Sump Pumps, Sewage Ejectors, and Controls

"When the wastes received are storm water and other clear water discharges, it is called a *sump basin* and the lifting and discharge equipment is called a *sump pump*.

When the receiving basin collects the discharge of sanitary wastes, it is called an *ejector basin* and the lifting and discharge equipment is called an *ejector pump*."

Engineered Plumbing Design II, Ch. 10,
The American Society of Plumbing Engineers (ASPE)

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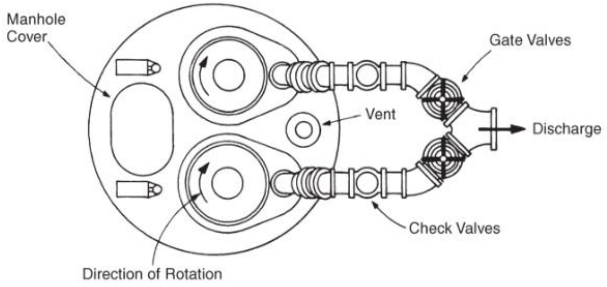
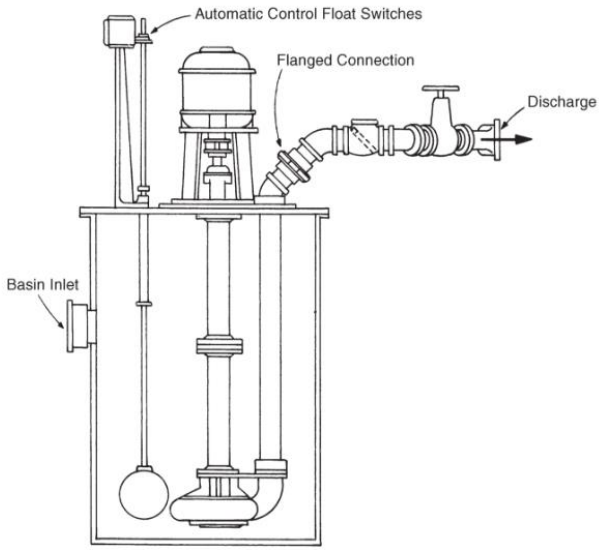
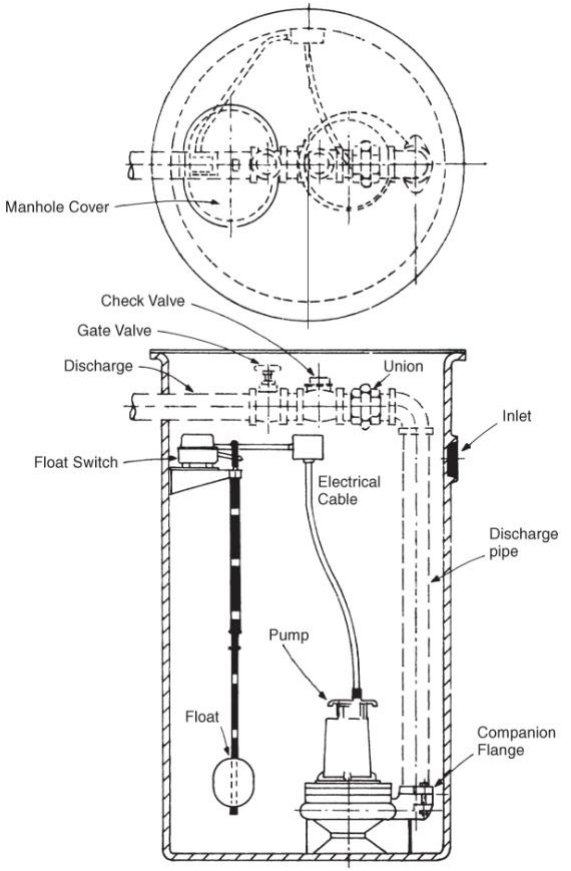
Learning Objectives

- Differences between Sump Pumps and Sewage Ejectors
- Requirements of the Plumbing Code
- Pump and Wetwell Basin Sizing
- Specifying Pump Controls







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Differences between Sump Pumps and Sewage Ejectors (per ASPE)

Sump Pump and Basin: Receives and discharges storm water and clear water waste

- The basin does not need to be airtight or vented, unless required by Code, because of the lack of objectionable odors; however, it is recommended to remove hydrogen sulfide gas
- Storm water contains rainwater, snow, ice, or other natural precipitation
- Clear water is drainage that does not contain human waste

Sewage Ejector and Basin: Receives and discharges sanitary drainage or sewage waste

- The basin must be airtight and vented to prevent the escape of foul odors
- A vent is required to relieve the air in the basin as wastes discharge into it and to supply air to the basin while the contents are being discharged
- Sanitary drainage contains human waste, Sewage waste contains animal, vegetable, or chemical waste

Sump Pumps and Sewage Ejectors are considered Submersible Wastewater Pumps!

Requirements of the IPC – Sump Pumps

Chapter 11 Storm Drainage, Section 1113, Sumps and Pumping Systems

- The sump basin shall be a minimum of 18” in diameter and 24” deep, provided with access, and a removable cover which must support anticipated loads
- Drainage must flow into the basin by gravity
- Discharge piping shall meet the requirements of the IPC Ch. 11, be the same size or larger than the pump tapping, and shall include a gate valve and full-flow check valve
- The sump pump shall be sized appropriately for anticipated use requirements

Note:

- Section 1113 does not reference solids handling, where the valves should be installed, or how to connect the discharge to the storm drain; therefore, defer to Section 712

Requirements of the IPC – Sewage Ejectors

Chapter 7 Sanitary Drainage, Section 712 Sumps and Ejectors

- The basin shall only receive waste that cannot be discharged into the sewer by gravity
- The sump basin shall be a minimum of 18” in diameter and 24” deep, provided with access, a gastight removable cover which must support anticipated loads, and vented
- A check valve and full-open valve, located on the discharge side of the check valve, shall be installed on the discharge piping
- Access shall be provided to the valves and they shall be located above the basin cover
- When the discharge piping is below grade, the valves shall be accessible outside the basin in an access pit with a removable access cover
- The sewage ejector shall be sized appropriately for anticipated use requirements
- Discharge piping shall be copper, copper-alloy, CPVC, ductile iron, PE, or PVC and suitable for the system operating pressure, temperature, and for burial, as required

Requirements of the IPC – Sewage Ejectors

Chapter 7 Sanitary Drainage, Section 712 Sumps and Ejectors

- The effluent level shall not rise within 2” of the invert of the gravity drain inlet
- The sewage ejector shall automatically discharge the contents of the sewage basin
- The discharge piping shall connect to building sewer, building drain, soil stack, waste stack, or horizontal branch drain
- If connected to a horizontal branch drain, the connection shall be a to a wye fitting on its back so that the discharge enters into the top of the drain
- The wye fitting shall be located not less than 10 pipe diameters from the base of a soil stack, waste stack, or fixture drain
- Sewage ejectors serving water closets shall be capable of handling 2” spherical solids
- Other pumps and sewage ejectors shall be capable of handling 1/2” spherical solids

Sump Pumps

Sump Pumps, which discharge storm water and clear water discharge, are generally not designed to handle spherical solids larger than 1/2”.

- An example is an Elevator Sump Pump which Per ASME A17.1/CSA B44 - 2022 - Safety Code for Elevators and Escalators, must be capable of discharging 3,000 gph, or 50 gpm, to remove clear waste from an elevator sump basin
- Small sump pumps (<100 gpm) may have a semi-open impeller, which generates head between the impeller and casing walls, with min. 1/2” clearance between the impeller and housing, and are fitted with a vertical discharge
- Large sump pumps (>100 gpm) may have a non-clog semi-open or vortex impeller, which generates head between the casing walls, have larger clearances between the impeller and housing, and are fitted with either a vertical or horizontal discharge

Courtesy of Grundfos

Sewage Ejectors

Sewage Ejectors, which discharge sanitary drainage or sewage waste, are generally designed to handle 2” or larger spherical solids.

- Sewage ejectors, similar to large sump pumps, may have a non-clog semi-open, s-tube, or vortex (open) impeller, which generates head between the casing walls, have larger clearances between the impeller and housing, and are fitted with either a vertical or with a horizontal discharge
- Vortex impellers create a tornado-like effect in the pump volute and the solids make little contact with the impeller. The benefit of this design is a reduced chance of a clog. The downside is these are pumps are far less efficient (25-30%).
- Most sewage ejectors have a double mechanical cartridge shaft seal to separate the motor from the pumped liquid

Courtesy of Grundfos

Courtesy of Zoeller

Pump Types

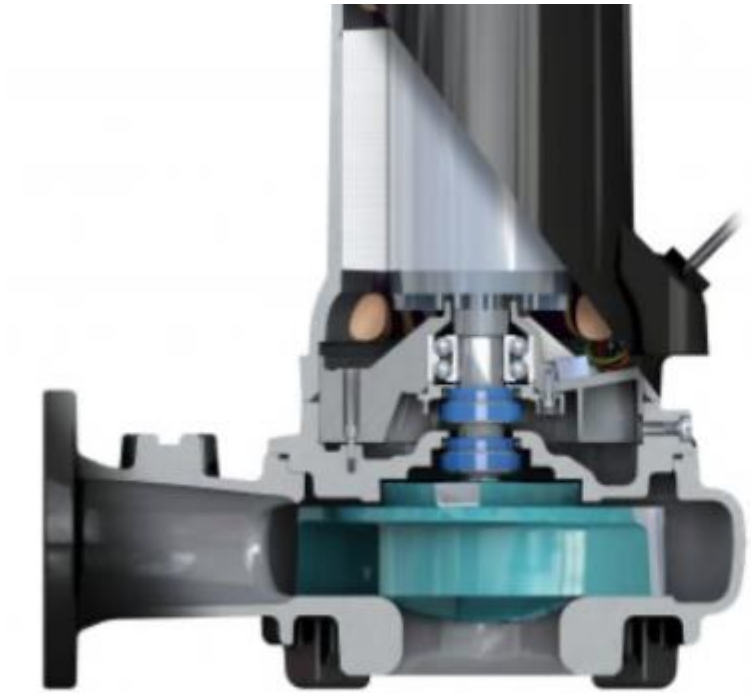
Horizontal discharge pump, courtesy of Grundfos

Vertical discharge pump with piggyback float switch, courtesy of Zoeller

Sump pump with vertical discharge and piggyback float switch, courtesy of Grundfos

Vertical enclosed shaft pit mounted pump, courtesy of Peerless

Impeller Types



Semi-open or S-tube impeller, courtesy of Xylem/B&G

Vortex impeller, courtesy of Xylem/B&G

Semi-open impeller, courtesy of Hydra-Tech Pumps

S-tube impeller, courtesy of Grundfos

Vortex impeller, courtesy of Grundfos

Simplex or Duplex? Emergency Power?

ASPE recommends a **Duplex** pump arrangement in ASPE PEDH Vol. 2 and Engineered Plumbing Design II

- Due to the danger of flooding caused by unusual rainfall conditions, or the failure of one pump, it is recommended that a **Duplex** sump pump system be provided
- Each pump should be sized to satisfy the peak inflow which provides a N+1 strategy in the event of a pump failure
- In critical or large applications, a triplex or quadplex pump system may be required

ASPE recommends **emergency power** for sump pumps in Engineered Plumbing Design II

- A power failure is more likely during a storm than at other times - just when the sump pump is most needed!

Sump Pump Basins

Courtesy of Park USA

Courtesy of AK Industries

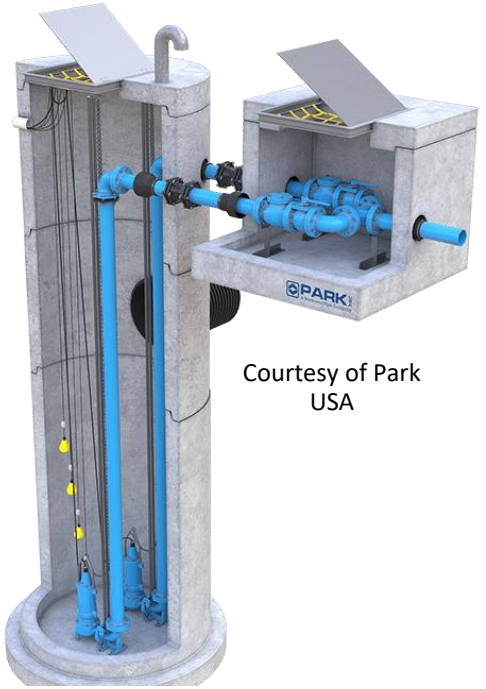
Sump Pump Basins receive storm water and clear water discharge

- The basins may be constructed by the General Contractor. Examples are an elevator sump, which is built into an elevator shaft floor, basins at the lowest level of a subterranean parking garage, or basins in a basement mechanical room. The interior of the concrete basin must be completely waterproofed and watertight sleeves must be provided for all pipe entries into the basin. Basin covers should be specified where required.
- Concrete, fiberglass, and non-corrosive basins should be specified as required
- Basin covers are not generally required to be gastight or vented, but, per ASPE, is recommended to remove hydrogen sulfide gas if the basin receives drainage from a condensing water heater or storage tank that has magnesium anode rods
- IPC Section 1113 does not stipulate that the valves are required to be outside the basin; however, it is required for valves to be accessible

Sewage Ejector Basins

Sewage Ejector Basins receive sanitary drainage or sewage waste

- The basins may be constructed by the General Contractor. Examples are basins in a basement mechanical room. The interior of the concrete basin must be completely waterproofed and watertight sleeves must be provided for all pipe entries into the basin. Basin covers should be specified where required.
- Basin covers are required to be gastight and vented
- Concrete, fiberglass, and non-corrosive basins should be specified as required
- IPC Section 712 requires that the valves are installed above the basin cover or in an access pit with a removable cover



Courtesy of Park USA

Courtesy of AK Industries

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Lift Stations (Packaged Basins)

Lift Stations, which are large structures typically specified by Civil Engineers, is a term manufacturers use to describe a packaged basin because they include many required accessories, such as float switches, base elbow rail system (auto-couplers and guide claws), guide rails, guide rail brackets, lifting chains, basin discharge piping, shutoff and check valves, and a basin cover with hatch.

- Float switches control the pump(s) and connect to the control panel
- The pump is attached to a guide claw which connects to the auto-coupler (base elbow rail system), and slides on the guide rails, which are supported by the guide rail bracket, when raised or lowered using the lifting chains
- The shutoff and check valves are connected to the basin discharge piping
- The basin cover with hatch is installed onto the basin top

Courtesy of Conery

Courtesy of Grundfos

Submersible Macerating Pumps

There are three types of submersible macerating pumps: grinder pumps, cutter and slicer pumps, and chopper pumps. Each type macerates solids differently.

Macerating pumps are not as versatile as solids-handling pumps.

Grinder pumps are applied in residential and commercial completely pressurized sewage collection systems to lift sewage into a gravity sewer.

Cutter and slicer pumps are heavy duty, submersible pumps for sewage and wastewater system to address clogging challenges in municipal applications characterized by light solids content.

Chopper pumps are designed to meet the rigorous demands of wastewater applications, catering specifically to collection systems, treatment plants, food processing, agriculture, and other scenarios with substantial solid content.

Cutter Pump, Courtesy of Crane

Chopper Pump, Courtesy of Crane/Deming

Grinder and Cutting Plate, Courtesy of Zoeller

Sizing Fundamentals - Sump Pump Flow

To determine the **Sump Pump Flow**, the storm water and clear water waste flow that will drain into the basin must be calculated

- A Geotechnical Engineering report may provide subsoil drainage system flow rates
- Clear water discharge should be included if they are designed to discharge continuously
- Per ASPE Engineered Plumbing Design II: Ch. 10 Sumps and Ejectors:
  - Runoff from paved and impervious areas can be calculated using a value of 1 gpm/24 ft^2 for locations where the annual rate of rainfall is 4 in./hr. Adjust rates as required.
  - The subsoil drainage system rate of discharge can be calculated using a value of 2 gpm for each 100 ft^2 of area where the soil is sandy and 1 gpm per 100 ft2 for clay soils
  - It is good practice to add a 25% safety factor to the total calculated flow for possible periods when calculated maximum flows are exceeded by unusual storm conditions
- The pump capacity should be equal to the peak inflow (plus the desired safety factor)

Sizing Fundamentals - Sewage Ejector Flow

To determine the **Sewage Ejector Flow**, the sanitary waste flow that will drain into the basin must be calculated

- Per ASPE Engineered Plumbing Design II: Ch. 10 Sumps and Ejectors and the IPC:
  - Calculate the total DFU of the plumbing fixtures that will drain into the basin
  - Floor drains, unless receiving continuous flow, should not be included
  - Use the conversion of GPM flow to DFU values: 1 GPM = 2 DFU
- The pump capacity should be equal to the peak inflow (plus the desired safety factor)

Sizing Fundamentals – Total Dynamic Head of the Pump

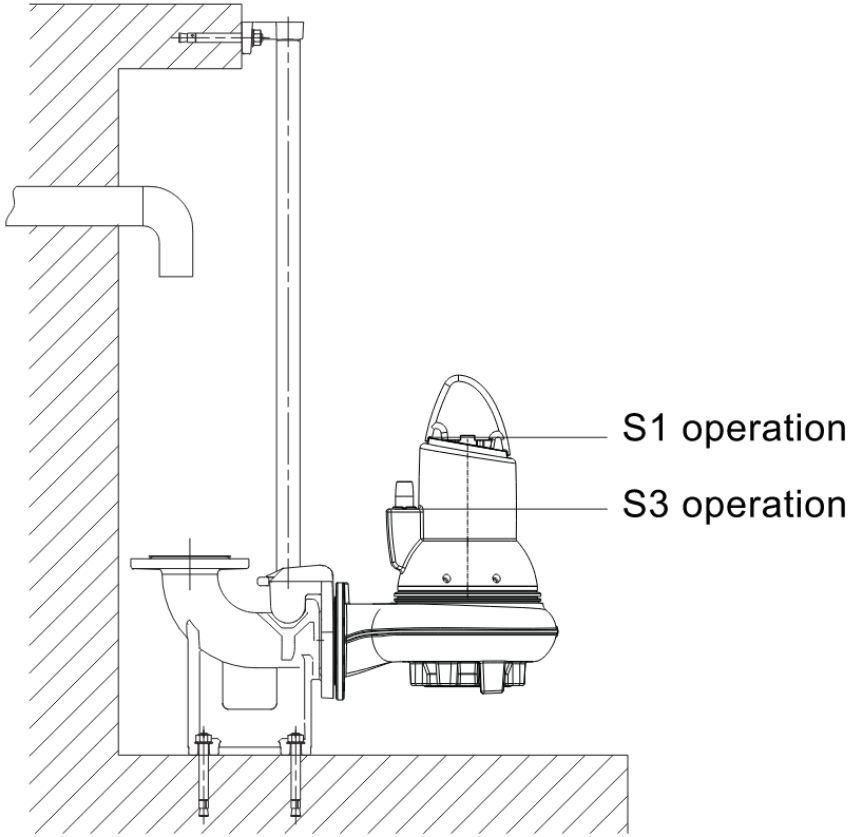
To calculate the **Sump Pump/Sewage Ejector Total Dynamic Head (TDH)**, add the static head and the friction loss in the discharge piping

- Size the pumped discharge piping as required per the application and control type: pump alternation (N+1) or lead/lag where multiple pumps may operate
- The static head is measured from the low water line in the basin up to the highest point pumped, to the point of discharge, or connection
- From the high point of the pump discharge piping to the connection with the gravity drain, the piping may be sized and sloped as a gravity drain
- The friction loss of the piping system should include the pressure loss of the fittings and valves
  - Include losses for the Shutoff Valves and Check Valves
  - Consult the IPC, Hazen-Williams, Darcy-Weisbach, or Manufacturer's data

Sizing Fundamentals - Basin

Sump Pump/Sewage Ejector Basins are sized to prevent excessive pump cycling and subsequent wear and tear on the pump motor

- For intermittent operation, consult the pump manufacturer's data to determine the maximum starts per hour, maximum run time, and minimum off time
- Continuous pump operation is allowed by some pump manufacturers providing that the motor is fully submerged because the fluid/effluent cools the motor
- The 'Pump Off' Float Switch must be set at a height per the pump manufacturer's criteria to ensure the pump inlet is partially submerged so the pump does not run dry
- Consult the pump manufacturer and select a basin diameter that will allow both pumps to be removed through the basin hatch



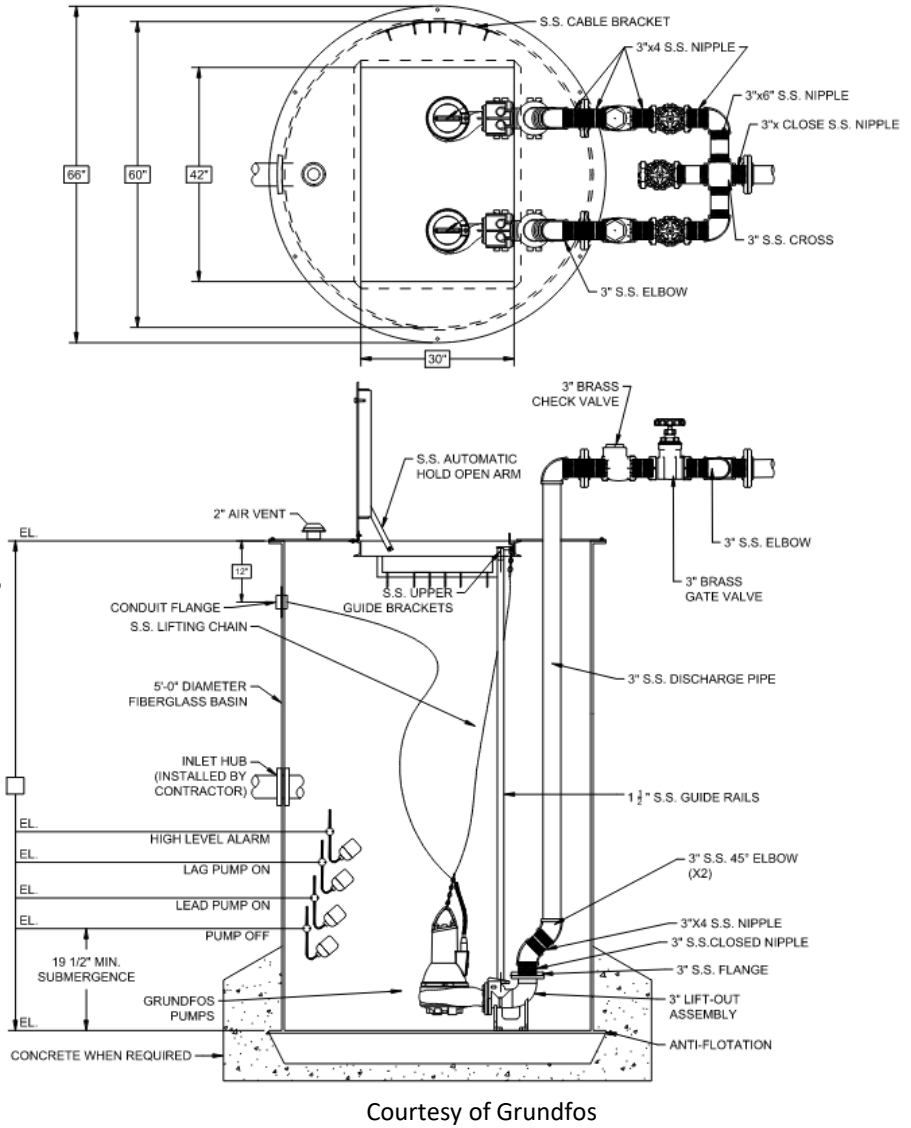
Continuous operation 'S1' when the pump is fully submerged to the top of the motor

Intermittent operation 'S3' when the pump is submerged to the bottom the cable plug.

Courtesy of Grundfos

Sizing Fundamentals - Basin (continued)

- An example would be to use a flow of 85 GPM and 5 minutes of pump run time between the high and low water levels
- Multiply the flow rate by the pump run time; 85 x 5 = 425 gallons min. basin capacity
- Using a 4 ft diameter basin, calculate the depth of the basin:
  - $0.7854(\text{Dia.}^2) \times \text{Depth} \times 7.5\ \text{gal/ft}^3 = \text{gal}$ or
  - $\text{Depth} = 425 / 0.7854 \times 4^2 \times 7.5 = 4.5\ \text{ft}$
- The high water level should be a minimum of 2” below the invert of the subdrain; Assume the low water level is a minimum of 12” above the bottom of the basin; Calculate the invert of the subdrain entering the basin, assume 2’-0”
- Add the values: 4’-6” + 2” + 1’-0” + 2’-0” = 7’-8” basin depth



Courtesy of Grundfos

Sizing Fundamentals - Pumped Discharge and Basin Vent

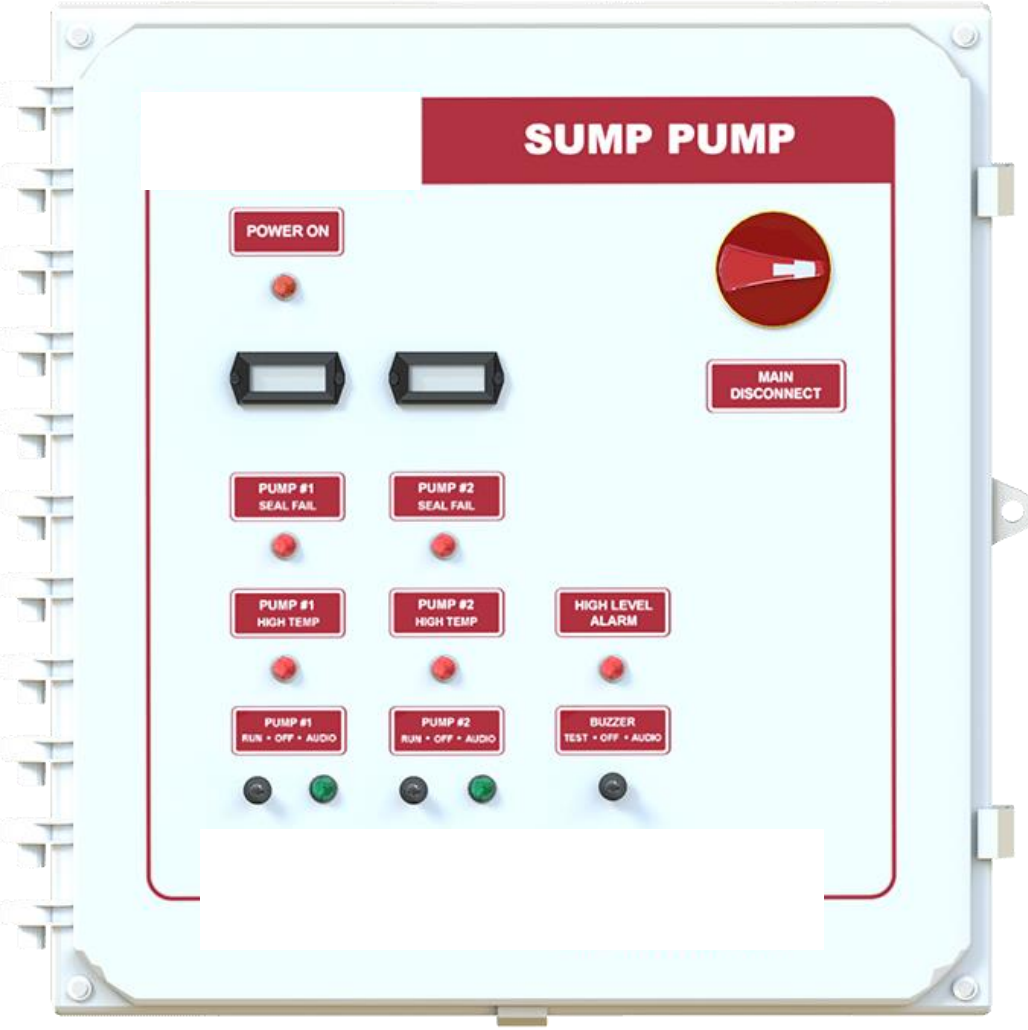
Size the **Pumped Discharge** and **Basin Vent** per the IPC and best engineering practice

- The pumped discharge should not be the smaller than the pump outlet
- Size the pumped discharge piping as required per the application and control type: pump alternation (N+1) or lead/lag where multiple pumps may operate
- Maintain pump discharge velocities to ensure scouring of the inner pipe walls
- On long pumped discharge piping runs, consider increasing the pipe size to reduce the friction loss and pump TDH
- Use the conversion of GPM flow to DFU values (1 GPM = 2 DFU) as a starting point to size the vent

The Control System

The Control System for Sump Pumps and Sewage Ejectors are a critical component of a well-designed Sump Pump and Sewage Ejector system

- If the pump(s) fail, and a proper Control System is not provided, a building could be deemed unoccupiable, unusable, and/or unlivable
- The Control System consists of a Control Panel and Float Switches
- The Control Panel ensures the system operates as designed as it monitors the Pump(s) and Float Switches, and contains the appropriate alarms to alert the end user in the event of a pump maintenance concern or pump failure. Dry Contacts and BACnet interfaces are available.



Courtesy of Cougar Systems USA

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The Control System (continued)

Courtesy of Grundfos

- The Control Panel can be configured for single or multiple pump operation and contains alarms, such as:
  - Oil chamber air and water sensors (potential pump seal failure)
  - Motor chamber moisture switch (potential motor failure)
  - Thermal switches in the stator windings (motor overheating because of a clogged impeller)
- A simplex pump control system for an Elevator Sump Pump can be as simple as a piggyback float switch; however, this setup has no alarming functionality so it is recommended to specify a high water alarm
- If the elevator is hydraulic, it is recommended to provide a Control Panel that can monitor an oil-in-water sensor to alarm if oil is detected
- A simplex pump Control System for a Sump Pump or Sewage Ejector in a Basin requires three float switches (Pump off, Pump On, and High Water Alarm) and a Control Panel to monitor the Float Switches and Pump

Courtesy of Cougar Systems USA

The Control System (continued)

Courtesy of Conery

- A duplex pump Control System for Sump Pumps and Sewage Ejectors in a Basin requires four float switches (Pump off, Lead Pump On, Lag Pump on, and High Water Alarm) and a Control Panel to monitor the Float Switches and Pump
  - The Control Panel can be setup for pump alternation to equalize run time or lead/lag where both pumps may operate either as designed or if the lead pump capacity is exceeded
- Float Switches in a Basin should be installed on as Float Rail to reduce a chance of hang up

Best Practices

- Specify valves to be outside the basin for all applications
- The check valve should be a weight-loaded swing check valve to eliminate water hammer when the pump shuts off
- The shut-off valve is required to be located on the discharge side of the check valve so that it can be closed and the check valve serviced
- A sump pump installed in a subterranean parking garage for dewatering should include a sand/oil interceptor in the drainage piping prior to entering the basin
- A sewage ejector that receives wastes containing grease, oil, gasoline, laundry, etc. should have the appropriate type of interceptor in the drainage piping prior to entering the basin
- Do not specify basins with junction boxes inside the wetwell basin unless they are NEMA 6P or IP68 rated

References

- ASPE PEDH, 2021, Vol. 1 Plumbing Systems: Ch. 1 Formulas, Symbols, and Terminology
- ASPE PEDH, 2022, Vol. 2 Plumbing Systems: Ch. 1 Sanitary Drainage Systems, Ch. 4 Storm Drainage Systems
- ASPE PEDH, 2020, Vol. 4: Ch. 4 Pumps
- ASPE Engineered Plumbing Design II: Ch. 10 Sumps and Ejectors
- ASPE Advanced Plumbing Technology II: Ch. 8 Pumps
- ASPE Pump and Pump Systems II: Ch. 2 Pressure and Flow Characteristics and Ch. 4 Types of Pumps
- International Plumbing Code: 2021 and 2024
    - Chapter 7 Sanitary Drainage, Section 712 Sumps and Ejectors
    - Chapter 10 Storm Drainage, Section 1113 Sumps and Pumping Systems

PEDH = Plumbing Engineering Design Handbook

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Thank you!

Q & A

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