BS ISO 19973-5:2015

BSI Standards Publication

Pneumatic fluid power — Assessment of component reliability by testing

Part 5: Non-return valves, shuttle valves, dual pressure valves (AND function), one-way adjustable flow control valves, quick-exhaust valves

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National foreword

This British Standard is the UK implementation of ISO 19973-5:2015.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Pneumatic fluid power — Assessment of component reliability by testing —

Part 5: Non-return valves, shuttle valves, dual pressure valves (AND function), one-way adjustable flow control valves, quick-exhaust valves

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

Partie 5: Clapets anti-retour, vannes sélecteur de circuit, distributeurs à deux pressions (fonction AND), limiteurs de débit réglable monodirectionnel, purge rapide

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Foreword

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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).

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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*.

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 *non-return valves, shuttle valves, dual pressure valves (AND function), one-way flow control valves, quick-exhaust 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.

INTERNATIONAL STANDARD **ISO 19973-5:2015(E)**

Pneumatic fluid power — Assessment of component reliability by testing —

Part 5:
Non-return valves, shuttle valves, dual pressure valves (AND function), one-way adjustable flow control valves, quick-exhaust valves

1 Scope

This part of ISO 19973 provides test procedures for assessing the reliability of the following types of pneumatic valves:

— non-return (check) valves;

— pilot-operated non-return valves;

— shuttle valves;

— dual pressure valves (AND function);

— one-way adjustable flow control valves;

— quick-exhaust 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 these pneumatic 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 understood as a number of cycles.

This part of ISO 19973 also specifies test equipment and threshold levels for tests to assess the reliability of these pneumatic 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 11727, *Pneumatic fluid power — Identification of ports and control mechanisms of control valves and other components*

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, IEC 60050-191, and the following apply.

NOTE Where a conflict of definitions exists for a term in any of these three documents, the following priority order applies: first, ISO 19973-5; second, ISO 19973-1; third, ISO 5598; and fourth, IEC 60050–191.

3.1
dual pressure valve (AND function)
valve in which an output signal is only obtained when both inlets are under pressure

Note 1 to entry: The weaker signal is fed to the output.

4 Symbols and units

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

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

NOTE 2 Ports are identified in accordance with ISO 11727.

5 Test equipment

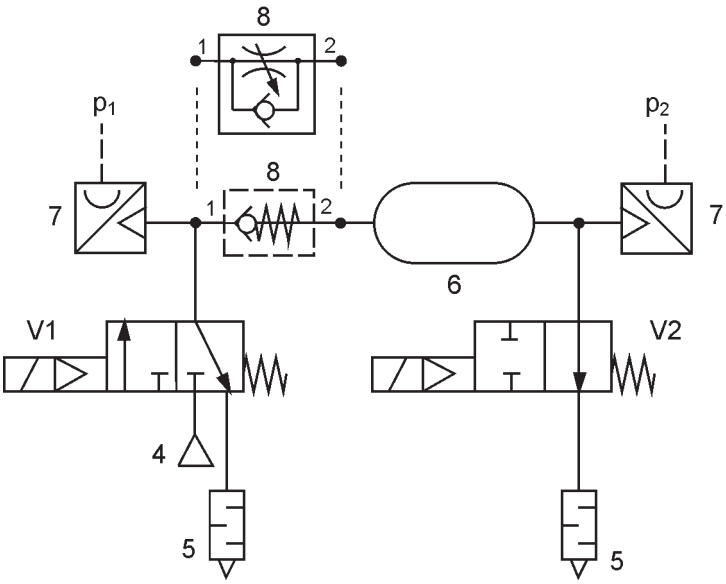
5.1 Basic test equipment

Basic test equipment shall conform to the requirements given in Table 1 and Figure 1 through Figure 5, depending on the type of valve under test (test unit). Any silencers fitted to exhaust ports shall not restrict the valve's flow rate. The rated flow rate of the directional control valves shall be equal to or greater than the rated flow rate of the test unit.

The basic circuits in Figures 1 through 5 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.

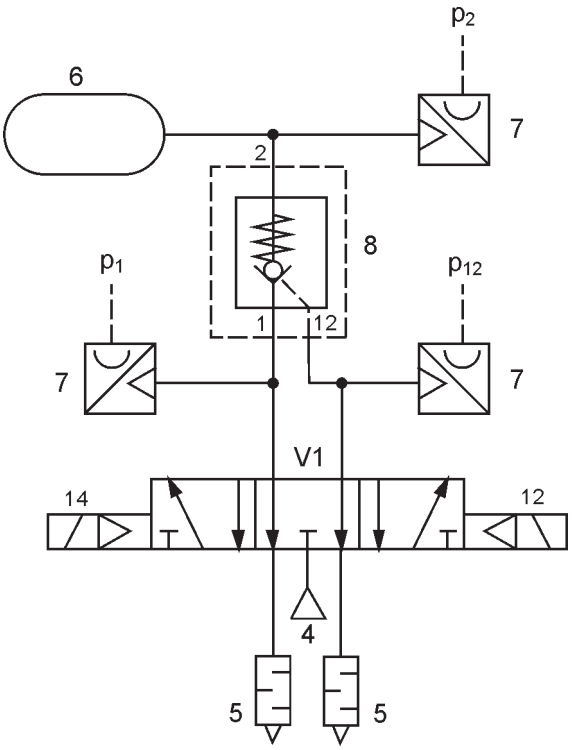
Table 1 — Key to the test circuit components shown in Figures 1 through 5

Key item number	Description
1, 2, 3	ports of the test unit
4	supply pressure
5	silencer
6	volume
7	pressure transducer, necessary for test set-up and intermediate functional tests only
8	test unit
12	pilot port
V1, V2	directional control valve



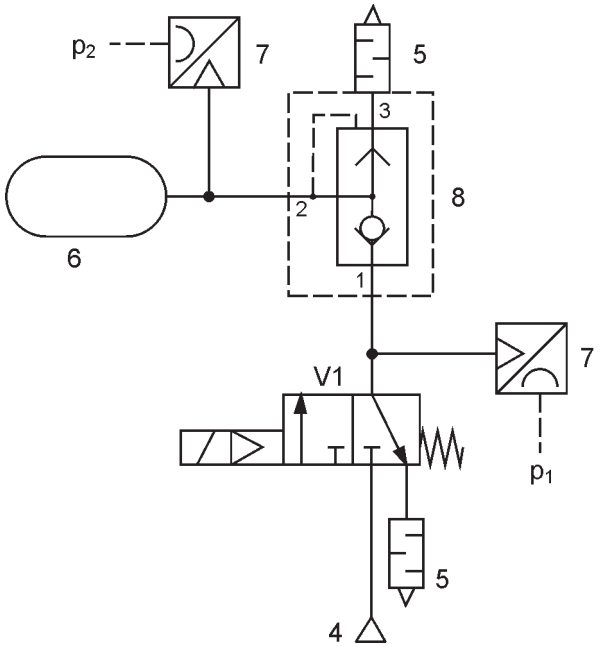
NOTE See Table 1 for the key to the test circuit components.

Figure 1 — Basic test equipment requirements for non-return valves and one-way flow control valves



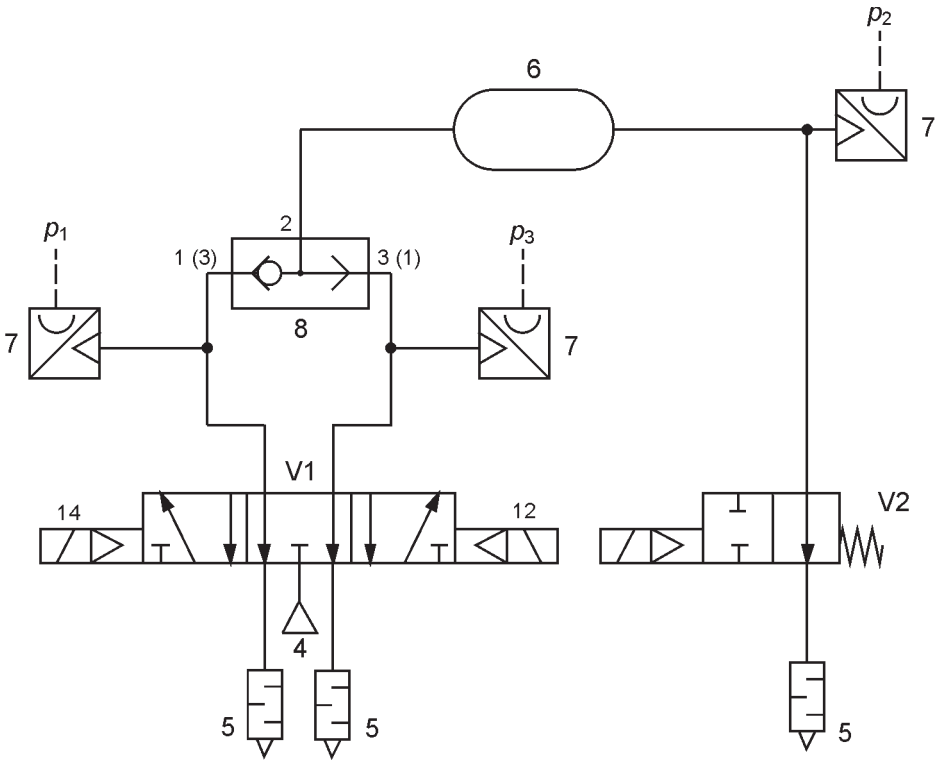
NOTE See Table 1 for the key to the test circuit components.

Figure 2 — Basic test equipment requirements for pilot-operated non-return valves



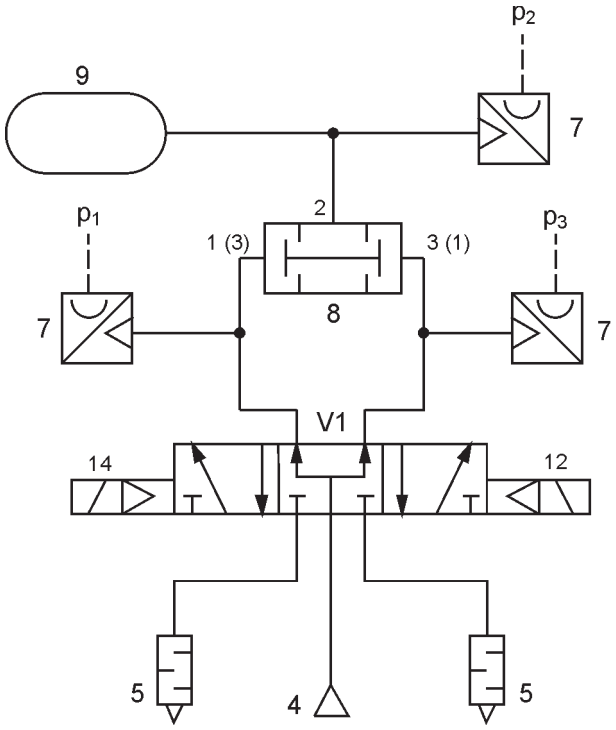
NOTE See Table 1 for the key to the test circuit components.

Figure 3 — Basic test equipment requirements for quick-exhaust valves



NOTE See Table 1 for the key to the test circuit components.

Figure 4 — Basic test equipment requirements for shuttle valves



NOTE See Table 1 for the key to the test circuit components.

Figure 5 — Basic test equipment requirements for dual pressure valves (AND function)

5.2 Connecting piping and volumes

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.

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.

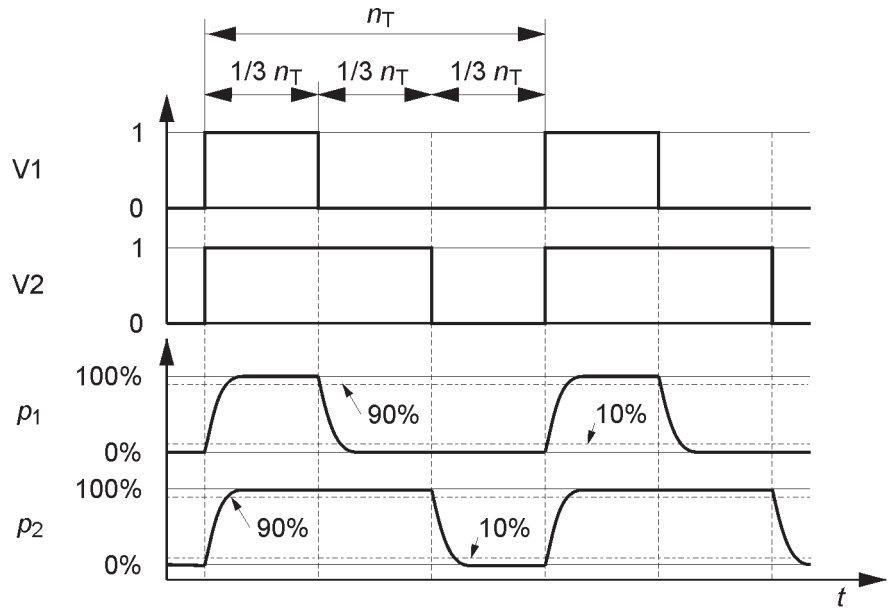
6.3 Cycling frequencies

6.3.1 Non-return valves and one-way adjustable flow control valves

6.3.1.1 The test units shall be operated in a manner that the pressure p_2 in the outlet port volume drops below 10 %, and rises above 90 %, of the supply pressure during the cycle.

6.3.1.2 The adjustment screw of one-way adjustable flow control valves shall be closed and locked in this position during the test.

6.3.1.3 The control signal shall be applied to the test units in accordance with Figure 6.



Key

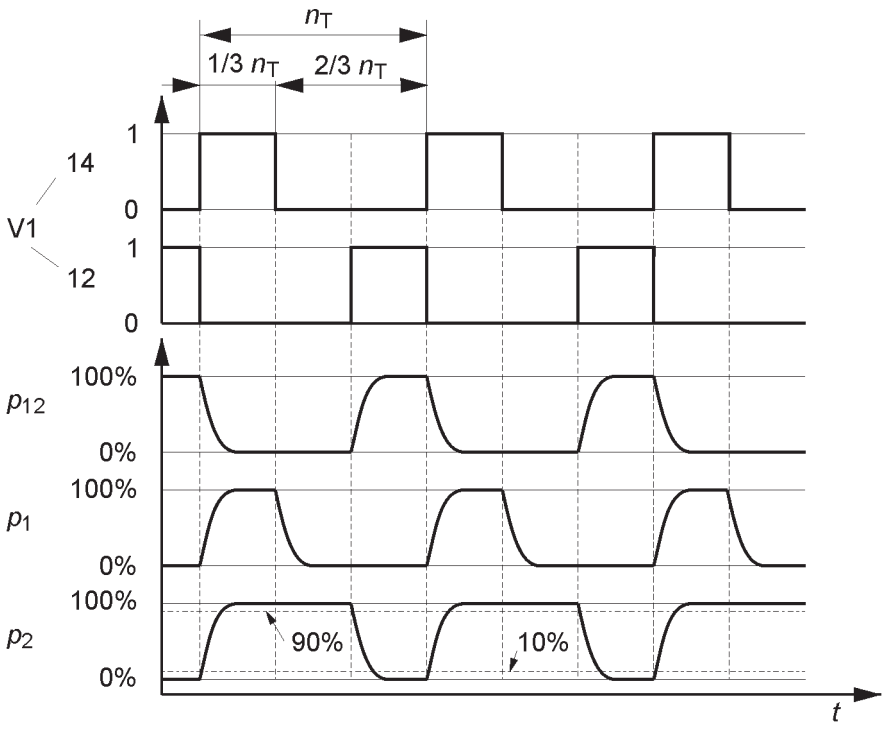
V1, V2	control valve signals	t	time
p_1	pressure at inlet port	n_T	cycle time
p_2	pressure at outlet port		

Figure 6 — Sequence of signals for non-return valves and one-way flow control valves

6.3.2 Pilot-operated non-return valves

6.3.2.1 The test units shall be operated in a manner that the pressure p_2 in the outlet port volume drops below 10 %, and rises above 90 %, of the supply pressure during the cycle.

6.3.2.2 The control signal shall be applied to the test units in accordance with Figure 7.



Key

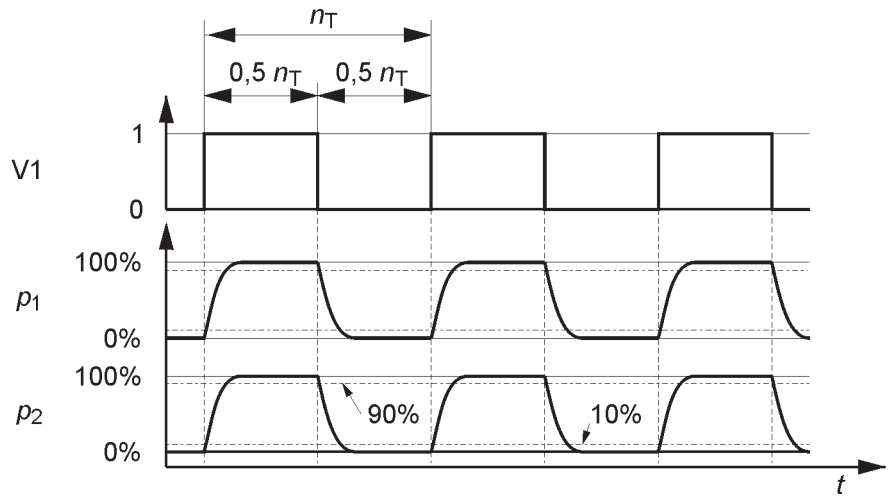
V1	control valve signals	p_{12}	pressure at pilot port12
p_1	pressure at inlet port	t	time
p_2	pressure at outlet port	n_T	cycle time

Figure 7 — Sequence of signals for pilot-operated non-return valves

6.3.3 Quick-exhaust valves

6.3.3.1 The test units shall be operated in a manner that the pressure p_2 in the outlet port volume drops below 10 %, and rises above 90 %, of the supply pressure during the cycle.

6.3.3.2 The control signal shall be applied to the test units in accordance with Figure 8.



Key

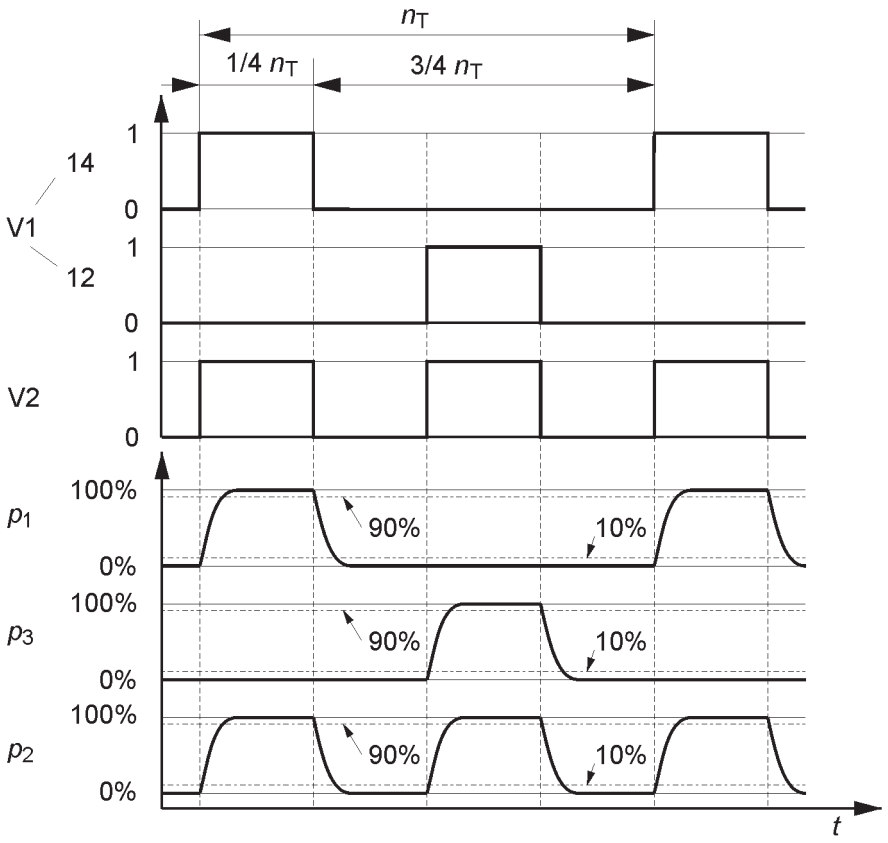
V1	control valve signal	t	time
p_1	pressure at inlet port	n_T	cycle time
p_2	pressure at outlet port		

Figure 8 — Sequence of signals for quick-exhaust valves

6.3.4 Shuttle valves and dual pressure valves (AND function)

6.3.4.1 The test units shall be operated in a manner that the pressure p_2 in the outlet port volume drops below 10 %, and rises above 90 %, of the supply pressure during the cycle.

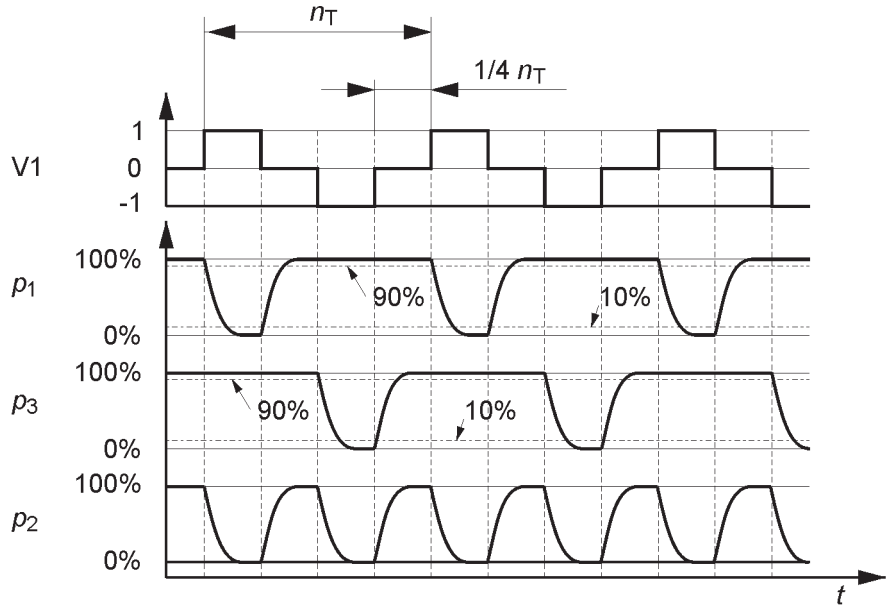
6.3.4.2 The control signal shall be applied to shuttle valves in accordance with Figure 9 and to dual pressure valves (AND function) in accordance with Figure 10.



Key

V1	control valve signal	p_3	pressure at port 3
p_1	pressure at inlet port	t	time
p_2	pressure at outlet port	n_T	cycle time

Figure 9 — Sequence of signals for shuttle valves



Key

V1	control valve signal	p_3	pressure at port 3
p_1	pressure at inlet port	t	time
p_2	pressure at outlet port	n_T	cycle time

Figure 10 — Sequence of signals for dual pressure valves (AND function)

7 Test procedure

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 measurements

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.

The test unit's termination life shall be determined in accordance with ISO 19973-1.

7.2.2 Measurement of leakage

The functional leakage (sum of the internal and external leakage) shall be recorded with test pressure applied to the defined port.

7.2.2.1 Non-return valves and one-way adjustable flow control valves

Apply test pressure at port 2 and measure the inlet leakage from port 2. The adjustment screw of one-way adjustable flow control valves shall be closed.

7.2.2.2 Pilot-operated non-return valves

First apply test pressure to port 2 with no pressure applied to ports 1 and 12, and measure the inlet leakage from port 2. Then apply test pressure to port 12 with no pressure applied to ports 1 and 2, and measure the inlet leakage from port 12.

7.2.2.3 Quick-exhaust valves

Plug port 2, then apply test pressure at port 1, and measure the inlet leakage from port 1.

7.2.2.4 Shuttle valves

Port 2 of shuttle valves shall be disconnected and closed by a plug. First apply test pressure to port 1 with no pressure applied to port 3, and measure the inlet leakage from port 1. Then apply test pressure to port 3 with no pressure applied to port 1, and measure the inlet leakage from port 3.

7.2.2.5 Dual pressure valves (AND function)

First apply test pressure to port 1 with no pressure applied to ports 2 and 3, and measure the inlet leakage from port 1. Then apply test pressure to port 3 with no pressure applied to ports 1 and 2, and measure the inlet leakage from port 3.

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, the pressure at the outlet ports of a test unit increases and decreases fully, a pressure gauge or pressure transducer shall be connected to the outlet ports of the test unit (see Figure 1 through Figure 5).

7.2.3.2 Measurement of shifting pressures for non-return valves and one-way adjustable flow control valves

Activate the directional control valves V1 and V2 and increase the pressure on port 1 of the test unit. The test unit has shifted correctly when the output pressure is greater than 10 % of the test pressure.

7.2.3.3 Measurement of pilot pressure for pilot-operated non-return valves

Apply the minimum test pressure at port 2 of the test unit. Activate control valve V1, and increase the pressure on port 12 until the test unit shifts correctly. Then deactivate the pilot pressure, and check the closing function of the non-return valve.

Apply the maximum test pressure at port 2 of the test unit, and repeat the procedure described in the first paragraph of 7.2.3.3.

7.2.3.4 Data to record

The pressure at which correct shifting occurs shall be recorded as the shifting pressure.

7.3 Recording of test data

The test data sheet given in Annex A can be used to record test data.

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 rate at any position, measured in accordance with 7.2.2, exceeds the values in Table 2.

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

Table 2 — Threshold values for leakage rate measured during the test

Sonic conductance C $dm^3/(s \cdot kPa)(ANR)$ [a]	**Maximum leakage rate** dm^3/h (ANR) [a]
$C \leq 0{,}010$	2,0
$0{,}010 < C \leq 0{,}016$	2,5
$0{,}016 < C \leq 0{,}028$	3,3
$0{,}028 < C \leq 0{,}046$	4,3
$0{,}046 < C \leq 0{,}080$	5,7
$0{,}080 < C \leq 0{,}130$	7,2
$0{,}130 < C \leq 0{,}220$	9,4
$0{,}220 < C \leq 0{,}360$	12,0
$0{,}360 < C \leq 0{,}600$	15,0
$0{,}600 < C \leq 1$	20,0
$1 < C$	25,0

[a] In accordance with ISO 8778.

8.4 Failure due to shifting pressures

A test unit shall be considered to have failed if the shifting pressure of valves measured in accordance with 7.2.3 exceeds the minimum shifting 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 part of ISO 19973. 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.

10 Test report

Data shall be reported in accordance with ISO 19973-1.

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 19973-5, *Pneumatic fluid power — Assessment of component reliability by testing — Part 5: Non-return valves, shuttle valves, dual pressure valves (AND function), one-way adjustable flow control valves, quick-exhaust valves.*"

Annex A
(informative)

Test data sheet

A data sheet for recording data from tests conducted in accordance with this part of ISO 19973 is given on the next two pages.

TEST DATA SHEET
ISO Accessory Reliability

Test Lab:						**Test No.:**				**Sheet**	**of**	
Type of test unit:					Mfg.	Model No. Port size:				Volume size at outlet port:		cm^3
Test Unit Identification No.						Forward sonic conductance, C_f, of test unit =						$dm^3/(s \cdot kPa)$ (ANR)
						Sonic conductance, C, of directional control valve =						$dm^3/(s \cdot kPa)$ (ANR)
Cycle test data						Inlet leakage @ test pressure Use only columns needed for a test unit				Shifting press.		Notes
						Pressurize port: __		Pressurize port: __		Minimum	Maximum	
						Leakage @ __	Leakage @ __	Leakage @ __	Leakage @ __			
Threshold value:												
Date	Counter	Cycles	Temp.	Inlet P_0	Dew Pt.						(if applicable)	
			°C	kPa	°C	dm^3/h (ANR)	dm^3/h (ANR)	dm^3/h (ANR)	dm^3/h (ANR)	kPa	kPa	

TEST DATA SHEET
ISO Accessory Reliability

Test Lab:		Test No.:	Sheet		of	
Enter data on this sheet when an observation is to be recorded.						

Date	Counter	Cycles	Test unit No.	Observations

TEST DATA SHEET
ISO Accessory Reliability

Test Lab:	**Test No.:**	**Sheet:**		**of**	
Copy pressure traces for each test unit on this sheet; at the beginning of the endurance cycling, and whenever a pressure trace is made.					

Bibliography

[1] ISO 6358, *Pneumatic fluid power — Components using compressible fluids — Determination of flow-rate characteristics*

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