## 6.4 Pumps

### 6.4.1. General Guidelines

All pumping equipment should be designed to provide reliable operation and a high certainty of containment. The information set out in the following identified sections also provides general guidelines relevant to the specification and design of the pumping system: 6.2 Materials of Construction; 6.3 Piping Items and Valves; and 6.5 Instruments. Additional information is included in Section 6.4.5.

Several common options available to pump phosgene are addressed here. As with other sections of the Manual, users have an independent obligation to conduct their own analysis for their specific circumstances as alternative or additional considerations may be required.

### 6.4.2. Mechanically Sealed Pumps

Where mechanical seals are employed for containment, a double seal with some type of pressurized barrier fluid should be considered. By way of reference, API 610 Plan 53 and Plan 54 are available for consideration on pressurized barrier fluid systems. The use of protective systems helps ensure that the seal and pump function correctly. Local and remote indications are more useful than no monitoring or local monitoring only.

Solid shafts should be considered. The use of a full shaft sleeve will reduce the stiffness of the seal supports system leading to premature failure of the mechanical seal. A "stub" sleeve has been used with a cartridge seal as an alternative. As a general guideline for users to consider, some companies aim for the stiffness of the shaft as measured by the slenderness ratio $L^3 / D^4$, at 60 or below. "L" represents the distance from the center of the impeller to the center of the radial bearing. "D" represents the diameter of the shaft in that same distance.

Evaluate whether all gasket and O-ring materials are compatible with the process fluids. Concerns have been raised over graphite being more permeable than other gasket materials. The resulting leakage over time combined with atmospheric moisture has caused corrosion to take place on bolts where it is difficult to monitor.

**One Example of a Mechanical Seal Arrangement:**

1. API Plan 53 or 54 with double mechanical seals.

2. Barrier fluids contain no water. The water can mix with the phosgene and create acids that accelerate corrosion in piping systems. The barrier fluid is compatible with the process.

3. Barrier fluid reservoir sight glasses are designed to contain phosgene in the event one of the seals leaks and allows phosgene to enter the barrier fluid system. Magnetic type or integral glass type level indicators have been used. Indicators of the exposed glass tube type may be less desirable. For more information, see Section 6.5, Instrumentation.

4. Barrier fluid reservoir designs can allow the addition of fluid without disturbing the pressure on the fluid.

   Screwed connections are more prone to leaks. They also appear weaker in resisting pipe strain and external forces because of concentrated stresses in their thread roots. Threaded connections in phosgene service may be undesirable. For more information see Section 6.3, Piping and Valves.

   Casing drains can reduce or eliminate trapped phosgene in equipment that must be serviced. Installing a sufficient quantity at the proper location can allow almost complete draining of the pump prior to decontamination and maintenance.

   Many manufacturers offer hydro testing as a method of testing their casings, and pumps to be used in phosgene service can use this service. Vessels have been tested to 1.5 times their working pressure and this reference may offer a useful pressure for these pump parts as well. Documentation of the hydro test, for record keeping, can reduce potential difficulties. Additional inspections to help ensure the integrity of the casing include dye penetrant, x-ray or helium leak tests. Other casting specifications can be added that will also require additional testing.

   Pumps function most efficiently and reliably if they are operated near their design flow. A general guideline has been between

25% less than and 5% greater than the best efficiency point (BEP).

Because low net positive suction head (NPSH) can create seal problems and reduce pump reliability, meeting the manufacturer's recommended minimum or a margin added for a safety factor helps prevent such occurrences. One safety factor that has been used previously is the manufacturer's NPSH + 5 additional feet of head.

For pump protection, instruments are available that measure, monitor or indicate some of or all of the following:

- Suction pressure
- Discharge pressure
- Seal fluid pressure
- Seal fluid flow
- Seal fluid level
- Vibration
- Minimum flow protection
- Supply level trip
- Power level

### 6.4.3. Sealless Pumps

With regard to sealless centrifugal pumps, magnetically driven and canned motor pumps are two common options. The following considerations relate to both types.

Because the inner rotor is cooled and lubricated by the process, failure can occur quickly and without warning. Therefore sealless pumps with a predictive device supplied by the manufacturer can help prevent such problems. For example, a predictive device would be one which measures rotor position to detect wear.

One feature that may help with difficult pumping applications including phosgene is to have the capability of using external circulation for cooling and lubricating the drive end of the sealless pump. This approach can be helpful with solids, and conditions that may flash or affect the lubrication of the internal pump bearings.

When vapor pressures and temperatures are near boiling in the rotor support area of the pump, a pressure-boosting device has been used in the drive end of the pump to improve bearing life. This mechanism has been used when the net positive suction head is marginal.

Minimizing penetrations of the process containing parts of the pump reduces the potential for leak paths.

Screwed connections are more prone to leaking. They also appear weaker in resisting pipe strain and external forces because of concentrated stresses in their thread roots. Threaded connections in phosgene service may be problematical. For more information, see Section 6.3, Piping and Valves.

Casing drains help reduce or eliminate trapped phosgene in equipment that must be serviced. Installing a sufficient quantity at the proper location can allow almost complete draining of the pump prior to decontamination and maintenance.

All gasket and O-ring materials should be compatible with the process fluids. Concerns have been raised regarding graphite being more permeable than other gasket materials. The resulting leakage over time combined with atmospheric moisture has caused corrosion to take place on bolts where it is difficult to monitor. Solid TFE "O" rings appear resistant to phosgene, but not as pliable which reduces the closeness of the seal.

Consider keeping process fluid temperature at the shaft / bearing interface lower than the boiling point of the fluid in the drive end at operating pressures as a means of helping to ensure the bearings are always lubricated. A margin of safety, for consideration, has been 20 degrees Fahrenheit.

Pumps function most efficiently and reliability if they are operated near their design flow. A general guideline for users to consider is between 25% less than and 5% greater than the best efficiency point (BEP).

Because low net positive suction head (NPSH) can create seal problems and reduce pump reliability, meeting the manufacturer's recommended minimum or a margin added for a safety factor will reduce the potential for such occurrences. One safety factor that has been used previously is the manufacturer's NPSH + 5 additional feet of head.

Because of the unique nature of sealless pumps, consideration should be given to the design of the control system. Because the process cools and lubricates the bearings, a control system that allows the pump to run at or near its design point generally helps provide for long pump life. This intention has often been addressed by recycling back to the suction supply vessel, not the suction of the pump. If long durations or large flows are involved, cooling of this “bypass” stream may be necessary to prevent the supply vessel from heating up.

Many manufacturers offer hydro testing as a method of testing their casings. Pumps to be used in phosgene service have used this service. Vessels have been tested to 1.5 times their working pressure and this reference may be considered for these pump parts as well. Documentation of the hydro test, for record keeping, can reduce potential difficulties. A refinement on hydro testing is available using a helium and nitrogen gas mixture and a detector to find minute openings in the casting that might allow phosgene to escape when the equipment is put into service. This test can be done on new equipment at the factory or in the plant. Additional inspection options to help ensure the integrity of the casing include dye penetrant, x-ray or underwater air tests. Other casting specifications can be added that will also require additional testing.

Sealless pumps are not well suited to pumping any liquid that is at its boiling point. If this must be done, then cooling of the pump and a pressurized recirculation system can increase pump reliability. An external flush may also be considered.

When applying a sealless pump, several operating points may need to be supplied to the manufacturer. These include normal operation, start-up conditions, and several sets of unusual circumstances that may be encountered. Changing conditions that can be encountered include viscosity changes, fluid make-up changes, specific gravity, pressure and temperature changes. This issue may be especially relevant if one plant uses a pump for more than one service.

#### 6.4.3.1. Magnetically Driven Pumps

Magnetically driven pumps are typically either of the single or the double containment shell design.

Hydro testing containment shells helps ensure that there are no leak paths outside of the containment portion of the pump. Hydro testing to 1.5 times the maximum operating pressure of the pump is a frequently used guideline available for consideration. If the containment shell is welded, it may also be tested by dye penetrant or x-ray examination.

Installing a replaceable rub ring between the outer magnetic and the containment shell as part of the design helps protect the containment shell from damage.

Evaluate whether the outer housing is rated for a pressure greater than or equal to the flange ratings of the pump.

Some type of shaft sealing device can be employed to prevent the release of process to atmosphere in the event of a containment shell failure. Consider whether this device can contain pressures greater than or equal to the flange ratings of the pump.

Attention should be provided to avoid magnetically driven pumps in applications where ferrous metals can accumulate in the drive mechanism.

For pump protection, instruments are available that measure, monitor or indicate some of or all of the following:

- Power level to detect minimum flow
- Bearing flush temperature
- Suction pressure
- Discharge pressure
- Supply level trip
- Flow level
- Vibration
- Acoustical energy
- Pressure in the outer housing
- Bearing temperature
- Containment shroud surface temperature (Single shrouded systems)
- Shroud inter-space pressure (Double-shrouded design)
- Liquid in the outer housing

#### 6.4.3.2. Canned Motor Pumps

It may be beneficial to establish that relief devices are used only where there is the possibility of venting to a scrubber system.

Consider benefits of only using pump with predictive devices (e.g., rotor position monitor).

For pump protection, instruments are available that measure, monitor or indicate some of or all of the following:

- Rotor position to detect wear of the thrust bearings
- Bearing wear when using carbon bearings
- Bearing temperatures
- Bearing lubricant temperature
- Direction of rotation
- Thermal cutouts
- Power to detect low flow
- Suction pressure
- Discharge pressure
- Supply level trip
- Flow
- Vibration
- Acoustical energy

### 6.4.4. Differential Pressure

Where practical, phosgene can be moved via differential pressure.

When possible, as with a new design, a combination of differential pressure, and gas only, may reduce the possibility of leaks, save maintenance efforts, and reduce the quantity that can be released.

### 6.4.5. References

The following references are available and may assist users with pump-related needs.

Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process; ASME B7301M-1991, The American Society of Mechanical Engineers, New York, N.Y.

Specification for Sealless Horizontal End Suction Centrifugal Pumps for Chemical Process; ASME B73.3M-1997, The American Society of Mechanical Engineers, New York, N.Y.

PIP RESP73H-97, Application of ASME B73.1M-1991, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process; Process Industry Practices (PIP), Construction Industry Institute, The University of Texas at Austin, Austin, TX.

PIP RESP001, Design of Pumping Systems that Use Centrifugal Pumps; Process Industry Practices (PIP), Construction Industry Institute, The University of Texas at Austin, Austin, TX.

PIP REEP001, Seal Flush and Lubrication Guidelines for Centrifugal Pumps; Process Industry Practices (PIP), Construction Industry Institute, The University of Texas at Austin, Austin, TX.