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CGA P-56–2022
CRYOGENIC VAPORIZATION SYSTEMS–PREVENTION OF BRITTLE FRACTURE OF EQUIPMENT AND PIPING

THIRD EDITION

PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued CGA P-56, *Cryogenic Vaporization System—Prevention of Brittle Fracture of Equipment and Piping*, jointly produced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 133, *Cryogenic Vaporisation Systems – Prevention of Brittle Fracture of Equipment and Piping*.

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 18-029
Atmospheric Gases and Equipment Committee

NOTE—Technical changes from the previous edition are underlined.

THIRD EDITION: 2022
SECOND EDITION: 2014
FIRST EDITION: 2006

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1 Introduction

Cryogenic (or cold) fluids can be inadvertently admitted to process piping and equipment due to the malfunctioning of cryogenic liquid vaporization systems, which can result in catastrophic failure due to brittle fracture. When certain metals, typically carbon steels, become cold they undergo changes in their structure, which makes them less ductile, i.e., they become brittle. Other metals such as stainless steels, aluminum, brass, and copper do not exhibit this ductile/brittle transition and remain ductile at low temperatures. This publication has been written to identify the hazards associated with cryogenic liquid vaporization systems and to recommend the safeguards to be taken.

2 Scope and purpose

This publication applies to cryogenic liquid supply systems, located either on a customer site or a production site, where cryogenic liquid is vaporized and is then supplied either as the primary or secondary source of gaseous product. This publication is limited to the prevention of brittle fracture in piping and associated equipment installed downstream of the vaporization system.

The secondary source of supply can be a back-up supply to a production plant when the production plant trips or is shut down, a supplementary supply to meet customer demand where it exceeds the capacity of the production plant (peak shaving), or as a back-up supply at a customer site (for example, a healthcare facility).

The safeguard principles presented in this publication apply to any process fluid supply system where the temperature of the cryogenic liquid source is less than the minimum temperature rating of the piping and/or associated equipment downstream of the vaporizer.

Examples include:

- nitrogen;
- oxygen;
- argon;
- helium;
- hydrogen;
- natural gas;
- carbon monoxide;
- methane; and
- ethylene.

Carbon dioxide and nitrous oxide are excluded from the scope of this publication; however, the principles of this publication may be applied.

The supply systems work by vaporizing cryogenic liquid, typically in response to decreasing pipeline pressure.

Supply systems are made up of the following:

- liquid supply from either a low pressure tank and pump arrangement or directly from a high pressure tank;
- vaporization system that could be a natural draft ambient air-heated type or one that uses an external energy source for example, steam, hot water, electricity, direct fired;
- interconnecting liquid and outlet gas piping, valves, and fittings up to the battery limit; and
- low temperature protection system (LTPS) as detailed in this publication.

Although this publication does not cover the following situations, the techniques listed may be considered for cold embrittlement prevention:

- Air separation and other cryogenic processes with columns, separators, or tanks in which a gas stream from a sump is normally supplied through downstream heat exchange equipment, or liquefaction units where a cryogenic fluid can exit through warm-end process piping during a shutdown or upset scenario. Cryogenic processes are assumed to have their own LTPS;
- Piping systems within which a fluid is expanded across a valve or restriction with the resultant temperature being less than the ductile-to-brittle-transition-temperature (DBTT) for the piping system; and
- Vessels that are depressurized rapidly: as work is done in a vessel by a gas expanding as it is discharged out of the valve, the temperature inside the vessel and the vessel wall can be lowered.

This publication recommends safe practice for the design of new cryogenic vaporizer systems. For existing systems, a risk assessment shall be undertaken to establish if any modifications are required. The principles developed in this publication can be used for this purpose.

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 Battery limit
Physical point where the rights and responsibilities of custody of the gaseous product transfers from the supplier to the customer.

3.2.2 Brittle fracture
Failure caused by a crack that propagates rapidly through the material. A brittle material has little resistance to failure once the plastic limit has been reached.

NOTE–Pressurized equipment subject to such a failure leads to a sudden and violent energy release, the projection of fragments and the release of a fluid that can be oxidizing, flammable, toxic, etc.

3.2.3 Ductile
Property of a metal that allows it to elongate, with a rapid increase in local stresses, prior to failing.

3.2.4 End use point
Physical location where gaseous product is consumed by the customer.