DESIGN STANDARDS

of the

DEPARTMENT OF WASTEWATER MANAGEMENT

Volume I

July, 1993

DEPARTMENT OF WASTEWATER MANAGEMENT
CITY AND COUNTY OF HONOLULU
STATE OF HAWAII

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DEPARTMENT OF WASTEWATER MANAGEMENT
CITY AND COUNTY OF HONOLULU
STATE OF HAWAII

DESIGN STANDARDS

Volume I

GENERAL REQUIREMENTS FOR WASTEWATER FACILITIES

DESIGN OF SEWERS AND PUMP STATIONS

JULY, 1993

APPROVED:

DIRECTOR

FORWARD

Volume I of these standards of design is established to serve as a guide and aid in the planning of wastewater facilities and in the design of sewers and wastewater pump stations that are to be operated and maintained by the Department of Wastewater Management, City and County of Honolulu. It is the intent of these standards to present procedural and major design requirements to facilitate the approval process. It is not the intent to restrict the designer from applying his engineering knowledge and experience nor from exercising his skill or judgement. Approval of reports and designs by the Department shall in no way relieve the designer of his responsibilities and professional obligations. He shall be held responsible for the adequacy of design, the accuracy and completeness of the plans and specifications, and the operability of the facilities.

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CHAPTER 30

DESIGN OF WASTEWATER PUMP STATIONS

31. Factors to be Considered

31.1 Type of Station:

31.1.1 Built-In-Place Wastewater Pump Station: Except as noted in Section 31.1.2, all pump stations shall be built-in-place and shall be of the dry well type.

31.1.2 Factory-Built Wastewater Pump Station: Factory-built pump stations are acceptable for temporary use under the following conditions:

a. Equipped with State Division of Occupational Safety & Health (HIDOSH) certified elevator for access and auxiliary ladder for emergency use.

b. The size of the enclosure shall be 8 feet minimum diameter. Access tube shall be 4 feet minimum diameter.

c. The size of the pumps shall not exceed 6 inches.

d. The pump motor shall be of a totally enclosed design conforming to NEMA standards. Motor frame size should not be larger than NEMA 326 U.

e. The number of pumps installed shall be two, one of which is a standby unit.

f. The pumps and motors should be pedestal mounted, close-coupled, or submersible (dry pit).

g. The design of the station, equipment and appurtenances provided shall meet all applicable portions of these standards.

h. Stations shall be properly protected against corrosion by protective coatings and cathodic protection as applicable.

i. Adequate ventilation shall be provided.

j. Flow measurement device shall be provided.

31.2 Wastewater Flows and Design Capacity:

31.2.1 Wastewater Flows: Wastewater flows shall be determined in accordance with Section 22.

31.2.2 Design Capacity: Wastewater pump stations shall be designed to discharge peak flows.

31.3 Location: Wastewater pump stations shall be located where tributary areas will be most effectively serviced and where development, construction, and operational costs would be at a minimum. Pump stations should not be subject to flooding and shall be readily accessible. Wastewater pump station sites should be located near a stream or body of water.

Wastewater pump station sites shall be adequate to allow on-site parking of service trucks and equipment and to buffer adjoining properties from noise. Future modification and expansion requirements shall be given consideration.

32. Site Improvements

32.1 Grading: Wastewater pump stations shall be properly graded and provided with adequate drainage facilities to carry away storm waters. Adjacent properties shall not be jeopardized by such provisions.

32.2 Driveways and Parking Areas: Paved driveways and parking areas shall be provided for service trucks. Width of driveways should be 12 feet minimum. Pavement shall be of asphaltic concrete or Portland cement concrete. Concrete curbs shall be required for all pump stations. Entrance gates should be set inward, toward the station, at least 18-feet to provide safety for trucks entering or leaving the station.

32.3 Fencing: Pump station sites should be fenced in with a 6 feet high fence or wall. If requirements of Section 33.1 or the Comprehensive Zoning Code (CZC) dictates, masonry walls or other approved types of enclosures may be provided.

Where chain link fences are used, the wire fabric shall be 9 gauge minimum. In suspected corrosive areas corrosion protection or additional thickness shall be provided.

In isolated areas, three strands of barbed wire should be installed along the top of the fence on an arm projecting inward at an angle of 45 degrees.

Gates shall be provided with heavy duty padlock hasp fixture and shall be designed for safe opening and closing during strong winds. At facilities where HECO transformers are installed within the station's perimeter, the hasp shall be designed to accommodate two padlocks. This design will allow access with either padlock removed.

A minimum 1 foot wide gravel strip shall be provided under fencing. Gravel strip shall be contained with redwood or other approved durable material headers.

32.4 Landscaping: Sites shall be landscaped to blend with the surrounding environment to render a pleasing overall appearance. Consideration shall be made to minimize groundskeeping maintenance. Trees may be allowed within the facility's perimeter. However, root intrusion problems shall be considered. Chain link fencing shall be screened with landscaping to conform to the Land Use Ordinance.

In lieu of grass for ground landscaping, crushed rock such as coral chips, red cinder stone or blue stone shall be considered.

32.5 Sprinkler System: Adequate automatic sprinkler systems shall be installed for lawn/foliage irrigation.

For pump stations not located on treatment plant sites and landscaped with rock, cinder or coral aggregate, the sprinkler system may be a manually operated system. Sprinkler systems for this type of landscaping shall be designed to irrigate the plants and foliage only.

33. Structure and Appurtenances

33.1 Architectural Design: Wastewater pump stations shall be architecturally designed to be in harmony with surrounding development. Materials shall be selected to keep construction and maintenance cost at a practical level. As much as possible, non-corrosive materials shall be used. All architectural design shall be prepared by a registered architect.

33.2 Substructure: Built-in-place pump station substructures shall be reinforced concrete construction. All substructures shall be waterproof and watertight. Test borings shall be made to determine the soil characteristics and groundwater conditions at all pump station sites and foundations shall be suitably designed. Consideration shall be given to flotation during construction and/or flooding condition.

33.2.1 Dry Wells: Dry wells shall be sized to meet space requirements for equipment, piping and ease of maintenance. Adequate working space, at least 2 feet clear, shall be provided between and around pumps and other equipment. Provide 3 feet clearance for electrical equipment to comply with the National Electrical Code. Space and provisions for planned future pumps and equipment shall also be provided.

33.2.2 Wet Wells: Wet wells shall be designed on the basis of minimizing deposits of solids, preventing wastewater from becoming septic, and avoiding frequent starting of pumps. Minimum pump cycle (period from start to start) for any one pump shall be 5 minutes. Maximum retention time of wastewater in wet wells shall be 30 minutes at average flow (when computing retention time, total volume of wastewater in wet well shall be considered).

Wet wells shall have a minimum inside width of 5 feet and should be sized to keep the wastewater levels within the following limits:

a. High water level: Desired - invert of incoming sewer. Maximum - crown of incoming sewer.

b. Low water level: Not lower than top of pump casing.

c. Vertical distance between pump start and stop levels: 6 inches minimum.

Floors shall have a slope of 1:1 minimum, sloping towards a hopper bottom. The hopper bottom shall be designed for proper installation and function of pump suction inlets.

Influent lines shall be designed without vertical drops into the wet well to minimize release of entrained air/gases.

The wet well shall be divided into two or more sections, properly interconnected, to facilitate repairs and cleaning.

Wet wells shall have a PVC lining to protect against hydrogen sulfide corrosion unless corrosion is not expected.

33.2.3 Access: Reinforced concrete or structural steel stairways shall be provided for access to dry wells. Stairways shall have a clear passage of at least 30 inches. Stairs shall be provided with permanent non-slip treading. Factory-built stations shall be provided with man-lift elevators for primary access and a fixed ladder for backup use.

Access shall be provided to all wet well compartments by means of manholes and 316 stainless steel or other approved ladder rungs. Access manholes shall be located where they can best facilitate maintenance operations.

33.2.4 Ventilation: Dry well shall be ventilated by a mechanical air exhaust system providing at least one air change every 3 minutes. Outlets of exhaust system should not be located less than 12 feet from any opening except when exhausting through the roof. Ventilation exhaust shall be located downwind of any inlet openings. Velocity in air ducts shall not exceed 1500 fpm. When required fan capacity is large, the use of two fans should be considered.

Switches for the operation of the ventilation equipment shall be interlocked with the dry well light switch.

Ventilation shafts shall be provided for wet well compartments with only one access opening.

33.2.5 Drainage: Dry well floors shall be constructed to drain by gravity into trench drains channeled to a sump. The sump pump shall be a submersible unit.

Minimum sump pump capacity shall be 25 gpm with exception of stations equipped with water seal systems, hydraulic operated cone-check valves, or similar type equipment. These stations shall be provided with duplex submersible pumps, each capable of pumping at least 50 gpm. A switch for lead/lag operations shall be provided at the MCC.

Sump pump discharge shall enter the wet well adjacent to and as high as possible to the ground floor level. For pump stations with capacities greater than 20 mgd, sump discharge shall enter into both wet well compartments with valves for isolating flows.

Trench drains should be covered with corrosion resistant gratings. Floor framing for gratings, including their anchoring devices shall be 316L stainless steel.

33.3 Superstructure: Except for factory-built stations, all pump stations shall have a superstructure.

33.3.1 Floor Elevation and Area: Ground level floors shall be a minimum of 1 foot above the regulatory flood level of the area immediately adjacent to the pump station. The latest flood zone map shall be consulted. Floor areas shall be adequate for mechanical equipment, electrical equipment and controls, sanitary facilities, storage, and future expansion. Adequate working space, at least 2 feet clear, shall be provided between and around all equipment. Provide 3 feet clearance for electrical equipment to comply with the National Electrical Code.

33.3.2 Height: Height of superstructure shall provide adequate working height. Whenever possible, height of superstructures shall be adequate to permit the removal of motor rotor from its stator or the removal of other equipment of larger size with the installed hoisting equipment.

33.3.3 Materials of Construction: The following materials are acceptable for construction of superstructures:

a. Beams and Columns - reinforced concrete or structural steel.

b. Roof - reinforced concrete.

c. Wall - masonry or reinforced concrete.

Other materials may be considered if requirements of Section 33.1 dictates.

33.3.4 Insect Screens: All openings in the structure for ventilation or light, except doorways, shall be equipped with removable stainless steel insect screens.

33.3.5 Doors: Doors shall be of adequate size to permit removal of pumps, motors, and other equipment.

Locks shall be able to be keyed to the Department of Wastewater Management master key.

33.3.6 Roofing: Unless otherwise approved, roofing shall be 15 pound asphalt felt built-up roofing. Roofing shall be a minimum of 5-ply for permanent installations and 3-ply for temporary installations. Flashing shall be copper.

33.3.7 Railings and Stairways: Railings and stairways shall conform to HIOSH regulations and City Building Codes.

33.3.8 Outdoor Enclosures: Gages, meters, and control devices installed outdoors shall be mounted within weather protected enclosures. Gages integral of other devices such as bearing thermometer on motors are excepted. HECO meter shall be located to permit easy viewing by HECO.

33.4 Provision for Equipment Removal: Provisions shall be made to facilitate removing pumps and other equipment for repair and maintenance.

33.4.1 Openings: Openings shall be provided in ground and intermediate level floors of pump stations.

Ground level floor openings shall be covered with removable gratings and provided with removable pipe posts and guard chains around its periphery. Stationary posts with removable pipe railing sections shall be provided around intermediate floor openings. All openings shall be provided with portable peripheral curbing and shall be large enough to provide ample room to install or remove pumps and other equipment.

33.4.2 Hoists: Built-in-place pump stations shall be equipped with trolley type hoists traveling on steel beams or traveling bridge cranes.

Traveling bridge cranes shall be provided for installations equipped with 6 mgd pumps and larger. Bridge cranes shall be electrically controlled.

Hoists for station with a vertical lift of 25 feet or more (pump room floor to top floor) shall be electrically powered. Plug-in type hoists operating on single phase 120 volts may be allowed for small stations.

33.4.3 Eye Bolts: Eye bolts for block and tackle type hoist shall be provided over pumps, valves, header piping, and other locations to facilitate maintenance operations and equipment removal. The load rating of each eyebolt shall be shown on the plans.

33.4.4 Headroom: Sufficient headroom, including room for lifting device, shall be provided to allow pump rotating element to be removed without disturbing the pump volute.

33.5 Station Facilities:

33.5.1 Sanitary Fixtures and Accessories:

a. Built-in-place pump stations shall be provided with the following minimum sanitary fixtures and accessories:

1. Service sink - acid resisting, white enameled, cast iron body, stainless steel rim.

2. Water closet - vitreous china, wall hung, close-coupled closet combination with open front, black closet seat without cover.

3. Paper towel dispenser - chromium plated.

4. Toilet paper holder - chromium plated.

5. Paper toilet seat cover dispenser - chromium plated.

6. Soap dish - chromium plated.

7. Waste paper basket - plastic or noncorrosive material.

8. Wall mirror - approximately 12 in. x 24 in.

9. Small storage cabinet for janitorial supplies - approximately 12 in. wide, 18 in. high, and 8 in. deep.

b. Factory-built stations located in isolated areas shall be provided with the minimum fixtures and accessories listed in the preceding paragraph and housed in a suitable structure.

c. Whenever required by the City, additional sanitary fixtures and accessories shall be provided as follows:

1. Lavatory (vitreous china) for pump stations of capacities greater than 20 mgd.

2. Shower for pump stations of capacities greater than 20 mgd and also for pump stations in isolated areas. Shower shall be equipped with soap holder-grab bar combination and curtain rod. A minimum of 6 lockers and a 30 gallon hot water heater with timer shall be provided where showers are installed.

d. Plumbing code: Plumbing shall conform to the requirements of the State Department of Health and to the Plumbing Code of the City and County of Honolulu.

33.5.2 Light Fixtures and Receptacles:

a. Light fixtures: Light fixtures shall be provided to supply adequate illumination within pump stations and shall be mounted where relamping can be accomplished with reasonable ease. Light fixtures shall also be installed next to exterior doors on the outside and around the perimeter of the building with at least one light over the wet well cover manholes. Wet wells shall not require light fixtures. In general, light fixtures below ground level shall be vaportight fixtures. Fluorescent fixtures using 48 inch T-8 type tubes are preferred. High pressure sodium fixtures

shall be used if appropriate.

b. Night lights: Night lights shall be provided above all building entrances and equipped with lamp shades to prevent glare beyond the perimeter fence line. Consideration shall be made for a night light at the perimeter entrance gate. Night lights shall be automatically controlled by photocells.

c. Emergency lights: Battery-powered emergency lights shall be provided at all floor levels of the pump station and emergency generator location or building. Emergency lights shall be connected to the normal service via a receptacle, mounted adjacent to the emergency light.

d. Receptacles: Weather-proof receptacles shall be installed at all floor levels of pump station and outside the building, adjacent to the wetwell.

e. Electrical code: Electrical system shall conform to the National Electric Code, the Building Code of the City and County of Honolulu, and the Flood Hazard Ordinance of the City and County of Honolulu.

33.5.3 Telephone: Telephone terminal cabinet and touch tone instrument shall be provided unless waived by the City.

33.5.4 Miscellaneous Equipment: All pump stations shall be equipped with the following:

a. Fire extinguishers: Fifteen lbs. CO_2 for MCC room and generator area. Ten lbs. dry chemical for lower floors. All fire extinguishers shall be wall mounted.

b. First aid kit meeting City standards.

c. Eight inch electric clock.

d. Plastic trash receptacle, thirty gallons capacity with cover.

e. Desk and chair.

f. Storage cabinet for flammable materials.

g. Legal size drawer file cabinet with lock.

34. Pumps, Motors, and Controls

34.1 Sewage Pumps and Motors:

34.1.1 General: Major pump stations, except factory-built WWPS, shall be equipped with a minimum of three pumps. After evaluation, smaller pump stations may be equipped with two pumps. Pumps shall be capable of operating over the range of flows without excessive cycling and without long retention time (Section 33.2.2).

Variable speed drives shall be utilized for wastewater treatment plant influent pump stations and whenever conditions such as long retention periods or short pumping cycles cannot be avoided. Dual speed motors may be considered where appropriate.

All pump stations shall be equipped with a standby pump equal in capacity to the largest of the main pumping units. The main pumping units shall be capable of handling the station's peak flow without the use of the standby unit.

Pumps shall be capable of passing spheres of at least 2½ inches and shall have a minimum discharge opening of 4 inches in diameter. Speed of pumps shall not exceed 1200 rpm.

Pumps shall be capable of safely rotating in reverse direction at full runaway speed without damage to appurtenances under the shutoff head of the units. The brake horsepower required at full motor speed at any head along the curve shall not exceed the rated horsepower of the motors.

34.1.2 System Head-Capacity Curves: Pumps should be selected so that the head-capacity characteristics correspond as nearly as possible to the overall station requirements.

This should be accomplished by the preparation of the system head-capacity curves showing all conditions of head and capacity under which the pumps will be required to operate. The system head-capacity curves should be developed using standard hydraulic methods for determining friction losses to show the minimum and maximum head losses that can be expected. The equivalent length method using the Hazen-Williams formula is preferred.

34.1.2 (Con't.)

Minimum and maximum head losses should be determined using "C" values of 150 (new PVC or polyethylene pipe), 140 (other new pipe), 120 (aged PVC or polyethylene pipe) and 100 (other aged pipe), or as appropriate.

The system head-capacity curves should consist of the following:

a. System curves: Curves showing total dynamic losses in the force main at varying pumping rates for minimum and maximum static heads.

b. Individual pump characteristic curves:

   Curves furnished by pump manufacturer showing pump's head-capacity characteristics. Curves at minimum and maximum anticipated speeds shall be furnished for variable speed pumps.

c. Modified pump curves: Curves showing pump's head-capacity characteristics at the station header, obtained by deducting friction losses in the suction and discharge piping of each individual pump from their characteristic curves at corresponding pumping rates.

d. Combined modified curves: Curves showing multiple pump operation, obtained by adding capacities at points of equal heads on the modified pump curves.

e. NPSH Curves: Curves showing the available system net positive suction head (NPSHA) and the pump's required net positive suction head (NPSHR) shall also be evaluated to minimize the occurrence of cavitation. The NPSHA and NPSHR curves shall include the operating conditions of minimum static suction head and maximum frictional loss (C=100) over the entire operating range of each pump. For variable speed pumps where operation of a single pump at the maximum speed will result in cavitation, NPSHA and NPSHR curves shall also be evaluated at the highest variable speed that the pump will experience when it is operated alone or when operated simultaneously with other pumps.

Figure 34.1.2 illustrates a set of system head-capacity curves. The intersection of the modified pump curves and combined modified curves with the system curves shows the station capacity for the several conditions of operation. Pumps should be selected and rated so that the maximum station pumping capacity available (at maximum wet well Figure 34.1.2 level and C=100) equals or exceeds the anticipated peak flow into the station. Pumps should also be rated at the minimum heads at which each is expected to operate. Minimum shutoff heads should be specified. Pumps should have their maximum overall efficiency at or near the rated capacity and head and should operate with reasonable efficiency over their operating ranges.

34.1.3 Types of Pumps: All pumps shall be vertical units. Motors for stations with pump capacities greater than 2 mgd shall be installed on the ground level floor and connected to pumps with removable driveshafts, intermediate driveshafts, and equipped with removable and adjustable flexible couplings.

For pumps of less than 2 mgd capacity, submersible pumps may be used for dry pit installation. Consideration for pump on/off cycling shall be made to avoid high motor temperature.

Motors for stations with pump capacities less than 2 mgd may be pedestal mounted. Vertical, close-coupled units may be used for temporary pump stations.

34.1.4 Pump Construction:

a. Dry Pit Pump

1. Handholes shall be provided on the periphery of pump casings and suction elbows for purposes of inspection and removal of obstructions. Handhole covers shall be flanged and secured to bossed sections and shall have interior surfaces formed to match interior surfaces of casting to which attached. Pump casing handhole should be located so that visual inspection can be made of the discharge end as well as the volute. Handholes should be a minimum of 4 inches or about half

34.1.4 (Con't.) of the pump size.

2. Pumps shall have flanged suction and discharge nozzles, faced and drilled to conform to ANSI Class 125 lb. standard. Pumps of sizes greater than 5 inches shall be furnished with suction elbows that are separate and not integrally cast with any other part of the pump. Suction elbows shall be designed to prevent cavitation. Guide vanes shall not be used in suction nozzles.

3. Pumps of sizes greater than 5 inches shall be provided with either fabricated structural steel supports or cast iron ribbed supports. Cast iron supports shall be integrally cast with the pump casing or suction nozzle.

4. Base plates or sole plates shall be provided. Plates shall be anchored by stainless steel bolts with stainless steel lock washers and grouted to reinforced concrete pedestals. Hardened steel jacking screws for leveling and for aligning of pumps should be provided. Mating surfaces shall be machined and all holes shall be drilled and shall not be burned.

5. Intermediate drive shaft sections should be not more than 12 feet in length. Where more than one drive shaft is required, self-aligning steady bearings shall be provided at each intermediate location. Bearings shall be equipped with mechanism to allow alignment adjustments. Bearing and shaft guards shall be provided. Safe access to bearing and guards shall be provided. Grease fittings shall be equipped with extension tubing to facilitate lubrication.

6. Drain and air release lines shall be provided for all pumps. Drain lines shall be installed at the packing drip reservoir and at the center line of the suction pipe. Air release line shall be installed at high point of pump casings. Connecting points shall

34.1.4 (Con't.) be bossed, drilled, and tapped. Minimum size shall be ½ inch. Air release lines from pump to the first valve shall be brass. Provisions shall be made for a sampling tap for wastewater unless waived by the City.

7. Other features of pumps shall be as follows:

a). Bearing housing - of single cast piece or fabricated structural steel.

b). Bearings - not less than two.

c). Shaft sleeve - replaceable stainless steel sleeve, from the outside end of the seal gland to the impeller, and set screwed to the drive shaft.

d). Sealing gland - double mechanical seal with suitable fluid sealing/lubrication system.

e). Casing and impeller wearing rings - stainless steel and "Z" or "L" shaped.

f). Suction plate - separate from suction elbow (pumps 5 inches and smaller may be excepted).

g). Taper pins and jacking screws - on all machined joints and handholes.

h). Eyebolts or other provisions for lifting - on volute and bearing housing.

i). Impeller locknut - with smooth surface, no sharp corners and edges, and easily removable and replaceable.

j). Seals - on both the upper and lower sections of the bearing housing.

k). Tapered shaft - tapered for the full length of fit and keyed to the impeller. Exception may be

34.1.4 (Con't.) made for 4 inch pumps.

8. Stock bronze fitted pumps with cast iron casings and bronze impellers are permitted for temporary installations. Impeller rings and shaft sleeve shall be bronze.

b. Submersible Pump

1. Handholes shall be provided on the periphery of pump casings and suction elbows for purposes of inspection and removal of obstructions. Handhole covers shall be flanged and secured to bossed sections and shall have interior surfaces formed to match interior surfaces of casting to which attached. Pump casing handhole should be located so that visual inspection can be made of the discharge end as well as the volute. Handholes should be a minimum of 4 inches or about half of the pump size.

2. Pumps shall have flanged suction and discharge nozzles, faced and drilled to conform to ANSI Class 125 lb. standard. Pumps of sizes greater than 5 inches shall be furnished with suction elbows that are separate and not integrally cast with any other part of the pump. Suction elbows shall be designed to prevent cavitation. Guide vanes shall not be used in suction nozzles.

3. Base plates or sole plates shall be provided. Plates shall be anchored by stainless steel bolts with stainless steel lock washers and grouted to reinforced concrete pedestals. Hardened steel jacking screws for leveling and for aligning of pumps should be provided. Mating surfaces shall be machined and all holes shall be drilled and shall not be burned.

4. Drain and air release lines shall be provided for all pumps. Drain lines shall be installed at the center line of the suction pipe. Air release line shall be installed at high point of pump casings. Connecting points shall

34.1.4 (Con't.) be bossed, drilled, and tapped. Minimum size shall be ½ inch. Air release lines from pump to the first valve shall be brass. Provisions shall be made for a sampling tap for wastewater unless waived by the City.

5. Other features of pumps shall be as follows:

a). Pump shaft shall be stainless steel.

b). Bearings - not less than two, sealed, and grease lubricated.

c). Seal - tandem, double mechanical seal running in an oil reservoir. It shall be composed of two separate lapped-face seals, each consisting of one stationary and one rotating tungsten-carbide ring; with each pair held in contact by a separate springs. The compression spring shall be protected against exposure to the pump liquid.

d). Casing and impeller wearing rings - stainless steel and "Z" or "L" shaped.

e). Suction plate - separate from suction elbow (pumps 5 inches and smaller may be excepted).

f). Taper pins and jacking screws - on all machined joints and handholes.

g). Eyebolts or other provisions for lifting - on volute and bearing housing.

h). Impeller locknut - with smooth surface, no sharp corners and edges, and easily removable and replaceable.

i). Tapered shaft - tapered for the full length of fit and keyed to the impeller. Exception may be made for 4 inch pumps.

j). Sensors, indicators, and alarm - provide the following:
High temperature - sensor, indicator, and alarm
Vibration - sensor or alarm
Seal leakage - sensor or alarm

34.1.5 Motor Construction:

a. Dry Pit Motor

1. Motors shall conform to the latest standards of the NEMA and the IEEE. Motors shall have ample capacity to operate the pumps under all head and discharge conditions without overloading. Starting current taken by the motors shall not exceed the values as regulated by the Hawaiian Electric Company or as permitted by the emergency generator. Motors shall be capable of safely rotating in the reverse direction at runaway speed without damage to appurtenances under shutoff head. Motors shall operate pumps through flexible shafts and couplings. Vertical shaft motors mounted on floors shall be furnished with rugged cast iron or steel foundation rings. Motors shall be induction type, drip proof, and suitable for operation from 230/460 volts, 3 phase, 60 cycle A.C. power systems. Motors shall have a service factor of 1.15. All pump motors shall have running time meters installed at the starter. All pump motors above 20 HP shall have an ammeter installed at the starter.

   Dry pit sump pump motor shall have running time meters installed at the starter.

2. Motors 100 HP or larger shall be provided with oil lubrication. Smaller sized motors shall be grease lubricated. Motors 7½ HP or larger shall be provided with space heaters. Variable speed motors shall be provided with a RPM measuring device with a 4 to 20 milliamp output and a panel mounted digital RPM indicator.

b. Submersible Motor

1. Motors shall conform to the latest standards of the NEMA and the IEEE. Motors shall have ample capacity to operate the pumps under all head and discharge conditions without overloading. Starting current taken by the motors shall not exceed the values as regulated by the Hawaiian Electric Company or as permitted by the emergency generator. Motors shall be capable of safely rotating in the reverse direction at runaway speed without damage to appurtenances under shutoff head. Motors shall be suitable for operation from 230/460 volts, 3 phase, 60 cycle A.C. power systems. Motors shall have a service factor of 1.15. All pump motors shall have running time meters installed at the starter. All pump motors above 20 HP shall have an ammeter installed at the starter. The motor power wiring shall be brought up directly to the level of the MCC.

2. Pump motors shall be housed in a watertight casing and shall have moisture resistant insulated windings. Pump motors shall have cooling characteristics suitable to permit continuous operation in a non-submerged condition.

34.1.6 Indicating Pressure Gauges: Indicating pressure gauges shall be provided at discharge nozzle and suction plate of pumps. Indication shall be in feet. Isolation valves and stainless steel diaphragm seals shall be provided at gauges.

34.1.7 Testing: All wastewater pumps shall be factory tested in accordance with the ASME Power Test Codes or the Standards of the Hydraulic Institute. Five (5) certified copies of the pump curves and data shall be furnished with each pump requiring drive motors 40 HP or smaller. For pumps requiring drive motors greater than 40 HP, a witness shop test shall be required and five (5) certified copies of the pump curves, data and report shall be furnished with each pump. Each pump casing shall be tested under a

hydrostatic pressure of not less than 60 psi. All impellers, including spares, shall be statically and dynamically balanced.

All electric motors shall be tested by the motor manufacturer. Routine tests are required for motors rated at 40 HP or less and Witnessed Complete Tests shall be required for motors larger than 40 HP. Five (5) copies of the certified or witnessed test data shall be furnished for each motor.

All pumps shall be field tested to demonstrate satisfactory operations.

34.1.8 Spare Parts: All installations shall be furnished with the following minimum spare parts:

a. For each pump:

1. One set renewable sleeve for the pump shaft.

2. One set of gaskets for all pump casing joints.

3. One set of wearing rings, complete, for both pump casing and impeller.

4. All parts recommended in the manufacturer's O & M manual.

b. In addition to the above, provide for each different size pump:

1. One complete pump, including suction plate.

2. One set of each type of bearing used in the pump and shafting.

3. One packing gland complete with rings, nuts, bolts, and one box of coil packing (if applicable).

4. One mechanical seal assembly (if applicable).

c. For submersible pump:

1. One complete pump unit with stand.

d. For motor:

1. One set bearings, complete for each size of motor 30 HP or larger.

2. One set space heaters for each size of motor.

3. One set brushes for each wound rotor motor.

4. One brush holder assembly (for each size of wound rotor motor).

e. For generator:

1. All parts recommended in the manufacturer's O & M manual.

2. One circuit board for the voltage regulator.

f. For ventilation fan:

1. One set fan drive belts.

34.2 Starters and Controls:

34.2.1 Liquid Level Controls: The operation of wastewater pump motors shall be automatically controlled by liquid level sensing devices, actuated by wastewater level fluctuations in the wet well. Float type, pneumatic type, or a combination of float and pneumatic type device should be provided. Automatic control settings shall be manually adjustable.

Duplicate control units shall be provided for all pump stations equipped with split wetwell chambers. Controlling devices should also be capable of alternating the lead pump and setting off high and low level alarm. The operating range of controlling devices shall conform with the requirements of Section 33.2.2.

34.2.2 Selector Switches: HAND-OFF-AUTO selector switches shall be provided to operate pumps. Selector switches shall be located at the motor control center and watertight switches

next to pumps. Both selector switch settings must be the same in order for the pump to operate (Example: HAND-HAND or AUTO-AUTO).

Automatic and manual control for variable speed pumps shall be capable of being adjusted over the effective speed range.

34.2.3 Starters: Unless otherwise restricted by the Hawaiian Electric Company starters shall be of the combination, magnetic, across-the-line type. Reduced voltage starters shall be of the auto-transformer type.

34.2.4 Control Centers: Starters shall be mounted and wired as an integral part of free standing, unitized, enclosed control centers.

Control centers shall be designed and constructed in accordance with the latest standards of the NEMA and the IEEE. Starters for temporary installations may be surface mounted.

Control center cabinets shall be installed to permit full opening of doors without interference from adjoining cabinets, walls or other equipment. Split hinge doors may be used to prevent opening interference.

All major components of control centers shall be by one manufacturer. If more than one control center is to be installed it should preferably be of the same type and manufacturer. The manufacturer must have a qualified electrical service engineer permanently assigned and residing in the State of Hawaii. All panel units, devices, indicating lights, and instrumentation shall be identified by engraved nameplates or metal collars.

34.2.5 Indicating Lights and Elapsed Time Meters:

Appropriate indicating lights and elapsed time meters should be installed for each starter. The running time meters shall be non-resetting, digital display, including a one-tenth hour feature. Indicating lights should be of the push-to-test type or light emitting diode (LED).

34.3 Instrumentation and SCADA System:

34.3.1 Pump stations should be provided with instrumentation and SCADA systems with the following:

a. Telemeter:

1. Discharge flow.

2. Discharge pressure.

3. Wet well level.

b. Report-back of operational status:

1. Sewage pumps.

2. Sump pumps.

3. Emergency generator.

4. Other items of importance to operations.

c. Alarms:

1. Normal power source failure.

2. Alternate power source failure.

3. Generator operating.

4. Main buss power failure.

5. Low level in wet well.

6. High level in wet well.

7. High level in pump room sump.

8. Other equipment failures which could endanger pump station operations.

9. Building intrusion.

34.3.2 When conditions dictate that installations be remotely controlled from supervisory stations, the following additional functions should be provided:

a. Report-back:

1. Operational status of each pump (running or not running).

2. Operational status of any other item of importance to remote control operations.

b. Supervisory remote controls:

1. Start and stop pumps.

2. Other control functions of importance to remote control operations.

c. Alarms:

1. Warning of transfer to supervisory remote control operations.

2. Other alarms of importance to remote control operations.

34.3.3 All readings, alarms, and indications, shall be relayed to supervisory stations designated by the Department of Wastewater Management.

34.3.4 Instrumentation systems should be provided by one supplier with field and shop maintenance facilities and full time local service engineers.

34.3.5 Flow Meters:

a. Flow meter receiving instruments at the pump station shall be capable of totalizing, indicating, and recording flows.

b. Recorder shall be electronic type with a month duration, 4-inch wide strip chart and a visible face of approximately 4 inches.

c. Indicator shall be 4 inches long or shall be digital with approximately one inch high numerals.

d. Flow meter pressure differential producers shall be of the standard venturi type. Insert type differential producers or Dall tubes shall not be permitted.

e. Magnetic flow meters may not be used.

34.3.6 Level Meters:

a. Wet well level meter receiving instruments at the pump station shall be capable of indicating and recording wet well levels.

b. Recorder shall be electronic type with a month duration, 4-inch wide strip chart and a visible face of approximately 4 inches.

c. Indicator shall be 4 inches long or shall be digital with approximately one inch high numerals.

d. Fuel level (inventory) meter shall be installed in the generator room for diesel fuel tank systems.

34.3.7 Pressure Meters:

a. Force main pressure meter receiving instruments at the pump station shall be capable of indicating and recording pressure.

b. Recorder shall be electronic type with a month duration, 4-inch wide strip chart and a visible face of approximately 4 inches.

c. Indicator shall be 4 inches long or shall be digital with approximately one inch high numerals.

d. Single recorder with three inputs may be used.

34.3.8 Strain Gauge Sensors: Strain gauge sensors should not be used unless absolutely necessary.

34.3.9 Instrumentation Panels: All pertinent receiving instruments, devices, alarms, indicating lights, and remote controls shall be mounted on centralized instrument panels. All items shall be identified with engraved nameplates. Electrical power to the panel and all instruments shall be through an uninterruptible power supply unit.

34.3.10 Indicating Lights: Appropriate indicating lights shall be provided to show the status of equipment operation, alarms, controls, etc.

Indicating lights shall be of the push-to-test type or light emitting diodes (LED).

34.3.11 Amperage Meter: An analog ammeter shall be provided for each sewage pump motor.

35. Piping, Including Valves

35.1 Wastewater Pump Piping:

35.1.1 Discharge and header (manifold) piping for wastewater pumps shall be not less than 4 inches in diameter. Suction piping shall be not less than 6 inches in diameter.

35.1.2 Velocities in wastewater pump piping shall be as follows:

a.	Suction from wet well	5 fps (desirable max.)
		6 fps (absolute max.)
b.	Discharge to header	7 fps (desirable max.)
		8 fps (absolute max.)
c.	Header (Manifold)	6 fps (desirable max.)
		7 fps (absolute max.)
		2 fps (desirable min.)
		1.5 fps (absolute min.)
d.	Discharge risers	3 fps (absolute min.)

35.1.3 Pipe and fittings shall be cast iron or ductile iron, cement lined and coated on the inside. Cast iron pipes shall be Class 150 and fittings ANSI Class 250. Ductile iron pipe shall be Class 52 minimum. Buried pipe and fittings shall be protected on the outside with an approved corrosion protection coating and cathodic protection. Zinc chromate primer shall be used on the outside for exposed piping to be painted with enamel. In general, joints shall be flanged with flanges faced and drilled to conform to ANSI Class 125 lb. standard with full face gaskets. Adequate braces and supports shall be provided for piping to assure that no undue strains are induced.

35.1.4 Piping shall be arranged so that all pumps discharge into a common header. In permanent pump stations, discharge lines shall not enter headers perpendicularly. Base bends, properly supported on concrete pedestals, shall be provided at the bottom of vertical risers. Headers shall be properly blocked to resist water hammer.

35.1.5 Suction lines shall have turned-down bellmouth inlets. Bottom of the bellmouth shall not be more than D/2 nor less than D/3 (in which D is the diameter of the suction bell) above the floor of the wet well. Reducers used on the suction side of pumps shall be of the eccentric type to prevent air pockets.

35.1.6 Gate valves in suction lines, except for temporary pump stations and pump stations with capacity 1 mgd or smaller, shall be provided with extension stems to floor stand operators on the ground level floor. In general, gate valves shall be solid wedge, rising stem type with iron body, bronze trimmed, outside screw and yoke, and flanged ends. Flanges shall conform to ANSI Class 125 lb. standard except where high pressures are encountered. Valve operators for valves 16 inches or larger shall be electrically motorized. All motorized actuators shall have manual operation back-up provisions.

35.1.7 Swing check valves shall be provided on the discharge side of pumps and shall be placed horizontally between the gate valves and the pumps. Where damaging effects of water hammer are anticipated, valves with controlled rate of closure shall be installed (see Section 38.10 on water hammer). In general, swing check valves shall be iron bodied, bronze trimmed with outside lever and weight, and flanged ends. Flanges shall conform to ANSI Class 125 lb. standard except where high pressures are encountered.

35.2 Sump Pump Piping: All sump pump fixed piping in wetwells shall be schedule 80 PVC and in dry wells shall be brass. A gate valve and check valve shall be installed on the discharge line. Flanged joints or unions shall be provided on the discharge line to facilitate dismantling of the piping. Minimum diameter of the discharge line shall be 2 inches. Velocity in discharge risers shall not be less than 3 fps. The discharge point shall be installed at the highest elevation possible to prevent reverse flow when the wet well is filled to capacity. Typical discharge elevation should be under and close to the ground floor.

The sump pump shall be fitted with a flexible PVC hose, minimum 2-inch diameter. Camlock fittings shall be provided for the PVC hose connectors to the pump and fixed piping.

35.3 Waste, Drain, and Vent Lines: Pipe and fittings shall be extra heavy cast iron soil type, except piping installed above ground or inside pump stations and piping 2½ inches in diameter or smaller, may be standard weight galvanized steel pipe with standard cast iron screwed, recessed drainage fittings. Cleanouts shall be provided as necessary and shall be solid cast brass, rough finish with square heads. Bronze access frames and covers shall be provided for finish floors and walls.

Frames and covers for wall installation shall be square with polished finish. Those for floor installations shall be round with scoriated finish. Cleanout shall be readily accessible.

35.4 Potable Water Piping: Water piping and fittings 3 inches in diameter or smaller shall be copper except that water piping 1 inch in diameter and smaller within structures shall be Type K copper pipe with standard brass fittings.

Exposed water piping and fittings larger than 3 inches in diameter shall be of galvanized steel. Exposed water piping within structures shall be installed at elevations that permit easy access for maintenance.

Buried water piping and fittings larger than 3 inches in diameter shall be schedule 80 PVC. A locating wire, conductive tape, or other means of locating the buried plastic piping shall also be provided.

35.5 Sprinkler System Piping: Sprinkler system piping shall be solvent welded schedule 40 PVC. Lawn risers shall be PVC or polypropylene and shrubbery risers shall be galvanized steel.

35.6 Piping Between Flow Tube and Instruments: Piping between flow tube to flow transmitter shall be 1 inch minimum diameter 316 stainless steel. Horizontal runs shall have a minimum declining slope of ¼ inch per foot from the flow tube to the in-station equipment and shall be permanently supported and braced to prevent sediment traps and/or air pockets. Piping shall be connected to the flow tube on a horizontal axis. 316 stainless steel valves, unions and necessary fittings shall be installed close to the flow tube to facilitate maintenance. 316 stainless steel ball valves, gate valves, unions, tees and elbows shall be used on the entire system. The flow transmitters and diaphragm seals shall be installed inside the pump station and mounted for easy access and maintenance.

35.7 Pipe Sleeves: Pipe sleeves shall be provided whenever small piping passes through concrete walls. Wall pipe shall be used for larger piping.

36. Emergency Provisions

Emergency facilities shall be provided to protect pump stations and the community from possible damages that may result from power failure, emergency maintenance shutdown, pumping capacity being exceeded, or other unforeseen circumstances.

36.1 Overflow: Pump stations shall be provided with overflow piping whenever discharge into a stream or other body of water is possible without creating undue hazards to health and property upon the approval of the Director. Overflow lines shall be sized to handle peak flows whenever possible and shall be set at elevations low enough to prevent or minimize backup of wastewater into any house or building. Flap gates shall be provided. An assessment addressing the use of the overflow shall be provided.

36.2 Standby Electric Power Equipment: Stations shall be equipped with a diesel powered generator(s) to provide electric power to pump the peak flow. The generator's synchronous speed shall be 1800 RPM. The engine-generator set shall be a new, standard, current model and in accordance with ANSI and NEMA standards. Provide vehicular access including a pad for a portable generator.

Fuel daytank if required, of approved capacity, equipped with two fuel pumps. Pumps shall have a manual selective feature for automatic primary and standby operations.

36.2.1 Operation of the emergency facilities shall be automatic upon power failure. Power failure monitors shall monitor all three phases. Monitoring of one phase of a three-phase system is not adequate.

36.2.2 Automatic load transfer switches shall conform to Hawaiian Electric Company requirements. When possible, bypass of the automatic transfer switch and manual override of automatic functions should be provided.

36.2.3 Major pump stations may require the installation of dual Hawaiian Electric Company power in addition to an engine driven generator.

36.2.4 A plug for connection of a portable load bank shall be provided to fully load the generator periodically. The connection shall be made to the generator side of the transfer switch via a circuit breaker. This connection can also

be used to connect a portable generator when the installed generator is not available for service.

36.2.5 Telemetering and SCADA systems shall be powered through an uninterruptable power supply unit. The uninterruptable power supply shall be sufficiently sized to furnish emergency power for a minimum 30 minutes.

36.3 Fuel Storage System: The system shall comply with Federal, State and City regulations. The fuel tank capacity shall be based on 2 days at peak sewage flow and 5 days at the daily average flow. However, the fuel tank shall not be smaller than 1,000 gallons.

Underground fuel tank installation shall be designed to prevent surface water infiltration into the fuel tank system.

A leak alert monitor shall be provided with capabilities to display fuel inventory, and with audio and visual leak alarms.

36.4 Portable Pump Facilities: Where feasible, pump stations should be equipped to pump wastewater from the wet well into the force main with a portable pump. This shall be accomplished by providing fixed discharge and suction piping for the portable pump with connections to the force main and the wet well. The portable pump discharge piping shall be connected to the downstream side of the flow meter tube and shall include a gate valve, 90° elbow, flanged reducer (if required), and a blind flange. The suction piping shall be connected to the wet well and shall include piping with a 90° elbow and a blind flange. All piping for the portable pumps shall be sized with consideration to the capacity of the installed pumps and the operating characteristics of the available standby pumps. Portable pumps should be located near the wet well to minimize the possible occurrence of cavitation. Provide vehicluar access including a pad for a portable engine-driven pump.

37. Miscellaneous

37.1 Potable Water Supply: All pump stations shall be provided with a potable water supply system for sanitary fixtures, lawn sprinkling, washdown, and other maintenance purposes.

Adequate and conveniently located water outlets shall be provided for flushing and washing purposes. Hose bibbs shall be 3/4-inch with vacuum breakers at all floor levels and outside of pump station. Stop cock valves

shall be provided immediately before each hose bibb located within the building.

Two conveniently located 1½-inch diameter standpipes shall be provided adjacent to the wetwell. The standpipes shall have 1½-inch angle globe valves for National Standard fire hose thread and end cap with chain. A 3/4-inch hose bibb with vacuum breakers shall be installed on the standpipe directly below the 1½-inch globe valve.

The main water supply line shall be 2-inch in diameter, metered and equipped with a master valve located within the station's perimeter fence. A 2-inch reduced pressure backflow preventer shall also be provided and located within the station's perimeter fence.

Under no circumstances shall potable water supply be directly connected to sewage pumps or piping. Seal water, positive air gap and/or pneumatic water tanks shall be provided as necessary.

The potable water supply system shall conform to City, State, and Federal codes and regulations.

37.2 Painting: All pump stations shall be painted in accordance with the best practice and in strict compliance with the paint manufacturer's instructions and recommendations. No lead-base primer or paint shall be used. A minimum of two finish coats over one prime coat shall be required. Color shall be recommended by the architect and approved by the City. Standard colors of the City shall be considered.

37.3 Corrosion Protection: All materials and equipment exposed to corrosive conditions shall be either corrosion resistant or protected with appropriate protective coatings or linings.

37.4 Odor Control: All stations shall be provided with a 6-inch wetwell vent pipe to be used for treatment of foul odors. The vent pipe shall be schedule 40, 316 stainless steel, permanently installed through the wetwell slab and covered with a blind flange. A receptacle, at appropriate voltage, shall be installed near the vent pipe.

38. Force Mains

38.1 Locations: Force mains should be located in streets or along road right-of-ways whenever possible.

In locating force mains, ease of installation and maintenance and elimination of high points shall be

considered. Air release valves shall be installed on high points. Easement widths shall conform to the requirements as set forth in Section 24.5.

38.2 Sizing:

38.2.1 Force mains shall be sized not less than 6 inches in diameter (6 inches upon approval).

38.2.2 Velocities in force mains shall be as follows:

a. Minimum: 3.0 fps (desirable)
1.75 fps (absolute)

b. Maximum: 10.0 fps

38.2.3 Force mains shall be designed to carry the maximum rate of pumping without excessive frictional head loss. Total dynamic head should not exceed 100 feet.

38.3 Materials: The material selected shall be adapted to local conditions with special consideration given to the quality of wastewater, possible septic conditions, soil characteristics, internal pressure, abrasion, external loadings, foundations, necessity of reducing the number of joints and other similar problems. Corrosion resistant lining, coating, wrapping, and cathodic protection shall be used when corrosion protection is required. Insulating flanges or fittings may be required at entrance or exits from buildings. The following materials are acceptable for force mains subject to the conditions indicated:

38.3.1 Ductile Iron Pipe (Cement or other approved lining and Coated): Ductile iron pipe shall be tape wrapped and have cathodic protection where the force main may be subjected to external corrosion.

38.3.2 Reinforced Concrete Pressure Pipe: Reinforced concrete pressure pipe shall not be used where force mains may be subjected to more than 150 feet head.

38.3.3 Polyvinyl Chloride (PVC) Pipe: PVC pipe shall comply to AWWA C-900 for pipes 12-inch diameter and smaller and AWWA C-905 for pipes with diameter greater than 12 inches.

38.3.4 High Density Polyethylene (HDPE) Pipe: HDPE pipe shall be the heat fused joint type and the maximum SDR shall be 17.

38.4 Cover: Minimum and maximum cover over force mains shall conform to the requirements as set forth in Sections 24 and 27.

38.5 Clearances: Clearances between force mains and other utilities shall conform to the requirements as set forth in Sections 24 and 27.

38.6 Alignment and Grade: Pipe shall be laid in a straight alignment and with constant grades where possible. Force mains may be curved by deflecting the joints to eliminate the necessity for fittings. In no case shall the deflection exceed the maximum as set forth by the manufacturer for the type of pipe used. Fittings shall be used when alignment or grade changes cannot be accomplished by joint deflection.

38.7 Appurtenances

38.7.1 Air Bleeders: Air bleeders and valves shall be provided at high points. A corporation stop shall be provided at the force main connection. Internal and external corrosion shall be considered.

38.7.2 Blow Offs: Blow off valves and vaults will not generally be required. However, a blow off valve and vault may be required where sedimentation may occur.

38.7.3 Emergency By-Pass: Whenever possible, emergency by-pass facilities should be provided.

38.7.4 On force main bypass systems designed to discharge into a body of water, stream, etc., two discharge valves shall be provided on the bypass line. The valves shall be designed to permit access for maintenance. Provision shall be included to allow removal of sewage between the two valves. This installation will allow valve maintenance-exercising without causing a sewage spill incident.

38.8 Structural Considerations:

38.8.1 Pipe Loads: Force mains shall be designed to withstand all internal and external forces to which they may be subjected. Internal forces will be the pressure from the wastewater and the water hammer effect. External forces to be considered are loads due to:

a. trench backfilling.

b. superimposed uniform loads.
c. superimposed concentrated loads.

38.8.2 Foundation: Test borings shall be made to determine soil conditions. Beddings shall be designed to adequately support pipe and minimize settlement.

38.8.3 Reaction Blocks and Anchorage: Reaction blocks and anchorage shall be provided at bends and fittings. Reaction block and anchorage may be required at joint deflections.

38.9 Termination: Force main discharge outlets shall be designed to minimize turbulence and sulfide release and be submerged at all times. The interior surface of the outlet manhole and first downstream manhole shall be protected with plastic lining.

38.9.1 Discharge manholes are a constant source of odor complaints. The severity of odor and its treatment shall be considered. A suitable odor control means shall be incorporated.

38.9.2 Gravity connection to the force main discharge manhole and connection to the first leg of the gravity line exiting the discharge manhole will not be permitted. Foul gases within the discharge manholes can travel into gravity lines and laterals and result in odor complaints.

38.10 Water Hammer: Water hammer shall be investigated and necessary measures shall be provided for in the design of force mains.

Water hammer effect caused by the sudden shutoff of pumps or the rapid closing of valves shall be investigated. The following method may be considered by the designer if he deems it appropriate.

38.10.1 Determine maximum water hammer pressure.

Max. water hammer pressure (ft)

$$= \text{Static head (ft)} + \frac{av}{g}$$

where:

$a = 4660/(1 + KB)^{\frac{1}{2}}$ = velocity of sound in water in the force main in fps.

K = ratio of the elastic modulus of water to

that of the pipe material.

B = ratio of pipe diameter to wall thickness.

v = maximum velocity in the force main at peak flow or the destroyed velocity.

g = acceleration due to gravity = 32.2 ft/sec/sec

38.10.2 Where the maximum water hammer pressure is less than the strength of the pipe used, no further investigation need be made.

38.10.3 Where the maximum water hammer pressure is greater than the strength of the pipe used, further investigation shall be made in the following manner:

a. Determine one cycle period.

One cycle period = $\frac{2L}{a}$

where L = length of the force main in feet.

b. Determine line constant.

Line constant = $\frac{av}{2gH}$

where H = static head in feet.

c. Determine allowable pressure rise.

Allowable pressure rise =

$$\frac{\text{Allowable pipe strength (ft)}}{\text{Static head (ft)}}$$

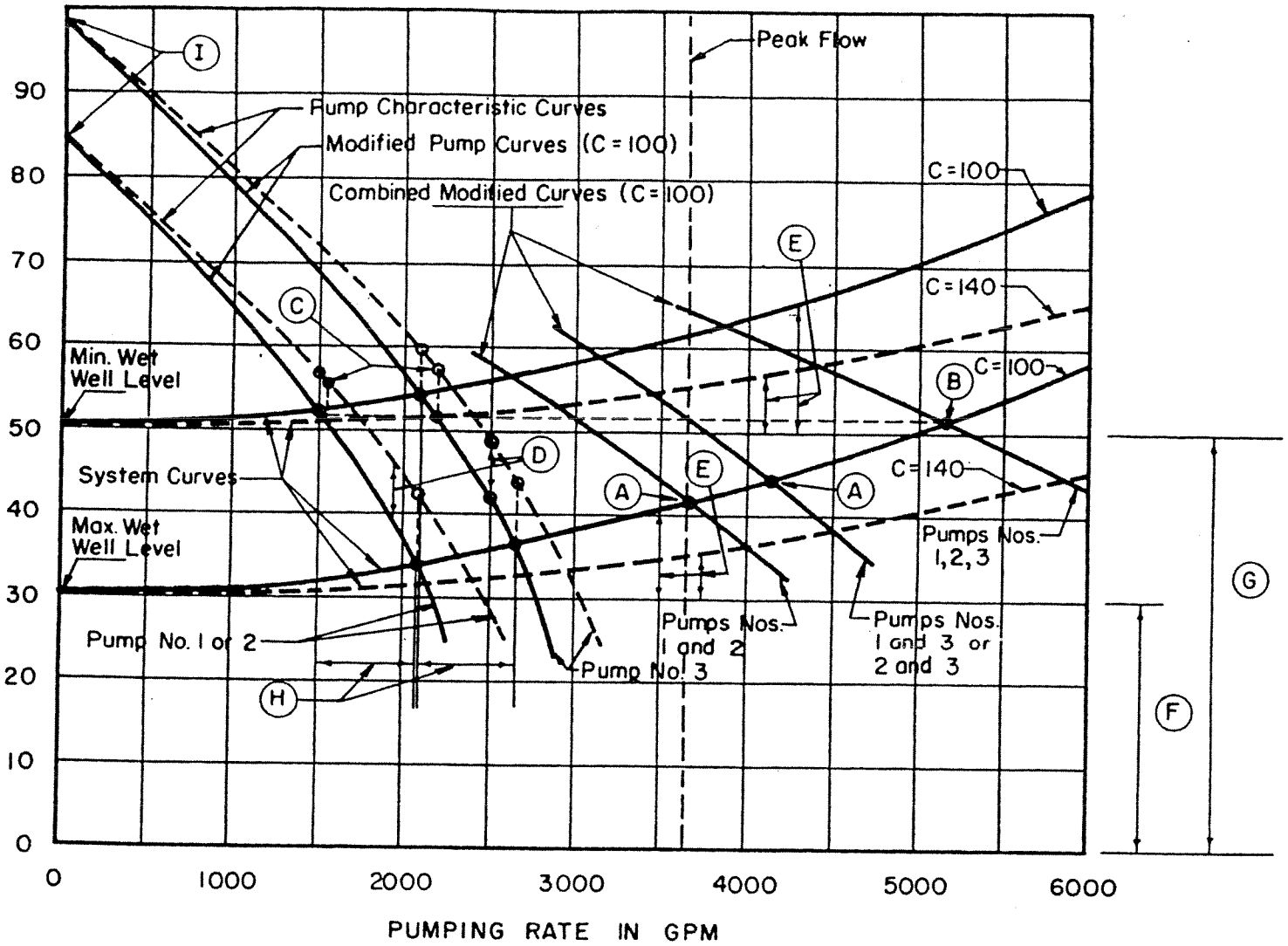
d. Apply these factors to the Allievi Chart (Fig. 38.10) and obtain factor "r".

e. Determine time of closure.

Time of closure = "r" times one cycle period.

38.10.4 If the time of closure is less than 2 seconds, no special design consideration is needed.

38.10.5 If the time of closure is greater than 2 seconds, some special design consideration for the control of water hammer is necessary. The use of slow closing valves or higher strength pipe shall be investigated.

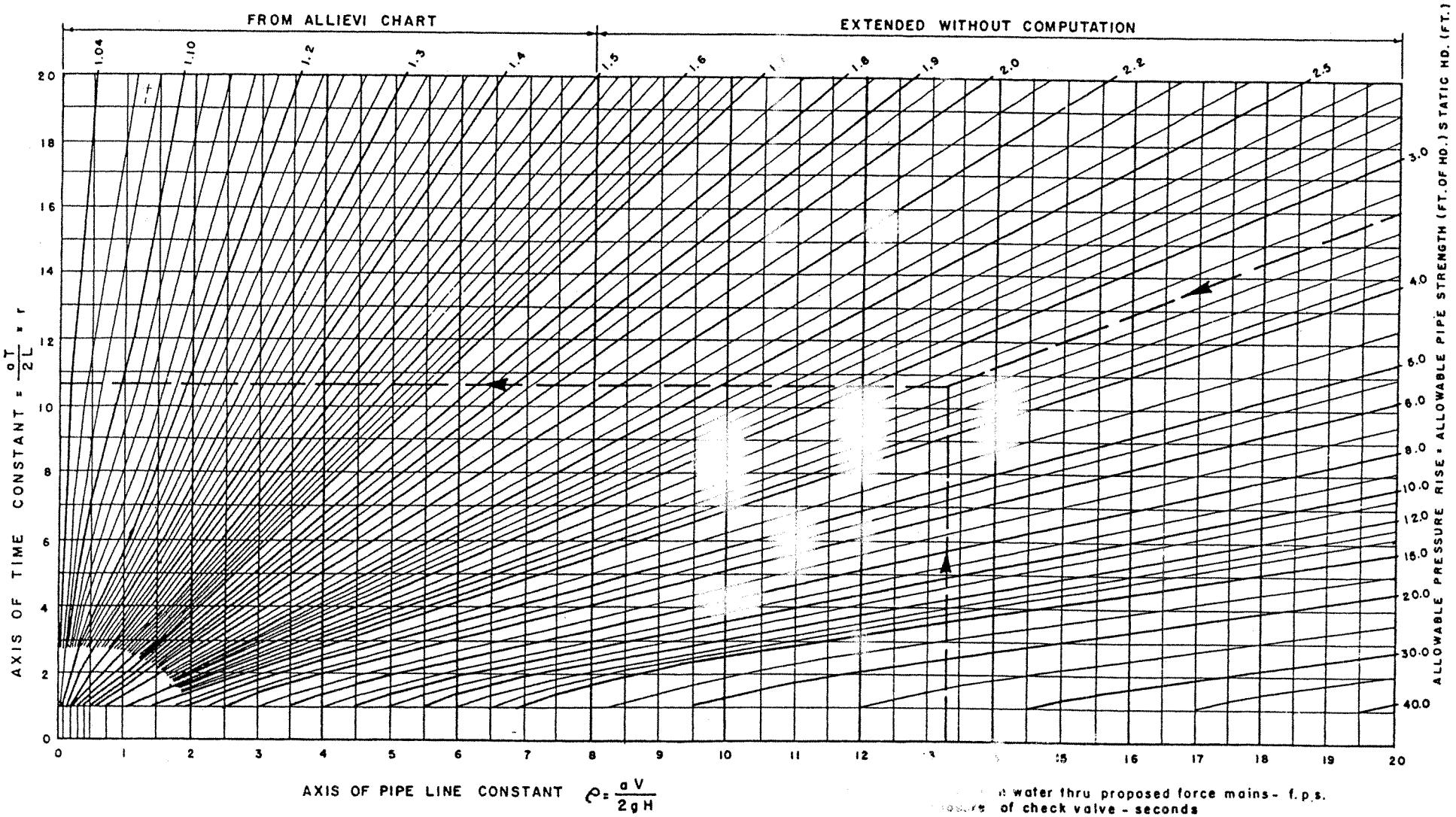


Ⓐ Pumping capacity with two pumps in operation.
Ⓑ Maximum station pumping capacity.
Ⓒ Rated capacity and head of pumps.
Ⓓ Friction losses in suction and discharge piping of pumps. (Typical anywhere along curve)
Ⓔ Friction losses in force main. (Typical anywhere along curve)
Ⓕ Static head with sewage level in wet well at maximum operating level.
Ⓖ Static head with sewage level in wet well at minimum operating level.
Ⓗ Operating ranges of pumps.
Ⓘ Pump shutoff heads.

Note: 1. For clarity, modified pump curves and combined modified curves for C = 140 have been omitted. These curves should be shown to obtain maximum possible station pumping capacity and minimum possible head within the operating ranges of pumps.

2. For new pipe, C = 140 except for PVC or Polyethelene pipe, C = 150.

FIG. 34.1.2 TYPICAL SYSTEM HEAD-CAPACITY CURVES



water thru proposed force mains - f.p.s.
of check valve - seconds
of force main - feet
V = Max velocity in force main or destroyed velocity - f.p.s.
g = Acceleration of gravity - 32.2 f./s./s.

Figure 38.10

GLOSSARY

The usage of these terms in this glossary is intended for use only for these Design Standards. These definitions may conflict with City and County legal documents.

Branch Sewer - A sewer which receives wastewater from a relatively small area and discharges into a trunk sewer.

City, or City and County - City and County of Honolulu, a municipal corporation.

Contractor - One who furnishes the materials, labor, and equipment necessary for the physical accomplishment of the work.

Department of Health - The Department of Health, State of Hawaii.

Designer - A registered engineer actively furnishing the professional and technical skill required in planning, administration, and construction of the works.

Director - Director, Department of Wastewater Management, City and County of Honolulu, or his authorized representatives.

Domestic Wastewater - The water carried wastes produced from non-commercial or non-industrial activities and which result from ordinary human living processes.

Dry Well - Compartment where non-submerged pumping equipment, devices, and appurtenances are installed.

Force Main - A pipeline conveying wastewater under pressure from the discharge end of a pump station to a point where wastewater flows by gravity.

Gravity Sewer - A sewer in which all wastewater flows in descending gradients from source to outlet, or where no pumping is required.

Ground Water - Subsurface water occupying the saturation zone of the ground.

Industrial Wastewater - All water carried wastes of the community excluding domestic wastewater, infiltration/inflow and uncontaminated water.

Infiltration/Inflow - Surface and ground water which leaks into a sewer through joints, manhole covers, or breaks.

Interceptor - A sewer which receives flows from one or more trunk sewers and conveys such wastewater to a point for treatment or disposal.

Invert - The lowest point in the internal cross section of a conduit, manhole, sump or wet well, etc.

Lateral Sewer or Lateral - A sewer which serves no more than three (3) lots, which discharges into a branch or other sewer, and which has no other common sewer tributary to it.

Manhole - An access shaft or chamber from the surface of the ground to a sewer.

Master Plan - The Water Quality Management Plan (208 Plan) for the City and County of Honolulu and detailed documents prepared to implement the 208 Plan.

Permanent Wastewater Facilities - Wastewater facilities which are built according to the wastewater master plan as to location and capacity and intended to be at that location indefinitely.

Sanitary Sewer - A pipe or conduit for carrying wastewater to which storm, surface, and ground water are not intentionally admitted.

Shall - Indicates a mandatory requirement.

Should, Preferred, Recommend - Indicates discretionary use on the part of the City and County.

Siphon or Inverted Siphon - A sewer, often crossing beneath a gulch, a watercourse or an obstruction, which runs full or under greater than atmospheric pressure because its profile is depressed below the hydraulic grade line.

Slope - The inclination or gradient of the invert of a sewer expressed as a decimal, or percentage.

Standard Details - The current edition of the Standard Details for Public Works Construction, Departments of Public Works, City and County of Honolulu and the Counties of Kauai, Maui, and Hawaii.

Standard Specifications - The current edition of the Standard Specifications for Public Works Construction, Departments of Public Works, City and County of Honolulu and the Counties of Kauai, Maui, and Hawaii.

Temporary Wastewater Facilities - Wastewater facilities which are built for private development (subdivision) and intended to remain in service only until their needs are over. Temporary facilities expected to be in service for 10 or more years as determined by the Department of Wastewater Management shall be designed and constructed as a permanent facility.

Trunk Sewer, Main Sewer, or Main - A sewer which receives flows from one or more branch sewers.

Wastewater Facilities - A comprehensive term which includes facilities for collecting, transporting, pumping, treating, and disposing of wastewater.

Wastewater Pump Station - An installation employing mechanical equipment and devices for raising or lifting wastewater and discharging it into a gravity system or a wastewater facility.

Wastewater Treatment Plant - An arrangement of devices and structures where wastewater is treated to remove or alter its objectionable constituents and thus render it less offensive and hazardous.

Wet Well - Compartment used for the storage of wastewater for pumping purposes.

ACRONYMS

ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE, INC.
HECO	HAWAIIAN ELECTRIC COMPANY
IEEE	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.
NEMA	NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION
SCADA	SUPERVISORY CONTROL AND DATA ACQUISITION