PENTAIR

AURORA®

AURORA® ENGINEERING DATA

MAINTENANCE AND OPERATING INSTRUCTIONS

NOTE! To the installer: Please make sure you provide this manual to the owner of the equipment or to the responsible party who maintains the system.

Part # A-03-203 | | 12/04/12

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CALIFORNIA PROPOSITION 65 WARNING:

⚠WARNING This product and related accessories contain chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

NAME PLATE DATA

AURORA PUMP IDENTIFICATION DATA

Name plate data shown on the Aurora Pump Division name plate located on each pump is permanently recorded at the Aurora factory for ready reference. The serial number stamped on the name plate identifies your pump and should be noted in any correspondence with Aurora Pump Division or your local Aurora Pump sales office. It is suggested that the data shown on the name plate be entered at the right for ready reference. Space has also been provided to enter other particulars of your pump and its electrical components.

Model No.:

Serial No.:

MOTOR

Make:

Model No.:

Serial No.:

Electrical Rating:

Horsepower:

Revolutions per Minute:

INTRODUCTION

GENERAL. In this manual you will find general instructions for installing, operating and maintaining most of the standard Aurora Pumps. For advice on component or operational problems not covered in the text, or for maintenance instructions for specific Aurora Pumps, consult your local Aurora Pump sales office.

Your Aurora Pump is rugged and durable, designed and constructed to give many years of satisfactory service with only a minimum of attention. Like all precision machinery, however, it should be treated with care. This manual has been prepared to help you understand how your pump functions and how best to install and operate it. Taking a few minutes to read through the manual may save many hours of labor and greatly prolong the useful life of your pump.

Service Information for Electrical Components. Information on the electrical components of your pump assembly is not covered in this manual. Motors and electrical controls must often be selected to accommodate specific power supply conditions or requirements. For this reason Aurora Pump Division recommends that the manufacturer of electrical equipment be consulted directly for maintenance or repair instructions. Electrical equipment used on Aurora Pumps is manufactured by well established firms that maintain distributors and service branches all over the world. Their representatives are ready to assist in keeping your installation in top shape.

INSTALLATION

Unpacking Equipment. Check the contents of each box or crate for shortages and for damage that may have occurred during shipment. Be careful that small parts do not become lost in wrapping materials. Report any loss or damage at once.

Planning the Installation. The pump should be located so that short, direct suction and discharge lines may be used. Plan the piping so as to employ the minimum number of bends, elbows and fittings. Remember that each extra foot of piping increases pipe friction loss and reduces the effectiveness of the installation. Make sure that there will be sufficient head room and floor space after installation to permit proper inspection and maintenance of the pump and auxiliary equipment. Provide weather shelter if necessary and protect the pump against flooding.

Foundation. The pump should be set on a foundation which will absorb any vibration and provide a permanent and rigid support. A one-three-five mix concrete pad of liberal thickness over a solid footing is usually satisfactory. Mounting bolts should be set into the concrete as shown in Figure 1. The diameter of the pipe sleeves around the bolts should be about two and one-half times that of the bolt. This allows the bolt to be moved slightly for final positioning. When the concrete has set and cured, the top surface of the pad should be cleaned and the bolt sleeves loosely stuffed with waste to prevent them from filling when the unit is grouted in.

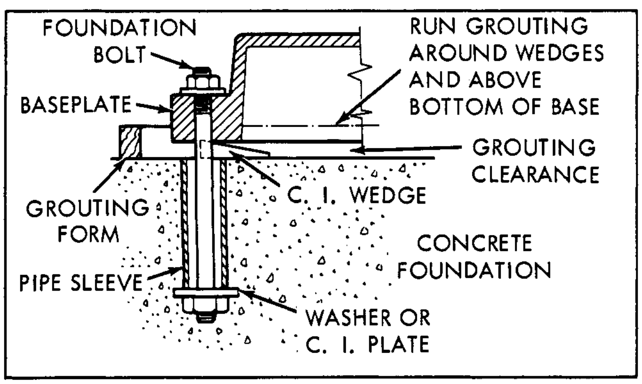

Figure 1. Foundation Bolts

Setting the Pump. Your Aurora pump may come mounted on a baseplate which accommodates both pump and motor. This arrangement, however, may not be suitable for all applications, and your equipment may not be provided with a common base. In any event it is important that the units be level and in alignment with each other. Pumps and motors mounted together at the factory were accurately aligned. However this alignment is easily disturbed by shipment and should not be relied on. Realignment is necessary after the complete unit has been leveled on the foundation and again after the grout has set and foundation bolts tightened. Alignment must be checked after the unit has been piped and periodically thereafter.

Leveling the Unit. When the unit is received with the pump and the motor mounted on a baseplate, it should be placed on the foundation and the coupling halves disconnected. The base plate should be supported by rectangular blocks with shims or metal wedges having a small taper, see Figure 1. Blocks or wedges should be placed near the foundation bolts and always under the part of the frame carrying the most weight. The number of blocks required will depend upon the length of the baseplate and the weight of the units. A gap of about 3/4 inches to 1-1/2 inches should be allowed between the baseplate and foundation for grouting. Adjust the blocks or wedges until the pump and motor shafts are level. Using a level check the faces of the coupling halves and suction and discharge flanges for vertical and horizontal alignment.

NOTE

Flexible couplings should not be used to compensate for misalignment of pump and motor shafts. The purpose of flexible couplings is to allow for temperature changes and permit end movement of shafts while transmitting power from motor to pump.

Flexible Coupling Alignment. The faces of the coupling halves should be spaced far enough apart so that they cannot strike each other when the motor shaft is moved hard over toward the pump. Also adequate allowance should be made to compensate for thrust bearing wear. The tools required for checking the alignment of flexible couplings are a straight edge and a taper gauge or a set of feeler gauges.

Check for angular alignment by inserting a taper gauge at four points, every 90 degrees, around the coupling; see Figure 2. The units will be in angular alignment when the measurements indicate that the coupling faces are the same distance apart at all points.

Check for parallel alignment by placing a straight edge across both coupling rims at top, bottom and both sides. The unit will be in parallel alignment when the straight edge rests evenly on the coupling rims at all positions. Allowance may be necessary for temperature changes. Care must be taken to have the straight edge parallel to the pump and motor shafts.

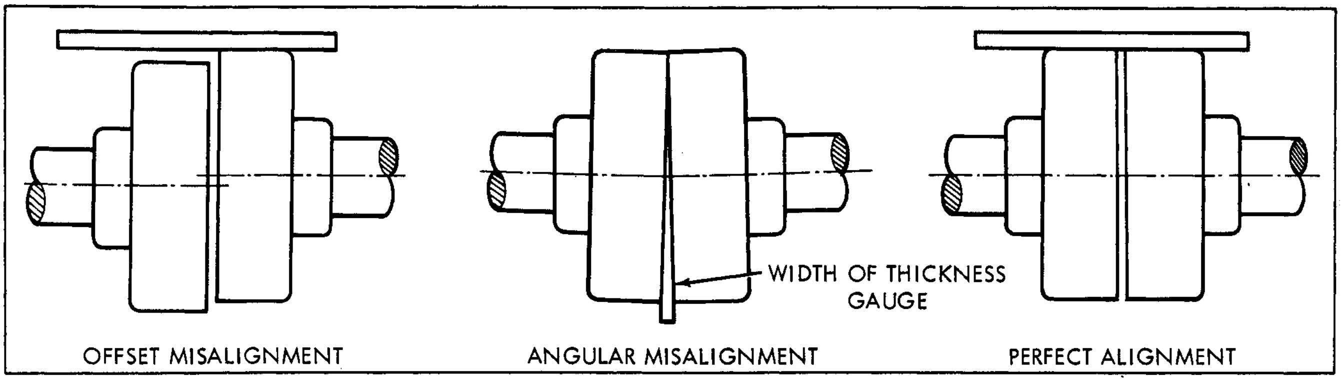

Figure 2. Coupling Alignment

Angular and parallel misalignment can be corrected by means of shims under the motor mounting feet. It is important to remember that adjustments made in one direction may disturb adjustments already made in another direction. For this reason your final inspection should be a thorough one. It should not be necessary to readjust the shims under the pump.

If pump is to be connected to the prime mover by gears or chains, the alignment should be checked by a straight edge across the faces of the gears or sprockets. This should be done in two directions at an angle as large as permitted by the relative size of the gears or sprockets. When pumps or prime movers will be heated in operation, e.g., steam driven prime movers, or pumps handling hot liquids, the unit should be aligned under the thermal conditions that contraction and expansion due to changes in temperature may be taken into account.

Grouting the Installation. When the alignment operations have been completed the foundation bolts should be tightened evenly but not too firmly. The unit can then be grouted to the foundation.
The grouting mixture recommended is one part portland cement to three parts sharp sand with only enough water to thin the mixture to pouring consistency. Too much water will cause the cement to float out of the mix and weaken it considerably. Before pouring the grout, construct a simple wooden form around the unit to be grouted in and thoroughly wet down the concrete surface onto which the grout will be poured. While the grout is being poured puddle continuously to expel trapped air and to make sure the cavities beneath the baseplate are completely filled. Finish by striking along the top edge of the form with a trowel to remove excess grout and to improve appearance.

CAUTION

Do not fully tighten the foundation bolts until the grouting has hardened.

After the grouting has set and the foundation bolts tightened, a recheck of the alignment should be made.

PIPING. The operating efficiency of your Aurora Pump often depends upon the details of the suction and discharge piping. To eliminate any possible strain on the pump casing, the suction piping and the discharge piping should be supported near the pump. It is usually advisable to increase the size of both suction and discharge pipes at the pump nozzles in order to decrease the head loss from friction. The piping should be arranged with the minimum number of bends. Wherever possible bends should be long radius design. A typical piping layout is shown in Figure 3.

NOTE

Do not use elbows on either the suction or discharge nozzles of the pump. The use of elbows at these points greatly increases friction and results in head loss.

Discharge Piping. The discharge piping should include both a check valve and a gate valve. The check valve should be installed between the pump and the gate valve to protect the pump from excessive pressure and to prevent water from running back through the pump in case of power failure. The gate valve is used in priming, starting and when shutting down the pump.

Suction Piping. The suction pipe must be kept free of air leaks, particularly when the suction line is long and the static suction lift is high. It is advisable to keep the suction pipe short, setting the pump as near the liquid source as possible.

Slope of Suction Pipe. A horizontal suction line must have a gradual rise to pump. Suction lines must always pass under other interfering piping. Any high point in the suction pipe will become filled with air and thus prevent proper operation of the

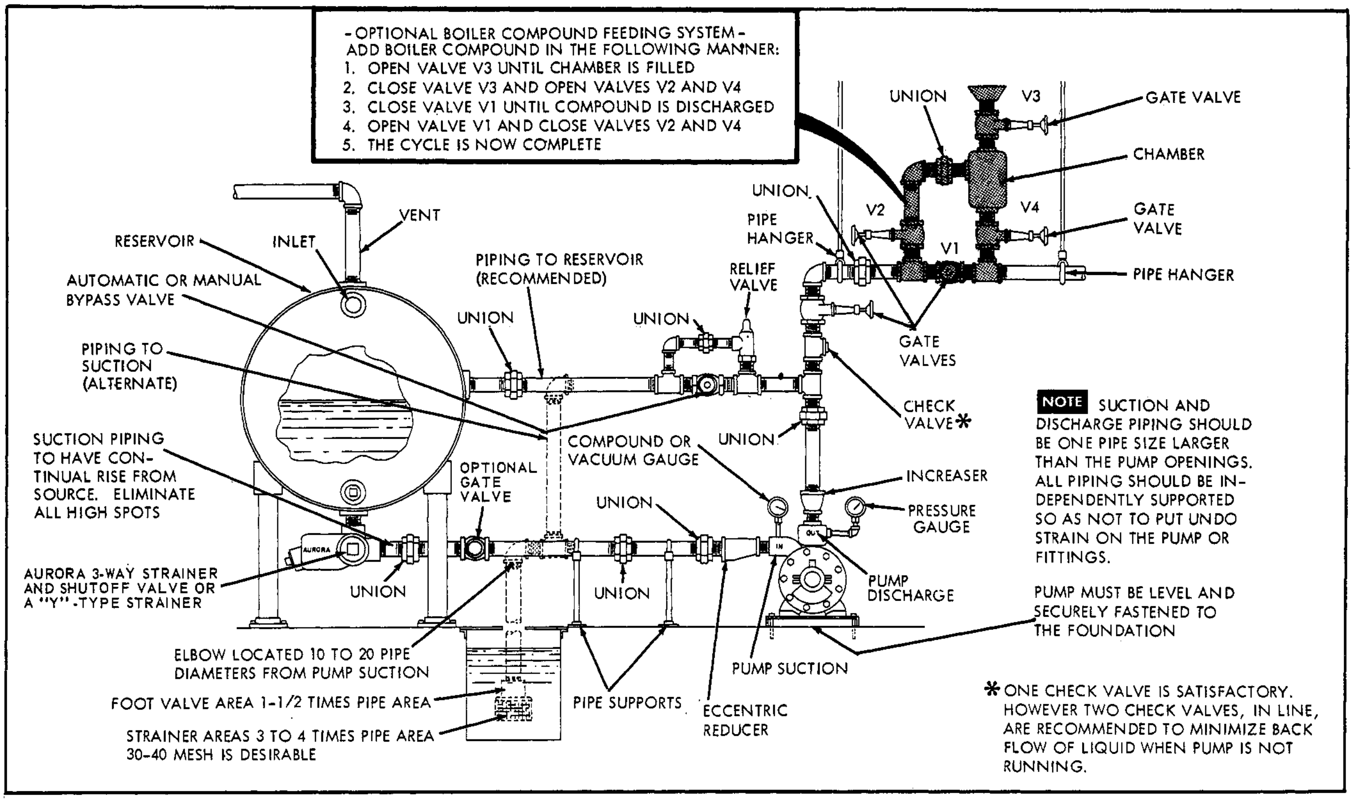

Figure 3. Typical Piping Arrangement

pump. A straight taper reducer should not be used in a horizontal suction line as an air pocket is formed in the leg of the reducer and the pipe. An eccentric reducer should be used instead. Small air pockets that may cause trouble may be formed in the top of any gate valves installed in the suction line in such a manner that the valve stems are vertical. It is recommended that gate valves in the suction line be installed so that the stems are horizontal. Trouble caused by an air pocket in the suction line can usually be stopped temporarily by priming and starting the pump several times.

Foot Valve. When the suction lift is not very high, it is frequently advisable to install a foot valve to facilitate priming. A foot valve should not be used when the pump is operating against a high static head, as failure of the driver would allow the water to rush back suddenly causing a heavy water hammer.* The foot valve should be of the flat type rather than of the multiple spring type and have a clear passage for water at least to the same area as that of the suction pipe. Care must be taken to prevent foreign substances from being drawn into the pump or choking the foot valve. For this purpose an effective strainer should be provided.

Pipes must line up naturally when connected. Do not force them into place with flange bolts. This may draw the piping out of alignment. Pipes should be supported independently of pump so as not to put any strain on the pump casing. After the piping has been installed alignment should be checked again and if necessary correction made. For unusually long discharge lines a packed slip joint should be provided to compensate for pressure or temperature changes. Air conditioning and service pumps installed in buildings where noise is objectionable should be insulated from the steel work and walls and the discharge pipe should be insulated from the pump so that no noise or vibration can be transmitted.

Final Check on Alignment. Check the alignment after the piping has been completed using the straight edge and thickness gauge method. As the unit had been aligned before completing the piping, piping strains are the likely cause of any misalignment found. Changes should be made accordingly. If the stuffing boxes are properly adjusted and the pump and drives properly aligned, the unit easily turns over by hand.

* The condition of "water hammer" is caused by an increase in pressure due to changes in the velocity of liquid flowing through a pipe line. When the velocity is changed by closing a valve or by some other means, the magnitude of the pressure produced is frequently much greater than the static pressure on the line, and may cause rupture or damage to the pump, piping or fittings. Water hammer may be controlled by regulating valve closure, or the use of relief valves and slow closing check valves.

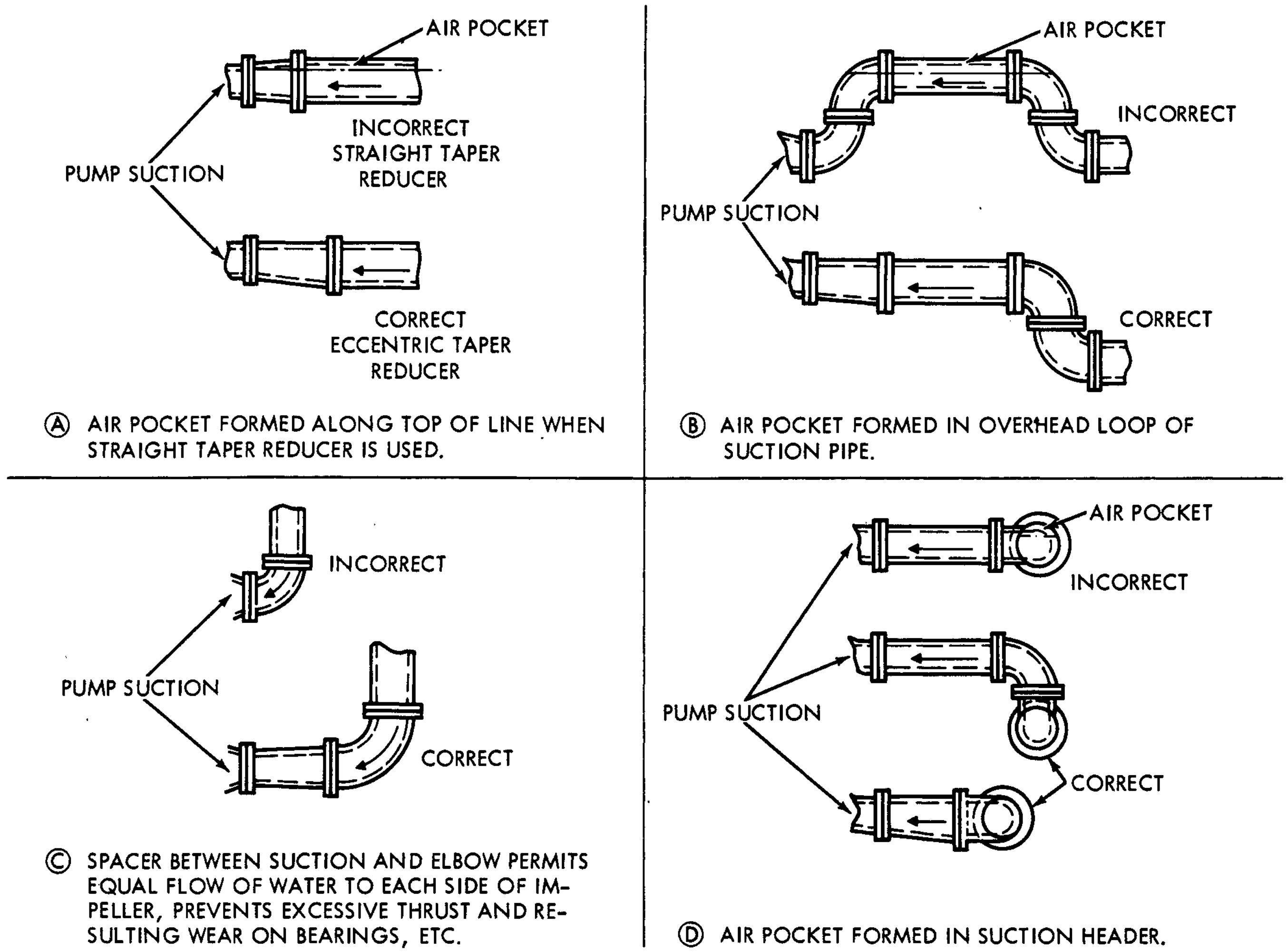

Figure 4. Piping Arrangements

PRE-STARTING INSTRUCTIONS. Before coupling to the pump, check the direction of motor rotation. An arrow located on the pump casing indicates the correct rotation of the impeller. The motor should turn in this same direction. (If it does not see Figure 6: Maintenance and Troubleshooting Chart, item 1-e.) After coupling, again check the coupling alignment in the manner described on Page 2 of this manual. The unit may now be primed and started.

CAUTION

Do not operate the pump without liquid as serious damage could occur. Many of the pump components depend upon the liquid for lubrication. Consult the maintenance section of this manual for lubrication instructions prior to operating the pump.

PRIMING. The pump must be primed before starting so that both the pump casing and suction line are filled with liquid. Centrifugal pumps may be primed by any of the following methods. For turbine pumps, the foot valve priming method is recommended.

Priming by Ejector or Exhauster. When steam, high pressure water, or compressed air is available, the pump may be primed by attaching an air ejector to the highest points in the pump casing. This will remove the air from the pump and suction line, provided a tight valve is located in the discharge line close to the pump. As soon as the ejector waste pipe throws water continuously, the pump may be started. After starting, a steady stream of water from the waste pipe indicates that the pump is primed. If this stream of water is not obtained, the pump must be stopped at once and the process of priming repeated. A foot valve is unnecessary when this kind of device is used.

Priming by Foot Valve Only. When it is not practicable to prime by ejector or exhauster, the pump may be primed by the use of a foot valve. The foot valve will prevent liquid running out through the suction inlet and the pump can be completely filled with liquid from some outside source. Pet cocks on top of the pump should be opened during filling to allow the air to escape. A tight foot valve will keep the pump constantly primed so that the pump may be used for automatic operation. The valve must be inspected frequently, however, to see that it does not develop leaks and thus allow the pump to be started dry.

Priming by Vacuum Pumps. When neither of the above methods of priming are practicable, the pump may be primed by the use of a vacuum pump to exhaust the air from the pump casing and suction line. A wet vacuum pump is preferable, as it will not be injured if water enters it. When a dry vacuum pump is to be used, the installation must be such as to prevent liquid being taken into the air pump. The manufacturer's instructions should be followed.

Air in Liquid. It sometimes happens that there is a considerable amount of air or gas in the liquid pumped. If this is so, there may be a tendency for the gases to separate in the passages of the pump. For this reason air cocks placed on top of the casing should be opened occasionally to allow the air to escape. If there seems to be an unusual amount of air, these vents may be left open slightly at all times during operation of the pump. These vents may be connected to drain pipes if desired.

Position of Discharge Valve on Starting. A turbine pump, primed and operating at full speed with the discharge gate valve closed, develops a very high internal pressure. For this reason, the gate valve must open when the pump is being started.

On the other hand, a high or medium head centrifugal pump, when primed and operated at full speed with the discharge gate valve closed, requires much less power than when it is operated at its rated capacity and head with the discharge gate valve open. For this reason, it is advantageous to have the gate valve closed when a centrifugal pump is being started.

OPERATING THE PUMP. With the coupling halves connected and with the unit properly primed, the unit may be started. Check for excessive noise or vibration and correct as required (see Troubleshooting Chart). If running correctly the pump should be operated until temperatures have stabilized. The pump should then be shut down and the alignment rechecked. Alignment checks must be made with the coupling halves disconnected and again after they are reconnected.

Packing Adjustment. When the pump has run for several minutes some seepage should develop around the shaft on pumps with stuffing boxes. This seepage is required to lubricate the packings and cool the stuffing box. At initial starting the packing gland nuts should be no more than finger tight. After the packing has been run-in some adjustment may be necessary. Always make adjustments while the pump is running. Care must be taken that the gland is drawn up evenly and not too tightly. Watch for signs of heating. If the stuffing box becomes warm, shut the pump down and let the packing and shaft cool before restarting or readjusting. A seepage rate of 5 to 10 drops per minute is adequate for cooling and lubrication. Periodically check the stuffing boxes and adjust as required.

Throttling the Discharge. It is generally not advisable to throttle or restrict the discharge on a turbine pump. If it is required, relief piping may be necessary because of the high pressures that may be built up within the pump. Consult your local Aurora sales office for advice or recommendations particular to your situation.

Shutting Down. If the pump does not have a flooded suction, the operator may close the suction valve as the pump is shut off.

CAUTION

Do not run pump with suction closed for more than a few seconds. In this manner the pump will maintain its prime for restarting for short periods. Best practice would be to use either a foot valve or check valve in the suction piping if it will be necessary for the pump to maintain its prime while shut down.

Freezing. During cold weather, care must be taken to prevent the pump from freezing when it is not in operation. It is advisable, when there is any possibility of freezing, to drain the pump casing of all liquid during the shut-down period by removing the plugs in the bottom of the casing.

MAINTENANCE AND TROUBLESHOOTING CHART

Inspection and Lubrication. Aurora pumps are designed to operate efficiently for years, but like all machinery require regular inspection and care. The purpose of regular inspection and maintenance is to prevent breakdowns and to obtain the longest service life possible.

Lubrication of Bearings. Aurora Pumps may be equipped with either non-regreaseable or regreaseable bearings. Non-regreaseable bearings are lubricated for life at the factory and require no further attention. Aurora pumps equipped with regreaseable bearings require periodic lubrication through the zerk or lubrication fittings in the housing. Lubricate the bearings at regular intervals using a grease of high quality. Lime, lithuim, lithuim-soda or calcium base greases such as LUBRICO L206 bearing grease (Master Lubricant Co.) or Enco multipurpose grease (Humble Oil and Refining Co.) are recommended as lubricants for pumps operating in both wet and dry locations.

Mixing of different brands of grease should be avoided because of possible chemical reactions which could damage the bearings. Accordingly, avoid grease of a vegetable or animal base which can develop acids or any grease containing rosin, graphite, talc and other impurities. Under no circumstances should old grease be reused.

Commercial brands named here are not the only acceptable ones. Consult your Aurora Pump sales of-

TROUBLE	PROBABLE CAUSE	REMEDY
1. No discharge with pump running	a. Pump speed too low	a. Correct wrong or poor electrical connections.
	b. Discharge head too high	b. Clear obstructions from outlet piping.
	c. Impeller clogged	c. Backflush with clear water; disassemble pump to remove obstruction if necessary.
	d. Suction clogged	d. Remove and clean strainer. Disassemble and flush suction piping if necessary.
	e. Pump rotation is clockwise (against direction of arrow on casing)	e. To reverse a three-phase motor, switch any two of the three power lead connections at the motor or controller; replace a single-phase motor.
2. Inadequate discharge	a. Pump speed too low	a. See 1.a. above.
	b. Discharge head too high	b. See 1.b. above.
	c. Impeller clogged	c. See 1.c. above.
	d. Impeller damaged or worn	d. Replace impeller.
	e. Channel rings damaged or worn	e. Replace channel rings.
3. Excessive power consumption	a. Motor speed too high	a. Internal wiring of motor is incorrect; replace motor.
	b. Discharge head too low	b. Consult local Aurora Pump sales office.
4. Excessive noise	a. Foreign matter rotating with impeller	a. See 1.c. above.
	b. Discharge head too high	b. See 1.b. above.
	c. Magnetic hum	c. Consult motor manufacturer
5. Excessive vibration	a. Foreign matter rotating with impeller	a. See 1.c. above.
	b. Impeller damaged	b. Replace impeller.
	c. Unsupported suction or discharge piping.	c. Support and secure piping.

Figure 5. Troubleshooting Chart (Pumps)

SYMPTOM	PROBABLE CAUSE	REMEDY
Motor fails to start	Defective power supply	
	Blown or defective primary fuses	Check voltage across all phases above disconnect switch.
	Blown or defective secondary fuses	Check voltage below fuses (all phases) with disconnect closed.
	Open control circuit	
	Overload trips are open	Push reset button.
	Defective holding coil in magnetic switch	Push start button and allow sufficient time for operation of time delay, if used, then check voltage across magnetic holding coil. If correct voltage is measured, coil is defective. If no voltage is measured, control circuit is open.
	Loose or poor connections in control circuit	Make visual inspection of all connections in control circuit.
	Magnetic switch closes	
	Poor switch contact	Open manual disconnect switch, close magnetic switch by hand and examine contactors and springs.
	Open circuit in control panel	Check voltage at T1-T2-T3.
	Open circuit in leads to motor	Check voltage at leads in outlet box.
	Leads improperly connected	Check lead numbers and connections.
Motor fails to come up to speed	Low or incorrect voltage	Check voltage T1-T2 and T3 in control panel and at motor leads in outlet box.
	Incorrect connection at motor	Check for proper lead connections at motor, compare with connection diagram on motor.
Motor fails to come up to speed (Cont.)	Overload - Mechanical	Check impeller setting. Check for a locked or tight shaft.
	Overload - Hydraulic	Check impeller setting. Check GPM against pump capacity and head.
Motor runs hot	Inadequate ventilation	Assure adequate supply of fresh air. Check air blast through motor by feeling air discharge at bottom of motor.
	Overload	Check load with ammeter.
	Unbalanced supply voltage	Check supply voltage with voltmeter.
Motor vibrates	Headshaft misaligned	Remove top drive coupling and check alignment of motor to pump.
	Worn shaft bearings or bent shaft	Disconnect motor from pump and run motor only to determine source of vibration.
	Hydraulic disturbance in discharge piping	Check isolation joint in discharge piping near pump head.
	Motor not mounted securely	Secure properly and check alignment.
Motor noisy	Worn thrust bearing	Remove dust cover, rotate rotor by hand and make visual examination of balls and races. (Bearing noise is usually accompanied by a high frequency vibration.)
	Electrical noise	Most motors are electrically noisy during the starting period. This noise should diminish as motor reaches full speed.

Figure 6. Troubleshooting Chart (Electric Motors)

fice for names of other suitable brands available in your locality.

Over lubrication should be avoided as it may result in overheating and possible bearing failure. Under normal application adequate lubrication is assured if the amount of grease is maintained at 1/3 to 1/2 the capacity of the bearing and adjacent space surrounding it. Approximately 1/2 ounce of grease is required to maintain this level.

In dry locations each bearing will need lubrication at least after every 600 hours of running time or every 6 to 12 months, whichever is more frequent. In wet locations the bearings should be lubricated after every 300 hours of running time or every 4 to 6 months, whichever is more frequent. A unit is considered to be installed in a wet location if the pump and motor are exposed to dripping water, to the weather, or to heavy condensation such as is found in unheated and poorly ventilated underground locations.

Regreaseable pump bearings are lubricated initially by the manufacturer and need no special attention when first installed. Subsequently, at proper intervals, they should be lubricated with clean grease of an appropriate type. If the pump has been standing idle for a long period of time, has been flooded out, or if it has been operating for several months in a very dusty or very wet location, the bearing should be cleaned with gasoline or kerosene and new grease applied. To clean, wipe the bearing housing with a clean rag soaked in gasoline or kerosene, and flush all surfaces. Dry with compressed air if available. If not, allow the solvent to evaporate before relubricating the bearing.

When ball bearings are regreased temperatures will rise until the excess grease is expelled. The bearing housings are purposely designed to expell excess grease to prevent continual over-heating of the bearings.

When newly installed on a pump bearings sometimes will run hot until they have properly seated and the excess lubricant has been expelled.

Belt Drive. When installing pump for v-belt drive, belts must be in perfect alignment. Any misalignment will cause excessive belt wear and will shorten the life of the belts. V-belts should be only tight enough to prevent slippage; when running the tight side of belt should be at the bottom.

Packing. Pumps leaving our plant are packed and lubricated ready for use. When a pump is to be repacked the following procedure must be followed. The packing used for clear cold water is square braided acrylic yarn impregnated with special lubricant, TFE dispersion, and graphite.

After the glands have been removed, the packing, cut to proper length and compressed just enough to slide readily without being mashed is inserted into stuffing box. Pressure with the fingers should be sufficient for pushing the rows of packing into place. If it is not, either the packing is too large or some obstruction exists. The rings are placed so that splices are staggered. If lantern rings are used, they are placed in line with the water seal tubing, which usually means symmetrically in regard to packing rings. If number of rings is uneven, the extra ring is placed to the outside. After all rings are placed, glands are put into position and tightened to permit only a few drops seepage each minute. This slight seepage helps lubricate the pump shaft at the packing joints.

A troubleshooting chart has been provided to aid in locating trouble if problems arise.

The motor which drives your Aurora pump may or. may not require lubrication. Consult the manufacturer's recommendations for proper maintenance instructions.

CENTRIFUGAL PUMP IMPELLER ROTATION

The tests shown below were made and plotted to show the effect of running a centrifugal pump in the wrong direction, and also what happens when casing and impeller are of opposite hand, namely, a right hand impeller in a left hand casing or vice versa. All tests were made with the same casing and impeller. The casing being reversible, either R.H. or L.H., depending on assembly.

1. Head and B.H.P. curves A show correct impeller and casing assembly with the correct direction of rotation.
2. Head and B.H.P. curves B show opposite hand impeller running the reverse direction for the casing.
3. Head and B.H.P. curves C show opposite hand impeller, but running the correct direction for the casing.
4. Head and B.H.P. curves D show correct impeller and casing assembly, but wrong direction of rotation. (See Figure 8 for chart)

It will be noted that in cases B, C & D the B.H.P. increases and the head and capacity is reduced when compared to correct operation curve A. The peak efficiency point and value is indicated for each curve.

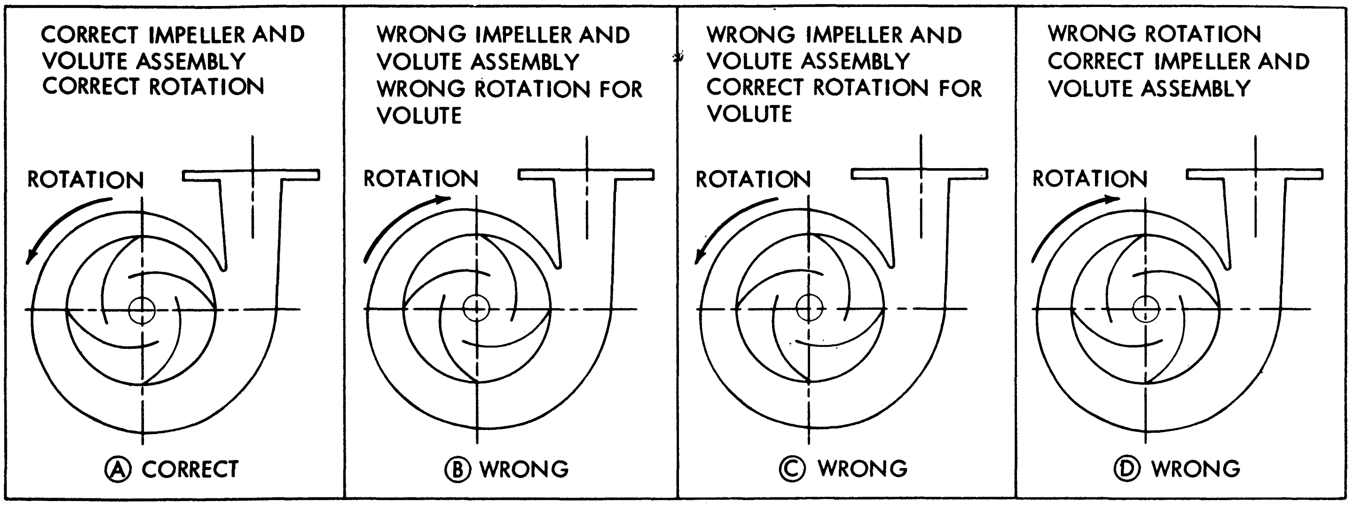

Figure 7. Rotation Chart

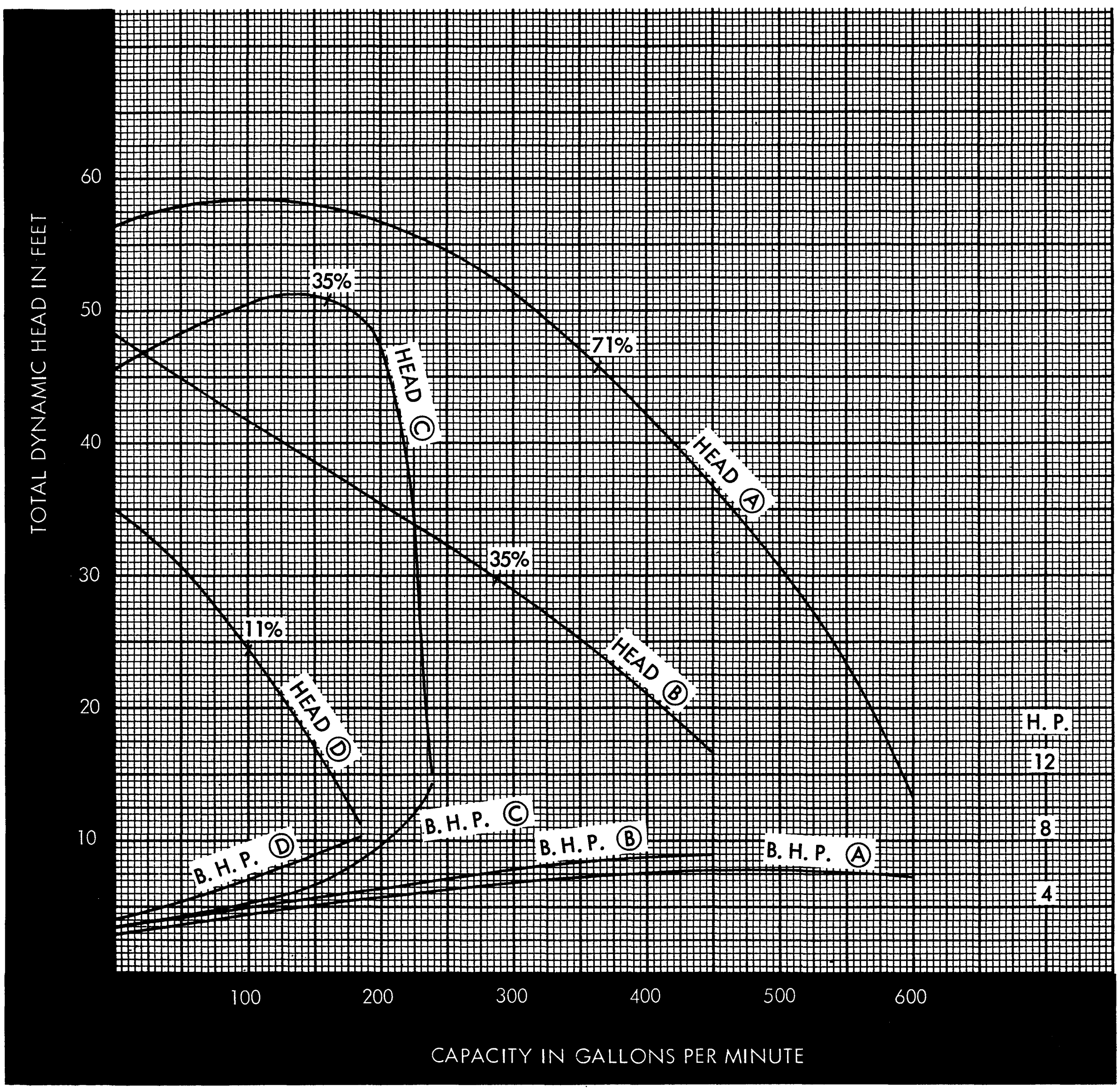

Figure 8. Head and B.H.P. Chart

SCHEDULE 40 STEEL PIPE—FRICTION LOSS FOR WATER IN FEET PER 100 FEET

U. S. Gallons per Minute	1/4 In. V Ft/Sec	1/4 In. h_f Frict.	3/8 In. V Ft/Sec	3/8 In. h_f Frict.	1/2 In. V Ft/Sec	1/2 In. h_f Frict.	3/4 In. V Ft/Sec	3/4 In. h_f Frict.
0.8	2.47	12.7						
1.0	3.08	19.1						
1.2	3.70	26.7						
1.4	4.32	35.3	2.35	7.85				
1.6	4.93	45.2	2.68	10.1				
1.8	5.55	56.4	3.02	12.4				
2.0	6.17	69.0	3.36	15.0	2.11	4.78		
2.5	7.71	105.0	4.20	22.6	2.64	7.16		
3.0	9.25	148.0	5.04	31.8	3.17	10.0		
3.5	10.79	200.0	5.88	42.6	3.70	13.3		
4.0	12.33	259.0	6.72	54.9	4.22	17.1	2.41	4.21
5	15.42	398	8.40	83.5	5.28	25.8	3.01	6.32
6			10.08	118	6.34	36.5	3.61	8.87
7			11.8	158	7.39	48.7	4.21	11.8
8			13.4	205	8.45	62.7	4.81	15.0
9			15.1	258	9.50	78.3	5.42	18.8
10			16.8	316	10.56	95.9	6.02	23.0
12					12.7	136	7.22	32.6
14					14.8	183	8.42	43.5
16					16.9	235	9.63	56.3
18							10.8	70.3
20							12.0	86.1
22							13.2	104
24							14.4	122
26							15.6	143
28							16.8	164

U. S. Gallons per Minute	1 In. V Ft/Sec	1 In. h_f Frict.	1 1/4 In. V Ft/Sec	1 1/4 In. h_f Frict.	1 1/2 In. V Ft/Sec	1 1/2 In. h_f Frict.
6	2.23	2.68				
8	2.97	4.54				
10	3.71	6.86				
12	4.45	9.62	2.57	2.48		
14	5.20	12.8	3.00	3.28		
16	5.94	16.5	3.43	4.20	2.52	1.96
18	6.68	20.6	3.86	5.22	2.84	2.42
20	7.42	25.1	4.29	6.34	3.15	2.94
22	8.17	30.2	4.72	7.58	3.47	3.52
24	8.91	35.6	5.15	8.92	3.78	4.14
26	9.65	41.6	5.58	10.37	4.10	4.81
28	10.39	47.9	6.01	11.9	4.41	5.51
30	11.1	54.6	6.44	13.6	4.73	6.26
35	13.0	73.3	7.51	18.2	5.51	8.37
40	14.8	95.0	8.58	23.5	6.30	10.79
45	16.7	119.0	9.65	29.4	7.04	13.45
50	18.6	146	10.7	36.0	7.88	16.4
55			11.8	43.2	8.67	19.7
60			12.9	51.0	9.46	23.2
65			13.9	59.6	10.24	27.1
70			15.0	68.8	11.03	31.3
75			16.1	78.7	11.8	35.8
80					12.6	40.5
85					13.4	45.6
90					14.2	51.0
95					15.0	56.5
100					15.8	62.2

U. S. Gallons per Minute	2 In. V Ft/Sec	2 In. h_f Frict.	2 1/2 In. V Ft/Sec	2 1/2 In. h_f Frict.	3 In. V Ft/Sec	3 In. h_f Frict.	4 In. V Ft/Sec	4 In. h_f Frict.
25	2.39	1.29						
30	2.87	1.82						
35	3.35	2.42	2.35	1.00				
40	3.82	3.10	2.68	1.28				
45	4.30	3.85	3.02	1.60				
50	4.78	4.67	3.35	1.94	2.17	0.662		
60	5.74	6.59	4.02	2.72	2.60	0.924		
70	6.69	8.86	4.69	3.63	3.04	1.22		
80	7.65	11.4	5.36	4.66	3.47	1.57		
90	8.60	14.2	6.03	5.82	3.91	1.96		
100	9.56	17.4	6.70	7.11	4.34	2.39	2.52	0.624
120	11.5	24.7	8.04	10.0	5.21	3.37	3.02	0.877
140	13.4	33.2	9.38	13.5	6.08	4.51	3.53	1.17
160	15.3	43.0	10.7	17.4	6.94	5.81	4.03	1.49
180			12.1	21.9	7.81	7.28	4.54	1.86
200			13.4	26.7	8.68	8.90	5.04	2.27
220			14.7	32.2	9.55	10.7	5.54	2.72
240			16.1	38.1	10.4	12.6	6.05	3.21
260					11.3	14.7	6.55	3.74
280					12.2	16.9	7.06	4.30
300					13.0	19.2	7.56	4.89
350					15.2	26.1	8.82	6.55
400							10.10	8.47
450							11.4	10.65
500							12.6	13.0
550							13.9	15.7
600							15.1	18.6

U. S. Gallons per Minute	5 In. V Ft/Sec	5 In. h_f Frict.	6 In. V Ft/Sec	6 In. h_f Frict.	8 In. V Ft/Sec	8 In. h_f Frict.
160	2.57	0.487				
180	2.89	0.606				
200	3.21	0.736				
220	3.53	0.879	2.44	0.357		
240	3.85	1.035	2.66	0.419		
260	4.17	1.20	2.89	0.487		
300	4.81	1.58	3.33	0.637		
350	5.61	2.11	3.89	0.851		
400	6.41	2.72	4.44	1.09	2.57	0.279
450	7.22	3.41	5.00	1.36	2.89	0.348
500	8.02	4.16	5.55	1.66	3.21	0.424
600	9.62	5.88	6.66	2.34	3.85	0.597
700	11.2	7.93	7.77	3.13	4.49	0.797
800	12.8	10.22	8.88	4.03	5.13	1.02
900	14.4	12.9	9.99	5.05	5.77	1.27
1000	16.0	15.8	11.1	6.17	6.41	1.56
1100			12.2	7.41	7.05	1.87
1200			13.3	8.76	7.70	2.20
1300			14.4	10.2	8.34	2.56
1400			15.5	11.8	8.98	2.95
1500					9.62	3.37
1600					10.3	3.82
1700					10.9	4.29
1800					11.5	4.79
1900					12.2	5.31
2000					12.8	5.86
2100					13.5	6.43
2200					14.1	7.02

NOTE: The above table shows average values of pipe friction for new pipe. For commercial installations it is recommended that 15% be added to the above values. No allowance for aging of pipe is included.

Based on Standards of the Hydraulic Institute, Page E(1) - 3 and 4, May 1965

Equivalent Length of New Straight Pipe for 90°Regular Elbow (Flanged Steel)

Size Elbow, inches	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6	8	10	12	14	16	20	24
Equivalent Feet Straight Pipe	1.2	1.6	2.1	2.4	3.1	3.6	4.4	5.9	7.3	8.9	12	14	17	18	21	25	30

Based on Standards of the Hydraulic Institute, Page E(1) - 7, May 1965

Figure 9. Friction Head Loss of Water in Pipes (Sheet 1 of 2)

SCHEDULE 40 STEEL PIPE—FRICTION LOSS FOR WATER IN FEET PER 100 FEET

U. S. Gallons per Minute	10 In.		12 In.		14 In.	
	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.
650	2.64	0.224	......	......	......	......
700	2.85	0.256	......	......	......	......
750	3.05	0.291	......	......	......	......
800	3.25	0.328	......	......	......	......
850	3.46	0.368	......	......	......	......
900	3.66	0.410	2.58	0.173	......	......
950	3.87	0.455	2.72	0.191	......	......
1000	4.07	0.500	2.87	0.210	2.37	0.131
1100	4.48	0.600	3.15	0.251	2.61	0.157
1200	4.88	0.703	3.44	0.296	2.85	0.185
1300	5.29	0.818	3.73	0.344	3.08	0.215
1400	5.70	0.940	4.01	0.395	3.32	0.247
1500	6.10	1.07	4.30	0.450	3.56	0.281
1600	6.51	1.21	4.59	0.509	3.79	0.317
1700	6.92	1.36	4.87	0.572	4.03	0.355
1800	7.32	1.52	5.16	0.636	4.27	0.395
1900	7.73	1.68	5.45	0.704	4.50	0.438
2000	8.14	1.86	5.73	0.776	4.74	0.483
2500	10.2	2.86	7.17	1.187	5.93	0.738
3000	12.2	4.06	8.60	1.68	7.11	1.04
3500	14.2	5.46	10.0	2.25	8.30	1.40
4000	16.3	7.07	11.5	2.92	9.48	1.81
4500	......	......	12.9	3.65	10.7	2.27
5000	......	......	14.3	4.47	11.9	2.78
6000	......	......	17.2	6.39	14.2	3.95
7000	......	......	......	......	16.6	5.32
8000	......	......	......	......	......	......

U. S. Gallons per Minute	16 In.		18 In.		20 In.		24 In.	
	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.
1400	2.54	0.127	......	......	......	......	......	......
1600	2.90	0.163	......	......	......	......	......	......
1700	3.09	0.183	......	......	......	......	......	......
1800	3.27	0.203	2.58	0.114	......	......	......	......
1900	3.45	0.225	2.73	0.126	......	......	......	......
2000	3.63	0.248	2.87	0.139	2.31	0.0812	......	......
2500	4.54	0.377	3.59	0.211	2.89	0.123	......	......
3000	5.45	0.535	4.30	0.297	3.46	0.174	2.39	0.070
3500	6.35	0.718	5.02	0.397	4.04	0.232	2.79	0.093
4000	7.26	0.921	5.74	0.511	4.62	0.298	3.19	0.120
4500	8.17	1.15	6.45	0.639	5.19	0.372	3.59	0.149
5000	9.08	1.41	7.17	0.781	5.77	0.455	3.99	0.181
6000	10.9	2.01	8.61	1.11	6.92	0.645	4.79	0.257
7000	12.7	2.69	10.0	1.49	8.08	0.862	5.59	0.343
8000	14.5	3.49	11.5	1.93	9.23	1.11	6.38	0.441
9000	16.3	4.38	12.9	2.42	10.39	1.39	7.18	0.551
10,000	......	......	14.3	2.97	11.5	1.70	7.98	0.671
11,000	......	......	15.8	3.57	12.7	2.05	8.78	0.810
12,000	......	......	......	......	13.8	2.44	9.58	0.959
13,000	......	......	......	......	15.0	2.86	10.4	1.12
14,000	......	......	......	......	16.2	3.29	11.2	1.29
15,000	......	......	......	......	......	......	12.0	1.48
16,000	......	......	......	......	......	......	12.8	1.67
17,000	......	......	......	......	......	......	13.6	1.88
18,000	......	......	......	......	......	......	14.4	2.10
19,000	......	......	......	......	......	......	15.2	2.33

U. S. Gallons per Minute	30 In. Sch. 20		36 In. I D		42 In. I D		48 In. I D	
	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.
5000	2.43	0.0535	......	......	......	......	......	......
6000	2.91	0.075	......	......	......	......	......	......
7000	3.40	0.100	......	......	......	......	......	......
8000	3.89	0.129	2.52	0.0442	......	......	......	......
9000	4.37	0.161	2.84	0.0551	......	......	......	......
10,000	4.86	0.196	3.15	0.0670	2.32	0.0314	......	......
12,000	5.83	0.277	3.78	0.094	2.78	0.0441	......	......
14,000	6.80	0.371	4.41	0.126	3.24	0.0591	......	......
16,000	7.77	0.478	5.04	0.162	3.71	0.0758	2.84	0.0391
18,000	8.74	0.598	5.67	0.203	4.17	0.0944	3.19	0.0488
20,000	9.71	0.732	6.30	0.248	4.63	0.115	3.55	0.0598
25,000	12.1	1.13	7.88	0.378	5.79	0.176	4.43	0.091
30,000	14.6	1.61	9.46	0.540	6.95	0.250	5.32	0.128
35,000	17.0	2.17	11.0	0.724	8.11	0.334	6.21	0.172
40,000	......	......	12.6	0.941	9.26	0.433	7.09	0.222
45,000	......	......	14.1	1.18	10.4	0.545	7.98	0.278
50,000	......	......	15.8	1.45	11.6	0.668	8.87	0.341
60,000	......	......	......	......	13.9	0.946	10.64	0.484
70,000	......	......	......	......	16.2	1.27	12.4	0.652
80,000	......	......	......	......	......	......	14.2	0.849
90,000	......	......	......	......	......	......	16.0	1.06

U. S. Gallons per Minute	54 In. I D		60 In. I D		72 In. I D	
	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.	V Ft /Sec	h_f Frict.
15,000	2.10	0.0194	......	......	......	......
20,000	2.80	0.0333	2.27	0.0198	......	......
25,000	3.50	0.0504	2.84	0.0301	......	......
30,000	4.20	0.0713	3.40	0.0424	2.37	0.0173
35,000	4.90	0.0958	3.97	0.0567	2.76	0.0231
40,000	5.60	0.124	4.54	0.0730	3.16	0.0297
50,000	7.00	0.189	5.67	0.112	3.94	0.0450
60,000	8.40	0.267	6.81	0.158	4.73	0.0637
70,000	9.81	0.358	7.94	0.213	5.52	0.0850
80,000	11.2	0.465	9.08	0.275	6.31	0.110
90,000	12.6	0.586	10.2	0.344	7.10	0.138
100,000	14.0	0.715	11.3	0.420	7.89	0.168
120,000	16.8	1.02	13.6	0.600	9.47	0.237
140,000	......	......	15.9	0.806	11.0	0.321
160,000	......	......	......	......	12.6	0.414
180,000	......	......	......	......	14.2	0.522
200,000	......	......	......	......	15.8	0.642

NOTE: The above table shows average values of pipe friction for new pipe. For commercial installations it is recommended that 15% be added to the above values. No allowance for aging of pipe is included.

Based on standards of the Hydraulic Institute, Page E(1) - 4, May 1965

Figure 9. Friction Head Loss of Water in Pipes (Sheet 2 of 2)

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WARRANTY

Seller warrants equipment (and its component parts) of its own manufacture against defects in materials and workmanship under normal use and service for one (1) year from the date of installation or start-up, or for eighteen (18) months after the date of shipment, whichever occurs first. Seller does not warrant accessories or components that are not manufactured by Seller; however, to the extent possible, Seller agrees to assign to Buyer its rights under the original manufacturer's warranty, without recourse to Seller. Buyer must give Seller notice in writing of any alleged defect covered by this warranty (together with all identifying details, including the serial number, the type of equipment, and the date of purchase) within thirty (30) days of the discovery of such defect during the warranty period. No claim made more than 30 days after the expiration of the warranty period shall be valid. Guarantees of performance and warranties are based on the use of original equipment manufactured (OEM) replacement parts. Seller assumes no responsibility or liability if alterations, non-authorized design modifications and/or non-OEM replacement parts are incorporated If requested by Seller, any equipment (or its component parts) must be promptly returned to Seller prior to any attempted repair, or sent to an authorized service station designated by Seller, and Buyer shall prepay all shipping expenses. Seller shall not be liable for any loss or damage to goods in transit, nor will any warranty claim be valid unless the returned goods are received intact and undamaged as a result of shipment. Repaired or replaced material returned to customer will be shipped F.O.B., Seller's factory. Seller will not give Buyer credit for parts or equipment returned to Seller, and will not accept delivery of any such parts or equipment, unless Buyer has obtained Seller's approval in writing. The warranty extends to repaired or replaced parts of Seller's manufacture for ninety (90) days or for the remainder of the original warranty period applicable to the equipment or parts being repaired or replaced, whichever is greater. This warranty applies to the repaired or replaced part and is not extended to the product or any other component of the product being repaired. Repair parts of its own manufacture sold after the original warranty period are warranted for a period of one (1) year from shipment against defects in materials and workmanship under normal use and service. This warranty applies to the replacement part only and is not extended to the product or any other component of the product being repaired. Seller may substitute new equipment or improve part(s) of any equipment judged defective without further liability. All repairs or services performed by Seller, which are not covered by this warranty, will be charged in accordance with Seller's standard prices then in effect.

THIS WARRANTY IS THE SOLE WARRANTY OF SELLER AND SELLER HEREBY EXPRESSLY DISCLAIMS AND BUYER WAIVES ALL OTHER WARRANTIES EXPRESSED, IMPLIED IN LAW OR IMPLIED IN FACT, INCLUDING ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Seller's sole obligation under this warranty shall be, at its option, to repair or replace any equipment (or its component parts) which has a defect covered by this warranty, or to refund the purchase price of such equipment or part. Under the terms of this warranty, Seller shall not be liable for (a) consequential, collateral, special or liquidated losses or damages; (b) equipment conditions caused by normal wear and tear, abnormal conditions of use, accident, neglect, or misuse of said equipment; (c) the expense of, and loss or damage caused by, repairs or alterations made by anyone other than the Seller; (d) damage caused by abrasive materials, chemicals, scale deposits, corrosion, lightning, improper voltage, mishandling, or other similar conditions; (e) any loss, damage, or expense relating to or resulting from installation, removal or reinstallation of equipment; (f) any labor costs or charges incurred in repairing or replacing defective equipment or parts, including the cost of reinstalling parts that are repaired or replaced by Seller; (g) any expense of shipment of equipment or repaired or replacement parts; or (h) any other loss, damage or expense of any nature.

The above warranty shall not apply to any equipment which may be separately covered by any alternate or special warranties.

PERFORMANCE: In the absence of Certified Pump Performance Tests, equipment performance is not warranted or guaranteed. Performance curves and other information submitted to Buyer are approximate and no warranty or guarantee shall be deemed to arise as a result of such submittal. All testing shall be done in accordance with Seller's standard policy under Hydraulic Institute procedures.

LIABILITY LIMITATIONS: Under no circumstances shall the Seller have any liability under the Order or otherwise for liquidated damages or for collateral, consequential or special damages or for loss of profits, or for actual losses or for loss of production or progress of construction, regardless of the cause of such damages or losses. In any event, Seller's aggregate total liability under the Order or otherwise shall not exceed the contract price.

ACTS OF GOD: Seller shall in no event be liable for delays in delivery of the equipment or other failures to perform caused by fires, acts of God, strikes, labor difficulties, acts of governmental or military authorities, delays in transportation or procuring materials, or causes of any kind beyond Seller's control.

COMPLIANCE WITH LAW: Seller agrees to comply with all United States laws and regulations applicable to the manufacturing of the subject equipment. Such compliance shall include: The Fair Labor Standards Acts of 1938, as amended; Equal Employment Opportunity clauses of Executive Order 11246, as amended; Occupational Safety and Health Act of 1970 and the standards promulgated thereunder, if applicable. Since compliance with the various Federal, State, and Local laws and regulations concerning occupational health and safety, pollution or local codes are affected by the use, installation and operation of the equipment and other matters over which Seller has no control, Seller assumes no responsibility for compliance with those laws and regulations, whether by way of indemnity, warranty, or otherwise. It is incumbent upon the Buyer to specify equipment which complies with local codes and ordinances.

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