INTERNATIONAL STANDARD

ISO 4406

Second edition
1999-12-01

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

Transmissions hydrauliques — Fluides — Méthode de codification du niveau de pollution particulaire solide

Reference number
ISO 4406:1999(E)

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Printed in Switzerland

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.

International Standard ISO 4406 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 6, *Contamination control and hydraulic fluids*.

This second edition cancels and replaces the first edition (ISO 4406:1987), which has been technically revised. The new edition introduces a three-part code for contamination levels measured with automatic particle counters calibrated in accordance with ISO 11171. It also introduces equivalent particle sizes for such counters, based on calibration with NIST standard reference material SRM 2806.

The particle sizes to be reported for measurement by using a microscope, $\geqslant 5$ µm and $\geqslant 15$ µm, are unchanged from those specified in ISO 4406:1987.

Defining the automatic particle counter code sizes in this way validates direct comparison of measurements made in accordance with this standard using either measurement method, or between such measurements and data records based on ISO 4406:1987.

Annex A forms a normative part of this International Standard.

Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. Solid-particle contaminant is always present in the hydraulic fluid, and the amount needs to be determined because the contaminant may cause serious problems.

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

1 Scope

This International Standard specifies the code to be used in defining the quantity of solid particles in the fluid used in a given hydraulic fluid power system.

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 4407:1991, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the counting method using a microscope.*

ISO 11171:1999, *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.*

3 Code definition

3.1 General

The purpose of this code is to simplify the reporting of particle count data by converting the numbers of particles into broad classes or codes, where an increase in one code is generally a doubling of the contamination level.

The original code in accordance with ISO 4406:1987 stated the reporting at two sizes, $\geqslant 5$ µm and $\geqslant 15$ µm, but the sizes in this revision have been changed to account for the use of a different calibration standard for optical automatic particle counters. The reported sizes are $\geqslant 4$ µm(c), $\geqslant 6$ µm(c) and $\geqslant 14$ µm(c), the last two of these being equivalent to the 5 µm and 15 µm particle sizes obtained using the ISO 4402:1991 method of calibrating automatic particle counters. ISO 4402:1991 has been replaced by ISO 11171:1999. Throughout this International Standard, the use of µm(c) means that particle size measurements are carried out using an automatic particle counter which has been calibrated in accordance with ISO 11171.

Measurement of particles using an optical microscope as specified in ISO 4407:1991 establishes the size of a particle as being equal to its longest dimension, whereas an automatic particle counter derives the size of an equivalent particle from its cross-sectional area, a value different in most cases from that determined using a microscope. The particle sizes to be reported for measurement by microscope, $\geqslant 5$ µm and $\geqslant 15$ µm, are unchanged from those specified in ISO 4406:1987.

CAUTION — Particle counts are affected by a variety of factors. These factors include procurement of sample, particle counting accuracy, and the sample container, where used, and its cleanliness. Proper care should be taken during sample procurement to ensure that the sample obtained is representative of the fluid circulation in the system.

3.2 Basis of code

The code for contamination levels using automatic particle counters comprises three scale numbers, which permit the differentiation of the dimension and the distribution of the particles as follows:

— the first scale number represents the number of particles equal to or larger than 4 µm(c) per millilitre of fluid;

— the second scale number represents the number of particles equal to or larger than 6 µm(c) per millilitre of fluid;

— the third scale number represents the number of particles equal to or larger than 14 µm(c) per millilitre of fluid.

The code for microscope counting comprises two scale numbers using 5 µm and 15 µm.

3.3 Allocation of scale numbers

3.3.1 The scale numbers are allocated according to the number of particles counted per millilitre of the fluid sample (see Table 1).

3.3.2 A step ratio of generally two, as given between the upper and lower limits for the number of particles per millilitre in Table 1, has been adopted to keep the number of scale numbers within a reasonable limit and to ensure that each step is meaningful.

3.4 Determination of code using automatic particle counter analysis

3.4.1 Counting shall be undertaken in accordance with ISO 11500 or another recognised method, using an automatic particle counter calibrated to ISO 11171.

3.4.2 A scale number shall be allocated to the number of particles equal to or larger than 4 µm(c).

3.4.3 A second scale number shall be allocated to the number of particles equal to or larger than 6 µm(c).

3.4.4 A third scale number shall be allocated to the number of particles equal to or larger than 14 µm(c).

3.4.5 The three numbers shall be written one after the other and separated by oblique strokes (slashes).

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.

3.4.6 When applicable, include either a "*" (too numerous to count) or a "—" (no requirement to count) notation when reporting the scale number.

EXAMPLE 1 */19/14 means that this sample has too many particles equal to or larger than 4 µm(c) to count.

EXAMPLE 2 —/19/14 means that there was no requirement to count particles equal to or larger than 4 µm(c).

Table 1 — Allocation of scale numbers

Number of particles per millilitre		Scale number
More than	Up to and including	
2 500 000		> 28
1 300 000	2 500 000	28
640 000	1 300 000	27
320 000	640 000	26
160 000	320 000	25
80 000	160 000	24
40 000	80 000	23
20 000	40 000	22
10 000	20 000	21
5 000	10 000	20
2 500	5 000	19
1 300	2 500	18
640	1 300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2,5	5	9
1,3	2,5	8
0,64	1,3	7
0,32	0,64	6
0,16	0,32	5
0,08	0,16	4
0,04	0,08	3
0,02	0,04	2
0,01	0,02	1
0,00	0,01	0

NOTE Reproducibility below scale number 8 is affected by the actual number of particles counted in the fluid sample. Raw counts should be more than 20 particles. If this is not possible, then refer to 3.4.7.

3.4.7 When the raw data in one of the size ranges results in a particle count of fewer than 20 particles, the scale number for that size range shall be labelled with the symbol ⩾.

EXAMPLE A code of 14/12/⩾7 signifies that there are more than 80 and up to and including 160 particles equal to or larger than 4 µm(c) per millilitre and more than 20 and up to and including 40 particles equal to or larger than 6 µm(c) per millilitre. The third part of the code, ⩾7, indicates that there are more than 0,64 and up to and including 1,3 particles equal to or larger than 14 µm(c) per millilitre, but less than 20 particles were counted, which lowers statistical confidence. Because of this lower confidence, the 14 µm(c) part of the code could actually be higher than 7, indicating a particle count more than 1,3 particles per millilitre.

3.5 Determination of code using microscope sizing

3.5.1 Counting shall be undertaken in accordance with ISO 4407.

3.5.2 A scale number shall be allocated to the number of particles equal to or larger than 5 µm.

3.5.3 A second scale number shall be allocated to the number of particles equal to or larger than 15 µm.

3.5.4 In order to relate to counts obtained with an automatic particle counter, the code shall be stated in three-part form with the first part given as a "—", e.g. —/18/13.

4 **Identification statement** (reference to this International Standard)

Use the following statement in test reports, catalogues and sales literature when electing to comply with this International Standard:

"Solid contaminant code conforms to ISO 4406:1999, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles.*"

Annex A
(normative)

Graphical presentation of the code number

For automatic particle counter analysis, the contaminant code is determined by allocating a first scale number to the total number of particles equal to or larger than 4 µm(c), allocating a second scale number to the total number of particles equal to or larger than 6 µm(c) and allocating a third scale number to the total number of particles equal to or larger than 14 µm(c), and then writing these three numbers one after another separated by oblique strokes (slashes). For an example, see 22/18/13 in Figure A.1. For analysis by microscope, use a "—" in place of the first scale number and allocate the second and third numbers based on the counts at 5 µm and 15 µm, respectively.

Interpolation is acceptable, extrapolation is not permissible.