Compressed Gas Association
The Standard For Safety Since 1913

# CGA P-57—2021

## AVOIDANCE OF FAILURE OF STEEL CYLINDERS CONTAINING CARBON MONOXIDE AND CARBON MONOXIDE/CARBON DIOXIDE MIXTURES

THIRD EDITION

## PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued CGA P-57, *Avoidance of Failure of Steel Cylinders Containing Carbon Monoxide and Carbon Monoxide/Carbon Dioxide Mixtures Cylinders*, jointly pro-duced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 95, *Avoidance of failure of steel cylinders containing CO and CO/CO2 mixtures*.

This publication is intended as an international harmonized standard for the worldwide use and application of all members of the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.

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Work Item 17-054
Specialty Gases Committee

NOTE—Technical changes from the previous edition are underlined.

THIRD EDITION: 2021
SECOND EDITION: 2013
FIRST EDITION: 2007

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# 1 Introduction

This publication was originally published in 1993 after a number of incidents where steel cylinders violently ruptured.

Incidents have occurred in the past with carbon monoxide and carbon monoxide/carbon dioxide mixtures cylinders. These incidents led to either leak or rupture of the cylinders. During 1990 two incidents leading to violent ruptures were reported in Asia and North America, and a similar one in South Africa in 1991.

Following reports of earlier incidents, investigations were performed, and results from some of them were published in the 1976-1979 period [1, 2, 3]. [1]

These investigations concluded that:

- Low alloy carbon steels are sensitive to cracking in a carbon dioxide-carbon monoxide-water environment (stainless steels and aluminum alloys are not sensitive to this cracking phenomenon);
- It is believed that the three components carbon dioxide, carbon monoxide, and free water are needed at the same time to lead to this cracking phenomenon, i.e., cylinders that have contained sufficient moisture to have raised the dew point of the gas above the operational temperature. See also ISO 11114-1, *Gas Cylinders - Compatibility of Cylinder and Valve Materials with Gas Contents - Part 1: Metallic Materials* [4];

  NOTE—A content of at least 13% of chromium is necessary to make the steel immune to this stress corrosion cracking (SCC) phenomenon [1, 2, 3].
- Cracking occurs over a wide range of carbon dioxide/carbon monoxide ratios and down to very low partial pressures;
- Cracking has been observed down to applied loads of 25% to 30% of the yield stress;
- Probability for cracking decreases as temperature increases; and
- The mechanism is understood to be local dissolution of iron due to the carbonic acid formed between water and carbon dioxide, with general corrosion being inhibited by carbon monoxide. This phenomenon leads normally to transgranular cracks with branching. See Figure 1 for typical example. This phenomenon has nothing to do with hydrogen embrittlement, which normally leads to intergranular cracks. Therefore, the recommendations of EIGA Doc 100, *Hydrogen Cylinders and Transport Vessels*, do not apply [5].

Since the first publication of this document in 1993 new incidents, with steel cylinders filled at high pressure have occurred. These incidents and recent experience confirm that a very low moisture level shall be ensured.

NOTE—By ensuring a low moisture level, the conversion of carbon monoxide to carbon dioxide can be minimized.

# 2 Scope

This publication covers the selection of gas cylinders including; seamless, welded, and non-refillable cylinders, used for carbon monoxide and for carbon monoxide/carbon dioxide mixtures, e.g., laser gases. For purposes of this publication, cylinder(s) also means tubes unless otherwise stated. Intentionally made mixtures containing less than 5 ppmv carbon monoxide or 5 ppmv carbon dioxide are not affected by this publication.

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