HOW TO DEAL WITH PRE-CHARGE LOSS IN BLADDER ACCUMULATORS DUE TO GAS PERMEATION

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The trade-off to using low-temperature bladder compounds in mobile hydraulic applications is higher gas permeation rates through the bladder at working temperature.

Hydraulic bladder accumulators are the preferred choice in mobile applications where rapid cycling, high fluid contamination and fast response times are required. Bladder accumulators are used in a wide variety of mobile hydraulic systems to optimize system performance and prolong equipment life by asorbing shock, maintaining system pressure or providing a backup power supply of hydraulic energy. Typical mobile hydraulic applications are listed in Table 1 – Mobile Applications For Hydraulic Bladder Accumulators.

What most designers don't account for is the inherent loss in pre-charge that occurs over time due to gas permeation through the bladder. Left unchecked, this pre-charge loss leads to poor performance and premature bladder failure.

This issue is of most concern in mobile applications where there can be a significant difference in the temperature when the equipment is not in use (-60˚ to 100˚F) and when it is at working temperature (0°F to 250°F). The key is to fully understand the Permeability Factor of the selected bladder material for low temperatures vs. the potential pre-charge loss due to gas permeation at working temperature.

In that gas permeation cannot be avoided, it needs to be factored into the application specification. The pre-charge needs to be routinely checked and maintained throughout the life of the equipment application.

BLADDER ACCUMULATORS – AN OVERVIEW

Hydraulic bladder accumulators consist of a fluid section and a gas section (Figure 1). The flexible rubber bladder acts as a gas-proof screen. The fluid around the bladder is connected with the hydraulic circuit so that the accumulator draws in fluid, thus compressing the gas. When the pressure drops, the compressed gas expands and forces the stored fluid into the circuit. A poppet valve, normally held open by spring pressure, prevents the bladder from extruding out of the fluid port.

Bladder accumulators provide the following advantages over piston and diaphragm accumulator designs. Specifically they:

- work better with fluids that have low lubricity, including water,
- are more contamination tolerant,
- are lighter in weight,
- have a very quick response – especially at low pressures (under 100 PSI), and
- can be repaired quickly and easily should there be a failure.

FIGURE 1.

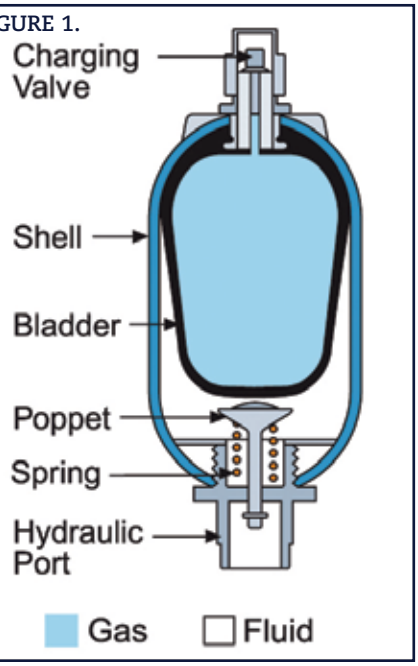


FIGURE 1. BLADDER ACCUMULATOR DIAGRAM

FIGURE 2. PERMEABILITY FACTOR & BLADDER COMPOUNDS

FIGURE 3. MINIMUM USE TEMPERATURE & BLADDER COMPOUNDS

FIGURE 2.

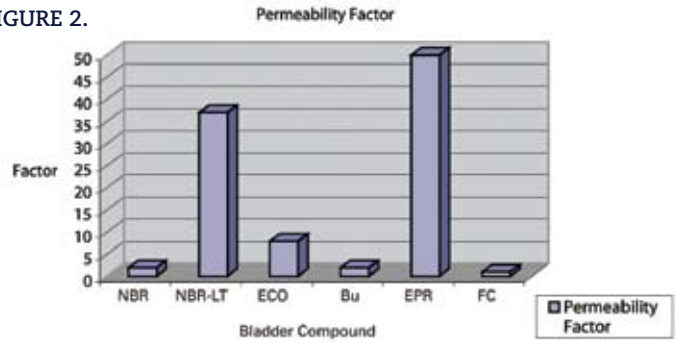
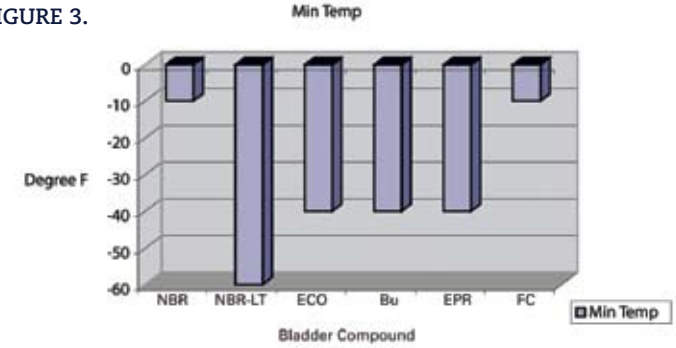


FIGURE 3.



SELECTION CONSIDERATIONS

There is a range of bladder compounds available that permit accumulator use in temperatures from -60˚F to 250˚F. Each compound has a specific minimum low temperature limit. Most important, each has a gas pre-charge loss Permeability Factor that can range from "minimal" to "significant" depending on the application working temperature. Because of the vast performance differences in bladder compounds, the No. 1 application consideration is the fluid to be used in the system. The No. 2 consideration is the application temperature range.

BLADDER COMPOUNDS FOR LOW TEMPERATURE APPLICATIONS

Bladder compounds for low-temperature applications (-60˚F to 0˚F) include those listed in Table 2. Nitrile bladders are considered suitable for most fluid power applications. The other compounds are designed to provide compatibility with a wide range of fluids, working temperatures and gas permeation requirements. To determine which material is appropriate for a given application, always refer to the fluid manufacturer's recommendation.

THE GAS PERMEABILITY ISSUE SIMPLIFIED

As you gain low-temperature capability in a bladder compound, permeability of the bladder increases and hence greater pre-charge loss due to gas permeation at working temperature.

To show the direct correlation, the permeability potential of each bladder compound was tested to define the relationship between bladder compound permeability and temperature.

The Gas Permeability Factor was determined by rating the permeability (potential loss of gas pre-charge through the bladder) of each compound on a scale of 0 to 50 at 70˚F. The higher the Permeability Factor, the faster gas pre-charge would be lost in a low-temperature application using that bladder compound. Bladder Material Codes for Parker accumulators have been assigned to simplify compound identification in manufacturing and on through packaging, marketing, shipment, and customer use (Table 3).

EPR, for example, has a low temperature limitation of -40˚F, but a Permeability Factor of 50. For comparison, a Hydrin bladder would be four times more permeable than that of a Nitrile bladder in the same application. Likewise, an EPR bladder would be 25 times more permeable than a Nitrile bladder.

The Permeability Factor increases or decreases with temperature, setting up a trade-off situation for having to use a low-temperature bladder compound. If the application requires a -40˚F bladder material because the equipment needs to be left out in the cold overnight, the upside is that the bladder won't shatter at low temperature. The downside is that the pre-charge in the bladder will have to be checked more often because of the higher working temperature when the oil warms up.

BLADDER MINIMUM TEMPERATURE USE VS. PERMEABILITY FACTOR CHARTS

The following charts will assist bladder accumulator users when they have a low temperature application. Figure 2 – Per-

meability Factor & Bladder Compounds shows the permeability of each compound on a 0 to 50 Permeability Factor scale. Again, the Permeability Factor was determined by testing each compound at 70˚F. Nitrile, Butyl and Fluorocarbon compounds are graphically shown to have relative low Permeability Factors. Nitrile LT and EPR compounds have relatively high Permeability Factors.

Figure 3 – Minimum Use Temperature & Bladder Compounds shows the lowest temperature in which each bladder compound can be used. Referencing both charts, it is graphically easy to see that the Nitrile LT compound, for example, has excellent low temperature capability at -60˚F, but the trade-off for that low-temperature performance is a relatively high Permeability Factor of 37. This is a solid confirmation that using this bladder compound will require more frequent maintenance checks for the loss of pre-charge due to gas permeation.

MANAGING GAS PRE-CHARGE

When pre-charge is lost in a bladder accumulator, it changes the available volume in that application. Example: Where emergency power, or the auxiliary power source, is supplementing pump flow, or where the accumulator is sized based on how much volume is needed to accomplish the task, too low a pre-charge can have rapid and severe consequences. Specifically, in an emergency situation there would not be enough fluid to complete the cycle, or the cycle would slow down.

Should pre-charge continue to be lost, the point is eventually reached where the bladder will be damaged. That "point" occurs when the maximum ratio exceeds 4 to 1 between the maximum pressure and the pre-charge. If, for example, the maximum pressure is 2,000 PSI, the pre-charge should not go below 500 PSI. This is the point where damage to the bladder begins.

Depending on the application, such a loss of pre-charge could represent a significant safety issue. Emergency power and emergency steering applications are prime safety issue examples.

Restated, pre-charge loss is inherent in bladder accumulators that occurs over time due to gas permeation through the bladder. Hence, pre-charge needs to be monitored on a regular basis, especially if the chosen bladder compound has a high permeability rate.

How long will a pre-charge last in a given application? As previously noted, the "life factors" are the bladder compound and temperature. Every application presents many variables. For new applications, the recommended pre-charge maintenance protocol is to…

- Check pre-charge once a month for the first six months. If there are no problems…
- Extend the maintenance period to two months. If there are no problems…
- Extend the maintenance period to three months… and continue the maintenance extension on a monthly basis until a precharge maintenance comfort level is reached for that application.

In some applications, the working temperatures may be sufficiently moderate that pre-charge only needs to be checked on a yearly basis. The procedure for checking pre-charge is detailed in the supplied Maintenance Bulletin for bladder accumulators.

Can a portion of the pre-charge be lost when checking the pre-charge level? Yes, it's possible. Bladder accumulators are available in sizes ranging from 5 cubic inches up to 400 gallons. Hence, the smaller the accumulator, the less amount of gas is in play. For this reason, care must be taken in checking the pre-charge level of smaller accumulators to ensure that the correct amount of pre-charge is always maintained.

BLADDER LIFE EXPECTANCY

Properly designed and sized for the application, and with pre-charge checked as part of a regular maintenance schedule, the bladder should last for the life of the application. In that bladder accumulators and the bladder compound selected are application specific, there is no reason to replace a bladder unless it fails.

TABLE 1. MOBILE APPLICATIONS FOR HYDRAULIC BLADDER ACCUMULATORS

Brakes (park and service) - wheel loaders, backhoes, off-highway vehicles
Ride Control - wheel loaders, backhoes, skid steering
Steering - off-highway vehicles
Hitch cushion - bowl scrapers
Energy recovery - excavators
Trach take-up - steel and rubber tracks on bulldozers and backhoes
Pilot lines to supplement pump flow - wheel loaders, bull dozers and backhoes
Piolot lines to suppress shock - wheel loaders, bulldozers and backhoes
Supension systems - trucks, sprayers
Transmission to keep brakes/clutch park releaser
Shock counterbalances - comoines
Shock absorption - scraper blades, sprayer arms

TABLE 2.

	Min. Temp (°F) [1]
• Nitrile	-10
• Nitrile LT	-60
• Hydrin	-40
• Buty	-40
• EPR	-40
• Fluorocarbon	-10

[1] The Temperature listed is the lowest temperature in which the compound can be used.

TABLE 3.

	Min. Temp (°F) Factor	Permeability Factor	Parker Bladder Code
• Nitrile (NBR)	-10	2	-1
• Nitrile LT (NBR-LT)	-60	37	-40
• Hydrin (ECO)	-40	8	-4
• Buty (Bu)	-40	2	-6
• EPR	-40	50	-8
• Fluorocarbon (FC)	-10	1	-28

"THE PRE-CHARGE NEEDS TO BE ROUTINELY CHECKED AND MONITORED THROUGHOUT THE LIFE OF THE EQUIPMENT APPLICATION."

DIFFERENCES IN BLADDER COMPOUNDS/MANUFACTURE

Bladder accumulator manufacturers worldwide have varying approaches to the compound formulations they use and the method of manufacture. Parker's compound expertise has developed specific and proven formulas for all bladder compounds it manufacturers and sells. Parker also has its own bladder engineering and manufacturing facility. As such, Parker has total quality control of the bladder compound, bladder manufacture, and its incorporation into a fully assembled accumulator.

APPLICATION-SPECIFIC HELP

With Greer Bladder Products, Parker has over 70 years of experience in formulating bladder compounds and in making the finest, highest quality bladder accumulators. All 70 years of bladder accumulator application experience is available through Parker's worldwide customer service network to make sure that all customers get the right bladder, right bladder size and compound for their application. In addition, the very latest in accumulator sizing technology is available with Parker's in-Phorm Accumulator Sizing and Selection Software (3.7 is the most current version). The software performs the necessary calculations and eases the process of sorting through catalog drawings, charts and tables.

FOR MORE INFORMATION,

contact Parker Hannifin Corporation, Hydraulic Accumulator Division; tel: (815) 636-4104; on the web: www.parker.com/accumulator.