INTERNATIONAL STANDARD

ISO 21018-4

First edition
2016-11-01

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

Part 4:
Use of the light extinction technique

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

Partie 4: Technique d'absorption de lumière

Reference number
ISO 21018-4:2016(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

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 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.

The committee responsible for this document is 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*

— *Part 4: Use of the light extinction technique*

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 contaminant particles in the liquid interferes with the ability of the hydraulic liquid to lubricate and causes wear. The extent of contamination in the liquid has a direct bearing on the performance and reliability of the system and should be controlled to an appropriate level.

Quantitative determination of particulate contamination requires precision both in obtaining a representative sample of the liquid and the measurement of the contamination. The awareness of the benefits of cleanliness monitoring has led to the development of instruments that operate online (i.e. directly connected to a system) in an attempt to reduce measurement errors that are inherent with bottle samples. Automatic particle counters (APC) and monitors have been developed and are extensively used.

Instruments using this technique have become widely used in the industry and an International Standard is required in order to standardize operating procedures. This part of ISO 21018 defines procedures for the use of light extinction instruments in evaluating the cleanliness level of a hydraulic liquid. It also includes procedures for calibrating and verifying that the instruments are operating correctly to ensure consistent results.

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

Part 4:
Use of the light extinction technique

1 Scope

This part of ISO 21018 specifies a method for the determination of the particulate contamination level using the light extinction technique (also known as light blockage or light obscuration) either online or off-line in containers. It also defines procedures for calibrating the instruments and verifying their correct operation both in the laboratory and in service.

In general, the techniques described in this part of ISO 21018 are suitable for monitoring

— the general cleanliness level in hydraulic systems,

— the progress in flushing operations, and

— support equipment and test rigs.

The use of this method is applicable to single-phase liquid systems only.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 5598, *Fluid power systems and components — Vocabulary*

ISO 11171:2010, *Hydraulic fluid power — Calibration of automatic particle counters for liquids*

ISO 16889, *Hydraulic fluid power — Filters — Multi-pass method for evaluating filtration performance of a filter element*

ISO 11943[1], *Hydraulic fluid power — On-line automatic particle-counting systems for liquids — Methods of calibration and validation*

3 Terms and definitions

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

---

[1] To be published.

3.1
light extinction
reduction in intensity of a light beam passing through the sensing volume caused by the interaction of the light with single particles

[SOURCE: ISO 11500:2008, 3.3]

3.2
extraneous contamination
contamination that is not an integral part of the fluid from which a sample was taken, but was introduced into the sample from another source

Note 1 to entry: Extraneous contamination increases the measured level of contamination such that the sample appears to be more contaminated than it really is.

4 Health and safety

Operate the instrument in accordance with the manufacturer's instructions. Follow local health and safety procedures at all times.

WARNING — The use of this International Standard can involve hazardous materials, operations and equipment. This International Standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5 Equipment

5.1 General

If the analysis is performed using sample bottles or containers (see 6.5), sampling apparatus (see 5.2.1) could be required. Such apparatus shall avoid introducing contamination when the inlet hose is inserted. For the process of calibration and verification of correct operation, use the equipment detailed in 5.2.

5.2 Equipment for online and off-line calibration and verification

5.2.1 Bottle sampling apparatus, for transferring the calibration or verification sample to the instrument. If a pressure chamber is used to force the liquid through the device at constant pressure, a suitable source of filtered, dried and regulated air is required.

5.2.2 Calibration and verification dust, test dust, designated RM8631, used for calibration or verification or both, shall have a size distribution measured using an automatic particle counter (APC) calibrated in accordance with ISO 11171 or ISO 11943. RM8631 is available from NIST and consists of 20 g of dry dust taken from the same lot as the dust in SRM 2806 and is provided with reference values from 1 micron to 50 microns.

5.2.3 Flushing fluid, separate fluid compatible with the verification fluid for flushing the instrument prior to verification. The fluid shall be pre-cleaned to fewer than 15 particles sized >4 µm(c)/mL or no more than 0,5 % of the expected population of the smallest measured particle size.

NOTE The unit µm(c) refers to particle sizes determined using an APC calibrated in accordance with ISO 11171 or ISO 11943.

5.2.4 Oven, non-circulating, capable of providing a temperature, controlled to ± 5 °C, between 100 °C and 150 °C for drying the test dust. For drying the calibration and verification dust (refer to 5.2.2).

5.2.5 Reference particle counter, an APC calibrated in accordance with ISO 11171 or ISO 11943.

5.2.6 Sample agitating device, suitable for re-dispersing the contaminant within the contents of the sample bottle, such as an ultrasonic bath rated at 3 000 W/m^2 to 10 000 W/m^2 of base area, or a three-axis shaker. The agitating device shall not alter the basic size distribution of the test dust or the contaminants in samples being analysed.

5.2.7 Sample bottles, cleaned and validated in accordance with ISO 3722. Use the following Required Cleanliness Levels (RCLs):

a) for sample bottles used for mixing the test dust: <100 particles ≥ 4 µm(c)/mL of sample bottle volume

b) for sample bottles used for verifying system cleanliness or for preparing the calibration verification samples: <5 particles ≥ 4 µm(c)/mL of sample bottle volume

5.2.8 Solvent, compatible with the instrument and equipment used and miscible with the test liquid. Any solvent used shall be filtered to 0,8 µm or better to achieve an RCL of <2 particles ≥ 4 µm(c)/mL.

5.2.9 Solvent dispenser, pressurized, fitted with a 0,8 µm inline membrane filter at the outlet.

5.2.10 Test rig, validated in accordance with ISO 11943.

5.2.11 Test liquid, conforming to the requirements used for online calibration or validation and conforming to the requirements stated within ISO 16889.

5.2.12 Vacuum source, to de-aerate the test liquid samples after shaking, and may be incorporated in the bottle sampling apparatus. An ultrasonic bath can be used as an alternative method (see 5.2.6).

NOTE 1 De-aeration might not be required if the instrument utilizes a constant pressure source.

NOTE 2 The effectiveness of ultrasonics in removing air is reduced as the viscosity of the test liquid increases.

5.2.13 Verification samples, sample bottles containing a suspension of RM8631 in oil that is compatible with the instrument concerned and at a concentration specified by the instrument manufacturer. The particle size distribution shall be determined using a reference particle counter (see 5.2.5).

5.2.14 Weighing balance, with a resolution of 0,05 mg or better.

6 Operating procedures

6.1 General

Select the mode of operation from the following:

- from a pressurized line (see 6.2);
- by suction from a system reservoir (see 6.3);
- by suction from a bulk container (see 6.4);
- from a sample bottle (see 6.5).

Operating online from a pressurized source is preferred as it eliminates contamination from the environment. Select the sampling position and sampling valves in accordance with ISO 4021. If periodic or continuous trend monitoring is being carried out on a machine or process, take repeat samples from the same place, in the same manner and under similar operating conditions.

6.2 Operating from a pressurized line for the field contamination monitor

6.2.1 General

WARNING — Ensure that all equipment and procedures used are safe and compatible with the maximum system pressure.

Select the sampling valve or apparatus so that it complies with ISO 4021. Position the sampling valve in a flow line that carries a significant flow and at a point of turbulence, such as after an elbow. Any pressure tap used as a sampling valve shall comply with the requirements of ISO 4021. Such a tapping point can require sustained flushing by recording the cleanliness level.

6.2.2 Procedure

6.2.2.1 Stabilize the system at its normal operating conditions. Ensure that the instrument operates properly at both the minimum and maximum pressure observed where connected to the hydraulic system.

6.2.2.2 Establish whether there is any liquid residual from a previous analysis in the instrument and whether the residual liquid is miscible with the current test liquid. If there is any doubt, flush the previous fluid out of the unit in accordance with the instrument manufacturer's recommendations.

6.2.2.3 Clean the sampling valve or apparatus with a suitable solvent and lint-free, non-shedding cloth or wipe.

6.2.2.4 Operate the instrument in accordance with the manufacturer's instructions. If the instrument does not have an automatic self-flushing sequence, run the instrument to ensure that the sampling line and instrument are adequately flushed. If the instrument was previously used to analyse a different but miscible liquid, flush with at least 10 complete volumes (instrument and connecting pipes) of system liquid and direct to waste.

6.2.2.5 Analyse the sample in accordance with the manufacturer's instructions. Perform at least two analyses and compare the results. Repeat the analysis if either:

a) the difference between two successive codes for instruments whose output is in cleanliness codes is greater than 1 code, or

b) the difference in particle counts is greater than 10 % at the smallest particle size being monitored.

Refer to error sources listed in 6.4.1.

6.2.3 After analysis, close the sample valve and ensure that any residual pressure has been exhausted from the sampling line before disconnecting the instrument.

6.2.3.1 Record the data.

6.3 Operating from a system reservoir for the field contamination monitor

6.3.1 General

Select the reservoir sampling device so that it complies with ISO 4021. Sampling should only be conducted during system operation when liquid is moving within the reservoir.

6.3.2 Procedure

6.3.2.1 Stabilize the system at its normal operating conditions and check that there is sufficient liquid movement in the reservoir to promote adequate dispersion of the particles in the area where the sample is taken.

NOTE If there is insufficient movement, the sample analysed might not be representative of the whole.

6.3.2.2 Establish whether there is any liquid residual from a previous analysis in the instrument and whether the residual liquid is miscible with the current test liquid. If it is not miscible or there is any doubt, flush the previous fluid out of the unit in accordance with the instrument manufacturer's recommendations.

6.3.2.3 Clean the reservoir entry area where the sampling line is inserted and secure any screws, fittings, etc. Clean the sampling valve or apparatus with a suitable solvent and lint-free, non-shedding cloth or wipe.

6.3.2.4 Insert the inlet hose into the reservoir so that it draws from a representative portion of the liquid (normally mid-depth).

6.3.2.5 If the instrument does not have an automatic self-flushing sequence, run the instrument to ensure that the sampling line and instrument are adequately flushed. Do not exceed the minimum sensor pressure or the maximum viscosity value stated by the manufacturer. If the instrument was previously used to analyse a different but miscible liquid, flush with at least 10 complete volumes (instrument and connecting pipes) of system liquid and direct to waste.

6.3.2.6 Either position the outlet line in the reservoir so that re-entrainment of the sample into the monitor suction line does not occur or direct the outlet to another container or waste.

6.3.2.7 Analyse the sample in accordance with the manufacturer's instructions. Perform at least two analyses and compare the results. Repeat the analysis if either:

a) the difference between two successive codes for instruments whose output is in cleanliness codes is greater than 1 code, or

b) the difference in particle counts is greater than 10 % at the smallest particle size being monitored.

Refer to error sources listed in 6.4.1.

6.3.2.8 Record the data.

6.4 Operating from a bulk container for the field contamination monitor

6.4.1 General

This procedure requires the sample to be sucked (or sipped) from the bulk container by a pump, either integral with the instrument or specially provided. This procedure can be subject to error and variability in measurement and can require additional stages. Such sources of error include:

— an inactive liquid source: It can be impracticable to agitate the container to re-distribute the particles and the extracted sample might not be representative of the whole. A secondary circulating pump can be necessary;

— high viscosity: The liquid can be at ambient temperatures and have a high viscosity. A vacuum can be generated when the pump sucks the liquid and this can release air or starve the inlet to the instrument. This can reduce the flow rate or cause erratic operation of the instrument.

6.4.2 Procedure

6.4.2.1 Agitate the container to redistribute the particles. If this is impractical, provide a secondary circulating pump to distribute the particles. If the sample cannot be agitated, do not proceed as lack of proper agitation can lead to non-representative results; note the inability to agitate the sample in the report.

6.4.2.2 Establish whether there is any liquid residual from a previous analysis in the instrument and whether the residual liquid is miscible with the current test liquid. If it is not miscible or there is any doubt, flush the previous fluid out of the unit in accordance with the instrument manufacturer's recommendations.

6.4.2.3 Clean the entry area with a suitable solvent and lint-free, non-shedding cloth or wipe where the sampling line is inserted and the outside of the sampling line.

6.4.2.4 Position the inlet hose in the bulk container so that the inlet hose draws from below the surface of the liquid. If a secondary pump is used, position the inlet pipe away from both the suction and return hoses and in an area of circulation.

6.4.2.5 If the instrument does not have an automatic self-flushing sequence, run the instrument to ensure that the sampling line and the instrument are adequately flushed. Do not exceed either the minimum sensor pressure or the maximum viscosity values stated by the manufacturer. If the instrument was previously used to analyse a different but miscible liquid, flush the previous fluid out of the unit in accordance with the instrument manufacturer's recommendations.

6.4.2.6 Position the return hose either in the bulk container so that re-entrainment of the sample into the instrument suction line does not occur or direct the outlet to another container or waste as required.

6.4.2.7 Analyse the sample in accordance with the manufacturer's instructions. Perform at least two analyses and compare the results. Repeat the analysis if either:

a) the difference between two successive codes for instruments whose output is in cleanliness codes is greater than 1 code, or

b) the difference in particle counts is greater than 10 % at the smallest particle size being monitored.

Refer to error sources listed in 6.4.1.

6.4.2.8 Record the data.

6.5 Operating from a sample bottle for the field contamination monitor

6.5.1 General

This is the least favoured option as analysis from sample bottles can result in substantial errors from the introduction of extraneous contamination; the cleaner the system, the greater the error. These errors can be reduced by the use of a bottle sampling apparatus combined with appropriate procedures (see ISO 11500). If a bottle sampler is not available, it is recommended that a sampling probe be made to facilitate taking the sample from the bottle or container and so avoid having to immerse the inlet hose into the sample bottle. In addition, such a probe can be easily cleaned. Once the sample liquid has passed through the instrument, it shall be directed to waste. The liquid shall not be returned to the sample bottle or container.

6.5.2 Procedure

6.5.2.1 Any residual liquid from a previous analysis shall be flushed from both the instrument and any connecting hoses in accordance with the instrument manufacturer's recommendations.

6.5.2.2 If necessary, validate the cleanliness level of the apparatus in accordance with the manufacturer's instructions. Clean the instrument such that the background analysis is less than 10 % of the subsequent analysis.

6.5.2.3 Re-suspend the contaminant in the sample bottle by agitating it by either shaking the sample bottle by hand for 30 s or using a suitable sample-agitating device (5.2.6). Remove the air using a suitable device (see ISO 11500). Do not allow more than 2 min to elapse before starting the analysis.

NOTE 1 For liquids with viscosity $> 50\ \text{mm}^2/_\text{s}$ at the test temperature, a longer agitation time can be necessary.

NOTE 2 The viscosity can be reduced by the addition of clean solvent (5.2.8) before shaking.

6.5.2.4 Flush the external surfaces of the sampling tube with filtered solvent, then immerse the tube in the sample bottle to approximately 5 mm above the base. Do not allow the end of the pipe to touch the bottom of the bottle.

6.5.2.5 Operate the instrument (and the bottle sampling apparatus if used) in accordance with the manufacturers' instructions. Initially flush the instrument with the sample liquid or perform a first analysis and discard the results. Make at least two further analyses and compare the results.

6.5.2.6 If the difference between successive analyses is greater than one contamination code or the difference in particle counts is greater than 10 % at the smallest particle size being monitored, this indicates that the contents of the container might not be sufficiently homogeneously distributed. Repeat 6.5.2.2 to 6.5.2.5 as appropriate.

6.5.2.7 Record the results.

7 Calibration and verification procedure

7.1 General principles

Particle size calibration or verification of light extinction instruments shall be carried out using RM8631 test dust and performed using a test rig that conforms to ISO 11943. A calibration shall be conducted on new instruments or after major service, and at periodic intervals not to exceed one year. Verification of correct operation shall be carried out either using ISO 11943 or by using prepared suspensions of RM8631 test dust in the test liquid whose particle size distribution has been certified using a reference particle counter (5.2.5) whose calibration is traceable to ISO 11171 or ISO 11943.

7.2 Required equipment

Some or all of the equipment listed in 5.2 are required.

7.3 Determination of particle concentration limits

Use the procedures of ISO 11171:2010, Annex B to determine maximum particle concentration limits of each instrument, or use the manufacturer's recommended maximum levels obtained in a similar manner.

7.4 Calibration

7.4.1 Perform a particle size calibration in accordance with ISO 11943, then verify the calibration in all other modes of instrument operation as applicable.

NOTE Some instruments operate in multiple modes, such as pressure and suction. In such instances, the calibration (that is, adjusting of threshold values) can be performed in one of the modes, and it is only necessary to perform a verification check on the other modes.

7.4.1.1 Pressure line sampling mode (if applicable)

Verify calibration using the test rig for at least three inlet pressure levels as follows:

- minimum recommended inlet pressure;
- maximum recommended inlet pressure;
- midpoint inlet pressure between minimum and maximum inlet pressures.

7.4.1.2 Suction sampling mode (if applicable)

Verify calibration in suction mode by either:

- sampling from the test rig, or
- using bottle samples containing either SRM 2806 or a secondary calibration suspension prepared and verified in accordance with ISO 11171:2010, Annex F.

7.4.2 Record the data in accordance with Clause 9.