
**Pneumatic fluid power — Assessment
of component reliability by testing —**

**Part 2:
Directional control valves**

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

Partie 2: Distributeurs



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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.

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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 131, *Fluid power systems*.

This second edition cancels and replaces the first edition (ISO 19973-2:2007), which has been technically revised.

ISO 19973 consists of the following parts, under the general title *Pneumatic fluid power — Assessment of component reliability by testing*:

- *Part 1: General procedures*
- *Part 2: Directional control valves*
- *Part 3: Cylinders with piston rod*
- *Part 4: Pressure regulators*
- *Part 5: Non-return valves, shuttle valves, dual pressure valves (AND function), one-way adjustable flow control valves, quick-exhaust valves.*

Introduction

In pneumatic fluid power systems, power is transmitted and controlled through a gas under pressure within a circuit. Pneumatic fluid power systems are composed of components and are an integral part of various types of machines and equipment. Efficient and economical production requires highly reliable machines and equipment. This part of ISO 19973 is intended to provide requirements and test conditions that permit the assessment of the inherent reliability of pneumatic and electro-pneumatic directional control valves.

It is necessary that machine producers know the reliability of the components that make up their machine's pneumatic fluid power system. Knowing the reliability characteristic of the component, the producers can model the system and make decisions on service intervals, spare parts inventory and areas for future improvements.

There are three primary levels in the determination of component reliability:

- a) preliminary design analysis: finite element analysis (FEA), failure mode and effect analysis (FMEA);
- b) laboratory testing and reliability modelling: physics of failure, reliability prediction, pre-production evaluation;
- c) collection of field data: maintenance reports, warranty analysis.

Each level has its application during the life of a component. A preliminary design analysis is useful to identify possible failure modes and eliminate them or reduce their effect on reliability. When prototypes are available, in-house laboratory reliability tests are run and initial reliability can be determined. Reliability testing is often continued into the initial production run and throughout the production lifetime as a continuing evaluation of the component. Collection of field data are possible when products are operating and data on their failures are available.

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Pneumatic fluid power — Assessment of component reliability by testing —

Part 2: Directional control valves

1 Scope

This part of ISO 19973 provides test procedures for assessing the reliability of pneumatic directional control valves by testing and the methods of reporting the results of testing. General test conditions and the calculation method are provided in ISO 19973-1. The methods specified in ISO 19973-1 apply to the first failure, as obtained with the three-points moving average (3PMA) method, without repairs, but excluding outliers.

The lifetime of pneumatic and electro-pneumatic directional control valves is usually given as a number of cycles. Therefore, whenever the term “time” is used in this part of ISO 19973, this variable is to be understood as cycles.

This part of ISO 19973 also specifies test equipment and threshold levels for tests to assess the reliability of pneumatic directional control valves.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1219-1, *Fluid power systems and components — Graphical symbols and circuit diagrams — Part 1: Graphical symbols for conventional use and data-processing applications*

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

ISO 8778, *Pneumatic fluid power — Standard reference atmosphere*

ISO 19973-1, *Pneumatic fluid power — Assessment of component reliability by testing — Part 1: General procedures*

ISO 80000-1, *Quantities and units — Part 1: General*

IEC 60050-191, *International Electrotechnical Vocabulary, chapter 191: Dependability and quality of service*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598, ISO 19973-1 and IEC 60050-191 apply.

NOTE Where a conflict of definitions exists for a term in any of these three documents, the following priority order applies: first, ISO 19973-1; second, ISO 5598; and third, IEC 60050-191.

4 Symbols and units

Units of measurement shall be in accordance with ISO 80000-1.

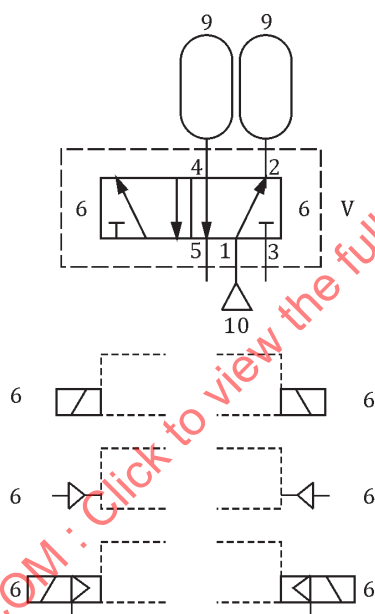
NOTE Graphical symbols used in this part of ISO 19973 conform to the requirements given in ISO 1219-1.

5 Test equipment

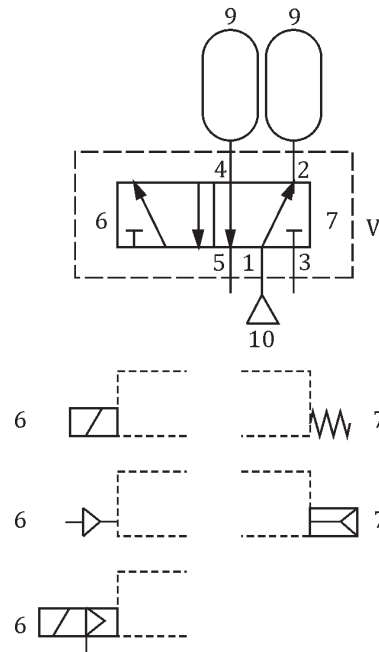
5.1 Basic test equipment

Basic test equipment shall conform to the requirements given in [Figure 1](#). Any silencers fitted to exhaust ports shall not restrict the valve's flow rate.

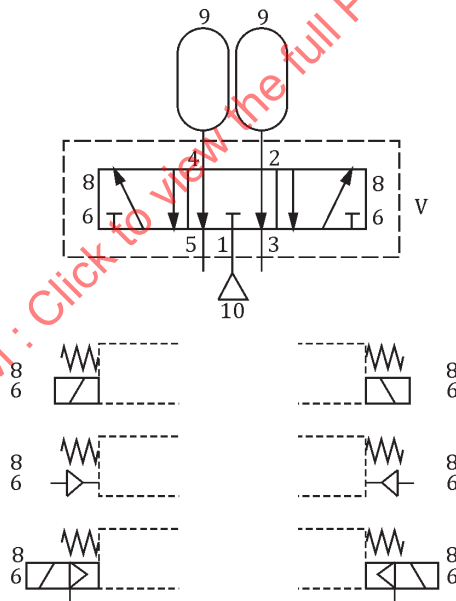
The basic circuits in [Figure 1](#) do not incorporate all the safety devices necessary to protect against damage in the event of component failure. It is important that those responsible for carrying out the test give due consideration to safeguarding both personnel and equipment.



a) Two-position bi-stable valves



b) Two-position mono-stable valves with spring or air return



c) Three-position valves

Key

1 to 5 ports	9	volume	
6	control signal: electrical, pneumatic, or pilot operated	10	supply pressure to port 1
7	spring or air-spring return	V	valve being tested
8	spring return to centre position		

NOTE The pilot supply can be either internal or external as long as it has the capability described in 7.2.

Figure 1 — Basic test equipment requirements

5.2 Connecting piping and volume

5.2.1 Connect the volume to the outlet ports of the test units either directly or by means of sections of tubes, in a manner that does not restrict flow.

NOTE Volume sizes are given in ISO 19973-1.

5.2.2 Tubes in the connecting lines shall be kept as short as possible so that the volumes can be charged and vented within the times provided by the control signal.

5.3 Simultaneous operation of multiple pneumatically operated valves

When testing pneumatically operated valves, several test units may be operated simultaneously from one control valve. In doing so, the control pressure described in [6.3.1](#) shall be applied to all test units.

6 Test conditions

6.1 General test conditions

The general test conditions shall be in accordance with ISO 19973-1.

6.2 Initial condition

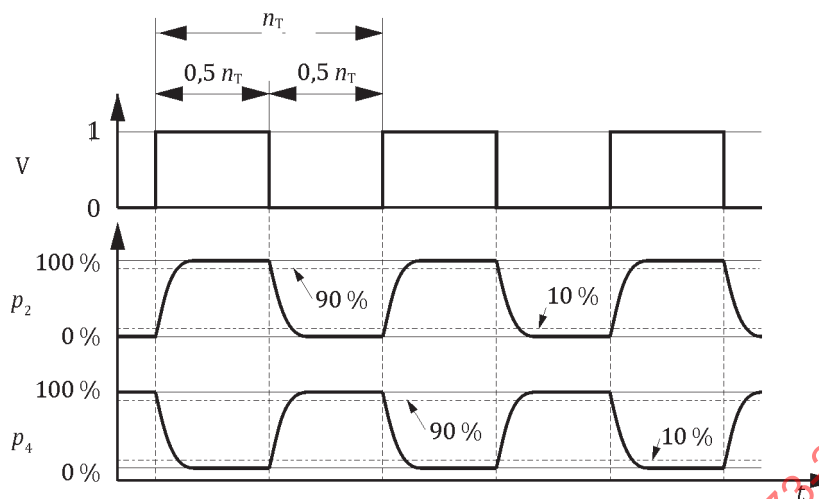
All new test units shall pass a functional check (see [7.2](#)) and the initial test data shall not exceed the threshold levels defined in this part of ISO 19973.

6.3 Cycling frequencies

6.3.1 Actuate the test valves in a manner to ensure that the pressure in the outlet port volumes drops below 10 %, and rises above 90 %, of the supply pressure during the cycle.

6.3.2 The ratio between the actuation-impulse on/off times shall be 1:1.

6.3.3 For mono-stable two-position valves, the control signal shall be applied in accordance with [Figure 2](#).

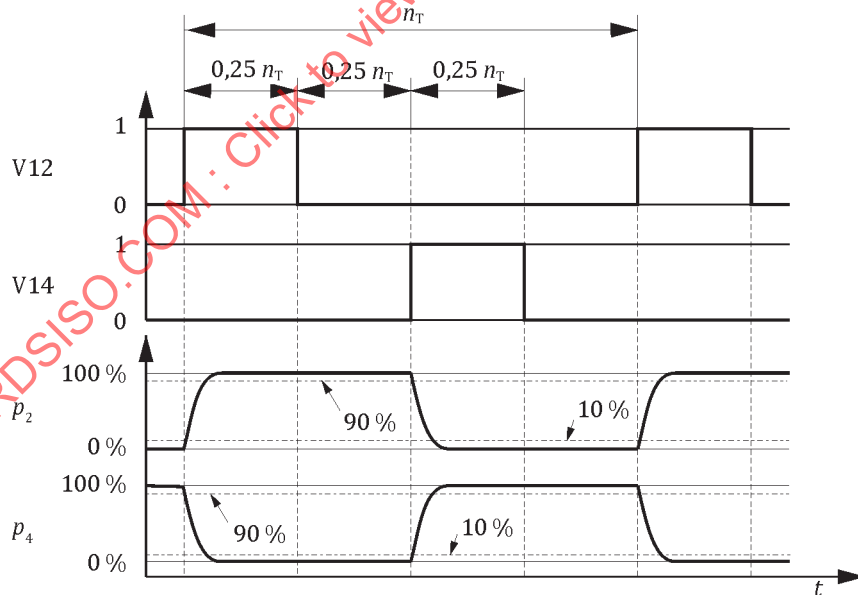


Key

V	valve control signal	0	control valve signal OFF
t	time	n_T	cycle time
1	control valve signal ON	p_2, p_4	pressure in the outlet port volumes

Figure 2 — Control signal for mono-stable two-position valves

6.3.4 For bi-stable and three-position valves, the control signal shall be applied in accordance with [Figure 3](#).



Key

V12, V14	valve control signals	0	control valve signal OFF
t	time	n_T	cycle time
1	control valve signal ON	p_2, p_4	pressure in the outlet port volumes

NOTE Outlet pressure is shown as an example for a bi-stable two-position valve.

Figure 3 — Control signal for bi-stable and three-position valves

7 Test procedures

7.1 Timing of checks and measurements

7.1.1 The following checks and measurements shall be made before, during, and after the endurance test:

- functional check in accordance with [7.2.1](#);
- measurement of leakage in accordance with [7.2.2](#);
- measurement of shifting pressure in accordance with [7.2.3](#).

7.1.2 Measuring intervals shall be determined in accordance with ISO 19973-1.

7.2 Type and scope of checks and measurement

7.2.1 Functional check

Test units shall be checked acoustically, optically, and tactilely under test conditions to determine whether the test units and the valves controlling them are operating correctly. The functional check is to see whether switching failures, incomplete charging of an output, or detectable or audible leakage is occurring. Remarkable characteristics shall be documented.

7.2.2 Measurement of leakage

7.2.2.1 The functional leakage (sum of the internal and external leakage) shall be recorded in each valve position (including the centre position of three-position valves), with test pressure applied to the inlet port.

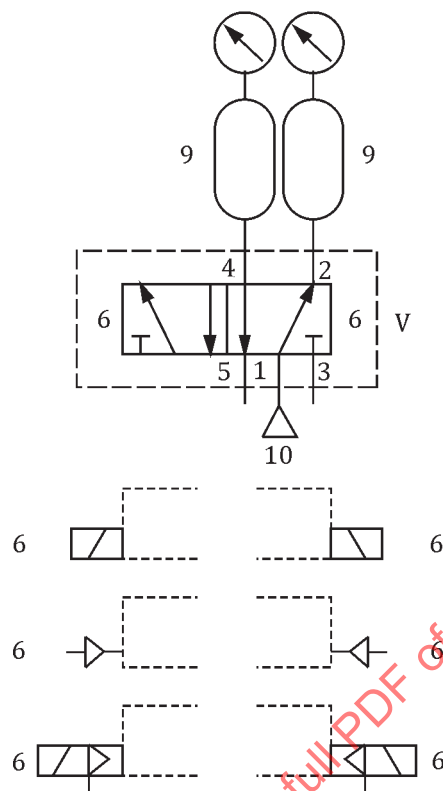
7.2.2.2 In addition, the following types of leakage may be measured for the valve type indicated:

- for pneumatically controlled valves: leakage rate in all internal pneumatic pilot lines and control chambers without test pressure applied to the inlet port, but with pilot pressure applied;
- for valves with auxiliary pilot air: leakage rate in all internal pneumatic pilot lines in all valve positions without test pressure applied to the inlet port, but with pilot pressure applied;
- for three-position valves with closed centre position: leakage rate in the closed centre position at the open outlet ports with inlet pressure applied to the inlet port; then leakage at the exhaust ports after applying test pressure to the outlet ports;
- for three-position valves with other types of centre positions: leakage rate at the exhaust ports with the valve in the centre position and with test pressure applied to the inlet port, with outlet ports closed;
- for electrically controlled bi-stable valves: leakage rate in each valve position with the solenoid energized and de-energized.

7.2.3 Measurement of shifting pressures

7.2.3.1 Determination of correct shifting

To determine if the test unit is shifting correctly, that is, whether the pressure at the outlet ports of a test unit increases and decreases fully without leakage, a pressure gauge or pressure transducer shall be connected to the outlet ports of the test unit (see [Figure 4](#)).

**Key**

- 1 to 5 ports
- 6 control signal: electrical, pneumatic, or pilot-operated
- 9 volume
- 10 supply pressure to port 1
- V valve being tested

Figure 4 — Measuring circuit**7.2.3.2 Measurement of immediate shifting pressures for mono-stable two-position valves****7.2.3.2.1 Shifting pressure for electrically operated valves**

For valves with internal pilot supply, apply the electrical control signal (with nominal voltage) as an ON-OFF pulse, and increase the pressure continuously on port 1 until correct shifting is observed.

For valves with an external pilot supply, apply test pressure to port 1. Apply the electrical control signal (with nominal voltage) as an ON-OFF pulse, and increase the pressure continuously on the pilot port until correct shifting is observed.

7.2.3.2.2 Shifting pressure for pneumatically operated valves

Apply test pressure to port 1. Activate the control valve alternately, and increase the pressure on the pilot until correct shifting is observed.

7.2.3.3 Measurement of immediate shifting pressures for bi-stable valves and three-position valves

7.2.3.3.1 Shifting pressure for electrically operated valves

For valves with an internal pilot supply, apply the electrical control signal (with nominal voltage) at each side alternately and increase the test pressure continuously on port 1 until the valve shifts in all valve positions.

For valves with an external pilot supply, apply the test pressure to port 1. Apply the electrical control signal (with nominal voltage) at each side alternately and increase the pilot pressure continuously until the valve shifts in all valve positions.

7.2.3.3.2 Shifting pressure for pneumatically operated valves

Apply the test pressure to port 1, apply control signal at control valves alternately and increase the pilot pressure at the control valves continuously until the valve shifts in all valve positions.

7.2.3.4 Measurement of shifting pressures after rest period

After performing the test specified in [7.2.3.2](#) and [7.2.3.3](#), allow the test units to remain motionless in the pressurized condition for 24 h, then repeat the tests from [7.2.3.2](#) and [7.2.3.3](#). Mono-stable valves shall remain in the position from which the next shift requires the higher shifting force. With supply pressure continuously applied to the inlet port, increase or decrease the pilot pressure until the valve shifts. Record the pilot pressure at which the valve first shifts.

If the test valves are internal pilot types, use the external pilot exhaust port to either apply or reduce a supplementary pilot pressure for this test. If necessary, the pilot flow path in the test valve may be modified to permit control of this supplementary pilot pressure.

7.2.3.5 Data to record

The immediate shifting pressure and the shifting pressure after the rest period shall be recorded.

8 Failure criteria and threshold levels

8.1 General

A test unit shall be considered to have failed if any one of the threshold levels or failure criteria specified in [8.2](#) through [8.4](#) is reached. The termination life shall be determined in accordance with ISO 19973-1.

8.2 Functional failure

A test unit shall be considered to have failed if it does not provide the functionality specified in [7.2.1](#).

8.3 Failure due to leakage

A test unit shall be considered to have failed if the total leakage at any position, measured in accordance with [7.2.2](#), exceeds the values in [Table 1](#). [Table 1](#) shows the values of 4 and 5 port valves. For 2 and 3 port valves, 50 % of the values in [Table 1](#) shall be used as threshold values.

The determination of threshold values for leakage rates is shown in ISO 19973-1:2015, Annex B.

Table 1 — Threshold values for leakage rate measured during the test

Sonic conductance C $\text{dm}^3/(\text{s} \cdot \text{kPa})(\text{ANR})^a$	Maximum leakage rate $\text{dm}^3/\text{h} (\text{ANR})^a$	
	Valves with soft sealing (class 1.5 ^b)	Valves with metal-to-metal sealing (class 2.0 ^b)
$C \leq 0,01$	6,0	20
$0,010 < C \leq 0,016$	8,0	25
$0,016 < C \leq 0,028$	11,0	33
$0,028 < C \leq 0,046$	14,0	43
$0,046 < C \leq 0,080$	18,0	57
$0,080 < C \leq 0,130$	23,0	72
$0,130 < C \leq 0,220$	30,0	94
$0,220 < C \leq 0,360$	38,0	120
$0,360 < C \leq 0,600$	50,0	160
$0,600 < C \leq 1$	63,0	200
$1 < C$	80,0	250
^a In accordance with ISO 8778. ^b See ISO 19973-1:2015, Annex B.		

8.4 Failure due to shifting pressures

A test unit shall be considered to have failed if the shifting pressure for solenoid valves or pneumatically operated valves measured in accordance with 7.2.3 exceed the minimum working pressure given in the manufacturer's datasheet or product specification.

8.5 Customised agreements

Individual customers and industry segments may use different threshold levels and requirements that do not conform to this International Standard. Special agreements shall be documented in test reports and in catalogue data.

9 Data analysis

Test data shall be analysed in accordance with ISO 19973-1. An example of a test data sheet is shown in Annex A.

10 Test report

Data shall be reported in accordance with ISO 19973-1. Any deviation from this part of ISO 19973 shall be documented in the test report.

An example of test results is shown in ISO 19973-1:2015, Annex G.

11 Identification statement (reference to this part of ISO 19973)

It is recommended that manufacturers use the following statement in test reports, catalogues and sales literature when electing to comply with this part of ISO 19973:

“Reliability and lifetime of pneumatic valves assessed in accordance with ISO 19973-2, Pneumatic fluid power — Assessment of component reliability by testing — Part 2: Directional control valves.”

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Annex A
(informative)

Test data sheet

An example of a test data sheet is shown on the next two pages.

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