PUMPING SYSTEMS
GENERAL INFORMATION
SECTION INDEX

A BRIEF HISTORY OF SMITH & LOVELESS, INC.

Smith & Loveless Inc.
Above All Others.

Smith & Loveless was founded in 1946 by B. Alden Smith and Compere Loveless as a sales engineering firm representing several manufacturers in the wastewater industry.

Early in their association, Smith & Loveless recognized the need for complete factory-built wastewater pump stations and began manufacturing this equipment. Their first three stations were built for the municipal wastewater system of Salina, Kansas. These units were fabricated in a converted barn less than three miles from the present plant location.

As demand for this equipment grew, Smith & Loveless built their first manufacturing plant, a modest structure a few miles from the present plant site. Sales increased rapidly and within a short time, Smith & Loveless had sales representatives throughout the United States and Canada. Because of this rapid growth, it was necessary to expand this plant five times in four years.

The present site in Lenexa, Kansas, (a Kansas City suburb), was selected in 1957. By 1958, the new manufacturing facility was ready for production. The present plant has been expanded several times, more than tripling the original manufacturing and office space. (Over 100,000 square feet or 10,628 square meters of manufacturing space.)

Late in 1959, Smith & Loveless was acquired by Trans Union Corporation which was based in Lincolnshire, Illinois. This acquisition complemented markets served by other divisions of that firm, as well as providing additional capital for expansion and research and development, ensuring Smith & Loveless' leadership in the wastewater industry.

In February 1981, Trans Union merged with the Marmon Group, a large privately held corporation.

In October 1981, the management of Smith & Loveless Division purchased the assets of the Division from the Marmon Group, and Smith & Loveless, Inc., was reborn. Smith & Loveless renewed its commitment to maintain its role as a leader in the water and wastewater treatment and pumping industry through the design and production of quality equipment and by providing superior service.

To continue to strengthen its leadership position, Smith & Loveless, on October 1, 1984, purchased two firms: **SCIENCO®**, Inc., St. Louis, Missouri, and **DI-SEP®** Systems International, Inc., of Santa Fe Springs, California. On August 1, 1985, Smith & Loveless added another subsidiary by acquiring St. Louis Marine Systems, Inc., renamed **FAST®** Systems, Inc. In 1987, Smith & Loveless made another step to provide additional capabilities in water treatment by acquiring K-W Industries. K-W was previously located in Omaha, Nebraska. In 1993, the above companies and their products were all absorbed into Smith & Loveless, Inc. and its product lines.

In a move to both strengthen Smith & Loveless, Inc.'s water product line and expand into the European marketplace, Smith & Loveless Limited, an affiliated company of Smith & Loveless, Inc., acquired the majority interest in Kalsep Limited of Camberley, England on March 29, 1995. Licenses granted allow Smith & Loveless products to be sold by Kalsep Limited and Kalsep Limited's water products to be sold in Smith & Loveless' markets.

Further international expansion occurred on March 20, 1998, when Smith & Loveless, Inc. formed an alliance with Smith & Loveless New Zealand Ltd. of Auckland, New Zealand. Smith & Loveless New Zealand Ltd. was granted licenses to market and sell Smith & Loveless, Inc. technology and equipment in New Zealand and Australia. And in a strategic move in August 1999, Smith & Loveless Limited - UK began to actively market and sell Smith & Loveless, Inc. technology in the United Kingdom.

On the domestic front, in June 2000, Smith & Loveless Georgia Inc. was formed. This allows the Company to provide superior pump station sales and service to its Georgia customers.

Further enhancing parts and retrofit products and service to existing customers, Smith & Loveless formed the After Market Division, April 15, 2002.

Smith & Loveless continues to expand and offer solutions for a world of water problems.

Smith & Loveless, Inc. • 14040 Santa Fe Trail Drive • Lenexa, KS 66215-1284, USA
Phone: (913) 888-5201 • Fax: (913) 888-2173
www.smithandloveless.com • answers@smithandloveless.com

NOTES ON DESIGN OF SEWAGE LIFT STATIONS

This information has been compiled from reference books, as well as from the suggestions of consulting and City engineers. It has been proven by our experience in building thousands of sewage lift stations in successful service in all parts of the country, under widely varying conditions of temperature, humidity, etc. Much of the material will seem elementary to most readers, but it is offered with the thought that it would be a convenience to many to have it readily available for reference.

NEED FOR PUMPING

1. Where the topography is such that good sewer grades for gravity flow are not possible without excessive depth and with the consequent high construction costs. The sewer grade is carried as low as is practical, then the sewage is raised by a lift station to bring the sewer close to the surface again.

2. Where the sewer discharges into a river or other body of water with the hydraulic gradient of the sewer below the river surface. In many cases, such lift stations are only used during high water or flood conditions, and are bypassed most of the time.

3. Where the hydraulic gradient is such that there is insufficient head for gravity flow through a treatment plant.

4. Or where it is necessary to boost the sewage over a ridge through a long discharge line, or force main, to a point from which it will flow by gravity. Such force mains are generally of cast iron pipe of the kind used for water mains.

TYPES OF SEWAGE LIFT STATIONS

Wet Pit Pump Stations with submersible sewage pumps are sometimes used to serve fixtures too low for flow by gravity into the sewer systems. Many Board of Health rules will not permit the use of such equipment where reliability is important. This construction places the most important equipment right down in the sewage where it is subject to rapid deterioration of the motor, bearings, shaft seal, etc., and the equipment is not accessible for maintenance.

Dry Pit Pump Stations (vacuum primed or flooded suction) offer the lowest cost per gallon of capacity combined with good reliability. For average and larger capacities they are more efficient than ejectors and submersible pumps and, hence, require less connected horsepower and consume less electric power.

DETERMINATION OF PUMPING RATE

Most of the volume of sanitary sewage and industrial wastes originates from the water supply. Hence, any determination of needed pump capacity should start with the records for water consumption for similar areas of the City. Actual measurements indicate that sewage flow will normally vary from 70% to 130% of water consumption. Therefore, designers often assume that the average (not peak) rate of sewage flow, including some allowance for groundwater infiltration, will equal the average rate of water consumption.

The amount of groundwater which infiltrates into the sewers through poor joints, cracked pipe, manhole walls, basement drains, etc., varies so widely that prediction is difficult. When available, local experience data is the best guide. Maximum infiltration rates of 50,000 gallons per day per mile of sewer are frequently encountered in well built sewer below groundwater level. A common design allowance is 1,000 to 2,000 gallons per day per acre served, depending on the groundwater level and condition of the sewer.

The maximum rate during the day is used to establish the pump design capacity. For sanitary sewers in a residential area, the maximum is generally two to three times the average flow. For a very small residential area, it may be four times. For commercial areas, the peak may reach 150% of the average. For industrial areas, it will generally be somewhat less. Most textbooks and health department standards recommend an assumed design flow of 250 gallons per day per capita for normal residential areas that have a water consumption of 60 to 125 gallons per capita per day. When sewers are below the groundwater level, an allowance for infiltration should be added to this peak figure at the rate of 1,000 to 2,000 gallons per acre per day.

Assuming 100 gallons per capita per day average flow, four people per house and a peak flow of three times the average, a good rule of thumb in determining maximum flow is to allow one gallon per minute per residence for the average subdivision. This includes a 20% addition for infiltration. Thus, for 100 residences use two pumps, each rated 100 GPM. For larger areas, see the following table.

Number of Houses*	GPM Firm Capacity Per House
30 – 200	1.0
250 – 400	0.9
450 – 600	0.8
Over 600	0.7

* Assume 1 house equals 2 apartments with 2 people each.

* Assume 1 house equals 4 trailer or motor court units.

Lift Stations are also used to handle storm water from highway underpasses, low intersections, parking lots and similar limited areas.

For storm water flow, the rate is best estimated by the Formula:

$$Q = \frac{CiA}{43{,}200}$$

Where Q = Flow in cubic feet per second
A = Drainage area in square feet
i = Average intensity of precipitation in inches per hour

C = Coefficient of runoff

The coefficient of runoff will vary with the duration of rainfall at the assumed rate, the condition of saturation from previous rains, the kind of surface, and the time required for flow to reach the drain from the farthest point. Commonly C will vary from 0.6 to 0.95 for impervious surfaces, or 0.2 to 0.60 for pervious surfaces.

NOTE: *Because 1 Acre = 43,560 Square Feet, the above formula is also given as Q = CiA where A = Area in Acres.*

DETERMINATION OF PUMPING HEAD

It is important to make an accurate determination of the pumping head. With pumps, any appreciable error in head calculation will result in a variation of capacity of equal or greater magnitude. For small capacities, a 10% error in head will commonly result in over a 25% increase or decrease in capacity. It is also important to remember that sewage pumps bought for small capacities, say 100 GPM, are operating very close to their shutoff (or maximum) head. Thus, it is particularly important to determine accurately the static lift. The use of an engineer's level is recommended.

The Total Dynamic Head (TDH) is the sum of the following:

1. The static lift which is the vertical distance from the water level (generally THE LOW WATER LEVEL) in the sump or wet well to the water surface at the outlet of the force main.

2. The pipe friction in the suction and discharge lines. See the chart at the end of this section for determining friction loss for various sizes of pipe; also the chart for converting valves and fittings into equivalent lengths of straight pipe. The selection charts for Smith & Loveless Lift Stations include friction loss values through the piping in the station.

3. The velocity head ($V^2/2g$) is the energy possessed by the water because it is in motion. For velocity of 8 feet per second, the velocity head amounts to 1.0 feet. Quite commonly, this factor is small compared with the total head. As a result, it is frequently omitted from the head calculation.

PIPE FRICTION COEFFICIENT FOR SEWAGE

The friction loss chart at the end of these notes is based on the Williams & Hazen formula using a Coefficient of C = 100, identified as the average coefficient for 15-year-old cast-iron pipe in a water distribution system. For new cast-iron pipe, the coefficient would be 125 to 130, producing friction losses 61.4% to 66.4% of the values from the table. New PVC pipe might be as little as 54% of the values in the table.

It is impossible to predict what the coefficient of friction will be with the passage of time. If velocities are low, solids may be deposited in the invert, reducing the cross section and restricting flow. If the water supply and/or the groundwater infiltration are corrosive, the pipe surface may blister or roughen. Tests of old cast-iron pipe force mains indicate, however, that grease and slime coatings formed from the sewage seem to protect the pipe surface. If these coatings become too thick, they restrict flow by reducing the effective cross section. Quite probably losses based on C = 100 are quite conservative, perhaps too conservative. If local test data or inspection of local force mains indicates that sewage force mains stay in good condition, smooth and substantially unobstructed, the engineer would be justified in using smaller losses than those from the table. Our experience in dealing with cast-iron pipe has been that a C-factor of

120 generally results in a good balance between total head specified and energy consumed.

SELECTING SIZE OF PIPE

If the force main is too small, excessive friction losses will result. Also, excessive velocities will accentuate any difficulties with water hammer or surge problems since the maximum pressure so developed varies directly with the initial velocity. See the section on “Water Hammer”. If the force main is too large, it will cost too much. For handling sewage, a minimum of 2.0 feet per second is required to prevent solids from depositing in the bottom of the pipe. Since most house connections are 4”, both gravity and pressure lines should be 4” minimum.

It will frequently be found that a force main of adequate size for one pump alone will deliver little extra sewage with the second pump also in service. Sometimes two force mains are provided, each to a different location. A careful check of operating head conditions of both routes is necessary to ensure that the pumps will operate satisfactorily for either. It may be desirable to use a smaller size pipe for the route with the lower static head, thus increasing the friction head and maintaining an adequate total dynamic head to avoid noisy pump operation.

WATER HAMMER IN FORCE MAINS

The analysis and formulas for water hammer found in most handbooks do not apply because they are based on a situation where the flow is interrupted at the outlet end of the line. For a pump station, however, the interruption of flow results from shutting off the pump at the inlet and followed by slamming of the check valve when the flow reverses. When the pump stops the entire mass of water in the suction line, the pump and discharge line is free to continue in motion under its own momentum until the column comes to rest, and then starts to travel in the reverse direction. It is the sudden closing of the check valve after flow reversal that causes water hammer trouble in pump stations. If the valve is of a type which closes quickly before any reverse flow takes place, the pressure increase from the returning wave will be relatively small. Should the valve stick, however, and then slam after high reverse velocities have built up, then the resulting pressures may rupture the pipe or valve. Spring-loaded check valves are desirable so that the valve closes before flow reversal, preventing water hammer.

SIZE OF PUMPS

Because most house connections are 4”, the smallest pump (or pipe) size should be 4”. Since the velocity should be 2.0 feet per second or more, it follows that the minimum pump capacity should be approximately 75 GPM (2.0 feet per second in a 4” pipe). The sewage pump should be capable of handling the industry standard 3” spherical solid. Small pumps that will pass 3” solids will have their peak efficiency at 400 to 800 GPM, depending on speed and impeller diameter. Such pumps are inefficient at small capacities and are operating close to their shutoff, or maximum head.

MOTOR SIZE AND TYPE

Three-phase current is always superior to single-phase because of the greater dependability of three-phase motors. Single-phase motors have starting switches that often fail because of repeated operation. The starting winding is not rated for continuous duty so if the switch fails, the winding will burn out. Single-phase pump motors larger than 5 HP should never be used. For single-phase jobs, particular care should be used in checking with the Power Company regarding wire sizes and transformer capacities. Low voltages at the end of the long single-phase lines are a common cause of difficulty. Where possible, two sources of electric power are desirable to ensure continuity of service. If a three-phase service is not available in the area, we recommend a phase-power converter be used in conjunction with a three-phase pumping installation to facilitate changeover when the three-phase service becomes available.

WET WELL DESIGN

History – The number of sewage lift stations on sewage collection systems was very small in the early 1900’s. There were several reasons for this. The main reason was the unreliability because of the lack of technology. Sewer systems were built where the sewage could be collected by gravity. Sewage treatment plants had pumps and wet wells. Large building with extensive below ground space used ejectors for sewage elevation to gravity sewers. Domestic sewage that could not be handled by gravity was disposed of in septic tanks. Population increase forced more installations of sewage lift stations. The early sewage wet wells for these installations were basically round brick structures or square cast in place concrete structures. The bottom was flat. The pump suction was above the bottom. Pump operation was controlled by floats on rods or tape reels. The earlier wet wells were made large to try to eliminate the flow fluctuation and store it so the pumps could operate for long periods of time to even out the flow. The even flow was felt to be a necessity both for the sewage treatment plant operation and the pump operation. Little interest was developed in wet well design. Problems encountered in sewage pumping were a fault of wet well design in the majority of the cases. This was not realized due to the lack of technology.

It was not until after 1946 when Smith & Loveless entered the factory-built lift station business that we became interested in wet well design. Wet well improvement became a necessity for successful pump station operation. This was also the first time that any company dealt with a large quantity of wet wells. This allowed technology to be gathered rapidly.

Purpose – The wet well is placed primarily at a point where the sewage from one or more gravity lines can be collected. This dictates the location of the wet well. On flat land, the depth of the sewer dictates when the cost of laying pipe calls for a lift station. In hilly land, the change in elevation dictates the need for a sewage lift station.

The second purpose of the wet well is to provide sufficient storage so that the lift station can operate satisfactorily. In doing this, the wet well provides the change in elevation required to go from the influent sewer level to the pump suction level.

The third purpose of the wet well is to provide for a transfer of the contents to the pump suction. This third purpose is the most important consideration in wet well design. Originally, it was thought to be one of the least important.

Materials – The first wet wells were of concrete, the universal construction material. Most of the wet wells so constructed were rather large. As wet well design changed and the volume of storage decreased (both as a requirement and the evolution of smaller lift stations) round brick wet wells began being built. The cost of bricklaying has changed this concept to pre-cast concrete wet wells (See Figure 1).

In every case, the interior of the wet well should be coated with some material to prevent deterioration of mortar or concrete by the fumes often encountered in the wet well. The most economical materials for this are bitumastic coatings of fairly thick film properties (1/8” to 1/4”).

The more recent coatings are epoxy, coal-tar epoxy, polyester and polyurethane. The best of these at the present time is epoxy. This material can be applied in a film thickness of 6 to 10 mils and give satisfactory service.

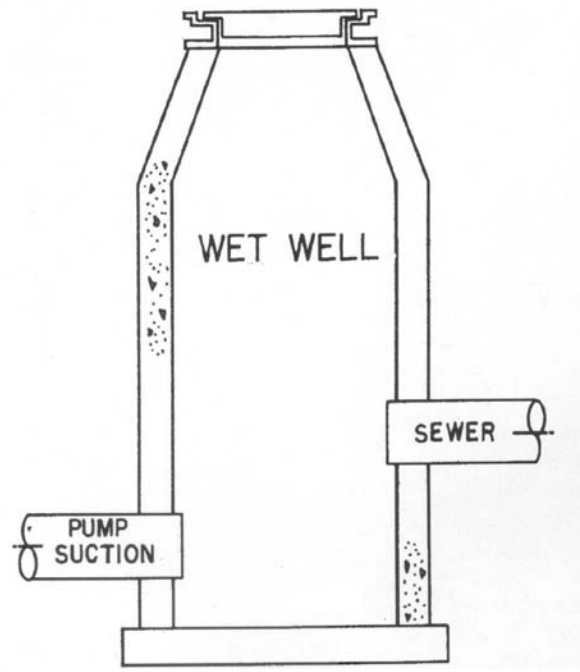


Figure 1

Shape – Wet well shape is extremely important. Improper shape can cause severe pump station operating problems. Pump clogging can be a result of the bottom shape. Loss of prime can be a result of suction line entry into the wet well. Sewer entrance can cause pump priming problems. Suction vortexing and resulting loss of prime is another problem. Wet well shape must be altered to fit the type of pump operation expected. Each type of wet well will be examined, and its construction discussed.

Small lift stations with flows up to 300 GPM usually have round wet wells. The round pre-cast concrete wet well is probably the most economical. The round wet well should be at least four feet (4') in diameter. This is the smallest diameter within which work can be readily performed. The shape of a typical wet well is shown in Figure 1.

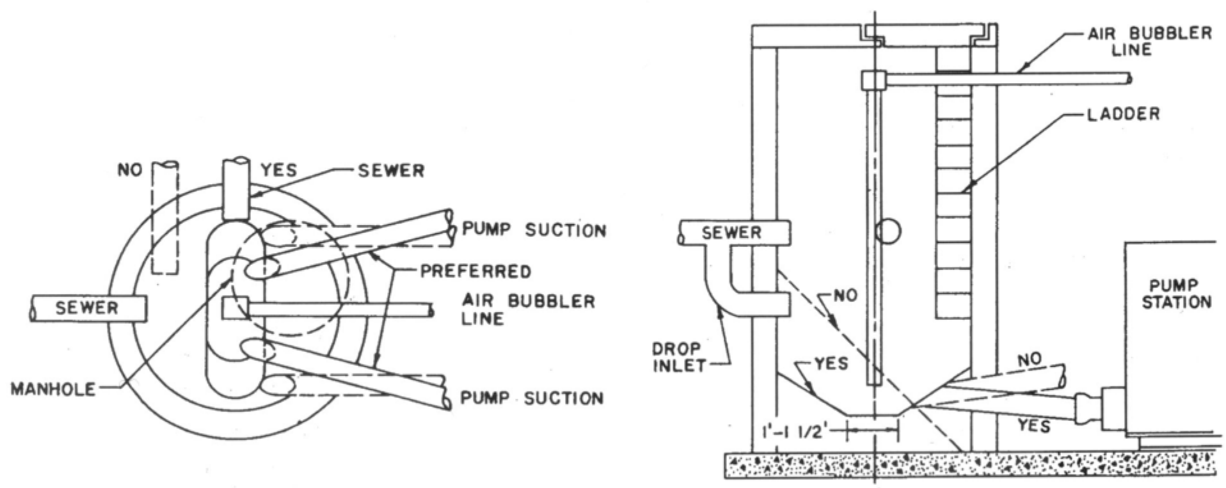


Figure 2

Starting at the bottom, each item and the reason for its importance will be discussed. The bottom of the wet well should be high enough to let the suction pipe slope upward from the pump station toward the wet well. The reason for this is that entrained air from the sewage splashing down into the wet well can enter the suction pipe when the pump is idle. With the slope as recommended, the accumulated air will move back up the pipe into the wet well. If the pipe slopes upward toward the pump station, the air will move up the pipe to the pump, and may cause it to airlock. The slope is extremely important if an eccentric plug valve is used at the pump suction. Air will accumulate ahead of the plug and back toward the wet well. When the pump starts up, it will suck the bubble of air into the pump, causing it to lose prime (See Figure 3).

The flat bottom of the wet well should be from one foot to one and a half feet (1' – 1-1/2'). The 1' width is necessary to stand comfortably and work. The 1-1/2' dimension is necessary to keep the velocity high enough to sweep the bottom clean of all solids. The sides of the hopper bottom will preferably slope toward the middle and the suction pipe openings. The slope can be as flat as 1 to 1. A greater slope will consume a larger volume of the wet well. A smaller slope may cause solids to settle and accumulate. The solids accumulation may come loose in large pieces, which can enter the pump and cause clogging. A steeper slope is not necessary because raw sewage solids are fairly heavy, and will slide down this slope. The 60° slope so often used in sewage work is not really necessary, as there is no light sticky floc that is customary in the treatment plant. A slope from one side only, as shown by the dotted line in Figure 2, can result in reduced volume in the wet well to a greater height.

The wet well should have an aluminum or other non-corrosive-type ladder. This is necessary to provide easy access to the wet well for cleaning and maintenance.

The incoming gravity sewer lines should come into the wet well on a radial line (Figure 2). If they come in at a point near tangent to the wall, they may cause the wet well contents to vortex and cause the pump to suck air from the induced vortex. The inlet sewer line or lines should be arranged so that the water splashing down into the wet well will not carry entrained air into the pump suction. If the inlet sewer comes in high up in the wet well, a drop inlet may help prevent the long fall that would entrain air. Carrying the level in the wet well higher and closer to the inlet sewer may help prevent entrained air.

The entrance manhole should be to one side of the top above the ladder rungs to provide easy access to the ladder.

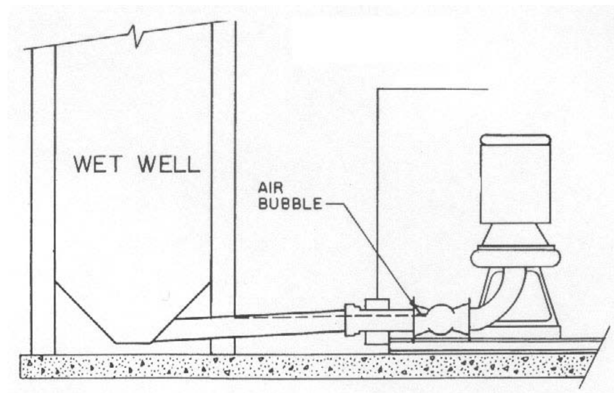


Figure 3

The air bubbler pipe, if used, will ideally be terminated six inches (6") above the pump suction lines. It should never be less than a minimum of two inches (2") above these lines, and should be located between the lines in order to prevent air from the bubbler system entering the pump suctions.

If a round brick manhole is used, the same construction as the round pre-cast concrete or cast concrete wet well should be used.

Square, cast concrete manholes should have minimum dimensions of 4' x 4' for working room. The same requirements for the round wet wells prevail.

Some wet well features encountered are definitely not recommended. A 90° elbow on the inlet of the pump suction (Figure 4) is one of these features. This type of construction has been used to get the pump station at a higher elevation, supposedly prevents vortexing and air entry into the pump and provide a bell mouth on the suction to get better entry to the suction line. In a sewage wet well, there are drawbacks to the 90° ell that can cause serious problems.

First, the entrained air, dissolved gases and liberated gases will enter the suction pipe and become trapped in the suction line and pump. This will cause the pump to airlock and not to pump. This occurs mainly when the pump is idle.

Second, paper and rags tend to accumulate in the sump of idle pumps. These often form large pads and, when the pump is turned on, the large pad can cause pump stoppage. This occurs quite frequently in wet wells serving hospitals, trailer courts and factories where paper and rag usage is higher. Large areas of flat bottoms provide areas for paper and rags to accumulate and move to the pump after a buildup causing pump stoppage. There have been pump stations where this occurred several times a day. Taking off the suction ells and filling the floor up to the suction line has greatly reduced or eliminated the problem. It has been found that most pump stoppage from paper and rags can be prevented by proper wet well design. Sewage pumps above six inches (6") in size seldom have paper and rag stoppage. Originally, this was believed to be a result of the large passages. Actually, it is probably because of the large pumpage rates causing higher velocities on the wet well floors and keeping the rag and paper accumulation to a minimum.

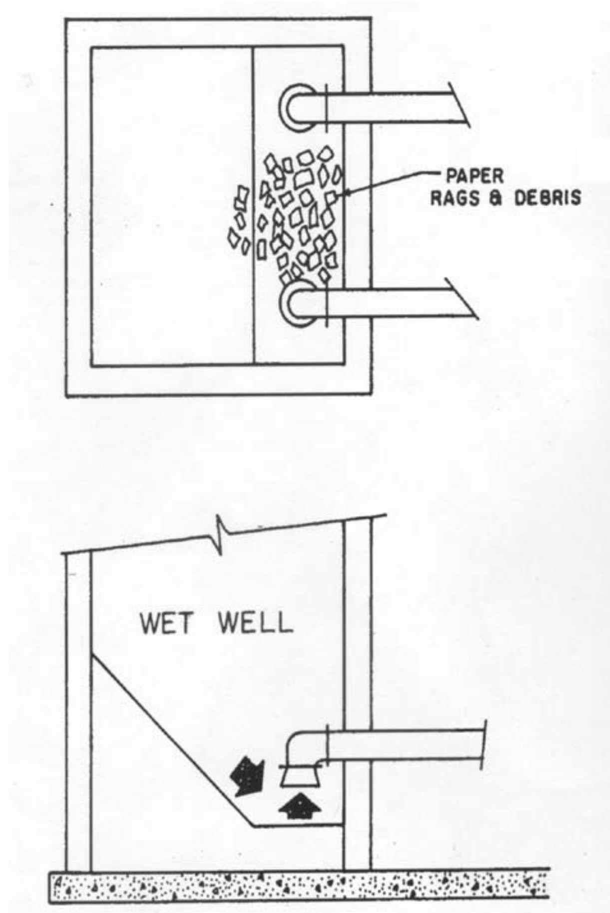


Figure 4

Larger pumps require larger wet wells. The wet wells again may be round or square. They are almost always concrete, poured in place. As the wet well gets larger, the sloped bottom rises higher at the 1 to 1 slope. The flat bottom should be kept to a minimum (Figure 5). If the pumps are separated considerably, it may be necessary to have a wedge in between the pump suctions to prevent paper and rag accumulation (Figure 6).

Where reliability must be extreme as required by a pumping station at the inlet to a treatment plant, a multi-compartment wet well may be required. This means the wet well must be divided into at least two separate compartments. This allows one compartment to be dewatered for any required work. The other compartment and the pumps connected thereto can remain operable. Care should be taken to provide adequate piping and valving between compartments to ensure common wet well levels during normal operation.

Size – It is impossible to design a wet well to provide continuous operation of a constant speed pump. The sewage inflow will not be the same at any period so the pumps will have to turn off and on. Continuous or long operating pumping is thought to be desirable for a sewage treatment plant. This gives an even flow into the plant, and gives the treatment process a chance to stabilize at this flow. If the wet well was to come close to providing this function, it would require a huge wet well. This would be impractical. In fact, if the sewage remains in the wet well for very long, it becomes septic. This causes an odor and corrosion problem. The practical solution to this is step flow or variable flow pumping. If the sewage is pumped for a short duration, the flow is not great enough to disturb the plant. This fits into the wet well possibilities of space versus retention time much better. The governing condition now is how often can the pump be started without damage to the motor and starter. Small horsepower motors can be started more often than large horsepower motors. The frequency of motor start depends on the WR^2, or inertia, of the load. Pump inertia is small so frequent starts are possible.

Wet well mounted lift stations have evolved from technology gained from many years of operation of buried dry pit lift stations. It was found from experience with smaller pump stations that pump cycles as low as two minutes did not cause motor or starter problems. The pumps in the wet well mounted-type stations are controlled by displacement switches. It is easily possible with displacement switches to have spacing within 6 inches or 1/2 foot of level in the wet well. This allows a wet well capacity of 50 gallons between pump start and pump stop in a 4 foot diameter wet well. This is ideal for medium size package treatment plants because the low quantity of sewage entering the plant is not enough to disturb plant operation. This is less than most ejectors, and at near the same rate of flow. A conventional 30 gallon ejector discharges at a 60 GPM rate. The WR^2 of the sewage pump used in the wet well mounted lift station is so small that the current inrush to the motor is of the duration of one second. This is not sufficiently long to cause heat problems when the motor is started every two minutes.

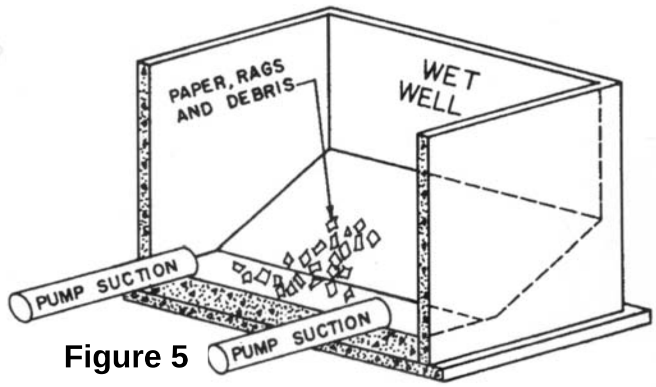


Figure 5

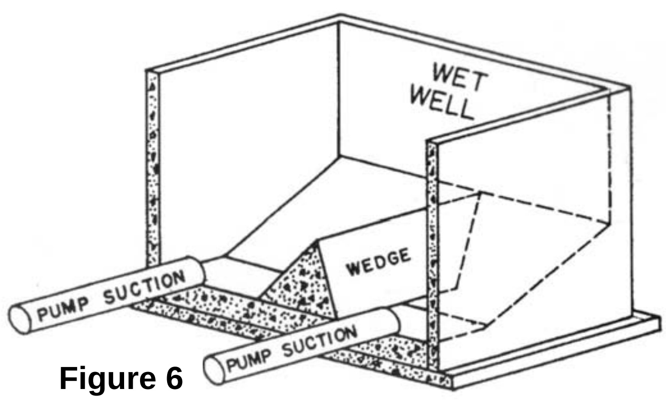


Figure 6

In dry pit below ground lift stations, the established practice was more conservative because technology had not been gained to show more frequent starting was possible. The general guideline on buried dry pit lift stations was gained from considerably earlier experience.

Experience has shown that starting small pumps every four minutes has not produced any problem with motors or starters at horsepower as high as 30. Motors from 30 HP to 75 HP have been started as often as every six minutes. Motors from 75 HP to 100 HP as often as every eight minutes, and motors from 100 HP to 200 HP every ten minutes. Motor and starter manufacturers may not agree with this, but they must cover all extenuating circumstances for all kinds of equipment. The above data is based on experience gathered from a great number of lift stations.

Another design criteria is to have the Start/Stop wet well levels sufficiently separated that conventional pressure switches will be sensitive enough to operate. Sensitive pressure switches require delicate settling, and are not as easy for the average operator to adjust. Many conventional pressure switches have a minimum differential of 24”. This means the minimum pump start to pump turnoff should be two feet of wet well level.

The duration of pump cycle is given by the formula:

(1)

$$t = \frac{V}{Q_D - Q_I} + \frac{V}{Q_I}$$

t = Time in minutes.

V = Wet well volume from pump start to pump off.

Q_D = Pump Discharge (GPM).

Q_I = Inflow rate into wet well (GPM).

$\frac{V}{Q_D - Q_I}$ = the time to pump the wet well down.

$\frac{V}{Q_I}$ = the time for the wet well to fill.

In a two-pump pump station, one pump is designed to handle peak flow. The second pump is for standby. If the peak flow is twice the average daily flow, then QD – $2Q_I$ for the average pump cycle. Using a wet well volume between start and stop equal to the pumpage rate is a good rule of thumb for small lift stations. This results in the following:

From formula (1) $t = \frac{2}{2 - 1} + \frac{2}{Q_I}$ = 4 minutes

This fits the pump starting allowance. It also happens to be the minimum length pump cycle. Variation in inflow from this point will increase the pump cycle length.

Using formula (1) and dividing by $\frac{V}{Q_D}$ gives:

$$\frac{t}{\frac{V}{Q_D}} = \left(\frac{1}{1 - \frac{Q_I}{Q_D}}\right) + \left(\frac{1}{\frac{Q_I}{Q_D}}\right) \qquad (2)$$

$$t = \frac{V}{Q_D}\left(\frac{1}{1 - \frac{Q_I}{Q_D}}\right) + \left(\frac{1}{\frac{Q_I}{Q_D}}\right) \qquad (3)$$

If we plot the right hand member of the equation versus $\frac{Q_I}{Q_D}$ we get the graph shown in Figure 7. We can, from this graph, multiply the right hand side of the equation in parentheses or any point on the left hand or abscissa of the graph (X) by $\frac{V}{Q_D}$ and get the time of the pump cycle.

From the curve, it can be seen that when the inflow rate is one-half of the discharge rate, the pump cycle is of shortest duration. To double the cycle length to eight minutes, the wet well capacity from pump start to pump stop should be twice the pump rate. Thus, with larger pumps when the cycle time is longer, more capacity is provided in the wet well.

PUMP CYCLE FOR VARIOUS WET WELL VOLUMES

MULTIPLY "X" BY $\frac{V\,(GAL.)}{Q_D\,(GPM)}$ = PUMP CYCLES IN MINUTES

V = WET WELL VOLUME (GAL.)

Q_D = PUMP RATE (GPM)

$$X = \left(\frac{1}{1 - \frac{QI}{Q_D}} + \frac{1}{\frac{QI}{Q_D}} \right)$$

Q_I / Q_D = INFLOW RATE (GPM) / PUMPING RATE (GPM)

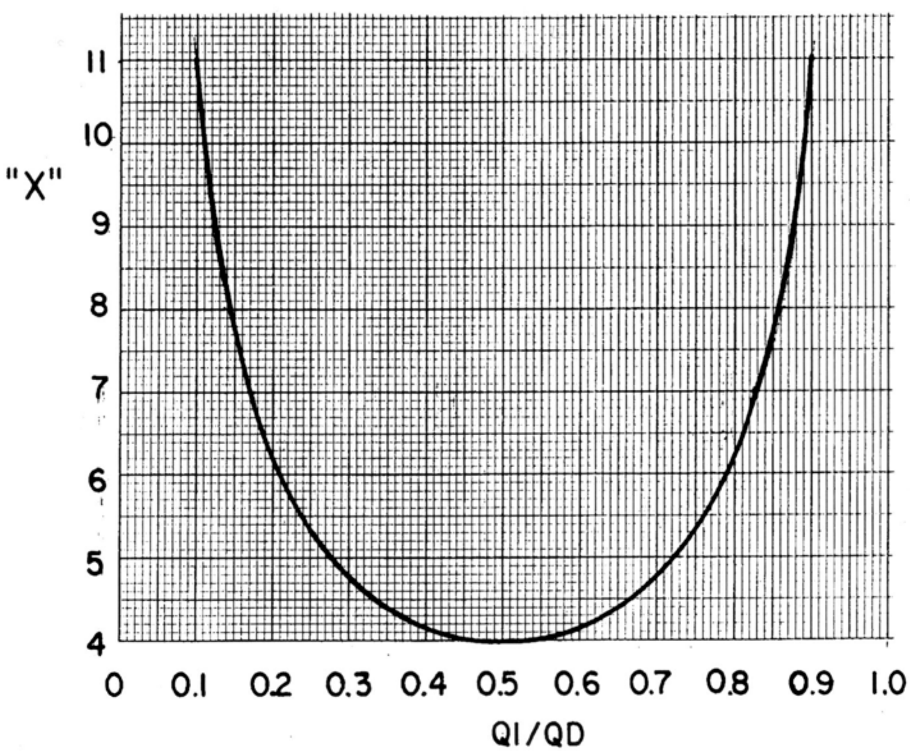


Figure 7

LEVEL SWITCHES

There are several systems in common use for turning the pumps off and on. The most common are:

1. Air Bubbler
2. Displacement Switches
3. Hydrodynamic Level Transducer
4. Sonic Transducer

The air bubbler system has an air pipe that extends down into the wet well, and terminates above the top of the pump suction lines. Air is forced down through this pipe at low flow rates. The back pressure or air pressure at low flow rates. The back pressure or air pressure required to overcome the water submergence is used to operate pressure switches to control the pumps. A low air rate is required so that head loss in the pipe does not affect the resulting pressure. The airflow rate should be high enough to fill the down pipe as fast as the water level falls when pumping. This keeps air flowing out of the pipe at all times so the end of the air pipe does not clog from deposits of grease, etc. A small pipe makes it possible to use low air rates, and yet not have clogging problems. A 3/4-inch pipe is an ideal size for low flow rates. A flow rate of 0.2 scfm to 0.4 scfm is ideal for using 3/8" O.D. control tubing or tubing in this range. An air bubbler system is not affected by velocities in the wet well, nor is it affected by grease buildup on the sides of the wet well. This makes the air bubbler system one of the more reliable systems in use.

Displacement switches used to control pump operation are of the type that tilt on water level fluctuation, but do not float. By doing this, they stay free of grease buildup. A floating switch will build up with grease and float at different levels, or may not float at all after a large grease buildup. Displacement switches can be affected by water velocity in the wet well. The wet well must be such that the switch cannot bang against the side of pipes, wet well or otherwise become tangled. The displacement switch is, therefore, not as reliable on wet wells having high flow rates unless the shape of the wet well allows for this problem. The displacement switch must be far enough from the sides of the wet well that grease will not build up on the walls and trap the switch. For smaller diameter wet wells, displacement switches have proven to be very reliable and cost effective.

CONSTANT SPEED PUMPS

If the sewage pump station houses only constant speed pumps, the levels mentioned for pump operation are suitable. With two-pump operation, if a common "Off" switch is not provided, the high level pump should turn off at a lower level than the low level pump. This is necessary in case the low level pump malfunctions (running but not pumping to capacity), so that the wet well level will always be pumped down by the high level pump, causing both pumps to turn off.

A common "Off" point normally cannot be incorporated without using a single switch common to both pumps. Consequently, when separate switches are used, allowance should be made in wet well depth and operating levels in order to turn off the high level pump at the lower level.

VARIABLE SPEED PUMPS

When variable speed type variable flow pumps are used, the wet well levels, as a minimum, should be those used for constant speed pumps. This will ensure reliable level switch operation. In some cases, the wet well should be made larger depending on the response time of the variable speed controller. Caution should be used to ensure the wet well is not pumped down and the pumps shut off before the variable speed controller can respond to the level change in the wet well. An inadequate wet well size may result in excessive pumping cycle.

For more details on variable speed and other forms of variable rate pumping, reference the section entitled Variable Frequency Controls.

FLOTATION

Any structure extending below the groundwater table, or extending into a fluid soil, must be checked to be sure that buoyant forces do not exceed the total downward forces. Special care should be taken on locations where the structure is to be placed in very fine sandy soil that is, or may become, saturated. Such soil, known as "quicksand", can become very fluid and can flow like water.

BUOYANCY CALCULATION

The upward acting forces are calculated as follows: in coarse sand, gravel or stable soil, assume the buoyant force is equal to the weight of displaced water (62.4 pounds per cubic foot) for all parts of the structure below the maximum anticipated groundwater table. In quicksand, assume the buoyant force equals the weight of the displaced soil, say 100 pounds per cubic foot.

DOWNWARD FORCES

For unstable soils, like quicksand, disregard the weight of the soil on top of the station. For all other soils, assume that the full weight of dry soil is effective over the net top area of the main chamber.

For saturated soils, assume that the effective weight of the soil is the dry weight, less the weight of an equal volume of water. For most soils, you can assume (100 – 62.4) or a net effective weight of 37.6 pounds per cubic foot.

Add the forces so calculated to the gross weights obtained for the structure. Use the empty weight of the wet well. Do not use the shipping weights of lift stations, as these are often too conservative. If the sum of the downward forces exceed the sum of the buoyancy forces, obviously the structure will not float.

Note that the calculations ignore such added restraining factors as skin friction between the structures and the soil, adhesion between the concrete base and the leveling concrete, shear between overburden and adjoining soil, etc.

If the sum of the downward forces does not exceed the buoyant forces, and the station has a base slab, anchor the station to the base slab and include its weight in the above calculation. Such additional concrete has an effective weight of (150 – 62.4) = 87.6 pounds per cubic foot in water, or (150 – 100) = 50 pounds per cubic foot in "quicksand".

UNDERGROUND STATIONS

On underground lift stations, the wet well should be set on a well-reinforced slab common to both the lift station and the wet well. This prevents differential settling and damage to the suction lines. The suction lines from the pumps to the wet well should be supported on grout to prevent earth settlement from breaking the pipes. Ideally, integral base beam suctions (see **DUO-DUCT®** Section) should be used. The wet well should be placed as close as possible to the pump station to reduce suction losses and further guard against differential settling. Preferably, the soil around the wet well and suction pipes should be compacted.

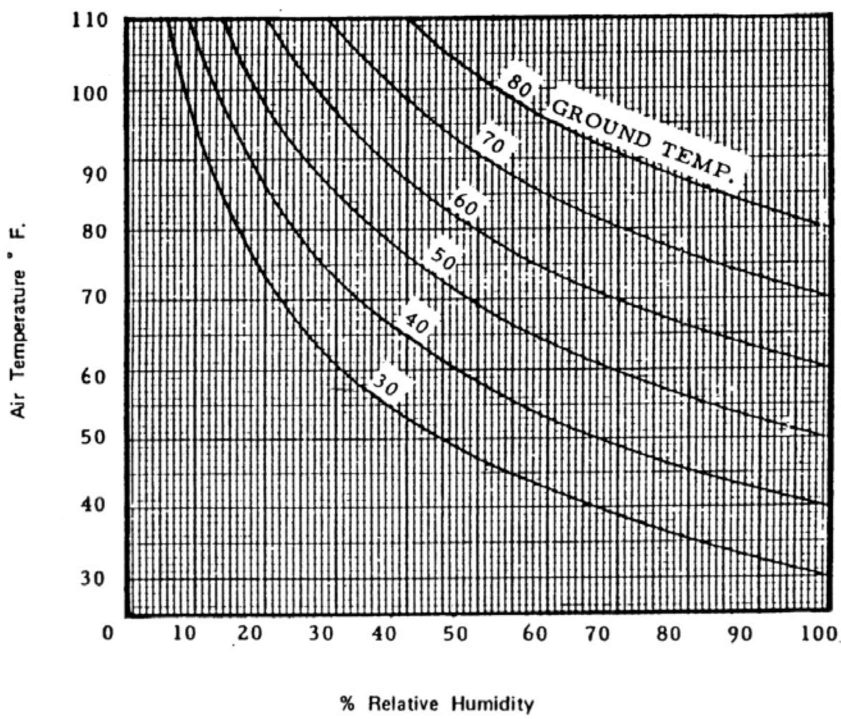
HUMIDITY CONTROL

Any underground structure, whether of concrete or steel, in most parts of the country is subject to condensation problems during part of the year. From about 6 feet underground down to the maximum depth practical for pump stations, the ground temperature will be almost constant the year around. In the vicinity of Kansas City, the ground temperature is about 52 degrees F. When the outside air temperature is above the ground temperature, it will be cooled when it comes in contact with the station walls. The reduction in temperature will raise the relative humidity, possibly to 100%, which is the "dew point". When the humidity of the cooled air does reach 100%, then condensation will occur on the cold surface.

The following chart, together with local weather information and ground temperature, will enable the engineer to determine the seriousness of the problem. If the air temperature and the relative humidity intersect above the ground temperature line, then condensation will take place on the floor, ceiling and walls of any underground structure, as well as on the equipment in the station.

In most parts of the country, it will be necessary to combat humidity introduced with the outside air. In all parts of the country, mechanical pump shaft seals are needed to keep out excess humidity from shaft leakage. A refrigeration-type dehumidifier should be used such that the air is drawn through the dehumidifier automatically, and the moisture drained to the sump. Such dehumidifiers, with sealed motor-compressor units are very dependable and long-lived. All Smith & Loveless underground lift stations incorporate a balanced dehumidification and ventilation system necessary to maintain a conditioned air atmosphere.

CHART FOR PREDICTING CONDENSATION



VENTILATION

It is universally recognized that underground dry pit pump stations require a ventilation system to bring fresh air into the station and exhaust stale air. The ventilation system maintains the clean, dry environment by providing at least 20 air changes per hour when running continuously.

At Smith & Loveless, Inc., it is our position that it is essential to arrange the ventilating blower so as to pull air into the station through an inlet duct and force the discharge out through the entrance tube. Our reasoning is due to a ground temperature of approximately 55°F., any warm humid air drawn down the tube will have moisture condense on the tube walls. The condensate can build and drip into the station creating a damp to wet environment unsuitable for equipment performance and life, as well as unpleasantness for maintenance personnel. By pulling the air down a duct and mixing into the dry station environment, the fresh air is dehumidified before being exhausted out the entrance tube without condensation forming on the walls.

This ventilation concept has been employed in the design of Smith & Loveless stations for years, and we have found the arrangement to be the most effective for optimum station ventilation and dehumidification.

In order to maintain our position of producing the world's finest pump stations, Smith & Loveless will take a firm stand against specifications requiring air to be drawn down the entrance tube and discharged from the station via a PVC pipe duct, as this arrangement is demonstrably detrimental to providing a proper station environment.

SMITH & LOVELESS "SAWS"
STATION ADVANCED WARNING SYSTEM

The Smith & Loveless "SAWS" (Station Advanced Warning System) package is standard on all factory built pump stations. The contacts should be connected to a dialer or SCADA system. All vacuum primed and underground pump stations include, as standard, the following:

- High Water Alarm Contact.
- Run Time Meter for each pump.
- Fail to Pump Alarm Contact for each pump (Including failure to prime on vacuum primed stations).

The High Water alarm condition will be sensed by either a separate float (displacement) or pressure switch or by an additional level sensing point in the electronic level controller, if furnished. This will give an indication of failure of the pump station to keep up with the inflow to the wet well for any reason.

The Running Time Meter provided for each pump is either a separate, panel-mounted hour meter or is incorporated in the electronic controller display, if furnished. This feature will allow comparison of operating times between the pumps for equalizing wear or detecting alternation or standby control problems.

The Fail-To-Pump alarm incorporates S&L multi-sensor switches mounted on the station check valve arms to detect when the valve is opened by pumped flow. An adjustable timer, either in the control panel or incorporated in the PLC controller, will allow time for the pump to prime (if vacuum primed) and come up to speed and begin delivering discharge flow to open the check valve before sending an alarm signal. The timer will begin timing when the pump is called on to run by the level sensor in the wet well, and typically will be set for up to 5-1/2 minutes on vacuum primed stations or 30 seconds for flooded suction underground stations. This time should be adjusted during startup of vacuum primed stations based on normal time to prime, plus 30 seconds for the pump to begin pumping. A separate Fail to Pump alarm will be provided for each pump. This feature will allow indication of failure of the pump to deliver flow when called on for any reason, including failure to prime.

As standard, either a common local (powered) alarm contact or remote (dry) alarm contact will be provided to indicate any alarm condition in the station. Optional individual remote alarm contacts are available in combination with the common local alarm.

The inclusion of the "SAWS" features as standard on all Smith & Loveless pumping stations enhances the operator's ability to do preventative and corrective maintenance and respond quickly in an emergency to prevent damage or overflows.

FRICTION OF WATER IN PIPES AND FITTINGS

WILLIAMS & HAZEN FORMULA C = 100

Loss of Head in Feet Due to Friction per 100 Feet of 15 year old Cast Iron Pipe

Williams & Hazen Coefficient "C" =	Multiplier to Adjust Chart	Pipe Description
100	1.000	Average 15 year old cast iron pipe
110	0.840	Vitrified sewer pipe
120	0.715	New wrought iron pipe
120	0.715	Average 5 year old cast iron pipe
130	0.615	Average new cast iron pipe
140	0.540	Very straight & smooth cast iron pipe
140	0.540	New steel pipe; Cement asbestos pipe
150	0.470	New CI pipe w/cent. spun bituminous lining

* Gallons Per Min.	4 Inch Pipe Vel.	4 Inch Pipe Fric.	6 Inch Pipe Vel.	6 Inch Pipe Fric.	8 Inch Pipe Vel.	8 Inch Pipe Fric.	10 Inch Pipe Vel.	10 Inch Pipe Fric.	12 Inch Pipe Vel.	12 Inch Pipe Fric.	14 Inch Pipe Vel.	14 Inch Pipe Fric.	16 Inch Pipe Vel.	16 Inch Pipe Fric.
40	1.02	0.23												
60	1.53	0.48												
75	1.91	0.73												
100	2.55	1.23	1.13	0.17										
125	3.19	1.86	1.48	0.28										
150	3.83	2.61	1.71	0.32										
175	4.45	3.44	2.00	0.48										
200	5.11	4.43	2.27	0.62										
225	5.77	5.45	2.57	0.74										
250	6.40	6.72	2.80	0.92										
275	7.03	7.99	3.06	1.15										
300	7.66	9.38	3.40	1.30	1.91	0.32								
350	8.90	12.32	3.98	1.75	2.23	0.43								
400	10.21	16.00	4.54	2.22	2.55	0.55	1.63	0.19						
450	11.50	19.80	5.11	2.76	2.87	0.68	1.84	0.23						
500	12.77	24.10	5.67	3.36	3.19	0.83	2.04	0.28	1.42	0.12				
550	....	....	6.24	4.00	3.51	0.99	2.25	0.33	1.57	0.14				
600	....	....	6.81	4.70	3.83	1.16	2.45	0.39	1.71	0.16				
650	....	....	7.38	5.45	4.15	1.34	2.66	0.46	1.85	0.19	1.37	0.09		
700	....	....	7.94	6.25	4.47	1.54	2.86	0.52	2.00	0.22	1.47	0.10		
750	....	....	8.51	7.10	4.79	1.75	3.06	0.59	2.13	0.24	1.58	0.11		
800	....	....	9.08	8.00	5.11	1.97	3.27	0.67	2.28	0.27	1.68	0.13		
850	....	....	9.65	8.95	5.43	2.21	3.48	0.75	2.41	0.31	1.79	0.14		
900	....	....	10.21	9.95	5.75	2.46	3.68	0.83	2.56	0.34	1.89	0.16		
950	....	....	10.78	11.00	6.06	2.71	3.88	0.91	2.70	0.38	2.00	0.18		
1000	....	....	11.35	12.10	6.38	2.98	4.08	1.01	2.84	0.41	2.10	0.20	1.59	0.10
1050	....	....	11.90	13.30	6.70	3.21	4.29	1.09	2.98	0.44	2.20	0.22	1.67	0.11
1100	....	....	12.50	14.40	7.03	3.56	4.49	1.20	3.13	0.49	2.31	0.23	1.75	0.12
1150	....	....	12.95	15.60	7.35	3.84	4.71	1.34	3.27	0.53	2.42	0.25	1.83	0.13
1200	....	....	13.62	16.90	7.66	4.18	4.90	1.41	3.41	0.58	2.52	0.28	1.91	0.14
1250	....	....	14.10	18.50	8.00	4.45	5.11	1.51	3.55	0.62	2.63	0.29	1.99	0.15
1300	....	....	....	....	8.30	4.85	5.31	1.64	3.69	0.67	2.74	0.32	2.07	0.16
1400	....	....	....	....	8.95	5.56	5.71	1.88	3.98	0.78	2.94	0.37	2.22	0.19
1500	....	....	....	....	9.57	6.32	6.13	2.13	4.20	0.88	3.15	0.42	2.39	0.21
1600	....	....	....	....	10.21	7.12	6.53	2.40	4.55	0.98	3.36	0.48	2.55	0.25
1800	....	....	....	....	11.50	8.85	7.35	2.99	5.11	1.23	3.78	0.58	2.87	0.30
2000	....	....	....	....	12.77	10.80	8.17	3.63	5.67	1.50	4.20	0.71	3.19	0.37
2200	....	....	....	....	....	....	8.98	4.33	6.25	1.78	4.60	0.81	3.51	0.46
2400	....	....	....	....	....	....	9.80	5.09	6.81	2.10	5.04	0.96	3.83	0.54
2600	....	....	....	....	....	....	10.61	5.90	7.38	2.43	5.46	1.13	4.15	0.62
2800	....	....	....	....	....	....	11.41	6.77	7.95	2.78	5.88	1.29	4.46	0.70
3000	....	....	....	....	....	....	12.24	7.69	8.52	3.17	6.25	1.50	4.79	0.78

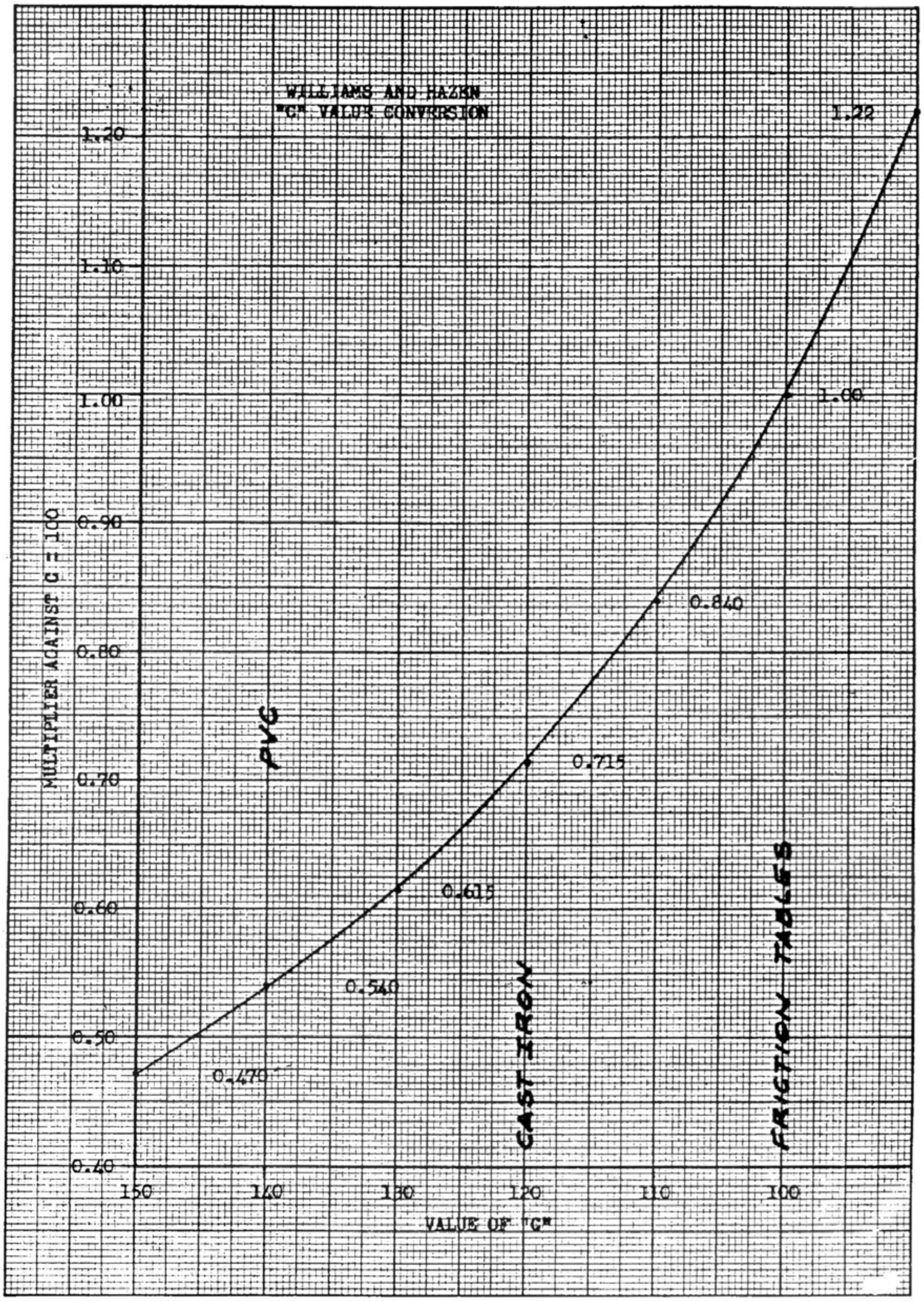
* Gallons Per Min.	12 Inch Pipe Vel.	12 Inch Pipe Fric.	14 Inch Pipe Vel.	14 Inch Pipe Fric.	16 Inch Pipe Vel.	16 Inch Pipe Fric.
3200	9.10	3.51	6.68	1.67	5.12	0.88
3400	9.66	3.91	7.10	1.86	5.44	0.98
3600	10.25	4.37	7.52	2.08	5.77	1.10
3800	10.80	4.90	7.95	2.36	6.07	1.20
4000	11.35	5.39	8.40	2.55	6.38	1.34
4500	12.78	6.70	9.45	3.20	7.20	1.65
5000	14.20	8.15	10.50	3.90	7.96	2.02
5500	....	....	11.55	4.65	8.78	2.39
6000	....	....	12.60	5.39	9.56	2.82

Length of Straight Pipe which will give same Friction Loss as Listed Valves and Fittings

Pipe Size	Std. Elbow	Long Radius Elbow	45° Elbow	Tee through Side	Gate Valve Open	Swing Check Valve Open
4"	11'	7'	5'	22'	2.3'	27'
6"	16'	11'	7.7'	33'	3.5'	40'
8"	21'	14'	10'	43'	4.5'	53'
10"	26'	17'	13'	56'	5.7'	67'
12"	32'	20'	15'	66'	6.7'	80'
14"	36'	23'	17'	76'	8.0'	93'
16"	42'	27'	19'	87'	9.0'	107'

(Add to Actual Pipe Length to get Equivalent Length for use with Friction Factor from above Table).

*Use twice the rated capacity for Mon-O-Ject® and Duo-O-Ject® pneumatic ejector stations.


WILLIAMS AND HAZEN
"C" VALUE CONVERSION
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
MULTIPLIER AGAINST C = 100
1.22
1.00
0.840
0.715
0.615
0.540
0.470
PVC
CAST IRON
FRICTION TABLES
150
140
130
120
110
100
VALUE OF "C"

USEFUL FORMULAS

1. $V = \dfrac{0.4085 \times Q}{D^2}$

V = Velocity of Flow in Feet Per Second

Q = Capacity in U.S. Gallons Per Minute (GPM)

D = Inside Diameter of Pipes in Inches

2. $BHP = \dfrac{Q \times H}{3960\ (Eff.)} \times Sp.\ Gr.$

BHP = Brake Horsepower Required by the Pump

Q = Capacity in U.S. Gallons Per Minute (GPM)

H = Head in Feet

Eff. = Efficiency of Pump

Sp. Gr. = Specific Gravity of Fluid Pumped

3. $Q_2 = Q_1 \left(\dfrac{N_2}{N_1} \right)$

$H2 = H1 \left(\dfrac{N_2}{N_1} \right)^2$

$BHP_2 = BHP_1 \left(\dfrac{N_2}{N_1} \right)^3$

N_1 = Primary Speed of Centrifugal Pump in RPM

N_2 = Secondary Speed of Centrifugal Pump in RPM

USEFUL CONVERSIONS

Multiply	By	To Obtain
Cubic Feet Per Second	448.86	U.S. Gallons Per Minute
Cubic Meters Per Second	15,852	U.S. Gallons Per Minute
Imperial Gallons Per Minute	1.20	U.S. Gallons Per Minute
Liters Per Second	15.852	U.S. Gallons Per Minute
Feet	0.3048	Meters
Meters	3.281	Feet
Feet of Water	0.4335	Pounds Per Square Inch
Pounds Per Square Inch	2.307	Feet of Water
Horsepower	0.746	Kilowatts
Kilowatts	1.341	Horsepower
Kilometers	1,000	Meters
Meters	100	Centimeters
Kilograms	2.205	Pounds

Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F
0	32.0	13	55.4	26	78.8	39	102.2	52	125.6	65	149.0	78	172.4	91	195.8
1	33.8	14	57.2	27	80.6	40	104.0	53	127.4	66	150.8	79	174.5	92	197.6
2	35.6	15	59.0	28	82.4	41	105.8	54	129.2	67	152.6	80	176.0	93	199.4
3	37.4	16	60.8	29	84.2	42	107.6	55	131.0	68	154.4	81	177.8	94	201.2
4	39.2	17	62.6	30	86.0	43	109.4	56	132.8	69	156.2	82	179.6	95	203.0
5	41.0	18	64.4	31	87.8	44	111.2	57	134.6	70	158.0	83	181.4	96	204.8
6	42.8	19	66.2	32	89.6	45	113.0	58	136.4	71	159.8	84	183.2	97	206.6
7	44.6	20	68.0	33	91.4	46	114.8	59	138.2	72	161.6	85	185.0	98	208.4
8	46.4	21	69.8	34	93.2	47	116.6	60	140.0	73	163.4	86	168.8	99	212.0
9	48.2	22	71.6	35	95.0	48	118.4	61	141.8	74	165.2	87	188.6	100	212.0
10	50.0	23	73.4	36	96.8	49	120.2	62	143.6	75	167.0	88	190.4	---	---
11	51.8	24	75.2	37	98.6	50	122.0	63	145.4	76	168.8	89	192.2	---	---
12	53.6	25	77.0	38	100.4	51	123.8	64	147.2	77	170.6	90	194.0	---	---

Warranty Certificate

SMITH & LOVELESS, INC., Lenexa, Kansas, manufacturer of the Factory Built Pump Station warrants it to be free from defects in materials and workmanship for a period of up to one (1) year commencing at the time the pump station is placed in operation by SMITH & LOVELESS-authorized personnel, but in no event is the pump station warranted for longer than eighteen (18) months from the date of shipment unless extended warranty is purchased from the manufacturer. This warranty is contingent upon start-up of the equipment by SMITH & LOVELESS-authorized personnel, and THE WARRANTY WILL BE VOIDED IF START-UP IS PERFORMED BY ANYONE ELSE.

SMITH & LOVELESS will be the single source of responsibility to the owner for the warranty of the pump station and all its components provided by SMITH & LOVELESS.

During the warranty period, if any part is defective or fails to perform as specified when operating at design conditions and if the pump station has been environmentally and physically protected prior to start-up and has been installed and is being operated and maintained in accordance with the written instructions provided by SMITH & LOVELESS, SMITH & LOVELESS will repair or exchange at our discretion such defective part free of charge. Defective parts must be returned by the owner postage paid to SMITH & LOVELESS, if so requested.

When covered by the above warranty, SMITH & LOVELESS will provide, without cost to the owner, such labor as may be required to replace, repair or modify the following, but no other, major components: the steel structure, principal pumps, pump motors, suction and discharge piping and valve assembly. Except for labor provided by SMITH & LOVELESS under the preceding sentence, the cost of labor and any other expenses resulting from replacement of defective parts and from installation of parts furnished under this warranty shall be borne by the owner.

SMITH & LOVELESS will not assume responsibility for the cost of any repairs or alterations made to the pump station structure or its components unless SMITH & LOVELESS has given specific written authority therefor.

The replacement or repair of parts normally consumed in service, such as pump seals, light bulbs, oil, grease, packing, V-belts, etc. is considered part of routine maintenance and upkeep and such parts are not eligible for repair or exchange free of charge under this warranty.

SMITH & LOVELESS makes no other warranty expressed or implied and SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTY AS TO THE MERCHANTABILITY OF THE FACTORY BUILT PUMP STATION OR AS TO ITS FITNESS FOR ANY PARTICULAR PURPOSE. SMITH & LOVELESS is not responsible for consequential or incidental damages of any nature resulting from such things as, but not limited to, defects in design, material, workmanship, or delays in delivery, replacements, or repairs.

The waiver or abridgment of any single provision or group of provisions, either by ruling or agreement, shall not be construed to alter or void any other provisions of this warranty.

Smith & Loveless Inc.

Above All Others.™