CGA G-4.11—2011

RECIPROCATING COMPRESSORS FOR OXYGEN SERVICE

FIRST EDITION

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PREFACE

As a part of a program of harmonization of industry standards, the European Industrial Gases Association (EIGA) and the Japan Industrial and Medical Gases Association (JIMGA), with the participation of the Asia Industrial Gases Association (AIGA) and the Compressed Gas Association (CGA) have produced CGA G-4.11 *Reciprocating Compressors for Oxygen Service – Code of Practice* (EIGA Doc 10/09). This standard is intended as a joint AIGA/CGA/EIGA/JIMGA international harmonized standard for the worldwide use and application by all members of AIGA, CGA, EIGA, and JIMGA. The CGA edition has the same technical content as the EIGA/JIMGA edition, however, there are editorial changes primarily in formatting and spelling and references to regional regulatory requirements.

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Work Item 05-156
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1 Introduction

As a part of a program of harmonization of industry standards, a working group has been set up under joint lead of the European Industrial Gases Association (EIGA) and the Japan Industrial and Medical Gases Association (JIMGA) by a group of experts representing major industrial gases producers in Japan, Western Europe and North America and is based on the technical information and experience currently available to the authors.

This publication has been reviewed by a number of suppliers.

Oxygen compression represents a special risk in that the compressor can burn violently. This publication defines design and operating parameters for reciprocating oxygen compressors. Compliance with this publication will reduce the likelihood of, and the hazards arising from, a fire in a compressor to be equal or lower than those commonly accepted in the air separation industry. There is less demanding technology in a reciprocating compressor than in a centrifugal one. Potential rubbing velocities, gas velocities and inventories are all lower. For these reasons more flexibility in design is allowed in a reciprocating compressor than in a centrifugal compressor as defined in the EIGA Doc 27, *Centrifugal compressors for oxygen service* [1].

This publication has made a significant contribution to the safe compression of oxygen primarily because the suppliers and users have fully and frankly shared their philosophies and experiences. It is recognized by the working group members that the feedback of operating experiences makes a powerful contribution to safe operation and design. This publication requires that all those who build and operate reciprocating oxygen compressors that have been specified to comply with this publication should contribute towards it by fully reporting the circumstances surrounding oxygen fires.

For the purpose of safe operation of the compressor and its auxiliaries the user and the supplier shall establish full agreement on the possible and expected modes of compressor operation (e.g., specified operating points, normal operating range, startup and shutdown, etc.).

1.1 Scope

This publication applies to conventional ringed and labyrinth compressors having a crosshead and distance piece. Most operating experience exists in compressors above 17 700 ft^3/hr (500 Nm^3/hr) at pressures up to 1233 psi (8500 kPa) with oxygen purity of 90% or greater and with maximum 10 ppm water (volume basis).[1] Additionally experience suggests that at a discharge pressure below 29 psi (200 kPa) the likelihood of ignition is low and the consequence of ignition slight since the trapped inventory is small and fire is difficult to sustain at low pressures. This working group believes this publication can be applied to 1450 psi (10 000 kPa)without further special precaution.

The safe and reliable compression of oxygen using reciprocating compressors can only be achieved by the successful combination of many factors. This publication identifies and addresses the following factors.

1.1.1 Design of the compressor system (Sections 3 and 4)

- Robust and well proven compressor design
- Safe materials in critical areas
- Comprehensive instrumentation
- Safety shutdown system

1.1.2 Cleaning, preservation, and inspection (Section 5)

- Correct and properly enforced procedures and well trained personnel

[1] 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* [2].

1.1.3 Erection, testing, and commissioning (Section 6)

- Skilled and well trained erection personnel
- Comprehensive testing program to verify the design

1.1.4 Operation (Section 7)

- Well trained and experienced personnel
- Correct procedures

1.1.5 Planned maintenance (Section 8)

- Condition monitoring
- Planned preventive maintenance
- Well trained and experienced person
- Personnel protection (Section 2)
- Identification of the hazard
- Safety barriers
- Location of the compressor
- Emergency procedures

1.2 Other specifications

Additional guidance on installation and operation can be found in CGA G-4.6, *Oxygen Compressor Installation and Operation Guide* [3]. CGA and EIGA are aligned in their aims and values and CGA G-4.6 shall be regarded as complementary to this publication.

In case of conflict between this publication and the user's specification the information included in the order shall take precedence. The compressor supplied shall be in conformity with the rules of the country of the user and/or of the supplier.

1.3 Application of the publication

1.3.1 Oxygen purity

This publication is based on experience in manufacturing and operating reciprocating oxygen compressors and it is applicable to those machines operating on dry gases containing 90% oxygen and above, and less than 10 ppm water (volume basis).

1.3.2 Oxygen-enriched gases

Experience in compressing oxygen-enriched gases containing less than 90% oxygen is very limited at this time. In the absence of such experience or established data, the working group members recommend that this publication shall be considered for reciprocating compressors operating on oxygen-enriched gases, and the degree of implementation shall be agreed between supplier and user.

1.3.3 Moisture

Experience in compressing oxygen containing moisture is limited. Special precautions need to be taken particularly with reference to the materials of construction. Additional requirements shall be agreed between supplier and user.

1.3.4 Discharge pressure

The recommendations in this publication are based on the experience gained in the compression of oxygen up to 1450 psi (10 000 kPa).

1.3.5 Suction pressure

Traditional experience is with compressor suction pressure of less than 29 psi (200 kPa). This is the application that has been considered when putting forward the best design of ancillary systems. However, if the compressor has an elevated suction pressure it is possible that some ancillary systems may need modification and appropriate risk assessment shall be made.

1.3.6 Driver

The majority of experience has been with the use of constant speed electric motor drivers. This publication has been written giving the best solution for this type of driver. However, where another type of driver (e.g., variable speed electric motor requires a different solution) this has been clearly pointed out in the publication (resonance, vibrations, and lubrication issues).

1.4 Definition of terms

1.4.1 Terminology

Although the application of this publication is voluntary, a clear distinction is made between the definition of shall and should as used in the publication:

- Shall is used when application of a procedure is to be considered as a mandatory requirement and is used wherever criterion for conformance to specific recommendation allows no deviation;
- Should is used when application of a procedure is recommended;
- May and need not are used when the application is optional; and
- Will is used to indicate the future only, not a degree of requirement.

1.4.2 Maximum continuous speed of the compressor

The maximum continuous rotating speed of the compressor is determined primarily by the valve life cycle. The maximum continuous rotating speed shall not exceed 750 rpm.

1.4.3 Maximum operating temperature

The highest temperature that can be measured anywhere in the main gas stream, under the most severe operating conditions. See 4.7.3.

2 Compressor installation

2.1 Hazard area

2.1.1 Description

The hazard area is defined as the area where an incident is most likely to occur and as a consequence is capable of causing danger and/or injury to personnel. It is necessary to consider a number of pertinent factors when determining whether or not an area should be classified as a hazard area such as:

- specific equipment service conditions of pressures, temperatures, gas velocities, purity, contaminants, etc.;
- compressor and other system equipment design factors such as type, size, materials of construction, operating speed, internal clearances, type of seal system, etc.;
- history for equipment of similar design and operating conditions;