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Standard for Actuators and Mounting Kits for Valves

API STANDARD 6DX

THIRD EDITION, XXXXXXXXXXXXXXX, 202X

BALLOT DRAFT

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Introduction

Changes from 2nd to the 3rd Edition

This standard is the result of updating the requirements from API Standard 6DX, 2nd Edition, including Addendum 1. The revision of API 6DX, 3rd Edition, was developed based on input from the API 6DX Task Group global technical experts. The technical revisions have been made to accommodate the needs of the industry and address interpretations to move this standard to a higher level of service to the petroleum and natural gas industry. Highlights of some of the significant changes between the 2nd Edition and 3rd Edition, include:

- Annex A, Sizing of Actuators, is normative.
- Valve data requirements have been moved to Annex A.
- The standard addresses 3rd party suppliers of actuators (valve manufacturer, distributor/stockist, value-add-center, integrator, etc.) and defines requirements for these organizations to follow.
- Provide new definitions for *manufacturer*, *module* and *secondary gearbox*.
- Provide new figures (Figure 1-5) for different types of actuators.
- Revised Figure 1 (now Figure 6) for clarity.
- Added requirements for the assembly of modules by the supplier.
- Added requirements for testing of actuators by the supplier.
- Added requirements for functional test of valve and actuator assembly.

Units of measurement

In this specification, data are expressed in both U.S. customary (USC) and metric (SI) units.

Rounding

Except as otherwise required by this specification, to determine conformance with the specified requirements, observed or calculated values are rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding method of ASTM E29 or ISO 80000-1, Annex B, Rule A.

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1 Scope

This standard defines the requirements for design, mechanical integrity, and sizing of actuators and related components used on valves that conform to API Specification 6D.

This standard is applicable to the following:

- a) electric actuator (including secondary gearbox);
- b) pneumatic actuator;
- c) hydraulic actuator;
- d) Electro-hydraulic;
- e) Direct gas;
- f) override system;
- g) actuator assembled from modules;
- h) mounting kit.

This standard is not applicable to the following:

- g) operators installed on control valves;
- h) operators used for regulation;
- i) operators in subsea service;
- j) handheld powered devices;
- k) operator control system equipment/components;
- l) instrument tubing;
- m) fittings.

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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.

API Specification 6D,¹ *Specification for Valves*

ASME Boiler and Pressure Vessel Code,² Section VIII, Division 1, *Rules for Construction of Pressure Vessels*

ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, Alternative Rules, *Rules for Construction of Pressure Vessels*

ASME Boiler and Pressure Vessel Code, Section IX, *Welding and Brazing Qualifications*

ASNT SNT-TC-1A, *Non-Destructive Testing*

ASTM A370,³ *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM B733, *Standard Specification for Autocatalytic (Electroless) Nickel-Phosphorus Coatings on Metal*

ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

AWS D1.1/D1.1M,⁴ *Structural Welding Code — Steel*

AWS QC1, *Standard for AWS Certification of Welding Inspectors*

EN 10204,⁵ *Metallic products — Types of inspection documents*

ISA 7.0.01⁶, *Quality Standard for Instrument Air*

¹ American Petroleum Institute, 200 Massachusetts Ave, NW, Washington, DC 20001, USA.

² American Society of Mechanical Engineers International, 345 East 47th Street, New York, NY 10017-2392, USA.

³ American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA.

⁴ American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, www.aws.org.

⁵ CEN, European Committee for Standardization, Central Secretariat, Rue de Stassart 36, B-1050 Brussels, Belgium.

⁶ International Society of Automation, 3252 S. Miami Blvd. #102, Durham, NC 27703, <https://www.isa.org/>

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ISO 148-1,⁷ *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 4406:1999, *Hydraulic fluid power — Method for coding the level of contamination by solid particles*

ISO 5210, *Industrial valves — Multi-turn valve actuator attachments*

ISO 5211, *Industrial valves — Part-turn actuator attachments*

ISO 8573-1, *Contaminants and purity classes*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

ISO 12944-2, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments*

ISO 80000-1:2009, *Qualities and units — Part 1: General*

IEC 60529,⁸ *Degrees of protection provided by enclosures (IP Code)*

MSS SP-101, *Part-Turn Valve Actuator Attachment — FA Flange and Driving Component Dimensions and Performance Characteristics*

MSS SP-102, *Multi-Turn Valve Actuator Attachment — Flange and Driving Component Dimensions and Performance Characteristics*

NACE MR0175/ISO15156⁹ (all parts), *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

SAE AS4059¹⁰, *Contamination Classification for Hydraulic Fluids*

⁷ International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

⁸ IEC, International Electrotechnical Commission, Central Office, 3, rue de Varembe, CH-1211 Geneva 20, Switzerland

⁹ National Association of Corrosion Engineers, NACE International, 15835 Park Ten Place, Houston, Texas 77084, www.nace.org.

¹⁰ SAE International, 400 Commonwealth Drive, Warrendale, PA 15096, <https://www.sae.org/>

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3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

actuator

Electrically, pneumatically, or hydraulically powered device bolted or otherwise attached to the valve for applying torque or thrust to open and close a valve.

3.1.2

actuator, linear

Actuator that transmits thrust to the valve for a defined linear stroke.

3.1.3

actuator, multi-turn

Actuator that transmits torque to the valve by a rotation of more than one revolution.

3.1.4

actuator, part-turn

Actuator that transmits torque to the valve by a rotation of one revolution or less.

3.1.5

breakaway thrust

breakaway torque

Maximum thrust or torque required to operate a valve at maximum pressure differential.

3.1.6

cycle

Operation from the fully closed to fully open and return to the closed position, or fully open to fully closed and return to the open position.

3.1.7

drive shaft

Driven component of the mounting kit (drive adapter, drive tube) that allows transmission of torque and/or thrust from an actuator to the valve shaft/stem.

3.1.8

drive train

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Parts in the actuator and mounting kit designed to provide the transmission of torque/thrust, not including the valve stem.

3.1.9

manufacturer

An organization that makes the original equipment in conformance with the requirements of this Standard.

3.1.10

maximum allowable stem torque/thrust

MAST

Maximum torque/thrust that is permissible to apply to the valve drive train without risk of damage, as defined by the valve manufacturer/supplier.

3.1.11

maximum pressure differential

maximum difference between the upstream and downstream pressure across the valve closure member at which the closure member may be operated (see API 6D).

3.1.12

mechanically loaded parts

Actuator and mounting kit parts that transmit torque/thrust or other structural loads, or any combination thereof.

3.1.13

module

A sub-assembly of parts when combined with other sub-assemblies comprise a complete actuator (e.g., power cylinder, spring canister, transmission gearing).

3.1.14

mounting kit

Components that may be comprised of combinations of the following: mounting spool, drive shaft, drive key, dowel pin, and bolting.

3.1.15

mounting spool

Structural component (e.g. bracket, pipe, adapter flange) that connects the actuator to the valve.

3.1.16

no visible leakage

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As applied to air or gas testing, a leak that produces no visible formation of bubbles in a water immersion test or after the application of leak detection fluid at the test pressure and for the duration of the test.

3.1.17

operating time

Duration expressed in seconds of the complete stroke at the drive train output for multi-turn and linear actuators, or the complete angular stroke at the drive train output for partial-turn actuators.

3.1.18

pressure-containing parts

Parts such as those identified in 5.6 whose failure to function as intended results in a release of contained fluid into the environment.

3.1.19

pressure, design

Pressure defined for the design of the actuator pressure-containing and mechanically loaded parts, as defined by the actuator manufacturer.

3.1.20

pressure, maximum operating

Maximum allowable pressure to supply at the actuator pressure port which generates design torque/thrust for the power stroke for the expected life of an actuator, as defined by the actuator manufacturer/supplier.

3.1.21

pressure, maximum rated

Maximum pressure permissible into the actuator for pressure-containing and mechanically loaded parts with reduced life expectancy, as defined by the actuator manufacturer.

3.1.22

pressure, maximum supply

Maximum available pressure to be supplied at the actuator pressure port, as defined by the purchaser.

3.1.23

pressure, minimum operating/working

Minimum pressure at which the actuator provides the torque/thrust to operate the actuator, inclusive of safety factor, as defined by the actuator manufacturer.

3.1.24

pressure, minimum supply

Minimum available pressure to be supplied at the actuator pressure port, as defined by the purchaser.

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3.1.25

purchaser

An organization or individual that purchases equipment.

Example Valve manufacturer, distributor/stockist, value-add-center, integrator, end-user.

3.1.26

secondary gearbox

Device, which may include multiple gear reductions, and is used to transmit torque and/or thrust from an actuator to a valve stem.

3.1.27

stall torque

Maximum torque that an electric actuator develops when the motor is energized, and the output drive is locked.

3.1.28

stem/shaft

Part that connects the valve closure member to the actuator.

3.1.29

stroke

Movement of the valve closure member from the fully closed position to the fully open position, or vice versa.

3.1.30

supplier

Manufacturer or third-party provider of the actuator or the actuator and valve assembly.

Example Valve manufacturer, distributor/stockist, value-add-center, integrator.

3.1.31

temperature, maximum design

Maximum temperature at which the actuator is capable of operating.

3.1.32

temperature, maximum operating

Maximum temperature at which the actuator is required to operate.

3.1.33

temperature, minimum design

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Minimum temperature at which the actuator is capable of operating.

3.1.34

temperature, minimum operating

Minimum temperature at which the actuator is required to operate.

3.1.35

torque/thrust, design

Torque/thrust of an actuator at maximum spring force, maximum supply voltage, or maximum operating pressure with torque/thrust-limiting or pressure-reducing protection devices deactivated; or that can be transmitted by an included in-line gear train (e.g. secondary gearbox).

3.1.36

torque/thrust, maximum

Torque/thrust of an actuator at specified voltage/pressure with torque/thrust-limiting or pressure-reducing protection devices active; or that can be transmitted by an included in-line gear train (e.g. secondary gearbox).

3.1.37

torque/thrust, rated

Torque/thrust of an actuator at specified voltage/pressure, including the in-line gear train (e.g. secondary gearbox), delivered for one cycle for a defined number of cycles.

3.1.38

voltage, maximum supply

Maximum available voltage to be supplied at the actuator.

3.1.39

voltage, minimum supply

Minimum available voltage to be supplied at the actuator.

3.2 Symbols and Abbreviated Terms

3.2.1 Symbols

For the purposes of this document, the following symbols apply.

S_m	design stress intensity
S_y	specified minimum yield strength
t	thickness

3.2.2 Abbreviated Terms

For the purposes of this document, the following abbreviated terms apply.

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BM	base metal
BPVC	Boiler and Pressure Vessel Code
CE	carbon equivalent
HAZ	heat-affected zone
HBW	Brinell hardness, tungsten ball indenter
HIPPS	High Integrity Pressure Protection System
HPU	hydraulic power unit
HRC	Rockwell C hardness
MT	magnetic-particle testing
MAST	maximum allowable stem torque/thrust
NDE	non-destructive examination
PQR	procedure qualification record
PT	penetrant testing
PWHT	post-weld heat treatment
RT	radiographic testing
UT	ultrasonic testing
WM	weld metal
WPQ	welder performance qualification
WPS	weld procedure specification

4 Actuator Types and Configurations and Performance

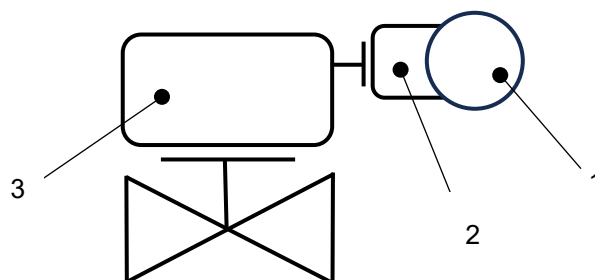
4.1 General

Actuators shall be part-turn, multi-turn, or linear in action. Part-turn actuators shall be capable of withstanding torsional forces. Multi-turn actuators shall be capable of withstanding torsional forces and shall be capable of withstanding axial thrust if specified. Linear actuators shall be capable of withstanding axial thrust.

4.2 Actuator Types

4.2.1 Electric actuator

Typical configuration for electric actuator is shown, for illustration purposes only, in Figure 1.



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Key

- 1 electric motor unit
- 2 primary transmission mechanism
- 3 secondary gearbox

Figure 1 — Electric Actuator

Electric actuator which is a self-contained unit, may be comprised of an electric motor, primary transmission mechanism, limit and/or torque switches, handwheel for manual override, and a motor control package.

Electric actuator which is a modular design shall have modules that consist of:

- a) electric motor unit
- b) primary transmission mechanism (reduction from electric motor shaft speed to the defined output speed)

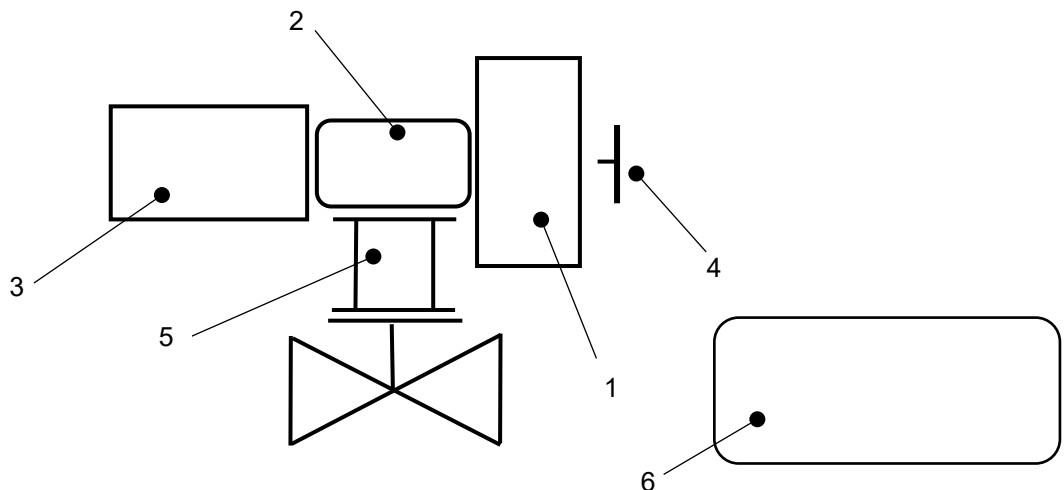
and may include:

- c) secondary gearbox
- d) spring canister
- e) manual override
- f) motor control package.

Electric actuators shall be powered from either an AC or DC electrical source. The output of electric actuators shall be part-turn, multi-turn, or linear in action.

4.2.2 Pneumatic Actuator

Typical configuration for pneumatic actuator is shown, for illustration purposes only, in Figure 2.



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Key

- 1 pneumatic cylinder
- 2 transmission mechanism
- 3 spring canister
- 4 manual override
- 5 mounting spool
- 6 air/volume tank

Figure 2 — Pneumatic Actuator

Pneumatic actuators shall be comprised of pneumatic cylinder, or another shape, transmission mechanism and travel stops.

Pneumatic actuators which are of a modular design shall have modules that consist of:

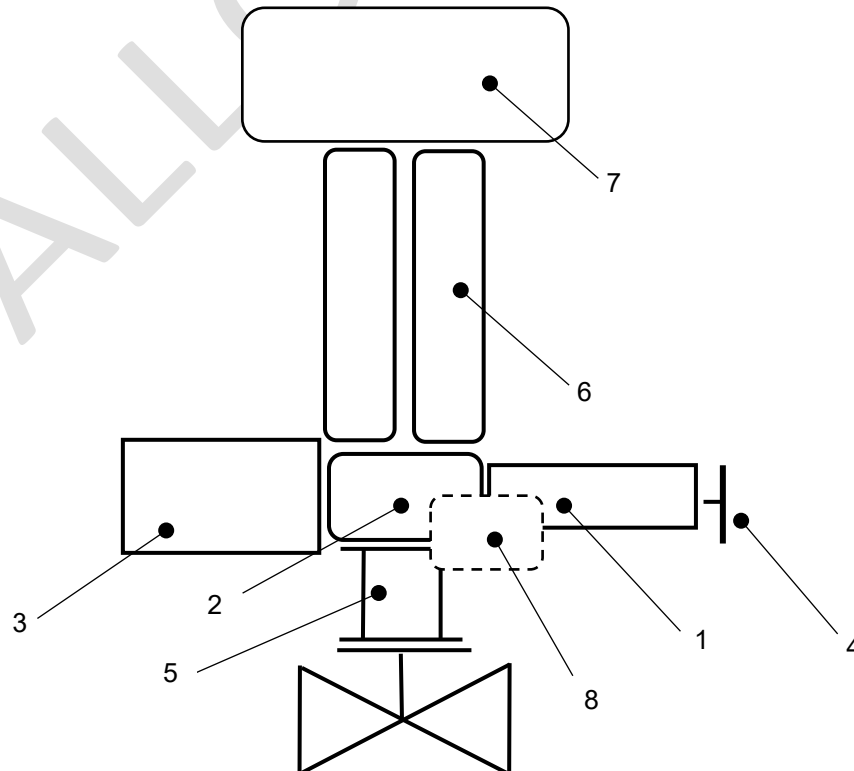
- a) pneumatic cylinder
- b) transmission mechanism

and may include:

- c) spring canister
- d) manual override.

4.2.3 Hydraulic actuator

Typical configuration for hydraulic actuator is shown, for illustration purposes only, in Figure 3.



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Key

- 1 hydraulic cylinder
- 2 transmission mechanism
- 3 spring canister
- 4 manual override
- 5 mounting spool
- 6 gas/hydraulic tank (optional)
- 7 accumulator/volume tank (optional)
- 8 instrumentation and controls

Figure 3 — Hydraulic Actuator

Hydraulic actuators (including gas/hydraulic) shall be comprised of a hydraulic cylinder, or another shape, transmission mechanism and travel stops.

NOTE Gas/hydraulic is also known as “gas-over-oil.”

Hydraulic actuators which are of a modular design shall have modules that consist of:

- a) hydraulic cylinder
- b) transmission mechanism

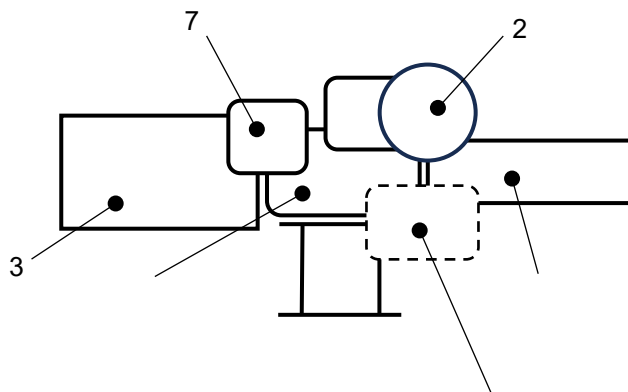
and may include:

- c) spring canister
- d) manual override
- e) gas/hydraulic tank
- f) accumulator/volume tank.

A gas/hydraulic actuator shall include a gas-hydraulic tank and be powered by the process gas or plant nitrogen.

4.2.4 Electro-hydraulic actuator

Typical configuration for hydraulic actuator is shown, for illustration purposes only, in Figure 4.



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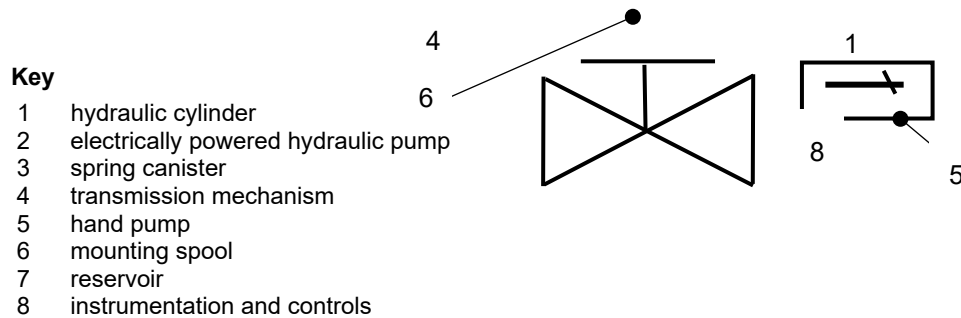


Figure 4 — Electro-hydraulic Actuator

Electro-hydraulic actuators shall be self-contained units, may be comprised of a hydraulic actuator, electrically powered hydraulic pump, hydraulic accumulator, reservoir, hydraulic cylinder, gearing, travel stops, piston, spring, screen filters at pump suction, reservoir filler caps, dual filters on the distribution system, check valve, relief valve on pump discharge and local gauges.

4.2.5 Direct Gas Actuator

Typical configuration for direct gas actuator is shown, for illustration purposes only, in Figure 5.

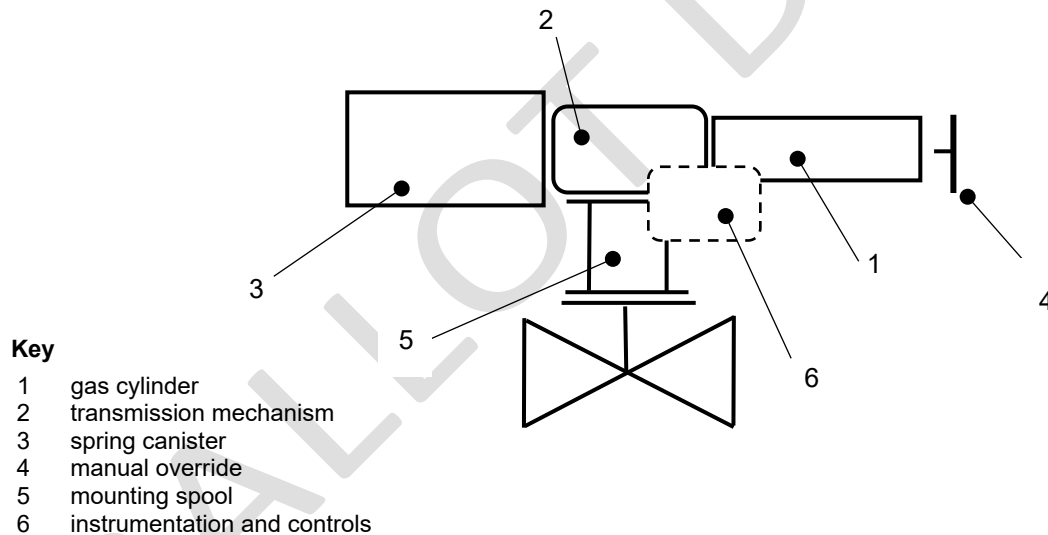


Figure 5 — Direct Gas Actuator

A direct gas part-turn and linear actuator shall be comprised of a pneumatic (gas) cylinder, transmission mechanism and travel stops and be powered by the process gas or nitrogen, as specified.

4.3 Action on Loss of Input Supply

When specified, upon loss of input power supply or receiving a “fail-to” signal, the actuator shall automatically drive the valve to, or remain in a pre-determined position.

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NOTE These positions are commonly known as “fail-open;” “fail-close;” or “fail-last.”

4.4 Quality Management System

Equipment shall be manufactured under the manufacturer's quality management system which shall conform to an internationally recognized standard such as API Q1 or ISO 9001.

5 Design

5.1 Design Process

5.1.1 General

Designs shall conform to the manufacturer's documented procedures and applicable quality management system requirements.

Design requirements shall include but not be limited to those criteria for size, test and operating pressures, material, environmental, and other pertinent requirements on which the design is based.

5.1.2 Design Documentation

Documentation of designs shall include methods, assumptions, calculations, and analysis. Design documentation media shall be clear, legible, reproducible, and retrievable. Design documentation shall be retained for 10 years after the last unit of that model, size, and rated working pressure is manufactured.

5.1.3 Design Review and Verification

The design shall be reviewed and verified by a qualified individual other than the individual who created the original design.

5.1.4 Design Validation

5.1.4.1 General

Design validation shall be performed in conformance with the manufacturer's validation procedure and the results of design validation shall be documented.

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5.1.4.2 Validation of Torque/Thrust

The manufacturer shall measure the start, minimum and end torque/thrust output values on a static test fixture in both the open and closed direction. The measured values shall not be less than the manufacturers minimum values.

5.2 Design and Operating Parameters

5.2.1 General

The following data shall be determined:

- a) minimum and maximum operating temperatures;
- b) minimum and maximum ambient temperatures;
- c) design torque/thrust output;
- d) maximum torque/thrust output;
- e) rated torque/thrust output;
- f) actuator type;
- g) actuator configuration (e.g., part-turn, multi-turn, or linear);
- h) minimum and maximum time of operation in the open and closed directions;
- i) location and orientation of position indicator in relation to the valve stem;
- j) orientation for installation (e.g. vertical pipe, horizontal stem);

5.2.2 Hydraulic Actuator Data Input

The following data shall be determined:

- a) control fluid type;
- b) minimum and maximum supply pressure;
- c) minimum hold open/close pressure, when available;
- d) actuator configuration (single or double acting);
- e) action on loss of hydraulic supply pressure (close, open, or fail-last);
- f) hydraulic supply connection type and size;
- g) end of stroke damping feature, when required; and
- h) hydraulic control tubing diameter and distance to HPU, when applicable.

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5.2.3 Pneumatic or Direct-Gas Actuator Data Input

The following data shall be determined:

- a) supply gas composition (air, nitrogen, or pipeline gas);
- b) minimum and maximum supply pressure;
- c) minimum hold open/close pressure, when available;
- d) actuator configuration (single or double acting);
- e) action on loss of pneumatic supply pressure (close, open, or fail-last);
- f) pneumatic supply connection type and size;
- g) end of stroke damping feature, when required; and
- h) pneumatic control tubing diameter.

5.2.4 Electric Actuator Data Input

The following data shall be determined:

- a) voltage, phase, frequency, current (for AC systems);
- b) voltage, current (for DC systems);
- c) voltage variation and frequency variation;
- d) number of consecutive valve strokes;
- e) number of starts per hour;
- f) action on loss of electric supply (close, open, or fail-last); and
- g) communication type/protocol between operating system and actuator.

5.2.5 Gas/Hydraulic Data Input

The following data shall be determined:

- a) control fluid type;
- b) supply gas composition (nitrogen, or pipeline gas, etc.);
- c) minimum and maximum supply pressure;
- d) actuator configuration (single or double acting);
- e) action on loss of hydraulic supply pressure (close, open, or fail-last);
- f) hydraulic supply connection type and size;
- g) gas-over-oil tank pressure design code;
- h) control tubing diameter and type of fitting;
- i) number of cycles and pressure for accumulator (i.e., backup tank) sizing, when applicable; and

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j) accumulator design code.

5.2.6 Electro-hydraulic Data Input

The following data shall be determined:

- a) voltage, phase, frequency, current (for AC systems);
- b) voltage, current (for DC systems);
- c) voltage variation and frequency variation;
- d) number of consecutive valve strokes;
- e) number of starts per hour;
- f) action on loss of energy (electric supply or hydraulic supply pressure) (close, open, or fail-last);
- g) communication type/protocol between operating system and actuator;
- h) control fluid type;
- i) minimum and maximum supply pressure;
- j) minimum hold open/close pressure, when available;
- k) actuator configuration (single or double acting);
- l) hydraulic supply connection type and size;
- m) end of stroke damping feature, when required; and
- n) hydraulic control tubing diameter and distance to HPU, when applicable
- o) recharge time of the accumulator storage system
- p) pre-charge pressure of the accumulator storage system

5.3 Interface with Valve

The interface dimensions shall be:

- a) per manufacturers standard; or
- b) specified by the purchaser.

Actuator and valve interface design shall minimize the misalignment of the actuator and/or mounting kit to the valve.

For interface mounting design with torsional resistance based on friction, the design shall be based on a coefficient of friction factor:

- c) not greater than 0.3; or
- d) greater than 0.3 if proven by validation.

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NOTE Guidance for the interface portion of the actuator is provided in MSS SP-101 or ISO 5211 for part-turn actuators and MSS SP-102 or ISO 5210 for multi-turn actuators.

5.4 Fluid Cleanliness Requirements

5.4.1 Hydraulic Actuators

The hydraulic fluid shall be defined.

The manufacturer shall ensure chemical compatibility with internal actuator parts, lubricants and environmental conditions.

See Annex B for supplemental options for service compatibility.

For self-contained fluid power units (i.e. units not intended for in-situ fluid replenishment), the fluid shall be defined by the manufacturer and approved by the purchaser.

Minimum hydraulic fluid cleanliness shall be in accordance with:

- a) SAE AS4059 Tab 1, class 6; or
- b) ISO 4406 17/15/12.

5.4.2 Pneumatic Actuators

Pneumatic actuators shall be powered by compressed air/gas. Minimum compressed air cleanliness shall be as defined in ISA 7.0.01 or ISO 8573-1, class 5 for particle size and class 3 for dew point.

5.5 Design Basis

The design shall be either stress-based or based on documented previous experience, including validation testing.

The design torque or thrust shall be that which is generated at the actuator maximum operating pressure, with a 1.1 times relief valve set pressure; or the stall torque of an electric actuator.

Design verification and validation, including a design review, shall be performed.

For pneumatic and hydraulic actuators:

- a) the pressure used for the design of the pressure-containing parts shall be specified by the actuator manufacturer;

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- b) the maximum rated pressure shall be defined by the actuator manufacturer and shall be less than or equal to the design pressure and greater than or equal to the maximum operating pressure.

NOTE Figure 6 shows the relationship between the various pressure definitions used in this document.


Pressure - Torque/Thrust Relationship									
Design Pressure			Rated Torque/Thrust			Without torque/thrust-limiting or pressure-reducing protection devices			
Maximum Rated Pressure			Operating Range	Operating Range	Maximum Design Torque/Thrust	With torque/thrust-limiting or pressure-reducing protection devices			
Maximum Operating Pressure	Operating Range	Operating Range			Minimum Design Torque/Thrust				
Maximum Supply Pressure					Operating Range		Operating Range		
Minimum Supply Pressure								Operating Range	Operating Range
Minimum Operating Pressure			Operating Range	Operating Range					
$Design\ Pressure \geq Maximum\ Rated\ Pressure \geq Maximum\ Operating\ Pressure \geq Maximum\ Supply\ Pressure > Minimum\ Supply\ Pressure > Minimum\ Operating\ Pressure$									

Figure 6—Relationship Between Pressure and Torque

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5.6 Pressure-containing Parts

5.6.1 General

Materials shall be selected based on the operating and ambient temperatures defined in 5.2.1.

Pressure-containing parts, such as the cylinder heads, pressure cylinder, accumulators (i.e. backup tank), gas-over-oil tanks, and/or vane housing, shall be designed in accordance with:

- a) ASME BPVC Section VIII, Division 1 or Division 2; or
- b) an internationally recognized design code or standard.

If the selected design code or standard specifies a test pressure less than 1.43 times the design pressure, the design pressure for the calculations shall be increased such that the hydrostatic test pressure in 11.1.2 can be applied.

NOTE 1 In addition to design requirements, regulatory requirements may require conformance to local regulations such as Pressure Equipment Directive 2014/68/EU or Pressure Equipment Safety Regulation (PESR).

NOTE 2 Associated fittings and actuator control equipment are not within the scope of this International Standard.

5.6.2 Tie-Rod and Bolting of Pressure-containing Parts

Materials shall be selected based on the operating and ambient temperatures defined in 5.2.1.

Bolting and tie-rod design for pressure-containing parts (e.g. cylinder and/or vane housing) shall be in accordance with the selected design code (see 5.6.1).

5.7 Mechanically Loaded Parts

5.7.1 General

Mechanically loaded parts shall be designed to accommodate the design torque/thrust, and shall include the following:

- a) torque/thrust generated at maximum rated cylinder pressure or as limited by relief valve or other pressure-limiting device, for double-acting pneumatic/hydraulic actuators;
- b) torque/thrust generated by either maximum compressed spring force or maximum rated cylinder pressure or as limited by relief valve or other pressure-limiting device, whichever is greater, for spring return actuators; and
- c) torque/thrust at stall condition ;

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- d) maximum force at the perimeter of the hand-wheel to achieve design torque output; or maximum input torque.

Mechanically loaded parts shall be designed to the following acceptance criteria. Analysis shall include evaluation of the results of stress, strain, and fatigue where applicable, encountered during operation at maximum torque/thrust output.

The design stress intensity value, S_m , shall be taken as 67 % of yield strength S_y at maximum operating temperature. In addition, the average primary shear stress across a section loaded under design conditions in pure shear (e.g. keys, shear rings, etc.) shall be limited to $0.6 S_m$.

The maximum primary shear under design conditions, exclusive of stress concentration at the periphery of a solid circular section in torsion, shall be limited to $0.8 S_m$.

The average bearing stress for resistance to crushing under the maximum design load shall be limited to the yield strength S_y at temperature.

These stress limits do not apply to the components of rolling-element or other proprietary bearings, or high bearing strength capable materials that are included in the actuator design where manufacturers' recommendations or limits derived from tests and service experience apply. These limits shall be justified in design documents.

5.7.2 Springs

5.7.2.1 Spring Design

For cylindrical helical spring or disc spring type on spring return actuators, the spring shall be designed in accordance with internationally recognized design codes or standards.

NOTE Examples of internationally recognized design codes or standards are EN 13906 and EN 16983.

If the spring size is outside the scope of internationally recognized design codes or standards, manufacturers standard design criteria, including known spring equations, shall apply.

Springs shall be validated according to 5.7.2.2.

5.7.2.2 Spring Validation

The spring shall be type tested by compressing to a length that represents maximum travel during usage a minimum of 50 times to verify the performance characteristics.

5.7.2.3 Production Testing

The manufacturer or spring vendor shall perform a test on all springs by full-load cycling a minimum of five times, followed by load testing, to validate the actuator spring design data.

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5.7.3 Bolting of Mechanically Loaded Parts

Bolting of mechanically loaded parts and mounting kit components shall be designed to accommodate the direct loading applied by the actuator design torque/thrust and, if applicable, purchaser-defined external loads (e.g. seismic, blast, structural, snow/ice).

The threaded portion of bolting shall not be subjected to direct shear due to transverse loading.

Bolting for actuators for connecting to quarter-turn valves shall not be subjected to design loads that put the bolt in shear.

For a valve without an anti-rotation feature (e.g. dowel pin or fitted bolt), the design shall include a calculation of bolt tension to generate a clamping force (e.g. between the valve and actuator, between the valve and mounting kit, and between the actuator and mounting kit) that is sufficient to prevent slippage of bolted connections.

5.8 Mounting Kit

5.8.1 General

The mounting kit shall be designed in accordance with the acceptance criteria of 5.6. Analysis shall include an evaluation of results of stress, strain, and fatigue where applicable, encountered during operation at maximum torque/thrust output.

Interface mounting using friction shall be based on 5.3.

The mounting kit shall be designed to transfer all loads from the actuator to the valve and to react to them, including loads of a minimum of 1.1 times the maximum torque/thrust output, and it shall include the following:

- a) torque/thrust generated at maximum rated cylinder pressure or as limited by relief valve or other pressure-limiting device, for pneumatic/hydraulic actuators;
- b) torque/thrust generated by either maximum compressed spring force or maximum rated cylinder pressure or as limited by relief valve or other pressure-limiting device, whichever is greater, for spring return actuators; and,
- c) torque/thrust at stall condition or 100 % of the allowed torque/thrust switch setting for electric actuators.

The maximum torque/thrust output shall be less than or equal to the design torque/thrust.

Deflections of the mounting kit shall not prevent the valve closure member from reaching the fully closed or fully open position or restrict actuator functionality.

The mounting kit design shall ensure the following:

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- d) parallelism of the mounting spool mounting faces;
- e) concentricity of the bolting of the mounting spool; and
- f) alignment of valve stem, coupling, and the actuator drive.

The acceptance criteria for these tolerances shall conform to the manufacturer's standard to prevent the loss of transmitted torque/thrust.

The mounting kit design shall accommodate the following conditions:

- g) installed orientation of the valve and actuator;

NOTE Valves installed with horizontal stems can require additional support (e.g. spigots) to ensure accurate alignment of valve and actuator during removal and refitting in field service.

- h) external loading from environmental effects (e.g. wind, snow, seismic activity) when specified;
- i) vibration, when specified;
- j) blast loading, when specified; and
- k) frequency of cycling and speed of operation.

See Annex B for supplemental options for orientation, environmental protection and environmental conditions.

5.8.2 Bolting of Mounting Kits

Bolting for mounting kits shall conform to 5.7.3.

5.9 Lifting

For actuators heavier than 50 lb (23 kg), lifting points shall be identified for lifting the actuator alone during installation or maintenance.

NOTE 1 Lifting points may be identified by means of labels, color coding, drawings, or a lifting plan document.

NOTE 2 Regulatory requirements may specify special design, manufacturing, testing, and certification of lifting points.

5.10 Manual Override

All mechanical override assemblies shall self-lock such that the position of the actuator cannot change.

Non-rising stem, internal screw gate valves do not require a self-locking feature.

Self-locking functionality shall be demonstrated by the manufacturer.

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The rotary motion of an override to close a valve shall be clockwise.

Pump handle/lever of manual hydraulic override of actuators shall conform to 5.11.

5.11 Handwheels and Levers

When a handwheel or lever is provided, the maximum force required at the handwheel, or lever shall not exceed 80 lbf (360N) at any point of travel.

Handwheel diameter and pump handle/lever of manual hydraulic override shall not exceed a nominal 40 in. (1 m). Spokes shall not extend beyond the perimeter of the handwheel.

5.12 Locking Devices

Actuators shall be designed with the ability to use a locking device if specified by the manufacturer or the purchaser.

5.13 Local Position Indicators

Actuators shall be furnished with a visible indicator to show the open and closed positions of the valve.

5.14 Travel Stops

Part-turn actuator shall include adjustable travel stops to set the open and closed positions of the valve.

Linear/multi-turn actuator shall have adjustable travel stops to set the open and closed positions of the valve if required by the application.

5.15 Orientation

Actuators with single or multiple-orientation capability shall be permitted, however, single-orientation shall be supplied if specified by the purchaser.

See Annex B for supplemental options for orientation.

5.16 Seals Preventing Water or Environmental Ingress

Actuators shall be designed and certified to IP-65 in accordance with IEC 60529 at a minimum.

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5.17 Pressure Protection

Operators and/or enclosed mounting kits shall be provided with a means of preventing pressure buildup in the mechanism resulting from leakage from the valve stem or bonnet seal leakage.

5.18 Lubrication Fittings

Operators may be equipped with one or more injection fittings permitting packing and lubrication of the gearbox.

6 Sizing of Actuators

When valve type and torque/thrust data are known, actuator shall be sized in accordance with Annex A.

7 Instrumentation/Regulation

7.1 Torque Limiting Settings—Electric Actuators

Torque-limiting devices shall be provided and shall be activated by default.

If the valve MAST is known (see Annex A), the torque-limiting devices shall prevent the actuator from exceeding valve MAST.

7.2 Torque/Thrust Limiting Controls—Pneumatic/Hydraulic Actuators

If the torque/thrust output of a pneumatic/hydraulic actuator exceeds the valve MAST, the actuator shall be provided with a regulator and/or a calibrated safety relief valve, or a pressure-limiting device, at a minimum.

The relief valve set value shall be such that the corresponding torque delivered by the actuator at the relief valve nominal set value plus the relevant tolerance will not exceed the valve MAST.

The torque/thrust output of a pneumatic/hydraulic actuator shall include any overpressure effects at full opening of the relief valve and if valve MAST is known (see Annex A) shall be less than the valve MAST.

7.3 Position and Load Stops

Table 1 through Table 6 shall apply to position and load stops for actuators depending on valve type.

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Table 1—Position and Load Stops—Axial Flow Valves

Valve Feature	Actuator Type	Actuator Position Stop	Setting Requirements
N/A	Hydraulic and pneumatic, double acting and spring	Closed on load/thrust. Open on position.	Actuator output shall be regulated to provide seal in closed position without overloading the drive train. Actuator stops shall control open position.
N/A	Electric	Closed on load/thrust. Open on position.	Actuator output torque shall be regulated to provide seal in closed position without overloading the drive train. Actuator stops shall control open position.

Table 2—Position and Load Stops—Ball Valves

Valve Feature	Actuator Type	Actuator Position Stop	Setting Requirements
Floating and Trunnion	All	Closed and open on position.	Actuator stops shall control position even if valve has integral stops.
Rising Stem	Hydraulic and pneumatic, double acting and spring	Closed on load/thrust. Open on position.	Actuator output shall be regulated to provide seal in closed position without overloading the drive train. Actuator stops shall control open position.
Rising Stem	Electric	Closed on load/thrust. Open on position.	Actuator output torque shall be regulated to provide seal in closed position without overloading the drive train. Actuator stops shall control open position.

Table 3—Position and Load Stops—Check Valves

Valve Feature	Actuator Type	Actuator Position Stop	Setting Requirements
With lock open feature.	All	Open on position. Closed N/A.	Open position shall be on stops in the actuator and not in the valve.

Table 4—Position and Load Stops—Gate Valves (Expanding)

Valve Type	Actuator Type	Actuator Position Stop	Setting Requirements
Conventional acting, with backseat.	All	Closed on load/thrust. Open on backseat.	Actuator output to be regulated to provide seal in open and closed position but without overloading the drive train.

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Double expanding, conventional acting, without backseat.	Hydraulic and pneumatic, double acting	Closed and open on load/thrust.	Actuator output shall be regulated to provide seal in closed position and gate expansion in the open position, without overloading the drive train.
Double expanding, conventional acting, without backseat	Hydraulic and pneumatic, spring return	Closed and open on load/thrust.	Actuator output shall be regulated to provide seal in closed position and gate expansion in the open position, without overloading the drive train.
Double expanding, conventional acting without backseat.	Electric	Closed and open on load/thrust.	Actuator output torque shall be regulated to provide seal in closed position and gate expansion in the open position, without overloading the drive train.

Table 5—Position and Load Stops—Gate Valves (Slab)

Valve Type	Actuator Type	Actuator Position Stop	Setting Requirements
Reverse acting with backseat	Hydraulic and pneumatic, double acting	Closed on backseat. Open on position.	Pressure to be regulated in closing position to create required backseat sealing force. Actuator stops shall control open position.
Reverse acting with backseat	Electric	Closed on backseat. Open on position.	Output to be regulated in closing position to create required backseat sealing force. Actuator stops shall be primary control for open position.
Reverse acting with backseat	Hydraulic and pneumatic, spring return	Closed on backseat. Open on position.	Spring load is required in closed position to create backseat sealing force. Actuator stops shall control open position.
Reverse acting, without backseat	All	Closed and open on position.	Actuator stops shall control position even if valve has integral stops.
Conventional acting with backseat	Hydraulic and pneumatic, double acting	Closed on position. Open on backseat.	Pressure to be regulated in open position to create required backseat sealing force. Actuator stops shall control closed position.
Conventional acting with backseat	Electric	Closed on position. Open on backseat.	Output to be regulated in open position to create required backseat sealing force. Actuator stops shall be primary control for closed position.
Conventional acting with backseat.	Hydraulic and pneumatic, spring return	Closed on position. Open on backseat.	Spring load is required in open position to create backseat sealing force. Actuator stops shall control closed position.

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Valve Type	Actuator Type	Actuator Position Stop	Setting Requirements
Conventional acting, without backseat.	All	Closed and open on position.	Actuator stops shall control position even if valve has integral stops.

Table 6—Position and Load Stops—Plug Valves

Valve Feature	Actuator Type	Actuator Position Stop	Setting Requirements
N/A	All	Closed and open on position.	Actuator stops shall control position even if valve has integral stops.

Valves with positive sealing shall require a specified load/torque to affect a seal, while valves with passive sealing shall require valve to be stopped on position.

8 Materials

8.1 Material Specification

Written specifications for metallic pressure-containing parts shall be issued by the manufacturer and shall conform to the design code selected in 5.6.1.

8.2 Composition Limits

8.2.1 Carbon Steel

For direct gas and gas-over-oil actuators that are exposed to sour gas as defined by NACE MR0175/ISO 15156, the following applies.

The chemical composition of carbon steel pressure-containing parts subject to welding, including weld repairs and overlays, shall meet the following requirements.

- a) Carbon content shall not exceed 0.23 % mass fraction.
- b) Carbon equivalent (CE) shall not exceed 0.33.

CE shall be calculated in accordance with Equation (1):

$$CE = \%C + \%Mn / 6 \quad (1)$$

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8.2.2 Austenitic Stainless Steel

For direct gas and gas-over-oil actuators that are exposed to sour gas as defined by NACE MR0175/ISO 15156, the following applies.

The carbon content of austenitic stainless-steel pressure-containing parts subject to welding, including weld repairs, shall not exceed 0.03 % mass fraction, except that for stabilized material a carbon content of up to 0.08 % mass fraction is permissible.

8.2.3 Ductile Iron

Ductile iron pressure-containing parts shall conform to a nationally or internationally recognized standard, such as ASTM A395 or ASTM A536, including requirements for micro-structural carbide and graphite content.

8.2.4 Other Materials

The chemical composition of other materials of pressure-containing parts subject to welding, including weld repairs, shall be per manufacturers standard.

8.3 Bolting

8.3.1 Bolting Used for Joining Pressure-containing Parts

Bolting material shall be selected to meet the requirements of the specified service.

Carbon and low-alloy bolting material shall have a maximum hardness of HRC 35 (HBW 321).

External bolting and tie-rods for offshore applications shall not be zinc plated, unless protected by an additional coating which meets a minimum of C5 medium rating per ISO 12944-2.

8.3.2 Bolting for Mechanically Loaded Parts

Written specifications for bolting of mechanically loaded parts and components of mounting kits shall be issued by the manufacturer and shall include, as a minimum, the following:

- a) mechanical properties;
- b) Charpy impacts, if applicable; and,
- c) type of inspection document in accordance with EN 10204.

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8.3.3 Fasteners

Fasteners that are not joining pressure-containing parts, transmitting torque/thrust or subject to other structural loads shall be per manufacturers specification.

8.4 Plating

If electroless nickel plating is provided for component performance, it shall be in accordance with ASTM B733, Type IV or V, SC3, class 2 (Type I-V), class 3, 4, or 6.

Other plating methodologies shall be per the manufacturer's specification.

9 Welding

9.1 Welding of Pressure-containing Parts

Welding, including repair welding, of pressure-containing parts and attachment welding to pressure-containing parts shall be performed in accordance with the design code selected in 5.6.1.

Welders and welding operators shall be qualified in accordance with the design code selected in 5.6.1.

NOTE The purchaser, material specifications and local requirements can specify additional requirements.

The results of all qualification tests shall be documented in a PQR.

PWHT shall be performed in accordance with the relevant WPS.

9.2 Structural Welding

Welding, including repair welding, of structural welds, including mounting kit, shall be performed in accordance with procedures qualified to AWS D1.1/D1.1M or an equivalent standard.

Welders and welding operators shall be qualified in accordance with AWS D1.1/D1.1M or an equivalent standard.

Alternatively, structural welding, WPS, and PQR in accordance with procedures qualified to the design code selected in 5.5 and welders and welding operators qualified in accordance with ISO 9606-1 or ASME BPVC Section IX are acceptable.

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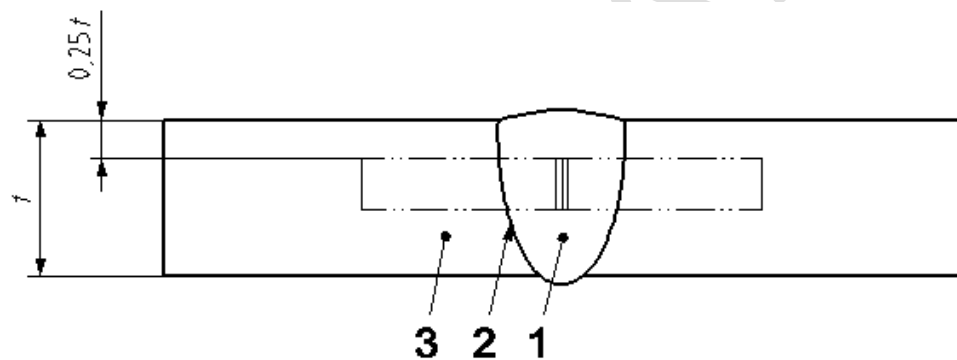
9.3 Impact Testing of Welds of Pressure-containing Parts

Qualifications of procedures for welding, including repair welding, shall be performed at the lowest temperature defined in the applicable material specifications or at the minimum design temperature.

Impact testing shall be performed on carbon, alloy, and stainless steel (except austenitic grades) for the qualification of procedures for welding on actuators with an allowable temperature below -20°F (-29°C).

NOTE Design standards and/or local requirements can require impact testing at minimum design temperatures above -20°F (-29°C).

A set of three weld metal impact specimens shall be taken from the weld metal (WM) at the location shown in Figure 2. The specimens shall be oriented with the notch perpendicular to the surface of the material.



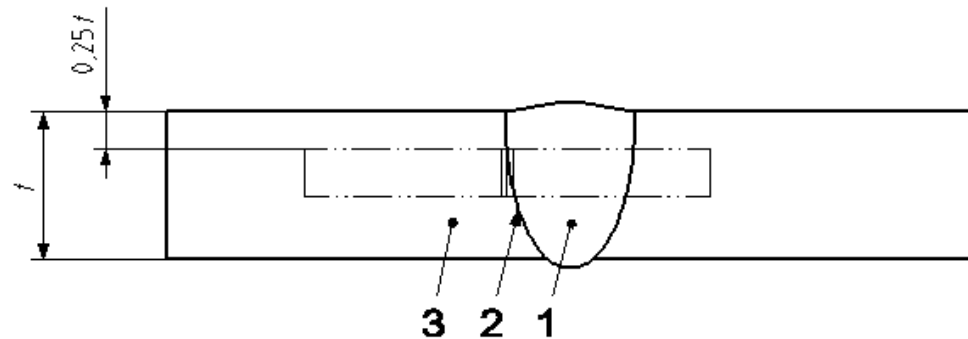
Key

- 1 weld metal
- 2 heat-affected zone
- 3 base metal

Figure 2—Charpy V-notch Weld Metal (WM) Specimen Location

A set of three impact specimens shall be taken from the heat-affected zone (HAZ) at the location shown in Figure 3. The notch shall be positioned perpendicular to the material surface at a location whereby a maximum amount of HAZ material is located in the resulting fracture.

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Key

- 1 weld metal
- 2 heat-affected zone
- 3 base metal

Figure 3—Charpy V-notch Heat-affected Zone (HAZ) Specimen Location

HAZ tests shall be conducted for each of the materials being joined when the base materials being joined are of a different P-number and/or group-number in accordance with the design code selected in 5.5 when one or both of the base materials being joined are not listed in the P-number grouping.

Impact testing shall be performed in accordance with ISO 148-1 or ASTM A370 using the Charpy V-notch technique. Specimens shall be etched to determine the location of the weld and HAZ.

Impact test results for full-size specimens shall meet the requirements of the material specification or the design standard.

Impact values of the weld metal and HAZ shall be equal to or greater than the base material.

9.4 Hardness Testing

For direct gas and gas-over-oil actuators that are exposed to sour gas as defined by NACE MR0175/ISO 15156, the following shall apply:

- a) Hardness testing shall be carried out as part of the welding procedure qualification on pressure-containing parts in process-wetted conditions if required to meet the requirements of NACE MR0175/ISO 15156.
- b) Hardness surveys shall be performed on BM, WM and the HAZ in accordance with the requirements of NACE MR0175/ISO 15156.

9.5 Repair

Repair of defects shall be performed in conformance with a documented procedure specifying requirements for defect removal, welding, heat treatment, non-destructive examination (NDE), and reporting as applicable.

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Surface defects that are removed shall not compromise the minimum wall thickness and shall provide a smooth transition between the ground area and the original contour.

Acceptance criteria shall be specified for the appropriate product form. The final NDE activities shall be conducted after post-weld heat treatment.

Weld repair of forgings and plates shall not be performed to correct material defects.

NOTE Weld repair on forgings and plates may be performed to correct machining errors.

Weld repair of castings shall be performed in conformance with the applicable material standard, including any PWHT when required.

When quench and tempering, solution anneal or PWHT temperature is within 50° F (28° C) or exceeds the tempering temperature of the original material, new mechanical testing shall be performed in conformance with the original material specification.

Repair of welds shall be performed in conformance with the applicable design code or standard listed in 5.6.1, including any PWHT, when applicable.

10 Quality Control

10.1 NDE and Inspection Requirements

10.1.1 General

NDE shall be conducted prior to coating or surface treatment. Final NDE activities shall be conducted after heat treatment.

The requirements in Section 10 shall apply to both actuator manufacturer and supplier.

10.1.2 Pressure-containing Parts

NDE of pressure-containing parts and welds shall be in accordance with the selected design code in 5.6.1.

Pressure-containing parts as identified in 5.6.1, in the finished condition shall be subjected to a visual inspection in conformance with the manufacturer's requirements.

10.1.3 Mechanically Loaded Parts, Including Mounting Kit

Visual inspection of welds shall be in accordance with AWS D1.1/D.1.1M or an equivalent standard.

Mechanically loaded parts in the finished condition shall be subjected to a visual inspection in conformance with the manufacturer's requirements.

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10.1.4 Castings

All castings shall be inspected in accordance with manufacturers written specifications.

The visual inspection method and acceptance criteria shall be in accordance with MSS SP-112 or to a nationally or internationally recognized standard.

10.1.5 Electroless Nickel Plating

Adhesion, thickness and porosity of electroless nickel plating shall be tested by one of the methods defined in ASTM B733. The inspection report shall define the method used for the individual tests.

10.2 Measuring and Test Equipment

10.2.1 General

Equipment used to inspect, test, or examine material or other equipment used for acceptance shall be identified, controlled, calibrated, and adjusted at specified intervals in accordance with instructions documented by the actuator manufacturer. The instructions shall be consistent with nationally or internationally recognized standards or by requirements specified by the test equipment manufacturer, to maintain the accuracy required by this standard.

10.2.2 Pressure-measuring Devices

10.2.2.1 Type and Accuracy

Test pressure-measuring devices shall be accurate to at least ± 2.0 % of full scale. Analog pressure gauges, when used in lieu of pressure transducers, shall be selected such that the test pressure is indicated within 20 % and 80 % of the full-scale value.

NOTE Pressure recording devices are outside the scope of this standard.

10.2.2.2 Calibration Procedure

Pressure-measuring devices shall be calibrated with a master pressure-measuring device or deadweight tester to at least three equidistant points of full scale (excluding zero and full scale as required points of calibration).

10.2.2.3 Calibration Intervals

Calibration interval shall conform to manufacturers' specification and shall not exceed one year.

10.2.3 Torque/Thrust measuring Devices

Torque/thrust measuring devices shall be accurate to within ± 5.0 % of the full scale.

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Torque/thrust measuring devices shall be calibrated with a master device to at least three equidistant points of full scale (excluding zero and full scale as required points of calibration).

10.3 Qualification of Inspection and Test Personnel

10.3.1 NDE Personnel

NDE personnel shall be qualified in conformance with the manufacturer's or supplier's documented training program that is based on the requirements specified in ASNT SNT-TC-1A or ISO 9712.

NOTE Alternative standards are acceptable provided they meet the minimum requirements of ASNT SNT-TC-1A.

A qualified Level III examiner, that conforms to the requirements of ASNT SNT-TC-1A or ISO 9712, shall approve all NDE procedures.

Minimum NDE Level 2 personnel shall perform all NDE inspection activities for interpretation of acceptance criteria.

NOTE For use of outsourced qualification of Non-destructive Examination (NDE) Services, see API 20D.

10.3.2 Visual Examination Personnel

Welding, quality control, pressure testing and machining personnel performing visual inspection for final acceptance shall undergo an annual vision examination in conformance with the manufacturer's or supplier's documented procedures that satisfy the applicable requirements of ASNT SNT-TC-1A or ISO 9712.

NOTE Alternative standards are acceptable provided they meet the minimum requirements of ASNT SNT-TC-1A.

10.3.3 Test Personnel

Personnel performing functional testing shall be trained in accordance with the manufacturer's or supplier's internal procedures.

10.3.4 Welding Inspectors

Personnel performing visual inspections of welding operations and completed welds shall be qualified and certified by one of the following:

- a) AWS QC1; or,
- b) welding inspector certified by the manufacturer's or supplier's documented training program.

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10.4 NDE of Repairs

10.4.1 Pressure-containing Parts

After defect removal, the excavated area shall be examined by magnetic particle (MT) or liquid penetrant (PT) methods in accordance with the design code selected in 5.6.1.

Repair welds shall be examined with a minimum of MT or PT.

Acceptance criteria shall be as specified in the design code selected in 5.6.1 for the appropriate product form.

The final NDE activities shall be conducted after post-weld heat treatment.

10.4.2 Mechanically Loaded Parts

Repair welds shall be examined with a minimum of MT or PT.

11 Assembly of Actuator Modules

11.1 General

Final assembly of modules shall be completed by the manufacturer or supplier in conformance to the manufacturer's procedures.

11.2 Cleanliness During Assembly of Hydraulic Actuators

Manufacturer shall have written a procedure to ensure cleanliness of all components and modules prior to and during assembly of the actuator.

After assembly, all tubing runs, and hydraulically actuated equipment shall be flushed to meet the cleanliness requirements of 5.4. Fittings, hydraulic couplings, etc. shall be blanked off after completion of flushing/testing to prevent particle contamination during storage.

11.3 Storage

Manufacturer and supplier shall store actuator modules in accordance with the manufacturer's procedure.

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12 Final Acceptance Testing

12.1 General

The manufacturer shall perform the tests in 12.2 and 12.3.

The manufacturer or supplier shall perform the tests in 12.4.

12.2 Pneumatic and Hydraulic Actuators

12.2.1 General

Each actuator shall be tested prior to shipment.

Testing shall be performed in the sequence detailed in 12.2.2, 12.2.3, 12.2.4, 12.3, and 12.4, as applicable.

Hydraulic actuators shall be tested with the manufacturer's or the supplier's standard fluid, unless otherwise specified by the purchaser.

Prior to testing, hydraulic test equipment fluid cleanliness shall be verified to meet the requirements of 5.4.

An electronic particle counter, or equivalent, with printout shall be used for documentation of the cleanliness level.

Pneumatic, direct gas and gas-over-oil actuators shall be tested with instrument-quality air, nitrogen, or other inert gas.

Pressure testing shall be performed in accordance with the manufacturer's written specifications.

Methods for monitoring pressures and/or leakage shall be in accordance with the manufacturer's written specifications. For pneumatic shell testing, the test pressure shall be applied, and the method for detecting leakage (e.g. bubble/soap solution, acoustic monitoring, manometer) shall be fully applied and in place prior to starting the test duration.

Supply pressure shall be isolated from the actuators being tested and shall be stabilized prior to the start of pressure-testing duration. The pressure-measuring device shall be installed in the test apparatus in such a manner that the device monitors the test pressure of the actuator. The minimum test pressures shall be maintained for the duration of the test and shall be held for the minimum test durations listed in Table 7 and Table 8 after stabilization as determined by the manufacturer.

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12.2.2 Shell Integrity Test for Pressure-containing Parts

The test pressure shall be a minimum of 1.43 times the design pressure, or in accordance with the design code in 5.6.1, whichever is higher.

The duration shall be in accordance with the design code in 5.6.1 or with Table 7, whichever is longer.

Table 7—Duration of Shell Tests

Test	Minimum Test Duration (seconds)
Pneumatic	60
Hydraulic	120

NOTE The manufacturer may extend the test duration, if necessary, to fully examine the potential leak paths.

For pneumatic shell test, there shall be no visible leakage (see 3.1.16) for the duration of the test.

For hydraulic shell test, there shall be no drop in pressure.

12.2.3 Piston Seal Test

12.2.3.1 General

The test pressure for all piston seal tests shall be a minimum of 1.1 times the maximum rated pressure. The test duration shall be in accordance with Table 8.

Table 8—Duration of Piston and Vane Seal Tests

Test	Minimum Test Duration (seconds)
Pneumatic	60
Hydraulic	120

Piston shall be cycled prior to performing the piston seal test.

Double-acting actuator piston shall be tested in each direction.

For pneumatic test, there shall be no visible leakage (see 3.1.16) for the duration of the test.

For hydraulic test, there shall be no drop in pressure.

12.2.3.2 Pneumatic or Direct Gas Actuators Piston Seal Test

Pneumatic piston seal tests shall be conducted with pressure applied to one side of the piston with the other side open to atmosphere.

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When monitoring by pressure, if an analog gauge is used, there shall be no visible drop in the pressure measurement system. When monitoring by pressure, if a digital gauge (such as a transducer) is used, the pressure shall not drop by more than 5 % of the test pressure during the test.

There shall be no visible leakage (see 3.1.16) during the test duration.

For hydraulic test, there shall be no drop in pressure.

12.2.3.3 Hydraulic and Electro-hydraulic Actuators Piston Seal Test

Hydraulic piston seal tests shall apply pressure to one side of the piston and then shall be isolated from the pressure source. Leakage shall be detected by visual inspection or by monitoring pressure.

When monitoring by pressure, if an analog gauge is used, there shall be no visible drop in the pressure measurement system. When monitoring by pressure, if a digital gauge (such as a transducer) is used, the pressure shall not drop by more than 5 % of the test pressure during the test.

For hydraulic test, there shall be no drop in pressure.

12.2.4 Rotary Vane Test

12.2.4.1 General

The test pressure for all rotary vane seal tests shall be a minimum of 1.1 times the maximum rated pressure. The test duration shall be in accordance with Table 8.

Actuators shall be operated prior to performing the rotary vane seal test.

Double-acting actuators shall be tested in each direction.

12.2.4.2 Pneumatic Rotary Vane Actuator

Pneumatic rotary seal tests shall be conducted with pressure applied to one side of the vane with the other side open to atmosphere. Leakage shall be detected by submersion in water or by application of a leak detection fluid.

There shall be no visible leakage (see 3.1.16) during the test duration.

12.2.4.3 Hydraulic Rotary Vane Actuator

Hydraulic rotary vane seal tests shall apply pressure to one side of the vane and then isolate from the pressure source. Leakage shall be detected by visual inspection and monitoring pressure.

Leakage rate shall be in accordance with the manufacturers standard, or by agreement.

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12.3 Electric Actuators

12.3.1 General

The production tests shall conform to 12.3.2, 12.3.3, and 12.3.4, at a minimum. Test results shall be recorded and made available to the purchaser.

All electric actuators (excluding secondary gearbox) shall be tested as described in 12.3.2, 12.3.3, 12.3.4, and 12.4.

Secondary gearbox performance data shall be validated by type test and calculation, or by agreement.

The tests in 12.3.2, 12.3.3, 12.3.4, and 12.4 shall be performed at a specified voltage/frequency, or by agreement. Tests shall be conducted in both directions using a calibrated test fixture.

12.3.2 Output Torque Test

12.3.2.1 Stall Torque

With the motor energized, torque-limiting devices de-activated and the output drive locked, the maximum torque shall be measured and recorded, if applicable. In the event of test limitations, and by agreement, the stall torque shall be reported based on calculation.

12.3.2.2 Rated Torque

With calibrated torque-limiting device(s) set at 100 % of the rated torque, the torque shall be measured and recorded to validate the manufacturer's rated torque/thrust output.

When supplied as modular, component parts, the manufacturer shall provide type test data which validates the torque or thrust.

NOTE 1 In addition, torque-limiting device(s) may be set to an operational value below 100 % by agreement.

A functional test of torque-limiting devices shall be carried out in order to demonstrate de-energization of the motor.

NOTE 2 Setting the torque-limiting device(s) to an operational value below 100 % does not remove the requirement to test the rated torque described above.

The output torque of the combined electric actuator and gearbox shall be derived via calculation based on gearbox validated performance data and electric actuator test results to validate ability to deliver torque output to meet the manufacturers specification.

12.3.3 Output Position Limiting Test

Functional testing of travel-limiting devices shall be performed to demonstrate de-energization of the motor at pre-set positions in both open and closed stroke.

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For multi-turn actuator/gearbox combinations, travel-limiting devices shall be set to the manufacturer's default output turns range or to a range specified by the purchaser.

For part-turn actuator/gearbox combinations, travel-limiting devices shall be set to the mechanical stops as applicable in accordance with the actuator manufacturer's or gearbox supplier's instructions.

12.3.4 Operating Time Test

12.3.4.1 Part-turn Actuator

For part-turn actuators, the operating time (see 3.1.18) of the actuator shall be validated and recorded.

12.3.4.2 Multi-turn Actuator

For multi-turn actuators, where the output turns are known, the operating time (see 3.1.18) of the actuator shall be validated and recorded.

Where output turns are unknown, the revolutions per minute of the actuator shall be recorded.

12.3.4.3 Linear Actuator

For linear actuators the operating time (see 3.1.18) of the actuator shall be validated and recorded. The stroke time shall be measured and recorded.

12.4 Actuator and Valve Functional and Performance Test

12.4.1 General

When installed on a valve, the elements of Section 12.4 shall apply.

The actuator and valve shall be tested to validate function and performance in accordance with the manufacturer's or supplier's documented procedures.

The following shall be performed:

12.4.2 Visual, dimensional, and sizing verification

Actuator dimensions and installation orientation shall be verified to purchaser specification.

Sizing calculations shall be documented and verified in accordance with the manufacturers specifications.

12.4.3 Stroke Test

Actuator and valve shall be stroked without pressure in the valve, for three cycles to ensure:

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- a) the assembly functions per manufacturers requirements;
- b) the stops are set correctly.

The stroke time shall be recorded and shall meet the purchasers requirement.

12.4.4 Fail action test

If applicable, actuator and valve shall have the fail-to action functionality tested by interrupting the signal/supply energy to ensure the fail-to mode condition is met.

12.4.5 Functional test of accessories

If applicable, accessories such as solenoid valves, limit switches, position transmitters, local open/close devices, remote open/close/stop devices, and reset buttons shall be tested in accordance with the manufacturer's or suppliers procedure.

12.4.6 Partial stroke test

If applicable, actuator and valve shall be partial stroke tested in accordance with the manufacturer's or suppliers procedure.

12.4.7 Functional test of actuator with accumulator

If applicable, actuator and valve shall be functional tested using the accumulator as the pressure source, for the number of strokes specified by the purchaser, in accordance with the manufacturer's or suppliers procedure.

13 Environmental Surface Protection for Transportation and Storage

Actuators, mounting spool (including the internal surfaces), couplings and fasteners in contact with the environment shall be protected against corrosion in accordance with the manufacturer's or suppliers standards or purchaser requirements.

Parts and equipment that have bare metallic surfaces shall be protected against corrosion in accordance with the manufacturer's or suppliers standards or purchaser requirements.

Exterior coating (e.g. paint) shall be specified.

14 Marking

Actuators shall be marked in accordance with the requirements of Table 9, Table 10, or Table 11.

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Table 9—Marking of Pneumatic/hydraulic Actuators

No.	Marking	Application on
1	Manufacturer's name or trademark	Actuator and/or nameplate
2	Model	Nameplate
3	Serial number	Nameplate
4	Maximum rated pressure	Nameplate
5	Maximum operating pressure (if specified)	Nameplate
6	Minimum and maximum supply pressure	Nameplate
7	Year of manufacture	Nameplate
8	"API 6DX" or "6DX"	Nameplate

Table 10—Marking of Electric Actuators

No.	Marking	Application on
1	Manufacturer's name or trademark	Actuator and/or nameplate
2	Model	Nameplate
3	Serial number	Nameplate
4	Supply voltage, phase and frequency	Nameplate
5	Voltage variation	Nameplate
6	Frequency variation	Nameplate
7	Power of electric motor	Nameplate
8	Hazardous area classification	Nameplate
9	Year of manufacture	Nameplate
10	"API 6DX" or "6DX"	Nameplate

Table 11—Marking of Electro-Hydraulic Actuators

No.	Marking	Application on
1	Manufacturer's name or trademark	Actuator and/or nameplate
2	Model	Nameplate
3	Serial number	Nameplate
4	Supply voltage, phase and frequency	Nameplate
5	Voltage variation	Nameplate
6	Frequency variation	Nameplate
7	Power of electric motor	Nameplate
8	Hazardous area classification	Nameplate
9	Maximum rated pressure	Nameplate
10	Maximum operating pressure (if specified)	Nameplate
11	Minimum and maximum supply pressure	Nameplate
12	Year of manufacture	Nameplate
13	"API 6DX" or "6DX"	Nameplate

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Each actuator shall be provided with a nameplate securely affixed and located as to be easily accessible. The marking on the nameplate shall be permanent and legible.

NOTE The items listed in Table 9, Table 10 and Table 11 are not in a prescriptive order.

15 Preparation for Shipment

All open ports shall be closed to protect the seal surfaces and threads and prevent water ingress.

The mounting surfaces shall be protected to prevent mechanical damage.

Spring return actuators shall be shipped with the spring in the fail-to position.

Fluid powered actuator shall be shipped with the actuator unpressurized.

NOTE Fluid powered actuators with enclosed systems may experience pressure fluctuation during transit due to a change in environmental temperature.

16 Documentation

The documentation specified in Table 12 shall be provided to the purchaser:

- Items 1, 4 and 5 with each actuator supplied
- Items 2, 3, 6 and 7 with each actuator size, type and configuration supplied

Table 12 —Required Documentation

Item	Description	Electric Actuators	Pneumatic/Hydraulic Actuators	Electro-hydraulic
1	Output torque/thrust data	X	X	X
2	Wiring diagram	X	If applicable	X
3	Schematic diagram	N/A	X	X
4	Pressure test results, shell	N/A	X	X
5	Leak test results, piston	N/A	X	X
6	Hazardous area certification	X	If applicable	X
7	General arrangement drawing with dimensions	X	X	X
X = Required N/A = Not Applicable				

The manufacturer shall supply a certificate of conformance to this standard. The certificate shall identify the actuator type, model, serial number; any additional requirement specified by the manufacturer or purchaser, and a certification statement that the actuator and mounting kit are in full conformance with this product standard edition and all addenda.

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The manufacturer shall provide procedures for the safe removal of the spring/spring module.

Documentation shall be provided by the manufacturer in legible, retrievable, and reproducible form and free of damage.

Documentation and records, where applicable and as listed in Table 12 and Table 13, shall be retained by the manufacturer for a minimum of ten years following the date of manufacture.

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Table 13—Record Retention

Item	Description	Mounting Kit	Electric Actuators	Pneumatic/hydraulic Actuators	Electro-hydraulic
1	Bill of materials	X	X	X	X
2	Design documentation	X	X	X	X
3	Hazardous area certification	NR	X	NR	X
4	Contract/project documentation	NR	X	X	X
5	Validation records	NR	X	X	X
6	Sizing calculations/confirmations	X	X	X	X
7	Welding procedure specification (WPS)	A	A	A	A
8	Weld procedure qualification record (PQR)	A	A	A	A
9	Welder performance qualification (WPQ)	A	A	A	A
10	Qualification records of NDE personnel	NR	NR	X	X
11	Material test report for pressure-containing parts, traceable to the unique serial number	NR	NR	X	X
12	Material test report for spring, traceable to the unique serial number	NR	NR	X	X
13	Serial number	NR	X	X	X
14	Certificate of conformance to NACE MR0175 (ISO 15156) (all parts) if applicable	A	NR	A	A
15	Circuit diagram	NR	X	NR	X
16	Installation, commissioning, and maintenance instructions	NR	X	X	X
17	Production test certificate for pneumatic/hydraulic actuators, including: — output torque — stroking times — pressure test, shell — pressure test, piston	NR	NR	X	X
18	Production test certificate for electric actuators, including: — output torque — stroking times	NR	X	NR	NR
19	Coating (paint) certificate	X	X	X	X
20	Cleanliness test report	NR	NR	H	H
21	Compliance with local directives and regulations (e.g. including but not limited to PED, ATEX, ASME, CRN)	NR	A	A	A
22	NDE report: RT; PT; MT; and UT	A	A	A	A

X = mandatory
A = mandatory (when applicable) to the specific design
H = hydraulic actuators only

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NR = not required

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Annex A

(Normative)

Sizing of Actuators

A.1 Required Valve Torque and/or Thrust Data

All required torque/thrust values shall reflect the process condition if known (e.g., low-temperature process media, pipeline operating pressure, viscous media, long stand-still time) and shall not include a safety factor in A.2.

The following data shall be determined:

- a) mounting interface dimensions (e.g., mounting flange, stem, key/drive) including details related to environmental seal (see 5.14);
- b) break-to-open torque or thrust (BTO);
- c) run-to-open torque or thrust (RTO);
- d) end-to-open torque or thrust (ETO);
- e) break-to-close torque or thrust (BTC);
- f) run-to-close (reseal) torque or thrust (RTC);
- g) end-to-close (reseal) torque or thrust (ETC);
- h) valve MAST;
- i) valve breakaway angle or breakaway percent of stroke;
- j) required pipeline and valve stem orientation (e.g. pipeline vertical, stem horizontal);
- k) length and direction of stroke to open and close for linear valves, if applicable;
- l) angle and direction of rotation for part-turn valve, if applicable;
- m) direction of rotation and number of turns for multi-turn valves, if applicable;
- n) thrust necessary to enable valve to maintain position, if applicable;
- o) number of cycles expected during the service life of the equipment;
- p) frequency of cycling and speed of operation;
- q) maximum frequency of operation (e.g. number of cycles per hour or per week), and
- r) number of full strokes from stored energy source in a power loss condition

The purchaser shall ensure that when purchasing an actuator for a valve, the MAST and maximum torque/thrust are compared to ensure compatibility of design.

NOTE There are potentially multiple entities involved in the process of purchasing an actuator or an actuated valve assembly. It is imperative that the information as described in A.1 is exchanged, to ensure that the necessary

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entities provide and receive the required information for the supply of an actuator, mounting kit, or actuated valve assembly.

A.2 Safety Factor

Using the method described in A.3, the actuator shall be sized by the manufacturer or the supplier to provide a safety factor based on one of the following service conditions:

- a) For an actuated valve in service other than defined in Item b) and Item c), the actuator shall be sized with a minimum safety factor of 1.3.
- b) An actuator used on an emergency shut-down valve (ESDV) and blow-down valve (BDV) shall be sized with a minimum safety factor of 1.5 in the fail-to direction, and a minimum safety factor 1.3 in the other direction.
- c) An actuator used on a HIPPS valve shall be sized for maximum process differential pressure across the valve, and the actuator shall be sized with a minimum safety factor of 1.5 to close the valve.

A.3 Method

The valve torque/thrust values and other related data shall be determined as described in A.1.1.

The actuator shall be sized using the torque/thrust values determined in A.1.1 at the maximum pressure rating of the valve unless otherwise specified by the purchaser.

The actuator shall be selected based on minimum supply voltage or minimum supply pressure, maximum compressed spring force, and other related data as described in 5.2.

If actuator output torque/thrust under maximum voltage/pressure exceeds valve MAST, the output shall be limited by electronics or by pressure regulation.

For pneumatic/hydraulic actuators, when the maximum supply pressure is reduced by means of a pressure-limiting device (e.g. a regulator, relief valve system, or other device), the pressure used to establish the maximum output torque/thrust shall be based on the relief valve set pressure, including any overpressure effects at full lift, whichever is higher.

For electric actuators, the maximum torque/thrust shall be based on the rated torque/thrust setting.

NOTE Some pressure-limiting devices may stop the valve from completing its stroke until the supply pressure returns to normal working pressure.

A.4 Documentation

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The number of handwheel turns (or lever strokes) to stroke the valve shall be provided to the purchaser.

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Annex B **(Informative)**

Specified Customization—Supplemental Options to Specified Design and Manufacturing Requirements

B.1 Environmental Protection

If specified, the enclosed mounting kit and hardware shall be provided with seals to minimize the ingress of water adjacent to the stem and/or packing to mitigate the occurrence of corrosion.

If specified, the enclosed mounting kit shall be provided with a drain at the lowest point.

B.2 Orientation

Details regarding installed orientation of the actuated valve assembly and the direction from which local access (e.g. override, handwheel, control panel, cable entry, local controls) is required, including pipeline direction and stem direction (e.g. horizontal, vertical, inclined, etc.) and actuator orientation (e.g. in-line or transverse to pipeline) shall be determined.

NOTE The most common orientation is pipeline horizontal, stem vertical, actuator in line with pipeline. It is important to understand the installation details to ensure proper actuator operation and local access to panel.

B.3 Service Compatibility

All parts in contact with the operating fluids and lubricants shall be suitable for the commissioning fluids and service specified.

Metallic materials shall be selected to avoid corrosion and galling, which can impair function and/or pressure-containing capability.

For gas-over-oil and direct gas actuators, all parts in contact with the pipeline fluids shall be suitable for the service conditions specified.

For pneumatic actuators, if compressed gases or pressurized fluids other than instrument air are used, the internal actuator parts and lubricants shall be compatible with the gas or fluid.

B.4 Environmental Conditions

All parts shall be suitable with the environmental conditions at the operating site defined by the purchaser.

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Aluminum, aluminum alloys and carbon steel actuators shall be coated or otherwise protected if used offshore or in coastal environments.

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- [1] ISO 8573-1:2010, *Compressed air — Part 1: Contaminants and purity classes*
- [2] ISO 13623, *Petroleum and natural gas industries — Pipeline transportation systems*
- [3] API Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*
- [4] API Specification 6D, *Specification for Valves*
- [5] EN 13906 (all parts), *Cylindrical helical springs made from round wire and bar — Calculation and design*
- [6] EN 16983, *Disc springs - Quality specifications — Dimensions*
- [7] MSS SP-25, *Standard Marking System for Valves, Fittings, Flanges and Unions*
- [8] ASNT ACCP-CP-1,¹¹ *ASNT Central Certification Program*
- [9] ISO 15609 (all parts), *Specification and qualification of welding procedures for metallic materials — Welding procedure specification*
- [10] MSS SP-55,¹² *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components — Visual Method for Evaluation of Surface Irregularities*
- [11] Pressure Equipment Directive 2014/68/EU
- [12] ASTM A395/A395M, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*
- [13] ASTM A536, *Standard Specification for Ductile Iron Castings*

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¹² Manufacturers Standardization Soc. of the Valve & Fittings Industry, 127 Park Street, N.E., Vienna, VA 22180, USA