INTERNATIONAL STANDARD

**ISO 18413**

First edition
2002-10-01

# Hydraulic fluid power — Cleanliness of parts and components — Inspection document and principles related to contaminant collection, analysis and data reporting



*Transmissions hydrauliques — Propreté des pièces et composants — Documents de contrôle et principes d'extraction et d'analyse des polluants et d'expression des résultats*



Reference number
ISO 18413:2002(E)

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Printed in Switzerland

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 18413 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 6, *Contamination control and hydraulic fluids*.

Annexes A to G of this International Standard are for information only.

## Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a pressurized liquid within an enclosed circuit. Contaminants present in the circulating working liquid may degrade system performance. One method of reducing the amount of these contaminants within the system is to clean parts and components prior to final assembly. Accurate assessment of the effectiveness of part and component cleanliness requires documentation of both the cleanliness requirement and the methods used for contaminant collection, analysis, and data reporting.

# Hydraulic fluid power — Cleanliness of parts and components — Inspection document and principles related to contaminant collection, analysis and data reporting

## 1 Scope

This International Standard specifies the content of an inspection document that includes both the cleanliness requirement for the specified part or component and the inspection method to be used for evaluating its cleanliness level. The cleanliness requirement and inspection method shall be established and agreed upon by the parties involved.

NOTE 1 Determination of what constitutes an appropriate cleanliness level requirement for any particular part or component is beyond the scope of this International Standard.

NOTE 2 For the purposes of this International Standard, approved functional liquids are considered to be components.

This International Standard is applicable to the wetted surfaces of any fluid power system part or component. Appearance defects and contamination by liquid or gaseous materials are not covered by this International Standard.



This International Standard does not address safety problems that may arise from hazardous materials, operations and equipment associated with its use. The user of this International Standard is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.



## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

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

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

ISO 11500, *Hydraulic fluid power — Determination of particulate contamination by automatic counting using the light extinction principle*

## 3 Terms and definitions

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

**3.1**
**component cleanliness**
amount or nature of contaminant collected from the wetted or controlled surfaces of a component, as measured by an applicable analysis method

**3.2**
**contaminant**
loose or detachable solid material present in a part or component or on a wetted or controlled surface of a part or component

NOTE For the purposes of this International Standard, contaminants include solid material suspended in liquids, but exclude liquids and gases. This definition differs from ISO 5598 in its exclusion of liquids and gases.

**3.3**
**controlled surface**
wetted surface of a part or component that is subject to a cleanliness requirement

**3.4**
**controlled volume**
wetted volume of a part or component that is subject to a cleanliness requirement

**3.5**
**end-point sample**
last sample in a series of repetitive samples, which produces a result that is $\leqslant$ 10 % of the sum of the previous samples



**3.6**
**inspection document**
written description of the part or component cleanliness requirement and the agreed inspection method



**3.7**
**inspection method**
procedure for contaminant collection, analysis and data reporting that is used to evaluate part or component cleanliness as specified by the inspection document

**3.8**
**part cleanliness**
amount or nature of contaminant collected from the wetted or controlled surfaces of a part, as measured by an applicable analysis method

**3.9**
**purchaser**
party that stipulates the requirements of a machine, equipment, system, part or component and judges whether the product satisfies those requirements

**3.10**
**representative sample**
material collected such that it is typical of the amount and nature of the contaminant contained in or on a part or component

**3.11**
**supplier**
party that contracts to provide the product(s) to satisfy the purchaser's requirements

**3.12**
**test liquid**
suitable liquid of known initial cleanliness used to remove, suspend and collect contaminant from a part or component which shall be compatible with the part or component being tested and the apparatus used

**3.13**
**validation**
process by which a test method evaluates the efficiency of the contaminant removal process or confirms that a laboratory analysis instrument is operating properly

NOTE This definition differs from ISO 8402:1994 (withdrawn in 2000) because, in this case, validation addresses the test method or laboratory analysis instrument, whereas in ISO 8402:1994 validation addresses the final product.

**3.14**
**wetted surface**
surface area of the part or component that is exposed to system liquid

## 4 Inspection document principles

### 4.1 Content

This International Standard specifies the content of the inspection document, not its format. The inspection document may exist as a single document or as a series of related documents. Regardless of format, the inspection document shall clearly identify the part or component cleanliness requirement and the agreed inspection method.

### 4.2 Part or component cleanliness requirement

The inspection document shall define the part or component cleanliness requirement. The cleanliness requirement should be consistent with the known and/or anticipated function or application of the part or component. Typical reference sources for consideration in determining the cleanliness requirement for a particular part or component include: historical data; existing company, industry, national, and international standards; functional performance, reliability, and durability requirements of the part or component; and data on similar parts or components.



The part or component cleanliness requirement shall be established and agreed upon by the parties involved.



NOTE Determination of what constitutes an appropriate cleanliness level requirement for any particular part or component is beyond the scope of this International Standard.

### 4.3 Inspection method

**4.3.1** The inspection document shall define the inspection method to be used to evaluate part or component cleanliness. The inspection method shall be established and agreed upon by the parties involved. The inspection method should be consistent with the design and the cleanliness requirement of the part or component.

**4.3.2** The inspection document shall define appropriate parameters applicable to collecting contaminant, conducting analyses, and reporting results. Typical reference sources for consideration in determining the agreed inspection method include: previously used methods of contaminant collection, analysis and data reporting; existing company, industry, national, and international standards; functional, reliability and durability requirements of the part or component; and methods used on similar parts or components. ISO standards should be used when these are available. If ISO standards are not available, national, industry and company standards may be used, in that order of preference.

### 4.4 Effectivity

The inspection document shall become effective upon mutual agreement between the parties involved, both of which shall maintain a copy of the applicable inspection document.

### 4.5 Conformance

**4.5.1** Unless otherwise stated in the inspection document, 4.5.2 and 4.5.3 shall apply.

**4.5.2** All parts or components shall meet the specified cleanliness requirement when evaluated by the agreed inspection method.

**4.5.3** Inspection of all parts and components may not be required. It is possible that some parts or components are required to meet a specified cleanliness level and that other parts or components have no cleanliness requirements.

NOTE Development and incorporation of cost-effective cleaning methods are encouraged as part of the normal manufacturing process. An audit process is commonly used to monitor conformance to dimensional, cleanliness and functional requirements.

### 4.6 Conformance verification

**4.6.1** Conformance to part or component cleanliness requirements may be verified either by the use of industry-accepted statistical sampling methods or by joint purchaser-supplier monitoring of the inspection processes.

**4.6.2** Verification of test results requires special care because differences in methods of contaminant collection or analysis of the same part or component will affect the results obtained. In addition, because the contaminant collection process results in cleaning of the part or component used as a test item, that same test item shall not be reused for subsequent conformance verification.

### 4.7 Additional information

**4.7.1** Unless otherwise agreed by purchaser and supplier, 4.7.2 to 4.7.5 shall apply.



**4.7.2** The inspection document shall specify both the required cleanliness level for the part or component and the scope of its applicability. The points in the process at which the cleanliness requirement applies shall be stated in the inspection document. Because prolonged or improper storage of parts or components may result in the introduction of new contaminants, such as oxidation products, the inspection document should, when applicable, address these factors.



**4.7.3** Temporary shipping covers are excluded from the inspection process; however, any contaminants contributed by such covers shall be included in the evaluation of part and component cleanliness.

**4.7.4** Contaminants contributed by such defects as nicks, blemishes and discoloration shall be included in the evaluation of part and component cleanliness.

**4.7.5** Where applicable, a requirement for allowable residual magnetic density may be included as part of the inspection document.

NOTE Residual magnetism can cause retention of contaminant on part or component surfaces and the formation of agglomerates, both of which affect contaminant collection and/or analysis.

## 5 Contaminant collection principles

### 5.1 General

The method of contaminant collection shall be agreed upon and stated in the inspection document. The measured part or component cleanliness depends greatly upon the procedures used to collect the contaminant for analysis. If the collected contaminant cannot be analysed directly, proper controls should be in place to ensure that a representative sample is collected. The effectiveness of the contaminant extraction or collection process should be confirmed using the concept of end point sampling. Testing personnel shall follow the contaminant collection method specified in the inspection document. Inspection facilities shall be as clean as practicable so as not to affect the measurement of part or component cleanliness.

## 5.2 Overview

Contaminant collection consists of various techniques for removing contaminants from controlled surfaces of parts and components, suspending contaminants in a suitable test liquid, then collecting the test liquid and suspended contaminants for analysis. This International Standard describes four basic contaminant collection techniques: agitation, pressure rinse, ultrasonic vibration and end use simulation. Other methods of contaminant collection may also be used when agreed upon between supplier and purchaser. The contaminant collection method shall be properly validated.

## 5.3 Agitation

**5.3.1** Contaminant contained within simple enclosed surfaces shall be removed by partially filling the part or component under test with an appropriate test liquid, sealing the openings, and agitating the part or component to remove the contaminant from the controlled surface and to suspend the contaminant in the test liquid. Immediately after agitation, all test liquid used in the test shall be drained and collected for analysis. Annex A provides additional information.

**5.3.2** Primary process variables to be controlled include: test liquid and its relevant properties, test liquid volume and temperature, type and duration of agitation, the number of samples collected up to and including the end-point sample, and the volume of test liquid collected for analysis.

**5.3.3** Consideration should be given to the size and mass of the part or component, the need for slings or fixtures, and any auxiliary equipment necessary for proper contaminant collection.



## 5.4 Pressure rinse

**5.4.1** Contaminant on exposed and accessible surfaces shall be removed by directing a stream of test liquid onto the controlled surface of the part or component, which is placed over appropriate liquid collection apparatus. Immediately after rinsing, all test liquid used in the test shall be collected for analysis. Annex B provides additional information.



**5.4.2** Primary process variables to be controlled include: test liquid and its relevant properties, test liquid pressure and flow rate, test liquid volume and temperature, the sequence followed in rinsing the part or component, the number of samples collected up to and including the end-point sample, and the volume of test liquid collected for analysis.

**5.4.3** Consideration should be given to the overall accessibility of controlled surfaces for rinsing, the size and mass of the part or component, the need for slings and fixtures, and auxiliary equipment necessary for proper contaminant collection.

## 5.5 Ultrasonic vibration

**5.5.1** Contaminant on surfaces accessible to ultrasonic vibration shall be detached from the surface by immersing the part or component in test liquid and applying ultrasonic vibration. Upon removal of the part or component from the ultrasonic bath, all test liquid used in the test shall be collected for analysis. Annex C provides additional information.

**5.5.2** Primary process variables to be controlled include: test liquid and its relevant properties, test liquid volume and temperature, equipment power settings, duration of exposure, the number of samples collected up to and including the end-point sample, the volume of test liquid collected for analysis, and the effectiveness of removing detached contaminant from the part or component surface and collecting the sample from the ultrasonic bath for analysis.

**5.5.3** Consideration should be given to the size and mass of the part or component relative to the capacity of the ultrasonic tank and to the shape of the part or component, because both factors affect the effectiveness of the ultrasonic bath.

### 5.6 End use simulation

**5.6.1** Contaminant on internal surfaces with limited accessibility shall be collected by installing the part or component on a test stand that simulates the end use application. The part or component is actuated while test liquid is circulated through the test stand. Upon completion of the simulation cycle, a representative sample of test liquid shall be collected for analysis. Annexes D and E provide additional information.

**5.6.2** A production test stand may be used for end use simulation. When a production test stand is used for the final cleaning process (i.e., with a clean-up filter on-line) it may be agreed by purchaser and supplier that the part or component cleanliness is determined from the analysis of samples collected from a suitable point downstream from the part or component.

**5.6.3** Primary process variables to be controlled include: test liquid and its relevant properties, test liquid volume and temperature, the simulation cycle used, circulation time, the size and number of samples collected, and the procedures for controlling any carryover effects from previous tests.

**5.6.4** Care should be used in the selection of simulation cycles (for example, cycles that generate contamination associated with break-in of the part or component) and in addressing potential sources of cross-contamination from other parts or components in the hydraulic system, especially when components are fitted to the test stand. It is important to minimize the generation of contaminant, because generated contaminant will introduce additional variability in subsequent contaminant analysis results.

## 6 Contaminant analysis principles



### 6.1 General

The method of contaminant analysis shall be agreed upon and stated in the inspection document. The measured cleanliness level of a part or component depends upon the procedures used to analyse the contaminant. Because the sample collected will often contain small amounts of contaminant diluted significantly in test liquid, good laboratory techniques are necessary to avoid both loss of contaminant and cross-contamination from other sources during analysis. Testing personnel shall follow the analysis method specified in the inspection document.



NOTE The presence of residual materials (such as liquids, protective films, or grease) may cause problems during analysis if these materials are not miscible with the test liquid.

### 6.2 Overview

A variety of standard laboratory methods may be used to produce the required part or component cleanliness data. The data reporting format and contaminant analysis method are closely related. This standard describes four basic contaminant analysis methods: gravimetric, particle size, chemical composition, and particle size distribution. Other methods of analysis may also be used when agreed upon between supplier and purchaser.

### 6.3 Gravimetric analysis

Obtain the sample so as to contain all of the contaminants collected from controlled surfaces. Contaminant is generally separated from the test liquid by filtration through a membrane under controlled conditions. Contaminant concentration (mass per area, mass per volume, mass per part, or mass per component) is determined by weighing the amount of material deposited on a membrane filter after filtration (see ISO 4405).

### 6.4 Particle size

Obtain the sample so as to contain all of the contaminants collected from controlled surfaces. Contaminant is generally separated from the test liquid by filtration through a membrane under controlled conditions. Contaminant residue is examined to determine particle size by means of optical microscope or optical image analyser (see ISO 4407), scanning electron microscope, or other image producing instruments.