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Pneumatic fluid power — Assessment of component reliability by testing —

Part 2: Directional control valves

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Transmissions pneumatiques — Évaluation par essais de la fiabilité des composants —

Partie 2: Distributeurs

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Foreword

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

A list of all parts in the ISO 19973 series can be found on the ISO website.

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Pneumatic fluid power — Assessment of component reliability by testing —

Part 2: Directional control valves

AMENDMENT 1

Clause 2 Normative references, Page 1

Add the following references to Clause 2.

ISO 12238, *Pneumatic fluid power — Directional control valves — Measurement of shifting time*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

Add the following new Annex B for the estimation of B_{10D} values for valves used in functional safety applications.

Annex B
(normative)

Estimating B_{10D} for valves used in functional safety applications

B.1 Introduction

When a machine is built, a risk assessment must be conducted for evaluation of potential hazards according to ISO 12100. This is also a requirement in the ISO 4413 and ISO 4414 standards for hydraulic and pneumatic systems. ISO 13849 is a standard that describes a method for risk reduction on safety related parts of control systems, in accordance with ISO 12100. Components in safety related parts of control systems shall have sufficient reliability to perform their function when a hazard occurs, otherwise the component is considered to have failed dangerously.

Reliability of a pneumatic component is typically characterized by its B_{10}, η and β values, obtained from a Weibull plot using all defined failures from Clause 8. B_{10D} values are obtained only from failures that are classified as dangerous. For pneumatic valves, shifting off-time failures are considered dangerous failures whereas shifting on-time failures are not considered dangerous because, according to the basic safety principle ("use of de-energization principle" of ISO 13849-2:2012, Table B.1), that is not the action typically required for implementing a safety function. Leakage is a performance failure and not considered a dangerous failure (unless it is so severe as to prevent a return shift). Minimum shifting pressure is not considered a dangerous failure because it is typically much lower than the operating pressure of a system. If these or additional failure types (based upon a specific application) lead to a dangerous failure, these failure mechanisms shall be considered as well. Additional failure mechanisms shall clearly be based on agreement between supplier and purchaser.

The method for estimating a B_{10D} life in this Annex is based on using the termination life at the first termination failure in a sample of seven test units. The cumulative failure for that first of seven test units is 9,4 % (from a Median Rank table). This is close to the 10 % level on which the B_{10D} life is defined, and the first failure life is considered to be an acceptable estimate for the B_{10D}. Thus, it is not necessary to continue the test after the first termination failure. If there is one suspension in the sample of seven test units, before a first termination failure occurs, the cumulative failure is 11,4 % at the first failure life. This is still considered to be an acceptable estimate of the B_{10D} life.

The ISO 13849 series of standards includes two other methods to estimate a B_{10D} life:

1) $B_{10D} = 2 \times B_{10}$ if only B_{10} data is available,

2) B_{10D} = 20 million cycles as a default value if data is not available.

These methods are applicable to a user of the ISO 13849 series of standards if no B_{10D} values are available; whereas this Annex is for a supplier for testing to estimate a B_{10D} value.

B.2 Test equipment and test conditions

Set up the test equipment in accordance with Clause 5.

B.3 Measurement of immediate shifting off-time

B.3.1 General

Testing can be integrated with the procedures described in Clause 7 if all failure data is included in one test program. But the special procedures in B.3.3 and B.3.4 for shifting time in the return-OFF function (shifting off-time) shall be followed for valves intended to be used in safety applications.

B.3.2 Functional check

Functional checks shall be conducted according to 7.2.1.

B.3.3 Immediate shifting off-time

The shifting off-time for each valve shall be recorded every time that data is taken. Start from a shifted position with all volumes attached (including pressure transducers). Apply a supply pressure of ≈6,3 bar (630 kPa) to the inlet port (and also to an external pilot port if so equipped). Conduct a shifting off-time test (exhaust test) in accordance with ISO 12238, with the exception that all volumes defined in ISO 19973-1 are attached.

B.3.4 Measurement of shifting off-time after 24 h rest period

Measurement of shifting off-time after 24 hours rest period shall be conducted on all test units after the immediate tests, keeping all volumes and pressure transducers attached. Apply the initial pressure settings of ≈6,3 bar (630 kPa) to the inlet port (and also to an external pilot port if so equipped). Perform a single shift-ON function and hold in this position for 24 hours. The valves shall remain motionless, with supply and pilot pressure applied, for at least 24 hours. After the 24-hour period has ended, conduct a shifting off-time test (exhaust test) to each valve in accordance with ISO 12238 with all volumes attached and with the following exceptions:

a) Do not perform any preliminary valve shifts.

b) Do not perform three test runs; only one shift is allowed.

c) The testing cannot be combined in sequence.

Test data is only valid for the first shift and shall be determined as described in accordance with ISO 12238, with the exception that all volumes defined in ISO 19973-1 are attached.

It is very important that the supply pressure to the inlet ports remains steady, and the valves are not actuated during the 24-hour period. The valve seals shall not be disturbed prior to their shifting test.

B.4 Failure criteria and threshold levels

Failure criteria according to Clause 8 shall be disregarded for the analysis of dangerous failures.

A test unit shall be considered to have failed dangerously if the shifting-off time exceeds the threshold level. The threshold level for shifting off-time is 2,5 times the catalogue rated value.

B.5 Data analysis

B.5.1 Testing may stop after the first shifting-off failure. The termination life for a test unit shall be the last cycle count at which the data did not exceed a threshold.

NOTE Terms "termination time" and "termination life" are defined in ISO 19973-1:2015, 10.2 and 10.3.

B.5.2 If a test unit experiences a failure from any other failure mode, but is still operational, it shall continue testing and will not be counted as a suspension in the sense of a dangerous failure. If it is not operational, it shall be removed from testing and be counted as a suspension.

B.5.3 The value of B_{10D} will be the cycle count of the termination life if the number of suspensions before the termination life does not exceed one suspension. If more suspensions occur, then the test is invalid or additional test specimens need to be added to the test.

B.5.4 If the testing is stopped and no shifting-off failure has been observed, the test termination time shall be the value of B_{10D}.

NOTE If the sample size exceeds 7 test units, the true B_{10D} value is larger than determined according to B.5.3 and B.5.4. This estimation is therefore a conservative assessment.

B.6 Examples

B.6.1 B_{10D} testing with or without suspensions

Consider a test run on a sample of seven test units and parameters related to three failure modes (leakage, shifting pressure and shifting off-time) are measured during a reliability test. Raw data from each parameter are collected as the test progresses. When a failure has occurred (either by no longer being able to perform a required function, or by exceeding the threshold in a *3PMA*), the cycle count at which the test unit was last observed in satisfactory condition is recorded as the termination life.

The target of the test is to determine the B_{10D} value of the test units.

See Table B.1 for an example of the data collected during such a test. The data for the test units are recorded from the observations when a unit fails by any failure mode for the first time. In case of the failure modes "leakage" and "shifting pressure" the exceeding of threshold levels was recorded, but the test was continued. For example, test unit number 3 reaches a threshold level for a shifting off-time failure at the cycle count of 69 million (shaded cells). After this observation, the test was ended.

Table B.1 — Example of test unit cycle counts and failure modes for a sample that contains no suspended test units

Termination life from *3PMA*	Failure mode leakage	Failure mode shifting pressure	Failure mode shifting off-time	Note
33×10^6	Test unit No. 3	—	—	Test continued
48×10^6	—	Test unit No. 7	—	Test continued
57×10^6	Test unit No. 1	—	—	Test continued
69×10^6	—	—	Test unit No. 3	Dangerous failure
69×10^6	Test ended – all other test units still operating.			

Test result: The B_{10D} life is 69×10^6 cycles.

B.6.2 Termination of testing without shifting off-time failures

Consider a test run on a sample of seven test units as described in B.6.1.

During the test the failure modes "leakage" and "shifting pressure" occurred, but no “shifting off-time” failure. At 160 million test cycles the test was ended. There were no suspensions up to this cycle count.

Table B.2 — Example of test unit cycle counts and failure modes for a sample that contains no shifting off-time failures

Termination life from *3PMA*	Failure mode leakage	Failure mode shifting pressure	Failure mode shifting off-time	Note
42×10^6	—	Test unit No. 4	—	Test continued
67×10^6	—	Test unit No. 1	—	Test continued
77×10^6	—	Test unit No. 3	—	Test continued
79×10^6	Test unit No. 6	—	—	Test continued
84×10^6	Test unit No. 7	—	—	Test continued
87×10^6	—	Test unit No. 2	—	Test continued
101×10^6	Test unit No. 5	—	—	Test continued
160×10^6	Test ended – no shifting off-time failure occurred.			

Test result: The B_{10D} life is 160×10^6 cycles.

B.7 Test report

A test report shall be prepared in accordance with ISO 19973-1:2015, Clause 12, except that the confidence limit is not required. Results shall be described as B_{10D}.

If the test was integrated with the methods described in Clause 7, then the results of β, B_{10}, and η shall also be given.

B.8 Test data sheet

An updated example of the test data sheet from Annex A including columns for shifting off-time is shown in Tables B.3 and B.4.