



SURFACE VEHICLE RECOMMENDED PRACTICE

J1227™

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Assessing Cleanliness of Hydraulic Fluid Power Components and Systems

RATIONALE

This document was revised to update Table 1 and associated references throughout the document.

SAE J1227 has been reaffirmed to comply with the SAE Five-Year Review policy.

FOREWORD

There is an increasing awareness that the reliability, productivity, and economy of use of hydraulic systems is directly related to the cleanliness level achieved. In addition, there is strong evidence that start up failures of both new and overhauled systems are often contaminant-caused catastrophic failures. Contaminant built in to each component making up a hydraulic system, and contaminant generated in assembling the components and systems, are significant contributors to these failures.

This SAE Recommended Practice is intended as a guide toward standard practice but may be subject to frequent change to keep pace with experience and technical advances, and this should be kept in mind when considering its use.

1. SCOPE

To describe laboratory methods for determining and reporting the contaminant level of the wetted portion of hydraulic fluid power components, parts, subsystems and systems, and of fill fluids. For each type of item, it provides a method of obtaining the liquid sample and the contamination level thereof. It also includes procedures for establishing a sampling plan and guidelines for establishing levels of acceptance, but does not set those levels.

1.1 Purpose

To provide a basis for measuring and reporting cleanliness levels so that built-in contamination and premature failures of hydraulic systems can be minimized.

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.

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2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1277 Method for Assessing the Cleanliness Level of New Hydraulic Fluid

2.1.2 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 3722 Fluid Sample Containers - Qualifying and Controlling Cleaning Methods

ISO 3938 Contamination Analysis - Method for Reporting Analysis Data First Edition

ISO 4021 Particulate Contamination Analysis - Extraction of Fluid Samples from Lines of an Operating System

ISO 4406 Method for Coding the Level of Contamination by Solid Particles

ISO 5598 Fluid Power Systems and Components - Vocabulary

ISO 11171 Calibration of Automatic-Count Instruments for Particles Suspended in Liquids

ISO 11500 Determination of Particulate Contamination in Liquids by Automatic Particle Counting (APC)

ISO 18409 Hose and Hose Assemblies - Method of Collecting a Fluid Sample for Analyzing Cleanliness

2.1.3 ASQ Publications

Available from American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203, Tel: 800-248-1946 (United States or Canada)), 001-800-514-1564 (Mexico) or +1-414-272-8575 (all other locations), www.asq.org.

ASQ Z1.4-1971 Sampling Procedures and Tables for Inspection by Attributes

2.1.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D6304 Standard Test Method for Determination of Water in Liquid Petroleum Products

3. OUTLINE OF METHOD

- a. Select the item to be evaluated. If sampling plan is required, refer to ASQ Z1.4.
- b. Obtain representative liquid sample per Section 4.
- c. The fluid sample should be evaluated per Section 5.
- d. Report resulting data in accordance with Section 6.
- e. Compare the results with the requirements of Sections 7, 8, and 9.
- f. Resolve any disputes using the guidelines of Section 8.

- g. Before tests are started, verify that all needed information is available in accordance with Section 10.
- h. Define new terms (see italics) per Section 11.
- i. Index per Section 12.

4. METHODS OF OBTAINING REPRESENTATIVE LIQUID SAMPLES

4.1 Collection methods for obtaining representative liquid samples are considered for the following categories:

- a. Complete systems and integral subsystems - see 4.2 and 4.3.
- b. Static components - see 4.2 and 4.4.
- c. Dynamic components - see 4.2 and 4.5.
- d. Parts - see 4.2 and 4.6.
- e. Fill-hydraulic fluid - see 4.7.

4.1.1 Items a, b, and c in 4.1 provide for collecting a sample from complete components or systems without disassembly. Some may prefer to disassemble the components and to obtain the contaminated sample from the parts. This is not recommended for the following reasons:

- a. The process of disassembly and assembly generates contaminants.
- b. Areas of parts may be exposed which are not accessible in the assembled components.
- c. Moving a dynamic component will generate contaminant which would not be observed when evaluating the parts.

4.2 General Cautions Applicable to Obtaining Representative Liquid Samples

4.2.1 Reynolds Number

It is possible for a unit to test clean when using oil at room temperature, but test dirty when tested with the same oil at high temperature. Likewise, it is possible for a unit to test clean during an evaluation and test dirty if evaluated using a higher flow rate or using an oil with lower viscosity.

These results are to be expected because the removal of particles from surfaces is proportional to the turbulence in the system which, in turn, is dependent upon the Reynolds number attained. Ideally, flushing and cleanliness testing should be performed at a Reynolds number which is at least as high as the maximum Reynolds number that the unit will see in normal service. To achieve this, it is sometimes necessary to flush with a low viscosity liquid.

Reynolds number can be calculated with the following equations:

English Units	Metric Units
$R = \frac{35\,873Vd}{\nu}$	$R = \frac{1000Vd}{\nu}$
$R = \frac{14\,646Q}{\nu d}$	$R = \frac{21\,220Q}{\nu d}$

(Eq. 1)

where:

R = Reynolds number	dimensionless	dimensionless
V = fluid velocity	feet per second	meters per second
d = pipe inside diameter	inches	millimeters

ν = viscosity	Saybolt seconds	centistokes
Q = flow rate	U.S. gallons per minute	liters per minute

4.2.2 Vibration and Shock

With some components and systems, a cleanliness level measured at one laboratory will be significantly changed when measured at another laboratory if the unit is subjected to vibration and shock during transit. Likewise, the cleanliness level of a unit can be significantly changed when installed on a vehicle in field operations. To determine if vibration and shock are significant in altering contaminant levels in a particular case, it is recommended that the unit or system be tested for contamination both before and after being subjected to the worst vibration and shock expected in shipping and use.

4.2.3 Selecting a Clean Test Liquid (see 11.2)

Select a clean test liquid that is compatible with the component or system being evaluated. If different from the system hydraulic fluid, assure that either:

- The clean test liquid is totally removed so that it does not contaminate the system fluid, or
- The two liquids are compatible (including additive packages) so that the mixture will still meet system requirements.

CAUTION: Halogenated hydrocarbons (such as trichloroethane and other chlorinated solvents) have been reported to be a source of accelerated corrosive/erosive wear in hydraulic systems; special precautions should therefore be taken to remove them so as to assure that none can be carried over into the hydraulic fluid.

4.2.4 Draining Components

When draining components, care must be exercised to assure that the fluid sample is not contaminated by contact with normally non-wetted surfaces, such as external surfaces and threaded portion of ports. This can be minimized by installing a precleaned fitting into the port (hand tighten without thread sealant) so that the fluid can be poured in a controlled stream into the verified clean container.

4.2.5 Location of Sampling Valves

Locate sampling taps and valves in a turbulent portion of the line, and above the centerline of any horizontal line so as to avoid trapping contaminants. For maximum assurance that the samples taken and the counts reported are indeed representative, please also refer to the standards in Table 1 Section 4.

4.2.6 Diffusers

Where diffusers are called out (Figures 1, 2, and 3), ensure fluid level is high enough to avoid breaking of fluid surface by returning fluid.

4.2.7 Dilution Factors When Using Circulating Systems

If the volume of the liquid in the circulating system is large as compared to the volume of the component or subsystem being tested there will be a distortion in the number of large particles reported. This volume ratio should be kept as small as is practical.

4.3 Complete Systems and Integral Subsystems

Those which can be pressurized and have normal flow such as some hydrostatic and steering systems:

4.3.1 Evaluate systems and integral subsystems by withdrawing a sample from the turbulent portion of the pressurized subsystem using the ISO 4021 method shown in Table 1 Section 4, or sample from the reservoir if needed. Such sampling should occur after the subsystem has reached an agreed upon temperature, and has been fully exercised and pressurized. The temperature selected should consider both safety and 4.2.1. Exercise subsystem by operating a portion of the time at maximum rated flow so as to obtain maximum Reynolds number per 4.2.1, and for a time sufficient to pass 10 times the total test system hydraulic fluid volume through the subsystem. While still operating, withdraw the fluid samples into a verified clean container. If it is necessary to connect the subsystem to a precleaned ($\leq 10\%$ rule) flow test stand, the comments of 5.4 and definition of 11.4 should be considered.

4.4 Static Components (Such as Reservoirs, Fittings, Tubing, Filter Housings, Manifolds, etc.)

Static components can be evaluated by two basic methods. The first (which is historically probably the most commonly used) is a slosh test, which uses movement of a partially filled component to transfer the contaminant from the wetted surfaces of the static component to the clean test liquid. The second method is a flow test and recognizes the importance of achieving a Reynolds number equal to or greater than that achieved in service (see 4.2.1), and which measures the contaminant increase contributed by the static component to a circulating system. The slosh test is normally simpler and more economical and should suffice, except where it can be shown that the flow test removed significantly more contaminant.

4.4.1 Slosh Test

Fill the component 1/3 to 1/2 full of clean test liquid and seal the component so that it can be mechanically agitated, vibrated, and shocked so as to loosen contaminants without spilling the test liquid. A specified plan for agitation, vibration, and shock consistent with the geometry of the component should be followed (see 4.2.2). The sealing method should be validated to assure that it does not add significant contamination. The fluid sample should be removed from large components, using the ISO 4021 method of Table 1 Section 4. Smaller components should be completely drained into a verified clean container (see 4.2.4).

4.4.2 Flow Test

Where appropriate, connect the static component to a precleaned ($\leq 10\%$ rule) flow test stand capable of achieving a Reynolds number at the wetted surfaces of the component at least equal to the maximum it will see in service (see 4.2.1). The test stand can be similar to that shown in Figure 3 with the static component connected at points A and B and the directional control valve (7) positioned such that flow through the static component is in the normal direction of flow. Flow through the component for a time sufficient to assure that a hydraulic fluid volume at least equal to 10 times the test system liquid volume has passed through the component. After the minimum flow time withdraw a sample per ISO 4021 (Table 1 Section 4) (see 5.4).

4.5 Dynamic Components

Dynamic components are considered in the following subcategories:

- a. Rotating components - pumps and motors - see 4.5.1.
- b. Reciprocating components - cylinders and accumulators - see 4.5.2.
- c. Hoses - see 4.5.3.
- d. Valves - see 4.5.4.

Obtain the liquid sample for each subcategory of dynamic components, as follows: