

CGA S-7—2018

**STANDARD METHOD FOR
SELECTING PRESSURE RELIEF
DEVICES FOR COMPRESSED
GAS MIXTURES IN CYLINDERS**

SIXTH EDITION

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Work Item 17-007
Cylinder Valve Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendix A (Normative) is a requirement.

NOTE—Appendix B (Informative) is for information only.

SIXTH EDITION: 2018
FIFTH EDITION: 2013
FOURTH EDITION: 2005
THIRD EDITION: 2003

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1 Introduction

This standard presents a method for selecting pressure relief devices (PRDs) for compressed gas mixtures packaged in cylinders having water capacities of less than or equal to 1000 lb (454 kg) (see U.S. Department of Transportation (DOT) Title 49 of the U.S. *Code of Federal Regulations* (49 CFR) Part 173.301[f]). This standard also applies to DOT 3AX, 3AAX, and 3T cylinders having water capacities greater than 1000 lb (454 kg) that comply with the specifications, charging, and maintenance regulations of DOT or the corresponding specifications and regulations of Transport Canada (TC) [1, 2].¹

This method is more involved than the method for determining the appropriate valve outlet connections for gas mixtures. For the latter, as described in [CGA V-7, Standard Method of Determining Cylinder Valve Outlet Connections for Industrial Gas Mixtures](#), mixture component rating numbers are assigned to the various compressed gases based on the physical properties of the gases: flammability (F), toxicity (T), state of the gas (S), and corrosivity (C) (FTSC) [3, 4]. The higher the mixture component rating number (1 through 6), the more influential that gas becomes in determining the outlet connection for the mixture in which that gas is a component.

Valve outlet connection assignments are broadly separated into connections for groups of gases having similar properties such as high and low pressure, flammability, corrosivity, toxicity, and inertness. Since 1978, this system has proven satisfactory in avoiding hazardous connections.

The physical characteristics of a mixture consisting of several pure gases could be dramatically different depending on the concentration of each gas in the mixture. Depending on these concentrations, a mixture could be flammable or nonflammable, toxic or nontoxic, liquefied or nonliquefied, and corrosive or noncorrosive. Since the mixture is released to the atmosphere when the relief device functions, the characteristics of the escaping gas mixture shall be well defined.

A method was established for assigning the relief device for each mixture, just as is done for pure gases in [CGA S-1.1, Pressure Relief Device Standards—Part 1—Cylinders for Compressed Gases](#) [5]. To use this method, the FTSC code shall be determined (see [CGA P-47, Guidelines for FTSC Codes and Current Gas Listings](#)) [4]. In some cases, determining the FTSC number is straightforward. However, in other cases the FTSC number is not as obvious, and in most cases this determination is the responsibility of the gas mixture producer. It shall be understood that some of the considerations made in determining the selection of the PRD used in this standard are based on experience.

The method outlined in this standard is designed to handle the proliferation of mixtures entering the commercial market.

The continued use of previously recognized and installed devices is not restricted by this edition of the standard. However, if a PRD is replaced, the new device shall meet the requirements of this standard.

2 Scope

This method is applicable to the determination of the PRD to use with compressed gas mixtures in cylinders having water capacities of less than or equal to 1000 lb (454 kg). This standard also applies to DOT 3AX, 3AAX, and 3T cylinders having water capacities greater than 1000 lb (454 kg) that comply with the specifications, charging, and maintenance regulations of DOT or the corresponding specifications and regulations of TC [1, 2].

This method is limited to those compressed gas mixtures with known flammability, toxicity, state, and corrosivity. In addition, the DOT/TC rating and dimensions of the cylinder and the final pressure shall be known.

For the selection of PRDs for a single component compressed gas, see [CGA S-1.1](#) [5]. For multicomponent compressed gases (mixtures), the method for selection of relief devices in this standard shall be used. Where a mixture is predominantly made up of a single component in a mixture, the gas producer shall determine whether the properties of this mixture dictate it being treated as a single component compressed gas or a gas mixture.

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

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 Algorithm

Series of formatted questions that when answered in sequence will result in the selection of one or more PRDs.

3.2.2 Compressed gas

Any material that exerts in a container an absolute pressure of at least 40.6 psia (280 kPa, abs)² at 68 °F (20 °C).

3.2.3 Final pressure

Charged settled pressure at 70 °F (21.1 °C).

3.2.4 Gas mixture

Purposeful combination of two or more commodities resulting in a compressed gas.

3.2.5 Hazard zone A

Material with a toxicity LC₅₀ less than or equal to 200 ppm.

3.2.6 Hazard zone B

Material with a toxicity LC₅₀ greater than 200 ppm and less than or equal to 1000 ppm.

3.2.7 Hazard zone C

Material with a toxicity LC₅₀ greater than 1000 ppm and less than or equal to 3000 ppm.

3.2.8 Hazard zone D

Material with a toxicity LC₅₀ greater than 3000 ppm and less than or equal to 5000 ppm.

3.2.9 Lethal concentration fifty (LC₅₀)

Concentration of a substance in air for which exposure for a specified length of time is expected to cause the death of 50% of the entire defined experimental animal population.

NOTE—See [CGA P-20](#), *Standard for the Classification of Toxic Gas Mixtures* [7].

3.2.10 Producer

Site where the compressed gas mixture is packaged into cylinders and the personnel who perform the work.

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](#), *Metric Practice Guide for the Compressed Gas Industry* [6].

4 Types of pressure relief devices

Types of pressure relief devices (PRDs) are designated as follows:

4.1 Type CG-1

A rupture disk.

4.1.1 Limitations

Since this is a pressure operated device designed to release the entire contents of the container, there is no way to prevent the complete release of the contents, either because of normal functioning or premature rupture of the device.

4.2 Type CG-2

A fusible plug using a fusible alloy with yield temperature no greater than 170 °F (76.7 °C) or less than 157 °F (69.4 °C). Nominal yield temperature is 165 °F (73.9 °C).

4.2.1 Limitations

Since this is a thermally operated device, it does not protect against overpressure from improper charging practices. This device releases the entire lading of the container when it functions, and is limited to use on cylinders of 500 psi (3450 kPa) service pressure or less. This device may be used in higher service pressure cylinders provided that the product pressure does not exceed 500 psi (3450 kPa) at 68 °F (20 °C) and the device type is mandated by this standard or TC regulations.

4.3 Type CG-3

A fusible plug using a fusible alloy with yield temperature no greater than 224 °F (106.7 °C) or less than 208 °F (97.8 °C). Nominal yield temperature is 212 °F (100 °C).

4.3.1 Limitations

Same as for CG-2 (see 4.2.1).

4.4 Type CG-4

A combination rupture disk/fusible plug device using a fusible alloy with yield temperature no greater than 170 °F (76.7 °C) or less than 157 °F (69.4 °C). Nominal yield temperature is 165 °F (73.9 °C).

4.4.1 Limitations

Since this device is a combination device, it requires both excessive pressure and temperature to cause it to operate. This device does not function due to pressure unless the fusible metal is melted out first. Such a combination device cannot prevent an improperly filled (overfilled) cylinder from rupturing due to hydrostatic pressure at room temperature or any temperature below the melting temperature of the fusible metal, as will devices that contain only a rupture disk (CG-1). There is no way to prevent the complete release of the contents when this device functions.

4.5 Type CG-5

A combination rupture disk/fusible plug device using a fusible alloy with yield temperature no greater than 224 °F (106.7 °C) or less than 208 °F (97.8 °C). Nominal yield temperature is 212 °F (100 °C).

4.5.1 Limitations

Same as for CG-4 (see 4.4.1).

4.6 Type CG-7

A pressure relief valve.

4.6.1 Limitations

This device maintains the pressure in the container at a limit as determined by the set pressure of the valve and thus does not protect against rupture of the container when the application of heat weakens the container to the point where its rupture pressure is less than the operating pressure of the device.

WARNING: PRDs cannot prevent rupture of a cylinder under all conditions of fire exposure. When the heat transferred to the cylinder is localized, intensive, and remote to the relief device, or when the fire builds extremely rapidly such as in an explosion and is of very high intensity, the cylinder can weaken sufficiently to rupture before the relief device operates or while it is operating.

5 Description of method and procedures

5.1 Algorithm

The algorithm has been designed to assist the gas mixture producer to quickly and correctly determine the appropriate PRD(s) for gas mixtures. The algorithm is shown in Figure 1 (U.S. customary units) and Figure 2 (SI units). Application of the algorithm is illustrated for selected gas mixtures in Examples 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13.

5.2 Responsibility for selection of the pressure relief device

The responsibility for the selection of the PRD lies with the gas mixture producer. Although the algorithm does permit a degree of flexibility in the selection of the relief device for some cylinders, the flammability, toxicity, state, and corrosivity of the mixture shall be determined first. [CGA P-47](#) provides the definitions of the FTSC codes and lists the codes for most of the gases that are commonly used in mixtures [4].

5.3 Directions for use of the algorithm

The following directions and constraints govern the use of the algorithm:

- The final mixture properties (flammability, toxicity, state of the gas, corrosivity, and final pressure) are known by the gas mixture producer;
- The producer shall determine the mixture's flammability. As used in the algorithm, flammable means having an F rating of 2, 3, or 5; and
- The producer shall determine the mixture's toxicity. In accordance with DOT (49 CFR 173.115), the toxicity of the mixture can be calculated from the concentrations and toxicity of the components as follows (see [CGA P-20](#) for additional details regarding mixture toxicity calculations [7]).

$$LC_{50, \text{mix}} = \frac{1}{\sum_{i=1}^n \frac{\text{Concentration}_i}{LC_{50, i}}}$$

Where:

n = Number of toxic components

Concentration_{*i*} = Concentration of the *i*th toxic component, expressed as a decimal fraction of the whole, for example, 0.05 for a 5% mixture and 5 x 10⁻⁶ for a 5 ppm mixture. This number is dimensionless.

LC_{50, *i*} = LC₅₀ of the *i*th toxic component, in ppm

LC_{50, mix} = LC₅₀ of the mix, in ppm

For a mixture with a single toxic component, this simplifies to:

$$LC_{50, \text{mix}} = \frac{LC_{50, \text{toxic component}}}{\text{Concentration}_{\text{toxic component}}}$$

- As used in the algorithm, corrosive means having a C rating of 1 or greater;
- Other definitions conform with those of DOT or TC, if applicable;
- Pressurization of the vapor space above a condensed liquid for the purpose of withdrawal does not constitute a gas mixture;
- If a 110% fill is authorized, only the CG-1 device is allowed;
- When the CG-2 device is indicated, it allows use of the CG-3 device where the final mixture properties permit. Likewise, when the CG-4 device is indicated, the CG-5 device may be used where the final mixture properties permit;
- The decision of whether the CG-2 or CG-3 device is used as well as whether the CG-4 or CG-5 device is used shall be made by the gas mixture producer as authorized by the latest edition of [CGA S-1.1](#) based on the producer's classification of the final mixture according to its properties [5]; and
- Where two or more types of PRDs are indicated, only one of them is required. Care should be taken that the selection made conforms to all requirements in 49 CFR and [CGA S-1.1](#) [1, 5]. For example, see [CGA S-1.1](#) regarding the requirements for relief devices at both ends of the cylinder if the cylinder length exceeds 30 in (762 mm) [5].

5.4 Procedure for assigning a pressure relief device for a mixture

With an understanding of the directions in 5.3, the following procedures shall be followed to assign a PRD for a mixture (see Appendix B for a worksheet format):

- a) In the worksheet, list the components and concentration thereof in the proposed gas mixture in the first two columns;
- b) Enter the FTSC code for each mixture component directly from [CGA P-47](#) in the next four additional columns [4];
- c) Add the LC_{50} in the last column from [CGA P-47](#), if available [4];
- d) Verify that the DOT/TC rating and dimensions of the cylinder to be filled as well as the final pressure of the mixture are compatible with each other and are in compliance with pertinent regulations contained in 49 CFR 173.301(a)(8) [1];
- e) Calculate the toxicity (T) of the mixture as described in 5.3 and assign F, S, and C codes based on experience and the properties of the components of the mixture;
- f) Using the mixture's FTSC code established in step e), answer each question, beginning at the start of the algorithm, until a determination of the PRD is accomplished; and
- g) Size the PRD in accordance with the requirements of the latest edition of [CGA S-1.1](#) [5].

THIS ALGORITHM IS FOR GAS MIXTURES ONLY

U.S. Customary Units

LEGEND

Y = yes
 N = no
 CG = type of pressure relief device
 CG 1,4 = either CG-1 or CG-4
 < = less than
 > = greater than
 ≤ = less than or equal to
 L = cylinder length
 O.D. = outside diameter

If a 110% fill is authorized, only the CG-1 device is allowed.

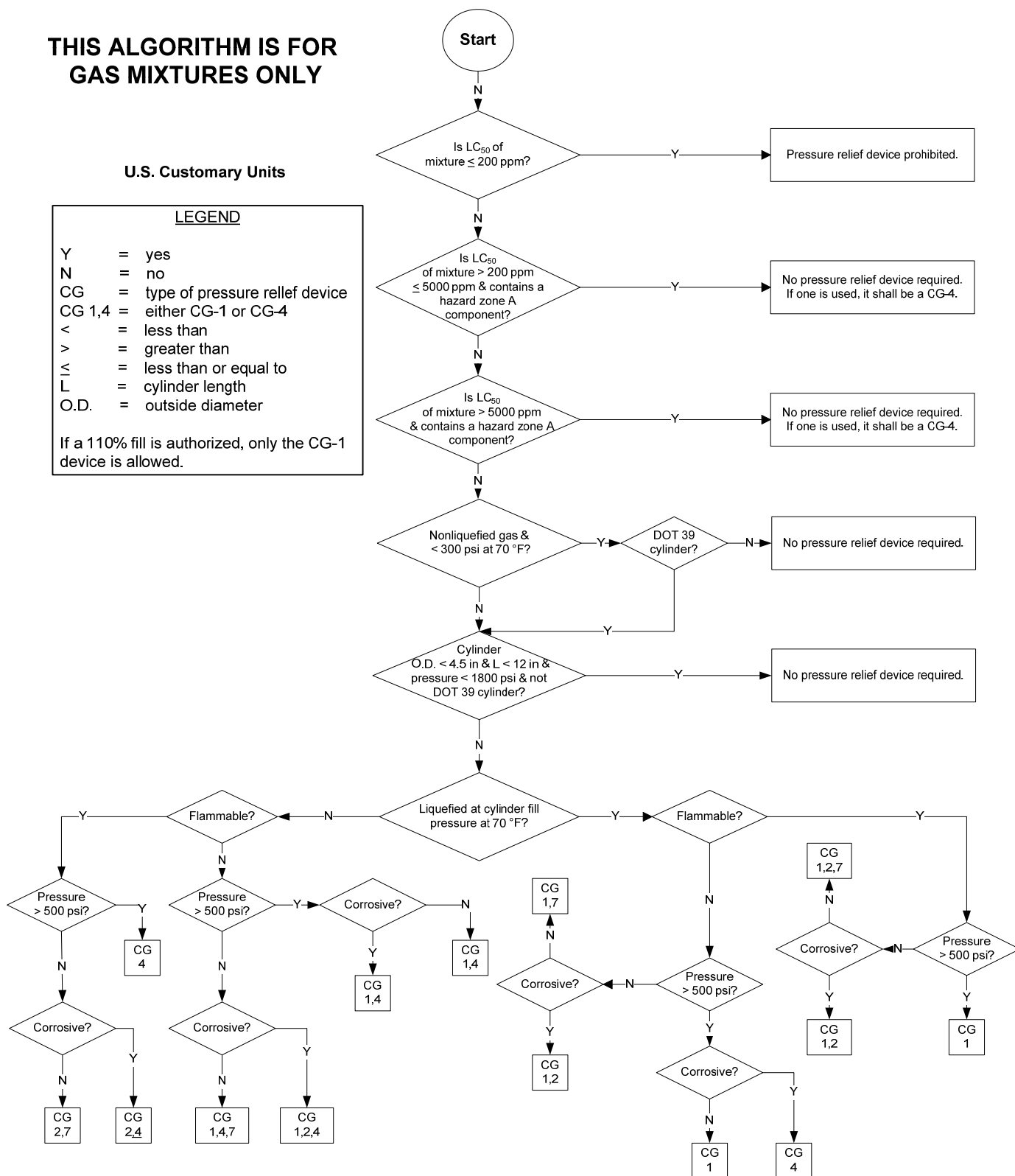


Figure 1—Algorithm for gas mixtures (U.S. customary units)

THIS ALGORITHM IS FOR GAS MIXTURES ONLY

SI units

LEGEND

Y = yes
N = no
CG = type of PRD
CG 1,4 = either CG-1 or CG-4
< = less than
> = greater than
≤ = less than or equal to
L = cylinder length
O.D. = outside diameter

If a 110% fill is authorized, only the CG-1 device is allowed.

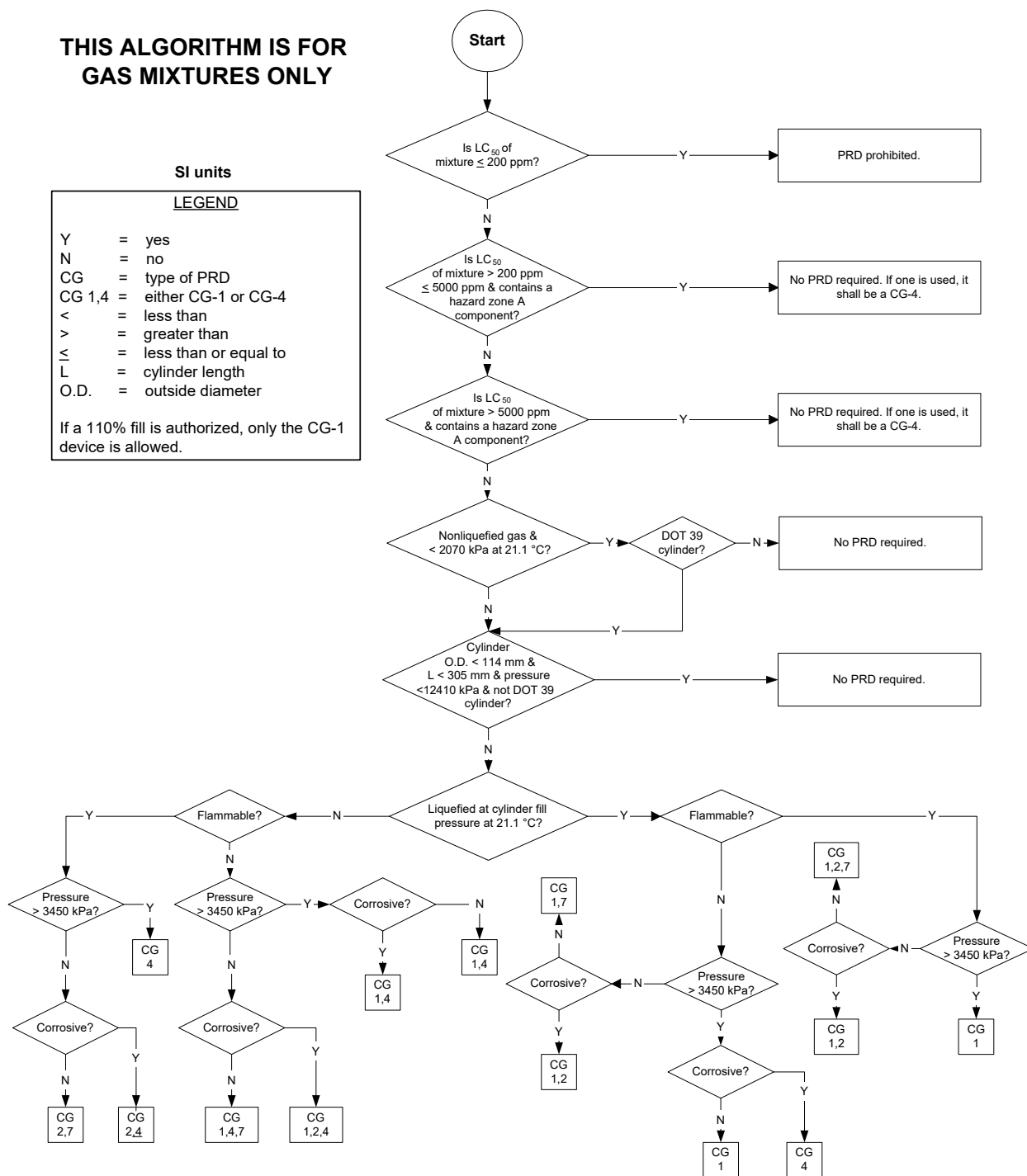


Figure 2—Algorithm for gas mixtures (SI units)

Worksheet for Example 1—100 ppm hydrogen, balance nitrogen (U.S. customary units)

NOTE—This worksheet is an example and the FTSC code is current as of the date of this publication. See [CGA P-47](#) for the most current FTSC code [4].

	COMPONENTS	CONCENTRATION	F	T	S	C	LC ₅₀
1.	Hydrogen	100 ppm	2	1	6	0	> 5000 ppm
2.	Nitrogen	Balance	0	1	6	0	> 5000 ppm

DOT CYLINDER RATING: 3AA2015

FINAL PRESSURE: 2000 psi at 70 °F
2226 psi at 131 °F

DIMENSIONS: 9 in diameter 51 in length

MIXTURE FTSC: 0 1 6 0

MIXTURE LC₅₀: > 5000 ppm, no zone A component

STEPS ON ALGORITHM: (See Examples 1 and 2)

- a) Mixture LC₅₀ is > 200 ppm;
- b) Mixture is nonliquefied but pressure is > 300 psi;
- c) Cylinder has an outside diameter (OD) > 4.5 in;
- d) Mixture nonliquefied at 70 °F;
- e) Mixture is nonflammable (as determined by gas producer);
- f) Pressure is > 500 psi;
- g) Mixture is not corrosive (as determined by gas producer); and
- h) PRD is CG-1 or CG-4.

OBSERVATIONS:

- Either device is suitable;
- Since the length of the cylinder is < 65 in, only one PRD is required; and
- The pressure in the cylinder at 131 °F will be < 5/4 times the service pressure of 2015 psi.

Worksheet for Example 2—100 ppm hydrogen, balance nitrogen (U.S. customary units)³

NOTE—This worksheet is an example and the FTSC code is current as of the date of this publication. See [CGA P-47](#) for the most current FTSC code [4].

	COMPONENTS	CONCENTRATION	F	T	S	C	LC ₅₀
1.	Hydrogen	100 ppm	2	1	6	0	> 5000 ppm
2.	Nitrogen	Balance	0	1	6	0	> 5000 ppm

DOT CYLINDER RATING: UN 200 BAR (Note: 200 Bar = 2900 psi)

FINAL PRESSURE: 2900 psi at 70 °F
3228 psi at 131 °F

DIMENSIONS: 9 in diameter 51 in length

MIXTURE FTSC: 0 1 6 0

MIXTURE LC₅₀: > 5000 ppm, no zone A component

STEPS ON ALGORITHM: (See Examples 1 and 2)

- Mixture LC₅₀ is > 200 ppm;
- Mixture is nonliquefied but pressure is > 300 psi;
- Cylinder has an OD > 4.5 in;
- Mixture nonliquefied at 70 °F;
- Mixture is nonflammable (as determined by gas producer);
- Pressure is > 500 psi;
- Mixture is not corrosive (as determined by gas producer); and
- PRD is CG-1 or CG-4.

OBSERVATIONS:

- Either device is suitable;
- Since the length of the cylinder is < 65 in, only one PRD is required; and
- The pressure in the cylinder at 131 °F will be < 5/4 times the service pressure of 2015 psi.

³ A UN cylinder that is stamped for a 200 bar (2900 psi) service pressure has a test pressure of 300 bar (4350 psi). The PRD setting would be required to be set no higher than the test pressure according to the requirements of 49 CFR 173.301(f)(3), since the mixture for this example is a Division 2.2 compressed gas.

For a mixture that is classified as Division 2.1 or Division 2.3, the PRD setting shall be set at the test pressure of the cylinder.

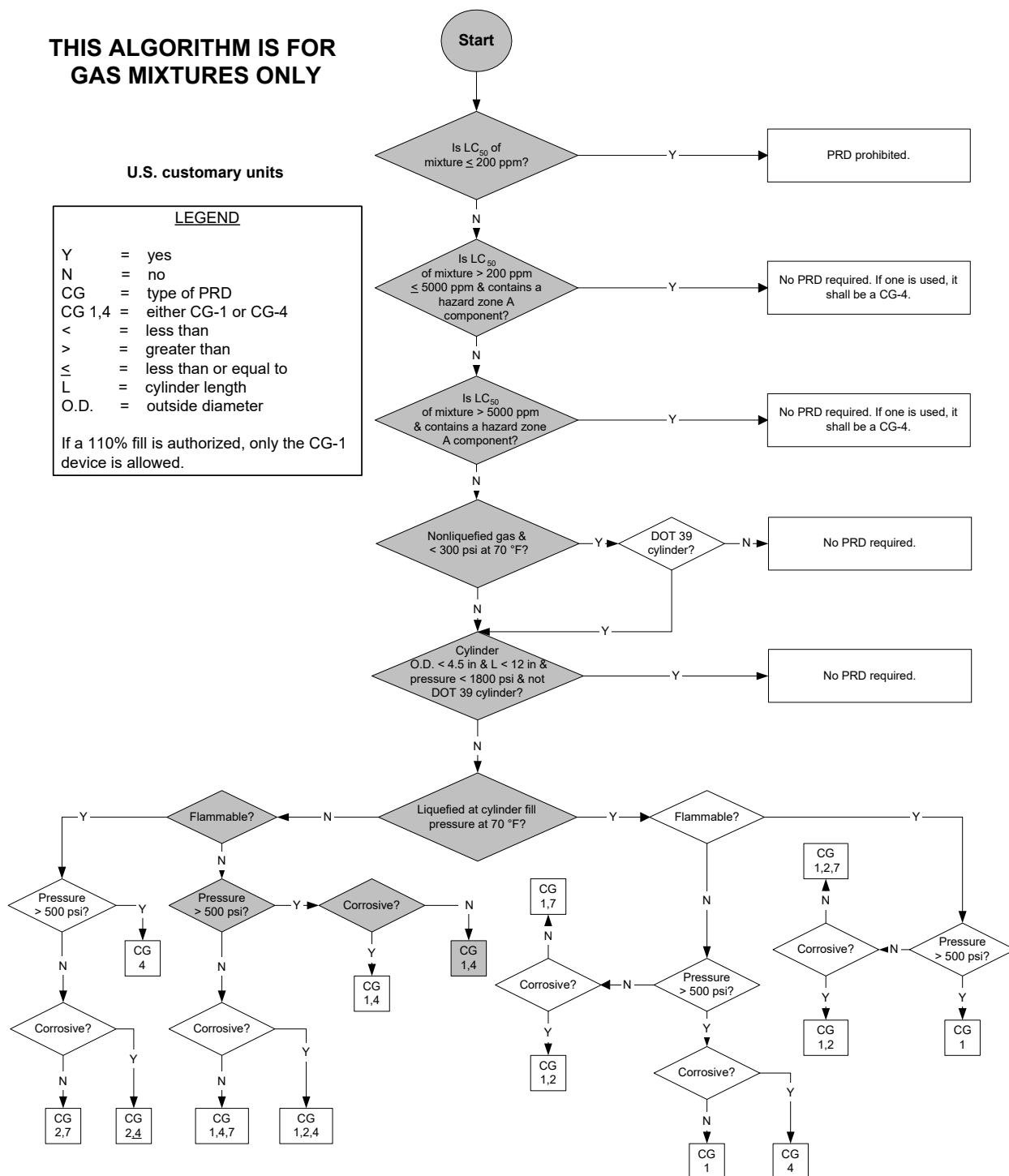
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U.S. customary units

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Y = yes
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CG 1,4 = either CG-1 or CG-4
< = less than
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L = cylinder length
O.D. = outside diameter

If a 110% fill is authorized, only the CG-1 device is allowed.



Examples 1 and 2—100 ppm hydrogen, balance nitrogen (U.S. customary units)