INTERNATIONAL STANDARD

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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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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 21018-1 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 6, *Contamination control*.

ISO 21018 consists of the following parts, under the general title *Hydraulic fluid power — Monitoring the level of particulate contamination of the fluid*:

— *Part 1: General principles*

— *Part 3: Use of the filter blockage technique*

A Part 2, dealing with the calibration and verification procedure for field contamination monitoring, and a Part 4, dealing with the use of the light extinction technique, are under development.

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 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 that this be controlled to levels that are considered appropriate for the system concerned. Hydraulic 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, beyond which corrective actions are implemented to normalize the levels. These are often referred to as the required cleanliness level (RCL). The cleanliness level is obtained by sampling the hydraulic liquid and measuring the particulate contamination level. If the level is above the RCL, then corrective actions are necessary to restore the situation. 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 might not be appropriate, or relevant, and 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 are not so 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 International Standard 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 part of ISO 21018 specifies methods and techniques that are applicable to the monitoring of particulate contamination levels in hydraulic systems. 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 part of ISO 21018 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 part of ISO 21018 can also be applicable for other liquids (e.g. lubricants, fuels and process liquids).

NOTE Instruments used to monitor particulate contamination 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 referenced documents are indispensable for the application 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 4406:1999, *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 11500:1997, *Hydraulic fluid power — Determination of particulate contamination by automatic counting using the light extinction principle*

ISO 11943, *Hydraulic fluid power — On-line automatic particle-counting systems for liquids — Methods of calibration and validation*

ISO 12103-1:1997, *Road vehicles — Test dust 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 and the following apply.

3.1
automatic particle counter
APC
instrument that automatically counts and sizes individual particles suspended in a liquid using the light extinction principle

3.2
coincidence
detection of two or more particles as a single particle

NOTE Adapted from ISO 11500:1997, definition 3.2.

3.3
dynamic range
ratio of the largest and smallest particle size that a sensor can analyse

3.4
filter medium
fabric of the filter that removes and retains particles

3.5
gel
shapeless material that lacks definition and can interfere with the counting or monitoring process

NOTE Gels are usually formed by chemical reaction with the hydraulic liquid.

3.6
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 of the liquid in that line passes through the sensor

3.7
off-line analysis
analysis of a fluid sample by an instrument that is not directly connected to the hydraulic system

3.8
on-line analysis
analysis performed on a fluid supplied directly to the instrument by a continuous line from the hydraulic system

NOTE The instrument can be either permanently connected to the flow line or connected prior to analysis.

3.9
mesh
type of filter medium that is made by weaving strands of wire or material filaments

3.10
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 and shall be stated in each standard

3.11
pore size
size of hole in the filter medium as stated by the instrument manufacturer

3.12
qualitative data
data that have less precision or accuracy than quantitative methods and usually gives results in ranges rather than exact numbers

3.13
quantitative data
data in the form of an exact numerical value of a parameter

3.14
required cleanliness level
RCL
liquid cleanliness level specified for a system or process

3.15
sampler
device for extracting a representative sample from a larger source

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 These can interfere with the effectiveness of the instrument either by obscuring particles or by coincidence effects.

NOTE 2 They can be small wear particles or products of hydraulic liquid degradation.

3.17
suction (sip) analysis
analysis of a sample drawn by instrument pump from a non-pressurized container and delivered to the instrument sensor

3.18
ISO codes
code defining the quantity and distribution of solid particles in the fluid used in a given hydraulic fluid power system, consisting of three numbers separated by a slash

EXAMPLE A code of 22/18/13 signifies that there are more than 20 000 and up to and including 40 000 particles equal to or larger than 4 µm(c), more than 1 300 and up to and including 2 500 particles equal to or larger than 6 µm(c) and more than 40 and up to and including 80 particles equal to or larger than 14 µm(c) in 1 ml of a given fluid sample.

See ISO 4406.

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. Ensure that the correct safety fuse is fitted to electrical equipment.

4.3 Mechanical fluid power

Instruments shall be connected to pressurized lines 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 Volatile liquids

Flammable liquids shall be used

a) in accordance with the relevant material safety data sheet (MSDS),

b) at a temperature below the stated flash point,

c) away from potential sources of ignition.

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

4.4.2 Solvents

Solvents shall be used in well-ventilated areas and the generation of an aerosol mist shall be avoided.

4.4.3 Electrical earthing/grounding

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

4.4.4 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 MSDS.

4.4.5 Chemical compatibility

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

5 Selection of monitoring technique

5.1 General

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

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

b) purpose for which the analysis is required;

c) parameter(s) to be measured;

d) properties of the liquid.

5.2 Selection

Select the monitor by considering the operational parameters detailed in Annexes A and B and choose the instrument or technique that satisfies the individual requirements for monitoring.

NOTE Clause A.1 explains the modes of operation and analysis and Clause 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 part of ISO 21018 gives general procedures that limit errors. Precautions relating to a specific technique are given in the relevant part of ISO 21018.

6.2 Obtaining representative samples

6.2.1 Select the sampling position consistent with the reasons for sampling. See ISO 4021.

NOTE 1 The importance of using the correct sampling technique(s) cannot be over-emphasized. 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 6.3 to 6.6 are typical good practice for obtaining reliable results and should be read in conjunction with ISO 4021.

6.2.2 Use sampling valves that conform to ISO 4021.

6.2.3 For general monitoring, take the sample when the system is running and conditions are stable.

NOTE A period of 30 min after start-up is suitable.

6.2.4 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.

6.3 Off-line sampling

6.3.1 Use sample bottles that have been cleaned and verified in accordance with ISO 3722.

6.3.2 Site the sampling valve consistent with the reason for sampling.

6.3.3 Position the sampling valve in a location where good mixing conditions exist.

6.3.4 Flush the sampling valve and transfer line at a flow rate of at least 2 l/min with a minimum flushing volume of 500 ml. Use higher flushing volumes (1 l to 3 l) if

a) valves do not conform to the requirements of ISO 4021,

b) long transfer lines are used,

c) the system liquid is clean (i.e. $\leqslant$ 14/12/9 in accordance with ISO 4406:1999).

6.3.5 Take the sample in a manner so as to minimize the ingress of environmental contamination.

6.3.6 Cap the sample immediately after it is taken and label with a unique identification.

6.3.7 Do not take samples from drain valves.

6.4 On-line analysis

6.4.1 Use sampling valves and procedures defined in ISO 4021.

6.4.2 Provide sufficient supply pressure to avoid instrument starvation or cavitation.

6.4.3 Flush the sampling lines with at least 1 l to 2 l of liquid sample after connection and before analysis.

6.4.4 Continue the analysis until the data from two successive samples satisfy one of the following requirements.

a) The results are within the limits set by the instrument manufacturer.

b) The difference in test results is less than 10 % at the minimum particle size being monitored if the required output is particle count.

c) The same cleanliness code is recorded.

6.5 In-line analysis

Install the instrument in a location

a) that is exposed to the majority of the flow;

b) where good mixing conditions exist.

6.6 Suction (sip) analysis from reservoirs or containers

6.6.1 Take the sample from a location where the liquid is in motion.

6.6.2 Shake and well mix the contents of static containers before extracting the sample.

NOTE This method is the least-favoured option as the potential for errors and variability is greatest.

If mixing the contents of a bulk container is impractical, a note shall be made in the report.

6.6.3 Clean the area(s) surrounding the location where the sample is taken so that contamination does not fall into the sample, the container or reservoir.

6.6.4 Flush the sampling system with at least 10 complete volumes (instrument and connecting pipes) of system liquid.

6.6.5 Continue the analysis until the data from successive samples satisfy one of the following requirements:

a) The results are within the limits set by the instrument manufacturer.

b) The difference in test results is less than 10 % at the minimum particle size being monitored if the required output is particle count.

c) The same cleanliness code is recorded.