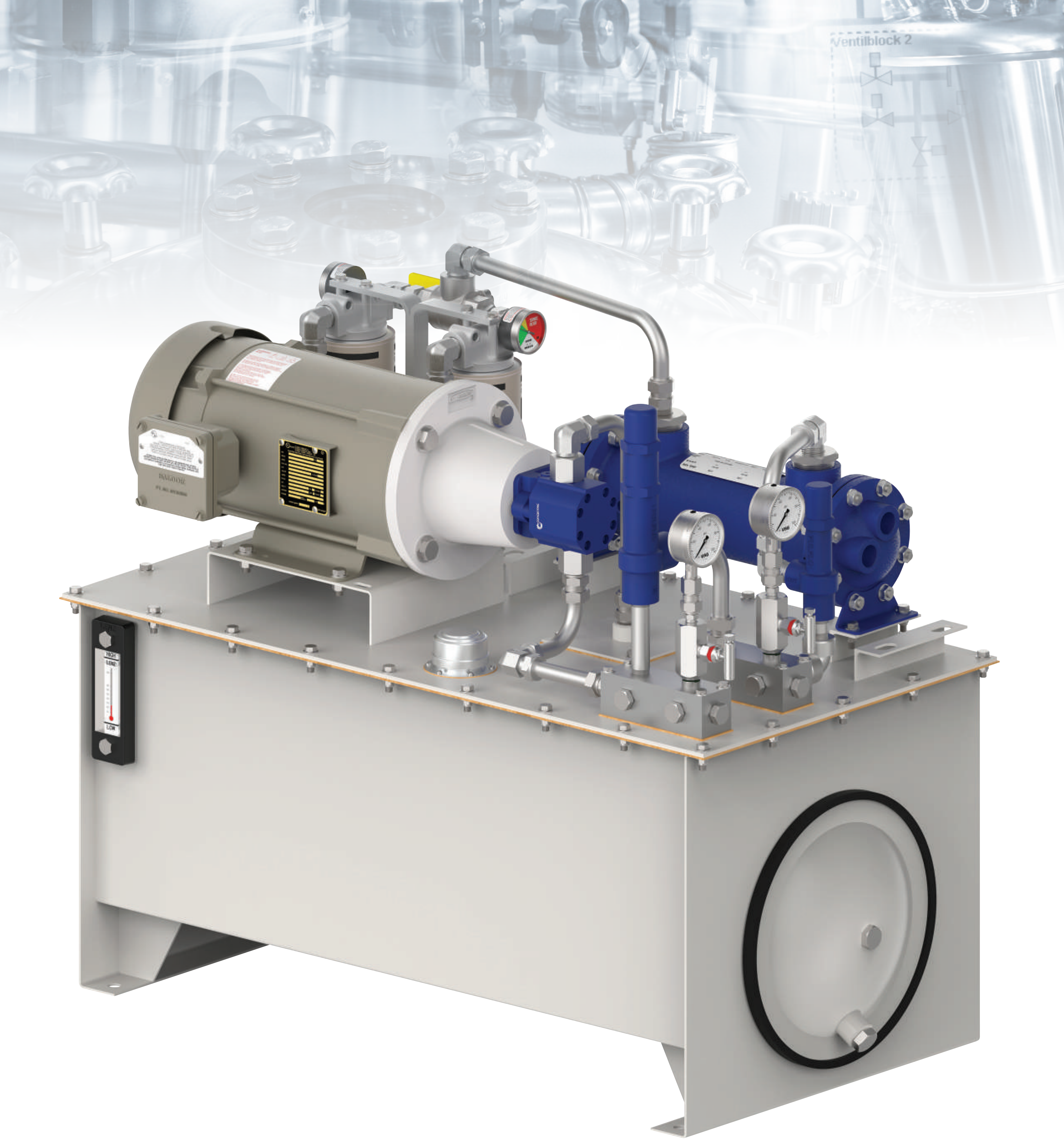
Design Guideline

API 682 Plan 54 Seal Support Systems


Ventilblock 2

API 682 Plan 54 utilizes an external source to provide a clean, pressurized barrier fluid to a dual-pressurized mechanical seal with minimal leakage across the primary sealing interface into the process stream. The measured leakage rate is typically a volumetric (ml/hr or fl. oz/hr) or mass rate (g/hr or lb/hr) and requires end-user approval with regards to process dilution. API 682 has traditionally listed little in way of guidance as to what drives a user to the selection of Plan 54 as a support system and what design considerations should be made in the process. Indicating that a mechanical seal support system will be a Plan 54 only means that dual seals are pressurized from an external source; in reality, the Plan 54 designation could cover anything from a process pump supplying conditioned barrier fluid under pressure, to a once-through water system in a chemical plant, all the way up to a stand-alone lubrication system designed to API 614 specifications (lubrication, shaft-sealing, and control-oil systems & auxiliaries for petroleum, chemical and gas industry services). The common determinant in arriving at this support system choice is the requirement for conditioned barrier fluid to adequately maintain the mechanical seal design integrity.

WHY SELECT API PLAN 54?

API Plan 54 is a pressurized external lubrication system (PELS) and has specific advantages over Plan 53A, B and C. The primary difference is that with a Plan 53 piping plan, the circulation rate required to cool and lubricate the mechanical seal is dependent on the size, internal circulation device and piping. With a PELS however, flow to the mechanical seal is not reliant on an internal circulation device, shaft speed or thermal siphon, which means actual desired barrier fluid circulation rate, can be achieved.

Circulation rate for heat removal

The minimum circulation rate required by the mechanical seal can be impacted by the limitations of the internal circulation device and as a function of the piping system's resistance. For example, a slow shaft speed, seal size greater than 3.5"/89 mm and generated heat in excess of 30,000 BTU/hr or 8,800 W per seal may require external means for necessary circulation rate for cooling and lubrication. A primary concern is of heat dissipation capability, especially with a Plan 53A system, which can be limited by the physical limitations of the cooling coils inside the reservoir. In addition, the larger the seal size, the more prevalent churning becomes, which subsequently increases the total heat load. Higher temperatures > 500°F/260°C will also increase total heat load on the seal due to the increased influence of heat soak.

Pressure

API Plan 54 is not limited by available nitrogen pressure, in either achievable barrier pressure or nitrogen entrainment in the barrier fluid, as in a Plan 53A. This means that a PELS can be used at much higher-pressure applications than a Plan 53A. Although API 682 expresses concern with gas absorption potential at pressures 150 psig/10 barg or greater; John Crane experience with synthetic barrier oils suggest gas absorption at pressures up to 300 psig/21 barg will not pose an issue provided the barrier temperature is < 250°F/121°C. Additionally, the barrier pressure is set externally by mechanical means, so the pressure applied to the seal will remain as desired unlike in a Plan 53B where the pressure will vary over time.

Volume

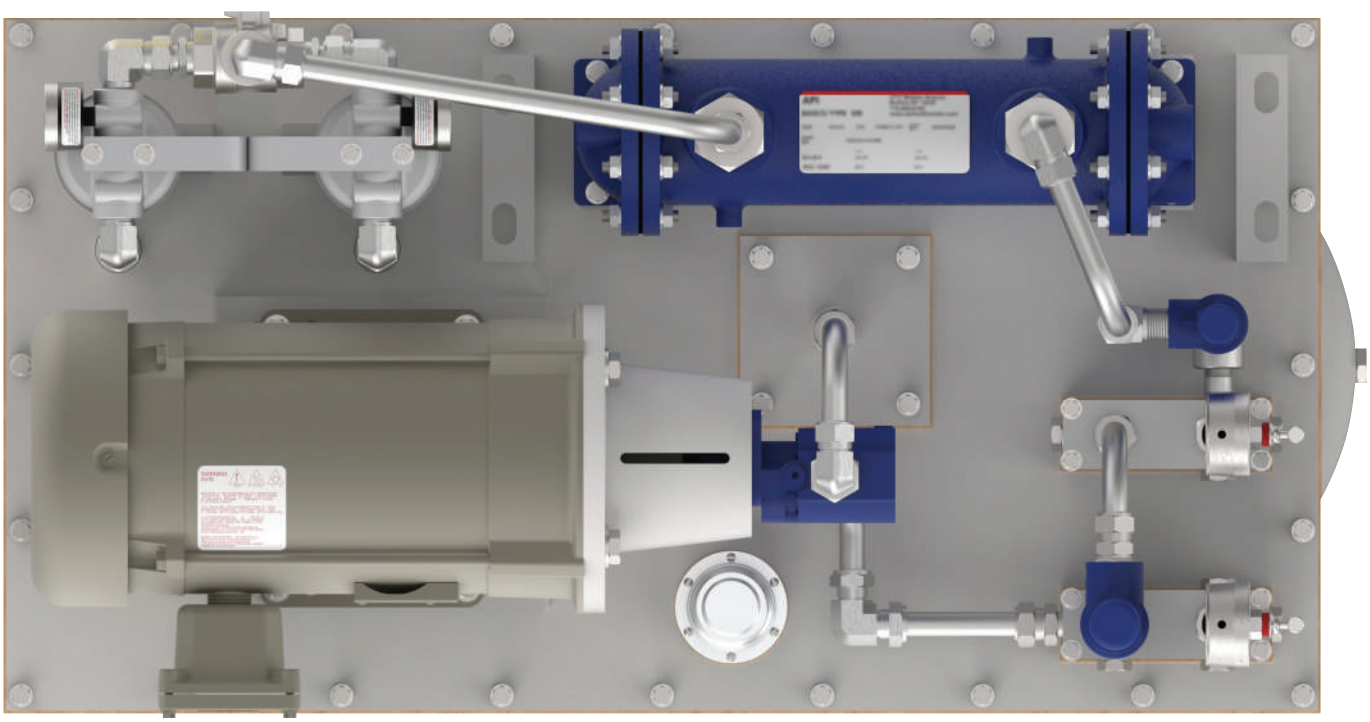
Barrier fluid capacity in the lubrication system reservoir is not limited as it is with a Plan 53A, B and C. The flexibility of increased reservoir capacity not only allows maintenance and replenishment intervals to be greatly extended, it also allows one PELS to be designed to adequately supply clean flush media to mechanical seals on multiple pieces of process equipment.

In practice, a standard size of system capacity can be specified to suit most applications. Derived from data and historical customer requirements, a John Crane global standard API Plan 54 system has a capacity of 30 gallons/ 136 liters and recommended for single process equipment lubrication per system.

Available Space

Plan 53A, B and C require close proximity to the seal to promote optimum circulation rate, based on shaft rotation. This becomes especially critical in high heat load applications, particularly in higher temperature services. A Plan 53A system, for example, could be considered in a high temperature application, but may require the use of a custom reservoir (10–20 gallon/40–80 liter capacity).

However, it may not be feasible to install a reservoir of this size within close proximity to the seal, in which case Plan 54 becomes advantageous. In this example, a sizeable reservoir made of either 6–8"/150–200 mm pipe can require a vessel that resides 10–15'/3–5 m above grade. The requirement of a ladder to access the refill port for normal preventative maintenance now becomes a potential safety issue. Some facilities are in the midst of enforcing strict fall prevention policies that require scaffolding (engineering design) and fall hazard review (administrative policy) to address issues where fall distance exceeds 6 feet/2 m. While API 682 4th Edition does require seal auxiliary system fill and vent access at grade, there are many applications that may fall outside of



Global Standardized Plan 54 Top Lid View the scope of this standard where access for these tasks would still need to be addressed from a safety standpoint.

There are no proximity criteria with a PELS; supply line size, resistance, and pressure drop should be evaluated at greater distances. With a system using a standalone pump and motor, there is more flexibility in location of the seal support system, both from a distance and grade perspective.

The ability to access equipment for both operational and maintenance tasks is a common concern. Particularly, the ability to easily access critical isolation/shut-off valves, safety equipment and utility stations with minimal obstruction. Maintenance costs and equipment down-time can even be reduced by improving ease of accessibility for maintenance work and reducing the scope of repair work.

Process Fluid Constraints

The nature of the process liquid can also drive the end-user towards a dual pressurized system. Volatile organic compounds (VOCs) require zero-emissions to the atmosphere and full containment in the event of a seal failure. With the appropriate instrumentation and an option of an alarm scheme within an engineered solution, a PELS offers the ability to contain process fluid while implementing a controlled shutdown of failed equipment. The pressurized arrangement also meets emissions control requirements by site LDAR (leak detection and repair) programs. Specialty chemical processing where the process liquid has a marginal temperature operating range before being subjected to polymerization is another ideal candidate for Plan 54 selection. Process fluid polymerization often results in damaged seal face components or potential seal hang-up; these occurrences can be avoided with a conditioned barrier fluid.

Flashing hydrocarbon services with poor lubricating properties are also suitable for a PELS (Ethane/EP Mix Pipeline service, for example). These applications typically meet Plan 54 criteria (high speed, high pressure, larger equipment sizes, etc.) as well as introducing the limitations of the process fluid having poor lubricity qualities. Issues with vapor pressure margin and flashing index can be addressed with implementation of a PELS that allows for the utilization of a conditioned lubricating film across the primary seal faces.

Summary of typical Plan 54 selection criteria

- Process fluid constraints – hazardous, zero-emissions, poor lubricity, etc.
- Barrier pressurization requirement 100% of the time (any doubt with a gas pressurization system, i.e. Plan 53A and B, should move selection towards Plan 54)
- Proximity requirements or insufficient space for proper Plan 53A, B and C
- Circulation rate required by the seal beyond pumping ring circulation rate (based on seal size and estimated system resistance with Plan 53A, B and C)

Increasingly, pressurized seal support systems are being specified for conventional process requirements to ensure more consistent operation, but other selection criteria might also be:

- Pump temperature > 500°F/260°C, ≤ 800°F/427°C in general
- Barrier pressure requirement ≥ 200 psig/14 barg

PLAN 54 SYSTEM DESIGN

End users, particularly in the oil and gas industry, often have default standards that can quickly add to the complexity of a lubrication system that results in a specified and engineered solution which John Crane consistently provides.

That being said, there are some general best practices that can be adapted to any pressurized external lubrication system, that transcend all industries and maintain the reliability and usability of the support system. Derived from customer data, John Crane has incorporated user best practice for its global standard API Plan 54 system.

Reservoir

When considering a pressurized external lubrication system, the variable that should be considered first is the capacity of the reservoir. The size of the reservoir will typically dictate the orientation and configuration of the remaining components of the system, which makes determination of its capacity a good starting point in system design.

Reservoir capacity is dictated by the amount of retention time that should be provided to the barrier fluid. Sufficient retention time is required to allow any entrained deposits in the barrier fluid to settle out as well as allowing any additional heat to dissipate from it. A good rule for minimum required retention time is 5 minutes; however, the longer that can be provided, the better (API 614 for example, recommends a retention time of 8 minutes for highly engineered support systems). Reservoir size will be determined by a simple calculation:

Required Circulation Rate x Retention Time = Reservoir Capacity

Therefore a 2.0 gal/min or 7.6 l/min circulation rate will net a reservoir capacity of 10 gallons/38 liters. The inclusion of additional seals to the system will naturally increase the reservoir size. The reservoir capacity will be based on the total required circulation rate by the entire number of seals dependent on the system, which can make for a very large reservoir. See Figure 1 for a typical system reservoir diagram.

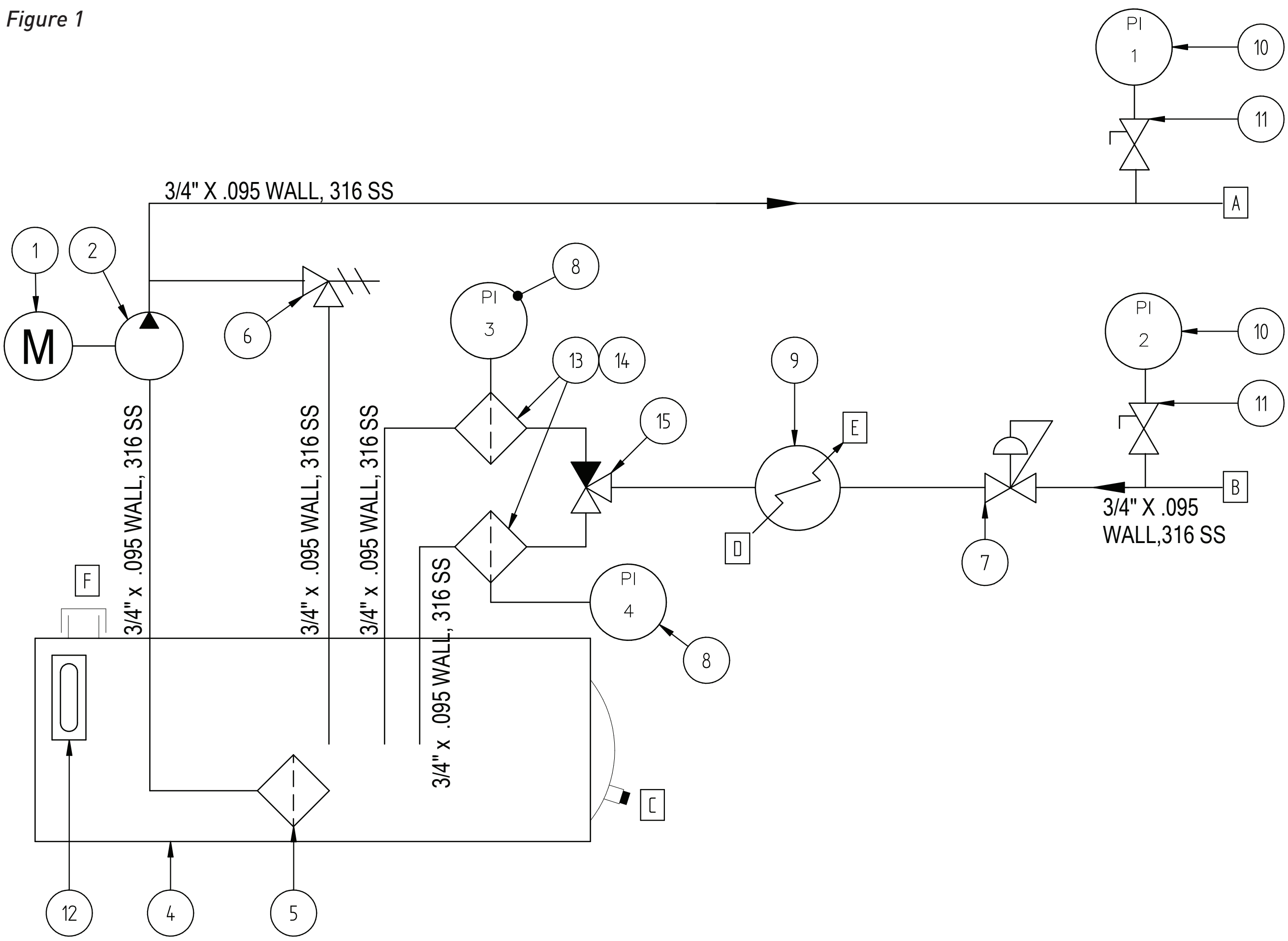
Integral to the reservoir design is consideration for mounting of the primary barrier fluid supply pump, which will pull suction from the reservoir. The preferred method of installation for the supply pump is to mount externally from the reservoir; not submerged. The main driver behind an externally mounted pump is for ease of maintenance and troubleshooting. Mounting the pump (Figure 1, item #2) externally may require additional steps in the system commissioning process to verify that the suction line is free of vapor pockets, but these items can be easily addressed through proper procedural steps. The inlet of the primary barrier fluid supply pump will include a suction strainer (Figure 1, item #5), which is an item that should be replaced on a recommended preventative maintenance interval.

In addition to retention time, it is good practice to include the following items into the reservoir design if possible:

- **Sloped bottom** – slope bottom of the reservoir towards the low point drain
- **Low point drain** – valved *(Point C in the diagram)*
- **Clean out cover** – allows accessibility to the reservoir during shutdown and outage periods for ease in cleaning (labelled in the diagram – sufficient diameter required for access)
- **Transparent level gauge** – measures liquid level of the system's barrier fluid within the reservoir *(Figure 1, item #12)*
- **Desiccant breather** – keeps contaminants out of the barrier fluid that could normally be introduced through a conventional reservoir fill/vent cap *(located at Point F in the diagram)*
- **Reservoir material** – stainless steel construction preferred *(Figure 1, item # 4)*

Along with the above items, there may be specific applications that mandate the use of additional controls for the barrier fluid, such as a heater. The use of a heater is determined based on barrier fluid properties, site ambient temperatures, and system operation. While still in the design stage, it is worthwhile to consider the addition of a port enabling future access for a heater should one be required.

Figure 1



Depending on the size and complexity of the pressurized lubrication system, the reservoir may be component mounted on a common skid with other items or serve as the mounting base (for smaller units). When a common skid is used to house the reservoir and system components, the skid design should take into consideration accessibility of each component to allow maintenance and troubleshooting. Inadvertent triggering of a critical device or personnel exposure to uninsulated hot tubing are undesirable outcomes of poor skid design and component placement.

Many end users already have site specific standards in place regarding circulating oil system skid requirements, so the new globalized standard Plan 54 has focused on the criticality of the decking design for the system. In addition to access, the system layout should not present attendant safety risks, either from overhanging components, or unnecessary proximity to high temperature parts.

Some typical items to consider in pressurized lubrication system configurations should include:

Troubleshooting/Maintenance

Within the first few hours of operation, any foreign material in the system plumbing will be flushed to the reservoir. This makes the placement of the system filtration elements a critical component of the design (discussed next). It is good practice to drain the reservoir and change out the suction strainer, and then refill the reservoir with clean fluid. Depending on the cost associated with the barrier fluid being used for service, a less costly alternative fluid may be used for this flushing and commissioning stage.

On a yearly basis, it is good practice to replace the suction strainer inside the reservoir along with the breather filter element, with a drain and flush incorporated on a bi-yearly basis. These items should be incorporated into the maintenance schedule so that they are not missed. Keeping up with the preventative maintenance of the system avoids potential seal issues that may be related to barrier fluid circulation rate and quality of the barrier fluid itself.

Figure 2

Filtration

Filtration should be included on any PELS as a standard component, and the filtration element(s) should be mounted on the return leg from the seal on the barrier fluid circuit to provide a first pass for eliminating contaminants that may be picked up inside the mechanical seal.

Unless compensated for in the design by the inclusion of a bypass line, simplex filtration will require that the lubrication system be shut down in order for the filter to be changed. Dual filtration is usually preferred as it adds a second filter in parallel to the filter in use. The second filter is a standby filter and by its inclusion allows filter replacement without shut down. The use of an additional filter requires that provisions be made for venting, draining, and isolation of each element so that maintenance can be performed. A filter element sized for 10 μm (micron) should be sufficient for most mechanical seal applications. *A typical dual-filter arrangement is shown in Figure 2*.

The diagram outlines a basic dual arrangement in which the filtration elements share a common distribution block. Whether dual or single filtration is in use, it is a good practice to monitor the health of the filter by some means. More complex monitoring can be adopted for this function in the form of differential pressure transmitters. The transmitter allows alarm signals to be tied to the filter differential pressure to provide advanced notification of potential problems with plugging or fouling. Pressure differential set points for filter replacement should be determined based on conversations with the end user. The complexity of the alarm scheme associated with this variable will be dictated by the criticality of the process equipment being sealed, among other factors. Generally speaking, the pressure drop across a new and clean filter element should not exceed 3 psi/0.2 bar.

Filter changeover is accomplished by a 3D ball valve between the two filters. It is important to exercise the transfer valve slowly when changing over between filter elements. Rapid switching of the valve could have multiple impacts, such as allowing air to be discharged into the fluid line or creating an instantaneous high differential pressure across the filter element that may cause collapse.

Due to the issues that can be created if the changeover process is not handled correctly, it is a recommended practice when considering a dual filter arrangement to include a means of equalizing the pressure on both filter elements. Under normal operation, the line remains open to equalize pressure on both filter elements. During filter element replacement, the line would be isolated to allow the desired element to be changed.

Position of the 3-way transfer valve as it relates to which filter is in use can be a source of confusion for some equipment operators. Fluid flow direction is indicated on the valve handle sleeve. Valve handle has 3 positions: 0°, 45° and 90°. At 0° valve handle is in horizontal position and fluid will pass through single filter – right hand side filter. At 90° valve handle is in vertical position, fluid will pass-through left-hand side filter only. At 45°, barrier fluid flow will be equal through both filters, this is the desired position during initial start-up. After the barrier fluid reaches normal operating temperature, the valve handle can be moved to the desired operating position to direct flow through one filter only. This process will be repeated during the filter element changeover or replacement process. In Figure 5, if the transfer valve handle is in horizontal position, arrow is lined up with the right side filter, indicating that it is in service."

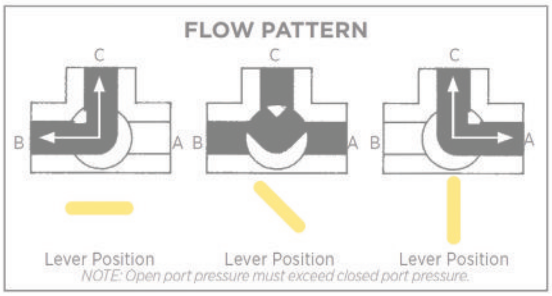


Figure 5

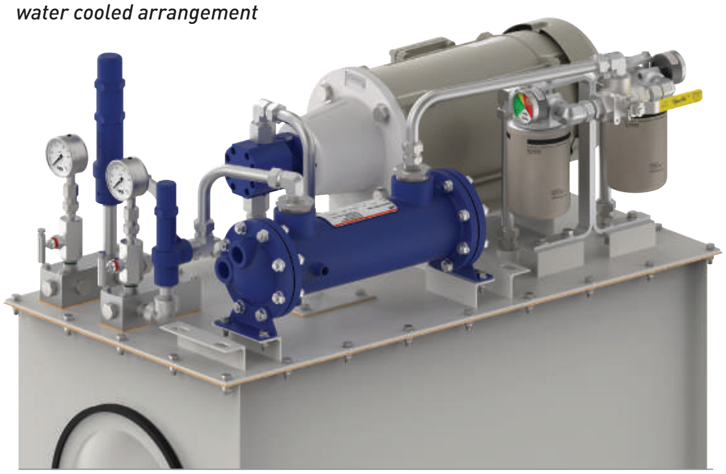
Troubleshooting/Maintenance

The filtration portion of a PELS will require more regular replacement than others. For this reason, accessibility to the filter element needs to be considered during the design process. Filter elements should be mounted to facilitate easy removal and replacement. While this is a relatively simple concept, it can often be overlooked at the design stage, especially if there are alterations to the system configuration.

Venting is a key aspect, especially critical to dual-filtration assemblies. As previously mentioned, having sufficient manual vent valves in place is highly recommended to allow venting of the system during start-up, and to allow trapped air to be bled from the system periodically (air may accumulate at the top of the assembly during normal operation). The manual vent is also critical to the changeover process between elements when used in conjunction with the transfer valve. The frequency of venting of the assembly beyond each start-up will vary between systems.

Maintenance on the filtration portion of the system is relatively simple as changing of the filtration element becomes the pacing item. As a general guideline, filter elements should be changed when the pressure drop approaches the predetermined value above a "new" element, or every 12 months, whichever occurs first. This frequency may be extended or increased based on the system performance; however, any time the barrier fluid is changed it is good practice to change the filtration element as well.

Figure 3: API Plan 54 with water cooled arrangement



Cooling

Even with adequate retention time for heat dissipation defining the reservoir size, supplemental cooling is beneficial to achieve maximum equipment reliability. When specifying cooling requirements, we must first define the acceptable criteria for allowable temperature rise, which is typically 30°F/16°C for lubricating oils used on the majority of pressurized external lubrication systems. One of the greater concerns is the impact of temperature on the utilized barrier fluid and the possibility of thermal breakdown that leads to more frequent maintenance tasks and unplanned equipment outages. An added cooling mechanism to the design of a PELS ensures a stable barrier fluid and optimal sealing environment.

Pressurized external lubrication systems will typically use one of three cooling mechanisms:

1. Internal cooling coil
2. Water-cooled shell and tube exchanger
3. Air-cooled exchanger design

The most frequently used option is the water-cooled shell and tube exchanger for reasons of increased efficiency and availability/operational cost of water as a coolant.

One arrangement for cooling design is to install an internal cooling coil within the reservoir assembly. The biggest advantage is the simplicity of the design, ease of installation and minimal cost. Cooling water travels through the cooling coil at a specified flow rate to minimize the temperature rise within the system. Since the coil is internal, the overall length and available surface area can be limited by available space within the reservoir. This arrangement is typically a single coil arrangement supplied on low heat load applications and within systems supporting single point process equipment.

A water cooled (WC) shell and tube design adds more flexibility with regards to overall design. The most common WC arrangement incorporates a shell and tube design with injection of one media through the shell inlet connection and flow directed through internal baffle plates to the outlet connection. The alternate media then counter flows through a series of tubing runs (bundle) that vary in shape and number of passes. The main components of the exchanger that promote heat transfer include tubing surface area, tube positioning to promote turbulent flow, and thermal conductivity characteristics of the material of construction. Due to being installed on the system skid, the overall capacity of the exchanger can be sized as large as required to meet cooling demand. This also allows for a more rugged design with regards to internal tubing/baffle design, tubing support, shell construction and mounting brackets. In addition, the externally mounted shell and tube design allows for improved access to the coil/bundle elements via flanged end-connections when preventative maintenance is required. Figure 3 depicts a typical design for a pressurized external lubrication system with a water-cooled arrangement.

Alternately air cooled (AC) exchangers are typically utilized when cooling water is not readily available, typically at a remote site or potentially in a tank farm area. In some cases, the end-user does not have a suitable cooling water system and impurities can lead to premature fouling, which would also promote the use of an AC exchanger. The primary facility requirements for utilization of an air cooled exchanger include a reliable power source and ambient conditions where the temperature is lower than desired outlet temperature of the circulation loop, with a 30°F/16°C minimum temperature differential considered to be a good guideline. **Primary components of the AC exchanger include the following:**

- Tube bundle to channel oil through the exchanger
- Motor-driven fan to provide cooled air for heat dissipation
- Plenum chamber to direct air flow
- Control device to regulate process outlet temperature. Design can vary between manual louvers, pneumatic/ electrically operated louvers, variable frequency fan drives, etc.

While the AC design has advantages in eliminating the requirement of cooling water, it does have additional concerns not associated with the water-cooled designs. Periodic lubrication of the motor bearings is required to limit vibration of fan component and is an additional operational task that needs to be addressed prior to commissioning. In addition, the AC design is more susceptible to changing ambient conditions, which can impact the control scheme of the support system.

Regardless of the exchanger type selected for the system, there are certain considerations which apply to each arrangement:

- Cooling systems are typically installed on the primary return line from seal assemblies back to the reservoir
- Cooling coil/shell materials should be compatible with main process fluid
- Redundant exchangers should be considered on all critical equipment and where systems are in support of multiple pieces of process equipment
- Ability to vent, flush and drain exchanger components should be implemented as best practice, regardless of design orientation
- Single or multiple pass designs to be defined based on facility requirements (i.e. lean cooling water supply available, noise limitations associated with higher speed motors, etc.)
- System should be designed to allow for periodic back flushing or bundle replacement
- At a minimum, bulk reservoir temperature should be monitored at the skid with a gauge/thermometer
- Cooling water loop should include visible flow indicator on CW return line to ensure positive flow

Safety Package

PELS systems can be designed with an added layer of protection against severe duty parameters (high speed, high pressure, lubrication deficiencies, etc.) and process release to atmosphere, so that during a manufacturing unit upset or unplanned outage, the mechanical seal can still operate with positive system pressure and provide full containment of the process liquid.

The addition of an accumulator on the primary seal supply line serves as a pressure 'safety blanket' should there be an upset condition within the operating facility, main process pump or pressurized external lubrication system. **Examples of unplanned outages that could lead to reverse pressure situations and potential seal failure are as follows:**

- Power failure to system
- Failed PELS pump or motor components
- Designed interlock to shutdown PELS (low level trip)

Regardless of the mechanism that creates a scenario where the pump or motor are no longer operational, the goal of the safety package is to prevent a reverse pressure situation that could lead to potential process release, compromised mechanical seal assemblies, and cross-contamination of the support system. It should be noted that as the safety package is activated, the system is only providing pressure to the mechanical seal system and the unit is no longer circulating or cooling the barrier fluid. It is

also critical to keep in mind that there is a finite volume of liquid in the closed loop which is dictated by accumulator size and tubing or pipe size and length.

The safety package loop may contain the following critical components:

- Pressure switch
- Accumulator w/bladder
- Check valve
- Isolation valve
- Solenoid/Actuating valve

As the system pressure in the supply line from the lubricator tank decreases, the charged accumulator begins to reverse flow liquid through the supply line, which activates the check valve to seal and activates the front end of the closed loop system. Simultaneously, the pressure switch communicates a signal to the solenoid valve on the outlet connection to close, which prevents migration of the barrier fluid back to the supply tank. The mechanical seal assemblies are still operating with positive pressure (no circulation) and will seal the finite volume of liquid as a function of their working condition. If the sealing interfaces have been damaged or there is an alternate component leak path, the volume of liquid in the accumulator will decrease and the pressure in the system will decay rapidly. Design of all associated valves should incorporate "bubble-tight" components to prevent slow bleed-down of system pressure when activated.

Alarm/Monitoring

John Crane does not recommend continued operation of the main process pump while operating with the safety package engaged. Many engineered pressurized external lubrication systems are equipped with the appropriate pressure and flow alarms or transmitters that communicate the system integrity with the end user's Distributed Control System (DCS); however, there are scenarios such as installations in remote locations where it is not feasible to monitor the unit from the process control room. In any case, communication with operations is required to optimize equipment reliability and limit process exposure to the atmosphere.

As previously discussed, the safety package when energized does not provide cooling to the barrier fluid as the system loop is closed. Operation of the main process pump with the safety package engaged will lead to increased heat loads at the sealing interface, probable face damage associated with thermal rotations and increased seal leakage. The recommended control scheme is to operate with an interlock between the PELS and the main process pump. As the safety package is activated, the pressure switch should communicate a signal to the main process pump to shut down. This system can be designed to shut down the unit on "low-low Pressure"/Plow-low) to prevent nuisance equipment trips.

Troubleshooting/Maintenance

The recommended preventative maintenance schedule for the accumulator component, if incorporated into the design, is simple and can be executed while the unit is operational. A charging kit mounts to the top of the accumulator and will register a pressure value. The system should be recharged if the pressure setting registers at less than 10% of the original charge pressure. A periodic test of the gas charge pressure should be conducted on a quarterly basis. The maintenance frequency can be adjusted based on equipment/ service criticality.

A second preventative maintenance task includes integrity testing of components on the closed loop system. Components to be checked, if incorporated, include the main pressure sensing switch, solenoid valve and check valve. In addition, all tubing and piping connections and fittings should be inspected once the unit is decommissioned as they often serve as leak points and "false" seal leaks. During normal operation, valve positioning should be confirmed. This ensures that the accumulator is liquid full, while charged with pressure

Control

Paramount to reliable operation of pressurized external lubrication systems is the ability to determine the quality and condition of the circulating barrier fluid. Monitoring and controlling the barrier fluid temperature and pressure are two variables that have the most immediate impact on the mechanical seal performance. Degradation in pressure is obviously undesirable as a loss of containment of the process fluid is the potential result, which can lead to unnecessary personnel exposure, environmental impacts, and equipment damage. Failure to maintain a desirable barrier fluid temperature can have equally detrimental effects to mechanical seal performance as repeated exposure to high temperatures will break down the fluid and impact lubricity over time. Accurately monitoring the temperature of the barrier fluid allows the end user to proactively address concerns as opposed to reacting to upsets. As a general rule, the complexity of the PELS control scheme should be in line with the importance of the equipment to the overall process and the associated hazards.

Barrier pressure for the system is set downstream of the mechanical seal by a pressure regulating or pressure control valve (PCV) of some kind. Additionally, high temperature services require additional consideration with a pressure reference line as there will now be another exposed line in the circuit that personnel would potentially come into contact with. Pressure referencing is possible in dirty, thermally sensitive, and hot services but requires the use of specialized instruments.

Figure 4

Constant backpressure downstream of the mechanical seal in a PELS is a reliable alternative and can be used in both single and multiple seal system arrangements. Typically, the back pressure set point is maintained the greater of either 10% or 30 psig/2.0 barg above the estimated maximum seal chamber pressure. This pressure set point determination is made because a system operating at 1000 psi (69 bar) will likely have larger pressure spikes than a 100 psi (6.9 bar) application. For this reason, arbitrarily applying a blanket designation of 30 psig/2.0 barg as a P requirement for all systems, including high pressure applications, is not recommended. During operation, the back-pressure valve maintains upstream pressure (at the seal faces) by varying flow across the valve in response to pressure fluctuations. Provided accurate operating conditions are obtained ahead of time, a PELS can be reliably designed with a constant backpressure control scheme.

Another critical aspect of the control system is the implementation of a pump protection valve (PPV) on each individual motor component. The primary function of the PPV is to allow for recirculation back to the main reservoir should the supply line become obstructed or a downstream component is inadvertently blocked in. Typical engineered PELS set-point for the pump protection valve is approximately 150 psig/10 barg above normal operating pressure although may differ depending on application and design. John Crane typically sets the PPV at the factory prior to shipment and should be tagged accordingly. If the PPVs require setting in the field, it's imperative that an isolation valve be installed on the supply line to create a dead-headed environment to properly adjust the PPV to the proper pressure setting. Figure 4 depicts some common pump protection and bypass valve designs.

It is crucial to communicate the importance of not adjusting the PPV once the system is operational. Adjustment to the PPV can lead to scenarios where the pressure is set too low and barrier fluid is recirculated to the reservoir at much lower pressures than originally designed. This can result in inadequate forward flow to supported mechanical seal assemblies and potential premature failure. It's recommended that local signage, operator training and administrative engineering (documented operating procedures) be implemented to prevent improper adjustment. Pressurized external lubrication system shut down is required to readjust the PPV to the original setting.

Monitoring of barrier fluid temperature is a necessity in pressurized external lubrication systems as it provides an indication of the heat exchanger effectiveness in addition to being a troubleshooting aide when monitoring other system parameters such as flow and filtration quality. In the simplest arrangements, a temperature indicator is placed in the fluid stream to provide a local indication.

Alarm/Monitoring

Alarm logic for any PELS should be determined during the system design process and the scale should reflect the importance of the equipment being sealed. As pressurized external lubrication systems can be designed to provide barrier fluid to multiple users, the alarm philosophies will reflect as such.

Single seal system

- Barrier fluid pressure
  - low pressure alarm based on decreasing pressure
  - low-low alarm to activate solenoid switch on safety package
- Barrier fluid level
  - low reservoir level (loss of barrier fluid across inner seal)
  - low-low reservoir level with automatic lubricator shutoff and interlock to shut down main process pump
  - high reservoir level (reverse flow of product through seal)
- Filter P alarm
  - gauge at minimum, but alarm tied to high filter DP for complex systems
- Temperature monitoring
  - high temperature alarm to facilitate troubleshooting by the site operations, maintenance, or reliability group
- Transmitters and switches
  - when feasible, transmitters are more desirable than switches for monitoring and trending capabilities

Items to consider when troubleshooting/maintaining

- Proper springs are installed
  - for pressure range in control valve (Fulflo valves especially)
- Proper springs are installed
  - for the pump protection valve
- System pump suction strainer
  - should be replaced once a year. Pump performance issues will result from plugged strainer, which will yield insufficient barrier fluid supply quality
- Filter elements
  - see filtration section; P measurement is essential along with filter replacement regularly so that barrier pressure is not compromised
- Strategically mounted temperature indicator
  - use to determine heat exchanger effectiveness and downstream filter performance. A plugged filter will reduce flow which will yield an increase in temperature at the TI
- Local pressure indicator with sensing point at each seal
  - use to determine barrier pressure at the seal if the system is mounted a distance away. Used in multiple seal systems with isolation valves on the inlet and outlet lines so that the seal can be isolated, and integrity checked (drop in pressure indicates a failed seal)

CONCLUSIONS

The API 682 standard provides standard solutions, as well as listing alternatives and customized solutions. API Plan 54 is applicable to multiple applications in the oil and gas, chemical industries and many other industries, but there are multiple drivers and considerations to address when considering the use of a pressurized external lubrication system for such applications. Historically, this has led to custom engineered systems and bespoke designs that can take longer to design and manufacture than standardized, proven systems.

With the introduction of the John Crane global standardized GS54 API Plan 54 system and it's best practice optimized design, this also provides an excellent solution for a wide range of applications across multiple industries. The GS54 enables avoidable complexity to be removed from system development, design and selection process all while providing the confidence and reliability demanded for a pressurized seal support system.

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If the products featured will be used in a potentially dangerous and/or hazardous process, your John Crane representative should be consulted prior to their selection and use. In the interest of continuous development, John Crane Companies reserve the right to alter designs and specifications without prior notice. It is dangerous to smoke while handling products made from PTFE. Old and new PTFE products must not be incinerated. ISO 9001 and ISO14001 Certified, details available on request.

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