Element quality is another issue under study, and objective tests of element construction and integrity are being developed. Tests of dirt-holding capacity are also available.

The proper placement of filters in a hydraulic system is extensively debated among designers. Only two locations are really suitable for filters: the pressure line and the return line. Naturally, pressure-line filters are more expensive than return-line filters because of the higher pressure. Whether you choose the pressure line or return line or both, you should select a location that will see full pump flow all, or most, of the time (Fig. 62). Otherwise, using a separate pump, you can create a "knee loop" arrangement sized to turn over the entire reservoir in 30 min or less.

Some designers recommend placing a strainer in the suction line of the pump, but others argue against placing anything that could cause a restriction in the suction line. The author does not recommend them, either, but if you decide to use suction strainers, they should be made of metal, easy to clean, with mesh weave no tighter than 100 mesh (149 micrometers). Finally, suction strainers should never be placed inside the tank out of sight.

Every filter or strainer should have some way of indicating that the unit is bypassing (dirty element). If you do not need the electrical type, opt for a vacuum-activated one over the mechanical type. Spin-on filters, which are increasingly popular, use differential pressure gauges or upstream and downstream gauges that require the user to subtract the readings to determine whether the unit is bypassing. A sign nearby to remind everyone of the bypass valve pressure setting is a good idea. Non-bypass filters should be used ahead of critical components like servo valves, with an electrical alarm to indicate clogging.

To reiterate, the simple expedient of filtering all of the fluid that goes into a tank eliminates a lot of trouble. Avoid using the common breather strainer because mechanics tend to pour oil through it into the system; eventually, when the strainer becomes clogged, they puncture it or remove it to make the oil flow faster. The optimal system involves mounting a filter on the access opening with a snap connector for the fill-pump hose. In a variation of this system, the filter is mounted on the return line with a tee and snap connector ahead of it; in this version, all flow including fill-line flow goes through the filter before re-entering the tank, so a larger filter is required (Fig. 59). Remember that return-line filters must be larger than pressure-line filters because of the flow.
Accumulators

Accumulators are devices that store pressurized fluid in a hydraulic system for various reasons. Primarily, they are used to:

- maintain system pressure while the pump unloads
- facilitate use of a smaller pump
- absorb pulsations and shockwaves
- store energy in emergencies
- keep system pressure constant

Three designs are popular: the gas-filled bag, the piston with gas on one side and the weighted. The two gas-filled designs rely on dry nitrogen because of its safety, inertness and low cost. If air were used, rapid compression in the presence of hot oil vapor could cause an explosion through dieseling.

Figure 64 shows a typical bottom-entry bag accumulator with an anti-extrusion valve that prevents the bag from migrating out into the pipeline. A tire valve molded into the bag permits gas charging from the top end. Accumulators must have isolation valves so rebuilds can be accomplished without system shutdown. Figure 65 shows a typical piston-type accumulator. Obviously, the seal is critical in this design because it separates the fluid from the gas. Although...
the weighted accumulator is very expensive (Fig. 66), it is essential where constant system pressure must be maintained. When the pump is on, the accumulator is forced to its peak position where switches shut the pump off. The weight then sustains pressure on the system, even as internal or external leakage occurs. To compensate for this leakage, the accumulator gradually falls; when it hits a bottom switch, the pump is kicked back on to raise the accumulator up to the top switch, and the process repeats.

When the system is shut down, the accumulator may be dangerous because of pressure built up in the system that may be stored there. The accumulator should have a safety valve that closes when a pump is started and opens back to tank when power is shut off. Otherwise, mechanics should be reminded to open the dump line valve (Fig. 67).

Initial charge pressure for the gas-filled design should not exceed about 60% of normal system pressure. With the weighted design, sufficient weight must be in the canister to generate the pressure required. Accumulators are normally placed between pump and directional valve; only when "sponginess" is needed (rarely) are they placed in cylinder lines.

**REFERENCE**


**BASIC HYDRAULIC FORMULA**

\[
\begin{align*}
P &= \frac{F}{A} \\
F &= P \times A \\
A &= \frac{F}{P} \\
A_{\text{BORE}} &= 3.14 (r_{\text{BORE}})^2 \\
A_{\text{BORE}} &= 0.7854 (D_{\text{BORE}})^2 \\
A_{\text{ROD}} &= A_{\text{BORE}} - A_{\text{ROD}} \\
V_{\text{L6}} &= A_{\text{BORE}} \times \text{STROKE} \\
V_{\text{L65}} &= A_{\text{ROD}} \times \text{STROKE} \\
V_{\text{ROD}} &= \frac{Q \times 231}{A_{\text{BORE}}} \\
T &= \frac{P \times \text{CID}}{6.28} \\
\text{RPM} &= \frac{Q \times 231}{\text{CID}} \\
\text{OUTPUT HP} &= Q \times P \times 0.000583 \\
\text{or} \\
\text{OUTPUT HP} &= \frac{Q \times P}{1714} \\
\text{INPUT HP} &= \frac{Q \times P \times 0.000583}{\text{Pump Efficiency}} \\
\text{or} \\
\text{INPUT HP} &= \frac{Q \times P}{1714 \times \text{Pump efficiency}} \\
\end{align*}
\]

\[P = \text{pressure, psi, } F = \text{force, lbs} \]

\[A = \text{Area, sq in.} \]

\[A_{\text{BORE}} = \text{Area of cylinder piston on cap end (sq in.)} \]

\[r_{\text{BORE}} = \text{Radius of cylinder piston (in.)} \]

\[D_{\text{BORE}} = \text{Cylinder piston diameter (in.)} \]

\[A_{\text{ROD}} = \text{Cross-sectional area of cylinder rod (sq in.)} \]

\[V_{\text{L6}} = \text{Liquid volume to extend cylinder (cu in.)} \]

\[V_{\text{L65}} = \text{Liquid volume to retract cylinder (cu in.)} \]

\[V_{\text{ROD}} = \text{Speed of rod (in./min)} \]

\[Q = \text{Liquid flow, gpm, from pump} \]

\[T = \text{Hyd motor torque (in.-lbs)} \]

\[\text{CID} = \text{Hyd. motor displacement (cu in.)} \]

\[\text{RPM} = \text{Shaft speed of hydraulic motor} \]

\[\text{Output HP} = \text{the horsepower required for a given flow at a known pressure} \]

\[\text{Input HP} = \text{the horsepower required to drive a hydraulic pump of a given volume at a known pressure} \]
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