INTERNATIONAL STANDARD

ISO 11171

Fifth edition
2022-03

Hydraulic fluid power — Calibration of automatic particle counters for liquids

Transmissions hydrauliques — Étalonnage des compteurs automatiques de particules en suspension dans les liquides

Reference number
ISO 11171:2022(E)

© ISO 2022



COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2022 – All rights reserved

Contents

Page

Foreword ..... **iv**
Introduction ..... **vi**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Materials and equipment **3**
5 Sequence of APC calibration procedures **5**
6 Sizing calibration procedure **9**
7 Data presentation **19**
8 Identification statement **20**
Annex A (normative) **Preliminary APC check** **21**
Annex B (normative) **Coincidence error procedure** **25**
Annex C (normative) **Flow rate limit determination** **29**
Annex D (normative) **Resolution determination** **34**
Annex E (normative) **Verification of particle-counting accuracy** **39**
Annex F (normative) **Preparation and verification of bottles of secondary calibration suspensions** **42**
Annex G (normative) **Dilution of calibration suspension samples** **46**
Annex H (informative) **Verification of particle size distribution of calibration samples** **49**
Bibliography **51**

© ISO 2022 – All rights reserved

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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 131 *Fluid power systems*, SC 6, *Contamination control*.

This fifth edition cancels and replaces the fourth edition (ISO 11171:2020), which has been technically revised.

The main changes are as follows:

— in term 3.8, particle size distribution, Note 1 to entry has been amended;

— in 6.12 c), 0,72 has been changed to 0,56;

— in 6.12 d) 1,32 has been changed to 1,56;

— in B.4, 3rd line, “mass concentrate” has been changed to “mass concentration”;

— B.8 has been amended to read: ……”calculate the theoretical number concentration of particles for each mass concentration, X_t.”;

— in Table B.1, the units for “X_t (particles/L)” have been corrected to “X_t (particles/mL)”;

— in D.3 c), 0,72 has been changed to 0,56;

— in D.3 d), 1,32 has been changed to 1,56;

— in D.7 a), 0,72 has been changed to 0,56;

— in D.7 e), 1,32 has been changed to 1,56;

— in G.6, the subscript in the denominator of Formula G.3 has been corrected from “V_0” to “V_S”;

— in Reference [6] in the Bibliography, the RM 8631 batch identifier has been changed from “a” to “b”;

— in Reference [7] in the Bibliography, the RM 8632 batch identifier has been changed from “b” to “a”.

© ISO 2022 – All rights reserved

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

© ISO 2022 – All rights reserved

Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. The fluid is both a lubricant and a power-transmitting medium. Reliable system performance requires control of the contaminants in the fluid. Qualitative and quantitative determination of the particulate contaminants in the fluid medium requires precision in obtaining the sample and in determining the contaminant particle size distribution and concentration. Liquid automatic particle counters (APC) are an accepted means of determining the concentration and size distribution of the contaminant particles. Individual APC accuracy is established through calibration.

This document is a standard calibration procedure for APC that are used for determining particle sizes and counts. The primary particle-sizing calibration is conducted using NIST SRM 2806x suspensions with particle size distribution certified by the United States National Institute of Standards and Technology (NIST) for particle sizes 30 µm(c) and smaller, and using polystyrene latex spheres at larger sizes.

A secondary calibration method uses suspensions of NIST RM 8631x, ISO MTD, or other test dust conforming to ISO 12103-1, which are independently analysed using an APC calibrated by the primary method. Minimum performance specifications are established for the APC coefficient of variation (CV) of sample volume, CV of flow rate, resolution and particle counting accuracy. The operating limits of an APC, including its threshold noise level, coincidence error limit and flow rate limits are determined.

© ISO 2022 – All rights reserved

Hydraulic fluid power — Calibration of automatic particle counters for liquids

1 Scope

This document specifies procedures for the following:

a) primary particle-sizing calibration for particle sizes 1 µm(c) and larger, sensor resolution and counting performance of liquid automatic particle counters that are capable of analysing bottle samples;

b) secondary particle-sizing calibration using suspensions verified with a primary calibrated APC;

c) establishing acceptable operation and performance limits;

d) verifying particle sensor performance using a test dust;

e) determining coincidence and flow rate limits.

This document is applicable for use with hydraulic fluids, aviation and diesel fuels, engine oil and other petroleum-based fluids. This document is not applicable to particle-sizing calibration using NIST SRM 2806b primary calibration suspensions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4787, *Laboratory glass and plastic ware — Volumetric instruments — Methods for testing of capacity and for use*

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

ISO 12103-1, *Road vehicles — Test contaminants for filter evaluation — Part 1: Arizona test dust*

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

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
automatic particle counter
APC
instrument that automatically:

© ISO 2022 – All rights reserved

a) senses individual particles suspended in a controlled volume of fluid using optical light extinction or light scattering principles;

b) measures the size of particles;

c) sorts or compiles particles into size ranges;

d) counts particles in each size range;

e) reports the number of particles in each size range per unit volume; and

f) facilitates instrument calibration according to this document.

Note 1 to entry: APC used for *particle size* (3.7) determination with hydraulic fluids, aviation and diesel fuels, engine oil and other petroleum-based fluids shall be calibrated in accordance with Clause 5 of this document.

3.2
threshold noise level
minimum voltage setting of an *APC* (3.1) at which the observed pulse-counting frequency does not exceed 60 counts/min due to electrical noise in the absence of flow in the *sensing volume* (3.3)

Note 1 to entry: The Brownian motion of any detectable particles in the sensing zone during performance of subclause A.2 can result in erratic results.

3.3
sensing volume
portion of the illuminated region of the sensor through which the fluid stream passes and from which the light is collected by the optical system

3.4
resolution
measure of the ability of an *APC* (3.1) to distinguish between particles of similar, but different, sizes as determined in accordance with Annex D of this document

3.5
coincidence error limit
highest concentration of NIST RM 8632x that can be counted with an *automatic particle counter* (3.1) with an error of less than 5 % resulting from the presence of more than one particle in the *sensing volume* (3.3) at one time

3.6
working flow rate
flow rate through the sensor used for sample analysis

3.7
particle size
projected area equivalent diameter of particles as determined by NIST using scanning electron microscopy traceable to SI units through a NIST length standard or using a liquid optical single particle *APC* (3.1) calibrated according to this document

Note 1 to entry: NIST uses scanning electron microscopy to determine the projected area equivalent diameter of particles in NIST standard reference material 2806x, where *x* is the letter used by NIST to designate the batch number of the certified *primary calibration* (3.9) suspension.

© ISO 2022 – All rights reserved

3.8
particle size distribution
cumulative number concentration of particles larger than a specified size, expressed as a function of *particle size* (3.7)

Note 1 to entry: A certified particle size distribution is one provided by a producer of *primary* (3.9) or *secondary calibration* (3.10) suspensions, and certifies that the particle size distribution reported for the suspensions was determined by NIST or determined according to Annex F of this document. The particle size distribution of SRM 2806x used for *primary calibrations* (3.9) shall consist of the values for Diameter [µm(c)] and the corresponding Cumulative Particle Concentration (part/mL) given in the Certificate of Analysis for Standard Reference Material® 2806x[5].

Note 2 to entry: Verification of particle size distribution of calibration samples is detailed in Annex H of this document.

3.9
primary calibration
sizing calibration conducted according to the sizing calibration procedure specified in Clause 6 of this document using NIST standard reference material 2806x for *particle sizes* (3.7) 30 µm(c) and smaller, and using polystyrene latex spheres at larger sizes

Note 1 to entry: For details of NIST standard reference material 2806x, see 4.4.

3.10
secondary calibration
sizing calibration conducted using secondary calibration suspensions

Note 1 to entry: The sizing calibration procedure is specified in Clause 6 and the preparation of secondary calibration suspensions is set out in Annex F.

3.11
multi-channel analyser
MCA
electronic device capable of sorting incoming electric pulses according to their amplitude

4 Materials and equipment

4.1 Polystyrene latex spheres that:

a) are in aqueous suspension;

b) have a nominal diameter of:

   1) 10 µm if used for resolution determination in accordance with Annex D;

   2) larger than 30 µm for particle size calibration in accordance with Clause 6 for particle sizes of larger than 30 µm;

c) have a coefficient of variation that is less than 5 % where the coefficient of variation is the ratio of the standard deviation of the latex particle diameters in the suspension to their mean particle diameter;

d) have a certificate of analysis that indicates that the latex spheres mean particle diameter and coefficient of variation were determined using techniques with traceability to national standards.

Once opened, suspensions of polystyrene latex spheres shall be used within three months unless the size distribution and cleanliness of the suspension have been verified.

NOTE 1 The size distribution of polystyrene latex spheres can be verified using the method described in D.14.

NOTE 2 Polystyrene latex spheres in aqueous suspension have a limited shelf life. Shelf life is a function of a variety of factors including temperature and microbial contamination of the suspension.

© ISO 2022 – All rights reserved