
Hydraulic fluid power — Sample calculations for ISO 11171

*Transmissions hydrauliques — Calculs des échantillons pour l'ISO
11171*





COPYRIGHT PROTECTED DOCUMENT

© ISO 2023

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

Contents

Page

Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 Example 1: Selection of threshold voltage settings.....	1
5 Example 2: Evaluating data quality.....	3
6 Example 3: Dilution of samples.....	5
7 Example 4: Relating particle size to threshold voltage setting for particles 30 µm(c) and smaller.....	7
8 Example 5: Relating particle size to threshold voltage setting for primary calibration of sizes larger than 30 µm(c).....	9
9 Example 6: Construction of calibration curve.....	11
10 Example 7: Calculation of coefficient variation for volume measurement using ISO 11171:2022, Clause A.8.....	12
11 Example 8: Determination of coincidence error limit.....	13
12 Example 9: Determination of flow rate limits using ISO 11171:2022, Annex C.....	14
13 Example 10: Determination of resolution using ISO 11171:2022, Annex D.....	17
14 Example 11: Verification of counting accuracy and secondary calibration suspensions using ISO 11171:2022, Clause E.1.....	18

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*, Subcommittee SC 6, *Contamination control*.

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.

Introduction

ISO 11171:2022, like its predecessors, retains traceability to the internationally accepted definition of a metre and reports particle size in units of $\mu\text{m}(\text{c})$. The methods for determining data acceptance criteria, coincidence error limit, working flow rate and resolution remain unchanged, but mathematical calculations and tools were first introduced in ISO 11171:2020 to ensure consistency in terms of how automatic particle counter (APC) calibration curves are created and used. For example, mathematical techniques have been introduced to determine the APC threshold settings used to obtain calibration data and a tool provided to generate calibration curves. Other mathematical equations to estimate the standard error of the calibration, to calculate normalized concentrations for diluted samples, and to calibrate at particle sizes larger than $30 \mu\text{m}(\text{c})$ were first introduced in 2020. This document uses example calculations that fully conform to ISO 11171.

Hydraulic fluid power — Sample calculations for ISO 11171

1 Scope

This document shows how to use the normative mathematical formulae and tools of ISO 11171. Examples are used to demonstrate their use for calibrating automatic particle counters (APCs).

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11171 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/>

4 Example 1: Selection of threshold voltage settings

The method of selecting threshold voltages for particle sizing calibration is specified in ISO 11171:2022, 6.3, which requires that:

- a minimum of 12 different threshold settings be used to construct a calibration curve;
- the first (lowest) threshold setting, J , be 1,5 times the threshold noise level of the APC;
- the highest threshold setting, H , corresponds to a particle size of approximately 30 µm(c) or smaller for primary calibrations and corresponds to a size that does not exceed the largest reported particle size that is in conformance with ISO 11171:2022, Annex F, for secondary calibrations;
- intermediate threshold settings be logarithmically spaced such that the value of each channel is K times greater than its preceding channel, where K is a constant defined by [Formula \(1\)](#):

$$K = 10^{(\log H - \log J)/(G-1)} \quad (1)$$

where G is the number of threshold settings used to construct the calibration curve and is greater than or equal to 12.

This example considers an APC with eight threshold settings that can be adjusted in 1 mV increments. The threshold noise level of the APC was determined to be 5 mV and its manufacturer indicated that 30 µm(c) is expected to correspond to a threshold voltage setting of about 2 600 mV.

The calibration curve will be determined using 12 threshold voltage settings, the minimum number permitted by ISO 11171. Thus, the value of H is 2 600 mV and the value of G is 12. The value of J is determined by [Formula \(2\)](#):

$$J = 1,5 \times 5 = 7,5 \quad (2)$$

Since this APC can only be adjusted in 1 mV increments, the value of J is rounded up to 8 mV for calibration. Using the values of G , H and J , the value of K can be calculated by [Formula \(3\)](#):

$$K = 10^{(\log H - \log J)/(G-1)} = 10^{(\log(2\,600) - \log(8))/(12-1)} = 1,692 \quad (3)$$

The threshold settings for the 10 intermediate channels are set at values corresponding to 1,692 times the value of each preceding channel as shown in [Table 1](#).

Table 1 — Threshold voltage settings for APC in Example 1

Threshold setting number	Calculation	Threshold voltage setting ^a
1	$1,5 \times 5 \text{ mV} =$	8 mV
2	$1,692 \times 8 \text{ mV} =$	14 mV
3	$1,692 \times 14 \text{ mV} =$	23 mV
4	$1,692 \times 23 \text{ mV} =$	39 mV
5	$1,692 \times 39 \text{ mV} =$	66 mV
6	$1,692 \times 66 \text{ mV} =$	111 mV
7	$1,692 \times 111 \text{ mV} =$	188 mV
8	$1,692 \times 188 \text{ mV} =$	317 mV
9	$1,692 \times 317 \text{ mV} =$	537 mV
10	$1,692 \times 537 \text{ mV} =$	908 mV
11	$1,692 \times 908 \text{ mV} =$	1 537 mV
12	$1,692 \times 1\,537 \text{ mV} =$	2 600 mV
^a Threshold voltage settings rounded off to the nearest mV based upon the capabilities of the APC in the example.		

This APC only has the minimum number of channels required in ISO 11171:2022, 6.4 (eight channels), but ISO 11171:2022, 6.3, requires data from twelve or more threshold settings to construct a calibration curve. ISO 11171:2022, 6.8, requires that data from at least two different samples be obtained for each of the threshold voltage settings (refer to ISO 11171:2022, 6.8) and that the channels used for a particular sample be distributed over the entire range to the extent possible. To meet these requirements in this example, eight different threshold settings chosen from the list of twelve can be used for the first sample and different combinations of eight threshold settings used for each of the other two samples.

An example of how to allocate threshold settings among the eight channels is shown in [Table 2](#), where the first column lists the twelve required threshold voltage settings and columns 2, 3 and 4 show the channels used to collect data at these settings for the indicated sample. The last column in [Table 2](#) shows the number of samples for which data are obtained for each threshold setting, confirming these requirements have been met.