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Hydraulic Power Circuit Filtration — SAE J931a

SAE INFORMATION REPORT

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SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
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Report of Construction and Industrial Machinery Technical Committee approved July 1965 and last revised June 1975.

1. **OBJECTIVE**—This SAE Information Report is primarily to familiarize the designer of hydraulic powered machinery with the necessity for oil filtration in the hydraulic power circuit, the degree of system cleanliness required, types of filtration and filters available and their location and maintenance in the hydraulic circuit.

2. **NECESSITY FOR FILTRATION**—The success of any hydraulic power application requires adequate cleanliness of the fluid. Contamination in the system directly affects the many high precision parts used in the hydraulic components and may drastically reduce their usable life. Proper filtration collects contaminant particles and prevents their recirculation in the system.

Most hydraulic systems circulate the same oil over and over again. Thus any contaminants or foreign particles in the oil will be recirculated unless removed.

Harmful contaminants come from three general sources:

(a) **BUILT-IN CONTAMINANTS**—Built-in contaminants are particles remaining in the system following assembly of the hydraulic circuit. Included are core sand, weld spatter, metal chips from manufacturing and assembly operations, and lint and abrasion dust from grinding and finishing operations.

(b) **INTRODUCED CONTAMINANTS**—Introduced contaminants are foreign particles which enter the system through fluid filler tubes, breather caps in reservoirs, cylinder rod seals and other seals, and added new oil.

(c) **GENERATED CONTAMINANTS**—Generated contaminants include—

1. *Wear Contaminants* such as small particles of metal, sealing materials, etc., which result from wear on the moving parts of components within the system.

2. *Chemical Reaction Contaminants* which are the result of chemical reactions within the fluid.

3. *Cavitation Generated Contaminants* which are the result of microscopic surface damage caused by shock waves from implosion of voids formed in the fluid by dynamic conditions such as excessive suction at the pump inlet.

4. *Metallic Erosion* due to impingement of fluid on metal at high velocity.

3. **DEGREE OF SYSTEM CLEANLINESS**—It is desirable to provide filtration which limits to a practical minimum the population and size of particles that can cause damage by abrasive wear.

In order to achieve an adequate fluid cleanliness level, it is not uncommon to filter the entire pump flow.

Consideration should be given to component manufacturer's recommendations for the desired level of filtration to achieve adequate component life.

The selection of a filter is based upon the rate at which contaminant is introduced and generated, as well as the

cleanliness level which must be achieved and maintained. The higher the rate of contaminant addition, the higher the elements particulate removal characteristics must be if a given level is to be maintained.

4. **FILTER SELECTION CRITERIA**—Filters are selected on the basis of structural integrity, service life, and the cleanliness level they are capable of maintaining downstream when exposed to standard test conditions; i.e., contaminant ingress, pressure drop characteristics, fluid flow, and fluid properties.

(a) **STRUCTURAL INTEGRITY**

1. *Collapse/Burst*—The pressure drop arising from outside to in (collapse) or inside to out (burst) flow that causes structural or medium failure of a filter element (per ISO/S2942).

2. *Flow Fatigue*—The number of flow cycles that a filter element can withstand without structural failure of the filter medium due to flexing (per ANSI B9324-1972).

3. *Material Compatibility*—The ability of a filter element to resist structural degradation in the presence of the fluid with which it must operate (per ISO/S2943).

4. *End Load*—The axial force applied to the end of a filter element which may cause permanent deformation or seal failure (per ANSI B93.21-1972).

(b) **RELATIVE SERVICE LIFE (RELATIVE FILTER CAPACITY)**

1. *ACFTD Capacity*—The amount of AC Fine Test Dust in grams which can be subjected to the filter at specified fluid conditions without exceeding a predefined pressure drop (per ANSI B93.31-1973).

(c) **FILTER RATING (SEPARATION PERFORMANCE)**

1. *Filtration Ratio*—The ratio of the number of particles larger than the specified size per unit volume in the influent to the number of particles larger than the size per unit volume in the effluent fluid (per ANSI B93.31-1973). The cited standard procedure is applicable for assessing elements which exhibit a 10 micro-metre filtration ration less than 75.0, a final reservoir gravimetric level of less than 200 mg/l, and that have a rated flow in the range between 4.0 l/min and 600 l/min (1 USGPM and 160 USGPM). Other procedures are being developed to extend these limits.

5. **FILTER TYPES AND FILTER LOCATIONS**

(a) **TYPES OF FILTER**—Filtration is accomplished by recognizing that a difference exists between some property of the base fluid and its contaminants. Properties used to discriminate fluid from contaminants are mass, density, and fluid viscosity. Particle size selection is the most commonly used filtration method.

(b) **TYPES OF FILTRATION**—Filtration within a system may be classified either as full flow or partial flow.

Full flow filtration is defined as the filtering of 100% of the circuit flow under normal operating conditions. Partial flow filtration is defined as the filtering by design of less than 100% of the circuit flow under normal operating conditions.

(c) TYPICAL FILTER LOCATIONS AND CIRCUITS

There are three basic filter locations in hydraulic power and hydrostatic circuits. These locations are in the suction line, the pressure line, and the return line.

It is common for each filter, regardless of its location within the circuit, to incorporate a bypass valve in the event that the pressure drop across the filter exceeds a prescribed amount. In addition, this bypass valve or any auxiliary parallel circuit can be utilized to achieve partial flow filtration. Crack or opening pressure drop are equally important to full flow pressure drop when selecting elements. Poor regulation of by-pass valves could result in partial flow filtration when full flow is expected.

In certain critical systems, particularly those employing servo valves, high pressure filters with no bypass valves have been used which will not collapse at maximum operating pressure. This acts as a 'dirt fuse' to shut down the system if the element is not changed when dirty.

In certain critical applications where no bypass is desired, filters may be used on suction lines, provided the reduced inlet pressure is not detrimental to the pump.

Figures 1-3 illustrate the locations of the filter in the three basic locations.

(d) FILTER TYPE AND LOCATION DESIGN

CONSIDERATION—The optimum filter type and location for a specific circuit can only be determined through an analysis of the following considerations:

1. Degree of filtration necessary for circuit components.
2. Location for protection of critical circuit components.
3. Ease of maintenance.
4. Contaminant holding capacity.
5. Cost.
6. Weight.

Consideration must be given to any choice of location to insure that the filter does not interfere with system performance. For example:

1. Filters in the pump inlet line must provide positive safeguards to prevent pump cavitation.
2. Filters placed in the pressure line must be capable of withstanding maximum system pressure.
3. Filters placed in the return line may be subjected to extreme flow surges.

Filters may be placed on any combination of locations; i.e., pump inlet, pressure line, return line.

6. DESIGN CONSIDERATION FOR FILTER

MAINTENANCE—The servicing of filter elements is of primary importance in all hydraulic circuits. A proper filter service schedule can only be set up through test and experience of the circuit involved.

If too frequent a change appears necessary, two alternatives are available, either the filter contaminant capacity must be increased, or the rate of entry or generation of contaminants within the system must be decreased.

Since filter elements must be cleaned and replaced frequently, ease of servicing is of importance in design.

Some filters contain differential pressure devices that signal when a filter element is dirty.

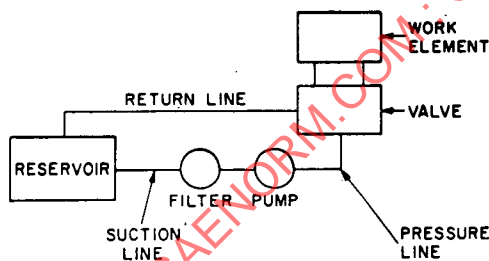


FIG. 1 LOCATION OF FILTER IN SUCTION LINE

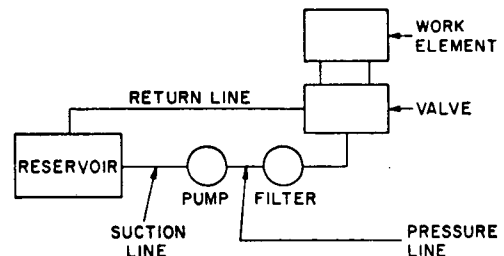


FIG. 2—LOCATION OF FILTER IN PRESSURE LINE

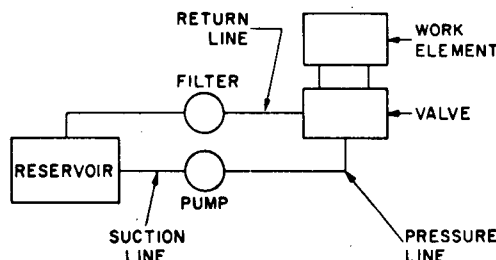


FIG. 3—LOCATION OF FILTER IN RETURN LINE