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Hydraulic fluid power -- Measurement techniques -- Part 1: General measurement principles

Transmissions hydrauliques -- Techniques de mesurage -- Partie 1: Principes généraux de mesurage

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Hydraulic fluid power — Measurement techniques —

Part 1:
General measurement principles

Transmissions hydrauliques — Techniques de mesurage —

Partie 1: Principes généraux de mesurage

Reference number
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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.

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 9110-1 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*.

ISO 9110 consists of the following parts, under the general title *Hydraulic fluid power — Measurement techniques*:

— *Part 1: General measurement principles*

— *Part 2: Measurement of average steady-state pressure in a closed conduit*

Annex A of this part of ISO 9110 is for information only.

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Introduction

The various International Standards listed in annex A provide unified testing methods for comparing the performance of different hydraulic fluid power components. Such comparisons may be made against a written specification (as in the case of production components), against a competitive component of equivalent purpose (for example in the selection of components by prospective purchasers) or between two slightly different designs (as in the case of experimental development). In order for such comparisons to be meaningful, the criteria measured must be valid parameters of the performance of the component under test and the method of measurement used must be capable of reliably determining any significant differences between the components being compared.

This part (ISO 9110-1) relates to general principles for the measurement of static or steady-state conditions. ISO 9110-2 deals with the measurement of average steady-state static pressure in a closed conduit.

Further parts will be published as technology develops.

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Hydraulic fluid power — Measurement techniques —

Part 1:
General measurement principles

1 Scope

This part of ISO 9110 establishes general principles for the measurement of performance parameters under static or steady-state conditions.

It gives guidance on the sources and magnitudes of errors to be expected in the calibration of and measurements using hydraulic fluid power components. It describes practical requirements for assessing the capability of the measuring system, and hence the level of accuracy of measurement of the system, or for assisting in developing a system which will meet a prescribed level of accuracy.

2 Definitions

For the purposes of this part of ISO 9110, the following definitions apply.

2.1 calibration: A set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system and the corresponding values indicated by a reference standard.

2.2 measuring instrument: A device intended to make a measurement, alone or in conjunction with other equipment.

2.3 measuring system: A complete set of measuring instruments and other equipment assembled to carry out a specified measurement task.

2.4 measurement: The set of operations for determining the value of a quantity.

2.5 random uncertainty; random error: An error which varies in an unpredictable manner in absolute value and sign when a large number of measurements of the same value of a quantity are made under effectively identical conditions.

2.6 reference standard: An instrument of the highest metrological quality available at a given location which is used to calibrate a working instrument of the same broad type.

2.7 repeatability of measurements: The closeness of agreement between the results of successive measurements of the same quantity carried out by the same method, by the same observer, with the same measuring instruments, in the same laboratory, over quite short intervals of time.

2.8 static conditions: Conditions under which the parameter does not vary with time.

2.9 steady-state conditions: Conditions under which the mean of a variable does not change with time and the variation of an instantaneous value of that variable is cyclic and can be described by a simple mathematical expression.

2.10 systematic uncertainty; systematic error: An error which, in the course of a number of measurements, made under the same conditions, of the same value of a given quantity, either remains constant in absolute value and sign, or varies according to a definite law when the conditions change.

3 Classes of accuracy

3.1 General

3.1.1 The uncertainty of measurement which can be tolerated in a fluid power test depends on the anticipated use of the data obtained. The result of a measurement may be a direct measure of the performance of the component, for example the pressure maintained by a regulating valve. In such a case, the allowable uncertainty is directly related to the degree of discrimination desired from the test. If the variable is an input to a calculated performance parameter, such as flow, being used in the calculation for overall efficiency of a hydraulic pump, the allowable uncertainty may be much less in order to maintain reasonable limits on the accuracy of the resulting calculation. If the variable is a test condition, such as the fluid temperature for conducting a motor performance test, the allowable variation may be quite large compared to the two circumstances mentioned above. The overall objective of the test should be considered in setting the permissible limits of uncertainty. If the test is required to discriminate between two minor changes in design, the allowed uncertainty may be quite small. If the test is intended only to determine whether or not a component has failed in service, the allowable uncertainty may be of the order of 10 % or more.

3.1.2 In order to accommodate the various needs of the test user, each of the International Standards describing unified testing methods, given in annex A, contains a table of permissible uncertainties for three measurement classes.

Class A is the most restrictive and is intended for those cases where the utmost discrimination between calculated parameters is required. Equipment capabilities and technical expertise required to perform class A measurements are generally found only in the most sophisticated laboratories.

Class B limits are intended to cover the measurement requirements for quality assurance testing by component suppliers and component selection evaluation by users. Class B measurements are within the capabilities of most fluid power testing laboratories.

Class C uncertainty limits could be achieved by users with little expertise in fluid power measurements using standard instrumentation. Such measurements are primarily intended to discriminate between functioning hydraulic components and those which have failed or were improperly manufactured.

3.2 Determination of uncertainty limits

The limits of uncertainty for determining the class of measurements are given by adding the component systematic uncertainties of the measuring system to the total random uncertainty. The total random uncertainty is the root mean square of the component random uncertainties of the system.

4 Classification of uncertainties

4.1 The component uncertainties of a measuring system may be associated with an individual element of a measuring system or with the system as a whole. Generally, lower uncertainties can be obtained by calibrating and evaluating the system as a whole.

4.2 Fixed errors such as a known deviation from the true value observed during calibration should be eliminated by adjusting the instrument or by modifying the results. If this is not possible, the error should be taken as the systematic error of the maximum value. For example, if the comparison of a pressure gauge with a standard reveals a 4 % deviation at the mid-range and 2 % at the end points, and if the information from the gauge is to be used without correction, then the gauge should be considered to contain a systematic uncertainty of 4 %.

4.3 Some errors are the result of a physical relationship with another variable (i.e. a secondary variable) and may be quantified through a known mathematical function of the independent variable. The effect of temperature on the output of a pressure transducer is an example of such an effect. Such errors may introduce either a systematic or random uncertainty component. If the error is neglected, as might be the case for a temperature effect over a narrow range of temperatures, the maximum uncertainty which could exist within the allowable range of the secondary variable shall be added as a systematic error. If a correction for the effect is used, then a random error component of the extent of the uncertainty of the measurement of the secondary variable shall be introduced.

4.4 All uncertainties which are known to exist in a higher level calibration standard should be regarded as systematic errors of the measurement being evaluated.

4.5 The measurement uncertainty due to repeatability (r) is regarded as a random error. In determining the uncertainty of an individual measurement, the full value of the repeatability uncertainty of the measurement system established in accordance with 5.1.2 should be used. If n readings are averaged to determine the measured value, the uncertainty due to repeatability is given by

$$r = \frac{\varepsilon}{\sqrt{n}}$$

where ε is the repeatability uncertainty determined in accordance with 5.1.2.

5 Assessment of uncertainties

5.1 Calibration

5.1.1 Calibration shall be carried out in accordance with the methods prescribed for each type of measuring system. Generally, this will consist of using the measuring system to measure an input stimulus of known (accepted) value, or of comparing with a reference standard with the calibration error at that point being taken as the average value of a least five repeated applications of the same nominal stimulus.

Calibration checks shall be made at several points within the range of interest as prescribed for each type of measurement system.

5.1.2 At each calibration point, the sample standard deviation at the j^{th} stimulus level, s_j, of the observed measurements shall be calculated using

$$s_j = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where

x_i is the observed value of the i^{th} iteration;

$\bar{x}$ is the mean of the observed values.

The largest of the standard deviations thus obtained shall be considered the repeatability uncertainty (ε) of the measuring system.

5.2 Partial calibration

5.2.1 Economic considerations and physical limitations may not allow calibration to be carried out at the number of points required by 5.1. In such cases, a partial calibration should be made, using the same basic techniques applied at a reduced number of points.

5.2.2 Knowledge of the measuring instrument characteristics and previous calibration results should be used to select the most appropriate calibration points but the end points of the range to be employed in actual measurements should be included.

5.3 Frequency of calibration

5.3.1 The interval between calibrations should be based on the class of measurement to be carried out and the stability of the instrumentation system. Between calibrations, the uncertainty associated with calibration error should be the greater of the uncertainties calculated from the two calibrations. If the uncertainty thus obtained is not within the applicable limit, then the interval to the next calibration should be halved and continued to be halved until such time as successive calibrations do fall within the limit. If this cannot be achieved within class C limits, the measuring system should be discarded.

5.3.2 For class A measurements, calibration should be carried out before each test set-up, or every 48 h of continuous usage, or if damage, abuse or calibration shift is suspected.

For class B measurements, the interval between calibrations should be no greater than one year and the interval between partial calibration not more than one month.

For class C measurements, partial calibration is required at least once a year.

Should the interval between uses of the measuring system exceed the required calibration interval, then partial calibration should be carried out after each usage.