INTERNATIONAL STANDARD

ISO 12584

First edition
2013-11-01

Aerospace — Hydraulic fluid components — Expression of particulate contamination levels

Aéronautique et espace — Composants pour fluides hydrauliques — Expression des niveaux de contamination particulaire

Reference number
ISO 12584:2013(E)

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Foreword

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The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 10, *Aerospace fluid systems and components*.

Introduction

The reliability of fluid circuits depends largely on the quantity and size of the particles conveyed by the fluid.

The cleanliness of the operating fluid is obtained and maintained by filtration at a level consistent with the sensitivity of the system components to particulate contamination and the life and reliability required by the operator of the system.

The cleanliness of the system at start-up is dependent on the cleanliness of the components as delivered, the amount of contamination added during the build process, the cleanliness of the hydraulic liquid used to fill the system, and how successful the liquid was in penetrating the clearances. The amount of contamination added from these processes must be controlled to minimize the damage to the system during the initial running period. Cleanliness specifications are fundamental to this.

This International Standard defines the terminology used in and the method of reporting and communicating the cleanliness of components used in aerospace fluid systems. This will ensure consistent and unambiguous reporting.

It also presents a coding system which allows cleanliness data to be reported either in a shortened manner or in a complete manner for communication purposes or for specifying cleanliness requirements.

Aerospace — Hydraulic fluid components — Expression of particulate contamination levels

1 Scope

This International Standard defines the method of reporting and communicating the contamination (or cleanliness) level of components used in aerospace fluid systems.

It also presents a coding system which allows cleanliness data to be reported, both in a shortened manner and in a complete manner, when communicating for reporting contamination level measurement results and for specifying cleanliness requirements.

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

ISO 18413, *Hydraulic fluid power — Cleanliness of parts and components — Inspection document and principles related to contaminant collection, analysis and data reporting*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
component
general term to cover a part, a subassembly, or a part assembly used on an aerospace fluid system

3.2
component cleanliness
condition of a component characterized by a level of particulate contamination

Note 1 to entry: Expression to be used preferably to set a specification.

3.3
component cleanliness code
CCC
alphanumeric expression of the particulate contamination level of a component or part for fluid circuits

3.4
particulate contamination
all undesirable particles which are in and on a component

Note 1 to entry: Expression to be used preferably to report measurements.

3.5
wetted surfaces
surface area of the component that is exposed to system liquid

EXAMPLE Hydraulic gear pump (see Figure 1).

Note 1 to entry: The wetted surface of a gear pump is the sum of the internal surfaces of the pump body (2 plates + 1 gear housing with 2 ports) and of the external surface of the two gear wheels. The example shown gives a simplified illustration and does not include all surfaces wetted by the hydraulic liquid.

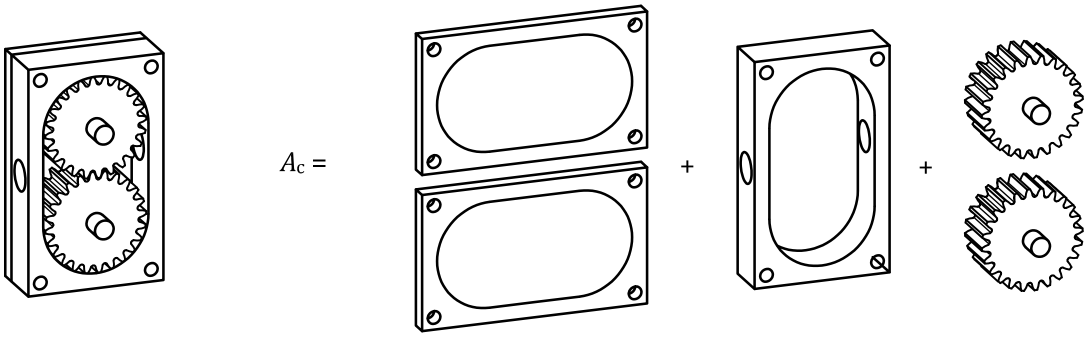

Figure 1 — Diagrammatic representation of the wetted surfaces of a hydraulic gear pump

3.6
wetted volume
V_c
volume of fluid contained in the component during normal operation

EXAMPLE Hydraulic gear pump (see Figure 2).

Note 1 to entry: The wetted volume of a gear pump is the volume of the gear housing minus the volume of the two gears. The example shown gives a simplified illustration and does not include all of the volumes filled with the hydraulic liquid.

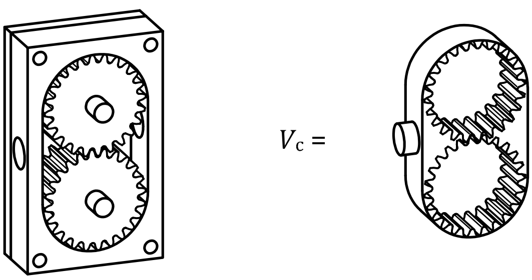

Figure 2 — Diagrammatic representation of the wetted volume of a hydraulic gear pump

4 Principle

The particulate contamination of a component is expressed by a level related to the number of particles in various size ranges and related to the wetted volume of the component. It is measured by counting particles after they have been extracted from the component by an appropriate extraction method (see ISO 18413).

5 Characteristics of the component

5.1 General

The fluid cleanliness code of ISO 11218 has served as a basis for the drawing up of the component cleanliness code. This fluid cleanliness code quantifies the number of particles of given sizes present in a given volume (100 cm^3) of fluid being analysed.

By definition, the contamination of a component is only present on its surfaces. Damage to components of the fluid circuit is caused only when particles detach from their surfaces and are transferred to the fluid in circulation. For this reason, the contamination of a component is quantified by the number of particles of given sizes present in a given volume of the component under analysis.

5.2 Determination of the wetted volume

5.2.1 Experimental method

5.2.1.1 Ensure that the interior of the component is dry.

5.2.1.2 Blank off all ports except one or more if necessary in order to allow a complete filling.

5.2.1.3 Prepare a volume of test fluid (V_1), known to within 1 %, of approximately 1,3 times the presumed wetted volume of the component. The test fluid shall be compatible with the materials of the component and shall have a viscosity below 5 mm^2/s at the test temperature.

NOTE It has proven to be practical to weigh this volume in its container, previously tarred, and to divide the mass of test fluid by its density.

5.2.1.4 Carefully fill the component with test fluid, avoiding the trapping of air. To achieve this, move the component gently in suitable directions so that all its parts are filled up. Add further test fluid as necessary.

5.2.1.5 Determine the volume (V_2) remaining in the container of 5.2.1.3.

5.2.1.6 Determine the volume (V_c) which has been required for the filling of the component:

$$V_c = V_1 - V_2$$

5.2.2 Method of calculation

If the computer's industrial drawing software possesses the function, calculate the wetted volume of the component.

5.2.3 Relationship between wetted surface area and wetted volume

Where a cleanliness specification or a cleanliness measurement result is expressed per unit surface area of the component, this value shall be calculated to the number of particles per unit volume of wetted volume of the component using Annex A.

5.3 Particulate contamination extraction

Extract the particulate contamination from the component using a method detailed in ISO 18413. The extraction method chosen shall be fully validated for the component being tested.

Analyse the extraction liquid using a technique detailed in ISO 18413 and obtain data at some or all sizes defined in Table 1, as specified in the Inspection Document. Present the data in terms of the differential number of particles in the relevant size ranges per component.

Wherever possible, or if otherwise specified, the complete volume of the extraction liquid shall be analysed. The reason for this is to ensure the large particles are not 'lost' in the sampling and preparation processes.

6 Expression of results

6.1 Required preliminary data

The expression of the level of particulate contamination of a component according to this International Standard requires data on its wetted volume.

6.2 Presentation of the results

6.2.1 Particle size distribution

Tabulate the data obtained in 5.3 in a suitable reporting sheet and calculate the numbers of particles per 100 cm^3 of the component volume. A typical form is given in Annex B.

6.2.2 Component cleanliness code (CCC)

6.2.2.1 Table 1 specifies the maximum number of particles of each size class acceptable within 100 cm^3 of wetted volume of the component. The code build-up defines the size, number, and particle size distribution of the contaminants. It transcribes the values which specify the cleanliness of fluids according to national aerospace fluid contamination standards.

Table 1 — Quantification of the contamination level of components

		Maximum number of particles per 100 cm^3 of wetted volume of component				
Size ranges in µm[a]		**5 < d ≤ 15**	**15 < d ≤ 25**	**25 < d ≤ 50**	**50 < d ≤ 100**	**More than 100[c]**
Size ranges in µm(c)[b]		**6 < d ≤ 14**	**14 < d ≤ 21**	**21 < d ≤ 38**	**38 < d ≤ 70**	**More than 70**
CONTAMINATION LEVEL	**Size classes**	B	C	D	E	F
	00	125	22	4	1	0
	0	250	44	8	2	0
	1	500	89	16	3	1
	2	1 000	178	32	6	1
	3	2 000	356	63	11	2
	4	4 000	712	126	22	4
	5	8 000	1 425	253	45	8
	6	16 000	2 850	506	90	16
	7	32 000	5 700	1 012	180	32
	8	64 000	11 400	2 025	360	64
	9	128 000	22 800	4 050	720	128
	10	256 000	45 600	8 100	1 440	256
	11	512 000	91 200	16 200	2 880	512
	12	1 024 000	182 400	32 400	5 760	1 024

a Measured by microscopy (manually, by image analysis or Scanning Electron Microscope), reporting the longest dimension of particles.

b Measured by APCs calibrated in compliance with ISO 11171, reporting the projected area equivalent diameter of particles.

c Including fibres (particles larger than 100 µm whose length is 10 times its width).

6.2.2.2 To give all the required flexibility for the expression of cleanliness as a function of the needs of the aerospace industry, the component cleanliness code can be expressed by all or part of the size classes of Table 1.

This is illustrated by the example in 6.3.

When all the classes are specified, write the CCC as:

CCC = (B9/C11/D10/E8/F8)

If the same cleanliness level is present for adjacent sizes, it is permissible to join the size letters with the number class, e.g. (…/EF8).

Where the cleanliness requirement only covers some of the standard sizes, report only those sizes specified. For example, if two sizes are specified, write the CCC as:

CCC = (B9/C11)

6.2.3 Component cleanliness class

Where the particulate contamination of a component is qualified by an overall value, it is possible to express it by a single class number. For specifying cleanliness, the cleanliness level stated applies to all sizes. When reporting cleanliness data, state the highest numerical value. In this case, write the CCC as:

CCC = (11)

6.3 Example

The cleanliness inspection per ISO 18413 of an electro-hydraulic directional control valve, whose wetted volume is 3 963 cm^3, gave the results given in Table 2. These data are then normalized to a volume of 100 cm^3 and then the Cleanliness Level obtained from Table 1.

Table 2 — Component cleanliness analysis and cleanliness classes

Size class	B	C	D	E	F
Number of particles per component	3 429 342	2 703 955	301 980	12 959	1 783
Number of particles for 100 cm^3 of wetted volume of component	86 534	68 230	7 620	327	45
Cleanliness class	9	11	10	8	8

Depending on how the cleanliness level is specified, write the component cleanliness code in one of the following ways:

a) If the cleanliness specification includes all of the sizes detailed in Table 1, write the CCC as:

CCC = (B9/C11/D10/EF8)

b) If the cleanliness specification only includes some sizes detailed in Table 1, in this case C and E, write the CCC as:

CCC = (C11/E8)

c) If the cleanliness specification has the same cleanliness level for all of the sizes detailed in Table 1, or reporting the highest value is specified, write the CCC as:

CCC = (11)

Annex A
(informative)

Relating wetted volume to wetted surface area of components

A.1 Volume-to-surface area (V/A) ratios (geometry factors)

The geometry of a hydraulic system may be characterized by its *G* factor, which is the ratio of its wetted volume (V_S) to its wetted surface area (A_S), that is, $G = V_S / A_S$.

The geometry of a component may be characterized by its *G*' factor, which is the ratio of its wetted volume (V_C) to its wetted surface area (A_C), that is, $G' = V_C / A_C$.

The more complex the item, the smaller *V*/*A* is. Table A.1 shows typical values for various hydraulic components.

These values are used to calculate the wetted surface of a component when *G* or *G*' and the volume of the component are known. Reciprocally, they are used to transform a cleanliness statement reported per surface area into a cleanliness statement for a volume.

Table A.1 — Typical values of *V*/*A* for various hydraulic components

Hydraulic component	Typical value of *V*/*A*
Reservoir	1 to 5
Pipe	0,2
Cylinder	0,5 to 0,6
Pump	0,001 to 0,05
Valve	0,001
Complete filter	0,05 to 2
Complete system	0,2 to 4

A.2 From surface to volume

To transform a cleanliness level per unit wetted surface area (N/cm^2 or equivalent) to a cleanliness level per unit wetted volume (N/cm^3), it is necessary to know the *V*/*A* ratio (cm^3/cm^2) of either the component or the subassembly or the system it is part of. In this case, $(N/cm^3) = (N/cm^2) / (V/A)$.

A.3 From volume to surface

To transform a cleanliness level per unit wetted volume (N/cm^3) to a cleanliness level per unit wetted surface area (N/cm^2), it is necessary to know the *V*/*A* (cm^3/cm^2) of either the component or the subassembly or the system it is part of. In this case, $(N/cm^2) = (N/cm^3) \times (V/A)$.

Annex B
(informative)

Typical component particulate contamination analysis report

B.1 Laboratory identification		
Date:	Operator:	Company:

B.2 Test component identification							
Type:				Wetted volume V_C =			cm^3
Reference:							
Supplier:				Number analysed:			
Prior external rinse:		o YES	o NO	Plugging caps:		o YES	o NO
Dismantling:		o YES	o NO	Demagnetising:		o YES	o NO
Packaging or container rinsing:				Analysis of shipment liquid:			
o YES	o NO			o YES	o NO		
Time between production o or shipment o & test .... Hours							

B.3 Test liquid		
Identification: _________	Kinematic viscosity: __________ mm^2/s	Temperature: _________°C

B.4 Contaminant extraction procedure			
o Agitation	o Pressure rinsing	o Ultrasonic agitation	o End-use simulation
Number of extractions:		Total volume of fluid used: .... mL	

B.5 Contaminant analysis technique				
o Microscope	o Image analysis		o Manufacturer:	
Model:	o Transmitted	o Reflected light	o Magnification:	
Membrane:	Manufacturer:	Material:	Pore diameter: .... µm	
o Automatic particle counter				
Manufacturer:	Counter model:		Sensor model:	
Calibrated on:	per ISO 11171	o Primary	o Secondary	
Sensor flow rate:	Volume per run: .... mL		Number of runs:	
Dilution: o NO o YES	Fluid type:	Cleanliness level:	Dilution ratio:	

B.6 Contaminant analysis results							
Particle size range / Class			Particle counting results			Component contamination level	
µm	µm(c)	Size Classes	Total, *N*	*N* / component	*N*/100 cm³ wetted volume		
5 < d ≤ 15	6 < d ≤ 14	B					
15 < d ≤ 25	14 < d ≤ 21	C					
25 < d ≤ 50	21 < d ≤ 38	D					
50 < d ≤ 100	38 < d ≤ 70	E					
> 100*	> 70	F					
Component Contamination Code: ISO 12584 CCC = (—/—/—/—/—)					Component Contamination Class: CCC = (—)		
Notes / Visual observations:							
** Including fibres (particles larger than 100 µm whose length is 10 times its width).*							

Bibliography

[1] ISO 11218, *Aerospace — Cleanliness classification for hydraulic fluids*

[2] ISO/TR 10686, *Hydraulic fluid power — Method to relate the cleanliness of a hydraulic system to the cleanliness of the components and hydraulic fluid that make up the system*

[3] NF L 41-101, *Hydraulic systems contamination by solid particles — Leading particulars*

ICS 49.080

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