**ANSI/AWWA C541-16**
(Revision of ANSI/AWWA C541-08)

American Water Works Association

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AWWA Standard

# Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates

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# Foreword

*This foreword is for information only and is not a part of ANSI*/AWWA C541.*

**I. Introduction.**

I.A. *Background.* This standard describes hydraulic and pneumatic cylinder- and vane-type actuating devices that are externally mounted on gate, ball, plug, cone, globe, knife gate, and butterfly valves and on slide gates suitable for use in water and wastewater utilities. This standard does not cover the pilot and control apparatus used to actuate the operating device.

I.B. *History.* The first edition of the ANSI/AWWA C540 standard, published in 1987, was the result of 12 years of effort by the AWWA Standards Committee on Power-Actuating Devices for Valves and Sluice Gates. The committee was formed by AWWA in 1974 and charged with the development of standards on actuators for valves and sluice gates, including electric motors and cylinders employing air, water, and oil. The second edition of the ANSI/AWWA C540 standard was approved by the AWWA Board of Directors on June 6, 1993, and added quarter-turn actuators. The third edition was approved on June 16, 2002. It added vane-type actuators and digital controls. In 2004, the original single standard was split by the Standards Council into two separate standards, one for electric motor–actuated devices (ANSI/AWWA C542) and one for hydraulic and pneumatic cylinder and vane-type actuators (ANSI/AWWA C541). These two standards replaced the ANSI/AWWA C540 standard. The first edition of ANSI/AWWA C541 was approved by the AWWA Board of Directors on January 27, 2008, and first published November 1, 2009. This edition was approved on Jan. 16, 2016.

**II. Special Issues.**

II.A. *Discussion.* ANSI/AWWA C541 describes only the design and performance of those actuating devices applied to systems with operating pressures normally encountered in water and wastewater utilities. Purchasers of hydraulic and pneumatic cylinder actuating devices and vane-type actuating devices should carefully review the requirements of this standard, evaluate the information to be provided to the manufacturer, and review the data to be supplied by the manufacturer. Such evaluations are essential to ensure proper application of hydraulic and pneumatic cylinder actuators and vane-type actuators for the intended use. Actuators in this

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standard are provided to serve various valve or gate applications. Each AWWA valve or gate standard, e.g., C561, may call for more stringent requirements than found in this standard. In such cases, the more stringent standard governs.

Specific requirements for controls and accessories and other items not described in this standard must be included in the purchase documents.

II.B. *Hydraulic Fluid.* Caution should be used in the selection of a hydraulic fluid to be used in a cylinder actuator. In the event of a malfunction involving leakage of fluid into the water supply, it is essential that the hydraulic fluid not impart any taste or odor or contain any contaminant substances harmful to the water supply or the public. If potable water is used as the hydraulic fluid, care must be taken to prevent backflow of this water into the potable system, or where applicable, use an NSF-approved food-grade hydraulic oil.

**III. Use of This Standard.** It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

This standard includes certain options that must be selected and specified by the purchaser to completely describe and obtain the actuator desired. In addition to the factors in Sec. III.A, Purchaser Options and Alternatives, other factors to be considered when sizing an actuator are described in Sec. 4.3, Actuator Sizing. The following summarizes the options that must be selected and the data that should be covered in the purchase documents describing actuators manufactured in accordance with this standard.

III.A. *Purchaser Options and Alternatives.* The following information should be provided or requested by the purchaser:

1. Standard used—that is, ANSI/AWWA C541, Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates, of latest revision.
2. Details of other federal, state, provincial, or local requirements (Sec. 4.1).
3. Valve and slide gate characteristics (Sec. 4.3).
    a. Size and type of valve or slide gate to be driven by the actuator.
    b. Rising stem, nonrising stem, or quarter turn.
    c. Valve stem data including (1) type of stem (threaded, round with keyway, square, splined, etc.); (2) if threaded, thread type, pitch, and lead; (3) dimensions of stem and keyway (if applicable); and (4) orientation (i.e., clockwise to close or clockwise to open).
    d. Weight of gate and stem for slide gate.


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e. Failure mode on loss of power: fail open, fail close, fail freeze, or fail in last position on loss of driver medium pressure, control signal, or both.

f. Seating/unseating torque in foot-pounds (newton-meters), maximum dynamic torque in foot-pounds (newton-meters), and when applicable, thrust in pounds (newtons) (Sec. 4.3.1.3).

g. Minimum hydraulic or pneumatic pressure available for sizing actuator (Sec. 4.3.1.2).

h. Maximum torque/thrust capability of the valve or slide gate (Sec. 4.3.2).

i. Direction of rotation of actuator handwheel to open valve or slide gate if other than counterclockwise (Sec. 4.4.10.8).

4. Specific actuator and equipment data. See Table A.1, Actuator Data Form, appendix A.

a. Special auxiliaries, such as fail-safe, spring-return pneumatic (Sec. 4.4.7.15, 4.4.8.12, and 4.4.9.7), or manual (mechanical) override (Sec. 4.4.10).

i. Fail-safe operation using a spring-return option allows a valve/actuator assembly to "fail" to a specified position, usually fully closed or fully open, on loss of driver medium pressure. For rotary valves, the rotation of the spring stroke must be specified in the purchase documents.

ii. Spring-return actuators and cylinders have a "starting torque" and "ending torque." Starting torque refers to the torque output of the actuator or cylinder at the beginning of the air stroke or spring stroke, as specified in the manufacturer's literature. Ending torque refers to the torque output of the actuator or cylinder at the end of the air stroke or spring stroke, as specified in the manufacturer's literature. Some actuators and cylinders have different starting torques and ending torques for the air and spring strokes.

iii. Declutchable manual gear override. When specified by the purchaser, a declutchable manual gear override shall be provided. The user may consider a declutchable manual gear override with a handwheel when there may be the need of manually operating a valve equipped with a hydraulic or pneumatic actuator, for example, in the event of a power outage. For rotary valves, it is good practice to mount the manual gear override between the hydraulic or pneumatic actuator and the valve to provide true stand-alone capability in the event of actuator failure or servicing. Handwheel rim pull force is determined by the effort required on the handwheel to operate the valve or gate closure member. Where the handwheel is a spoke design rather than a rim design, handwheel input force should be measured at 2 in. from the far end of the spokes. While this standard limits handwheel rim pull (Sec. 4.4.7.16 and


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4.4.10.3), the standard does not address handwheel diameters. Large-diameter handwheels reduce the rim pull effort but increase the risk of damage to the valve or gate due to the reduced effort on the handwheel producing higher torque output than the pneumatic or hydraulic actuator. Conversely, smaller-diameter handwheels increase the rim pull effort. Space considerations should also be taken into account when selecting handwheel diameters. The maximum pull on the rim of the handwheel should be specified by the purchaser if a lesser pull than 80 lb is required (Sec. 4.4.7.16 and 4.4.10.3). Maximum pull requirements have been found by some operators to be a high exertion of effort, and lesser pulls of 40 lb to 60 lb (18.1 kg to 24.2 kg) on the rim of the handwheel have sometimes been found to be beneficial.

b. Controls and special devices, such as solenoid valves, additional speed-control valves, manually operated valves, interconnecting piping, limit switches, and positioners.

c. Voltage available for solenoid valves.

d. Control signal available for positioners.

e. Special communication protocol.

f. Major design features (Sec. 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5, 4.4.6, 4.4.7, 4.4.8 and 4.4.9). This standard allows the use of galvanized tie rods (Sec. 4.4.6.8). Users should be aware that electrogalvanizing offers limited corrosion protection. If corrosion is a concern, the user should consider other means of protection including coatings or specifying a different material for the tie rods.

g. Lubrication requirements, such as food-grade grease or hydraulic fluid (Sec. 4.4.3.7, 4.4.7.14, 4.4.8.11).

h. Data by supplier: When required in the purchase documents, the supplier should provide the following:

i. Drawings and manuals (Sec. 4.2).

ii. Certification of nonmetallic-cylinder-material confirmation tests (Sec. 4.4.6.9).

iii. Certification of proof-of-design test (Sec. 5.2).

iv. Certification of performance test (Sec. 5.3).

v. Test certification (Sec. 5.4).

vi. Inspection and testing (Sec. 5.5).

vii. Affidavit of compliance (Sec. 6.3).

i. If required, adjustable flow-control devices and opening and closing speeds if other than specified (Sec. 4.5.2).



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j. Minimum and maximum pressure of driver medium when the valve or slide gate is to be operated (appendix B).

k. Driver medium properties—air, water, or oil (appendix B).

l. Pneumatic actuator prelubrication (Sec. B.3.2).

m. The actuator manufacturer and purchaser should be in agreement on whether air-line lubricators are required.

5. Operating requirements.

a. Type of service.

i. Open–close. Provide frequency of operation and the travel time duty cycle.

ii. Throttling/modulating. Provide operation conditions and the input signal to actuator.

b. Operating-cycle requirements. Travel time in inches (linear) or degrees (rotary) per second (or minute) from fully open to fully closed positions and fully closed to fully open positions under operating conditions. NOTE: Unless otherwise specified in the purchase documents, hydraulic and pneumatic cylinders and actuators will be supplied to operate from fully open to fully closed positions, or reverse, based on an adjustable range of the greater of 10 seconds (±20 percent) or 2–4 seconds per inch of nominal valve size at the minimum specified supply pressure. Standard travel time for slide gates is 12 in./min. Rate of closure can be significantly slower for larger gates such as slide gates.

c. Maximum unbalanced heads or differential pressures against which the valve or gate must open or close, and the maximum pipeline pressure.

d. Ambient temperature and humidity ranges.

e. Installation location: outdoors; indoors in a pit; in a vault; or in any hazardous location if applicable, as defined by the National Electrical Code. If submergence is expected, give depth and length of time of submergence for which the actuator is expected to operate.

6. Mounting and options.

a. Actuator orientation in relation to valve or slide gate.

b. Actuator mounting: directly mounted or remotely mounted on a floor stand and coupled with extension shafting.

c. Type of actuator (Sec. 4.4).

i. Oil-hydraulic cylinder per Sec. 4.4.3.

ii. Water-hydraulic cylinder per Sec. 4.4.4.

iii. Pneumatic cylinder per Sec. 4.4.5.



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iv. Nonmetallic water-hydraulic and pneumatic cylinder per Sec. 4.4.6.
v. Quarter-turn cylinder actuator per Sec. 4.4.7.
*(a)* Lever.
*(b)* Link and lever.
*(c)* Rack and pinion.
*(d)* Scotch yoke.
vi. Pneumatic quarter-turn rack and pinion per Sec. 4.4.8.
vii. Pneumatic quarter-turn vane-type actuator per Sec. 4.4.9.

d. Special coating system (Sec. 4.6).
e. If an agent of the purchaser is to visit the plant (Sec. 5.5).
f. Special shipping requirements (Sec. 6.2).

III.B. *Modification to Standard.* Any modification of the provisions, definitions, or terminology in this standard must be provided in the purchase documents.

**IV. Major Revisions.** Major changes made to the standard in this revision include the following: Added requirements for pneumatic quarter-turn rack and pinion actuators (Sec. 4.4.8), spring-return options (Sec. 4.4.7.15, 4.4.8.12, and 4.4.9.7), and manual gear overrides (Sec. 4.4.10).

**V. Comments.** If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603; write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098; or email at standards@awwa.org.


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# Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates

## SECTION 1: GENERAL

### Sec. 1.1 Scope

This standard describes hydraulic and pneumatic linear and quarter-turn actuators for operation of valves and slide gates in utility systems.

1.1.1 *Actuator types.* Actuators described in this standard consist of the following types (Figure 1):

1. Linear actuators producing a linear (push–pull) motion.
2. Quarter-turn actuators producing a rotary motion.
   a. Cylinder with link and lever mechanism.
   b. Cylinder with scotch yoke mechanism.
   c. Rack and pinion actuator.
   d. Vane actuator.

1.1.2 *Actuator function.* Actuators shall produce a rotary torque or linear thrust to actuate a valve or slide gate in open–close, throttling, or modulating service.

1.1.3 *Excluded actuators.* Electric-motor actuators are not included in this standard.



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