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Hydraulic fluid power — Monitoring the level of particulate contamination of the fluid —

Part 1: General principles

Transmissions hydrauliques — Surveillance du niveau de pollution particulaire des fluides —

Partie 1: Principes généraux

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Contents

Foreword

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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 document 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).

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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 6, *Contamination control*.

This second edition cancels and replaces the first edition (ISO 21018-1:2008), which has been technically revised. The main changes are as follows:

— 3.1 contains an updated definition for automated particle counter;

— 3.2 contains an updated definition for particle contamination model;

— 3.10 contains an updated definition for mesh;

— 3.11 now contains a note for the particle size definition;

— B.8.1 has been updated to accurately describe the capabilities of image analysis.

A list of all parts in the ISO 21018 series can be found on the ISO website.

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.

Introduction

In hydraulic fluid power systems, power is transmitted through a liquid under pressure within a closed circuit. The liquid is both a lubricant and a power-transmitting medium. The presence of solid particulate contamination in the liquid interferes with the ability of the hydraulic liquid to lubricate and causes wear to the components. The extent of this form of contamination in the liquid has a direct bearing on the performance and reliability of the system and it is necessary to control this to levels that are considered appropriate for the system concerned. Hydraulic oil filters are used to control the amount of particulate contamination to a level that is suitable for both the contaminant sensitivity of the system and the level of reliability required by the user.

Operators of hydraulic equipment are gradually defining maximum particle concentration levels for components, systems and processes. These are often referred to as the required cleanliness level (RCL). This cleanliness level is obtained by sampling the hydraulic liquid and measuring the particulate contamination level. If the contamination level is above the RCL, then corrective actions are necessary to reduce the contamination level. To avoid taking unnecessary actions, which can often prove costly, precision in sampling and measuring the particulate contamination level is required.

A comprehensive range of measurement equipment is available, but the instruments used are usually laboratory-based. This often requires that the equipment is operated in a special environment by specialist laboratories and this delays delivery of the test result to the user. To overcome this disadvantage, instruments are being continuously developed to determine the particulate contamination level, either using equipment that can be operated in or near the workplace or directly using on-line or in-line techniques. For equipment operated in the workplace, direct traceability to national measurement standards can be inappropriate, or irrelevant, as the instruments are used to monitor the general level of particulate contamination or to inform the user of a significant change in the level. When a significant change in the particulate contamination level is detected, the actual level is then usually qualified by using an approved particle-counting method. Also, these monitors can have simplified circuitry compared to similar laboratory units and this means that they can be less accurate and precise.

In addition, some instruments are designed to work on the “go/no-go” principle and their ability to rapidly evaluate the cleanliness level has resulted in an increase in their usage both in the fluid power industry and other markets. Unfortunately, the lack of a standardized method for their use, recalibration (if applicable) and means of checking the output validity means that the variability in the measurement data is at a level higher than is desirable.

This document has been developed to provide uniform and consistent procedures for instruments that are used for monitoring the contamination levels in hydraulic systems, especially those where direct traceability to national measurement standards is not possible or is not applicable.

Hydraulic fluid power — Monitoring the level of particulate contamination of the fluid —

Part 1:
General principles

1 Scope

This document specifies methods and techniques that are applicable to the monitoring of particulate contamination levels in hydraulic systems that cannot be calibrated in accordance with ISO 11171. It also describes the relative merits of various techniques, so that the correct monitor for a given application can be selected.

The techniques described in this document are suitable for monitoring:

a) the general cleanliness level in hydraulic systems;

b) the progress in flushing operations;

c) support equipment and test rigs.

This document can also be applicable for other liquids (e.g. lubricants, fuels and process liquids).

NOTE Instruments used to monitor particulate contamination that cannot be calibrated according to ISO 11171 are not considered as or claimed to be particle counters, even if they use the same physical principles as particle counters

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

ISO 5598, *Fluid power systems and components — Vocabulary*

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

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

ISO 12103-1, *Road vehicles — Test contaminants for filter evaluation — Part 1: Arizona test dust*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598, ISO 11171 and the following apply.

ISO and IEC maintain terminology 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/

3.1
automatic particle counter
APC
instrument that automatically:

a) senses individual particles suspended in a controlled volume of fluid using optical light extinction or light scattering principles;

b) measures the size of particles;

c) sorts or compiles particles into size ranges;

d) counts particles in each size range;

e) reports the number of particles in each size range per unit volume; and

f) facilitates instrument calibration according to this document.

Note 1 to entry: APC used for *particle size* (3.11) determination with hydraulic fluids, aviation and diesel fuels, engine oil and other petroleum-based fluids shall be calibrated per the requirements of ISO 11171.

[SOURCE: ISO 11171:2022, 3.1]

3.2
particle contamination monitor
PCM
instrument that automatically measures the concentrations of particles suspended in a fluid at certain sizes and cannot be calibrated in accordance with ISO 11171, and whose output may be as a *particle size* (3.11) distribution at limited sizes or as a contamination code

[SOURCE: ISO 21018-4:2019, 3.3]

3.3
coincidence error
error resulting from the presence of more than one particle in the sensing volume at one time

3.4
dynamic range
ratio of the largest and smallest *particle size* (3.11) that a sensor can analyse

3.5
filter media
filtration material that removes and retains particles as the fluid passes through

3.6
gel
semi-solid material that lacks a specific shape and can interfere with the counting or monitoring process

Note 1 to entry: Gels are usually formed by chemical reaction with the hydraulic liquid.

3.7
in-line analysis
analysis of a fluid sample of the liquid by an instrument that is permanently connected to a working flow line and where all the liquid in that line passes through the sensor

3.8
off-line analysis
analysis of a fluid sample by an instrument that is not directly connected to the hydraulic system

3.9
on-line analysis
analysis performed on a fluid supplied directly to the instrument by a continuous line from the hydraulic system

Note 1 to entry: The instrument can be either permanently connected to the flow line or connected prior to analysis.

3.10
mesh
type of *filter media* (3.5) with a uniform pore structure that is made by weaving strands of wire or material filaments, or fabricated directly

3.11
particle size
characteristic dimension of a particle that defines the magnitude of the particle in terms of a physically measurable dimension related to the analysis technique used, such as the longest dimension or the equivalent spherical diameter

Note 1 to entry: For automatic particle counters and light extinction particle contamination monitors, ISO 11171 defines particle size as the projected area equivalent diameter of particles. The equivalent diameter is determined by NIST using scanning electron microscopy traceable through a NIST length standard or an APC calibrated according to ISO 11171.

3.12
pore size
equivalent diameter of the holes in *filter media* (3.5) as determined by direct microscopic measurement or calculated from permeability data

3.13
qualitative data
data that have less precision or accuracy than quantitative methods and usually give results in ranges rather than exact numbers

3.14
quantitative data
data in the form of an exact numerical value of a parameter

3.15
required cleanliness level
RCL
hydraulic fluid cleanliness level required for a system, process or specification

[SOURCE: ISO 12669:2017, 3.9, modified — Note to entry has been omitted.]

3.16
silt
very small particles (< 3 µm in size) that are present in the liquid, often below the minimum detection size of the technique used

Note 1 to entry: Silt can interfere with the effectiveness of the instrument either by obscuring particles or by coincidence error effects.

Note 2 to entry: They can be small wear particles or products of hydraulic liquid degradation.

3.17
suction (sip) sampling
process of drawing a sample from a reservoir using a vacuum

3.18
suction (sip) analysis
analysis of a sample drawn by instrument pump from a non-pressurized container and delivered to the instrument sensor

4 Health and safety

4.1 General

Operate the instrument in accordance with the manufacturer’s instructions and follow local health and safety procedures at all times. Personal protective equipment shall be used when required.

4.2 Electric power

Take care when connecting the instrument to an electrical power source and follow the manufacturer's instructions.

4.3 Mechanical fluid power

Instrument connections to pressurized lines shall be in accordance with the instrument manufacturer’s instructions and in such a manner that the connection is secure and leak free. Any connectors used shall be suitable for the pressure at the point of sampling.

Ensure that internal pressure has been dissipated before taking off any fittings or closures.

NOTE See Clause 6 for guidance regarding sampling from pressurized lines.

4.4 Process liquids

4.4.1 Flammable or combustible liquids

If test liquids are flammable or combustible, they shall be used as follows:

a) in accordance with all local requirements;

b) in accordance with the relevant material safety data sheet (SDS).

The transfer of volatile liquids from one container to another container shall be carried out carefully due to the risk of sparking.

NOTE Follow the precautions for safe handling and usage described in the safety data sheet(s) of all fluids.

4.4.2 Chemical compatibility

Ensure that all chemicals and fluids used in the various processes are chemically compatible with each other and with any equipment used.

4.5 Electrical earthing/grounding

Apparatus used for filtering or dispensing solvents or any volatile flammable liquid shall be electrically earthed to avoid the risk of static discharge.

4.6 Environmental

All liquids and substances shall be disposed of in accordance with local environmental procedures.

Spillage shall be cleaned-up as detailed in the relevant SDS.

5 Selection of monitoring technique

5.1 General

The choice of instrument, or monitoring technique, depends upon, but is not limited to, the following aspects:

a) how the instrument is to be used, i.e. the mode of operation (A.2.4);

b) the purpose for which the analysis is required (A.2.2);

c) the parameter(s) to be measured (A.2.3);

d) the properties of the liquid (A.2.5).

5.2 Selection

Select the instrument and monitoring technique by considering the operational parameters detailed in Annex A and Annex B, and choose a combination that satisfies the individual requirements for monitoring.

NOTE A.1, explains the modes of operation and analysis and A.2, gives guidance on the various aspects to consider during selection and includes a selection matrix. Annex B gives a brief explanation of the different techniques and their advantages and disadvantages.

6 Procedures and precautions

6.1 General

Whichever monitoring or measurement technique is selected, there are a number of precautions that shall be taken to ensure that valid data are produced and errors are minimized.

This document gives general procedures that limit errors. Precautions relating to a specific technique are given in the relevant part of the ISO 21018 series.

6.2 Sampling

6.2.1 Obtaining representative samples

6.2.1.1 Select the sampling position consistent with the reasons for sampling (see ISO 4021).

NOTE 1 It is extremely important to use the correct sampling technique(s). The use of equipment connected to or mounted in or on the active flow line reduces the errors associated with extraneous contamination.

NOTE 2 The particulate contamination added to the sample from the sampling process can be much higher than the particulate concentration that exists in the liquid of some filtered systems.

The guidelines described in 6.2.2 to 6.2.3 are typical good practice for obtaining reliable results and should be read in conjunction with ISO 4021.

6.2.1.2 Use sampling valves that conform to ISO 4021.

6.2.1.3 For general monitoring, take the sample when the system is running and conditions are stable. Sampling 30 min after start-up is suitable.

6.2.1.4 For periodic monitoring of a machine or process, take repeat samples from the same place, in the same manner, when the machine or process is running normally and when operating conditions have stabilized.