to the Cashier at the One Stop Construction Center, 4th Floor City Hall, during filing of plan check applications with the Department of Building and Safety.

b. Two sets of plans are required for each discipline. Depending on the type of the project, the following plans shall be filed for checking:

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Persons Responsible for Plan Check Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>Structural Engineer</td>
</tr>
<tr>
<td>Electrical</td>
<td>Electrical Engineer</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Mechanical Engineer</td>
</tr>
<tr>
<td>Grading</td>
<td>Civil Engineer</td>
</tr>
<tr>
<td>Plumbing</td>
<td>Mechanical Engineer</td>
</tr>
</tbody>
</table>
Note: Refer to the appropriate Building, Electrical, Mechanical, or Plumbing Code of the City of Los Angeles for further information on when plan checks/permits are required.

c. If a permit is not secured within one (1) year after the plans have been filed for checking, such plan check will expire and no permit shall be issued until the plans are rechecked, approved and a new plan check fee paid.

d. Expiration of Permits. Permits are valid for two years after issuance, provided work is started within 180 days. The permit will expire if work is not started within 180 days, or started but suspended, discontinued, or abandoned for a continuous period of 180 days.
F 740 CONSTRUCTION

The pumping plant should be constructed in conformance with the specifications and drawings. It is important for the pumping plant design engineer to anticipate potential problems in construction and reflect mitigative action in the design drawings and specifications such as a pumping plant by-pass procedure. Although, the design project engineer will not be fully involved in the construction, this section includes important points the Design Engineer should include in the contract documents. The design project engineer should be available to reply to requests for clarification during construction and to review shop drawings.

F 740.1 SHOP DRAWING SUBMITTAL AND SHOP DRAWING REVIEW

The General Conditions/General Requirements and the Master Technical Specification specify the requirements for shop drawing submittal and review process. The project engineer should review those master documents and add project specific items.

The specifications should, as a minimum, describe the features of the equipment to ensure that the right equipment is supplied. Such pump features as capacity, head, minimum efficiencies, minimum size impeller, suction and discharge nozzles, maximum speed, and materials of construction should be included. The City requires a minimum of two manufacturers are cited with the added statement, "or equal."

Once the project is awarded, shop drawing submittals need to be reviewed and accepted. The shop drawing review is one way to check compliance with the specifications. It also serves as a mechanism to get from the contractor the equipment as specified. Where a substitution to specified equipment is proposed to the construction project Design Engineer for review, the design project engineer should be consulted.

F 740.2 EQUIPMENT INSTALLATION AND TESTING

The equipment installation and testing should be specified in each equipment specification. Normally, during the early stages of
design activity, it is recommended that the engineer selecting the equipment discuss with the equipment manufacturer's representative the installation procedures and testing services required. The Design Engineer should take into consideration how the equipment will be installed and provide necessary access such as roll-up doors, roof hatches, overhead crane and other necessary items. Normally, the equipment shall be specified to be installed by the Contractor under the supervision of a certified factory representative. After installation, the Contractor shall conduct trial operation of the equipment, and make the necessary adjustments as required. When the equipment becomes operational, the Contractor shall test the equipment in the presence of the City representative. The test shall include a performance test, simulating the manual and automatic operation, and checking of other components in compliance with the specifications. A continuous test using the actual process material shall be conducted without major breakdown prior to final acceptance. Refer to Procedural Memoranda, Part C for Startup and Operations and Maintenance Guidelines.

F 740.3 OPERATION AND MAINTENANCE MANUAL

The initial draft of the Operations Manual is normally prepared by the Design Engineer. This is then submitted to WCSD for review. The final version is completed prior to start-up operation. The Maintenance Manual is the responsibility of the Construction Management Group. The Operation and Maintenance Manual of the various equipment submitted by the Contractor are compiled and bound together to form the plant Maintenance Manual. The Design Engineer should specify the Operation and Maintenance manual requirements. Procedural Memorandum C-8, Design, Operations and Maintenance Manuals Guidelines, provides guidance on who is responsible for the various activities in the development of the O & M Manuals, as well as the submittal processing and approval.

F 740.4 PLANT OPERATOR'S TRAINING

Each pumping plant has unique operational requirements and some have equipment that requires familiarization by the plant operators. The Design Engineer should include provisions in the
Contract Documents regarding Plant Operator's training by the equipment manufacturer's representative. The number of training hours should be specified for each type of equipment. The Design Engineer should consult with WCSD on the level of training and number of hours required.

Refer to Procedural Guidelines C-1 for Operator Training Procedure.