

Lube Oil System Accumulators (LOSA)

"An accumulator shall be provided ... to maintain the turbine control-oil pressure during servo-control transients or to maintain lube-or seal-oil pressure while the stand-by pump accelerates from an idle condition to operating speed.... Unless otherwise specified, accumulator vessel shall be made of Series 300 stainless steel"...

API Standard 614 – Chapter 2, Paragraph 1.8 Accumulators.

Why Bladder Accumulators?

Bearings in turbo machinery require lubrication while they are running. All turbo machines are equipped with a lube oil system to provide the necessary lubrication at high pressure. These lubrication systems consist of from a high flow-rate pump, a reservoir and an accumulator. Accumulator is a very essential part in lube oil systems, because it supplies the lube oil to the bearings when the pump shuts down due to a power-failure or a pump changeover. This prevents the bearings from costly damage and increases the bearing life and overall reliability of the lube oil system.

API Standard 614 Requirements to LOSA

LOSA are designed in compliance with API 614, and in accordance with the ASME Section VIII, DIV. 1 of the Pressure Vessel and Boiler Code. These accumulators are constructed from a 300 series stainless steel shell and have a nitrile bladder, which forms a barrier between the gas and the fluid. If the working pressure is less than 500 psi, then the design allows a screen welded inside the flange to keep the bladder from extruding out of the fluid port. The screen is welded flush and smooth with the inside of the shell so as not to damage the bladder. If the pressure is more than 500 psi, then a plug and poppet design has to be utilized. At a low pressure the bladder material does not extrude through the holes in the screen but at a higher pressure the bladder will extrude through the holes in the screen. In a plug in poppet design a fully inflated bladder sits against the poppet and

closes the opening keeping the bladder from extruding out of the fluid port. The minimum shell safety factor needs to be 3.5:1.

Figure 1 shows bladder type accumulators designed according to requirements of API Standard 614 for installation within turbomachinery Lube-Oil Consoles.

LOSA are installed vertically in the system so that the gas valve molded into the bladder is on the top end and the fluid port is on the bottom end. The accumulator bladder must always be pre-charged with an inert gas that does not react with the bladder material or other components that the gas comes in contact with. Nitrogen is the best option because of its availability, chemical and physical properties, and cost. Nitrogen is very stable and non-reactive even under high pressure. Air should never be used because of its corrosive properties and the explosive situation it may create under high pressure.

The pre-charge should always be maintained between 70-80% of the minimum working pressure of the system. The high flexibility and low weight of the bladder causes the bladder response time to be very quick as compared to the pressure drop in the system. The quicker response enables the LOSA to maintain the pressure and flow of the lubricating oil and prevents the damage to the bearings and other components.

The pre-charge needs to be monitored periodically. The accumulator needs to be completely drained of the lube oil and the bladder needs to be fully

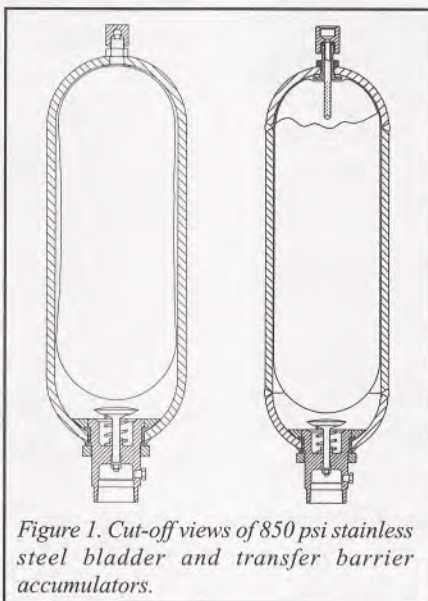


Figure 1. Cut-off views of 850 psi stainless steel bladder and transfer barrier accumulators.

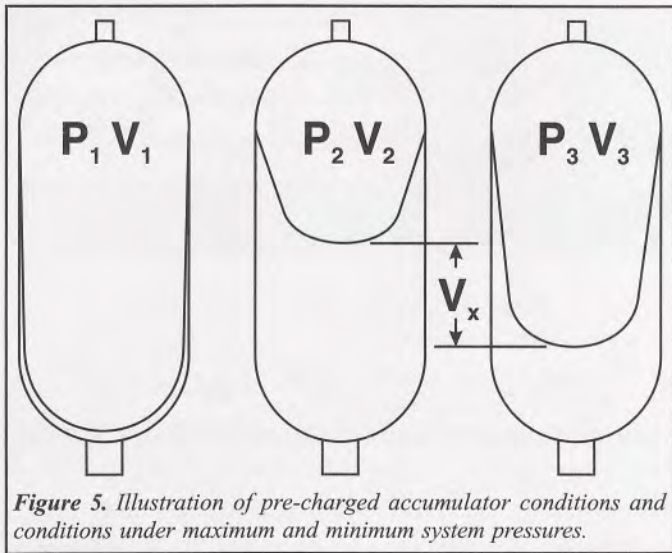


Figure 5. Illustration of pre-charged accumulator conditions and conditions under maximum and minimum system pressures.

P_2 = Maximum system design operating pressure, psia.

V_2 = The compressed volume of gas at maximum system's pressure P_2 , cu. in.

P_3 = The minimum system pressure, psia, at which the additional volume V_3 of lube oil is required.

V_3 = The expanded volume of gas at minimum system pressure P_3 , cu. in.

Based on a Boyle's Law for the following states:

$$P_1 V_1^n = P_2 V_2^n = P_3 V_3^n$$

or

$$V_1 (P_1)^{1/n} = V_2 (P_2)^{1/n} = V_3 (P_3)^{1/n}$$

and

$$V_x = V_3 - V_2$$

From Boyle's Law for the changing conditions from the fully charged accumulator to the discharge state:

$$V_2 (P_2)^{1/n} = V_3 (P_3)^{1/n}$$

and

$$V_3 = V_x + V_2$$

or

$$V_2 (P_2)^{1/n} = (P_3)^{1/n} (V_x + V_2)$$

and finally with respect to V_2 :

$$V_2 = \frac{(P_3)^{1/n} V_x}{(P_2)^{1/n} - (P_3)^{1/n}}$$

From Boyle's Law for the changing conditions from the pre-charged state to the fully charged accumulator:

$$(P_1)^{1/n} V_1 = (P_2)^{1/n} V_2$$

or

$$V_1 = \frac{(P_2)^{1/n} V_2}{(P_1)^{1/n}} = \frac{(P_2)^{1/n} (P_3)^{1/n} V_x}{(P_1)^{1/n} ((P_2)^{1/n} - (P_3)^{1/n})}$$

or

$$V_1 = \frac{V_x \frac{(P_3)^{1/n}}{(P_1)^{1/n}}}{1 - \frac{(P_3)^{1/n}}{(P_2)^{1/n}}} \quad (1)$$

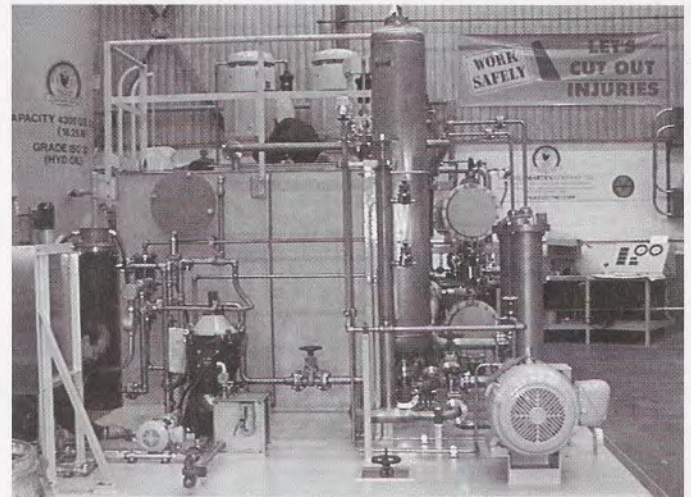


Figure 6. Actual photos of API 614 lube-oil console featuring 120 gallon, 500 psi accumulator designed for installation within gas turbine unit within power generation plant.

Example:

A gas turbine lube oil system requires a flow rate of 15 gpm at 100 psig system pressure. The maximum operating pressure is 115 psig. When the stand-by pump accelerates from the idle condition to operating speed, or in the case of the main oil pump shutdown, the system pressure must be maintained within 10% of the system pressure for at least 15 seconds.

Size an accumulator to supply oil in the case of pump shuts down.

Sizing

The required volume of fluid needed from the accumulator:

$$V_x = (15 \text{ gpm} / 60) \times 15 \text{ seconds} \times 231 = 866.25 \text{ cu. inches.}$$

Minimum system pressure (within 10% of the system pressure):

$$P_3 = (100 \times 0.90) + 14.7 = 90 + 14.7 = 104.7 \text{ psia.}$$

Maximum operating pressure:

$$P_2 = 115 + 14.7 = 129.7 \text{ psia.}$$

Polytropic constant for Nitrogen: $n = 1.4$

Precharge pressure of the accumulator:

$$P_1 = 70 \% \text{ of } P_3 = 0.70 \times 104.70 = 73.29 \text{ psia.}$$

By inserting the above values into the formula (1) the following accumulator size V_1 will be obtained:

$$V_1 = \frac{V_x \frac{(P_3)^{1/n}}{(P_1)^{1/n}}}{1 - \frac{(P_3)^{1/n}}{(P_2)^{1/n}}} \quad (1)$$

$$V_1 = 7,878.28 \text{ cu. inches, or 34.11 gallon.}$$

If the calculations do not give a standard size, the next larger standard size should be picked. Picking a larger size is always safer than picking a smaller size.



Figure 7. API 614 lube-oil console featuring 80 gallons, 500 psi accumulator; Console flow rate: 1175 gpm. Industry application: power generation.

For more information, contact Joe Cheema, Senior Project Engineer, at Fluid Energy Controls Inc. E-mail: jc@fecintl.com



FLUID ENERGY CONTROLS INC.
6431 Flotilla Street
LOS ANGELES, CALIFORNIA 90040
TELEPHONE (323) 721-0588 • FAX (323) 721-8368
E-MAIL: sales@fecintl.com • www.fecintl.com