CPI Pumping

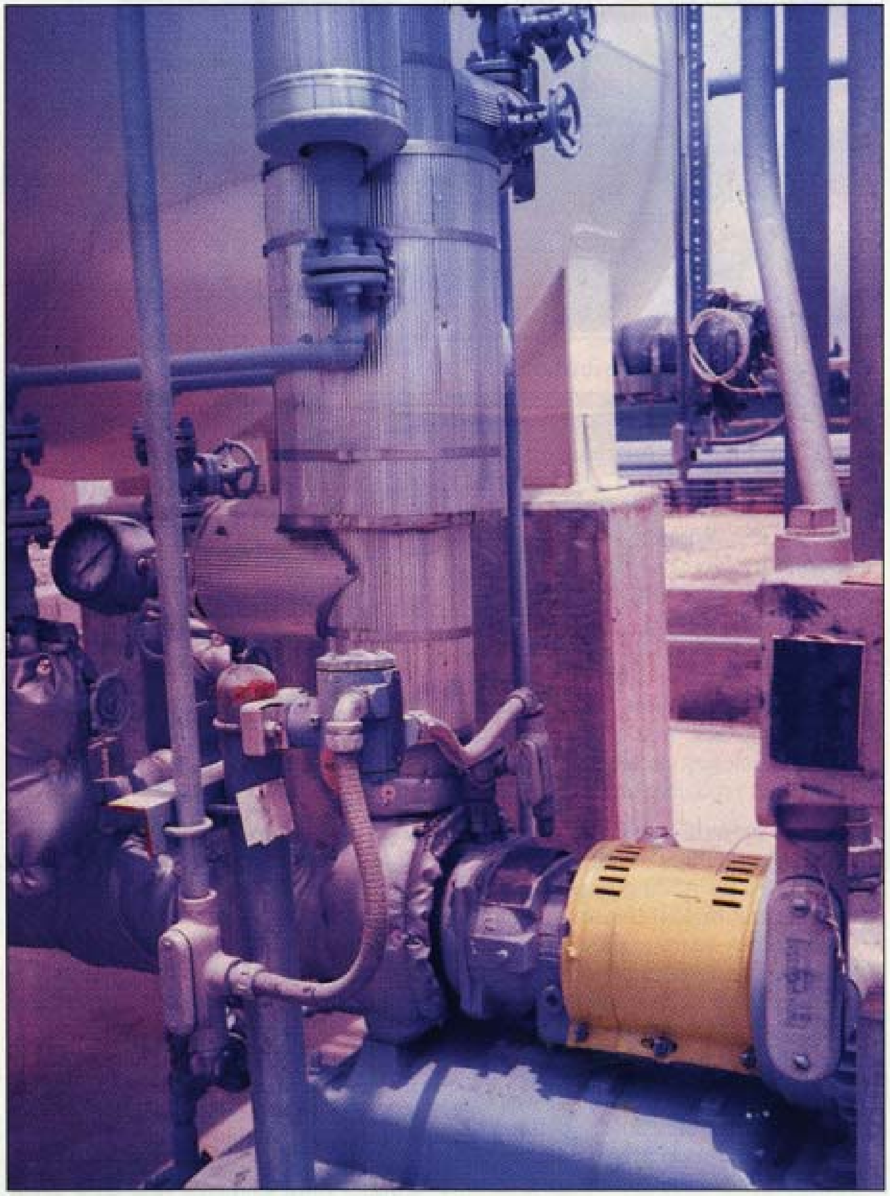
Increase reliability and reduce emissions through pump selection.

Today chemical manufacturers and users are faced with global competition and pending environmental restrictions that threaten to reduce profitability. The need to reduce overall operating costs has driven pump users at chemical plants to focus on improving reliability and eliminating or reducing fugitive emissions.

SEALED PUMPS

The mechanically sealed chemical process pump, which meets ASME/ANSI B73.1M standards, is the workhorse of chemical processing industries. It will continue to be used on a wide range of process applications—such as liquids containing significant amounts of solids (sodium chlorate, alum, sodium carbonate, chemical wastewater), light slurries (silver nitrate and acetone slurries), viscous liquids (above 150 cP, including black liquor and titanium dioxide), and stringy materials where sealless pumps may not be economical to use. In addition to its ability to handle tough services, the flexibility of the design—along with improved low-emission mechanical seals—continues to make ANSI pumps the standard in this field.

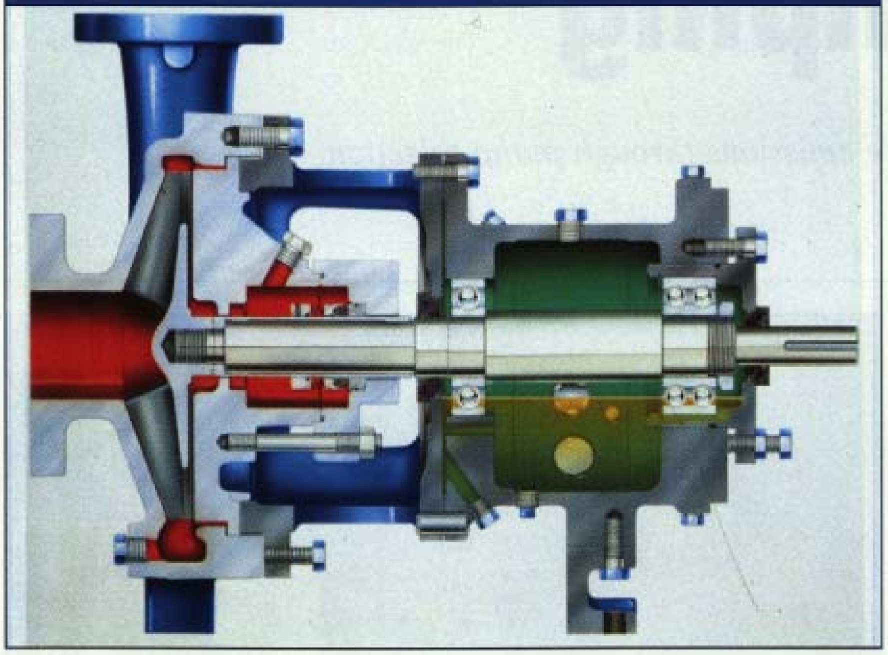
To elaborate on why sealless pumps are not economical to handle the above materials, we must note that they use enclosed impellers to reduce the axial thrust and increase reliability. (Although several manufacturers have tried using open or semi-open impellers in sealless designs, many of these have not been reliable at two-pole speeds.) Also, standard sealless pumps have small internal passageways to circulate



A mag drive pump in service.

BY RICHARD BLONG AND BOB MANION

FIGURE 1



ANSI pump improvements.

liquid for bearing lubrication and drive-end cooling, and mechanical seal manufacturers are rapidly improving the reliability of their products while reducing emissions to well below 500 ppm. With this in mind, consider the following:

1. Enclosed impellers are prone to plugging and premature wear in the above services due to small wear surface area. (Performance and efficiency cannot be renewed without replacing wear rings.)
2. Open or semi-open impellers are reliable in these services and are standard for ANSI pumps. (Simple external impeller adjustments allow easy maintenance of performance and efficiency, and there are no wear rings to replace, yielding long-term energy savings.)
3. The small internal passageways in sealless pumps are subject to plugging while handling liquids with only small amounts (5%) of solids. Viscosity handling is also limited.
4. Design solutions separate the pump end from the drive end to allow sealless pumps to handle these services, but these modifications can be expensive and may not be cost effective.

Considering all the facts, it's understandable that mechanically sealed ANSI pumps are the more economical choice to handle these types of liquids.

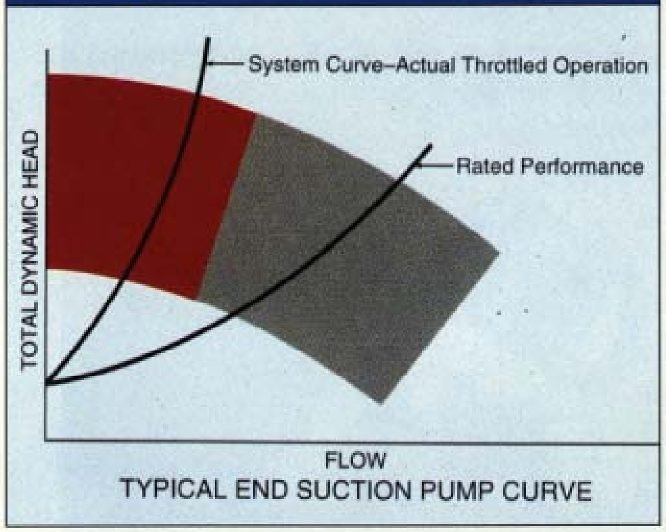
ANSI RELIABILITY IMPROVEMENTS

To meet emissions regulations and improve reliability, process industries have pushed ANSI pump manufacturers to improve performance. Some manufacturers have formed alliances with users to share technology and improve standard designs. By working together, the theoretical has been combined with the realities of applying pumps on a multitude of services and making them last.

These efforts have produced the features listed below that many major ANSI pump manufacturers have incorporated (Figure 1). At a minimum, users should purchase ANSI pumps with features that best meet their application needs. However, most new designs incorporate features systematically to provide reliable products. Compromising designs to save money or add standard plant features—substituting a vendor's standard labyrinth seal with the plant's standard oil seal, for example—may not be advisable. New ANSI pump features include the following:

1. Labyrinth oil seals are designed to prevent premature bearing failure from lubricant contamination or oil loss. These non-contacting seals have replaced Buna-rubber lip seals, whose useful life was three to six months under normal conditions. Materials of construction include carbon-filled Teflon, bronze, or stainless steel.
2. Increased oil sump capacity provides better heat transfer for more effective oil cooling. Bearings operating at lower temperatures contribute to longer life.
3. A rigid frame foot reduces the effect of pipe loads on shaft alignment. Misalignment won't exceed 0.002 in. under load, and pump and driver alignment is better maintained.
4. Bull's eye sight glasses insure proper oil level, which is critical to bearing life. Level oilers have often been misused, leading to over- or under-filling sumps, both of which contribute to bearing failure. Sight glasses are also convenient for checking the oil condition visually to determine if a change is necessary. Constant-level oiler manufacturers are just now introducing oilers that eliminate the potential for improper oil level settings while providing a sight glass, combining the best features of both methods.
5. Mounting flanges accommodate an optional adapter that simplifies pump/motor shaft alignment, saving the user time and money during installation.
6. Condition monitoring bosses on power ends provide consistent measurement points for temperature and vibration sensors. Many users report

FIGURE 2



Off-design (throttled) operation range (red) and recommended operation range (gray).

increased pump life from using predictive maintenance to identify and correct problems early. Taking measurements at the same point aids in proper interpretation of readings and allows personnel to move through the plant more quickly on inspections.

7. Engineered large seal chambers, specifically designed for today's mechanical seals, increase seal life through improved lubrication, cooling, air venting, and solids handling. The chambers allow seal manufacturers to engineer and apply more reliable designs, including cartridge seals.

These developments extend pump and seal life and reduce emissions at the same time. Experience shows that one cannot be accomplished without the other. For example, a mechanical seal with emissions in excess of regulations has already failed in its application.

Another benefit of these features is that several manufacturers and seal suppliers are extending unconditional warranties to as long as three years, helping to further lower operating costs.

SPECIALTY PUMPS FOR IMPROVED RELIABILITY

Many diversified chemical producers are moving production of commodity chemicals to the Asia-Pacific and Latin American regions to take advantage of lower labor and production costs. As a result, chemical production in the United States is being driven toward manufacturing specialty chemicals typically produced in small runs or batches. Examples include methylisobutylketone (MIBK) and paratertiarybutylphenol (PTBP). Pump applications for these batch-type processes are usually low flow, in the range of 0 to 100 gpm.

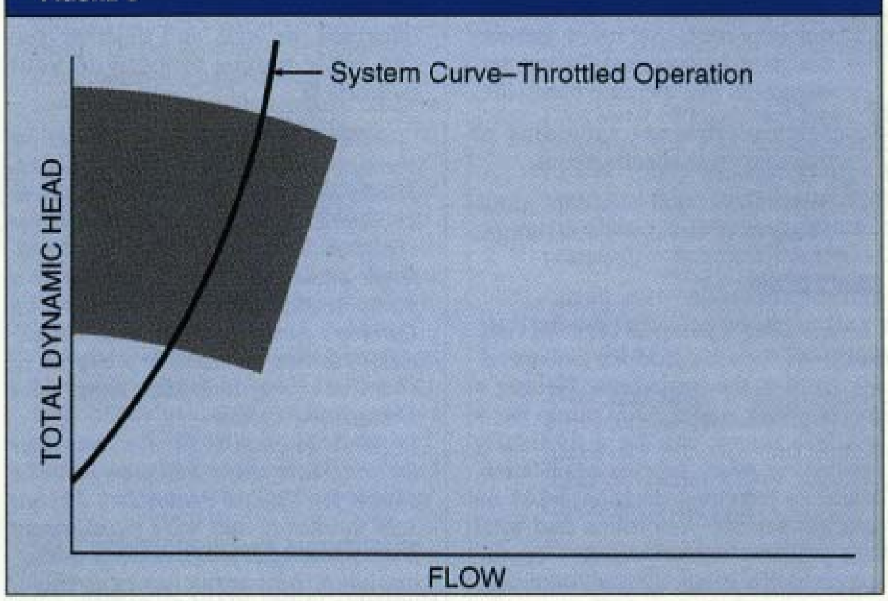
Traditionally, users install standard process pumps and throttle the discharge valves to obtain low-flow performance. However, these pumps are not designed to operate continuously in this range (Figure 2). Higher radial loads and increased shaft deflection lead to premature bearing and seal failure. Costly downtime and maintenance expenses result.

For low-flow operation, users should specify a pump designed to meet specific service conditions (Figure 3). ANSI pumps designed for low-flow operation are available to increase pump and plant reliability.

Improvements come from a casing and impeller designed for low-flow operation. Low-flow designs use concentric volutes and radial vane impellers to reduce radial loads, eliminating hydraulic and mechanical problems from throttled low flows (Figure 4). Some designs reduce radial loads as much as 85% compared to end-suction expanding volute pumps in this service (Figure 5). Shaft deflections from high radial loads are minimized, optimizing bearing, mechanical seal, and overall pump life. A disadvantage of low-flow ANSI pumps is that they sacrifice some efficiency to reliably handle viscous and solids-containing liquids.

Another approach to low flow–high head applications is the regenerative turbine pump. This design directs liquid by a passageway

FIGURE 3



Pump curve for a low-flow ANSI pump.

so that it circulates in and out of the impeller many times on its way from pump inlet to outlet. Both centrifugal and shearing action work together to efficiently develop relatively high heads at low flows. Regenerative turbines also use concentric volutes and radial vaned impellers to obtain the reliability benefits discussed above. One drawback is that this type of pump utilizes close running clearances to keep efficiency high and it is therefore normally used on clean liquid applications.

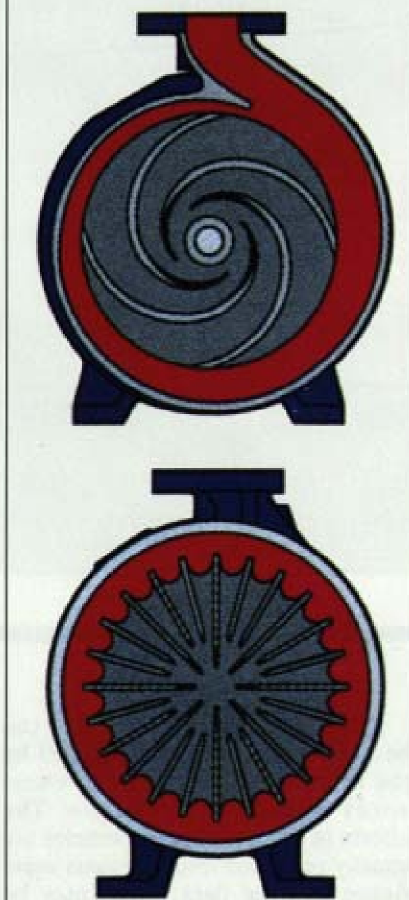
SEALLESS PUMPS

With the implementation of the Clean Air Act, sealless pumps offer a dynamic solution to controlling emissions. Not only should sealless pumps be strongly considered to control emissions of the 149 volatile organic compounds identified by the Environmental Protection Agency, but they should be viewed as solutions to many difficult applications encountered in CPI plants today. For example, if users are experiencing sealing problems because of the pumped product's poor lubricity (typical of acidic products in the range of 0–3 pH, such as sulfuric or hydrochloric acids), difficulty with product crystallization at seal faces (usually with caustic products in the range of 10–14 pH, such as sodium hydroxide and potassium hydroxide) or are frustrated with sophisticated auxiliary piping plans to provide clean, cool flush liquid to mechanical seal faces, sealless pumps may be the answer.

IMPROVED RELIABILITY WITH MAG DRIVES

It is well recognized that mechanical seals and bearings are the two items that fail most often in pumps. These failures are often directly related to improper application and installation, poor operating practices or lack of maintenance, pipe strain, or misalignment. All of these again lead to high bearing loads, shaft deflection, and bearing and seal failure. Magnetic drive pumps have neither a mechanical seal that can fail nor a driven shaft that can be subjected to pipe strain or misalignment. The driven shaft is separated from the drive shaft by a magnetic coupling, eliminating the two major causes of pump failure.

FIGURE 4



An expanding volute pump (top) and a circular volute pump with a radial vane impeller (bottom).

CRITICAL MAG DRIVE FEATURES

Reliable magnetic drive pumps must address two critical concerns:

1. proper lubrication of the journal bearings
2. removal of heat generated by eddy currents in the recirculation circuit

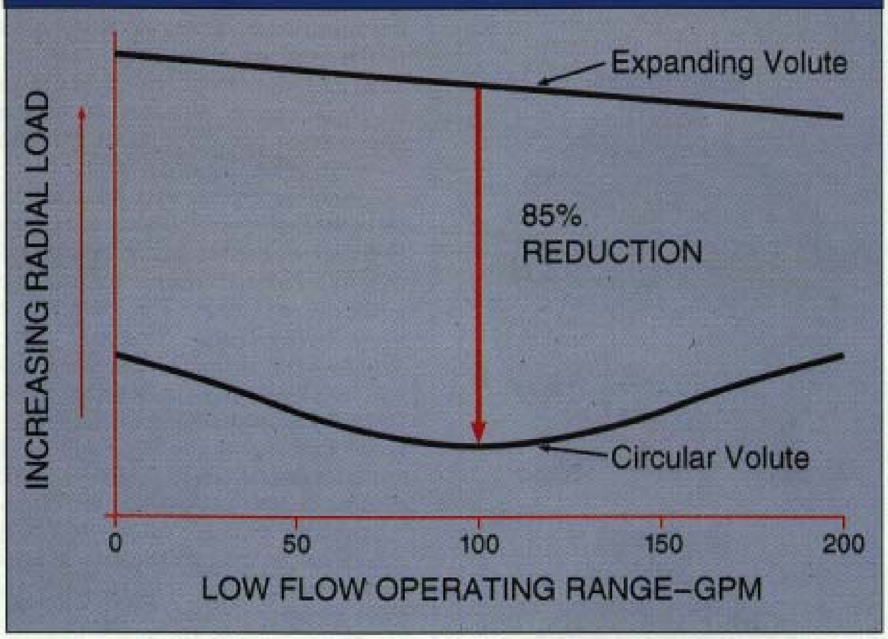
The design must deliver liquid to lubricate the bearings—it should not be flashing or have risen in temperature, which decreases lubricity, prevents proper cooling, and leads to bearing failure. Proper journal bearing lubrication directs cooling liquid to the bearings, then to the magnets. Dual path designs provide lubrication to these areas separately. Both approaches prevent flashing at the bearings, a leading cause of failure.

Another typical mag drive pump failure is liquid flashing at the impeller eye after being circulated through the drive end to remove eddy current heat. The result is a vapor-bound pump. New mag drive designs have virtually eliminated this problem by creating a constant pressurized circulation circuit that prevents flashing of cooling liquid and the associated failures (Figure 6). Not all new designs use pressurized circulation, and because most regulated liquids are volatile, this feature is necessary to achieve extended life in these services.

Regardless of the design features and modifications available from manufacturers, users are responsible for providing suppliers with as much data as possible on fluid and operating conditions. To apply sealless pumps properly, many factors must be considered:

- Is the flow continuous or intermittent?
- Upon shut-down, what reaction (if any) will the process fluid have to residual heat? Chemicals like butadiene and formaldehyde may polymerize, leaving deposits inside the drive section and on the bearings.
- Can the process shut down automatically, resulting in the pump operating at shut-off condition?
- Conversely, can the system allow the pump to operate at the extreme right of the pump curve, which can adversely affect $NPSH_R$ and cause motor overload or excessive thrust?
- What are the fluid characteristics, including vapor pressure curves, specific heat, viscosity over the process temperature range, and the effects of heating and cooling on the process fluid? Benzene freezes at 42°F (depending on the installation location,

FIGURE 5



Radial load curves.

address the possibility of exposure to low temperatures), and toluene diisocyanate freezes at 72°F and begins to polymerize at 127°F (again, protect the installation or use jacketing if necessary). Maleic anhydride freezes at 130°F (use heating jackets or temperature control).

- What about the customer's practical knowledge of the corrosive nature of the chemical? Sometimes the standard corrosion charts don't give the whole story.

ABRASIVES

When pumping fluids containing particles, the traditional solution is to use very hard bearings (silicon carbide) operating against a hard or coated journal. The application of sealless pumps should go beyond this seemingly easy approach. Consideration must be given to:

- the abrasiveness of the solids
- the size of the particles
- the quantity of particles
- whether they can agglomerate
- what creates the particles (reaction, catalyst, temperature)

The size of the particle that can be handled is usually determined by the impeller design and the clearances in the fluid passages. The effects of the quantity of particles are usually predicted from previous experience and test data. Solids may be formed by reactions to moisture (titanium tetrachloride), temperature (butadiene or formaldehyde), or a catalyst (any process that uses a catalyst that may vary in quantity or is subject to upsets).

When the fluid is understood, it may be best to use modifications, including: backflushing to keep particles out of the drive section, heating or cooling jackets, heat exchangers in flush lines, filters or specially designed units that utilize isolation chambers, built-in seals, and precision back-flushing to reduce process stream dilution, if economical. Otherwise a mechanically sealed ANSI pump may be the best solution.

MAG DRIVE CONDITION MONITORING

Magnetic drive pump reliability is also affected by operating practices. Condition monitoring devices can be applied to shut pumps down before a critical failure. Maintenance can then be performed, or operator errors corrected, before the pump is put back into service.

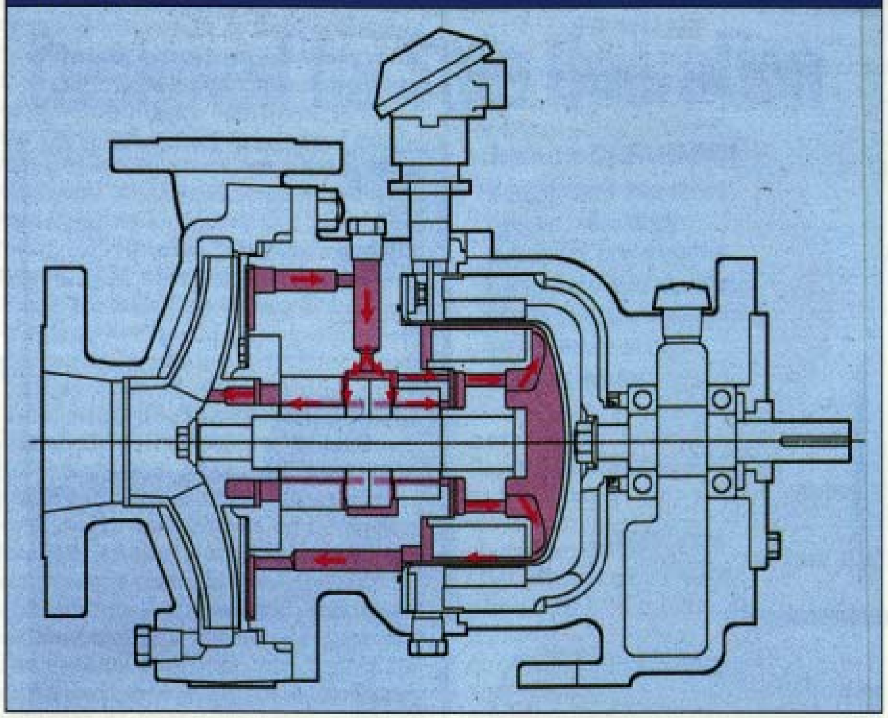
Temperature detection and power monitoring together provide the best basic protection. Temperature detection indicates internal pump problems such as plugged recirculation paths, while power monitoring prevents dry-run failure. Other devices available include low amp relays, leak detection indicators, and package control systems.

INSTALLATION

The effort involved in selecting the right pump for a given CPI application can be nullified by poor installation. As much effort, if not more, should be put into installation design to insure expected performance is achieved. (To understand how proper procedures improve equipment reliability see "Installation and Start-Up Troubleshooting," *Pumps and Systems*, November 1993.) Important steps include:

1. Lay out suction piping to provide NPSH available to the pump in excess of NPSH required. A common recommendation: $NPSH_A > NPSH_R$ + 2–5 ft. See "Pump Suction Conditions," *Pumps and Systems*, May 1993 and "How Much NPSH Is Enough?" September 1993.
2. Provide a straight run twice the length of the pipe diameter (2D) to the pump suction flange to prevent added turbulence at the impeller eye, which could lead to premature (incipient) cavitation.
3. Install conventional or cartridge mechanical seals according to manufacturer recommendations.
4. Meet seal flush requirements by providing an external flush at the necessary pressure and temperature, or add auxiliary piping for flushing on the pump.
5. Prepare the foundation before grouting the baseplate.
6. Select grout that will meet installation requirements.

FIGURE 6



Recirculation circuit.

7. Select a baseplate to maximize pump, seal, and motor reliability. Many vendors offer baseplates with enhancements such as .002 in./ft flatness, leveling screws, motor alignment screws, continuous drip rims, and other features designed to ease installation and alignment and increase pump life.
8. Align equipment according to manufacturer specifications.
9. Select and install condition monitoring devices for sealless pumps.

CONCLUSION

Selecting a pump to improve reliability will reduce emissions and operating costs at the same time. Neither a mechanically sealed ANSI pump nor a sealless pump can be universally applied on every process application. Make an informed decision based on specific service conditions and total cost (initial + maintenance + operating costs). To insure a return on investment, as much time and effort must be expended on the design of equipment installation as on pump selection. Although selecting equipment for increased reliability and reduced emissions may seem expensive in the short term, it saves money in the long run. Work with manufacturers' reps and rely on their expertise, but be informed, as well, and together you can apply pumps properly in your facilities. ■

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