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

Série aérospatiale — Systèmes de fluides et éléments constitutifs — Méthodes de prélèvement et de mesure de la contamination particulaire solide dans un fluide hydraulique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 10, *Aerospace fluid systems and components*.

This second edition cancels and replaces the first edition (ISO 5884:1987), which has been technically revised. The main changes compared to the previous edition are as follows:

- update of the document to be in line with current ISO rules;
- improved layout and clarity in definition;
- removal of sample analysis detail, with reference to relevant ISO method instead;
- improved sampling point recommendations;
- improved clarity of sampling methods and recommendations for preference.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 hydraulic fluids are dependent on various factors (e.g. thermal stability, viscosity), but in particular on the level of solid particle contamination. Regular fluid contamination testing is required to determine if the fluid is maintained within specified limits that are set by the aircraft manufacturer or hydraulic system operator.

In order to obtain consistent and comparable test results, the test methods detailed in this document should be used.

As a result of the rapid development and improvement of hydraulic systems and their components, which 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; and

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 can be system-generated, introduced from the outside, in-built or maintenance-generated, for example:

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 from abrasion, adhesion and fatigue; and

i) ingress of particles via piston gland seals.

0.4 Layout of this document

This document is sub-divided into the following clauses:

- Sampling apparatus (Clause 4):
  - Characteristics;

  - Preparation;
- Sampling (Clause 5):
  - Recommendations for sampling point location;
  - Recommendation of sampling frequency;
  - Sampling methods;
  - Recommendation of sample marking;
- Sample analysis methods (Clause 6);
- Test report recommendations (Clause 7).

INTERNATIONAL STANDARD **ISO 5884:2018(E)**

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

1 Scope

This document specifies best practice for sampling hydraulic fluid from aircraft hydraulic systems and other hydraulic systems associated with aerospace purposes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

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

ISO 4021, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system*

ISO 4405, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the gravimetric method*

ISO 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 4407, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the counting method using an optical microscope*

ISO 11171, *Hydraulic fluid power — Calibration of automatic particle counters for liquids*

ISO 11218, *Aerospace — Cleanliness classification for hydraulic fluids*

ISO 11500, *Hydraulic fluid power — Determination of the particulate contamination level of a liquid sample by automatic particle counting using the light-extinction principle*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at https://www.electropedia.org/

4 Sampling apparatus

4.1 General

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

To obtain meaningful results, reproducible at any place and at any time, it is essential to ensure that the sampling equipment is carefully prepared and maintained throughout the sampling process to prevent any addition of solid particle contamination to the hydraulic fluid sample taken. This is because additional solid particle contamination can be caused by using apparatus inadequately cleaned for the measurement.

All apparatus used for determination of the solid particle contamination level of hydraulic fluids shall be thoroughly cleaned before use in accordance with the procedure specified in 4.3.3.

It is important that for all sampling apparatus, due consideration is given to the suitability and resistance to both the cleaning fluid used to prepare the sample apparatus and to the fluid to be sampled. This is especially important when considering the compatibility differences between mineral oil /synthetic hydrocarbon and Phosphate Ester–based hydraulic fluids.

4.2 Sampling apparatus characteristics

4.2.1 Manual sampling apparatus

4.2.1.1 General

Most system fluid samples can be obtained with the use of a simple sample bottle and tubing (if necessary) to transfer the fluid from the sampling point to the bottle.

It is preferable to purchase suitable sample bottles that meet the provisions of ISO 3722. The system operator shall specify the required cleanliness level.

Tubing shall be pre-cleaned or purchased in a condition which is in accordance with a cleanliness level required by the system operator.

If cleaning manual sampling apparatus is required prior to use, then refer to 4.3.

4.2.1.2 Sample bottles

The sample bottles shall be made from glass or polyethylene terephthalate (PET or PETG). They shall have a maximum capacity of 250 ml and a minimum capacity of 100 ml. They should be sealed by means of caps (preferably of phenolic resin with glass bottles) which do not cause contamination. Otherwise, a non-flaking plastic film compatible with the hydraulic fluid should be used.

4.2.1.3 Sample tubing

The sample tubing (if necessary for sampling of fluid) shall be in accordance with the description given in ISO 4021.

4.2.2 Automated sampling apparatus

4.2.2.1 General

Automatic sampling of fluid systems can be carried out using equipment such as a field monitor or portable cleanliness monitor. These systems are preferred to bottle sampling methods as there is a much lower possibility of contamination of the results, especially in adverse environmental conditions.

Automated sampling monitors shall be flushed prior to use. This can be completed using the system fluid itself, or a fluid which has a similar viscosity and a cleanliness class better than the requirement for the system fluid. The volume of fluid used for flushing should be at least twice that of the hose used to connect the monitor to the hydraulic system.

4.2.2.2 Field monitors

Field monitors contain membrane filters suitable for subsequent microscopic analysis (ISO 4407) or gravimetric analysis (ISO 4405).

The membrane filters shall be pre-installed in the field monitor in a clean environment.

During flushing, the fluid should bypass the membrane and therefore a three-way valve shall direct the flow from the membrane. Following flushing and prior to sampling, the valve is actuated to direct the flow to the membrane filter.

4.2.2.3 Laser particle counter systems

Portable laser particle counter systems use light extinction techniques to produce an immediate analysis of the system cleanliness. The monitors shall be calibrated in accordance with ISO 11171. The output from the systems is in the form of a coded cleanliness level in accordance with ISO 4406 or cleanliness classes in accordance with ISO 11218.

NOTE SAE AS 4059 or NAS 1638 can also be taken as equivalent standards to ISO 11218.

ISO 11218 (or SAE AS 4059) should be used in place of NAS 1638, except in special circumstances where comparison to earlier data is necessary.

These types of monitors are affected by the occurrence of water droplets or air bubbles in the sampled fluid. Therefore, care shall be taken with the location of the sampling point (5.2).

4.2.2.4 Portable mesh blockage monitors

Portable mesh blockage monitors determine particulate contamination levels by passing a specified flow of sample fluid through a series of calibrated mesh screens in a specified sequence. Pressure drop build-up (or flow degradation), which is dependent on particulate contamination levels, is measured and converted via algorithms into:

- a coded cleanliness level in accordance with ISO 4406; or
- cleanliness classes in accordance with ISO 11218.

NOTE SAE AS 4059 or NAS 1638 can also be taken as equivalent standards to ISO 11218.

ISO 11218 (or SAE AS 4059) should be used in place of NAS 1638, except in special circumstances where comparison to earlier data is necessary.

These monitors are especially suited to systems in which the fluid is likely to contain free water or air bubbles and can also be used to measure viscosity, temperature and fluid water content (if equipped with a water sensor).

4.3 Sample apparatus preparation

4.3.1 General

Sampling apparatus requires careful preparation to achieve a high level of cleanliness and control prior to use. This ensures that sampled fluid is not contaminated by background contaminant already present on the sample apparatus itself.

Staff performing any cleaning procedures 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 repeatedly.

4.3.2 Solvents

4.3.2.1 General

Liquid solvents shall be used to ensure removal of both solid and liquid contamination of sampling equipment.

The solvents used shall be verified as physically and chemically compatible with the sampling equipment and shall not react with the hydraulic oil to be stored in the bottle.

The following solvents are recommended solvents. Other approved equivalents are permitted, but should be agreed prior to use.

- Solvent Type A: Water in accordance with ISO 3696, Grade 3.
- Solvent Type B: 2-propanol (isopropyl alcohol), reagent-pure.
- Solvent Type C: Hydrocarbon solvent (e.g. Petroleum Ether), reagent-pure.

The solvents used shall conform to at least the cleanliness requirement specified for the sampling apparatus and preferably to a higher cleanliness level. Solvents should preferably be purchased in the required cleanliness condition. If solvent filtration is required, then the procedure of 4.3.2.2 or 4.3.2.3 shall be followed.

4.3.2.2 Solvent pressure filtration (preferred method)

4.3.2.2.1 Apparatus

4.3.2.2.1.1 Pressure tank, stainless steel.

4.3.2.2.1.2 Filter-jet spray gun, with filter attachment, cleaned in accordance with 4.3.3.

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

4.3.2.2.2 Procedure

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

Nitrogen pressurization is recommended for any spray gun tanks filled with flammable fluids.

Continued use of the apparatus shall not require further cleaning, provided that the filter membrane remains in place. On removal of the filter membrane (usually connected with completion of batch sampling duties), the apparatus shall be cleaned again.

4.3.2.3 Solvent vacuum filtration

4.3.2.3.1 Apparatus

4.3.2.3.1.1 Vacuum pump.

4.3.2.3.1.2 Filtration apparatus, stainless steel or glass, cleaned in accordance with 4.3.3.

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

4.3.2.3.1.4 Wash bottles, clear glass or clear-transparent polyethylene terephthalate (PET or PETG), cleaned in accordance with 4.3.3.

4.3.2.3.2 Procedure

For vacuum filtration of the solvent, the filtration apparatus shall be fitted with a membrane filter and connected to the vacuum pump 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.

It is recommended that the clamp which holds the flask be connected to ground using a static dissipative connection.

When using a piece of compatible plastic film to seal the wash bottles, the film shall be cleaned with pre-filtered solvent and the film shall be placed over the mouth of the sample bottle with the edges of the film bent downwards and the cap screwed onto the bottle. Care shall be taken not to use excessive torque to tighten the cap, to avoid breaking the plastic film.

Continued use of the apparatus shall not require further cleaning, provided that the filter membrane remains in place. On removal of the filter membrane (usually connected with completion of batch sampling duties), the apparatus shall be cleaned again.

4.3.3 Cleaning procedure for sampling apparatus

Before the first use, any filtration apparatus, filter-jet spray gun or wash bottles should be cleaned 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 type A (4.3.2.1), filtered in accordance with 4.3.2.2 or 4.3.2.3;

e) rinse with solvent type B (4.3.2.1), filtered in accordance with 4.3.2.2 or 4.3.2.3;

f) rinse with solvent type C (4.3.2.1), filtered in accordance with 4.3.2.2 or 4.3.2.3 is preferred, but is not essential;

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

It is also possible to use a purpose built rig designed to carry out the cleaning process and therefore the use of solvent type B or type C only is acceptable.

4.3.4 Cleaning procedure for sample bottles

Sample bottles and caps shall be thoroughly cleaned in accordance with the procedure specified in 4.3.3. In carrying out steps d) to f) of 4.3.3, care shall be taken to ensure that the whole surface of the sample bottles is rinsed from bottom to top.

A small amount of solvent type C may remain in the sample bottle after the last rinse, if used. The resultant gas pressure inside the sample bottle helps to prevent contamination entering the bottle when opened.

When using a piece of compatible plastic film to cover the bottle opening, the film shall be rinsed with filtered solvent type B or type C and shall then be placed over the mouth of the sample bottle with the edges of the film bent downwards and the cap screwed onto the bottle. Care shall be taken not to use excessive torque to tighten the cap, to avoid breaking the plastic film.