SECTION 2.2.7.2
CANNED MOTOR PUMPS

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A canned motor pump (CMP) is a combination of a centrifugal pump and a squirrel cage induction motor built together into a single hermetically sealed unit (see Figure 1). The pump impeller (A) is normally of the closed type and is mounted on one end of the rotor shaft that extends from the motor section into the pump casing. The rotor (B) is submerged in the fluid being pumped and is therefore "canned" to isolate the motor parts from contact with the fluid. The stator (C) is also "canned" to isolate it from the fluid being pumped. Bearings (D) are submerged in system fluid and are, therefore, continually lubricated.

The canned motor pump has only one moving part, a combined rotor-impeller assembly that is driven by the magnetic field of an induction motor. A portion of the pumped fluid is allowed to recirculate through the rotor cavity to cool the motor and lubricate the bearings. A self-cleaning filter can be provided, on pumps having external circulation, to filter the recirculation fluid before it enters the bearing section of the motor. The stator windings and rotor armature are protected from contact with the recirculating fluid by a corrosion resistant, non-magnetic, alloy liner (E) that completely seals or "cans" the stator winding.

Modifications to the recirculation flow system are available to allow canned motor pumps to be used in any application including fluids up to 1000°F (538°C), volatile liquids, and liquids with solids.

BASIC DESIGN

Stator Assembly The stator assembly of canned motor pumps (see Figure 2) consists of a set of one or three-phase windings (A). Stator laminations (B) are constructed of low-silicon grade steel. Laminations and windings are mounted inside the cylindrical stator band (C). End bells (D and E), welded to the stator band, close off the ends of the stator

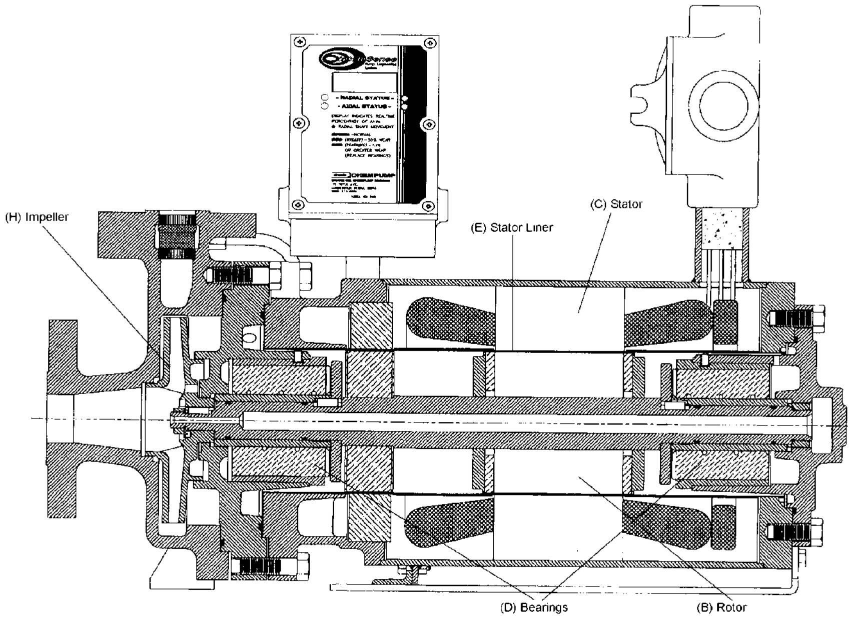


FIGURE 1 Typical canned motor pump

assembly. The stator liner (F) is supported on the outside diameter by the steel lamination of the motor. Back-up sleeves (G) are provided to strengthen those areas of the stator liner not supported by the stator laminations. The stator liner is, in effect, a cylindrical "can" placed in the stator bore and welded to the rear end bell and front end bell shroud to hermetically seal off the windings from contact with the liquid being pumped. Terminal leads (H) from the windings are brought out through a pressure tight lead connector (I) mounted on the stator band and terminated in a standard connection box.

Motors are either designed and manufactured specifically for use in canned motor pumps or components of conventional motor are modified. A variety of motor insulation types is available ranging from temperature limits of 266°F (130°C) to above 482°F (250°C).

Because the pump and motor are one unit, the complete assembly must be tested and approved for explosion-proof applications. Explosion-proof pumps are rated as either Class 1, Group D, Division 1 or Class 1, Group C & D, Division 1 locations. It is not uncommon to operate canned motor pumps with variable speed drive controllers.

Rotor Assembly The rotor assembly is a squirrel cage induction rotor constructed and machined for use in canned motor pumps (see Figure 3). It consists of a machined corrosion resistant shaft (A), laminated core (B) with copper or aluminum bars and end rings, corrosion resistant end covers (C), and a corrosion resistant can (D). Various methods are used to attach the impeller to the motor shaft (E).

The rotor end covers are welded to the shaft and to the rotor can that surrounds the outside of the rotor, thus hermetically sealing off the rotor core from contact with the liquid being pumped.

Some manufactures offer replaceable shaft sleeves (F) and axial thrust surfaces (G) for longer service life and ease of maintenance.

Bearings Only two bearings are required for canned motor pumps. These bearings are normally cooled and lubricated by the pumped fluid; therefore, they must be compatible

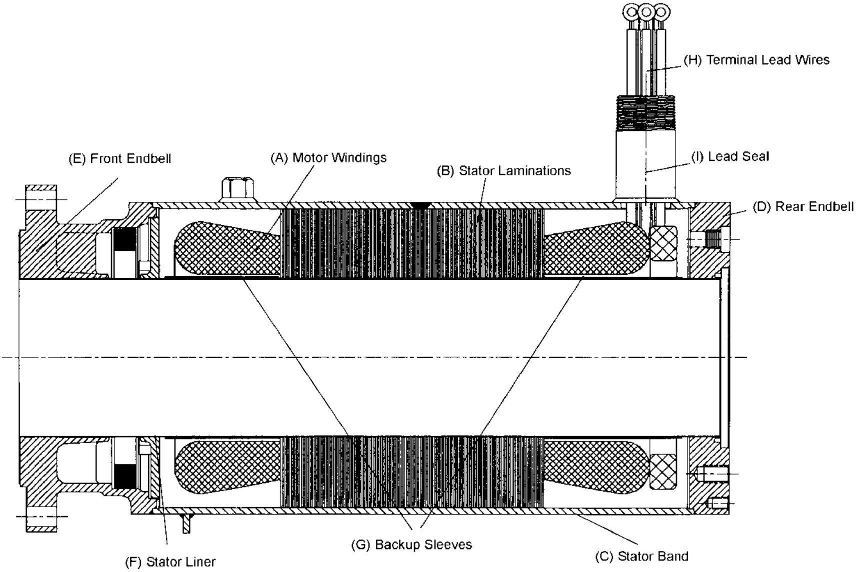


FIGURE 2 Stator assembly

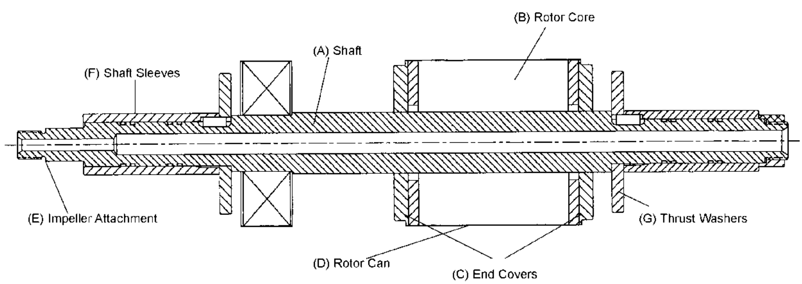


FIGURE 3 Rotor assembly

with the process fluid. A multitude of materials is available such as various grades of carbon graphite, silicon carbide, aluminum oxide, and many polymers. Bearing selection is dependent on the compatibility with the process fluid, amount of solids present, and pumping temperature.

A hydrodynamic bearing is the most common type of bearing used. The bearings can be either stationary or rotating with the rotor assembly. In either case, the fluid passes between the bearing and shaft journal, resulting on the rotating assembly running on a thin film of liquid, not the journal and bearing. Most bearings have helical grooves in the inside diameter to increase the flow of process fluid through the journal area, thereby decreasing the temperature of the bearings.

Internal Clearances The determination of the overall gap between the stator windings and the rotor armature is paramount in the design and operation of the pump. The wider the distance between the iron of the motor winding and the rotor armature, the less efficient the motor becomes. The material of construction of the stator liner and rotor sleeve also effects motor efficiency. Stainless steels and Hastelloy are the most common materials used for stator liners and rotor sleeves. Although stainless steel is less expensive, Hastelloy C has higher corrosion resistance, is a stronger material, and offers lower electrical losses. Motor efficiency in canned motor pumps is not only important for energy cost considerations, but also for the amount of heat input to the recirculation fluid.

The stator liner (a wetted, pressure boundary component) ranges in thickness between 0.010 to 0.040 in (0.254 to 1.016 mm). For high-pressure applications, the liner remains at the same thickness, but the outside diameter is supported by the motor laminations and by back up sleeves located on both sides of the motor. Canned motor pumps have been designed to withstand working pressures up to 5,000 lb/in^2 (345 bar) with 0.015 in (0.381 mm) stator liners and heavy walled back-up sleeves.

The rotor armature (a wetted component) is also protected from the process fluid by a sleeve and two end covers. The thickness of the rotor sleeve ranges from 0.010 to 0.25 in (0.254 to 6.35 mm). The radial running clearance between the rotating motor armature and the stationary stator liner is usually about 0.020 in (0.508 mm). The total diametral clearance can range from 0.040 to 0.075 in (1.016 to 1.905 mm), or higher, depending on the manufacturer's design.

Secondary Containment Canned motor pumps offer a level of safety and process fluid containment unavailable with any other type of pump. Positive, secondary containment of the process fluid is a built-in feature with canned motor pumps when the motor lead wires are housed in a pressure retaining lead seal. In case of a failure of the primary containment shell (stator liner), the outer stator band becomes a secondary containment vessel, preventing the process fluid from entering the environment.

The outer stator band is far removed from the rotation element, making it impossible for the rotating element to make contact. When secondary containment is required, the stator band assembly should be designed and tested to the same pressure and temperature rating as the pump.

PRINCIPLE OF OPERATION

Flow Path Most canned pumps, when pumping relatively clean fluids, will channel a small portion of the process fluid through the motor section. This fluid cools and lubricates the bearings and removes heat generated by the induction motor. The circulation path can be either external or internal to the pump. With external circulation (see Figure 4), the recirculation fluid is piped outside of the pump, through a filter, and then into the motor section of the unit. The filter assembly (see Figure 5) is self-cleaning and located in the discharge flange of the pump. Pumps having internal circulation have the recirculation contained within the pump. Filtering the recirculation liquid is not available with internal circulation.

In either external or internal circulation, the flow path is from the high pressure area of the pump (pump discharge or pump chamber at the tip of the impeller) returning to the low pressure area (near the hub or eye of the impeller). The amount of liquid recirculated through the motor section ranges from 2 to 16 gpm (7.5 to 60 l/m).

Many recirculation flow path modifications are available to allow a canned motor pump to pump any type of fluid. When pumping volatile fluids, the motor section can be pressurized by an auxiliary impeller located on the rotor. The recirculation fluid, which normally returns to the eye of the impeller, is channeled to the pressurized section of the liquid end, increasing the pressure in the motor section. This design allows a volatile fluid to remain liquid even with a temperature increase caused by motor heat (see Figure 6). Another method to handle fluids near their boiling point is to reverse the recirculation flow path. Instead of returning the heated liquid back to the eye of the impeller, the recirculation liquid is removed from the pump and returned to the suction vessel.

High temperature and slurry applications can be handled by canned motor pumps by isolating the bearings from the pumped fluid. The recirculating fluid in the motor section

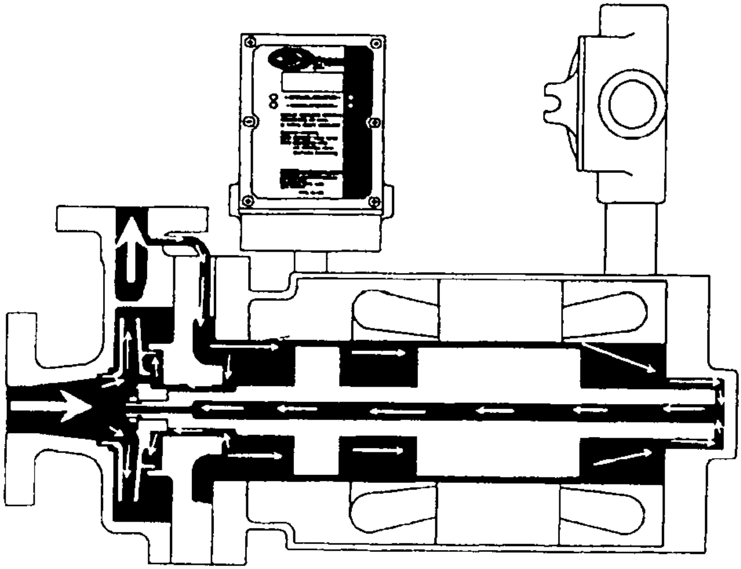


FIGURE 4 External circulation flow path

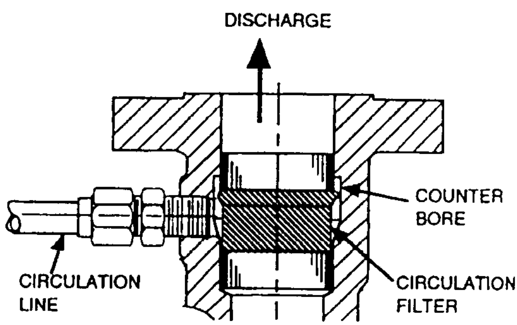


FIGURE 5 Self-cleaning filter assembly

is used for lubrication of the bearings and cooling of the motor. This fluid remains in the motor section and is circulated through the rotor cavity by an auxiliary impeller, which is an integral part of the rotor assembly. The fluid in the motor section is forced across the rotor and through the bearings, after which it flows through a heat exchanger. The heat exchanger is cooled by water or a suitable heat transfer fluid (see Figure 7). The motor section can be backflushed with a clean, cooled liquid when handling slurry.

In Hydraulic Institute Standard ANSI/HI 5-1-5.6, Figure 5.9 provides an excellent description of various recirculation flow plans for sealless pumps.

Thrust Balance Because most canned motor pumps use hydrodynamic bearings, the rotating assembly is allowed to float axially. This movement is known as "end play" and is defined as the movement of the rotor, in the axial direction, between the forward and

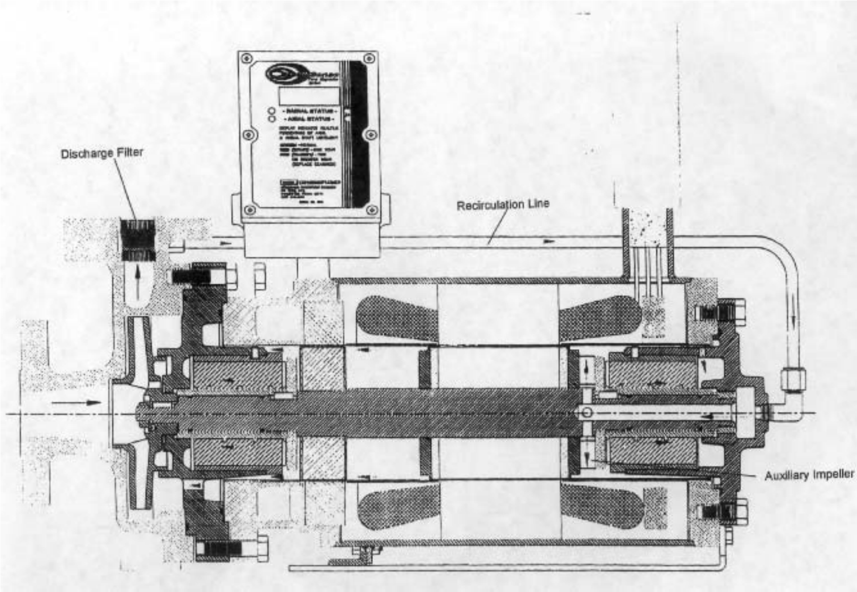


FIGURE 6 Pressurized circulation

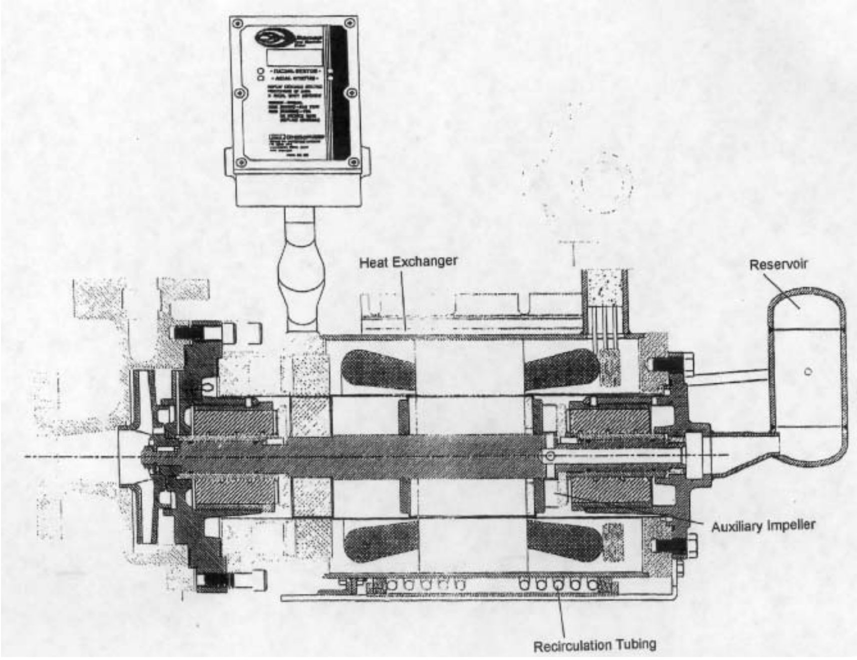


FIGURE 7 Isolated motor section

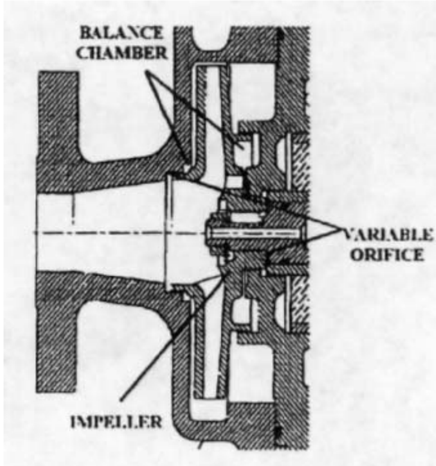


FIGURE 8 Automatic hydraulic thrust balance

rear contact points (normally the thrust bearings). Many canned motor pumps incorporate a principle of hydraulic thrust balance to position the rotation assembly between the forward and rear mechanical contact points. Based on hydraulic principles, automatic thrust balance is accomplished by the pressure of the pumped fluid. Pressure chambers are designed either within the pump chamber using the movement of the impeller or rear of the pump controlling the rate of return of the process fluid.

Figure 8 illustrates hydraulic thrust balance within the pump casing. Balance chambers are located on the front and rear of the impeller. When a change in axial load changes the position of the impeller, either forward or rear, there is an equalizing change of hydraulic pressure in the balance chambers, which immediately returns the rotation assembly into a balance position.

Pressure-Temperature Profile The single most important consideration in the application and successful operation of canned motor pumps is bearing environment control. The process fluid cools and lubricates the bearings and removes the heat generated by the motor. The bearings must remain in a liquid state to provide adequate bearing lubrication.

A number of variables must be considered when considering the state of the recirculation fluid. These variables include vapor pressure, specific heat, specific gravity, viscosity, pump efficiency, motor efficiency, motor load, recirculation flow rate, and the recirculation flow system. A vapor pressure curve versus temperature of the process fluid is also necessary. Figure 9 illustrates heat balance equations necessary to determine the temperature rise of the fluid within the motor section. Figures 10a, b, and c show pressure and temperature profiles for a specific fluid based on the heat balance equations within a canned motor pump modified for pressurized circulation. If the flow rate varies, a new profile should be calculated for each design condition.

A pressure-temperature profile should be calculated for any application where there is doubt concerning the condition of the recirculation fluid.

Installation The installation of a canned motor pump can be much less costly than a conventionally sealed unit because canned motor pumps do not require special baseplates or mounting pads. In fact, many canned motor pumps are stilt-mounted or bolted directly into the system piping. There is only one shaft in a canned motor pump; therefore, alignment of the pump to the driver is not necessary and pump orientation is not critical. The unit can be mounted either horizontally or vertically, with the pump casing

	pump model NC-A60-10-N5 Bypass, GP standard	0.000	Fluid- 95-5 TCS Reverse		Pressurise
desired flow, gpm	300.000		300.000		300.000
head, ft	240.000		240.000		240.000
temperature in, F	150		150		150
specific heat, btu/lb F	0.260		0.260		0.260
specific gravity	1.240		1.240		1.240
hydraulic power, hp	22.545		22.545		22.545
Total pump flow, gpm	300.000		300.000		300.000
pump efficiency - Note	58.0		58.0		58.0
motor output HP	38.871		38.871		38.871
Delivered Pump Head, Ft	240.000		240.000		240.000
motor efficiency, Note	80.0		80.0		80.0
motor input KW	36.233		36.233		36.233
Overall efficiency	46.4		46.4		46.4
impeller diameter, in.	8.500		8.500		8.500
Motor circulation flow,	6.600		6.000		6.000
Process Wire-Water Eff.	46.4		46.4		46.4
Total Circ rate, GPM, N	9.000		6.000		6.000
Psuct at NPSH= 61ft.	77.269		77.269		77.269
Temperature rise:					
Standard circ (pump)	1.37				1.37
temp. pump exit	151.4				151.4
circ flow (motor)	23.2				25.6
total temperature rise	24.6				26.9
max temp. circ. flow	174.6				176.9
Est. P vap, psia	63.102				
Reverse circ (pump)			0.82		
temp. pump exit			150.8		
circ flow (motor)			25.6		
Total temperature rise			26.4		
max. temp. circ. flow			176.4		
Est. P vap, psia			64.630		
Percent max circ flow			0.900		
Min. Motor pressure, psig			112.088		
Circ press/ differential			0.270		

Note 1. Efficiency at "Total pump flow"
Note 2. Total Circ Flow includes front bearing flow (does not affect te
Note 3. Motor efficiency includes windage loss (correct for specific gr
Note 4. System heat added with reverse circulation is "total heat" less

heat balance:

	standard		Reverse		Pressurise
Total heat input, btu/m	1104.689		1104.689		1104.689
Standard circ (pump)	1105.871		0.000		1105.871
Motor heat, btu/min	412.198		412.198		412.198
Circ flow heat	412.638		0.000		412.638
Also motor heat, btu/mi	412.198		412.198		412.198

FIGURE 9 Heat balance calculations

up or down. The sleeved bearings are located in the bearing housing. Alignment of the bearings is accomplished by a register fit between the bearing housings and the stator assembly.

Diagnostics Some canned motor pump manufacturers have developed diagnostic systems that monitor the condition of the internal wear surfaces of the pump. Because the

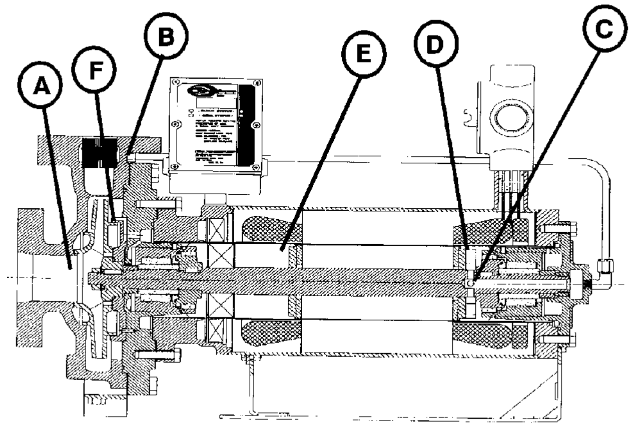


FIGURE 10A Pressurized circulation—points of reference

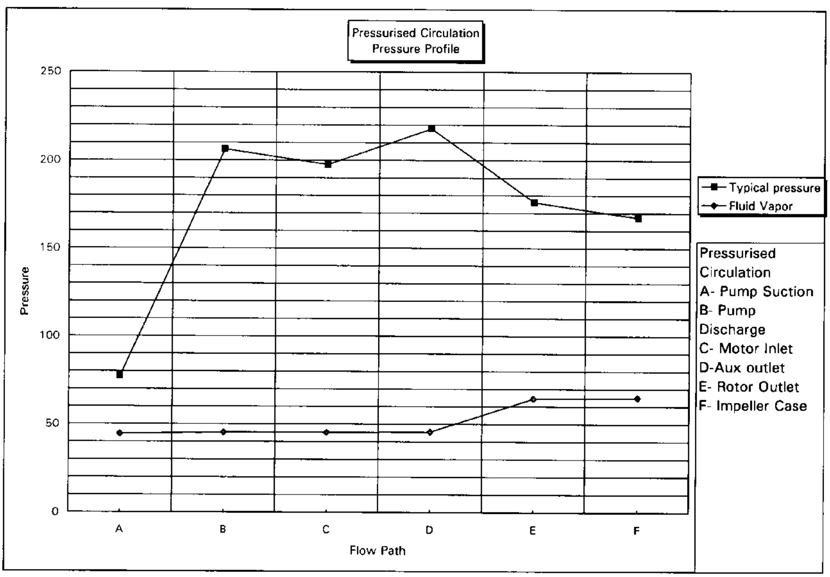


FIGURE 10B Pressurized circulation pressure profile

rotating components of the pump are not visible, even the direction of rotation can not be easily determined.

Advanced diagnostic systems indicate both axial and radial wear continuously. Continuous wear indication allows the pump user to trend the wear of the pump and schedule standard wear parts replacement long before a major failure occurs.

Remote outputs are also available on these diagnostic systems. These outputs include either a digital or analog signal, or a relay designed to shut down the pump—or signal an alarm—when a certain amount of bearing wear has occurred.

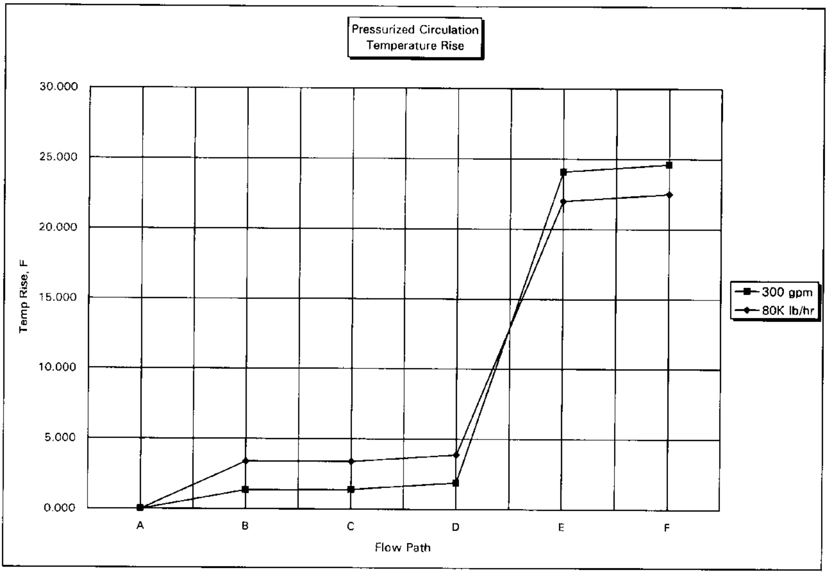
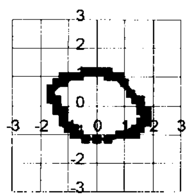


FIGURE 10C Pressurized circulation temperature rise

The diagnostic systems available today are perhaps the most significant advancement in the technology of sealless pumps. Figure 11, rotor position output data, illustrates the type of information available when using digital output linked to a data collection system.

Serial #	9630498-2							
DM ident.	964719							
program	crane2.1							
endplay	95							
update Global.XLM								
	DM ave	DM max	DM min	Dial	Switch			
forward	39.81	42	38	0	Zf = 25			
rear	-19	-	-	95	Zr=EC			



DM ave	DM max	DM min	Dial	Display	GPM	DM min	DM max	DM ave
37.26	39	35	7	0	0	92	99	96
32.05	34	30	11	0	20	83	90	87
36.12	38	34	6	0	60	90	97	94
35.62	38	34	8	0	80	90	97	93
29.41	31	27	14	0	100	78	85	82
11.43	13	9	42	0	110	48	54	52
7.9	10	5	45	1	120	41	49	46

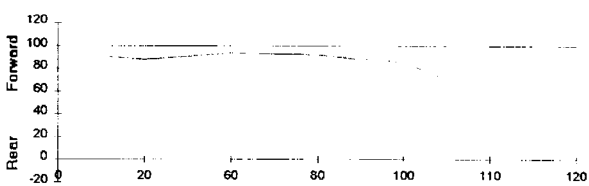


FIGURE 11 Rotor position output data

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3. Sealless Pumps for Petroleum, Heavy Duty Chemical, and Gas Industry Services, API Standard 685, 2000, American Petroleum Institute, 1220 L Street, Northwest, Washington, D.C. www.api.org.

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