BRITISH STANDARD

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Industrial valves — Actuators

Part 3: Pneumatic part-turn actuators for industrial valves — Basic requirements

ICS 23.060.20

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 15714-3:2009.

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

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Foreword

This document (EN 15714-3:2009) has been prepared by Technical Committee CEN/TC 69 “Industrial valves”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2010, and conflicting national standards shall be withdrawn at the latest by April 2010.

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1 Scope

This document provides basic requirements for pneumatic part-turn valve actuators, both double acting and single acting, used for on-off and modulating control duties. It includes guidelines, recommendations and methods for enclosure and corrosion protection, control and testing.

It does not apply to pneumatic actuators which are integral parts of control valves.

Other requirements, or conditions of use, different from those indicated in this document, should be subject to negotiations, between the purchaser and the manufacturer/supplier, prior to order.

The terms and definitions applicable to this European Standard are given in EN 15714-1.

2 Normative references

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

EN 12570, *Industrial valves — Method for sizing the operating element*

EN 60529, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

EN ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation (ISO 228-1:2000)*

EN ISO 5211, *Industrial valves — Part-turn valve actuator attachments (ISO 5211:2001)*

EN ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests (ISO 9227:2006)*

ISO 5599-2, *Pneumatic fluid power — Five-port directional control valves — Part 2: Mounting interface surfaces with optional electrical connector*

ASME B1.20.1:1983, *Pipe Threads, General Purpose (Inch)*

3 Classification/Designation

3.1 General

Part-turn valve actuators are classified by action and interface as detailed below.

3.2 Action

a) Double Acting (DA)

b) Single Acting (SA) with spring action to move clock-wise (CW) or counter clock-wise (CCW), as per 4.5.4

3.3 Actuator attachment

As per EN ISO 5211.

3.4 Performance data

3.4.1 Output torques

The guaranteed minimum output torque capability of the actuator, in both directions, at specified supply pressures shall be provided by the manufacturer/supplier.

Where the output torque varies with the stroke, in a non-linear relationship, tabulated data and/or torque/stroke curves shall be provided.

3.4.2 Minimum moving pressure

The actuator minimum moving pressure for double acting actuators, at ambient temperature, shall be made available, by the manufacturer/supplier upon request.

3.4.3 Operating time

The actuator manufacturer/supplier shall state the minimum operating time in both directions, without external load, at nominal pressure and without any significant external restriction on supply flow rate and exhaust.

3.4.4 Air volume

The manufacturer/supplier shall state the internal actuator displaced volume (litres) for both directions, including the dead volumes (see Clause 8).

3.4.5 Motive energy

3.4.5.1 Operating medium

The operating medium should be compressed air, unless otherwise specified.

Other compressed gases or pressurised fluids may be used, on agreement between the manufacturer/supplier and purchaser, ensuring they are compatible with internal actuator parts and lubricants.

3.4.5.2 Quality

The operating medium shall have a dew point equal to – 20 °C or, to be at least, 10 °C below the ambient temperature (ISO 8573-1, Class 3). The maximum particle size shall not exceed 40 µm (ISO 8573-1, Class 5).

3.4.5.3 Pressure

The manufacturer/supplier shall indicate the actuator's pressure limits. The maximum allowable pressure shall be at least 0,8 MPa (8 bar), unless otherwise specified. The minimum test pressure for pressurised parts shall be 1,43 times the maximum allowable pressure.

4 Design requirements

4.1 Endurance of part-turn actuators

The actuator shall be designed to have a minimum endurance, without maintenance, in accordance with values given in Table 1. These are based on a load of at least 60 % of the run torque at 0,55 MPa ≅ 5,5 bar supply pressure and in accordance with the test procedure detailed in Annex A.

Table 1 — Minimum number of cycles — Endurance test

Nominal torque [a] Nm	**Piston or vane actuator Minimum number of cycles** [b]	**Maximum stroking time for testing, based on 0-90°** s
≤ 125	500 000 [c]	3
≤ 1 000	500 000	5
≤ 2 000	250 000	8
≤ 8 000	100 000	15
≤ 32 000	25 000	20
≤ 63 000	10 000	30
≤ 125 000	5 000	45
≤ 250 000	2 500	60

[a] Based on EN ISO 5211.

[b] One cycle consists of nominal 90° angular travel in both directions (i.e. 90° to open + 90° to close). For angular travel other than 90°, the endurance shall be agreed between the purchaser and the manufacturer/supplier.

[c] For thermoplastic actuators the minimum number of cycles shall be 250 000.

4.2 Leakage

The actuator shall have no visible external leakage as detailed in Table 8 for the duration of the production test.

The test pressure shall be at least nominal pressure (0,55 MPa ≅ 5,5 bar).

The minimum duration for the leakage detection test shall be:

a) 15 s for volumes up to and including 2 l;

b) 30 s for volumes up to and including 5 l;

c) 60 s for volumes above 5 l.

4.3 Angle for part-turn actuators

Part-turn actuators without adjustable end-stops shall be designed for an output movement of 90° (- 0°, + 2°) as standard.

For part-turn actuators with adjustable end-stops and a standard nominal output movement of 90°, the adjustment range shall be stated by the manufacturer/supplier and shall be, at least, ± 3°.

Other angles are subject to agreement between the manufacturer/supplier and purchaser.

4.4 Environmental conditions

4.4.1 Ambient temperature

The actuator shall be designed for operation at an ambient temperature range between – 20 °C and + 60 °C, unless otherwise agreed between the manufacturer/supplier and purchaser.

4.4.2 Enclosure protection

The non pressurised enclosure of the actuator shall be IP 6X according to EN 60529 (excluding the exhaust port).

4.4.3 Corrosion protection

Pneumatic actuators shall be protected against external corrosion by proper material selection and/or surface treatment. The actuator manufacturer's technical documentation shall specify the corrosion protection category according to Table 2.

Table 2 — Environmental corrosion categories

Corrosion category	Typical environments	
	Exterior	Interior
C2 (low)	Atmospheres with low level of pollution. Mostly rural areas.	Unheated buildings where condensation may occur, e.g. depots, sport halls.
C3 (medium)	Urban and industrial atmospheres, moderate sulphur dioxide pollution. Coastal areas with low salinity.	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries.
C4 (high)	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal shipyards.
C5-I (very high — industrial)	Industrial areas with high humidity and aggressive atmosphere.	Buildings or areas with almost permanent condensation and with high pollution.
C5-M (very high — marine)	Coastal and offshore areas with high salinity.	Buildings or areas with almost permanent condensation and with high pollution.
Immersed in water [a]		
Im 1 (Immersed in fresh water)	River installations, hydro-electric power plants.	
Im 2 (Immersed in sea or brackish water)	Harbour areas and offshore structures.	
[a] Pneumatic actuators covered by this European Standard are not designed for permanent immersion unless otherwise specified.		

NOTE 1 Table 2 is taken, for reference purposes only, from EN ISO 12944-2. The actuator corrosion protection may also be achieved by systems/methods which deviate from those specified in EN ISO 12944-5.

NOTE 2 Table 2 may be used to define the corrosion category in order to help the actuator manufacturers to define the surface treatment for corrosion protection. Test assessment and test procedures are the responsibility of the manufacturer.

4.5 Basic design

4.5.1 Safety requirements

Actuators shall be designed taking into account the technical principles and specifications for safety. The design of spring return actuators shall permit the safe assembly/disassembly, when complying with the manufacturer/supplier’s instructions.

4.5.2 Part-turn actuator attachment

The attachment for part-turn actuators shall comply with EN ISO 5211.

The output drive of part-turn actuators may be an integral part or a removable component to allow it, when necessary, to be machined to suit the driven component of the valve.

The material of the drive component shall clearly be indicated in the manufacturer's/supplier's documentation.

4.5.3 Pressure connections and pilot valves interface

The actuators shall have two pressure connections, unless otherwise specified.

The position, location, orientation and form of the pressure connections shall be established by the manufacturer.

Connections shall be clearly identified with numbers (2 and 4), in accordance with ISO 5599-2. When pressurised, direction of movement shall be in accordance with Table 3 below, unless otherwise specified.

The dimensions of the pressure connections/interface shall be as specified in Tables 3 and 4 and Figures 1 and 2. The actuator shall be properly marked to indicate the type of thread.

Table 3 — Identification of the part-turn actuator pressure connections

Direction of movement (when viewed from the ancillaries' mounting interface)	Connection 2	Connection 4
	Counter-clockwise	Clockwise

Table 4 — Dimensions of the pressure connections for remotely mounted pilot valves

Air volume [a] V l	**Diameter** [b] **(minimum)** D	**D4** [c] **(minimum)** mm	
		EN ISO 228-1 (G)	**ASME B1.20.1 (NPT)**
$V < 1$	1/8“	8	7
$0,5 < V < 10$	1/4“	12	11
$5 < V < 25$	3/8“	13	11
$10 < V < 50$	1/2“	16	14
$25 < V < 100$	3/4“	17	15
$V > 50$	1“	20	17

[a] Air volume as defined in 3.4.4. The relationship between air volume V and dimensions of connections "2" and "4" are given as guidelines.

[b] According to EN ISO 228-1 (G) or ASME B1.20.1 (NPT).

[c] Min. proof strength of material $R_{p0,2}$ > 150 MPa and 0,8 MPa (8 bar) maximum operating pressure.

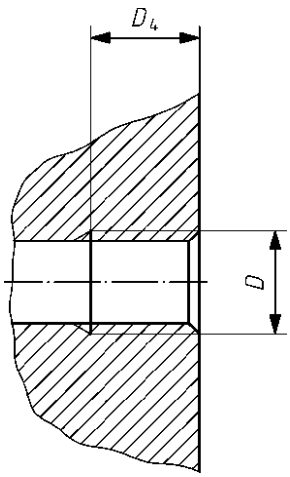


Figure 1 — Dimensions of pressure connections for remotely mounted pilot valves

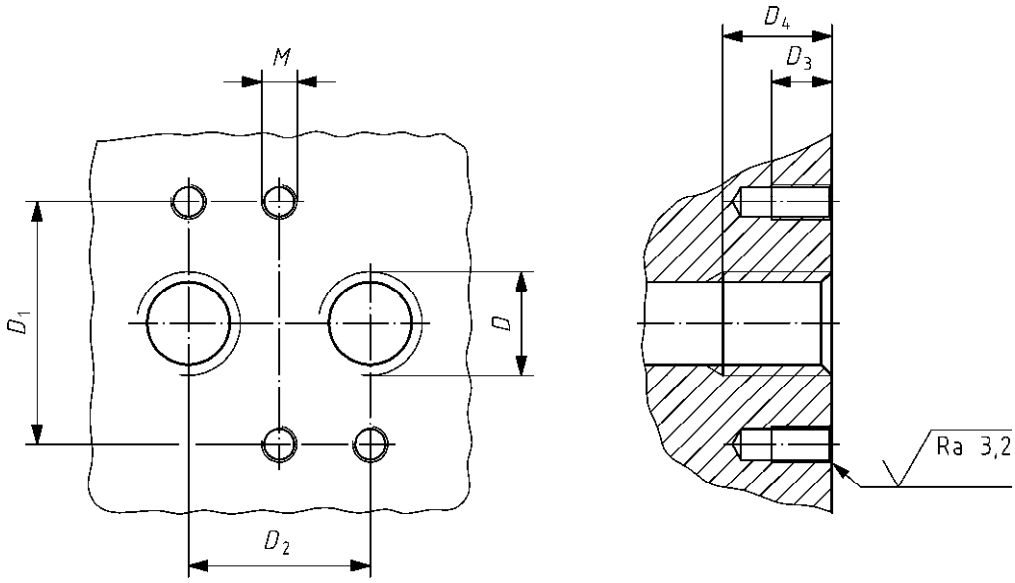


Figure 2 — Interface for direct mounted pilot valves

Table 5 — Interface for direct mounted pilot valves

Type of pressure connection flange	Air volume [a] *V*	*D* [b]	*D1* mm	*D2* mm	*D3* mm	*D4* [c] (minimum) mm	*M* mm
G ⅛ or ⅛ NPT	$V < 1$	⅛“	32	24	8	8	M5
G ¼ or ¼ NPT	$0,5 < V < 10$	¼“	32	24	8	12	M5
G ⅜ or ⅜ NPT	$5 < V < 25$	⅜“	45	40	10	13	M6
G ½ or ½ NPT	$10 < V < 50$	½“	45	40	10	16	M6

[a] Air volume as defined in 3.4.4 The relationship between air volume V and dimensions of connections "2" and "4" are given as guidelines.

[b] According to EN ISO 228-1 (G) or ASME B1.20.1 (NPT).

[c] Minimum proof strength of material $R_{p0,2}$ > 150 MPa and 0,8 MPa (8 bar) maximum operating pressure.

[d] The actuator shall have a suitable surface, to allow correct sealing of the ancillary component around the threaded connections "2" and "4" (see Figure 2).

4.5.4 Fail safe direction for spring return actuators

For spring return actuators, the direction of movement, on loss of supply pressure, shall be clearly and permanently indicated in accordance with Figure 3 (see Clause 6).

a) Turn clockwise (CW) **b) Turn counter clockwise (CCW)**

Figure 3 — Fail safe directions for part-turn actuators

4.5.5 Mechanical safety factors

Pressurised actuator enclosures shall be designed with minimum safety factors as given in Table 6 below, taking into consideration 3.4.5.3.

Table 6 — Minimum safety factors

Material	Proof strength as appropriate	Tensile strength
Ferritic steel	$R_{p0,2}/1,5$	$R_m/2,4$
Austenitic stainless steel, A5 >30 %	$R_{p1,0}/1,5$	—
Austenitic stainless steel, A5 > 35 %	$R_{p1,0}/1,2$	$R_m/3$
Cast steel	$R_{p0,2}/1,9$	$R_m/3$
Aluminium	$R_{p0,2}/1,5$	—
Aluminium (non hardenable)	$R_{p0,2}/1,5$	$R_m/2,4$
Other materials	Calculations shall utilise the values appropriate to the properties of the material.	

Unpressurised enclosures shall be designed to remain unpressurised also in case of malfunction or failure.

4.5.6 Position indication

The actuator shall be equipped with an indicating arrangement or device to clearly show the valve obturator's position, which shall be linked with the valve obturator during power and/or manual operation. It shall be possible to adjust the indicator when necessary.

4.6 Optional equipment

4.6.1 Ancillaries

The actuator design shall allow the attachment of ancillaries, such as:

a) limit switches;

b) positioner;

c) position transmitter;

d) solenoid and/or manual operated valves;

e) adjustable flow control devices;

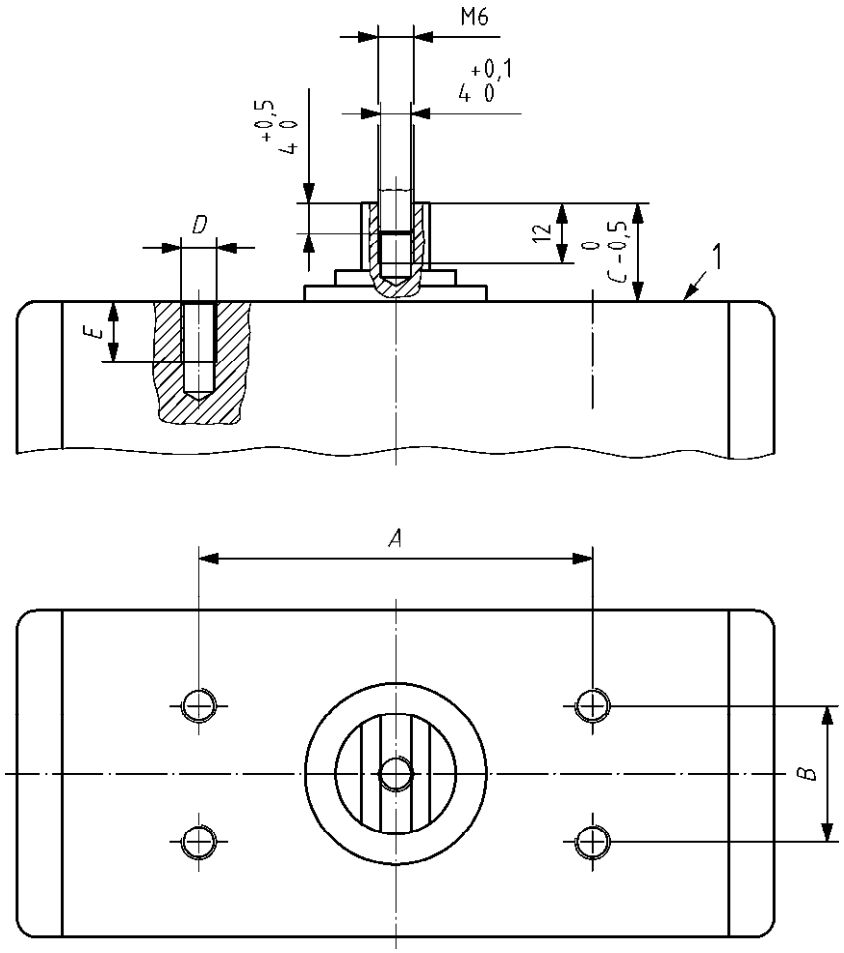
f) safety devices.

The actuator shall have an ancillaries' mounting interface as shown in Table 7 or as agreed between the manufacturer/supplier and the purchaser.

The actuator interface shall have 4 threaded holes according to Table 7 and Figure 4 (see also EN 60534-6-2).

The length C of the drive shaft, distances A and B of the holes and relevant attachment dimensions, for mounting level 1, shall be in accordance with Table 7.

The shaft shall have a slot and a threaded hole according to Figure 4. If the slot is used as a position indicator it shall be parallel to the pipe axis when the valve is open.



Key

1 level 1

Figure 4 — Dimensions of accessories flange for part-turn actuators

Table 7 — Dimensions of the actuator interface for the attachments of ancillaries for mounting level 1

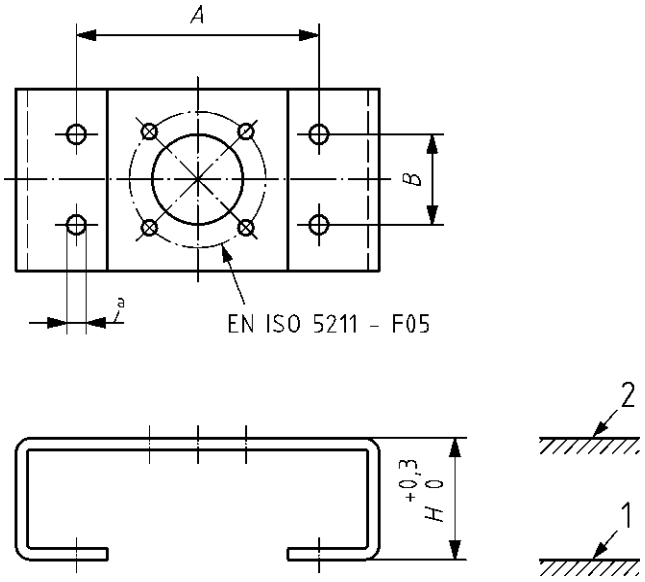
Size	Air volume [a] V l	A	B	C 0 − 0,5	D	E (minimum)	H + 0,3 0
AA 0	$V < 1$	50	25	15	M5	8	40
AA 1	$0,5 < V < 10$	80	30	20	M5	8	45
AA 2	$5 < V < 25$	80	30	30	M5	8	55
AA 3	$5 < V < 25$	130	30	30	M5	8	55
AA 4	$10 < V < 100$	130	30	50	M5	8	75
AA 5	$V > 50$	200	50	80	M6	10	105

[a] Air volume as defined in 3.4.4. The relationship between air volume V and dimensions of mounting levels 1 and 2 are given as guidelines.

The mounting of positioners and signal devices to part-turn actuators is also possible with a bracket with dimensions according to the Table 7 and Figure 5.

— Mounting Level 1 : fixing level for the bracket to an actuator with dimensions given in Table 7.

— Mounting Level 2: fixing level on the bracket for positioners and signal devices with F05 attachment in accordance with EN ISO 5211.



Key

a 5,5 (for M5) or 6,5 (for M6)

1 level 1

2 level 2

Figure 5 — Dimensions of optional ancillaries bracket

4.6.2 Manual operation

When specified, the actuator shall be supplied with a means of manual operation.

The manual operating forces shall be in accordance with EN 12570.

The design shall include the following safety related features:

a) The manual operating element (handwheel or lever) shall remain stationary under power operation.

b) The power operation shall be disabled before or when manual operation is engaged.

c) Clear and permanent indication shall be provided to show the opening/closing directions of the manual override which shall be clockwise to close, unless otherwise specified.

4.6.3 End stop adjustment for part-turn actuators

When required, part-turn actuators shall be supplied with at least one adjustable end stop (refer to 4.3).

5 Conformity assessment

5.1 General

The manufacturer/supplier shall demonstrate the compliance of his products to this European Standard by:

a) carrying out all the type tests (see 5.2) to ensure all “fitness for purpose” criteria are met;

b) controlling the production process (see 5.3) to ensure the required performance levels are continuously maintained.

5.2 Type tests

The type tests shall correspond to all requirements stated in Clause 4.

Type test shall be carried out on actuators that are representative of the current production.

Type tests results shall be recorded in a test report, detailing the type, quantity and sizes of the actuators tested and the test equipment and measuring devices used.

To qualify a range of actuators, of the same design and of the same action, manufactured under the same process and from the same or equivalent materials, the type tests may be carried out on a limited number of sizes by applying the following rule:

When an actuator having a nominal output torque “x” is qualified, all actuators having nominal output torques between 50 % x and 200 % x [x/2 or 2x] are considered qualified.

When an actuator with a rotation of “y” is qualified, all actuators having a rotation between “y/2” and “2y” are also considered qualified.

The type test shall be carried out by the manufacturer/suppliers, or by a competent testing institute.

A full report of these tests shall be retained by the manufacturer/supplier as evidence of compliance.

The appropriate type tests shall be repeated when the design, or the production process have been modified, which could affect the functional performances.

The type tests to be performed shall be those given in Table 8.

5.3 Control of production process and quality system

The manufacturer/supplier shall have a Quality Control System capable of ensuring manufactured products comply with the performance requirements of this European Standard.

The production verifications to be performed should be those given in Table 8.

Table 8 — Type and production tests

Clause	Requirement	Type tests	Production verifications
3.4.1	Output torque	Validate manufacturer/supplier's values at nominal pressure (5,5 bar) and ambient temperature (15 °C to 30 °C)	When required
3.4.5.3	Pressure	Shell test	When required
4.1	Endurance	Endurance test according to 4.1 and Annex A	—
3.4.2	Minimum moving pressure	Validate manufacturer/supplier's values at ambient temperature (15 °C to 30 °C)	—
4.2	Leakage	Validate manufacturer/supplier's values as per 4.2 and Clause A.5, at temperature ≤ – 20 °C and ≥ + 60 °C unless otherwise agreed between the manufacturer/supplier and purchaser	yes at room temperature (15 °C to 30 °C).
3.3.3	Operating time	Validate manufacturer/supplier's values	When required
4.3	Angle	Validate manufacturer/supplier's value (see 4.3 and 4.6.3)	If applicable, check 100 % output movement
3.3.4	Air consumption	Validate manufacturer/supplier's values	—
4.4.2	Enclosure	See technical data sheet and test reports of manufacturer/supplier according to EN 60529.	—
4.4.3	Corrosion protection	See technical data sheet and test reports of manufacturer/supplier according to EN ISO 9227.	—
4.5	Basic design	See manufacturer's drawings, materials classification, calculation, test reports and relevant standards.	—
4.5.6	Position indicator	See manufacturer's drawings	functional test
4.6	Optional equipment	See manufacturer's drawings, test reports and relevant standards	functional test with accessories, when fitted
6	Marking	See Clause 6	See Clause 6
8	Documentation	See Clause 8	See Clause 8

6 Marking

6.1 General requirements on marking

Each actuator shall bear the following permanent indications:

a) manufacturer/supplier’s name and/or trade mark;

b) model number;

c) serial number and/or date of manufacture;

d) maximum permissible pressure MPa or bar;

e) fail safe direction for spring return actuators (as per 4.5.4);

f) actuator attachment designation (as per 4.5.2);

g) mandatory marks.

The following information is optional:

h) reference to this European Standard;

i) pressure connection types (as per 4.5.3.);

j) ancillary attachment type (as per 4.6.1);

k) maximum output torque;

l) nominal output torque.

7 Part-turn actuator selection guidelines

Annex B gives detailed explanations for a proper actuator selection.

8 Documentation

The language of the relevant documentation shall be agreed between the manufacturer/supplier and the purchaser.

The Manufacturer/Supplier shall provide the following:

a) transport and storage instructions;

b) air volume (as per 3.4.4) and pressure connection type (as per Table 4);

c) installation, commissioning, operating and maintenance instructions;

d) mandatory documentation.

The following is optional:

e) detailed overhaul instructions;

f) pneumatic schematic and electric wiring diagram (when applicable);

g) itemized spare parts list;

h) list of recommended spare parts;

i) production test certificate (as per 5.3).

Annex A
(normative)

Endurance test procedure

A.1 General

Actuators complying with this European Standard shall be type-tested in agreement with the following:

A.2 Test equipment

The test rig shall provide a measurable torque, shall allow the attachment of the actuator and shall be suitably designed to allow the full travel of the actuator.

The test rig shall be equipped with following calibrated devices:

a) a leakage measurement device;

b) a pressure measurement device;

c) an operating cycle counter;

d) an instrument for measuring the applied torque and the operating stroke;

e) an angular position measuring device.

A.3 Test conditions

The test shall be conducted at room temperature (between 15 °C and 30 °C), under the conditions given in 4.1

The operating medium shall be compressed air at 0,55 MPa (5,5 bar) or that agreed between the manufacturer/supplier and the purchaser, and shall comply with 3.4.5.

A.4 Test procedure

The operating time and cycles shall be as specified by the manufacturer, in accordance with 4.1.

Torque values versus angular stroke, in 10° intervals in both directions of travel, shall be recorded, at room temperature between 15 °C and 30 °C, at least at the start and at the end of the endurance test.

External actuator leakage rates at room temperature shall be measured and recorded at the beginning and at the end of the test, at both end of travel positions.

A.5 Acceptance criteria

At the end of the test, results shall comply with following criteria:

The final torque values shall not be less than 90 % of the initial values.

The final operating stroke shall remain between 98 % and 102 % of the initial value.

The final leakage values at 0,55 MPa (5,5 bar) shall not exceed the rates given in Table A.1.

Table A.1 — Maximum leakage rates

Nominal torque Nm	**Maximum leakage** Nmm^3/s
≤ 125	100
≤ 2 000	200
≤ 8 000	500
> 8 000	1 000

Annex B
(informative)

Actuator selection guidelines

B.1 General

Actuated valve malfunctions are often due to the under sizing of actuators. The initial material cost «saving» is usually insignificant, compared with the costly production losses and/or danger presented to personnel.

Conversely, it is even more important, that excessive safety factors are not applied to valve torques which may result in selected actuators being capable of twisting/shearing valve stems and possibly transmitting a feedback signal that does not correspond to the valve position. This is usually associated with critical valve applications e.g. ESD (Emergency Shut Down) valves.

It is therefore essential that the correct size of actuator is selected together with any associated ancillary equipment.

To obtain all the information it may be necessary to question the end user, the contractor/designer, the valve manufacturer, the actuator manufacturer and ancillary equipment manufacturers.

The aim of these guidelines is to provide a clear understanding of the torque requirements and what parameters affect the correct actuator selection. Relevant questions need to be answered regarding the valve operating service, the actuator working parameters/environment, ancillary equipment and local regulations.

B.2 Selection parameters

Determine the appropriate torques and strokes taking into consideration the following parameters and questions.

1.0 Valve questions:

- 1.1. Valve manufacturer, type, size, function and operating characteristics.
- 1.2. Operating Conditions: media, temperature, pressure, flow rate, frequency of operation and required stroking time.
- 1.3. Valve torque characteristics [seating/unseating, dynamic torque (when applicable)].
- 1.4. Maximum allowable stem torque limitation (MAST).[1]
- 1.5. Safety factors.

2.0 Actuator questions:

- 2.1. Operating medium.
- 2.2. Supply pressure: minimum and maximum.
- 2.3. Duty: on/off or control.
- 2.4. Action: double acting or single acting, (spring to open or spring to close).
- 2.5. Fail-safe requirement: to open, close or stay put, also considering associated pilot valves.

1 Note that the valve stem is not necessarily the weakest part in the drive train.

2.6. Operating time in both directions.

2.7. Frequency of operations.

3.0 Ancillary questions:

3.1. Limit switches: type, voltage and local electrical regulations.

3.2. Positioners: pneumatic or electro-pneumatic.

3.3. Position transmitters: local electrical regulations.

3.4. Solenoid valve: consider all actuator questions (adjustable flow control devices may be required when considering 2.6).

4.0 Environmental conditions:

4.1. Indoor, outdoor, saline, corrosive chemicals, etc..

4.2. Enclosure protection type.

4.3. Hazardous or non-hazardous areas.

4.4. Ambient temperature.

NOTE These points are relevant to all ancillaries and suitable materials/protection should be selected.

B.3 Actuator selection

B.3.1 General

After providing answers to 1.0, it is the responsibility of the valve manufacturer to provide operating torque values, throughout the valve's stroke in both directions, including any relevant safety factors and the maximum torque that can be applied to the valve stem.

Once the valve's torque characteristic values have been established, select an actuator, considering the minimum supply pressure specified by the purchaser, that provides a torque (Start torque, Run torque (when applicable) and End torque) greater than the maximum valve operating torque, taking into consideration varying valve torque values throughout its stroke, in both directions.

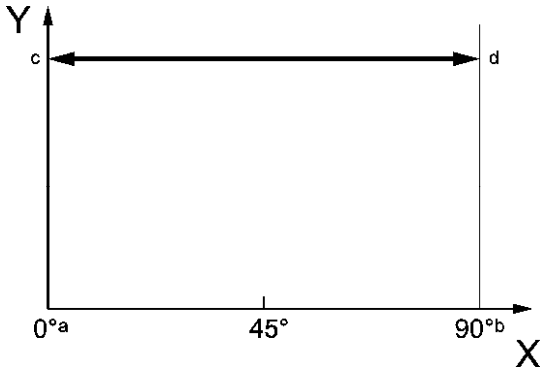
The Figures B.1, B.2, B.3 and B.4 give, as examples, the torque characteristics (force and vector) of the mainly used mechanical systems (rack and pinion, vane and scotch yoke actuators).

At the maximum supply pressure, the maximum output torque of the selected actuator shall not exceed the maximum allowable valve stem torque limitation (MAST).

Operating time is checked and if necessary, modifications and/or the appropriate ancillary equipment is selected.

Select appropriate materials, corrosion protection system, command and control ancillaries according to the environmental conditions, local regulations and purchaser requirements/specifications.

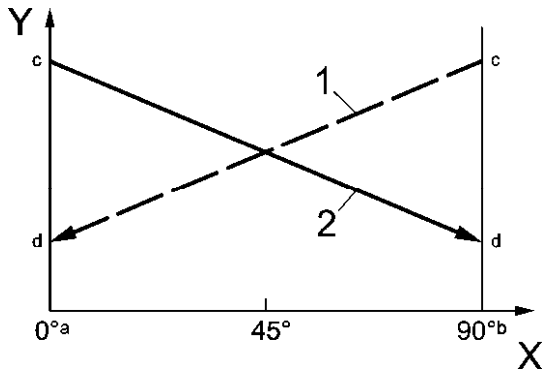
B.3.2 Torque characteristics for rack and pinion or vane actuators



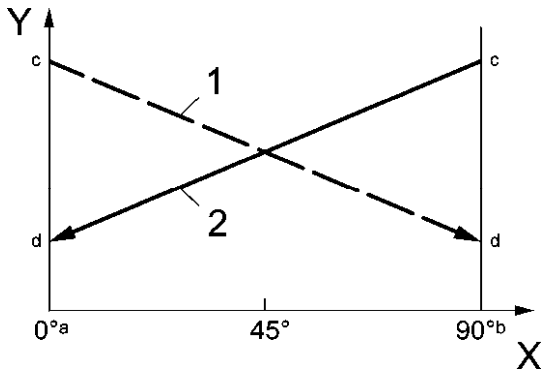
Key

X travel (degrees)
Y output
a closed
b open
c start opening, end closing
d end opening, start closing

Figure B.1 — Double acting actuator



a) fail safe close



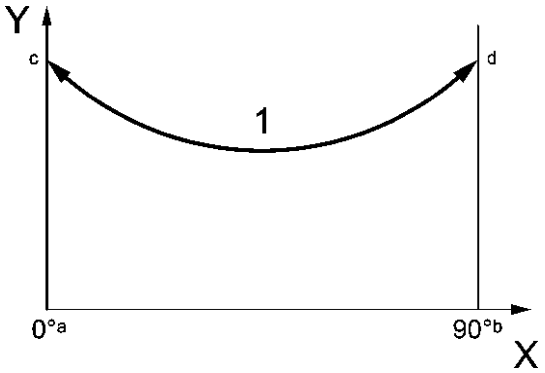
b) fail safe open

Key

X travel (degrees)
Y output
a closed
b open
c start
d end
1 spring
2 air

Figure B.2 — Single acting actuator

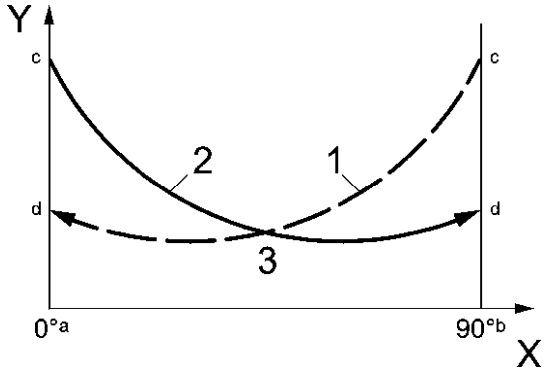
B.3.3 Torque characteristics for scotch yoke actuators (e.g. symmetric system)



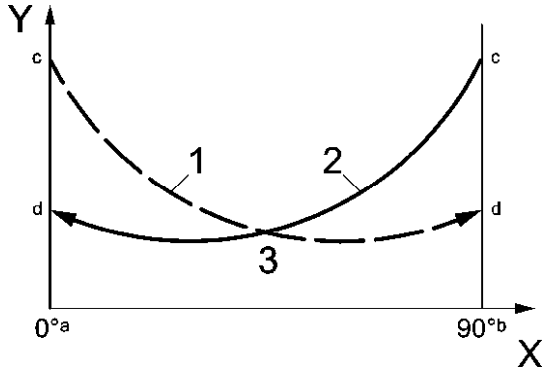
Key

X travel (degrees)
Y output
a closed
b open
c start opening, end closing
d end opening, start closing
1 run torque

Figure B.3 — Double acting actuator



a) fail safe close



b) fail safe open

Key

X travel (degrees)
Y output
a closed
b open
c start
d end
1 spring
2 air
3 run torque

Figure B.4 — Single acting actuator

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