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Buffer and Barrier Fluids

by Gordon Buck, Anne-Laure Louarn,
Joe Sehnal, Florian Wisniewski

Increasingly restrictive regulations on leakage and safety have resulted in an increase in the number of multiple seal arrangements. All wet multiple seals use an external fluid in addition to the process fluid that is to be sealed. The terms 'buffer fluid' and 'barrier fluid' are used to describe these fluids. As defined in API 682, a buffer fluid is used in unpressurized dual seals (traditional tandem seal arrangements). A barrier fluid is used in pressurized dual seals to isolate the pump process liquid from the environment. Gases may be used as buffer or barrier fluids depending on the design of the mechanical seals. The following information focuses on liquid buffer or barrier fluids. The first part of this paper defines the properties and families of buffer and barrier fluids. The second part discusses circulation systems, an essential consideration for the reliable operation of sealing systems.

I - Selecting a Buffer/Barrier Fluid

Several critical properties should be looked at when selecting a barrier or buffer fluid. Following are a few guidelines aimed at a better understanding of what a good lubricant should be. The words in italic are defined in the appendix of this paper.

A. One of the most important properties of a good buffer or barrier fluid is its viscosity.

The fluid should be thick enough to separate surfaces, prevent wear, yet thin enough to allow free movement, carry away heat and avoid ***carbon blistering*** if a carbon ring is being used. As a general rule, the following limitations are proposed:

- At process temperature, the viscosity should stay below 150 cSt (695 SUS) to provide adequate flow rates, and should not exceed 100 cSt (462 SUS) when lubricating a carbon ring to avoid carbon blistering.
- The lower viscosity limit is 1cSt (31 SUS).
- At start-ups, when the buffer/barrier fluid is at ambient temperature, the pump may overheat due to the high viscosity of the fluid (the viscosity will then decrease with increasing temperature). The needed shear force and heat generation may be so high that it could damage the seal. According to API 682, the maximum viscosity at minimum temperature should be 500 cSt (2310 SUS). Minimum temperature should be at least 5°F (2.8°C) above ***pour point***, and of course above freezing point. A heater may be added on the reservoir to keep the fluid at process temperature and eliminate cold starts.
- If the fluid is being exposed to a wide temperature range, its ***viscosity index*** should be maximized to ensure a stable viscosity.

B. A good buffer or barrier fluid should be a good heat transfer fluid.

The buffer/barrier fluid should remove heat generated at the faces very quickly. The physical properties of a fluid that reflect this ability are thermal conductivity and specific heat. The higher the process temperature, the higher these values should be. Water has a very good heat transfer ability. The ***specific gravity*** should be at least at 0.7 at process temperature. A higher specific gravity decreases the required flow rate and allows better heat removal.

C. A good barrier or buffer fluid should not present any potential danger whether equipment is running or stationary.

Safety should be a top priority when selecting a fluid. It should first not be a listed VOC (Volatile Organic Compound) or VHAP (Volatile Hazardous Air Pollutants) and second not be flammable in the considered application.

A process temperature at or above boiling point would cause the formation of vapor on and around the sealing faces on the atmospheric side. It would not only promote shortened seal life or catastrophic failure, but formed vapor could be a fire risk. The buffer fluid frequently operates near atmospheric pressure but can potentially reach the same temperature as the pump it serves. Therefore the atmospheric boiling point must be considered and should be at least 50°F (27.8°C) above the process temperature.

Flash point, and of course ***fire point*** must be at least 20°F (11.1°C) above process service temperature to avoid any vapor flammability risks. ***Vapor pressure*** and ***volatility*** should be checked at ambient temperature and pressure.

Refer to the MSDS sheet for proper handling and storage.

D. The fluid must be compatible with the metallurgy, elastomers and other materials of the sealing system.

Lubricants are generally non-corrosive to hardware and faces. Attention needs to be focused on the elastomeric parts of the seal that are more susceptible to chemical reaction.

The compatibility of a synthetic rubber with an oil is dependent on the value of the ***aniline point*** of the oil. A low aniline point causes high to extreme swelling of the elastomer. It results in softening of the elastomer that may permit extrusion of the secondary seal under high pressure, overdampening of the primary ring, and interface fluid film depletion. Ultimately, the faces may burn up or the seal rings may crack under tensile loads.

On the other hand, if the aniline point of the oil is too high, it will cause the secondary seals to shrink and harden, leading to secondary seal failure.

Table 1 on page 4 gives a brief overview of fluid/elastomer compatibilities.

E. The fluid should also be highly compatible with the process pumpage being sealed.

This compatibility is desired whether a buffer or barrier fluid is being considered. Situations that tend to cause any reaction are to be avoided.

The formation of gases, particles, high viscosity liquids or vapors as a consequence would disturb the fluid flow, plate the seal faces or cause wear and leakage. Each fluid must be individually considered based on its chemical compatibility with the process stream. Consult a process engineer at the customer's facility.

Caution: The barrier or buffer fluid slightly contaminates the process stream. Therefore it is important that the chosen barrier fluid meets the requirements of the end users, i.e. those who will buy the pumpage. John Crane customers should also consult with their clients regarding the chemical compatibility of the barrier/buffer fluid with their end product.

F. Foaming risks are to be avoided.

In pressurized systems, the barrier fluid is often pressurized by using a gas blanket (usually nitrogen) per API flush plan 53. In this case, problems can occur when the gas is absorbed into the barrier fluid. As pressure is relieved or temperatures rise, gas may be released from the fluid. This release of gas can cause foaming, resulting in loss of lubrication, heat transfer and circulation.

John Crane's policy is a maximum of 450 psig and a temperature limit of 250°F (139°C) when nitrogen is used to pressurize a system. This limit should be adjusted depending upon the barrier fluid used. If its gas solubility is high, the limit should be lowered. API 682 does not recommend pressurization above 150 psig with a gas blanket. At higher pressure, a circulating system that does not put the gas in direct contact with the lubricant should be used, such as a piston pressurization or an oil/air circulating pump. In the case of a buffer fluid vented to atmosphere, a good choice is to use a lubricant with a low gas solubility and a low vapor pressure.

The last issue that needs to be addressed is the importance of the size of the inlet/outlet ports and piping diameters (see part III). Big diameters will allow air bubbles to move away and prevent them from stopping the fluid circulation, unlike smaller diameters that will trap bubbles along the walls of the tube or pipe.

G. Fluid stability must be ensured for a longer maintenance cycle time.

The greater the stability of the fluid, the longer the maintenance interval. Fluids exposed to oxygen must resist oxidation at operating and static conditions. The oxidation of the fluid causes the formation of acids and carbonized by-products. This results in carbon deposit on the faces (coking), viscosity change, and loss of sealing and heat transfer properties. The oxidation resistance of a fluid is indicated by its ***total acid number***.

Synthetic oils are more susceptible to acid formation than hydrocarbons.

Unpressurized buffer fluids may loose volatile materials, causing an adverse effect on their original performance characteristics. Highly volatile fluids may cause as well dangerous conditions and pressure drop. Fluids with low vapor pressure are essential to keep the volume of the lubricant constant.

To summarize, an ideal buffer/barrier fluid would have the following properties:

- safe to use, handle, store
- not a VOC, VHAP or other regulated compound
- nonflammable
- good lubricity
- good heat transfer properties
- compatible with process fluid
- compatible with seal materials
- good flow qualities at very low temperatures
- remains a stable liquid at ambient temperatures
- non-foaming when pressurized
- low solubility of gas
- inexpensive

Restrictions on use of some chemical compounds has caused users and manufacturers of mechanical seals to review their recommendations on buffer or barrier fluids. As a result, some traditional and readily available fluids are no longer recommended. For example, the higher viscosity lubricating oils are likely to cause blistering of a carbon seal face. Automatic transmission fluid and automotive antifreeze contain additives that form deposits on the seal faces. Methanol and ethylene glycol are regulated VHAP.

II - John Crane Barrier/Buffer Fluid Families

To aid in the selection of buffer and barrier fluids, John Crane has established six groups or 'families', where fluids of like composition and/or properties are classified:

A. glycol solutions and water
B. alcohols
C. kerosenes and diesel fuels
D. petroleum based hydraulic and lubricating oils
E. synthetic hydraulic oils
F. heat transfer fluids

Following is a discussion on some commonly used fluids in each family:

A. Glycol Solutions and Water

Automotive anti-freeze is not recommended.

Water. Water can be a good barrier/buffer fluid. Viscosity is generally around 1 cSt (31 SUS) at modest temperatures; however, the viscosity is low at 212 °F (100°C) -- which is also the atmospheric boiling point. Also, in many climates, water may freeze at ambient conditions.

Ethylene glycol/water. A 50/50 mixture has been successfully used as a buffer fluid for tandem seal arrangements in many services. However, ethylene glycol is now classified as a VHAP and is being replaced by propylene glycol.

Propylene glycol/water. A 50/50 mixture has become a recommended buffer fluid for many services.

B. Alcohols

Caution: Alcohols can have a high rate of evaporation. Frequent re-fills may be required on a plan 52 (unpressurized buffer fluid). Check the properties of the alcohol type that is being considered.

Methanol. Although methanol has been used in the past as a buffer fluid for tandem seals in low temperature services, it is a VHAP and is not recommended. In addition to being toxic, methanol has a low boiling point and low viscosity. It is not a good seal face lubricant.

Propanol. 1-Propanol, or n-propyl alcohol, has replaced methanol as a buffer fluid for low temperature services. It has become one of the recommended buffer fluids for low temperature applications.

C. Kerosene and Diesel Fuel

The viscosity of diesel fuels and deodorized kerosenes can provide adequate seal face lubrication through a wide temperature range. Although not a flashing hydrocarbon according to API 682, diesel fuels and kerosenes may be classified as volatile organic compounds (VOC), especially at higher temperatures.

D. Petroleum Based Hydraulic and Lubricating Oils

Lube oils. Although turbine oils have been used extensively in the past, experience is that the anti-wear/oxidation resistant additives plate out on the seal faces. Reference temperatures of 40°C (104°F) and 100°C (212°F) are conventions used in measuring properties of lube oils. For example, an ISO grade 68 oil has a viscosity of approximately 68 cSt at 40 °C. John Crane's experience is that the lower viscosity grades, (less than Grade 32) provide better performance. Paraffinic based oils seem to be better than napthenic oils. Blistering of carbon seal faces is common when lube oils are used as buffer/barrier fluids -- especially ISO grades 32 and higher. Experience has shown that synthetic oils perform better than conventional turbine oils; this may be partially due to the (generally) lower viscosity of the synthetics.

Automatic transmission fluid. Automatic transmission fluid has the proper range of viscosities but is not recommended. Actual experience has generally been that automatic transmission fluid is a poor barrier fluid; the assumption is that the various additives are the problem.

E. Synthetic Based Hydraulic and Lubricating Oils

A number of synthetic lubricants have been developed in recent years.

There are numerous synthetic lubricants available in the marketplace. A number of these are under evaluation.

Royal Purple Barrier Fluid 22. Royal Purple Barrier Fluid 22, as an example, was developed specifically for buffer/barrier fluid FDA service and has proven to be a very effective buffer or barrier fluid both in laboratory tests and in the field.

F. Heat Transfer Fluids

Heat transfer fluids that have the ability to provide adequate lubrication throughout a wide range of temperatures and pressures can be used as buffer or barrier fluids. This class encompasses a broad spectrum of chemical families (water, steam, inorganic salts, certain liquefied metals, organic class fluids,...)This paper addresses the use of organic class heat transfer fluids. They fall into two categories:

- Petroleum based fluids called 'hot oils'
- Synthetic aromatic fluids, such as Dowtherm HT. They offer higher thermal stability, broader working temperatures range and are more effective than petroleum 'hot oils'.

Dowtherm. Dowtherm is a family of synthetic heat transfer fluids manufactured by Dow Chemical Company. Dowtherm types are A, G, LF, J, HT, and Q. Dowtherm HT is the recommended type for buffer or barrier fluid.

General Guidelines for John Crane Buffer/Barrier Fluid Families

Table I shows general guidelines of the John Crane Buffer/Barrier Fluid Families. Use of a fluid from these families does not necessarily ensure successful operation of a sealing system. The temperature range of each family covers all temperature ranges of each fluid included in this family. For a temperature range specific to a fluid, use Table II.

Caution: Check the allowable temperature range of elastomers before using them. Table I on page 4 addresses only chemical compatibility. The temperature range for a fluid family might not be the same as the listed compatible elastomers.

Details of flow, temperature rise, etc. must be checked for each application. Fluids in each family may be used in services more severe than indicated by the family specification providing that the properties and qualifications of the particular fluid are deemed suitable after appropriate engineering review.

Family	Practical Limit (Fluid temperature)				Elastomer
	Minimum		Maximum		
	°F	°C	°F	°C	
Glycols	-20	-29	185	82	E, X18, X48
Alcohols	-191	-85	157	70	B, E, X18, X48
Kerosene/Diesel	0	-18	180	82	X18, B, X, X48
Lube Oils	-20	-29	300	150	X18, N*, B, X, X48
Synthetic Oils	-25	-32	480	249	N*, B†, X, X48
Heat Transfer Fluids	0	-18	650	340	Check compatibility for each fluid

Notes: Elastomer material codes are:
B = Buna-N X = Fluoroelastomer
E = Ethylene propylene N = Neoprene
X48 = Perfluoroelastomer X18 = Aflas™

* Select appropriate compound based on aniline point of fluid.
† Check compatibility with formulation.

Table 1.
Guidelines for John Crane Buffer/Barrier Fluid Families

III - Piping Systems and Circulation

The performance of a barrier/buffer fluid depends on its properties, but is also closely linked to the performance of the pumping ring and the design of the piping system. The following information gives a broad overview of circulation systems and fluid flow rates.

API Plan 52 and 53

Figures 1-4 show the API schematics for API Plans 52 and 53, but cannot be used to predict the circulation rate. More details are required.

Plan 52 uses an external reservoir to provide buffer fluid for the outer seal of an unpressurized dual seal arrangement. During normal operation, circulation is maintained by an internal pumping ring. The reservoir is usually continuously vented to a vapor recovery system and is maintained at a pressure less than the pressure in the seal chamber.

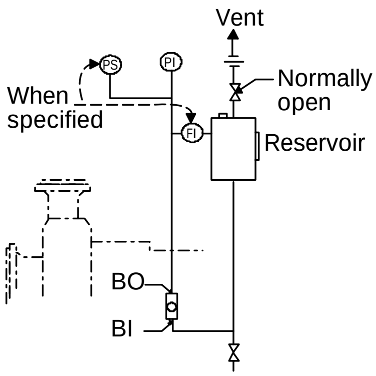

Figure 1. Plan 52

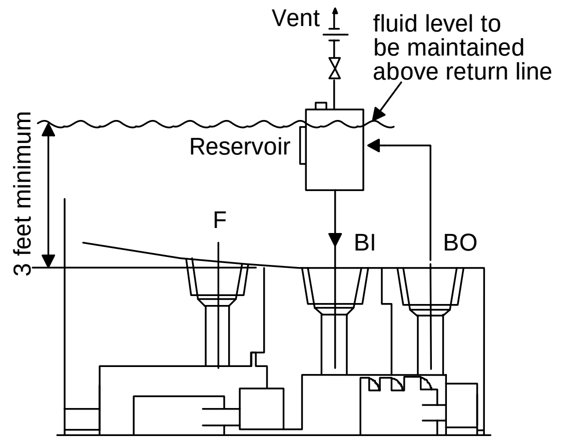

Figure 2. Seal Chamber for Plan 52

For Plan 52, the reservoir is located as close as possible to the seal. The John Crane recommendation is that the bottom of the reservoir be 12 to 30 inches above the centerline of the pump, and be within three feet (horizontally) of the seal. API 682 requires that the liquid level provides at least three feet of static head to the outer seal.

Plan 53 uses a pressurized external barrier fluid reservoir to supply clean fluid to the seal chamber. Circulation is by an internal pumping ring or a thermosiphon. Reservoir pressure is greater than the process pressure being sealed.

Plan 53 systems are very similar to Plan 52 systems except that Plan 53 is pressurized whereas Plan 52 system is usually vented.

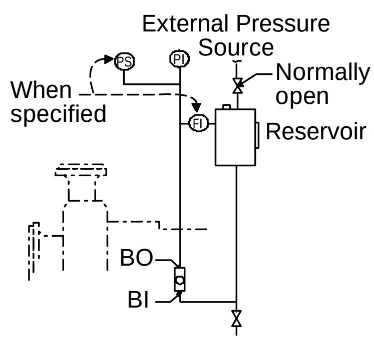

Figure 3. Plan 53

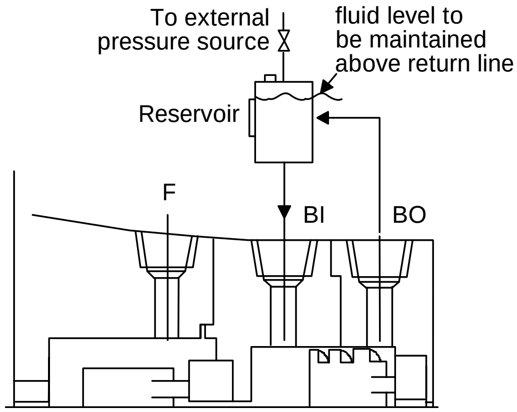

Figure 4. Seal Chamber for Plan 53

System Curves

A system curve shows the relationship of flow and pressure. As an example, in order to produce more flow, additional pressure (really pressure difference) is required. Figure 3 shows an example of a system curve for water and lube oil. The relationship between required differential head and flow rate depends on the considered system.

In Figure 5, the vertical axis is the head (or pressure) that is required to produce the flow rate on the horizontal axis. For example, if a flowrate of 2 gpm of water is desired, then the pressure difference in the system must be about 8 feet of liquid (3.5 psi of water). The pumping ring creates the pressure difference (exit pressure from the pumping ring minus entrance pressure to the pumping ring). If the pumping ring is not capable of providing 3.5 psi at the two gpm flow rate, then the flow through the system will not be two gpm.

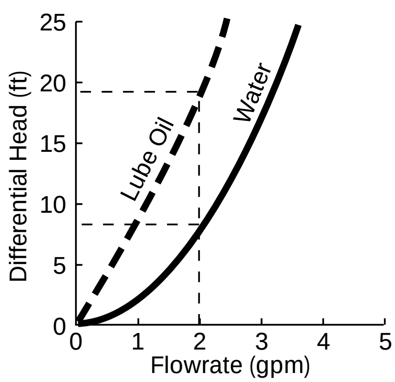

Figure 5.
Comparison of System Curves for Water and Lube Oil

Some of the variables that affect the system curve are: pipe size, pipe length, number of fittings, type of fitting, static head and type of fluid. Although the specific gravity of the fluid has some affect on the system curve, viscosity is the most significant fluid property. In particular, lubricating oils with viscosities greater than around 6 cSt (45.5 SUS) require more head to produce a given flow. Figure 5 shows that to produce a flowrate of two gpm of lube oil, the pumping ring must put up around 19 feet of head. This compares to 8 feet of head when water is the fluid. Figure 6 shows system curves for a typical Plan 52 or 53 system. These curves, based on water, are approximately true for viscosity less than 3 cSt (36 SUS). This figure illustrates the importance of using large diameters. For example, to circulate two gpm in 1/2" tubing requires a differential head of 15 feet (6.5 psi of water) but only 3 feet of head is required for 3/4" tubing.

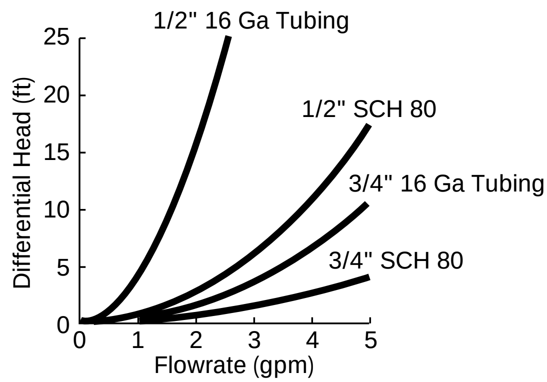

Figure 6. Plan 52 System Curves for Water

Pumping Rings

Any rotating component can produce some pressure from centrifugal effects. Even a smooth disk will act like a pump to some degree. Naturally, the pumping effect is less than would be obtained from a true impeller; however, it may still be adequate. This pumping effect is greatly enhanced if the rotating element is placed near a tangentially directed outlet port.

The pumping effect is increased when the clearance between the rotating element and outlet port is decreased. Keeping this effect in mind helps to emphasize that the clearance between any rotating component and the inlet port should be greater than the clearance at the outlet port. Alternately, the inlet port can be made tangentially (but opposite to the outlet). Testing has shown that increased radial clearances improve flow on paddle wheel (radial flow) pumping ring.

Figure 7 shows the measured performance curve for a 2-5/8" Type 8B-1 seal at 3600 rpm. Outlet ports were tangential and 3/8" in diameter. Performance is shown with and without the axial flow pumping ring. Pumping rate is much lower without an axial flow pumping ring; however, in many cases even this reduced performance may be adequate.

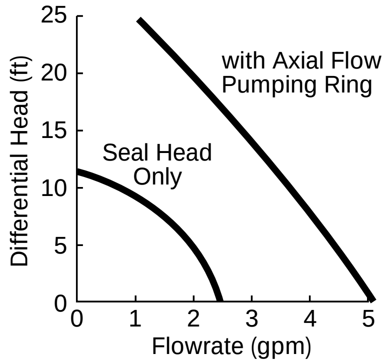

Figure 7. Performance Curve for a 2-5/8" Type 8B1 at 3600 rpm on water. Tangential exit used 3/8" diameter ports.

Combined Pumping Ring and System Curves

The actual circulation rate depends on both the pumping ring performance curve and the system curve. In fact, the circulation rate is determined by the intersection of these two curves. Figure 8 shows the performance of a 2-1/4" axial flow pumping ring in water. The radially directed ports were 1/2" diameter. Figure 8 shows that the expected circulation rate at 3600 rpm would be around 5.6 gpm for the standard Plan 52 system using 3/4" tubing. The circulation rate is reduced to around 2.1 gpm when 1/2" tubing is used. For this particular situation, either size tubing allows a reasonable circulation rate.

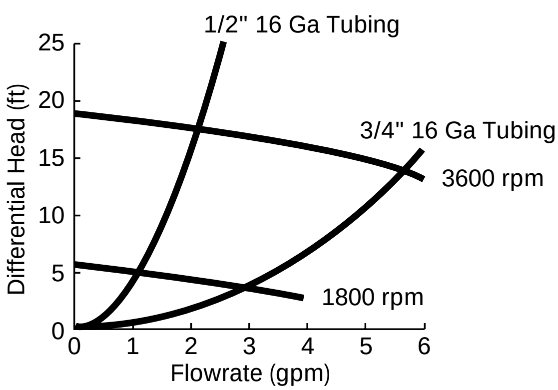

Figure 8. Performance of 2-1/4" axial flow pumping ring in Plan 52 systems. Radially directed ports are 1/2" diameter.

IV - Recommended Buffer and Barrier Fluids

John Crane Testing

John Crane has conducted a number of tests on various buffer and barrier fluids. Three types of tests have been used to determine recommendations for using these fluids.

The first test was a simple screening test designed to select candidates for further testing with seals. The second test was carried out with a complete mechanical seal and sealing system on several selected fluids. The last series of tests has been conducted on a sealing system conforming to API 682. Barrier and buffer fluids were evaluated in a 100 hours sequence on a cartridge seal. Pre and post test face measurements were taken, and critical operating conditions, such as temperatures, pressures, and horsepower were monitored. The process fluid was propane at ambient temperature. When a barrier fluid was tested, the outboard seal was pressurized 25 psi above process pressure.

A post test review and interpretation of test results concludes the following :

White mineral oils and silicon based oils produced very high torque and coefficient of friction in simple screening tests. Based on this result and poor field experience, these fluids were not tested further and are not recommended.

Grade ISO 32 oils have shown mixed results: In general PAO[1] based oils did not provide the best lubricity and caused significant wear on the faces. The higher viscosity of ISO 32 oils is likely to cause carbon blistering, requires a higher horsepower and generates more heat. ISO 32 PAO-Based Synth-1 failed twice causing a high seal leakage and coking on the faces, when tested as a barrier fluid. Therefore this oil is not recommended for use as a barrier/buffer fluid.

ISO 32 PAO-Based Synth-2 generated a high horsepower while demonstrating poor heat transfer and high face temperature. Based on these tests and field experience viscosity grades higher than 32 are not recommended unless dictated by high temperature applications.

Kerosene K1 successfully completed the test as a buffer and barrier fluid. Its low viscosity allowed low horsepower, low head pressure, and good heat removal capability showed by low faces temperatures. Face conditions were good after the test. It is therefore recommended as a buffer/barrier fluid.

Kerosenes grades higher than K3 are not recommended either as a barrier or buffer fluid due to their higher viscosity.

[1] PAO: Poly Aliphatic Olefin. Defines the molecular structure of the organic fluid. Molecules are unsaturated (olefin) straight chains (aliphatic) of carbon atoms.

☺ **Synth-3 and Synth-4 low viscosity synthetic hydrocarbons** gave excellent results and did not require a horsepower as high as ISO 32 oils due to their lower viscosity. They demonstrated good heat transfer capabilities. Conditions of faces were excellent.

☹ **Synth-5**, with a viscosity equivalent to an ISO 32 grade, had disappointing results. It generated high face temperature and wear. This oil may be suggested for high temperature applications.

☺ **Diester-based oils** such as Synth-6 performed well. In general, diester fluids demonstrate a better lubricity than PAO based oils. However, performance varied widely among different manufacturers. Diester-based Synth-7 generated some grooving on the primary ring and high heat at the faces. Reasons for these results are under review.

Conclusion: Oil-synthetics (non PAO) ran better, cooler than ISO 32 oils, and would provide a longer seal life.

Recommended Barrier and Buffer Fluids

Based on tests, fluid properties and field experience, the buffer and barrier fluids listed in Table II are recommended. Please refer to the customer's process engineers to check compatibility with processed fluid.

Conversion Data

Kinematic Viscosity Conversion Table

To obtain the Saybolt Universal Viscosity equivalent to the viscosity in cSt at a determined temperature of ***t*** **°**F, multiply the equivalent Saybolt Universal viscosity at 100**°**F by [1 + (***t*** -100) * 0.000064].

e.g: 10 cSt at 210**°**F are equivalent to 58.8 * 1.0070, or 59.2 SUS at 210**°**F.

Centi-stokes	SUS at 100°F	Centi-stokes	SUS at 100°F	Centi-stokes	SUS at 100°F
1	31.0	12	65.9	32	149.7
2	32.6	14	73.4	35	164.2
3	36.0	16	81.1	40	185.7
4	39.1	18	89.2	45	199.2
5	42.3	20	97.5	50	231.4
6	45.5	22	106.0	60	277.4
7	48.7	24	114.6	70	323.4
8	52.0	26	123.3	80	369.6
9	55.4	28	132.1	90	415.8
10	58.8	30	140.9	100	462.0

Table III. Kinematic Viscosity Conversion Table

Temperature Conversions

t(°F)= t(°C) * 9/5 + 32

t(°C) = [t(°F) - 32] * 5/9

Family	Fluid Name	Sp @ 60°F	Viscosity, cSt/SUS @ temperature, °F/°C		Pour Point °F/°C	Boiling Point °F/°C	Specific Heat @ 60°F Btu/lb°F	Thermal conductivity @ 60°F Btu/hr ft°F	Pump Temperature Range, °F/°C	
			104/40	212/100					Min	Max
Glycols and Water	Ethylene glycol in water (50% vol)	1.07	2.5/34.3	0.8/30.7	-30/-34	225/107	0.78	0.22	-20/-29	165/74
	Propylene glycol in water (50%vol)	1.05	2.6/34.0	0.7/30.5	-28/-33	222/106	0.79	0.21	-20/-29	170/77
	Water	1.00	0.68/30.5	0.29/29.9	32/0	212/100	1	0.34	40/4.4	160/71
Alcohols	n-Propyl-Alcohol	0.81	1.5/31.8	0.45/30.2	-195/-126	207/97	0.53	0.09	-191/-124	157/69
Kerosenes and diesels	K-1 Kerosene	0.83	1/31.0		-20/-29	300/149	0.46	0.086	-10/-23	250/121
	K-2 Kerosene	0.85	1.4/31.24	0.6/30.3	-30/-34	350/177	0.46	0.086	-20/-29	270/132
	D-1 Diesel	0.83	1.4/31.24	0.6/30.3	-30/-34	350/177	0.46	0.086	-20/-29	300/149
	D2-Diesel	0.86	2.7/35	1.0/31.0	-75/-59	360/182	0.46	0.086	10/-12	180/82
Lube oils	Lube-1	0.86	13.9/75.8	5.1/43.2	-75/-59	219/104	~0.5	~0.08	-20/-29	169/76
	Lube-2	0.85	9.5/59.4	2.6/34.0	10/-12	335/168	~0.5	~0.08	20/-6.7	285/140
	Lube-3	0.89	9.5/57.1	2.3/33.5	-58/-50	>300/>149	~0.5	~0.08	20/-6.7	275/135
Synthetic Lube oils	Synth-3	0.80	7/48.7	1.5/31.8	-80/-62	700/371	0.555	0.089	-25/-32	430/221
	Synth-4	0.82	22/106.0	3.3/36.9	-80/-62	700/371	0.569	0.085	25/-4	440/227
	Diester-Based Synth-6	0.96	37.2/173	5.35/43.4	-58/-50	493/256	0.528	0.079	62/17	440/227
Heat transfer fluids	Aromatic-1	1.01	29/135	4/39.1	25 /-4	650/343	0.35	0.071	55/13	600/316

Table II. Recommended Buffer and Barrier Fluids

Appendix

Critical properties definitions of barrier and buffer fluids and related ASTM tests

Property	Definition	Standard	Comment
Flash Point, in °F	Temperature at which a fluid gives off enough flammable vapor to flash in the presence of a flame. The temperature varies with different fluids. Flash point is a critical factor in evaluating fire hazards, and should be higher than service temperature if in contact with oxygen.	ASTM D92	
Pour Point, in °F	Lowest temperature at which a fluid will flow or pour before turning into a gel. Pour point is an important consideration with low temperature applications and refrigerants, and should be at least 5°F above minimum temperature at which fluid is exposed.	ASTM D97	
Viscosity, in SUS, cSt, or cPs	It is the measure of a relative resistance to a fluid to flow. Low viscosity fluids flow freely, high fluids flow sluggishly. Units are cSt (centistoke), cPs (centipoise) or SUS (Saybolt Universal Seconds).	ASTM D2270 ASTM D2161	The viscosity grade to be chosen depends on the temperature and the pressure range of the application. High viscosity grades are suitable for very high temperatures.
Viscosity Index	The viscosity index of a fluid indicates the degree of variation of viscosity with temperature. The higher the index, the more stable the viscosity with temperature change.	ASTM D2270	
Specific Gravity	The specific gravity of a liquid is the ratio of its density at specified temperature to that of water at 60°F. A higher Sg decreases the required flow rate and allows a better flow.	ASTM D1250 ASTM D287	
Specific Heat in BTU/lb°F	Ability to absorb heat		
Thermal Conductivity in BTU/Hr. Ft°F	Ability to transfer heat		
Aniline Point, in °F	The aniline point is the minimum temperature at which two equal volumes of aniline and fluid are miscible. It appears to characterize the swelling action of a petroleum oil on synthetic rubber.	ASTM D611	
Corrosivity	Ability of the fluid to interact chemically with metal parts of the sealing system.	ASTM D130 ASTM D665	This ASTM test measures the corroding action of petroleum products on metal. A copper strip is immersed in the tested fluid in presence of oxygen and metal catalyst. Its color after removal is ranked from 1 through 4. The higher the index, the more corroded the state. The index should be low (1a, 1b). Corrosion rate of 0.002"/ yr is sought.

Property	Definition	Standard	Comment
Total Acid Number	The TAN (Total Acid Number) in mg KOH/g indicates the degree of oxidation of the oil. The test assesses the oxidation stability of inhibited oils by evaluating the number of hours required to reach 2.0 mg KOH/g in presence of oxygen and a metal catalyst.	ASTM D943	
Foam	Dispersion of gas in the fluid under the form of microscopic bubbles.	ASTM D892	The test measures the volume of foam right after fluid has been blown by air for 5mn, and later, after having allowed it to settle for 10 mn. Repeated 3 times (75°F, 200°F, 75°F)
Gas Solubility	Ability of the fluid to absorb and blend uniformly with gas. Should be minimum.	ASTM D2780	
Volatility	Loss of mass by evaporation of a lubricating oil as a percentile of its total mass, in fixed conditions.	ASTM D972	
Water Separability	High demulsibility ability allows a lubricant to separate from water if contaminated when it stands in the reservoir. It facilitates the drainage.	ASTM 1401	The test must be passed.
Carbon Blistering	Carbon blisters are eruptions which occasionally occur on the rubbing face of carbon rings used in systems containing oil. Oil from the hydrodynamic films enters into the pores of the carbon running face. A rapid rise in temperature causes this oil under the surface to expand. When the oil cannot come out rapidly enough, a subsurface pressure occurs, leading to local cracking of the carbon.		
Wear	Damage resulting from friction.	ASTM D4172	The test is called 4 ball wear test: A steel ball is pressed and rotated on three other clamped balls covered with lubricant. The average size of the scar diameters on the 3 lower balls is used to compare lubricants. The scar diameter should be as small as possible. Lubricants must have good anti-wear properties in order not to damage the sealing faces and cause leakage.

References

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