BS ISO 19973-3:2015

BSI Standards Publication

Pneumatic fluid power — Assessment of component reliability by testing

Part 3: Cylinders with piston rod

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National foreword

This British Standard is the UK implementation of ISO 19973-3:2015. It supersedes BS ISO 19973-3:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/18, Fluid power systems and components.

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 3: Cylinders with piston rod

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

Partie 3: Vérins avec tiges de piston

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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 19973-3:2007), 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 cylinders with piston rod.

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.

Pneumatic fluid power — Assessment of component reliability by testing —

Part 3: Cylinders with piston rod

1 Scope

This part of ISO 19973 provides test procedures for assessing the reliability of pneumatic cylinders with piston rod, both single-acting and double-acting, 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-point moving average (*3PMA*) method, without repairs, but excluding outliers.

The lifetime of pneumatic cylinders is usually given in number of cycles or in kilometres. Therefore, whenever the term “time” is used in this part of ISO 19973, this variable is to be understood as cycles or kilometres.

This part of ISO 19973 also specifies test equipment and threshold levels for tests to assess the reliability of pneumatic cylinders with piston rods.

This part of ISO 19973 is intended to be applied to pneumatic piston rod cylinders that conform to ISO 6430, ISO 6432, ISO 15552, and ISO 21287; however, pneumatic piston rod cylinders that do not conform to these International Standards but are used in the same range of operating conditions can be tested in accordance with one of the classes defined in Tables 1 and 2.

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 10099:2001, *Pneumatic fluid power — Cylinders — Final examination and acceptance criteria*

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.

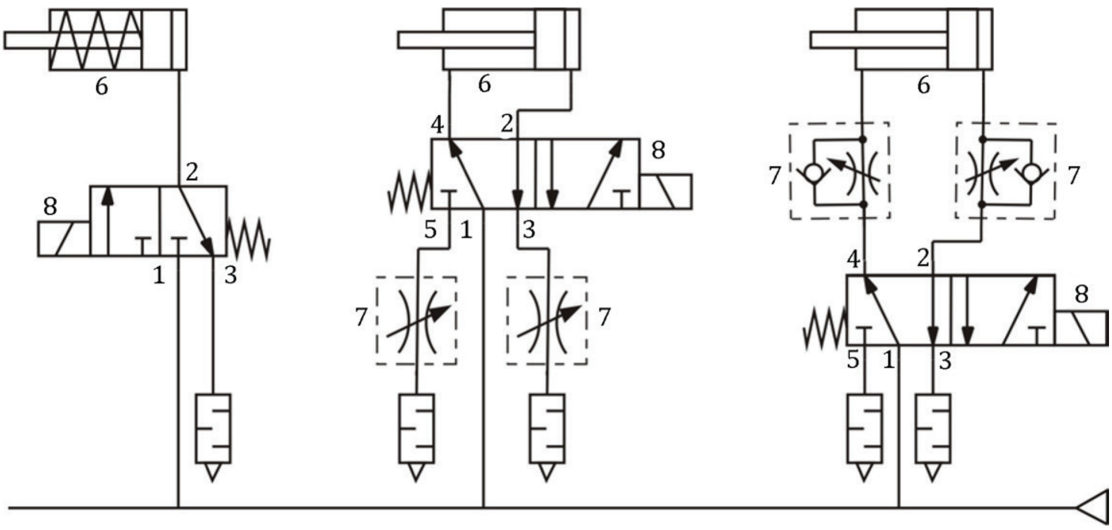
NOTE Graphical symbols used in this part of ISO 19973 conform to the requirements given in ISO 1219-1.

5 Test equipment

5.1 The test circuit typically includes a pressure source, the cylinders being tested, solenoid valves, and an adjustable flow control valve, which acts as a speed controller. See Figure 1 for a circuit diagram of an example test circuit.

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.

5.2 Cylinders to be tested shall be rigidly installed in the horizontal position and fixed to a secure base to reduce vibration. They shall be fixed at both ends. If necessary, alternate the motion of the cylinders to allow one to extend while another retracts.



Key

1 to 5 ports
6 pneumatic cylinder being tested
7 adjustable flow control valve (speed controller)
8 directional control valve

Figure 1 — Example of a test circuit for determining the reliability of a pneumatic piston rod cylinder by testing

6 Test conditions

6.1 General test conditions

All test units shall have passed an acceptance test conducted in accordance with ISO 10099. The general test conditions shall be in accordance with ISO 19973-1.

6.2 Initial condition

The leakage rate of new cylinders shall not exceed the values for this characteristic specified in ISO 10099:2001, Table 1.

6.3 Endurance test conditions

6.3.1 Orientation

The cylinder being tested shall be installed in the horizontal position.

6.3.2 Side loads

6.3.2.1 No side loads shall be applied to single-acting cylinders. Test results can be related only to the tested stroke.

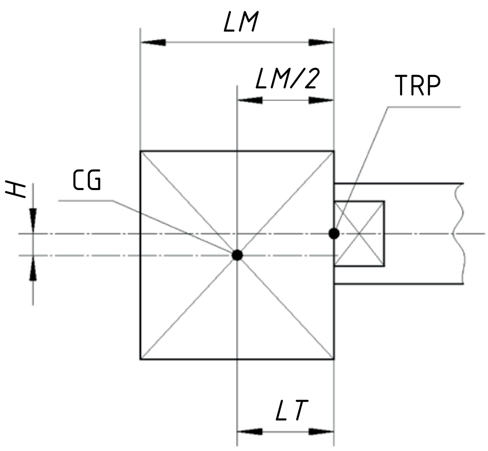
6.3.2.2 For double-acting cylinders, the side load shall be mounted as follows.

a) The side load shall be tightened against the shoulder of the piston rod close to the theoretical reference point (TRP) [see ISO 6099 and Figure 2 a)]. This mounting type should be preferred.

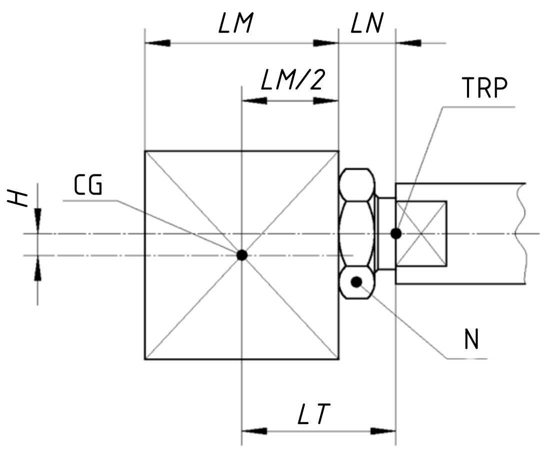
b) The side load masses and the distances from the TRP for double-acting cylinders shall be in accordance with Table 1.

c) When a counter nut is required, the side load shall be mounted with a clearance *LN* from the TRP [see Figure 2 b)]. However, the distance *LT* shall be maintained as shown in Table 1.

d) The side load shall be mounted to engage the piston rod at a distance *H* below the centre of gravity (CG). Values for *H* are given in Table 1.



a) Figure 2a)



b) Figure 2b)

Key

CG centre of gravity of the side load
H eccentricity of the side load
LT distance between TRP and CG
LM longitudinal length of the side load
LN optional space for a counter nut
N counter nut (optional)
TRP theoretical reference point

Figure 2 — Distance of centre of gravity of the side load from the cylinder's theoretical reference point (TRP) and its eccentricity

Table 1 — Side load masses and distances from the cylinder's theoretical reference point

Cylinder bore size	**Side load** kg[a]			***H*** mm ±0,5 mm	***LT***
	Class 1 – light (e.g. ISO 21287)	**Class 2 – medium** (e.g. ISO 6432)	**Class 3 – heavy** (e.g. ISO 6430 or ISO 15552)		
8	—	0,03	—	1,5	20
10		0,05			
12		0,07			
16		0,13			
20	0,20	0,20			
25	0,25	0,30			
32	0,40	—	2	3	50
40	0,60		3		
50	1,00		4		
63	1,50		6		
80	2,50		9		
100	3,50		12		
125	—		16	5	
160			20		
200			30		
250			40		
320			50		

[a] ±5 %.

6.3.3 Stroke lengths

The stroke lengths of cylinders to be tested shall be in accordance with Table 2. Methods to calculate side load masses for deviating test stroke lengths are given in Annex A.

Table 2 — Test stroke lengths for cylinders

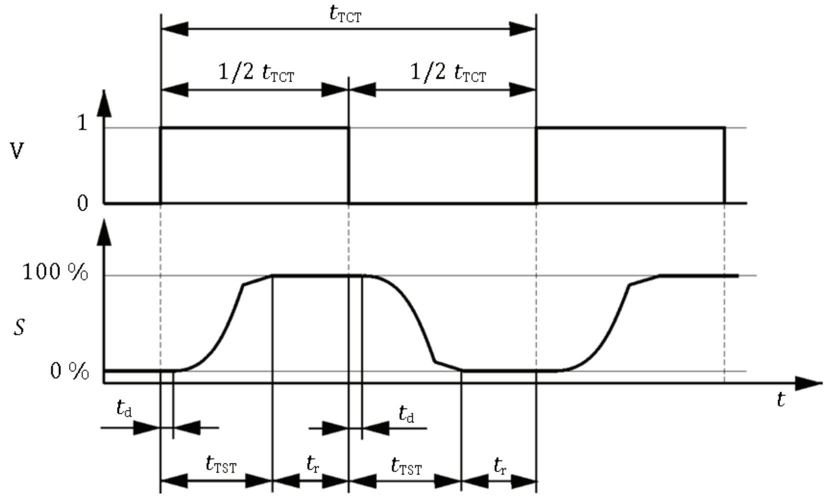
Dimensions in millimetres

<table>
<tr><th rowspan="3">Cylinder bore size</th><th colspan="5">Cylinder test stroke</th></tr>
<tr><th colspan="2">Class 1
(e.g. ISO 21287)</th><th colspan="2">Class 2
(e.g. ISO 6432)</th><th>Class 3
(e.g. ISO 6430 or ISO 15552)</th></tr>
<tr><th>double-acting</th><th>single-acting</th><th>double-acting</th><th>single-acting</th><th>double-acting</th></tr>
<tr><td>**8**</td><td rowspan="4">—</td><td rowspan="4">—</td><td rowspan="2">20</td><td rowspan="3">10</td><td rowspan="6">—</td></tr>
<tr><td>**10**</td></tr>
<tr><td>**12**</td><td>25</td></tr>
<tr><td>**16**</td><td>30</td><td rowspan="3">25</td></tr>
<tr><td>**20**</td><td>20</td><td rowspan="4">10</td><td>40</td></tr>
<tr><td>**25**</td><td>25</td><td>50</td></tr>
<tr><td>**32**</td><td>30</td><td rowspan="11">—</td><td rowspan="11">—</td><td rowspan="3">160</td></tr>
<tr><td>**40**</td><td>40</td></tr>
<tr><td>**50**</td><td rowspan="4">50</td><td rowspan="4">25</td></tr>
<tr><td>**63**</td><td rowspan="2">250</td></tr>
<tr><td>**80**</td></tr>
<tr><td>**100**</td></tr>
<tr><td>**125**</td><td rowspan="5">—</td><td rowspan="5">—</td><td rowspan="5">320</td></tr>
<tr><td>**160**</td></tr>
<tr><td>**200**</td></tr>
<tr><td>**250**</td></tr>
<tr><td>**320**</td></tr>
</table>

6.3.4 Test operating time

The test stroke time of the cylinder shall be verified in both directions in accordance with Figure 3. The test stroke time (t_{TST}) at setup shall be less than 50 % of the test cycle time (t_{TCT}) of the control valve. The test rest time (t_r) shall be below 20 % of the half test cycle time but greater than 0 %. This leads to Formula (1):

$$\frac{1}{2} t_{TCT} = t_{TST} + t_r \quad (1)$$



Key

V control valve signal
S cylinder stroke
t time
1 control valve signal ON
0 control valve signal OFF
t_{TCT} test cycle time
t_{TST} test stroke time
t_r test rest time
t_d delay time

Figure 3 — Test stroke time waveform

For a cylinder without air cushioning, Formula (2) may be used to calculate the half test cycle time:

$$\frac{1}{2} t_{TCT} = \frac{S}{V_m} \cdot 1,2 \quad (2)$$

For a cylinder with air cushioning, Formula (3) may be used to calculate the half test cycle time:

$$\frac{1}{2} t_{TCT} = \frac{S}{V_m} \cdot 1,4 \quad (3)$$

with S as the cylinder stroke length and V_m as the average stroke velocity of the cylinder.

The calculated half test cycle time includes a rest time of approx. 20 %.

As a guideline an average stroke velocity, V_m, of 500 mm/s ±50 % is recommended for all cylinders. Cylinders without air cushioning are recommended for operation in the lower velocity range.

The maximum test frequency $\left(\frac{1}{t_{TCT}}\right)$ shall be determined in a way that the requirements of ISO 19973-1, 8.4 are fulfilled.

6.4 Operating adjustments

6.4.1 Ensure that the installation screws remain tight during the test.

6.4.2 Operate the test cylinders so that the stroke time does not exceed the specifications in 6.3.4 at the start of cycling. The stroke time shall include the effects of any adjustable cushioning device used to prevent impact at the end of the stroke. Set the stroke time to the values given in 6.3.4.

6.4.3 As cycling continues, it is permissible for the stroke time to increase until the cylinder reaches its end position.

6.4.4 Adjust the cushioning device and the adjustable flow control valves to allow the cylinder to reach the end position.

6.4.5 When the operating adjustments allowed in this sub-clause no longer allow a test unit to reach the end position, operation of that test unit shall be stopped.

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:

a) functional check in accordance with 7.2.1;

b) measurement of the leakage in accordance with 7.2.2;

c) measurement of the minimum working pressure in accordance with 7.2.3;

d) measurement of the test stroke time in accordance with 7.2.4.

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

The functional check is to see whether both end positions are reached. 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.

7.2.2 Measurement of leakage

Leakage rate shall be measured in both end positions of the cylinder at the pressurized port at test pressure.

7.2.3 Minimum working pressure test (for double-acting cylinders only)

To determine the minimum working pressure, apply the side load determined in accordance with 6.3.2.2 and cycle the cylinder five to 10 times. Increase the pressure to the cylinder being tested continuously until the cylinder moves smoothly in both directions. Record the pressure at which this occurs as the minimum working pressure.

7.2.4 Stroke time test

The test units shall reach the stroke end positions in each direction within one half of the cycle time. Record if the cylinder has reached its end position when the directional control valve is operated.

If a cylinder type does not reach either end position within one half of the test cycle time specified because of its special design features (orifices, friction, etc.), the deviating test conditions shall be noted in the test report and, if necessary, in the catalogue data of the cylinder type.

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 8.5 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 leakage rate measured in accordance with 7.2.2 exceeds the leakage threshold levels given in Table 3.

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

Table 3 — Threshold level for leakage rate of cylinders

Cylinder bore size mm	**Maximum leakage rate** dm^3/h (ANR)[a]
8	6,0
10	
12	
16	9,0
20	
25	
32	18
40	
50	
63	35
80	
100	
125	70
160	
200	
250	140
320	

a In accordance with ISO 8778.

NOTE Values are valid for both directions of stroke.

8.4 Failure related to minimum working pressure

A test unit shall be considered to have failed if the minimum working pressure for the cylinder, measured in accordance with 7.2.3, exceeds the minimum working pressure given in Table 4.

Table 4 — Threshold level for minimum working pressure

<table>
<tr><th>Cylinder bore size
mm</th><th>Minimum working pressure
kPa (bar)</th></tr>
<tr><td>8</td><td>300 (3,0)</td></tr>
<tr><td>10</td><td rowspan="2">260 (2,6)</td></tr>
<tr><td>12</td></tr>
<tr><td>16</td><td rowspan="2">200 (2,0)</td></tr>
<tr><td>20</td></tr>
<tr><td>25</td><td rowspan="2">160 (1,2)</td></tr>
<tr><td>32</td></tr>
<tr><td>40</td><td rowspan="2">130 (1,3)</td></tr>
<tr><td>50</td></tr>
<tr><td>63</td><td rowspan="2">100 (1,0)</td></tr>
<tr><td>80</td></tr>
<tr><td>100</td><td rowspan="3">80 (0,8)</td></tr>
<tr><td>125</td></tr>
<tr><td>160</td></tr>
<tr><td>200</td><td rowspan="3">50 (0,5)</td></tr>
<tr><td>250</td></tr>
<tr><td>320</td></tr>
<tr><td colspan="2">NOTE Values are valid for both directions of stroke.</td></tr>
</table>

8.5 Failure due to exceeding the maximum test stroke time

A test unit shall be considered to have failed if the cylinder does not reach either end position within one half of the cycle time.

8.6 Customised agreements

Individual customers and industry segments can have requirements that do not conform to the requirements of this part of ISO 19973. Customized agreements on any deviations from this part of ISO 19973 shall be agreed between the cylinder manufacturer and its customer and shall be documented in test reports and in catalogue data.

9 Data analysis

Test data shall be analysed in accordance with ISO 19973-1. A test data sheet is shown in Annex B.

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.

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 piston rod cylinders assessed in accordance with ISO 19973-3, *Pneumatic fluid power — Assessment of component reliability by testing — Part 3: Cylinders with piston rod*.”

Annex A
(informative)

Methods for calculating side load masses and related dimensions

A.1 General

Test laboratories and cylinder manufacturers might want to test strokes other than those specified in this part of ISO 19973. This Annex assists them by providing methods to calculate side load masses, related dimensions and side load locations.

A.2 Symbols

In this Annex, the symbols listed in Table A.1 are used.

Table A.1 — Symbol list

Symbol[a]	Description	SI unit and value
AL	Piston diameter or bore of the cylinder	mm
d	Diameter of a round-shaped side load mass	mm
g	Acceleration of gravity	9,81 m/s^2
l_8	Length of the body of a cylinder conforming to ISO 15552	mm
LM	Longitudinal dimension of the side load mass	mm
LN	Optional space for counter nut	mm
LT	Distance between the theoretical reference point (TRP) and centre of gravity (CG)	mm
m_s	Mass used to create the side load	kg
M	Moment created by the side load	N·m
S	Cylinder stroke	mm
w	Width of a square-shaped side load mass	mm
WF	Distance between the TRP and the body of a cylinder conforming to ISO 6432	mm
WH	Distance between the TRP and the body of a cylinder conforming to ISO 15552 or ISO 21287	mm
XC	Distance between the TRP and bearing axis of a cylinder conforming to ISO 6432	mm
ZA	Length of the body of a cylinder conforming to ISO 21287	mm
ρ	Density of the side load material	kg/dm^3

[a] Other symbols can be used in other documents.

A.3 Calculation of side load masses related to stroke

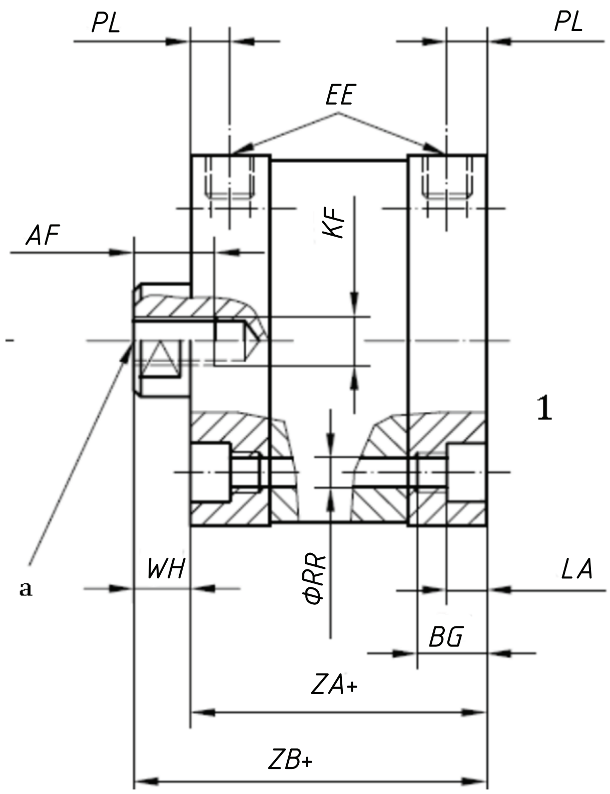
A.3.1 General

Side loads can be determined using Formulae (A.1), (A.2), or (A.3), depending on the cylinder class, which is based on the respective International Standards.

A.3.2 Class 1 (ISO 21287)

A.3.2.1 Basic dimensions

See Figure A.1 for the basic dimensions of cylinder conforming to ISO 21287 discussed in this Annex.



KeyT

1 drive for screw

a Theoretical reference point (TRP) according to ISO 6099.

Figure A.1 — Basic dimensions of cylinders conforming to ISO 21287 discussed in this Annex

A.3.2.2 Calculation of the moment

Use Formula (A.1) to calculate the moment:

$$M\left[\mathrm{N\cdot m}\right]=\frac{\left(LT+Stroke+WH+\dfrac{ZA}{2}\right)\left[\mathrm{mm}\right]\cdot Load\left[\mathrm{kg}\right]\cdot 9,81}{1000} \quad \text{(A.1)}$$

Table A.2 shows the results of calculating the moments for cylinders conforming to ISO 21287.

Table A.2 — Results of calculating the moments for cylinder conforming to ISO 21287

AL [mm]	LT_{min} [mm]	Stroke [mm]	*WH* [mm]	*ZA* [mm]	Load [kg]	*M* [N·m]
20	20	20	6	37	0,20	0,13
25	20	25	6	39	0,25	0,17
32	50	30	7	44	0,40	0,43
40	50	40	7	45	0,60	0,70
50	50	50	8	45	1,00	1,28
63	50	50	8	49	1,50	1,95
80	50	50	10	54	2,50	3,36
100	50	50	10	67	3,50	4,93

A.3.2.3 Calculation of the load

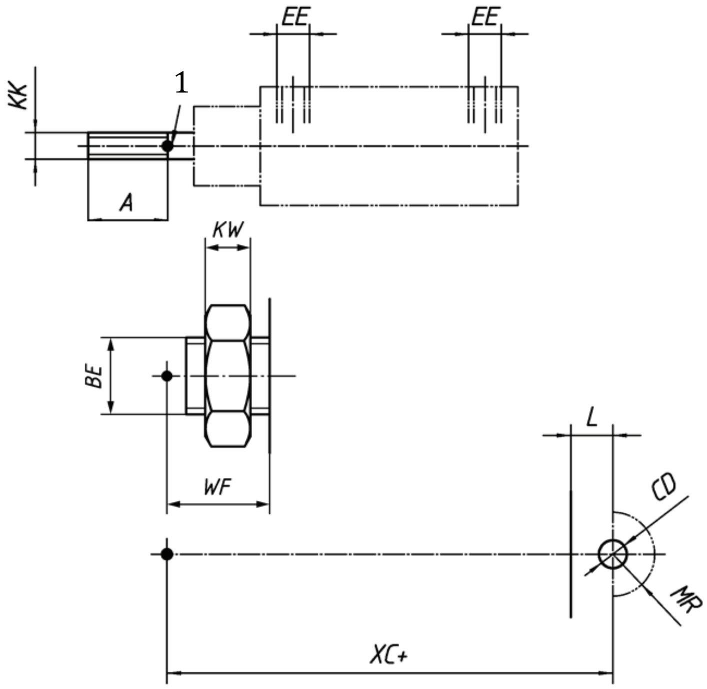
The test laboratory can determine the stroke, *LT*, and use Formula (A.2) to calculate the load:

$$Load\left[\text{kg}\right] = \frac{M\left[\text{N}\cdot\text{m}\right]\cdot 1000}{\left(LT + Stroke + WH + \frac{ZA}{2}\right)\left[\text{mm}\right]\cdot 9,81} \quad \text{(A.2)}$$

A.3.3 Class 2 (ISO 6432)

A.3.3.1 Basic dimensions

See Figure A.2 for the basic dimensions of cylinder conforming to ISO 6432 discussed in this Annex.



Key

1 theoretical reference point (TRP)

Figure A.2 — Basic dimensions of cylinders conforming to ISO 6432 discussed in this Annex

A.3.3.2 Calculation of the moment

Use Formula (A.3) to calculate the moment:

$$M\left[\mathrm{N}\cdot\mathrm{m}\right]=\frac{\left(LT+Stroke+WF+\dfrac{XC-WF-L}{2}\right)\left[\mathrm{mm}\right]\cdot Load\left[\mathrm{kg}\right]\cdot 9,81}{1000} \quad \text{(A.3)}$$

Table A.3 shows the results of calculating the moments for cylinders conforming to ISO 6432.

Table A.3 — Results of calculating the moments for cylinder conforming to ISO 6432

AL [mm]	LT_{min} [mm]	Stroke [mm]	*WF* [mm]	*XC–WF–L* [mm]	Load [kg]	*M* [N·m]
8	20	20	16	42	0,03	0,023
10	20	20	16	42	0,05	0,038
12	20	25	22	44	0,07	0,061
16	20	30	22	51	0,13	0,124
20	20	40	24	59	0,20	0,223
25	20	50	28	64	0,30	0,383

A.3.3.3 Calculation of the load

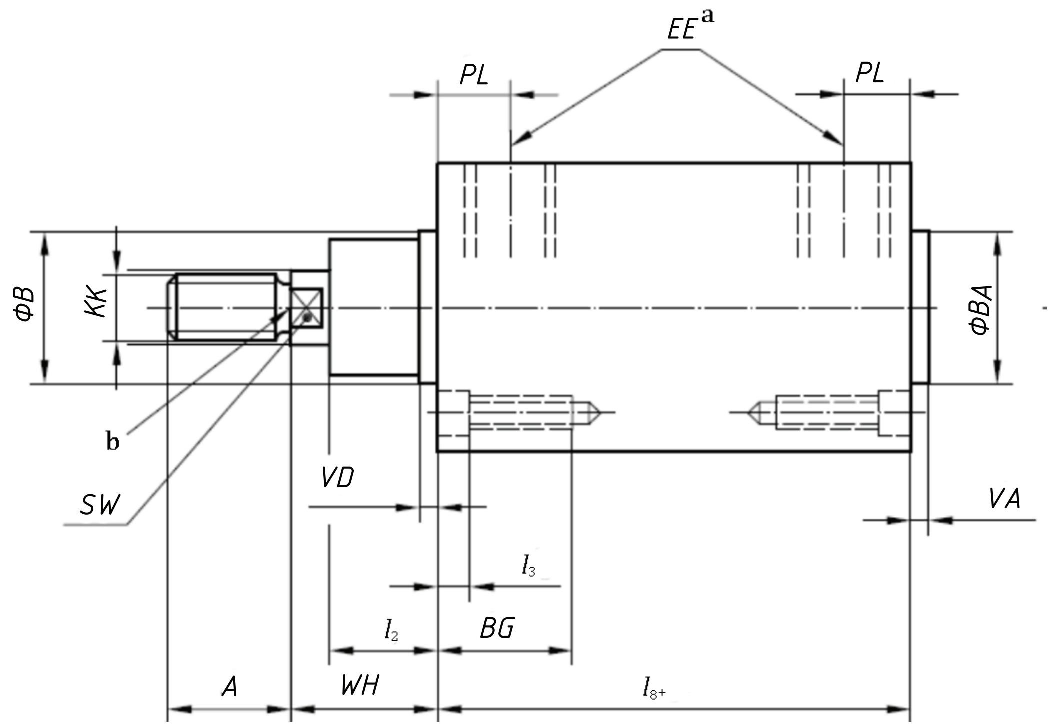
The test laboratory can determine the stroke, *L*, and use Formula (A.4) to calculate the load:

$$Load[\mathrm{kg}]=\frac{M[\mathrm{N}\cdot\mathrm{m}]\cdot 1000}{(LT+Stroke+WF+\dfrac{XC-WF-L}{2})[\mathrm{mm}]\cdot 9,81} \quad \text{(A.4)}$$

A.3.4 Class 3 (ISO 15552)

A.3.4.1 Basic dimensions

See Figure A.3 for the basic dimensions of cylinder conforming to ISO 15552 discussed in this Annex.



Key

a *EE* conforms to ISO 16030.

b Theoretical reference point (TRP).

Figure A.3 — Basic dimensions of cylinders conforming to ISO 15552 discussed in this annex

A.3.4.2 Calculation of the moment

Use Formula (A.5) to calculate the moment:

$$M[\mathrm{N} \cdot \mathrm{m}] = \frac{(LT + Stroke + WH + \frac{l_8}{2})[\mathrm{mm}] \cdot Load[\mathrm{kg}] \cdot 9,81}{1000} \tag{A.5}$$

Table A.4 shows the results of calculating the moments for cylinders conforming to ISO 15552.

Table A.4 — Results of calculating the moments for cylinder conforming to ISO 15552

AL [mm]	***LT*$_{min}$** [mm]	**Stroke** [mm]	***WH*** [mm]	***l*$_8$** [mm]	**Load** [kg]	***M*** [N·m]
32	50	160	26	94	2	5,55
40	50	160	30	105	3	8,61
50	50	160	37	106	4	11,77
63	50	250	37	121	6	23,40
80	50	250	46	128	9	36,20
100	50	250	51	138	12	49,44
125	50	320	65	160	16	80,83
160	50	320	80	180	20	105,95
200	50	320	95	180	30	163,34
250	50	320	105	200	40	225,63
320	50	320	120	220	50	294,30

A.3.4.3 Calculation of the load

The test laboratory can determine the stroke, L, and use Formula (A.6) to calculate the load:

$$Load[\mathrm{kg}] = \frac{M[\mathrm{N \cdot m}] \cdot 1000}{(LT + Stroke + WH + \frac{l_8}{2})[\mathrm{mm}] \cdot 9,81} \quad \text{(A.6)}$$

A.4 Side load masses and related dimensions

A.4.1 To make calculations easier, round- or square-shaped side load masses should be used.

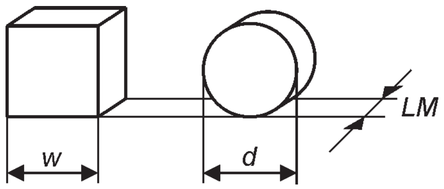


Figure A.4 — Shape of side loads

A.4.2 Side load masses, m_S, in kilograms, should be calculated using Formulae (A.7) and (A.8):

— For round-shaped side loads:

$$m_S = \frac{\pi}{4} \cdot d^2 \cdot LM \cdot \rho \cdot 10^{-6} \quad \text{(A.7)}$$

— For square-shaped side loads:

$$m_S = w^2 \cdot LM \cdot \rho \cdot 10^{-6} \quad \text{(A.8)}$$

where ρ is the density of the side load material (see A.4.3).

A.4.3 It is recommended that side loads be made from steel or brass, with the following densities:

— for steel, ρ = 7,85 kg/dm^3

— for brass, ρ = 8,50 kg/dm^3

A.5 Example of calculations

A.5.1 Example parameters

A double-acting cylinder conforming to ISO 15552 with a piston diameter of 32 mm and a stroke of 250 mm is tested in accordance with this part of ISO 19973. The side load is made from steel with a square shape. Space for a counter nut is taken into consideration. See Table A.5 for a summary of the values of all parameters.

Table A.5 — Parameters, symbols and values used in this example

Parameter	Symbol	Value
Test torque (see Table A.4 – cylinder dia. 32 mm)	M	5,55 N·m
Stroke	S	250 mm
Dimension *WH* (in accordance with ISO 15552)	WH	26 mm
Dimension l_8 (in accordance with ISO 15552)	l_8	94 mm
Space for counter nut	LN	10 mm
Longitudinal length of the square test load	LM	160 mm
Density of the test load material (steel)	ρ	7,85 kg/dm^3

A.5.2 Calculation of the load m_S

The load m_S can be calculated using Formula (A.9), which is a transformation of Formula (A.6):

$$Load[\text{kg}] = m_S = \frac{5,55[\text{N}\cdot\text{m}]\cdot 1000}{(90+250+26+\frac{94}{2})[\text{mm}]\cdot 9,81} \quad \text{(A.9)}$$

m_S = 1,37 kg

A.5.3 Calculation of the width of the load

The width of the square-shaped side load can be calculated using Formula (A.10), which is a transformation of Formula (A.8):

$$w[\text{mm}] = \sqrt{\frac{m_s[\text{kg}]\cdot 10^6}{LM[\text{mm}]\cdot \rho[\text{kg/dm}^3]}} \quad \text{(A.10)}$$

$$w[\text{mm}] = \sqrt{\frac{1,37[\text{kg}]\cdot 10^6}{160[\text{mm}]\cdot 7,85[\text{kg/dm}^3]}}$$

w = 33,0 mm

Annex B
(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 laboratory:		**Test number:**		**Sheet:**	of
Cylinder manufacturer:		**Model number:**		**Test unit identification number:**	
Bore: mm	**Rod diameter:** mm	**Stroke:** mm	**Port size:**	**Side load:**	kg
Cushions:	Rod end ☐ Cap end ☐ Both ends ☐ None ☐			**Side load distance:**	mm

			Temp.	**Inlet pressure** p_0	**Dew point**	**Cycle test data**						**Notes**
						Stroke time		**Inlet leakage dm³/h (ANR)**		**Minimum working pressure**		
						Extend	Retract	At rod end	At cap end	Extend	Retract	
			°C	kPa	°C	s	s	630 kPa	630 kPa	kPa	kPa	
		Threshold value:										
Date	**Counter**	**Cycles**										

Test laboratory:		**Test number:**		**Sheet:**		**of**	
Cylinder manufacturer:		**Model number:**		**Test unit identification number:**			

Date	**Counter**	**Cycles**		**Observations**

Bibliography

[1] ISO 6430, *Pneumatic fluid power — Single rod cylinders, 1 000 kPa (10 bar) series, with integral mountings, bores from 32 mm to 250 mm — Mounting dimensions*

[2] ISO 6432, *Pneumatic fluid power — Single rod cylinders — 10 bar (1 000 kPa) series — Bores from 8 to 25 mm — Mounting dimensions*

[3] ISO 15552, *Pneumatic fluid power — Cylinders with detachable mountings, 1 000 kPa (10 bar) series, bores from 32 mm to 320 mm — Basic, mounting and accessories dimensions*

[4] ISO 21287, *Pneumatic fluid power — Cylinders — Compact cylinders, 1000 kPa (10 bar) series, bores from 20 mm to 100 mm*

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