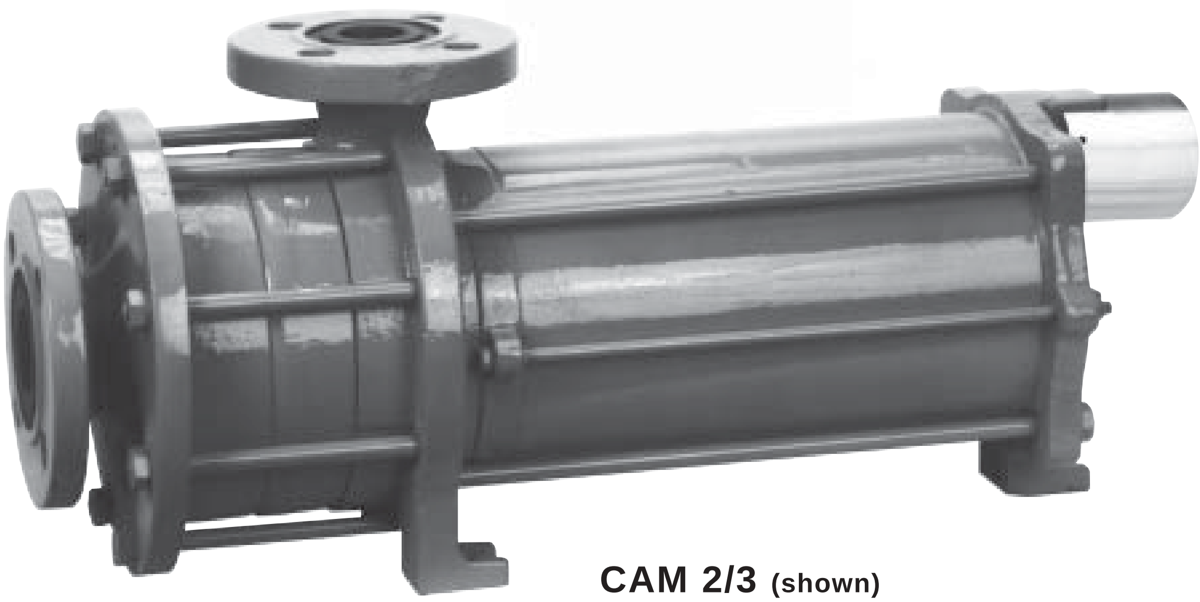
HERMETIC LIQUID REFRIGERANT PUMPS

Ideal for Liquid Overfeed and Liquid Re-Circulation

(Also Usable for Liquid Transfer & Liquid Pressure Boost)



CAM 2/3 (shown)

Hermetic pumps are superior to most other pumps for refrigeration systems because they are sealless, requiring no oil or grease lubricant , are very smooth and quiet, are not bothered by frost or moisture, and normally provide many years of reliable operation.

Like many fine pieces of machinery, Hermetic pumps must be properly installed with regard to system layout, sizing, and controls so the pump receives adequate solid liquid which is free of gas bubbles and abrasive particles. Following these instructions helps guarantee a long and trouble-free pump life.

OPERATOR INSTALLATION & INSTRUCTION MANUAL

(For CAM and CNF Series Pumps)

HANSEN TECHNOLOGIES CORPORATION

Bulletin HP237a
October, 1996

MATERIAL SPECIFICATIONS

Casing: Ductile Iron A356 (GGG-40.3)
Stator casing: Steel A529 Grade 40
Stator lining (Can): Stainless Steel A276 type 346T
Shaft: Chrome Steel A22C type 420
Impeller: Cast Iron A48; CAM Class 30,
CNF Class 35
Sleeves: Stainless Steel A276 type 346T
Bearings: Carbon type 23
Maximum operating pressure: 362 PSIG (25 bar)
Temperature range: -60F to 194F (-51°C to 90°C)
Lower Temperature:
To -150F with stainless steel construction (contact Hansen)
Housing: NEMA 4 construction (IP64/IP67/IP55)
CSA Listed: File No. LR75907-2

PUMP EQUIPMENT

Below is a drawing depicting a typical pump as would be supplied by Hansen, see Figure 1. Pumps come complete and pretested. Please note the protection devices which are provided with pump. One should become familiar with each or these devices and understand how, when properly installed and utilized, they can help to ensure a long and trouble-free pump life.

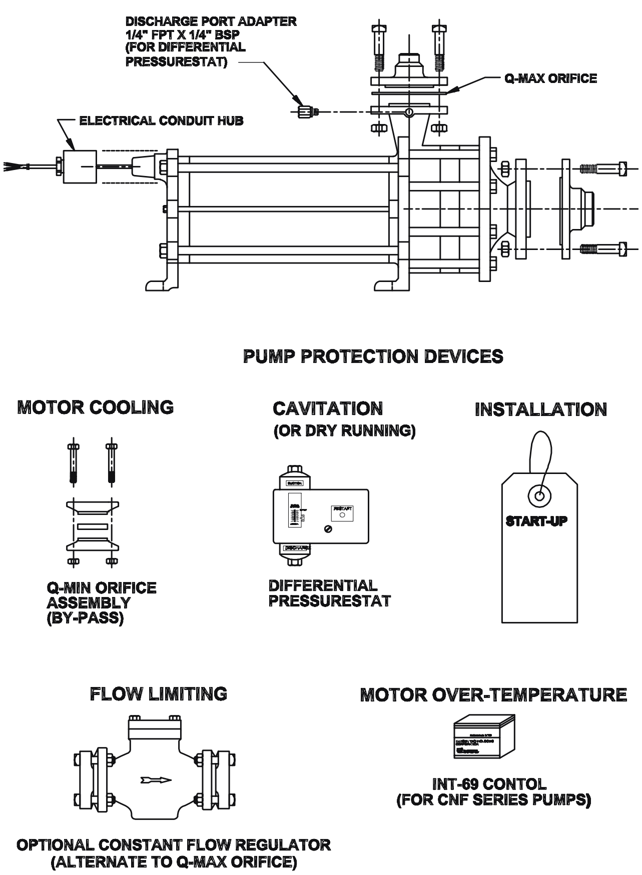


Figure 1

PUMP SUCTION LINE

Proper pump suction line sizing helps to minimize bubbling and vortexing of the liquid refrigerant which can cause cavitation or loss of prime. For ammonia, typical pump suction line sizing should deliver an optimum 3 feet per second from the accumulator vessel (pump recirculator). For halocarbons, a flow rate of 2.5 feet per second is optimum. The suction line should be sized for the maximum allowable pump flow, not the nominal design flow because pump demand can vary widely due to system demands such as defrost terminate and production start up. Undersizing the suction line is not tolerable, while oversizing should not exceed 1 or 2 pipe sizes. Suction line pipe sizing is listed in Table 2. Because the pump inlet is Venturi shaped, the pump inlet flange connection is normally one or two sizes smaller than the pump suction line pipe. Reducers on the pump inlet should be eccentric with flat side on top to avoid bubble accumulation in the suction line.

SUCTION LINE PIPE SIZING (Ideal)

PIPE SIZE	R717 GPM	Halocarbon GPM
1"	6.7	5.6
1¼"	12.0	10.0
1½"	16.5	13.8
2"	31.4	26.1
2½"	44.8	37.3
3"	69.1	57.6
4"	119.0	99.0
5"	187.0	156.0
6"	270.0	225.0

¾" thru 1½"= Schedule 80; 2" thru 6"= Schedule 40
Basis: R717 at 3 ft/sec; Halocarbon at 2.5 ft/sec

Table 2

Adequate NPSH (Net Positive Suction Head) is necessary to minimize the potential of cavitation during normal operating conditions. Typically, NPSH is defined as the static head of liquid (in feet) above the centerline of the pump inlet; see Figure 3. Insufficient available NPSH can cause the loss of pump pressure and lubrication; eventually leading to shortened pump bearing life. The system required minimum NPSH values for each pump are specified in the Standard Pump Specifications on page 20.

Avoid any unnecessary pressure drop in the pump suction line from valves, strainers, and fittings. Where needed, they should be of low pressure drop design. The pump suction line should be as short as possible and ideally piped with a steady downward slope to the pump. Horizontal runs should not exceed 18 inches. Baffle plates should be installed in the accumulator before the exit to the pump to eliminate vortex formation. The liquid level inside the vessel should be a minimum of ten inches above the vessel internal inlet to the pump suction line and located away from evaporator overfeed return, liquid makeup, hot gas condensate return and other piping arrangements. Some examples of correct and incorrect routing of suction piping are shown in Figure 2. The pump suction line, vessel, level column, and float switches should be insulated to minimize bubble formation.

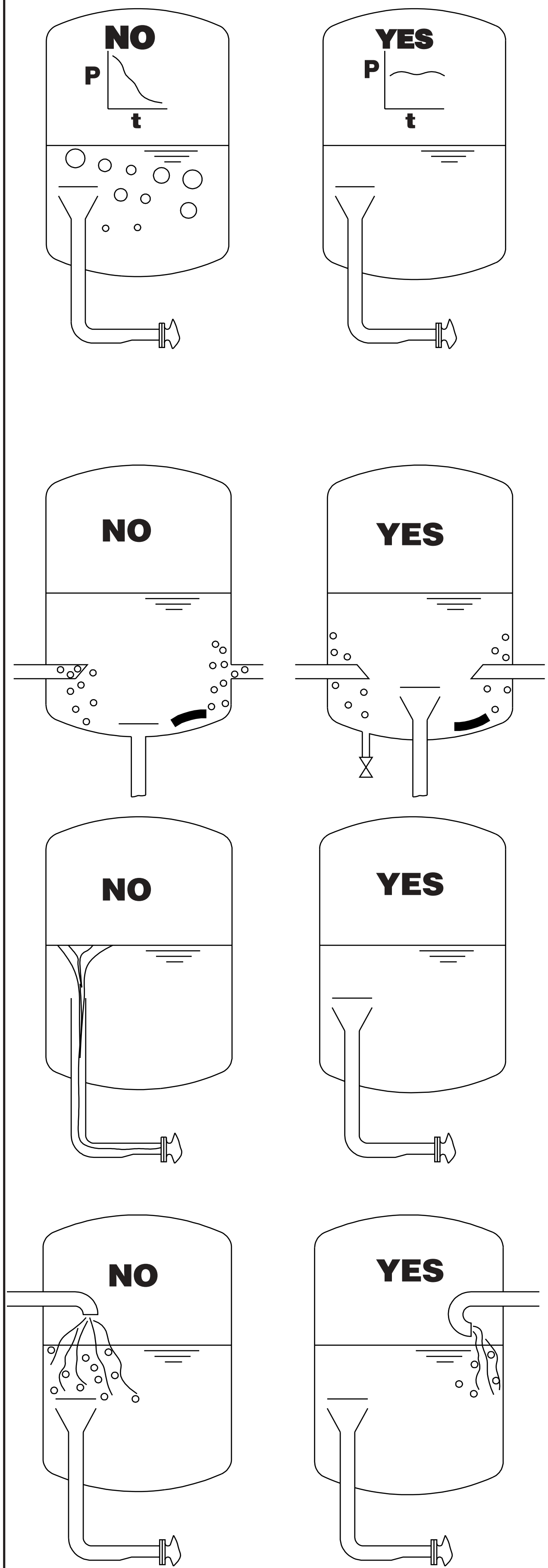


Figure 2

PUMP DISCHARGE LINE

The discharge line of a Hansen Hermetic pump normally must include a Q-max flow (capacity) control orifice (see page 4) or Constant flow (capacity) regulator (see page 5) to limit maximum flow to prevent cavitation and possible motor overload. Centrifugal pumps of all makes, whether canned or seal design, can operate inefficiently or at the higher NPSH than required region on the pump performance curve if capacity is not controlled. Typical pump discharge line sizing for ammonia should be based on a maximum of 7 feet per second and 5 feet per second for halocarbons; see Table 3.

DISCHARGE LINE PIPE SIZING (minimum)

PIPE SIZE	R717 GPM	Halocarbon GPM
1"	17	12
1¹/₄"	27	19
1¹/₂"	38	27
2"	63	49
2¹/₂"	107	76
3"	166	110
4"	274	196

Basis: R717 at 7 ft/sec; Halocarbon at 5 ft/sec.

Table 3

Normally, a check valve is located after the flow control device to prevent back flow and reverse rotation of the pump when multiple pumps are in parallel. A shut-off valve for servicing of the pump should be placed after the check valve with a relief device therein between. Alternately, a combination stop/check valve can be used in place of both (see Hansen Bulletin C519).

GENERAL INSTALLATION

A stable vessel pressure must be maintained to avoid the spontaneous vaporization (boiling) of liquid refrigerant inside the pump accumulator and associated piping. The system designer must ensure that compressor loading and loading sequences and defrosting cycles do not change vessel pressures too rapidly. As general rule, vessel pressure changes downward should be limited to 1 psi per minute to maintain solid liquid flow to pump.

For pump servicing, a valved pump-out line from the bottom of the pump suction line, near the pump, should be installed for the purpose of quickly evacuating liquid refrigerant and system oil. This should be in addition to properly sized, low pressure drop service/ isolation valves in pump suction and discharge lines.

Pumps should be properly mounted to eliminate vibration damage and thermodynamic strains as the pump and piping are cooled to operating temperature. All pipe work should be flushed to clean out welding slag and other foreign matter before operating pump. Unless the system is proven to be quite clean, a system filter should be installed in pump discharge line to remove silt, rust and particles which otherwise would continue to recirculate throughout the system. This can improve overall system life by minimizing wear to other components and bearings. See Hansen System Filter Bulletin HP782, available late 1996.

Q-min FLOW CONTROL ORIFICE

The supplied Q-min flow control orifice is required to vent gas from the pump and ensure proper pump cooling. The Q-min flow control orifice should be installed in a horizontal part of vent/bypass line and above the normal liquid level inside the vessel. The line from the Q-min orifice to the vessel must free drain into the vessel. For pump systems where operation at low flow rates is frequent, it is recommended that a bypass differential regulator be installed parallel with the Q-min orifice. The differential regulator opens at lower flow rates (and higher differential pressure) to maintain the pump nearer to the smoothest low flow pump operation region.

The vent/bypass line should be piped from the discharge line **before** the check valve, vertically back to the accumulator above the high level limit. Any shut-off valves in the vent line should be tagged and sealed in the open position for closing only during pump servicing. If multiple pumps in parallel are connected to a common pump discharge line, each must have a separate vent/bypass line with a Q-min orifice.

Q-max FLOW CONTROL ORIFICE

The Q-max flow control orifice limits the flow output of the pump preventing it from developing cavitation and operating at higher than acceptable NPSH requirements. It is normally installed between the pump flange and its companion outlet (discharge) flange. The Q-max orifice will help to prevent overloading of the motor during start up and varying load conditions such as after defrost. If higher discharge pumping head is desired, an optional Constant Flow Regulator can be used instead of a Q-max orifice. See Constant Flow Regulator section and typical pump curve (Figure 4).

CONSTANT FLOW REGULATOR

Constant flow regulator can be used instead of the Q-max flow control orifice when higher pump discharge pressures at higher flow rates are necessary to meet design conditions (Figure 4). Constant flow regulator capacities are matched to the performance of a specific pump type. This protects the pump from motor overload and provides a steady rate of flow to the system, and yet keeps the pump operating within the required NPSH range.

Constant flow regulators are not a check valves and will not prevent reverse flow. A detailed bulletin which describes specifications, applications and service instructions for these Constant Flow Regulators is available; Hansen Bulletin HP421. Spare factory calibrated, pre-assembled regulators may be ordered for Hansen or other pumps; specify GPM and refrigerant. Consult factory for proper sizing as not to exceed pump safe operating range.

LOW LEVEL CUTOUT

A low level float switch or level control (such as the Hansen Vari-level Adjustable Level Controls) must be installed to prevent liquid level in the vessel from dropping below system required minimum NPSH for the pump under the design conditions.

PRESSURE GAUGES

It is strongly recommended that a pressure gauge be installed at the ¼" NPT fitting (discharge port adapter) located just below pump discharge flange, see figure 3. This gauge can be an important tool when checking proper pump performance and rotation. It is also recommended that gauges be installed to sense pump suction pressure and discharge pressure after the Q-max or constant flow regulator to monitor pressure to system.

TYPICAL PUMP CURVE

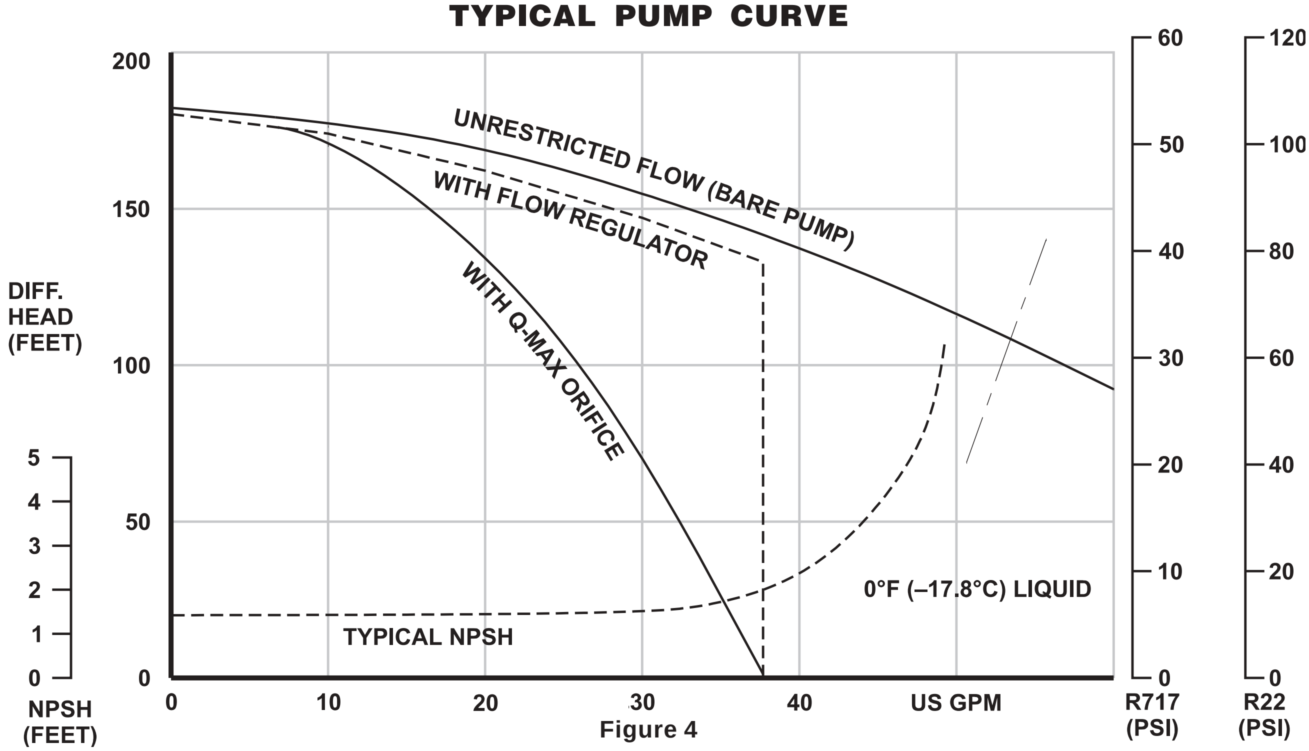


Figure 4

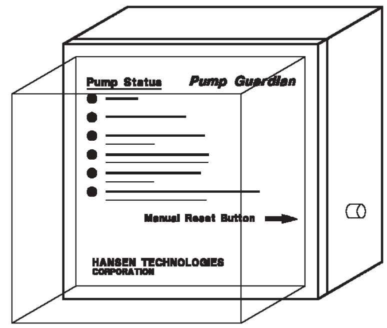
DIFFERENTIAL PRESSURESTAT

This control provides a dependable and economical pressure cutout for liquid refrigerant pumps. It can disable the pump when a loss of pressure is detected thus preventing pump from running dry. The standard, supplied pressurestat has a built-in 30 second time delay which enables pressure to build up at start-up and also avoids nuisance shutdowns when pressure briefly drops during the run cycle. Pressure is sensed across the inlet and outlet of the pump (See Figure 3). Pump outlet pressure should be sensed at the ¼" NPT fitting (discharge port adapter) located just below pump discharge flange. Pump inlet pressure should be sensed near the pump inlet on top of the suction line. The factory differential pressure setting is 10 psid.

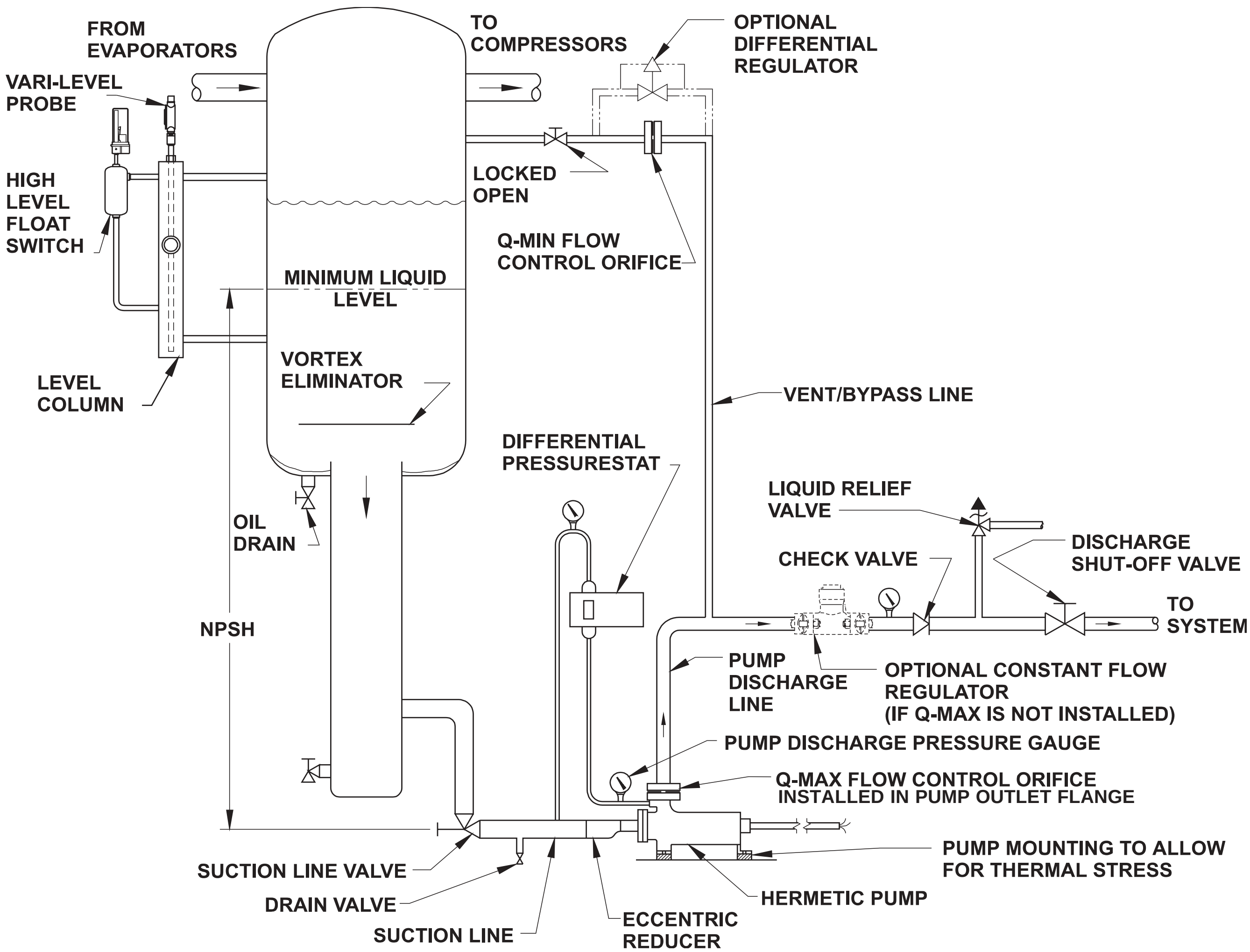
To reset pressurestat after it trips, simply push button located on front face of pressurestat. To avoid manually resetting pressurestat, contact factory for additional control requirements or consider using the *Pump Guardian* Pump Controller, see right.

PUMP CONTROLLER

A newly developed optional pump controller, the *Pump Guardian,* is available from Hansen. This pump controller is designed to safeguard refrigerant liquid pumps and to alert operators of harmful operating conditions as they occur. When properly connected, the *Pump Guardian* will provide excess-recycling protection to a pump thus preventing unnecessary damage before cause of reoccurring problem can be discovered and fixed. *Pump Guardian* also provides an integrated means of protection against cavitation, low liquid level, insufficient or loss of pump pressure, and motor-overtemperature. See wiring diagram on page 13 and Hansen Bulletin HP519.



TYPICAL PUMP INSTALLATION



Typical schematic piping provided to help assist system designers in applying and selecting pumps, valves, and controls. The designer is ultimately responsible for safe and satisfactory operation of the pumping system.

Figure 3

OVER-TEMPERATURE CONTROL

The CNF series pumps are provided with miniature thermistors which are imbedded in the windings of the electric motor stator. With an increase in temperature, these thermistors change their resistance value exponentially within their maximum allowed temperature range. Typically, a rise in resistance is caused by excess current draw due to low or high voltage, worn bearings, oil in pump or lack of refrigerant to pump. At a resistance value of about 4.5 k ohm, the INT-69 cuts off the motor by opening the motor contactor. This stopping of the pump should draw operator's attention to the possible causes of elevated winding temperatures. Note: INT-69 will allow pump to restart automatically after motor cools to normal temperature.

The thermistors are connected in series and are marked 5 & 6 (grey and white wires) in the main power cord (or a separate adjacent cord for model CNF 50-160 AGX 8.5). They are to be wired directly to terminals 1 and 2 of the INT-69 control in the motor control circuit, per wiring diagram (Figure 6). An alarm may be added using relay terminal "L". The INT-69 will not protect against single phasing of a 3-phase motor. Thermistors are sensitive electronic sensors and therefore **should never be connected directly to motor power or even the contactor pilot circuit.** Voltages of 115V, 230V or 440V will destroy the thermistors and possibly burn out one or more of the motor windings.

ELECTRICAL

Before attempting to connect pump electrical, verify that line voltage and pump name plate motor voltage are the same. Normally, motors are 3-phase, dual voltage but factory wired to name plate voltage. Refer to typical wiring diagrams on page 7. Standard control voltage is usually 110V (optionally 220V). To ensure motor and bearing protection, the differential pressurestat and INT-69 must always be part of the electrical control circuit; even in the "manual" pump start switch position. Pressurestat should be wired so that when pump is turned off, the power to the pressurestat is also off. This will prevent the pressurestat from de-energizing the control circuit. Pump Guardian pump controller is available to simplify wiring and integrate pump protective devices, see page 5.

Either "quick trip" or "electronic" overload relays must be installed for pump motor protection. Heaters on the motor starter "quick trip" or overloads should be sized to rated motor current or less. Pump should be separately fused at no more than three times the motor rated current (non-delay type fuses). Single phasing protection devices for these hermetic motors is recommended.

Test all safety devices before putting pump into full service (see Start-up Procedure section on page 8 and as supplied with pump).

ELECTRICAL SPECIFICATIONS

MOTOR TYPE (H.P. Nominal)	Nameplate Voltage	RPM Nominal	Motor Rating (kW)	Rated Current (amps)	Winding Resistance at Room Temp. (ohms)
AGX 1.0 (1.5 hp)	440/60	3400	1.15	2.90	13.40
	220/60	3400	1.00	5.00	4.40
	208/60	3400	0.90	4.70	4.40
	575/60	3400	1.15	2.20	21.80
	380/50	2800	1.00	2.90	13.40
AGX 3.0 (3 hp)	440/60	3400	3.40	7.50	6.00
	220/60	3400	2.80	13.00	2.15
	208/60	3400	2.50	12.30	2.15
	575/60	3400	3.00	5.70	10.40
	380/50	2800	3.00	7.50	6.00
AGX 4.5 (5 hp)	440/60	3400	5.00	11.00	3.65
	220/60	3400	4.30	19.00	1.30
	208/60	3400	3.90	18.00	1.30
	575/60	3400	5.00	8.40	6.25
	380/50	2800	4.50	11.00	3.65
AGX 6.5 (7.5 hp)	440/60	3400	7.40	16.00	2.45
	220/60	3400	6.30	28.00	0.90
	208/60	3400	5.70	26.50	0.90
	575/60	3400	6.50	16.00	4.25
	380/50	2800	6.50	16.00	2.45
AGX 8.5 (10 hp)	440/60	3400	9.70	20.00	1.50
	220/60	3400	8.30	35.00	0.60
	208/60	3400	7.50	33.10	0.60
	575/60	3400	9.70	15.20	2.45
	380/50	2800	8.50	20.00	1.50

Service factor of 1.0 is for all pump models listed.

Table 4

TYPICAL WIRING

The typical wiring diagram control logics shown in the two diagrams below will shut the pump off when the differential pressurestat trips (senses loss of pressure difference across the pump for more than 30 seconds). The pump must then be manually restarted by pressing the reset button on the standard pressurrestat. Other safety controls such as low level float switch, latching relays, etc., located in the control circuit, as shown, also stop the pump. but will automatically restart the pump when the safety control is re-engaged. If other control logic is required, it is the control designer's responsibility to ensure the pump is protected from running "dry" by including the differential pressurestat and low level float switch in the pump control wiring circuit and that such protection occurs in manual (if any) as well as automatic mode. Warranty is void if the differential pressurestat is not installed properly.

FOR CAM SERIES

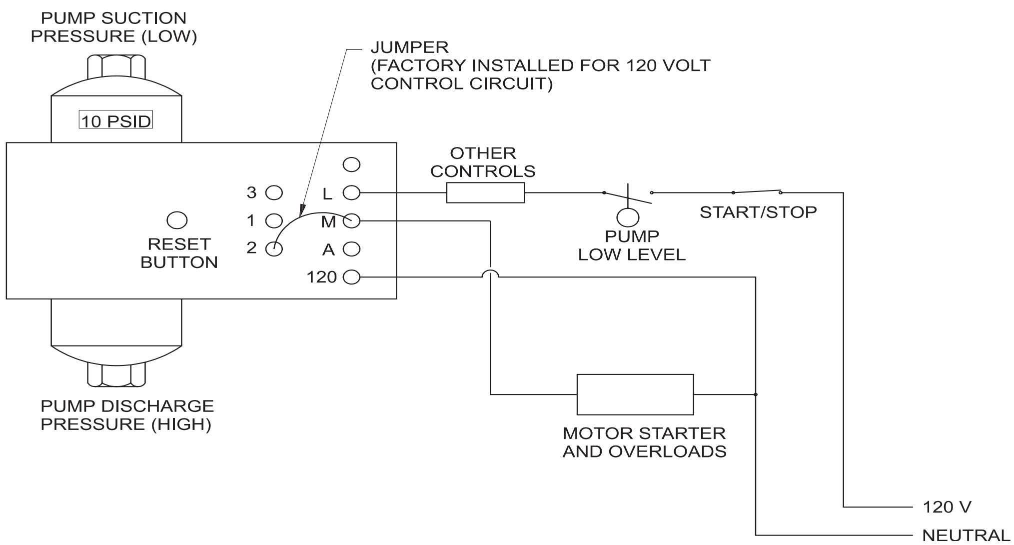


Figure 5

FOR CNF SERIES

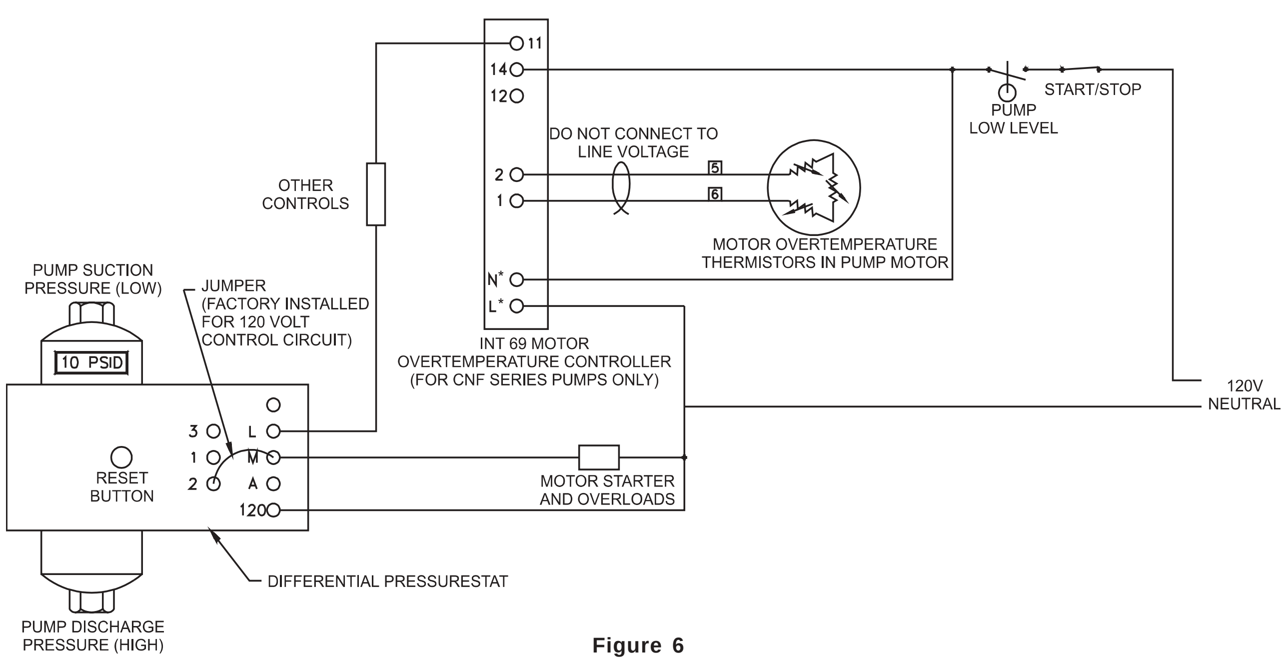


Figure 6

* On older INT-69 controllers these terminals, N and L, are designated Mp and R respectfully.

Note: Above diagrams depict 110v control circuit only. INT-69 motor over-temperature controllers for 200V are available.

START-UP PROCEDURE

The following is a general start-up procedure for commissioning Hansen Hermetic liquid refrigerant pumps. After the pump is properly installed and all the electrical work has been completed, but not powered, this procedure should be followed.

1. Leak check. If not already done, check for leaks by pressurizing the pump and associated piping. Opening the vent/bypass line is a good way to allow refrigerant gas into the pump. If the recirculator is operating in a vacuum, allow a small amount of liquid refrigerant from the accumulator into the pump by opening the pump inlet valve and then closing it. Allow liquid to vaporize and build up pressure to check for leaks at flange gaskets, welds, and pump gaskets. Three pressures should be sensed for monitoring pump performance (Figure 3): the recirculator vessel pressure, the pressure sensed by the pressurestat at pump discharge, and the line pressure to the system sensed after the Q-max flow control orifice or constant flow regulator.

2. Cool down pump. Open the pump inlet valve and the valve in vent/bypass line. Allow pump to cool to near the recirculator temperature. This may take 5 to 10 minutes to develop frost or sweat on the pump casing surface. Gas developed as a result of cooling the pump and associated piping will vent through the vent/bypass line.

3. Check for pump rotation. With the pump discharge shut-off valve ½ turn open and the Q-min vent/bypass line open, start pump and observe discharge pressure. Pressure should fluctuate for a few seconds and then remain steady as liquid enters the pump. (See Table 5 for approximate pressure differential between discharge and suction.) Stop pump and reverse two of the three power leads to the motor. Start pump again and observe the discharge pressure. Wire the pump leads to the position that produces the highest discharge pressure. This ensures proper rotation. Measure motor amp draw and compare to Table 4.

4. With pump operating, slowly open pump discharge valve and allow discharge line and system to fill with liquid.

5. Check differential pressurestat operation. Cavitate the pump by gradually closing the pump inlet valve with the pump running. Cavitating the pump in this manner will not harm the pump. This will starve the pump for liquid. Discharge pressure of pump should fall to nearly inlet pressure. The differential pressurestat should shut the pump off after 30 seconds. If not, stop the pump at once and the check wiring of differential pressurestat (Figure 5 and 6). Repeat the procedure to ensure that the differential pressurestat stops the pump after about 30 seconds of cavitation.

6. After the pump has "tripped off" on differential pressurestat shutdown, continue to observe differential pressurestat for a minimum of one minute for any overheating of the differential pressurestat time delay relay circuit. Shut off control circuit and rewire if necessary.

7. With the pump running, pull the low level float switch magnet away from the tube by lifting the switch housing or raise the low level set point on a probe type level control. The pump should shut off. If not, wire correctly.

8. Measure the current draw on each motor leg. The values should be equal or less than the running amps shown in Table 4.

9. Repeat this procedure with any standby pump.

Note: Pumps under normal operation make practically no noise or vibration. Do not run the pump if it makes unusual noise or vibration. Check for bearing wear every 5 years or sooner.

WARNING!!
Pump stops and starts in excess of 5 starts per hour is considered abnormal operation. This condition will result in reduced bearing life. A new pump controller, the *Pump Guardian* detects excessive pump starts and stops; see page 5 and page 13.

Note: The greatest danger to a pump at initial start-up is "trying" it before the system and pump are properly supplied with liquid. This can only happen if the pressurestat and low level switch are bypassed or incorrectly wired, especially for "manual" starter switch position.

Maximum Nominal Pump Pressure Differential in psi (bar)		
Model	R717	Halocarbon
CAM 1/2 AGX 1.0 (80mm)	-	40 (2.8)
CAM 1/3 AGX 1.0 (80mm)	31 (2.1)	64 (4.4)
CAM 2/2 AGX 1.0 (95mm)	-	46 (3.2)
CAM 2/2 AGX 3.0 (114mm)	34 (2.3)	70 (4.8)
CAM 2/3 AGX 3.0 (114mm)	49 (3.4)	-
CAM 2/3 AGX 4.5 (114mm)	-	105 (7.3)
CAM 2/5 AGX 3.0 (114mm)	82 (5.7)	-
CNF 32-160 (165mm) AGX 3.0	46 (3.2)	-
CNF 40-160 (169mm) AGX 4.5	49 (3.4)	-
CNF 40-160 (150mm) AGX 6.5	-	81 (5.6)
CNF 50-160 (158mm) AGX 6.5	43 (3.0)	-
CNF 50-160 (130mm) AGX 8.5	-	67 (4.6)

Differential pressures are based on refrigerant liquid temperature at 0°F (–17.8°C)

Table 5

PUMP DIMENSIONS

CAM Series

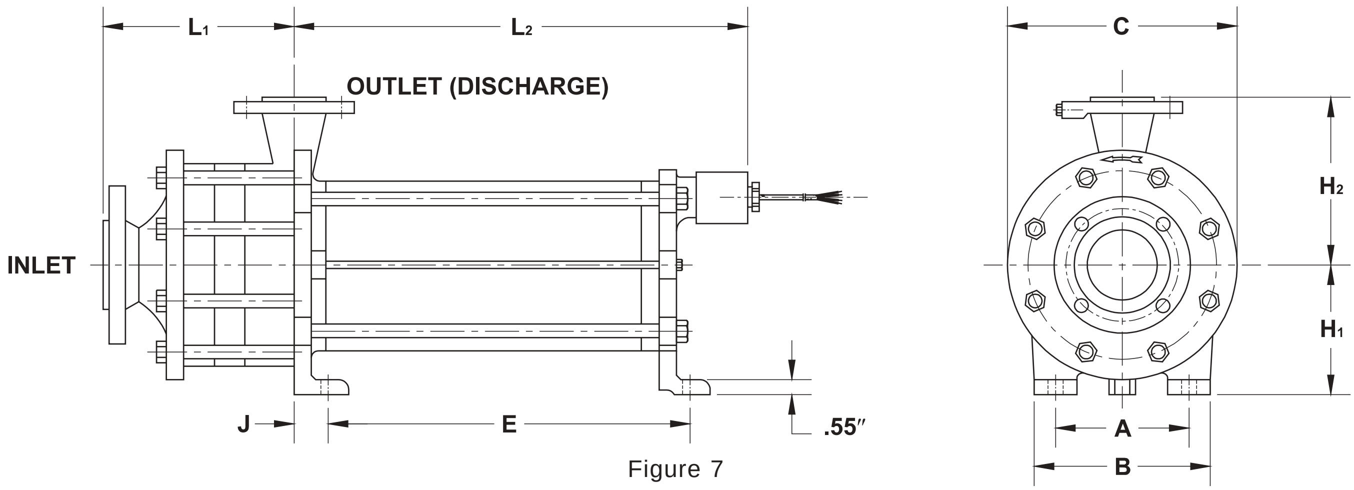


Figure 7

CNF Series

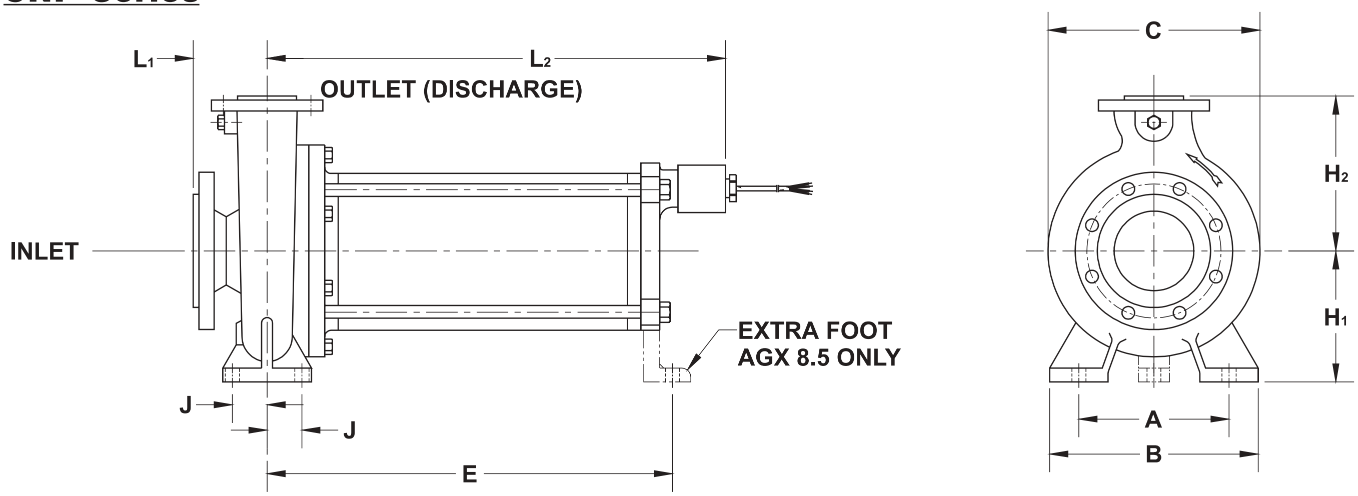


Figure 8

PUMP DIMENSIONS (INCHES)

PUMP CATALOG NUMBER	PUMP MOTOR	L_1	L_2	A	B	C	H_1	H_2	J	E	WELD NECK FLANGED CONNECTIONS INLET/OUTLET
CAM 1/2	AGX 1.0	4.4	13.9	5.1	6.7	6.9	3.5	4.7	1.2	9.5	1" / 3/4"
CAM 1/3	AGX 1.0	5.5	13.9	5.1	6.7	7.1	3.5	4.7	1.2	9.5	1" / 3/4"
CAM 2/2	AGX 1.0	5.3	13.9	5.1	6.7	8.3	4.3	5.5	1.2	9.5	1 1/2" / 1 1/4"
	AGX 3.0	5.3	16.3	5.1	6.7	8.3	4.3	5.5	1.2	12.7	1 1/2" / 1 1/4"
CAM 2/3	AGX 3.0	6.9	16.3	5.1	6.7	8.3	4.3	5.5	1.2	12.7	1 1/2" / 1 1/4"
	AGX 4.5	6.9	16.3	5.1	6.7	8.3	4.3	5.5	1.2	12.7	1 1/2" / 1 1/4"
CAM 2/5	AGX 3.0	10.1	16.3	5.1	6.7	8.3	4.3	5.5	1.2	12.7	1 1/2" / 1 1/4"
CNF 32-160	AGX 3.0	3.2	17.6	7.5	9.4	9.0	5.2	6.3	1.4	--	2" / 1 1/4"
CNF 40-160	AGX 4.5	3.2	17.6	7.5	9.4	9.0	5.2	6.3	1.4	--	2 1/2" / 1 1/2"
	AGX 6.5	3.2	17.6	7.5	9.4	9.0	5.2	6.3	1.4	--	2 1/2" / 1 1/2"
CNF 40-200	AGX 6.5	3.9	17.6	8.5	10.4	10.0	6.3	7.1	1.4	--	2 1/2" / 1 1/2"
CNF 50-160	AGX 6.5	3.9	17.6	8.5	10.4	10.0	6.3	7.1	1.4	--	3" / 2"
	AGX 8.5	3.9	21.1	8.5	10.4	11.4	6.3	7.1	1.4	17.75	3" / 2"
CNF 50-200	AGX 8.5	3.9	21.1	8.5	10.4	11.4	6.3	7.9	1.4	17.75	3" / 2"

Standard foot bolt hole diameter is .55″ (14 mm)

Table 6

TROUBLESHOOTING GUIDE

The three most common reasons why refrigerant pumps fail prematurely are cavitation, running dry, and excessive dirt in the system. This is true whether the pump is a centrifugal, turbine, or positive displacement pump and whether it is an open pump with shaft seal or a canned sealless pump. The greatest danger from cavitation for a pump is the loss of inlet liquid flow causing it to run dry. Cavitation for an extended period will greatly reduce the seal life of an open pump and the bearing life of a sealless pump. In many instances, cavitation can be avoided by properly installing pump suction lines, flow control devices, having sufficient NPSH available, and controlling radical changes in vessel pressure.

1. New System Start-Up. Cavitation is often experienced on new system start-up because the plant suction is being brought down to operating temperature. Bringing suction pressure down slowly over several hours will generally minimize the problem. In each step of pull down, the system pressure should be stabilized before operating the pump. This includes when pumps are turned off during times of peak electrical rates, and then restarted.

2. New System Start-Up—No Load. Sometimes plants are started where only a small portion of the normal load is operating. At this condition the compressor may be too large for the load. Select the smallest compressor available to handle the load and adjust the compressor loading and unloading rate to eliminate or minimize pressure variations. Also, the liquid makeup expansion valve should be adjusted to match the small initial system load. Extend feeding time of the liquid makeup solenoid valve to at least 50% to 75% open by further closing the hand expansion valve.

3. Liquid Makeup Expansion Valve Open Too Far. An expansion valve set too far open will feed only a short time. The flash gas generated will cause pressure to build up in the recirculator vessel and may load up a compressor. When the liquid makeup solenoid valve closes, the unnecessarily loaded compressor will quickly pull the vessel pressure down causing flashing in the liquid and potential pump cavitation. Set the expansion valve at a point where the liquid makeup solenoid valve is open at least 50%, and preferably 75%, of the time. This will minimize the increase in pressure in the recirculator and the unnecessary loading and unloading of the compressors.

4. Large Liquid Makeup Controls. On recirculator vessels where the liquid makeup line is 1½″ or larger, the condition stated in reason 3 is more severe and difficult to overcome. Therefore, the use of a dual liquid makeup control is recommended. The level at which each makeup valve is controlled should be offset. The amount of offset is dependent on the differential of each valve control device being incorporated. Typically 4″ to 6″ (0.10 m 0.15 m) is appropriate. A review of the system load profile should be analyzed to determine the sizing of each control valve. The upper level control valve or hand expansion valve should be sized for lighter or weekend load conditions. It will serve as a fixed bypass. Should the loading exceed the upper control valve's capacity, then the lower level control will cycle for the full system load capacity. Two liquid makeup controls will even out and slow the compressor loading and unloading sequence, thereby reducing fluctuation of the pressure and minimizing cavitation.

5. Defrosting Coils. The defrost scheme used in the plant can affect the recirculator vessel pressure. With today's larger coils, the amount of hot gas returning to the recirculator vessel can cause abnormal increases in pressure. The compressor tends to be fully loaded during defrosting. At the end of defrost, the suction pressures can drop quickly, thereby encouraging cavitation unless the unloaders are set to respond quickly. The use of pump out, bleed down, and liquid drainers can minimize the recirculator vessel pressure build up during defrost. Defrosting at one time only a small portion of the total number of coils will also minimize pressure fluctuation.

6. Compressor Computer Controls. During compressor loading, fast reductions in vessel pressure at a rate of more than 1 psi/minute (0.07 bar/minute) will likely cause pumps to cavitate. This is because a portion of the liquid in the vessel and pump suction line flashes to gas and is pulled into the pump inlet. Occasionally software logic may try to optimize something other than maintaining a stable recirculator vessel pressure. Software programming adjustments may be necessary to accomplish the goal of a stable recirculator pressure.

7. Other Reasons for Cavitation. Dirt, weld slag and foreign objects sometimes are pulled into the pump and block the entrance or lodge in the impeller. If a fine mesh strainer is needed, these should be installed in the pump discharge. In either case, pressure drop across the strainer must be monitored to maintain good system performance. Hansen manufactures a pump discharge system filter, contact factory for details. Excessive oil at cold operating temperatures can cause reduced flow and pressure in the pump, eventually causing cavitation. Improper inlet pipe size, routing, or length may cause gas bubbles to enter the pump or result in insufficient NPSH.

TROUBLESHOOTING

PROBLEM	CAUSE	ACTION
A. Pump cavitates, recirculator pressure drops too quickly.	1. Liquid makeup expansion valve too far open. 2. Compressor loading too fast. 3. Compressor unloading too slow. 4. Defrost controls oversized. 5. Wide compressor load variations. 6. A single, large expansion valve makes recirculator pressure control difficult.	1. Adjust expansion valve so that the liquid feed solenoid is open at least 50% and preferably 75% of the time. 2. Slow compressor loading rate, sequence compressor load in smaller increments. 3. Increase compressor unloading rate. 4. Defrost regulator oversized causing excess hot gas to return to recirculator. Control hot gas pressure to evaporator. Reduce regulator size and add bleed down to evaporator defrost control (see Bulletin F100 Frost Master). 5. Wide swings in compressor load may make recirculator pressures difficult to control. Size compressor capacities to match peak load and low load conditions. See also 6. 6. Systems requiring expansion valves $1\frac{1}{2}$" and larger should consider two parallel hand expansion valves and liquid feed solenoid valves. One sized for low load conditions, the second to make up the peak load condition.
B. Pump cavitates.	1. Improper piping of suction line. 2. Level in recirculator drops too low. 3. Improper piping of vent/bypass line.	1. Suction pipe sizing should allow for no more than 3 ft/sec (1 m/sec) velocity for ammonia and 2.5 ft/sec (0.75 m/sec) for halocarbons with a maximum suction line pressure drop of 1.5 static ft (0.5 static meters). 2. Reset low level controls. Revise system operating sequence and parameters. 3. Vent line must be installed between pump and pump discharge check valve.
C. Pump shuts off on differential pressurestat.	1. Vent/bypass line not open. 2. Pump not cooled down properly. 3. Differential pressurestat not sensing at correct point. 4. Pump suction line and recirculator not insulated. 5. Differential pressurestat wired improperly. 6. Pump running in reverse. 7. Oil in pump.	1. Open vent/bypass line to allow gas to vent from pump. 2. Allow refrigerant into pump and cool for 10 minutes until frost develops on pump casing. 3. Differential pressurestat must sense discharge pressure at $\frac{1}{4}$" NPT connection under pump discharge and suction pressure. Note: Pump must operate with minimum of 10 psid (0.7 bar) to allow differential pressurestat to stay "latched." 4. Insulate pump suction line and recirculator. Note: Insulation of the pump is not required. 5. Check wiring per Figure 5 & 6. 6. Check pump rotation, see Start-Up procedure section. 7. Drain oil from the pump.
D. Pump does not produce proper pressure. D. Low discharge pressure. D. Little or no discharge pressure.	1. Motor running in reverse. 2. Oil in pump. 3. Pressure gauge in wrong location. 4. Actual system required head lower than specified. 5. Pump is "gas bound."	1. Switch two leads of pump and check pressure. Take the higher of the two readings. See Start-Up Procedure section. 2. Drain oil from pump. Check system for oil problems. 3. A pressure gauge should sense pressure from $\frac{1}{4}$" NPT connection on pump flange discharge. A second pressure gauge after the Q-max discharge orifice or constant flow regulator will sense pressure of refrigerant going to the plant. 4. Verify correct Q-max flow control orifice or constant flow regulator. 5. Verify vent/bypass and pump suction lines are open. See Recommended Piping Schematic, Figure 3.
E. Bearing failure.	1. Pump running in reverse. 2. Improperly wired differential pressurestat. 3. Excessive pump cavitation. 4. Excessive dirt in system.	1. Switch two leads of pump and check pressure. Take the higher of the two readings. 2. Check wiring per Figure 5 & 6. Does not protect pump from cavitation or running dry. 3. See troubleshooting problems D & E. 4. Add filter to discharge line to clean system.
F. Motor failure.	1. Can lining rupture due to excessive bearing wear. 2. Single phasing. 3. Lack of motor cooling. 4. Improper voltage.	1. Replace can and bearings. Consult the factory or qualified motor repair shop for replacement. Also see troubleshooting problem G. 2. Check 3 phases. 3. Excessive dirt in system 4. Check voltage.
G. Insufficient flow.	1. Discharge check valve on standby pump leaking. 2. Piping or valve restriction. 3. Cavitation. 4. Pump running in reverse. 5. Oil in pump.	1. Verify that the discharge check valve on other pump(s) piped in parallel is not allowing refrigerant to flow back through the standby pump. 2. Check system for restrictions. Verify flow with pump curve and amp draw. 3. Reduce flashing in vessel, see troubleshooting cavitation section. Check for inadequate NPSH and elevate minimum liquid level. 4. Check pump rotation, see start up procedure. Switch two leads of pump and check pressure. Take the higher of the two readings. 5. Drain oil from pump.
H. Pump does not run.	1. Motor control circuit not operating. 2. Fuse blown. 3. Overload heaters sized incorrectly. 4. Low level. 5. Motor burned out. 6. Differential pressurestat is tripped. 7. Pump is out on overloads. 8. Differential pressurestat is tripped.	1. Check for control circuit power. 2. Check fuses - size fuses or circuit breaker for 3 times motor amp rating. 3. Check heaters - should be sized for rated motor current or less. 4. Low level float switch or level control not operating properly - level in vessel too low. 5. Disconnect motor leads and check resistance on all three leads. Resistance should be same value. See table 4. 6. Push manual reset button. If pump starts, verify minimum of 10 psi (0.7 bar) differential. 7a. Verify overload and heater sizing. Resize if required. 7b. Cold oil in pump. Drain oil. 7c. Impeller jammed by large object, excess weld penetration on suction flange, or piping stresses on pump. 8. Check for single phasing, tripped overload, or short in wiring.

CAM SERIES PUMP

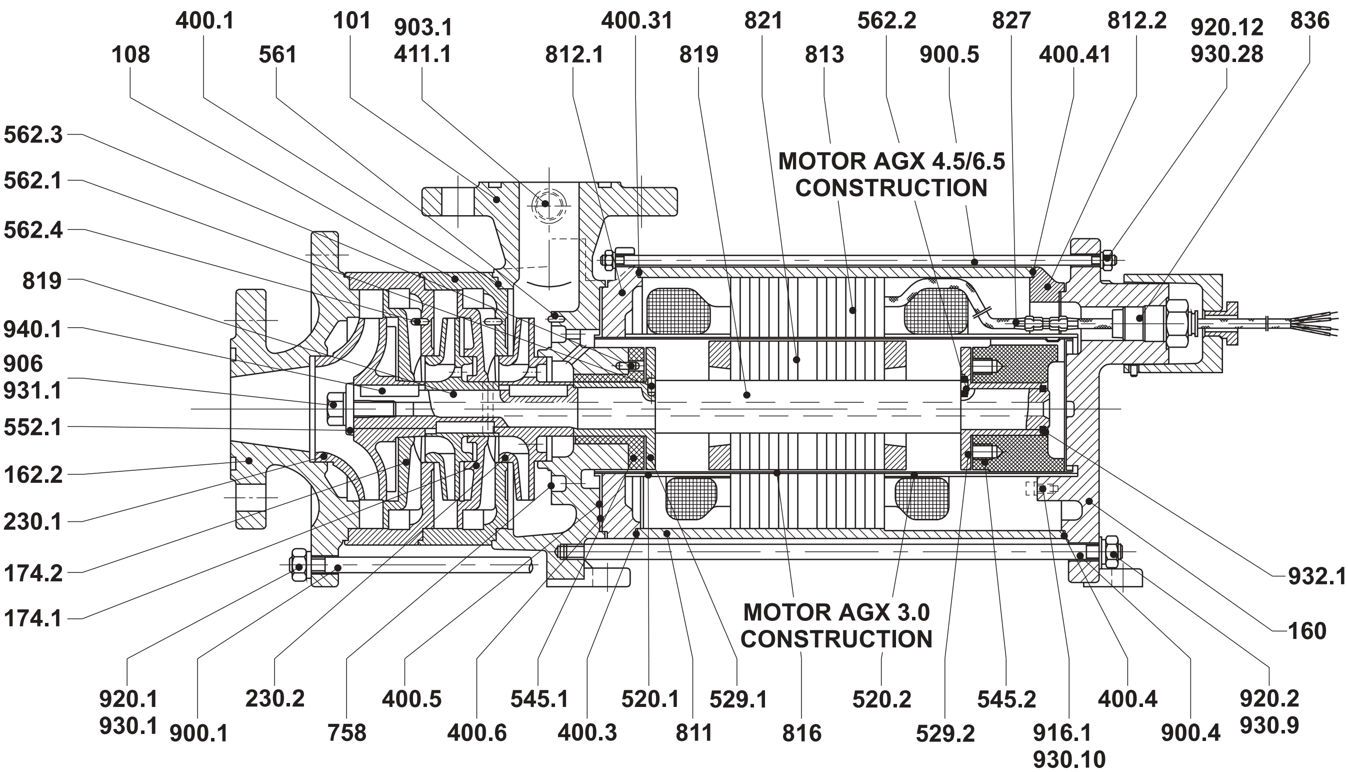


Figure 9

Item No.	Description	Item No.	Description	Item No.	Description
101	Pump Casing	529.1	Front Bearing Sleeve	827	Cable Adaptor
108	Stage Casing	529.2	Rear Bearing Sleeve	836	Cable Assembly
160	Motor Cover	545.1	Front Bearing	900.1	Stage Casing Stud Bolt
162.2	Suction Cover, Multi Stage	545.2	Rear Bearing	900.4	Stator Stud Bolt
174.1	Diffuser Insert	552.1	Retaining Plate	900.5	Stator Stud Bolt (small diameter)
174.2	Diffuser Insert	561	Dowel Pin	903.1	Gauge Port Plug
230.1	Impeller-Stage 1	562.1	Cylindrical Pin	906	Impeller Screw
230.2	Impeller-Multi Stage	562.2	Cylindrical Pin	916.1	Ground Screw
400.1	Motor Casing Gasket	562.3	Cylindrical Pin	920.1	Hexagon Stage Casing Nut
400.3	Motor Casing Gasket	562.4	Cylindrical Pin	920.2	Hexagon Motor Casing Nut
400.31	Motor Casing End Plate Gasket (AGX 4.5, 6.5)	758	Filter Insert	920.12	Hexagon Stator Casing Nut (small diameter)
400.41	Motor Casing End Plate Gasket (AGX 4.5, 6.5)	811	Motor Casing	930.1	Lockwasher
400.4	Sealing Plate Gasket	812.1	Motor Casing End Plate	930.9	Lockwasher
400.5	Sealing Plate Gasket	812.2	Motor Casing End Plate (AGX 4.5, 6.5)	930.10	Lockwasher
400.6	Gasket	813	Stator	930.28	Lockwasher
411.1	Gauge Port Ring	816	Stator Lining-Can	931.1	Tabwasher
520.1	Front Reinforcing Sleeve	819	Motor Shaft	932.1	Locking Ring
520.2	Rear Reinforcing Sleeve	821	Rotor	940.1	Parallel Key

Table 7

CAM SERIES PARTS LIST

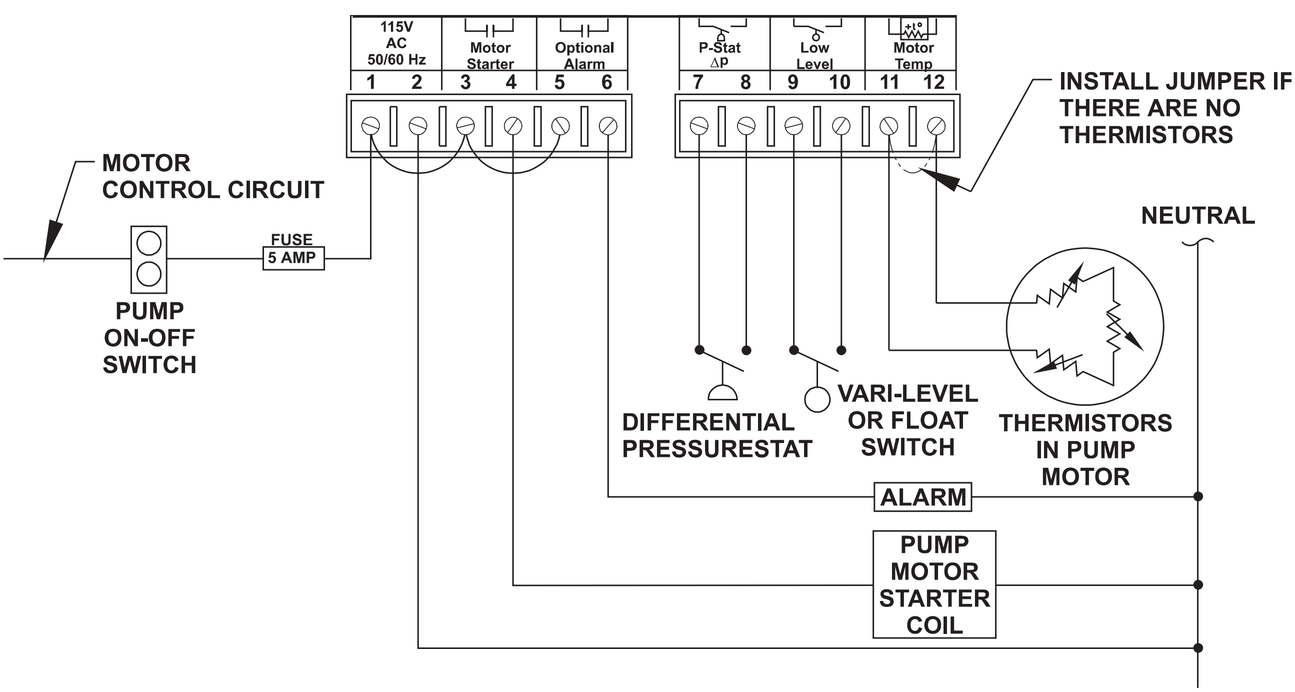
ITEM NO.	Catalog No. Motor Size (Impeller Diameter)	CAM 1/3 AGX 1.0 (80mm)	CAM 2/2 AGX 3.0 (114mm)	CAM 2/3 AGX 3.0 (114mm)	CAM 2/3 AGX 4.5 (114mm)	CAM 2/5 AGX 3.0 (114mm)
	Description	**Part Numbers**				
1*	Gasket Set	61-1035	61-1036	61-1050	61-1037	61-1052
230.1	Impeller - Stage 1	61-0285	61-0286	61-0286	61-0286	61-0286
230.2	Impeller - Multi Stage	61-0288	61-0287	61-0287	61-0287	61-0287
520.1	Front Reinforcing Sleeve	--	61-0207	61-0207	61-0209	61-0207
520.2	Rear Reinforcing Sleeve	--	61-0208	61-0208	61-0210	61-0208
529.1	Front Bearing Sleeve	61-0102	61-0065	61-0065	61-0065	61-0065
529.2	Rear Bearing Sleeve	61-0102	61-0065	61-0065	61-0065	61-0065
545.1	Front Carbon Bearing	61-0104	61-0067	61-0067	61-0067	61-0067
545.2	Rear Carbon Bearing	61-0104	61-0013	61-0013	61-0068	61-0013
816	Stator Lining - Can	61-0185	61-0183	61-0183	61-0182	61-0183
836	Cable Assembly	61-0197	61-0197	61-0197	61-0197	61-0197
931.1	Tabwasher	61-0153	61-0155	61-0155	61-0155	61-0155
940.1	Impeller Key	61-0088	61-0090	61-0090	61-0090	61-0090
--	Spare Motor	61-0200	61-0201	61-0201	61-0202	61-0201

*Gasket set consists of item numbers: 400.1, 400.3, 400.4, 400.5, 400.6, 411.1, and companion flange gaskets for CAM series pumps with AGX 1.0 or 3.0 motors. Item numbers: 400.1, 400.31, 400.4, 400.41, 400.5, 400.6, 411.1, and companion flange gaskets for CAM series pumps with AGX 4.5 or 6.5 motors.
Hermetic pump companion flange gaskets CAM 1/3 inlet, NW 25, 61.0037, outlet NW 20, 61.0036. CAM 2 (all) inlet, NW 40, 61.0039, outlet, NW32, 61.0038.

Table 8

PUMP CONTROLLER TYPICAL WIRING

(See also *Pump Guardian* Instruction Bulletin HP519)



Note: The Pump Guardian works with simple non-time delay, non-manual restart differential pressure cutouts having no integral time delay switch and also directly connects to any Hansen pump motor winding temperature sensor circuit with need of the INT-69 controller.

CNF SERIES PUMP

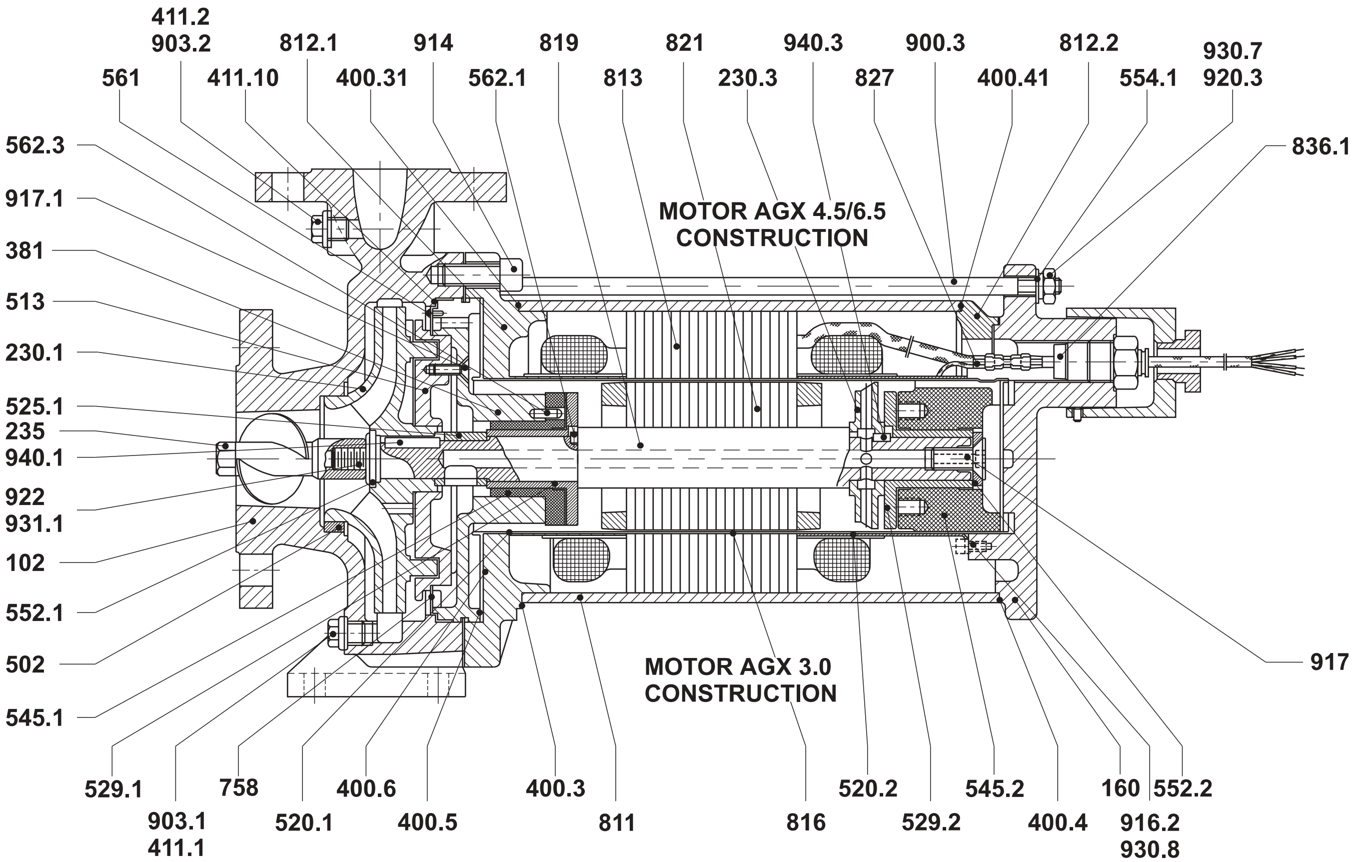


Figure 10

Item No.	Description	Item No.	Description	Item No.	Description
102	Volute Casing	520.2	Rear Reinforcing Sleeve	819	Motor Shaft
160	Motor Cover	525.1	Distance Sleeve	821	Rotor
230.1	Impeller	529.1	Front Bearing Sleeve	827	Cable Adaptor
230.3	Second Impeller	529.2	Rear Bearing Sleeve	836.1	Cable Assembly
235	Inducer	545.1	Front Bearing	900.3	Stator Stud Bolt
381	Bearing Insert	545.2	Rear Bearing	903.1	Screw Plug
400.3	Motor Casing Gasket	552.1	Retaining Plate	903.2	Screw Plug
400.4	Motor Casing Gasket	552.2	Retaining Plate	914	Int. Hex. Head Screw
400.5	Sealing Plate Gasket	554.1	Washer	916.2	Ground Screw
400.6	Sealing Plate Gasket	561	Grooved Dowel Pin	917	Countersunk Hex. Screw
400.31	Motor Casing End Plate Gasket (AGX 4.5, 6.5)	562.1	Cylindrical Pin	917.1	Countersunk Hex. Screw
400.41	Motor Casing End Plate Gasket (AGX 4.5, 6.5)	562.3	Cylindrical Pin	920.3	Hexagon Motor Casing Nut (17 mm)
411.1	Gauge Port Ring	758	Filter Insert	930.7	Lockwasher
411.2	Gauge Port Ring	811	Motor Casing	930.8	Lockwasher
411.10	Volute Casing Ring	812.1	Motor Casing Cover	931.1	Tabwasher
502	Wear Ring	812.2	Motor Casing Cover (AGX 4.5, 6.5)	940.1	Parallel Key
513	Wear Ring Insert	813	Stator	940.3	Parallel Key
520.1	Front Reinforcing Sleeve	816	Stator Lining - Can		

CNF SERIES PARTS LIST

Item No.	Catalog No. Motor Size (Impeller Diameter)	CNF 32-160 AGX 3.0 (165 MM)	CNF 40-160 AGX 4.5 (169 MM)	CNF 40-160 AGX 6.5 (150 MM)	CNF 50-160 AGX 6.5 (158 MM)	CNF 50-160 AGX 8.5 (130 MM)
	Description	**Part Numbers**				
1*	Gasket Set	61-1056	61-1040	61-1040	61-1053	61-1042
230.1	Impeller**	61-0317	61-0282	61-0309	61-0284	61-0283
235	Inducer	61-0318	61-0195	91-0195	61-0196	61-0196
472.1	Slide Ring	--	--	--	--	61-0075
502	Wear Ring	FACTORY	61-0069	61-0069	61-0082	61-0082
520.1	Front Reinforcing Sleeve	61-0207	61-0187	61-0187	61-0189	61-0191
520.2	Rear Reinforcing Sleeve	61-0208	61-0188	61-0188	61-0190	61-0192
525.1	Distance Sleeve	61-0070	61-0070	61-0070	61-0070	61-0077
529.1	Front Bearing Sleeve	61-0065	61-0065	61-0065	61-0065	61-0078
529.2	Rear Bearing Sleeve	61-0065	61-0065	61-0065	61-0065	61-0065
545.1	Front Carbon Bearing	61-0067	61-0067	61-0067	61-0067	61-0080
545.2	Rear Carbon Bearing	61-0013	61-0068	61-0068	61-0068	61-0068
816	Stator Lining¾Can	61-0306	61-0181	61-0181	61-0181	61-0184
836	Cable Assembly	61-0198	61-0198	61-0198	61-0198	61-0199
931.1	Tabwasher	61-0194	61-0194	61-0194	61-0194	61-0194
940.1	Impeller Key	61-0090	61-0090	61-0090	61-0090	61-0090
--	Spare Motor	61-0339	61-0203	61-0204	61-0204	61-0205

*Gasket set consists of item numbers: 400.3, 400.4, 400.5, 400.6, 411.1, 411.2, 411.10 and companion flange gaskets for CNF series pumps with AGX 3.0 motor. Item numbers: 400.31, 400.4, 400.41, 400.5, 400.6, 411.1, 411.2, 411.10, and companion flange gaskets for CNF series pumps with AGX 4.5 or 6.5 motors. Item numbers: 400.3, 400.4, 400.5, 400.6, 411.1,411.2, 411.10, and companion flange gaskets for CNF series pumps with AGX 8.5 motor.

**Older style CNF series pumps have a vane type impeller. Contact Hansen for part numbers. Hermetic pump companion flange gaskets CNF 32-160 inlet, NW 50, 61.0040, outlet, NW 32, 61.0039. CNF 40-160 (all) inlet, NW 65, 61.0041, outlet, NW 40, 61.0039. CNF 50-160 (all) inlet. NW80, 61.0042, outlet, NW 50, 61.0040.

Table 10

PUMP ACCESSORIES

Part Number	Description	Supplied Standard with:	
		Complete Pump	**Bare Pump (Spare Only)**
61.0001	Differential Pressurestat with 30 second delay (standard)	yes	no
61.0055	Replacement INT-69 motor over-temperature control, 120 volts (CNF series)	yes	no
61.0056	Replacement INT-69 motor over-temperature control, 220 volts (CNF series)	FACTORY (request)	no
FACTORY	Q-min flow control orifice (incl. flanges)	yes	no
FACTORY	Pump companion flanges	yes	no
FACTORY	Q-max flow control orifice	yes	no
FACTORY	Optional constant flow regulator (replaces Q-max orifice) for maximum capacity at higher discharge pressure	FACTORY (request)	no
PG1	Pump Guardian Pump Controller (115V standard, 230V available)	FACTORY (request)	no
FACTORY	Differential Pressurestat with no delay for use with *Pump Guardian* Pump Controller	FACTORY (request)	no

SERVICE AND MAINTENANCE

When properly installed, these pumps with their sealless design and hydrodynamic bearings generally experience very little wear on parts. Pumps should run vibration free and without noise. Noise or vibration indicates a fault, DO NOT RUN PUMP. Regardless, it is recommended that after five years the bearings be checked for wear (sooner if there is any unusual rotation noise or repeated safety device cutouts) that bearings be checked for wear.

Only qualified refrigeration technicians using suitable tools should dismantle and repair Hansen Hermetic Pumps. Follow refrigeration system safe procedures and read and understand the Caution section of this bulletin. Before attempting to remove or dismantle the pump, be sure it is completely isolated from the refrigeration system and all refrigerant is removed (pumped out to zero pressure).

AXIAL SHAFT PLAY

Leave the pump intact and through the pump inlet opening push the shaft completely back. Using calipers or other accurate measuring device, measure from the end of the shaft to the pump flange face. Next, pull the shaft completely forward and take a second measurement. The difference between the two measurements is the axial shaft play. If the difference is greater than the appropriate Maximum Axial Bearing Clearance ($S_{A\ MAX}$) in Table 11, replace the bearings.

BEARING REPLACEMENT

The item numbers in parenthesis and replacement parts referenced below are described on page 12 for CAM pumps and page 14 for CNF pumps.

CAM SERIES PUMPS

1. Loosen the 8 hexagon nuts (920.1), remove the suction cover (162.2).
2. Bend down the tab washer (931.1), unscrew the impeller screw (906) and take off the first impeller.
3. Remove the impeller key from the shaft, remove the stage casing (108) and take out the second impeller.
4. Remove any additional impellers.
5. Loosen the 4 hexagon nuts (920.2) and completely remove the motor from the pump casing (101). Take off the front bearing assembly (381).
6. Remove the rear carbon bearing (545.2) with the help of the stator stud bolts (900.4); see Figure 11. To prevent bearing and stator lining damage, pull the bearing gently, pushing the bearing back if necessary to wipe dirt particles from the stator lining. Lightly oil the stator lining to facilitate removal of the carbon bearing.
7. Measure the front and rear carbon bearing and bearing sleeve diameters (529.1/2). If the difference between diameters D_N and d_N exceeds the appropriate Maximum Bearing Clearance ($S_{N\ MAX}$) in Table 11, then replace the bearings and sleeves.
8. Check the stator electrical resistance per Stator Winding Inspection section (page 18).
9. Visually check stator lining "CAN" (816) for scratches, gouges, and dents. If the stator lining is damaged, return it to the factory or qualified motor repair shop for replacement.

CNF SERIES PUMPS

1. Loosen 8 socket (10 mm) screws (914) and withdraw the motor from the pump. Check the stator resistance per Stator Winding Inspection section.
2. To remove the rotor assembly, tap on the inducer to push the bearing insert (381), rotor, and impeller from the pump housing.
3. Bend up the tab washer (931.1) and remove the inducer (235) and the retaining plate (552.1). Withdraw the impeller (230) from the motor shaft (819). Take off the front bearing assembly (381).
4. To remove the auxiliary impeller and rear bearing and sleeve, loosen the countersunk hexagon (8 mm) screw (917) and withdraw the bearing sleeve (529.2) from the shaft.
5. Remove the carbon bearing (545.2) on the motor side with the help of the stator stud bolts (900.3); see Figure 10. To prevent bearing and stator lining damage, pull the bearing gently, pushing back if necessary to wipe dirt particles from the stator lining. Lightly oil the stator lining to facilitate removal of the carbon bearing.
6. Measure the front and rear carbon bearing and bearing sleeve diameters (529.1/2). If the difference between diameters D_N and d_N exceeds the appropriate Maximum Bearing Clearance ($S_{N\ MAX}$) in Table 11, then replace the bearings and sleeves.
7. Check the stator electrical resistance per Stator Winding Inspection section (page 18).
8. Visually check stator lining "CAN" (816) for scratches, gouges, and dents. If the stator lining is damaged, return it to the factory or qualified motor repair shop for replacement.

RE-ASSEMBLY

Check the impellers, wear rings, and bearings for wear traces and the stator lining for friction traces. Replace damaged parts; part numbers are listed on pages 13 and 15. Check for debris lodged in the passageway of the enclosed impeller. Clean all parts before assembly. If new impellers or rotors are installed, the complete assembly must be rebalanced.

To install rear bearing, first clean and lightly oil the stator lining. Install the bearing using the stator stud bolts (CAM 900.4, CNF 900.3) per Figure 11. Gently push bearing in to the can, lining up the notch in the bearing with the notch in the can. Careful do not to bend the stud bolts or twist the bearing. The remaining steps in reassembling the pump should be performed in the reverse order of disassembly. When reassembling the pump, use new gaskets. The impeller screw must be secured with a tab washer (931.1) in good condition. Torque bolts (914, 920.3) on CNF and nuts (920.1/2) on CAM to 40 ft-lbs. After assembly is complete, rotate the shaft by hand through pump inlet opening to make sure the rotor spins freely and recheck axial shaft play. Pressure test the pump for leaks before putting it back into service.

BEARING REMOVAL

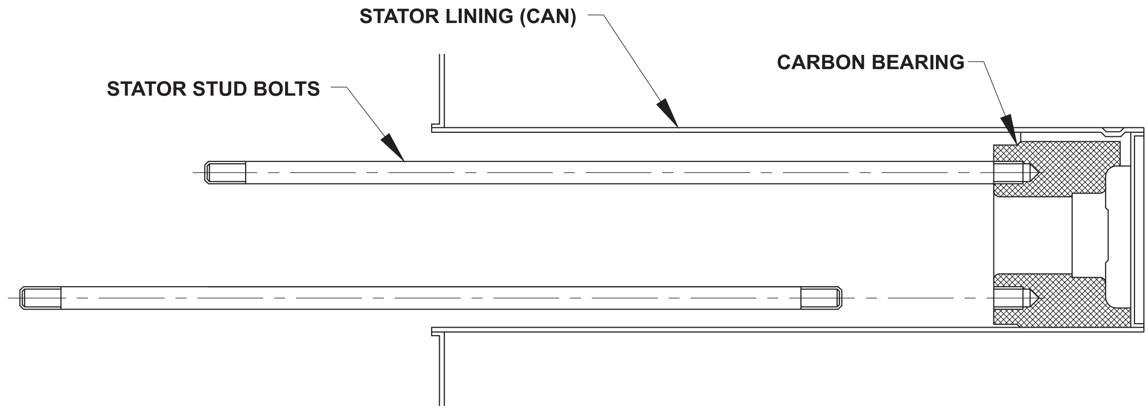


Figure 11

BEARING AND SLEEVE WEAR

At the point of most wear, measure both the outside diameter of the bearing sleeve (d_N) and the inside diameter of the carbon bearing (D_N), see below. Subtract the two measurements to determine the bearing clearance (S_N). Compare measurements to the values in Table 11. If the measured values exceed maximum values given, then replace the bearings and sleeves.

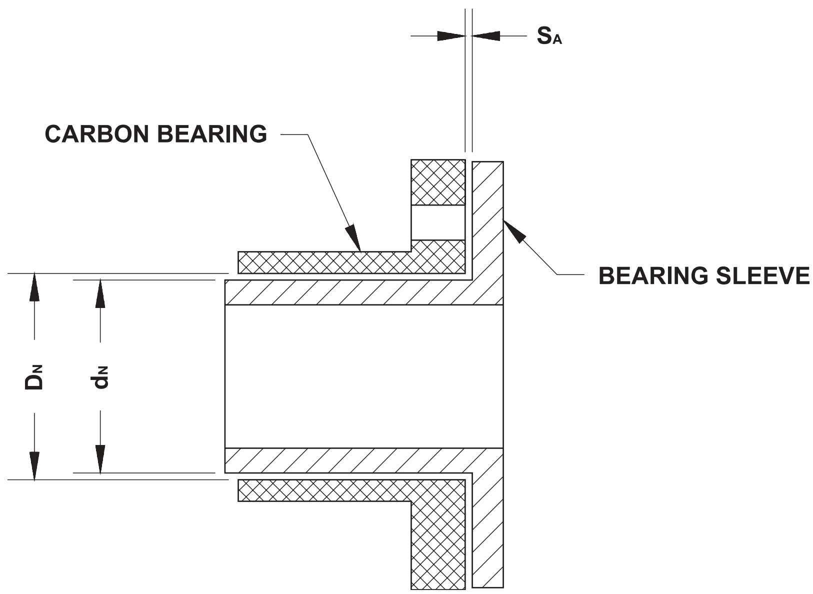


Figure 12

BEARING DIMENSIONS							
	DESCRIPTION	AGX 1.0		AGX 3.0, 4.5, 6.5		AGX 8.5	
		FRONT	REAR	FRONT	REAR	FRONT	REAR
D_N	Nominal Bearing ID	.945"		1.262"		1.772"	1.262"
d_N	Nominal Bearing Sleeve OD	.937"		1.252"		1.762"	1.252"
S_N*	Nominal Bearing Clearance	.008"		.008"		.010"	.008"
$S_{N\ MAX}$	Maximum Bearing Clearance	.013"		.013"		.016"	.013"
S_A	Nominal Axial Bearing Clearance	.031"		.031"		.031"	
$S_{A\ MAX}$	Maximum Axial Bearing Clearance	.059"		.059"		.059"	

*$S_N = D_N - d_N$

Table 11

STATOR WINDING INSPECTION

A multimeter and insulation tester are needed to check stator winding resistances. To test for ground fault, connect one test lead of the multimeter to the pump ground wire and the other test lead to the motor housing. The reading should be 0.1 ohm or less. With one test lead connected to the ground wire, check for electric short to ground by individually connecting each pump lead wire with the other test lead (also, check thermistor lead wires if pump is CNF series). Reading should be infinite, if not stator may need rewinding or dry baking to remove moisture.

Connect Tester Lead 1 to	Connect Tester Lead 2 to	Reading
U-1	V-1	U-1
U-1	W-1	V-1
V-1	W-1	W-1

Table 12

Next, verify motor winding by checking electrical resistance between pump lead wires by connecting the two test leads to the lead wires per Table 12. Compare the three reading taken to those in Table 4 (page 6). If CNF series, test thermistor resistance by connecting one lead to each thermistor wire, a constant, steady ohm reading should appear. If no reading or the reading is erratic, then thermistors need replacing.

Use installation tester (Megger) to test the electrical insulation by connecting one test lead to the ground wire and the other test lead individually to each of the pump lead wires. Readings should be 750 M ohms or more. If not, stator may need to be rewound or baked to remove moisture. Consult the factory or qualified motor shop.

CAUTION

Whenever a pump filled with cold liquid refrigerant is isolated from a system by closing valves in pump suction and discharge lines, the vent/bypass valve must be open. Otherwise, ambient heat may cause excessive hydrostatic pressure due to solid liquid thermal expansion in the pump leading to casing failure and possible serious injury.

Hermetic Pumps are for refrigeration systems only. These instructions and related safety precautions must be read completely and understood before selecting, using, or servicing these pumps. Only knowledgeable, trained refrigeration technicians should install, operate, or service these pumps. Stated temperature and pressure limits should not be exceeded. Pumps should not be removed or disassembled unless the system has been evacuated to zero pressure. See also Safety Precautions in the current List Price Bulletin and the Safety Precautions Sheet supplied with the product. Escaping refrigerant can cause injury, especially to the eyes and lungs.

WARRANTY

These pumps must never be operated without ample refrigerant liquid flowing through the pump for motor cooling and bearing lubrication. To help ensure liquid refrigerant flow, the following protective controls must be properly installed.

1. The supplied Differential Pressurestat must be connected to the pump suction or accumulator and the pump discharge to stop the pump if the pressure difference is less than 10 psi after the time delay period indicating inadequate flow.

2. A low level float switch or control must be installed to stop the pump if the liquid level above the pump inlet drops below stated system required minimum NPSH.

3. All CNF series pumps are supplied with thermistor motor over-temperature sensor (not standard for CAM). These **MUST BE** connected to the appropriate electronic circuit of the supplied INT-69 motor control module (or the optional *Pump Guardian* pump controller). The INT-69 must be wired to interrupt the motor control circuit if high motor temperature occurs. The thermistor must never be wired directly to line voltage or control voltage.

4. The supplied Q-max flow control orifice or constant flow regulator must be installed in the discharge line. See Q-max Flow Control Orifice or Constant Flow Regulator sections and Figure 3.

5. The supplied Q-min flow control orifice must be properly installed in the vent/bypass line. See the Q-min Flow Control Orifice section and Figure 3.

If the above precautions are followed and the pump is installed on a clean, properly-designed system, mechanical parts are guaranteed for one year from date of shipment and electrical parts for 90 days from date of shipment, F.O.B. the factory. The pump should normally operate for many years without servicing.

DISCLAIMER: This warranty does not pertain to any pump connected to a Differential Pressurestat having auto-reset or any different controls instead of the Hansen supplied Differential Pressurestat with manual reset. Differential Pressurestat or controls without manual reset must be used in conjunction with a device to alarm if more that (5) losses of differential pressure across the pump occur within an hour such as Pump Guardian. Failure to observe the above requirements can greatly shorten the life of the pump being with potentially pump destroying consequences.

PRESSURE/TEMPERATURE

Refrigerant Temperature (°F)	R717 (psig)	R22 (psig)	R134a (psig)
100	197.2	195.9	138.8
90	165.9	168.4	119.0
80	138.3	143.6	101.3
70	114.1	121.4	85.7
60	92.9	101.6	72.0
50	74.5	84.0	60.1
40	58.6	68.5	49.7
30	45.0	54.9	40.7
20	33.5	43.0	33.1
10	23.8	32.8	26.6
0	15.7	23.9	21.1
-10	9.0	16.4	16.6
-20	3.6	10.1	12.8
-30	1.6*	4.8	9.8
-40	8.7*	.52	7.4
-50	14.3*	6.1*	5.5
-60	18.6*	11.9*	4.0

*Inches of mercury below one atmosphere.

Table 13

GPM/TON RATIO

Refrigerant Temperature (°F)	R717	R22	R134a
60	0.075	0.236	0.242
50	0.073	0.226	0.233
40	0.070	0.217	0.223
30	0.068	0.208	0.215
20	0.067	0.204	0.208
10	0.065	0.196	0.203
0	0.064	0.189	0.195
-10	0.062	0.184	0.190
-20	0.061	0.178	0.184
-30	0.059	0.174	0.179
-40	0.058	0.169	0.174
-50	0.057	0.165	0.170
-60	0.056	0.161	0.166
-70	0.055	0.158	0.162
-80	0.053	0.154	0.158

To determine the GPM required, multiply the system tonnage by the factor in the above table at the required temperature. Multiply the resultant GPM by the system recirculation rate (i.e. 3:1, 4:1, etc.) to determine the required GPM of the pump.

Table 14

PRESSURE/HEAD (FT) RATIO

Refrigerant Temperature (°F)	R717	R22	R134a
100	0.253	0.495	0.501
90	0.257	0.505	0.511
80	0.260	0.515	0.518
70	0.264	0.524	0.531
60	0.267	0.533	0.540
50	0.271	0.542	0.549
40	0.274	0.550	0.557
30	0.278	0.559	0.566
20	0.281	0.567	0.573
10	0.283	0.574	0.578
0	0.287	0.582	0.588
-10	0.290	0.590	0.593
-20	0.293	0.597	0.602
-30	0.296	0.604	0.606
-40	0.299	0.611	0.614
-50	0.303	0.618	0.620
-60	0.305	0.625	0.627

To convert head (in feet) to psi, multiply the head by the factor in the above table at the required temperature.

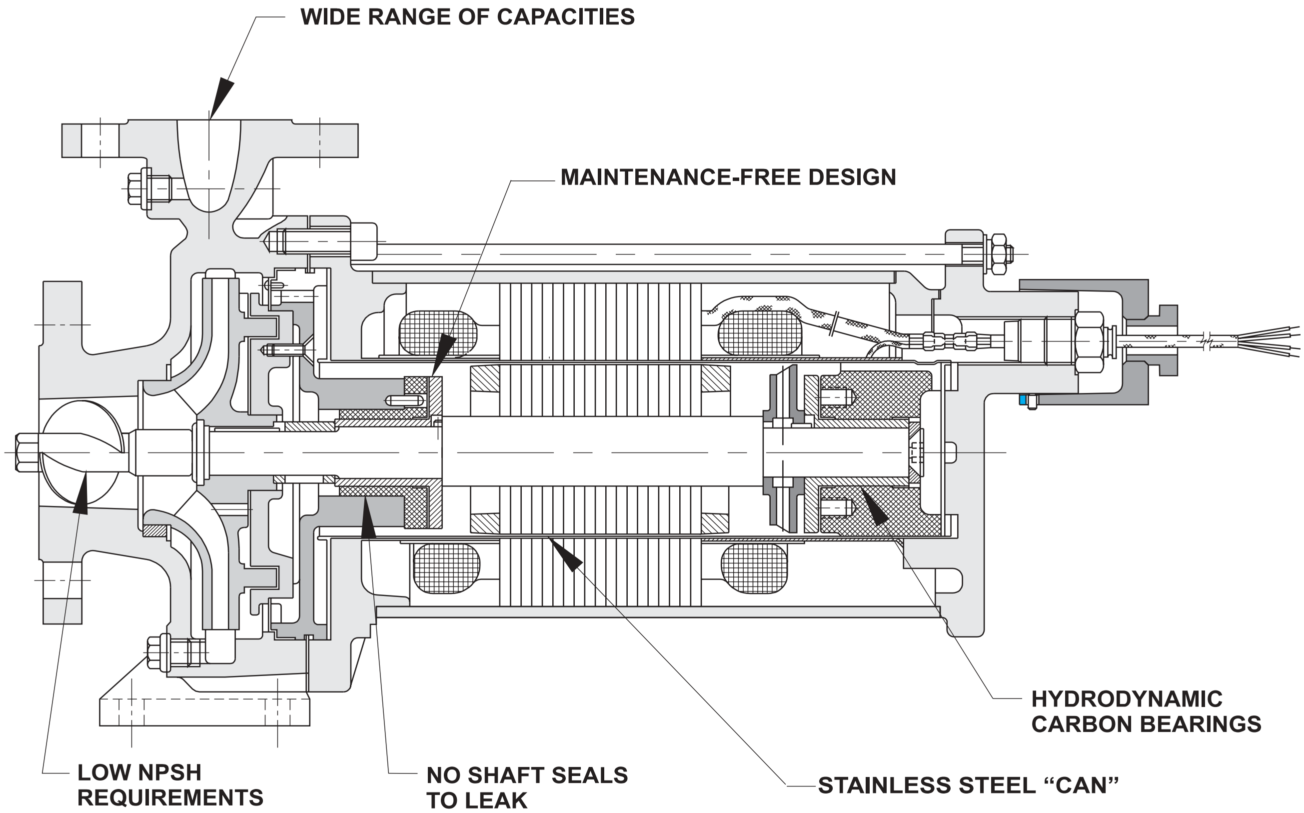
Table 15

STANDARD PUMP SPECIFICATIONS

Refrigerant	Catalog Number (impeller dia.)	Nom. H.P.	Weld Neck Flanged Connections Inlet/Outlet*	System Required Minimum NPSH †	Nominal Ratings With Q-max Orifice GPM	Nominal Ratings With Q-max Orifice PSID	Nominal Ratings With Flow Regulator GPM	Nominal Ratings With Flow Regulator PSID
Ammonia	CAM 1/3 AGX 1.0 (80 mm)	1 1/2	1" / 3/4"	2.5 ft	7	25	14	22
	CAM 2/2 AGX 3.0 (114 mm)	3	1 1/2" / 1 1/4"	3.5 ft	26	18	32	20
	CAM 2/3 AGX 3.0 (114 mm)	3	1 1/2" / 1 1/4"	3.5 ft	27	25	32	33
	CAM 2/5 AGX 3.0 (114 mm)	3	1 1/2" / 1 1/4"	3.5 ft	22	50	32	60
	CNF 32-160 (165 mm) AGX 3.0	3	2" / 1 1/4"	4.5 ft	50	25	60	37
	CNF 40-160 (169 mm) AGX 4.5	5	2 1/2" / 1 1/2"	5.5 ft	75	25	98	38
	CNF 40-200 (209 mm) AGX 6.5	7 1/2	2 1/2" / 1 1/2"	5.5 ft	75	36	98	51
	CNF 50-160 (158 mm) AGX 6.5	7 1/2	3" / 2"	5.5 ft	150	25	185	40
	CNF 50-200 (180 mm) AGX 8.5	10	3" / 2"	6.5 ft	150	31	185	47
R22, R134a, and Other Compatible Refrigerants	CAM 1/3 AGX 1.0 (80 mm)	1 1/2	1" / 3/4"	2.5 ft	9	35	14	45
	CAM 2/2 AGX 3.0 (114 mm)	3	1 1/2" / 1 1/4"	3.5 ft	22	35	32	40
	CAM 2/3 AGX 4.5 (114 mm)	5	1 1/2" / 1 1/4"	3.5 ft	27	35	32	65
	CNF 40-160 (150 mm) AGX 6.5	7 1/2	2 1/2" / 1 1/2"	5.5 ft	70	35	95	55
	CNF 50-160 (130 mm) AGX 8.5	10	3" / 2"	5.5 ft	140	35	175	40
Supermarket Pumps	CAM 1/2 AGX 1.0 (80 mm)	1 1/2	1" / 3/4"	2.5 ft	9	25	14	25
	CAM 2/2 AGX 1.0 (95 mm)	1 1/2	1 1/2" / 1 1/4"	3.5 ft	18	25	32	22

Above nominal ratings are based on 60Hz. Larger capacity and higher pressure boost pumps are available. Standard voltages: 440V/3/60Hz, 220V/3/60Hz, 575V/3/60Hz, 380V/3/50 Hz. Consult factory for 50 Hz applications and other voltages.

* Weld neck flanges are standard, however flanges bored to accept ODS coupling are available for CAM series pumps.
† Includes 1.5 ft. reserve for inlet piping losses.
Pump curves are available from factory.



TYPICAL SPECIFICATIONS

"Liquid refrigerant pump shall be centrifugal type, sealless hermetic design with rotor inside a stainless steel containment envelope (can) and internally cooled and lubricated by the pumped refrigerant. Isolated stator inside secondary containment chamber, as supplied by Hansen Technologies Corporation or approved equal."

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