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Hydraulic fluid power — Sample calculations for ISO 11171

Transmissions hydrauliques — Calculs des échantillons pour l'ISO 11171

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Foreword

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

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Introduction

ISO 11171:2022, like its predecessors, retains traceability to the internationally accepted definition of a metre and reports particle size in units of µm(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 µm(c) were first introduced in 2020. This document uses example calculations that fully conform to ISO 11171.

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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):

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

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.

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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):

$$J = 1{,}5 \times 5 = 7{,}5 \tag{2}$$

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):

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

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 × 5 mV =	8 mV
2	1,692 × 8 mV =	14 mV
3	1,692 × 14 mV =	23 mV
4	1,692 × 23 mV =	39 mV
5	1,692 × 39 mV =	66 mV
6	1,692 × 66 mV =	111 mV
7	1,692 × 111 mV =	188 mV
8	1,692 × 188 mV =	317 mV
9	1,692 × 317 mV =	537 mV
10	1,692 × 537 mV =	908 mV
11	1,692 × 908 mV =	1 537 mV
12	1,692 × 1 537 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.

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