

CGA P-20 — 2023

6TH EDITION

STANDARD FOR CLASSIFICATION OF TOXIC GAS MIXTURES

Documents

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NOTE—Technical changes from the previous edition are underlined.

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1 Introduction

Toxic designations for pure gases are well known. However, the list of gases included in this standard varies because the toxicity values that are used to determine whether or not a gas meets the definition of “toxic” or “poison”, in U.S. Department of Transportation (DOT) *Hazardous Materials Regulations* and Transport Canada's (TC) *Transportation of Dangerous Goods (TDG) Regulations* also vary [1, 2]. Subsidiary hazard classes and multiple labels for pure gases reflect DOT and TC requirements. Additional labels denoting subsidiary hazards in addition to the hazard class 2.3 may be required. The data within this publication may be used for acute toxicity categorization with the United Nations (UN) *Globally Harmonized System of Classification and Labelling of Chemicals* (GHS) [3].

Information on toxicity of gases has been obtained from a variety of sources. Specifically, LC₅₀ and LC_{Lo} data were obtained from the National Institute for Occupational Safety and Health (NIOSH), *Registry of Toxic Effects of Chemical Substances* (RTECS) and Sax's *Dangerous Properties of Industrial Materials*, Sixth Edition, and ISO 10298, *Gas Cylinders - Gases And Gas Mixtures - Determination Of Toxicity For The Selection Of Cylinder Valve Outlets* [4, 5, 6].

2 Scope and purpose

2.1 Scope

This publication applies to users, transporters, and manufacturers affected by label requirements and addresses classifications for gas mixtures that contain a toxic component(s). This standard categorizes gas mixtures under the transportation regulations that establish a toxicity threshold criterion based on LC₅₀ rat 1 hr values.

2.2 Purpose

The purpose of this publication is to establish a means to categorize toxic gas mixtures based on acute toxicity.

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 Lethal concentration fifty (LC₅₀)

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

NOTE—For this standard, LC₅₀ is defined by the following procedure: ten albino rats (five male and five female) are exposed to a test atmosphere for 1 hour and observed for 14 days. If five of the animals die within the 14 day observation period, the concentration level of the test atmosphere is the LC₅₀. Where test data is not available, an LC₅₀ value shall be assigned. See 4.3 for the selection of this LC₅₀ value.

3.2.2 Lethal concentration low (LC_{Lo})

Lowest concentration of a substance in air, other than LC₅₀, that has been reported to have caused death in humans or animals. The reported concentrations may be entered for periods of exposure which are less than 24 hours (acute) or greater than 24 hours (subacute and chronic).

3.2.3 Lethal dose fifty (LD₅₀)

Lethal dose to 50% of a specified population.

3.2.4 Mole fraction

Concentration ratio of a component in a gas mixture.

3.2.5 Threshold Limit Value—Time-Weighted Average (TLV®—TWA)

Time-weighted average concentration of a substance for a normal 8 hour workday and a 40 hour workweek to which nearly all workers can be repeatedly exposed, day after day, without adverse effect [7].

4 Description of method for determining gas mixture toxicity

4.1 DOT hazard zones of toxic gas mixtures

DOT's *Hazardous Materials Regulations* require that toxic gases or toxic gas mixtures be categorized into one of four hazard zones based upon LC₅₀ rat 1 hr values. They are defined as follows:

- Hazard zone A—gases (mixtures) with an LC₅₀ rat 1 hr $\leq$ 200 ppm;
- Hazard zone B—gases (mixtures) with an LC₅₀ rat 1 hr $>$ 200 ppm $\leq$ 1000 ppm;
- Hazard zone C—gases (mixtures) with an LC₅₀ rat 1 hr $>$ 1000 ppm $\leq$ 3000 ppm; and
- Hazard zone D—gases (mixtures) with an LC₅₀ rat 1 hr $>$ 3000 ppm $\leq$ 5000 ppm.

TDG Regulations, Section 2.14(c) classify gases or gas mixtures as toxic if their LC₅₀ value is less than or equal to 5000 ppm or if they are known to be toxic or corrosive to humans according to the current edition of this standard, ISO 10298, or other documentary evidence published in technical journals or government publications [2, 6].

See Table 1.

4.2 GHS acute toxicity categories

GHS also categorizes toxic gas mixtures into four categories but bases the toxicity categories on LC₅₀ rat 4 hr values. The acute toxicity categories under GHS are defined as follows:

- Acute toxicity category 1—gases (mixtures) with an LC₅₀ rat 4 hr $\leq$ 100 ppm;
- Acute toxicity category 2—gases (mixtures) with an LC₅₀ rat 4 hr $>$ 100 ppm $\leq$ 500 ppm;
- Acute toxicity category 3—gases (mixtures) with an LC₅₀ rat 4 hr $>$ 500 ppm $\leq$ 2500 ppm; and
- Acute toxicity category 4—gases (mixtures) with an LC₅₀ rat 4 hr $>$ 2500 ppm $\leq$ 20000 ppm.

NOTE—In GHS, the LC₅₀ values correspond to a 4 hr exposure.

See Table 2.

4.3 Classification procedures for toxic gas mixtures

The classification for toxicity of a gas mixture is based upon the LC₅₀ of the gas mixture. The LC₅₀ of a binary (two component) mixture composed of a toxic gas in a nontoxic gas is calculated as follows:

$$\text{LC}_{50} \text{ of gas mixture in ppm} = \frac{1}{\frac{\text{molar fraction of toxic component}}{\text{ppm LC}_{50} \text{ of toxic component}}}$$

OR

$$= \frac{\text{ppm LC}_{50} \text{ of toxic component}}{\text{ppm of toxic component}} \times 1\,000\,000$$

As indicated in the equation above, the LC₅₀ of the toxic component shall be known, calculated, or provisionally assigned.

The selection of an LC₅₀ value for a pure gas shall follow the algorithm in Figure 1. The preferred measurement standard is LC₅₀ rat 1 hr. LC₅₀ rat values for times different from, but closest to, 1 hour were selected and adjusted to the 1 hour exposed limit. Data for exposures less than 0.5 hour were eliminated. Table 3 shows normalization factors for times other than 1 hr.

If no LC₅₀ data for rats were available, the next animals of choice in order, were mouse, rabbit, guinea pig, cat, dog, and monkey. Table 4 ranks the animals of choice. Data for 1 hr were preferred.

If no LC₅₀ data were found for any animal, a search was conducted for a reliable LC_{LO} value using the same hierarchy of animals. The same normalization factors for times other than 1 hr were used.

If no reliable LC₅₀ or LC_{LO} value was obtained, a value was provisionally assigned based on any one or a combination of the following:

- decomposition or reaction products;
- correlation to LD₅₀ values (not inhalation);
- comparison to other published hazard levels; and
- analogy to similar products.

Any data chosen from these four were weighted according to the reliability of the data.

Based on the algorithm in Figure 1 along with normalization factors of Table 3 and the animal rankings of Table 4, LC₅₀ values have been obtained for a number of gases. These are listed in Table 1. Limiting concentrations for each gas in each hazard zone are as shown.

4.4 DOT limiting concentrations for gas mixture toxicity

The limiting concentrations for each gas mixture shown in Table 1 were calculated as follows:

$\frac{\text{LC}_{50} \text{ of pure gas in ppm}}{\text{LC}_{50} \text{ 200 ppm}}$	=	lowest mole fraction of a toxic component in a gas mixture that places the mixture in Hazard Zone A (x 100 for %)
$\frac{\text{LC}_{50} \text{ of pure gas in ppm}}{\text{LC}_{50} \text{ 1000 ppm}}$	=	lowest mole fraction of a toxic component in a gas mixture that places the mixture in Hazard Zone B (x 100 for %)
$\frac{\text{LC}_{50} \text{ of pure gas in ppm}}{\text{LC}_{50} \text{ 3000 ppm}}$	=	lowest mole fraction of a toxic component in a gas mixture that places the mixture in Hazard Zone C (x 100 for %)
$\frac{\text{LC}_{50} \text{ of pure gas in ppm}}{\text{LC}_{50} \text{ 5000 ppm}}$	=	lowest mole fraction of a toxic component in a gas mixture that places the mixture in Hazard Zone D (x 100 for %)