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# SURFACE VEHICLE INFORMATION REPORT

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## (R) Hydraulic Fluid Power Circuit Filtration - Application & Methods



RATIONALE

This SAE standard is revised to add new applicable ISO standards, updated definitions of contaminates, changed filter rating and service life to reference ISO standards.

## 1. SCOPE

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. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

#### 2.1.1 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI B93.21-1972 End Load Test Method for a Hydraulic Fluid Power Filter Element

ANSI B93.24-1972 Flow Fatigue Characteristics of a Hydraulic Fluid Power Filter Element, Method for Verifying the

ANSI B93.31-1973 Beta ratio (multi-pass test method)

ISO/S2942 Hydraulic fluid power - Filter elements - Verification of fabrication integrity and determination of the first bubble point

ISO/S2943 Hydraulic fluid power - Filter elements - Verification of material compatibility with fluids

ISO/16889 Hydraulic fluid power filters – multi-pass method for evaluating filtration performance of a filter element

ISO/4406 Hydraulic fluid power – fluids – method for coding the level of contamination by solid particles.

ISO/12103-1 Road Vehicles – Test Dust for Filter Evaluation

## 3. 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. 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. Proper filtration collects contaminant particles and prevents their recirculation in the system.

Harmful contaminants which may include but are not limited to core sand, weld spatter, metal chips, lint, abrasion dust, sealing materials, air and water, come from three general sources:

a. Built-in Contaminants - Built-in contaminants are particles remaining in the system following assembly of the hydraulic circuit.

b. Introduced Contaminants - Introduced contaminants are foreign particles which enter the system through filler tubes, breather caps in reservoirs, seals and added new oil.

c. Generated Contaminants - Generated contaminants include:

   1. Wear contaminant 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 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.

   5. Air contaminant which may be the result of a failed or improper shaft seal, non-sealing fittings, or agitation within a hydraulic reservoir.

   6. Water contaminant which may be the result of water vapor formation within a hydraulic reservoir.

## 4. 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.

## 5. 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 ingression, 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. Dirt-Holding Capacity – The amount of ISO MTD (ISO Medium Test Dust per ISO 12103-1) in grams which can be subjected to the filter at specified fluid conditions without exceeding a predefined pressure drop (per ISO 16889).

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 ISO 16889). The cited standard procedure is applicable for assessing elements which exhibit an average filtration ratio greater than or equal to 75 for particle sizes less than or equal to 25 micrometers(c) and a final reservoir gravimetric level of less than 200 mg/l..



## 6. 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, 2, and 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 a pump inlet suction line must provide positive safeguards to prevent pump cavitation, especially with cold temperatures which result in high oil viscosity.

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 and flow and/or pressure pulses.

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

7. 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.



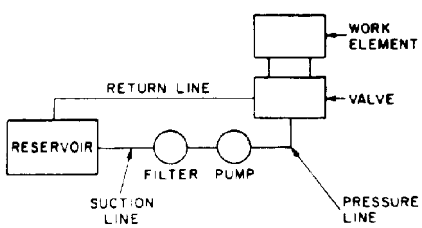


FIGURE 1 - LOCATION OF FILTER IN SUCTION LINE