



CGA E-4—2021 STANDARD FOR GAS PRESSURE REGULATORS

EIGHTH EDITION

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Work Item 20-031
Industrial Gases Apparatus Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendices A, B, and C (Informative) are for information only.

EIGHTH EDITION: 2021
SEVENTH EDITION: 2016
SIXTH EDITION: 2010
FIFTH EDITION: 2006

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1 Introduction

This publication establishes minimum performance and safety requirements for gas pressure regulators. These requirements are based on existing technology and represent the state of the art at the time of publication. There is no intent to discourage or impede future innovation of gas pressure regulators.

This publication does not address any personnel safety or health concerns, nor does it address any environmental requirements, which can be involved in the testing or making of these devices. Each manufacturer shall address these matters relative to their operations and comply with local, state/provincial, and national regulations and laws.

2 Scope

This publication specifies requirements for regulators used with compressed gases to reduce the supply pressure from a storage cylinder, pipeline, or other source to the use pressure.

This publication contains design and manufacturing requirements relating to materials, construction, performance, test procedures, information, marking, and packaging of pressure regulators. Appendix A provides information relating to regulator flow capacity calculations. For pressure regulators used with medical gases, additional requirements are specified in CGA E-7, *Standard for Medical Gas Pressure Regulators, Flowmeters, and Orifice Flow Selectors* [1].¹

This publication does not apply to liquefied petroleum gas (LPG) pressure regulators for equipment intended for installation and use in accordance with the requirements of NFPA 58, *Liquefied Petroleum Gas Code* [2].

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Creep

Continuing rise above set pressure, after downstream flow is shutoff due to an internal leak.

NOTE—Creep is sometimes referred to as crawl.

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2.2 Flow regulation

Change in set pressure, measured downstream from the regulator outlet passage, caused by a change in flow rate.

NOTE—Also known as droop. See 6.3 for more information.

3.2.3 Leak rate

Numerical expression for the amount of gas unintentionally leaked to the atmosphere, from the surrounding atmosphere, or inside a closed system.

NOTE—Leak rates are given in cubic centimeters per second (cc/s).

3.2.4 Oil-free, dry air or oil-free, dry nitrogen

Air or nitrogen with a dew point of -40°F [-40°C] or less and an oil content of 0.5 mg/m^3 or less.

3.2.5 Pressure

Force per unit area exerted by the gas on the walls of the gas container.

NOTE—In the customary U.S. system of measurement, pressure is expressed in pounds per square inch (psi). In ISO standards, pressure is expressed in units based on the Le System International d'Unites (SI system).

3.2.5.1 Bar

Metric unit of pressure. 1 bar = 100 kPa.²

NOTE—1 bar is equal to approximately 14.5 psi

3.2.5.2 High pressure

Inlet (cylinder or source) pressure.

3.2.5.3 Low pressure

Delivery (regulated) pressure.

3.2.5.4 Pounds per square inch absolute (psia)

Unit of pressure measurement with zero pressure as the base or reference pressure.

3.2.5.5 Pounds per square inch gauge (psi)

Unit of pressure measurement with atmospheric pressure as the base or reference pressure.

NOTE—Under standard conditions, 0 psi is equivalent to 14.7 psia (101 kPa, abs).

3.2.5.6 Set pressure

Regulated pressure set by the force exerted on the pressure sensing device of the regulator (e.g., the pressure the regulator is set to deliver).

3.2.6 Pressure gauge

Device that indicates the pressure relative to the environment.

3.2.7 Pressure regulation

Characteristic of pressure regulators manifested by a change in outlet pressure due to a change in inlet pressure, see 6.1.

NOTE—Also known as supply pressure effect.

3.2.8 Pressure regulator

Pressure control device that reduces the inlet pressure and maintains the outlet pressure at a prescribed pressure with changes of inlet pressure and flow rate.

² kPa shall indicate gauge pressure unless otherwise noted as (kPa, abs) for absolute pressure or (kPa, differential) for differential pressure. All kPa values are rounded off per CGA P-11, *Guideline for Metric Practice in the Compressed Gas Industry* [3].

3.2.8.1 Adjustable regulator

Pressure regulator provided with a means to adjust the outlet pressure at the will of the user.

3.2.8.2 Dome loaded regulator

Regulator in which the regulated (set) pressure is adjusted by gas pressure instead of by a spring force.

3.2.8.3 Flowgauge regulator

Pressure regulator having a flow restrictor in the outlet and an outlet pressure gauge calibrated to indicate the flow rate through the restrictor.

3.2.8.4 Flowmeter regulator

Combination of a flowmeter with a pressure reducing regulator that provides control of flow rate (volume).

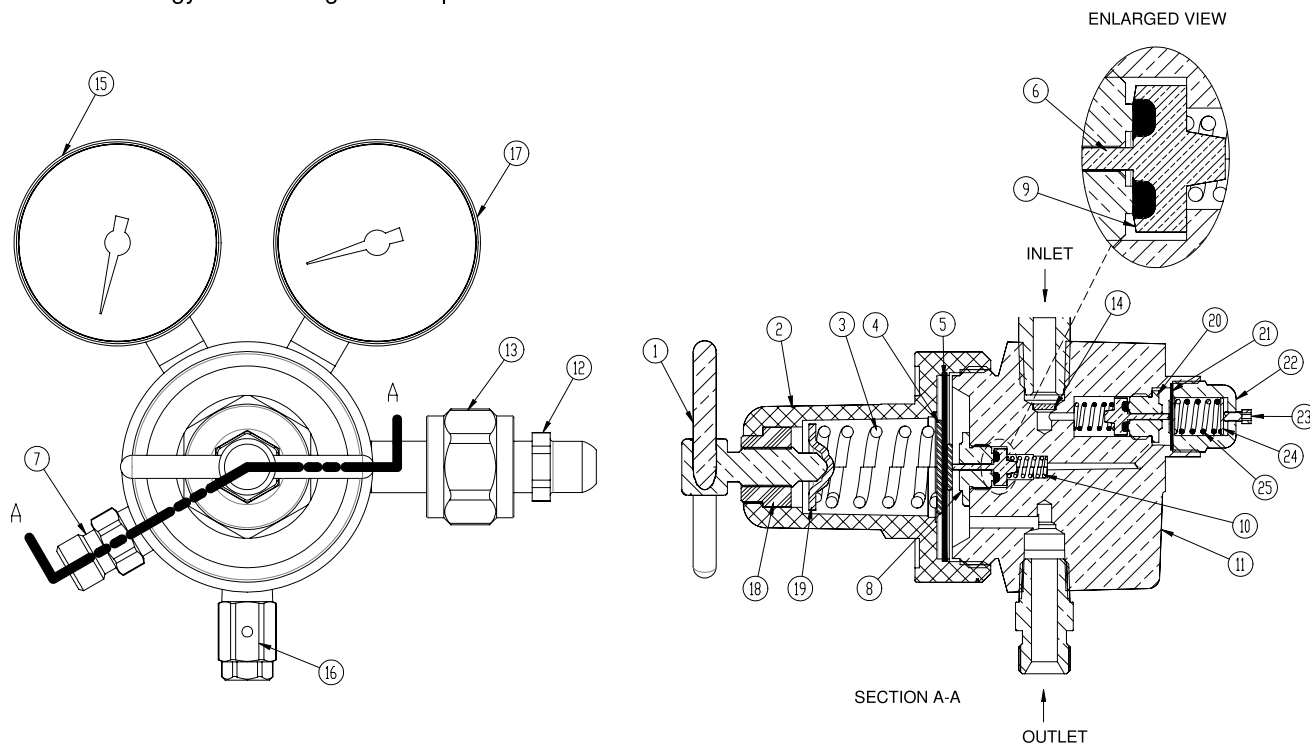
3.2.8.5 Line regulator

Regulator incorporated as a fixed part of a gas piping system (see 5.1.4).

3.2.8.6 Multi-stage regulator

Pressure regulator having two or more levels of pressure reduction.

A typical two-stage pressure regulator is shown in Figure 1. The components in Figure 1 are identified and reflect the terminology used throughout this publication.



#	Component	#	Component	#	Component
1	Pressure adjusting screw ¹⁾	10	Valve spring	18	Bushing
2	Bonnet (spring case)	11	Regulator body	19	Spring button
3	Pressure adjusting spring	12	Inlet nipple	20	1st stage valve nozzle
4	Diaphragm plate	13	Inlet nut	21	1st stage diaphragm assembly
5	Diaphragm	14	Inlet filter	22	1st stage bonnet (spring case)
6	Valve pin	15	Inlet pressure gauge	23	1st stage pressure adjusting screw ¹⁾
7	Outlet fitting	16	Pressure relief device (PRD)	24	1st stage spring button
8	Valve nozzle	17	Delivery pressure gauge	25	1st stage adjusting spring
9	Valve stem				

¹⁾ The pressure adjusting screw of a preset regulator is typically not adjustable by the user.

Figure 1—Typical two-stage adjustable regulator with indirect acting valves

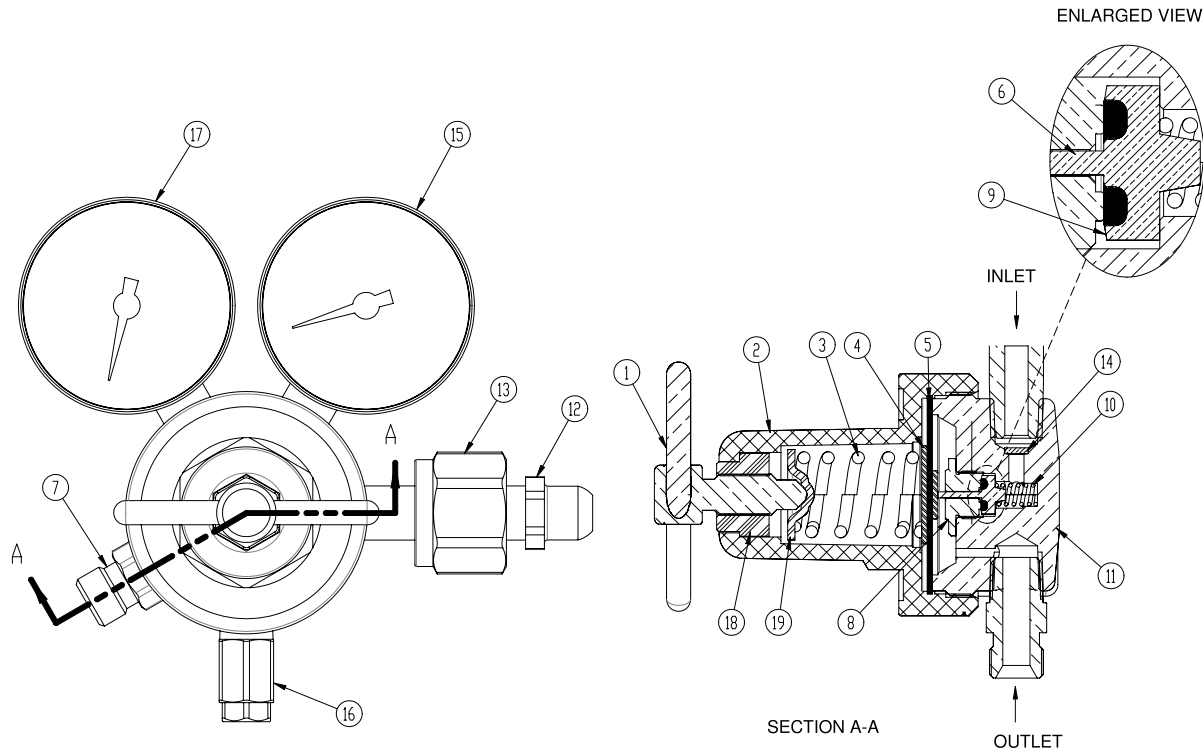
3.2.8.7 Preset regulator

Pressure regulator having a nonadjustable outlet pressure.

3.2.8.8 Single-stage regulator

Pressure regulator having only one level of pressure reduction.

A typical single-stage pressure regulator is shown in Figure 2. The components in Figure 2 are identified and reflect the terminology used throughout this publication.



#	Component	#	Component	#	Component
1	Pressure adjusting screw ¹⁾	8	Valve nozzle	14	Inlet filter
2	Bonnet (spring case)	9	Valve stem	15	Inlet pressure gauge
3	Pressure adjusting spring	10	Valve spring	16	Pressure relief device (PRD)
4	Diaphragm plate	11	Regulator body	17	Delivery pressure gauge
5	Diaphragm	12	Inlet nipple	18	Bushing
6	Valve pin	13	Inlet nut	19	Spring button
7	Outlet fitting				

¹⁾ The pressure adjusting screw of a preset regulator is typically not adjustable by the user.

Figure 2—Typical single-stage adjustable regulator with indirect acting valve

3.2.8.9 Station regulator

Detachable regulator intended for installation at station outlets of gas pipeline systems for welding, cutting, and allied processes at pressures of 200 psi (1380 kPa) or less.

NOTE—These regulators utilize inlet connections outlined in CGA E-3. See 5.1.3 for more information.

3.2.9 Pressure relief device (PRD)

Pressure-activated device designed to relieve excessive pressure in a regulator, see 5.4.

3.2.10 Rated flow capacity

Manufacturer's rated flow capacity, Q_R , determined from a flow regulation curve at the lowest inlet pressure at which the regulator is to be used, see 6.4.

3.2.11 Static increment

Increase in set pressure resulting from a reduction in flow from a relatively small flow to no flow sometimes referred to as lock-up, see 6.2.

3.2.12 Toxic gas

Gases and gas mixtures that are required to bear a poison gas label by the U.S. Department of Transportation (DOT) or Transport Canada (TC).

3.2.13 Valves

3.2.13.1 Balanced valve

Pressure regulator valve that balances the effects of the inlet pressure on the valve to reduce or eliminate change of outlet pressure caused by a change of inlet pressure.

3.2.13.2 Direct acting valve

Pressure regulator valve that has a tendency to open with an increase of inlet pressure.

3.2.13.3 Indirect or reverse acting valve

Pressure regulator valve that has a tendency to close with an increase of inlet pressure.

4 General requirements

Gas pressure regulators shall be designed, fabricated, and assembled so they will safely and reliably perform their intended functions.

4.1 Operating temperature range

4.1.1 Standard industrial regulators

Standard industrial regulators are regulators intended for use in general purpose industrial applications. They shall be capable of operating normally and shall meet the requirements of 4.4.1 and 4.4.2 within the temperature range of -20 °F to 120 °F (-29 °C to 49 °C).

4.1.2 Other applications

The operating temperature range shall be determined by agreement between manufacturer and purchaser.

4.2 Materials

All materials used in the construction of gas pressure regulators shall be resistant to the mechanical, chemical, and thermal effects of the gases to which they will be exposed under operating conditions in their intended service.

4.2.1 Metallic materials

4.2.1.1 Acetylene service (and other gases having similar chemical properties)

The copper content of metals likely to come in contact with acetylene or methylacetylene-propadiene stabilized (MPS) shall not exceed 65% mass, unless higher content alloys have been found to be compatible in the specific application by experience or by test. Bourdon tubes of pressure gauges and metallic inlet filters may exceed this requirement if higher content alloys have been found to be suitable in the specific application by experience or by test. Silver/copper solders or brazing alloys used in the construction of regulators for such gases shall have a maximum silver content of 46% and a maximum copper content of 37%.

Under certain conditions, acetylene forms readily explosive acetylide compounds when it comes in contact with copper, silver, and mercury. For this reason, acetylene and the use of these metals, or their salts, compounds, and high-concentration alloys is to be discouraged. While it is recognized that there is no reaction between pure, dry acetylene and copper (even pure copper), the presence of moisture and other impurities can enable and enhance the formation of explosive acetylide compounds. In environments where moist impure acetylene is

present, copper alloys with greater than 65% copper should be avoided. The maximum allowable copper content drops to 55% when ammonia is also present, and to 50% when the alloys have been contaminated with acids or caustic alkalis (such as carbide lime). See *Handbook of Compressed Gases* [4].

4.2.1.2 Oxygen service

Extreme care shall be used in the selection of metals for use in oxygen pressure regulators. See ASTM G88, *Standard Guide for Designing Systems for Oxygen Service* and ASTM G94, *Standard Guide for Evaluating Metals for Oxygen Service* [5, 6]. Serious risk of ignition and fire exists if unsuitable material is used or if the regulator design does not adequately compensate for material limitations.

4.2.1.3 Corrosive service

Pressure regulators intended for use in corrosive atmospheres or intended to convey corrosive gases shall be constructed of corrosion-resistant material or be otherwise protected, as by surface treatment, to ensure that the effect on the operation and mechanical strength is minimized.

4.2.2 Nonmetallic materials

4.2.2.1 Chemical resistance

Nonmetallic materials (seats, seals, diaphragms, lubricants, thread sealing compounds, etc.) shall be resistant to the chemical action of the gases and liquids or liquid vapors to which they will be exposed in service. The processing of elastomers and plastics involves the use of many chemical additives (hardeners, plasticizers, and lubricants) that can be leached out and result in degradation of the physical or mechanical properties of the material.

4.2.2.1.1 Liquid immersion

The chemical resistance of nonmetallic materials should be determined by comparison of their physical properties before and after immersion in test liquid(s). The specific test liquid(s) should be representative of liquid(s) that will be contacted in service, see Table 1. Elastomers should be tested in accordance with ASTM D471, *Standard Test Method for Rubber Property-Effect of Liquids*, whereas plastics should be tested in accordance with ASTM D543, *Standard Practice for Evaluating the Resistance of Plastics to Chemical Reagents* [7, 8].

Table 1—Recommended test liquids

Service gas	Test liquid
Acetylene	Acetone
Liquefied petroleum gases (LPG)	n-Hexane
Methylacetylene-propadiene stabilized (MPS)	Liquid MPS
Carbon dioxide	Liquid carbon dioxide
Nitrous oxide	Liquid nitrous oxide

4.2.2.1.2 Changes in physical properties

Changes in the values of physical properties (such as volume and mass) or of mechanical properties (such as tensile strength, elongation, compression set, and hardness) should be determined. It is the regulator manufacturer's responsibility to select materials that provide the required level of performance and safety for the specific gas service(s) marked on the regulator.

4.2.2.2 Resistance to aging

Elastomeric parts used in gas pressure regulators shall not crack or show visible evidence of deterioration following exposure to oxygen for a period of 96 hours at a temperature of $158^{\circ}\text{F} \pm 2^{\circ}\text{F}$ ($70^{\circ}\text{C} \pm 1^{\circ}\text{C}$) and at a pressure of $300\text{ psi} \pm 15\text{ psi}$ ($2070\text{ kPa} \pm 100\text{ kPa}$).

This accelerated aging test should be performed in accordance with ASTM D572, *Standard Test Method for Rubber-Deterioration by Heat and Oxygen* [9].

4.2.2.3 Resistance to ignition

Materials in contact with oxidizing gases (such as oxygen, nitrous oxide, compressed air, etc.) shall be carefully selected to ensure that they are adequately resistant to ignition. Material selection should be made based on the criteria for hazard evaluation contained in ASTM G63, *Standard Guide for Evaluating Nonmetallic Materials for Oxygen Service* [10]. Generally, the total mass of nonmetallic components used in the regulator design should be minimized to limit the available fuel if ignited.

Oxygen regulators, when tested in accordance with 7.1, shall withstand the effects of sudden pressurization with oxygen to a pressure equal to 1.2 times their maximum rated inlet pressure without ignition.

4.2.2.4 Rapid decompression

Elastomeric parts exposed to gas pressures over 400 psi (2760) shall be resistant to the effect of rapid depressurization. Such parts shall not swell excessively, blister, tear, or be otherwise damaged when rated service pressure of the service gas(es) is suddenly released. This resistance is dependent on the service pressure, the gas(es), and the elastomer material.

NOTE—Certain elastomers are particularly susceptible to rapid decompression in carbon dioxide and nitrous oxide service and should be avoided.

4.2.2.5 Lubricants

Lubricants used within pressure regulators shall be compatible with the gas and within the range of pressures and temperatures to which they could be exposed in service. Only lubricants specified by the regulator manufacturer shall be used and they shall be used only where specified by the regulator manufacturer.

4.2.2.6 Thread sealing compounds

Thread sealing compounds, as used in the regulator, shall be compatible with the gas within the range of pressures and temperatures to which they could be exposed in service. Only thread sealing compounds specified by the regulator manufacturer shall be used. These compounds shall be used only where specified by the regulator manufacturer.

4.2.2.7 Specialty gas service

Materials selection is as agreed to by the purchaser and manufacturer. Materials (seats, seals, diaphragms, lubricants, etc.) are to be selected to fulfill the mechanical, chemical, and physical requirements of the application. For example, high purity gases require materials that do not out-gas.

4.3 Cleanliness

Permissible cleanliness levels of gas pressure regulators and their component parts will depend on the intended application. Different levels of cleanliness are required for the following various reasons:

- hydrocarbon contamination of an oxygen regulator presents a severe risk of explosion;
- foreign particles can cause seat leak and creep; and
- contamination of high purity gases.

4.3.1 Oxygen service

4.3.1.1 Regulators

Regulators and their component parts shall be cleaned to remove oil, grease, and other contaminants according to the procedures specified in CGA G-4.1, *Cleaning of Equipment for Oxygen Service* [11].

4.3.1.2 Pressure gauges

Pressure gauges used on oxygen regulators shall comply with cleanliness level IV or better, as specified in ASME B40.100, *Pressure Gauges and Gauge Attachments* [12].

4.3.2 High purity gas service

The acceptable cleanliness level of regulators used in high purity gas service shall be determined by agreement between the manufacturer and purchaser.

4.4 Gas tightness

Gas tightness requirements of regulators will vary with intended application. Gas tightness can refer to a number of different phenomena:

inboard leakage of air into a high purity gas regulator;

leakage of the gas to the exterior; or

internal leakage of gas between high pressure and low pressure areas.

4.4.1 Seat leakage

When tested in accordance with 7.2.1, there shall be no detectable leakage across the operating valve seat(s) of a pressure regulator.

4.4.2 Overall leakage

General purpose industrial regulators shall, when tested in accordance with 7.2.2, have a total overall leakage rate not exceeding 3×10^{-3} cc/s, from threaded connections, diaphragm clamping surfaces, pressure relief devices (PRDs), pressure gauges, or any other area.

Gas tightness of regulators intended for use in hazardous or critical applications involving toxic or high purity specialty gases shall be agreed to by the purchaser and manufacturer.

Regulators used in toxic gas service inside shall be sealed or designed for captured venting of bonnets and relief devices, unless otherwise regulated by code, as could be the case with the use of gas cabinets.

4.4.3 Production leak test requirements

Manufacturers of pressure regulators shall perform seat leakage and external leakage tests on 100% of all regulators under the test conditions specified in 7.6.

4.5 Mechanical resistance

The mechanical resistance of pressure regulators shall encompass two aspects:

- fitness for service; and
- safety.

4.5.1 Fitness for service

4.5.1.1 Proof pressure

When tested in accordance with 7.3.1, the high pressure and low pressure chambers of regulators shall resist test pressures equal to 1.5 times the maximum pressures to which they are respectively rated without rupture, separation of components, or permanent deformation, for example, as measured by comparator.