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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Aerospace — Fluid systems and components — Methods for system sampling and measuring the solid particle contamination of hydraulic fluids

Aéronautique et espace — Systèmes de fluides et éléments constitutifs — Méthodes de prélèvement et de mesure de la contamination particulaire solide des fluides hydrauliques

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Aerospace — Fluid systems and components — Methods for system sampling and measuring the solid particle contamination of hydraulic fluids

0 Introduction

0.1 General

The design of modern hydraulic equipment for aerospace purposes, its use and performance are widely determined by the type and condition of the applicable hydraulic fluids.

The quality and serviceability of these hydraulic fluids are dependent on various factors (e.g. thermal stability, viscosity), in particular on the level of solid particle contamination which requires regular control if it is to be kept within the given limits.

To obtain comparable test results, uniform test methods as given in this International Standard have to be used.

As a result of the rapid development and improvement of hydraulic systems and their components, which have to meet critical requirements, the problem of solid particle contamination of hydraulic fluids has steadily increased. The need for maintaining a specified standard of fluid cleanliness in hydraulic systems requires continuous control of the number and size of the solid particle contaminants.

0.2 Solid particle contamination

Solid particle contaminants can be the cause of abrasion and wearing, thereby shortening the life of the components in a hydraulic system.

In a hydraulic system

a) components are subject to erosion (primarily in components with higher fluid velocities);

b) all moving parts are subject to wear by abrasion;

c) control valves are subject to silting (settlement of fine particles on the control bore).

0.3 Causes of solid particle contamination

Solid particle contamination of hydraulic fluids may be system-generated, introduced from the outside, in-built or maintenance-generated, e.g.

a) dust particles in the air;

b) metal particles, produced during the manufacture of parts;

c) sand residues on castings;

d) abrasion of seals;

e) oxide layers on welding seams and on heat-formed or heat-treated steel parts;

f) chemical and physical changes in the condition of hydraulic fluids;

g) maintenance of hydraulic systems (e.g. fibres, secondary contamination, etc.);

h) wear of components;

i) ingress of particles via piston gland seals.

0.4 Layout of this International Standard

This International Standard is sub-divided into the following sections:

— Section one: Cleaning of apparatus and sample bottles (clauses 3 to 7);

— Section two: Sampling (clauses 8 to 11);

— Section three: Methods for determining solid particle contamination (clauses 12 to 14);

— Section four: Test reports (clause 15).

1 Scope and field of application

This International Standard specifies measuring methods for determining the level of solid particle contamination of hydraulic fluids used in hydraulic systems and equipment for aerospace purposes. Three methods are specified in this International Standard:

a) microscopic method;

b) automatic particle counting method;

c) gravimetric method.

In addition, this International Standard lays down the procedures for cleaning the apparatus and sample bottles, and specifies the solvents to be applied and how these solvents shall be prepared. Requirements as to the selection of the sampling point and to different sampling methods are also specified.

2 References

ISO 3722, *Hydraulic fluid power — Fluid sample containers — Qualifying and controlling cleaning methods.*

ISO 4402, *Hydraulic fluid power — Calibration of liquid automatic particle-count instruments — Method using Air Cleaner Fine Test Dust contaminant.*

ARP 1192 A, *Procedure for calibration and verification.*

Section one: Cleaning of apparatus and sample bottles

3 Cleanliness

When establishing the solid particle contamination of hydraulic fluids, the test results may be adversely affected by not sufficiently taking account of the need for an optimum cleanliness.

In order to obtain meaningful results reproducible at any place and at any time, it is essential to ensure that the preliminary conditions prevent any additional solid particle contamination of the hydraulic fluid sample taken.

Additional solid particle contamination can be caused by using apparatus inadequately cleaned for the measurement.

All apparatus used for determining of the solid particle contamination level of hydraulic fluids shall be thoroughly cleaned before use in accordance with the procedure specified in clause 7. The apparatus shall be resistant to the solvent and the sample fluids.

4 Solvents

The solvents specified in 4.1 to 4.3 shall be used for the cleaning procedure.

4.1 Solvent A: De-mineralized or **distilled** or **de-ionized water,** or **water obtained from the conversion osmosis.**

4.2 Solvent B: 2-propanol (isopropyl alcohol), reagent-pure.

4.3 Solvent C: Petroleum ether, halogenated solvents, or other approved equivalents.

5 Filtration of solvents

5.1 Pressure filtration

5.1.1 Apparatus

5.1.1.1 Pressure tank, stainless steel.

5.1.1.2 Filter-jet spray gun, with filter attachment.

5.1.1.3 Membrane filter, having an aperture size less than or equal to 0,5 µm.

5.1.2 Procedure

The filter-jet spray gun (5.1.1.2), with a membrane filter (5.1.1.3) fitted, shall be connected by a hose to the pressure tank (5.1.1.1) containing the solvent. The gun shall produce a concentrated jet of filtered solvent for cleaning the surfaces. Precleaning is not required.

5.2 Vacuum filtration

5.2.1 Apparatus

5.2.1.1 Vacuum pump.

5.2.1.2 Filtration apparatus, stainless steel or glass.

5.2.1.3 Wash bottles.

5.2.1.4 Membrane filter, having an aperture size less than or equal to 0,5 µm.

5.2.2 Procedure

For vacuum filtration of the solvent, the filtration apparatus (5.2.1.2) shall be fitted with a membrane filter (5.2.1.4) and connected to the vacuum pump (5.2.1.1) by a hose. The solvent shall be filtered through the membrane filter by the vacuum in the flask of the filtration apparatus. The filtrate collected in the flask shall be transferred to the corresponding wash bottle (5.2.1.3).

6 Sample bottles

The sample bottles shall be made from glass, shall have a nominal capacity of 250 ml and a minimum capacity of 150 ml, and shall be sealed by means of caps (preferably of phenolic resin) which will not cause contamination. Otherwise a non-flaking plastic film compatible with the hydraulic fluid shall be used.

7 Cleaning procedures

7.1 General conditions

Staff performing the cleaning procedure shall wear lint-free clothes (e.g. cap, smock frock, boots) to avoid excessive secondary contamination by fibres.

The standard of the workroom shall be such as to ensure that the specified cleanliness standard can be achieved repeatably.

This condition is superfluous when working in a clean environment such as a clean-room or clean-cabinet.

7.2 Cleaning procedure for filtration apparatus and filter-jet spray gun

Before use, every part of the filtration apparatus and filter-jet spray gun shall be cleaned in accordance with the following method:

a) rinse with a degreasing fluid;

b) wash thoroughly in a hot water solution of detergent;

c) rinse twice with hot water (at a temperature of between 40 °C and 60 °C);

d) rinse twice with solvent A (4.1), filtered through a membrane filter having an aperture size less than or equal to 0,5 µm;

e) rinse three times with solvent B (4.2), filtered through a membrane filter having an aperture size less than or equal to 0,5 µm, to remove the water;

f) rinse three times with solvent C (4.3), filtered through a membrane filter having an aperture size less than or equal to 0,5 µm.

In carrying out steps d) to f), care shall be taken to ensure that the whole surface of the apparatus is pressure-rinsed from top to bottom.

7.3 Cleaning procedure for sample bottles

Before use, sample bottles and caps shall be thoroughly cleaned in accordance with the procedure specified in 7.2 a) to f) for filtration apparatus and filter-jet spray gun. In carrying out steps d) to f), care shall be taken to ensure that the whole surface of the sample bottles is pressure-rinsed from top to bottom.

After the last rinse, a small amount of solvent C remains in the sample bottle. The resultant gas pressure inside the sample bottle avoids contamination when the bottle is opened. When using a piece of plastic film, 100 mm × 100 mm in area, the film shall be rinsed with filtered solvent C and then placed over the mouth of the sample bottle with the edges of the film bent downwards and the cap screwed onto the bottle. The cap shall not be tightened too hard to avoid breaking the plastic film.

7.4 Checking and controlling cleaning methods

Checking the cleaned sample bottles shall be performed in accordance with ISO 3722.

Section two: Sampling

8 Sampling — General

When measuring the solid particle contamination of hydraulic fluids, the selection of the sampling point where a sample is taken from the hydraulic system and the way of taking it are of prime significance to the value of the sampling.

9 Apparatus

All apparatus and equipment used in sampling procedures A and B shall be thoroughly cleaned in accordance with the procedure specified in clause 7.

9.1 Sampling procedure A

9.1.1 Sample bottles, as specified in clause 6.

The sample bottles shall not contain more than 200 particles greater than 10 µm nor more than 500 particles greater than 5 µm per 100 ± 5 ml.

9.2 Sampling procedure B

9.2.1 Monitor, containing membrane filters suitable for the microscopic or gravimetric method (see clauses 12 and 14).

9.2.2 Graduated collecting bottle.

10 Sampling point

The sampling point differs from one hydraulic system to another and shall be defined by the system designer. However, the location should be a point where the best chances for a representative distribution of the solid particle contamination are given.

It is advisable, and, in some cases, will be required, to operate the system at full flow to ensure that the sample taken is representative of the aircraft at near flight conditions.

The following criteria shall be taken into account when defining the sampling point:

a) The sampling valve shall be automatic-closing and contain a separate cap with an integral seal capable of withstanding system pressure and be placed at the sampling point without the link tubing being too long.

b) A sample taken from the system reservoir is not necessarily to be regarded as representative for the system.

11 Sampling methods

11.1 Sampling procedure A (using sample bottles)

11.1.1 The sampling valve of the hydraulic system shall be capped. Wipe the cap clean with a lint-free cloth before removing the cap.

Successively open and close the sampling valve three to four times for a short period.

11.1.2 Open the sampling valve and release into a waste container a volume of hydraulic fluid to flush the sampling system (a minimum volume of 100 ml is recommended). In determining the minimum volume to be flushed, full account shall normally be taken of the link pipe volume.

11.1.3 Remove the sealing cap, with plastic film, if used, from the sample bottle (9.1.1) and drain off solvent from the bottle. Fill the sample bottle to 50 % to 70 % (100 ml min.) of its capacity.

11.1.4 Do not actuate the sampling valve throughout the sampling period.

11.1.5 Remove the bottle from sampling stream.

Close the sample bottle with sealing cap, and plastic film, if used, as specified in clause 6.

Close the sampling valve. To avoid contamination do not wipe the sampling valve. Replace the cap on the sampling valve.

11.1.6 Identify the sample as specified in 15.3.

11.2 Sampling procedure B (using the monitor)

11.2.1 Attach the sample-releasing apparatus to the quick disconnect coupling.

Fit the monitor (9.2.1) into the sample-releasing apparatus.

Position the three-way valve so that the hydraulic fluid is diverted by a hose before it reaches the monitor inlet.

11.2.2 Open the sampling valve and release into a waste container a volume of hydraulic fluid to flush the sampling system (a minimum volume of 100 ml is recommended). In determining the minimum volume to be flushed, full account shall normally be taken of the link pipe volume.

11.2.3 Position the three-way valve so that the hydraulic fluid filters through the monitor and flows into the graduated collecting bottle (9.2.2).

11.2.4 Close the sampling valve.

11.2.5 After the desired sample volume (100 ± 5 ml) has been taken, return the three-way valve to its initial position.

11.2.6 Before removing the monitor, attach the injector nozzle and ensure that the remaining fluid passes through the monitor. Then remove the monitor and mount caps.

NOTE — The whole procedure should be carried out with reference to the manufacturer's instructions.

11.2.7 Identify monitor as specified in 15.3.

11.2.8 Transportation of the monitors with the membrane filter from the sampling point to the laboratory shall be carried out with care to prevent contaminants dropping off the membrane. The surface holding the contaminants shall always be directed upwards and determination shall be made as quickly as possible.

Section three: Methods for determining solid particle contamination

Three methods for determining solid particle contamination of hydraulic fluids are laid down in this International Standard:

a) microscopic method (see clause 12);

b) automatic particle counting method (see clause 13);

c) gravimetric method (see clause 14).

12 Microscopic method

12.1 Principle

Filtration of a known volume of fluid under vacuum conditions through a membrane filter with an imprinted grid to collect the solid particle contamination on the filter surface. Counting and grouping of particles into size classes according to their largest dimension.

The filter is rendered transparent for examination under transmitted light and left opaque for examination under incident light. Under incident light, the use of multiple or episcopic illumination is recommended to reduce the core shadows.

12.2 Apparatus

12.2.1 Filtration apparatus, including

— a funnel, glass or stainless steel, approximately 250 ml capacity (150 ml min.);

— a clamping device;

— a glass or stainless steel support, including a sintered glass or stainless steel filter-holder screen.

12.2.2 Funnel cover (e.g. an element of a Petri dish).

12.2.3 Membrane filters, greater than or equal to 47 mm in diameter, with grid, with an aperture size less than or equal to 1,2 µm. Each grid square has 3,08 mm sides corresponding to approximately one-hundredth of the filtering area.

12.2.4 Vacuum flask.

12.2.5 Measuring cylinder, with a capacity of more than 100 ml.

12.2.6 Device for establishing a controllable vacuum.

12.2.7 Filter-jet spray gun, for the distribution of filtered solvent C (a pressure-operated system which discharges the solvent, in the form of a fine jet, through a membrane filter, the aperture size of which is less than or equal to 0,5 µm.)

12.2.8 Forceps, stainless steel, with unserrated tips.

12.2.9 Microscope slides, cover slips having a maximum thickness of 0,25 mm and lower slides with a minimum thickness of 1 mm are recommended, or **Petri dish,** with cover.

12.2.10 Means to obtain transparency of membrane filter.

NOTE — When using immersion oil, the refractive index shall be comparable to that of the membrane filter.

12.2.11 Monocular, binocular or projection microscope, for magnification X40 and X100 for incident light and, in addition, X400 for transmitted light, equipped with micrometer filar eyepiece for adjustment to the magnifications specified.

12.2.12 Stage micrometer, graduated in divisions of 0,1 mm and 0,01 mm.

12.2.13 Microscope light, variable intensity, used as source for incident or transmitted light.

NOTE — Prior to use, filtration apparatus (12.2.1), funnel cover (12.2.2), forceps (12.2.8), Petri dish and microscope slides (12.2.9) shall be cleaned in accordance with the procedure specified in 7.2.

12.3 Procedure

The use of a dust-free chamber with laminar flow for the filtration serves to reduce extraneous contamination.

12.3.1 Blank test filtration

This procedure shall be carried out periodically in accordance with quality control requirements to check the validity of the cleaning and test procedures.

12.3.1.1 Using forceps, remove a membrane filter (12.2.3) from the storage container and rinse it on both sides with filtered solvent C.

12.3.1.2 Place the membrane filter on the support of the filtration apparatus, grid face upwards, lower the previously cleaned funnel without pushing it over the filter and secure the assembly with the clamping device.

12.3.1.3 Pour 100 ml of filtered solvent C into a sampling bottle, cleaned in accordance with 7.3, and shake thoroughly.

12.3.1.4 Remove funnel cover, pour the contents of the bottle into the funnel and replace cover.

12.3.1.5 Apply the vacuum device (12.2.6) slowly up to 87 kPa (0,87 bar) max. and filter until the liquid level in the funnel is approximately 10 mm.