



CGA G-4.13—2023
CENTRIFUGAL COMPRESSORS
FOR OXYGEN SERVICE
SECOND EDITION

Currently in preview, click buy full version

PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued CGA G-4.13, *Centrifugal Compressors for Oxygen Service*, jointly produced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 27, *Centrifugal Compressors for Oxygen Service*.

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.

PLEASE NOTE:

The information contained in this document was obtained from sources believed to be reliable and is based on technical information and experience currently available from members of the Compressed Gas Association, Inc. and others. However, the Association or its members, jointly or severally, make no guarantee of the results and assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable commodity grade, test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedure.

This document is subject to periodic review, and users are cautioned to obtain the latest edition. The Association invites comments and suggestions for consideration. In connection with such review, any such comments or suggestions will be fully reviewed by the Association after giving the party, upon request, a reasonable opportunity to be heard. Proposed changes may be submitted via the Internet at our website, www.cganet.com.

This document should not be confused with federal, state, provincial, or municipal specifications or regulations; insurance requirements; or national safety codes. While the Association recommends reference to or use of this document by government agencies and others, this document is purely voluntary and not binding unless adopted by reference in regulation.

A listing of all publications, audiovisual programs, safety and technical bulletins, and safety posters is available via the Internet at our website at www.cganet.com. For more information contact CGA at Phone: 703-788-2700, ext. 799. E-mail: customerservice@cganet.com.

Work Item 17-015

Atmospheric Gases and Equipment Committee

NOTE—Technical changes from the previous edition are underlined.

SECOND EDITION: 2023

FIRST EDITION: 2012 (corrected 12/4/2017)

© 2023 – Reproduced with permission from, the European Industrial Gases Association. All rights reserved.

Contents	Page
1 Introduction.....	1
2 Scope and purpose	1
2.1 Management of hazards.....	1
2.2 Design of the compressor system	2
2.3 Cleaning, preservation, and inspection	2
2.4 Erection, testing, and commissioning	2
2.5 Operation.....	2
2.6 Maintenance.....	2
2.7 Other specifications.....	2
2.8 Speed.....	2
3 Definitions.....	2
4 Compressor design	3
4.1 Design criteria.....	3
4.2 General materials.....	4
4.3 Compressor parts.....	5
4.4 Rotor dynamic analysis, verification tests, and data to be provided.....	11
4.5 Balancing and vibration.....	12
4.6 Insulation and grounding.....	12
5 Process pipework.....	13
5.1 Extent.....	13
5.2 Connections.....	13
5.3 Welding.....	13
5.4 Prefabrication.....	13
5.5 Vents to atmosphere.....	13
5.6 Special piping.....	13
5.7 Bellows.....	14
5.8 Gaskets.....	14
5.9 Acoustic and thermal insulation.....	14
5.10 Silencers.....	14
5.11 Vaned elbows.....	14
5.12 Main suction filter.....	14
6 Manual valves.....	15
6.1 Manually operated main isolation valves.....	15
6.2 Manual valves that form part of the oxygen compressor envelope.....	15
7 Intercoolers and aftercoolers.....	15
7.1 Scope of supply.....	15
7.2 Types of coolers.....	15
7.3 Vents and drains.....	17
8 Lubricating oil system.....	17
8.1 General.....	17
8.2 Oil pumps.....	17
8.3 Filter.....	18
8.4 Oil heater.....	18
8.5 Oil vapor extractor system.....	18
8.6 Oil tank.....	18
8.7 Control.....	18
9 Controls and instrumentation.....	18
9.1 General.....	18
9.2 Control system.....	19
9.3 Anti-surge system.....	19

9.4	High oxygen temperature protection	20
9.5	High bearing temperature protection	22
9.6	Overspeed protection	22
9.7	Vibration and shaft position	22
9.8	Safety shutdown system valves	22
9.9	Oxygen humidity	23
10	Seal gas system	25
10.1	Compressor seal gas system	25
10.2	Bearing seal gas system	25
10.3	Schematic diagrams	25
11	Inspection and shipping	29
11.1	Introduction	29
11.2	Responsibility	29
11.3	Inspection and cleanliness standards	29
11.4	Preservation of oxygen cleanliness during shipping and storage	29
12	Compressor installation	30
12.1	Hazard area	30
12.2	Enclosure of the hazard area by a safety barrier	31
12.3	Access to the hazard area	31
12.4	Equipment location	31
12.5	Safety barrier	32
12.6	Safety barrier miscellaneous design features	37
12.7	Location	37
12.8	Fire protection and precautions	37
12.9	Protection of personnel	38
13	Erection and commissioning	38
13.1	Erection	38
13.2	Testing and commissioning	39
13.3	Commissioning on oxygen	42
14	Operation	43
14.1	General	43
14.2	Combustible matter	43
14.3	Machine rubs	43
14.4	Rotor/bearing instability	43
14.5	Machine vibrations	43
14.6	Leaking cooler tubes	43
14.7	Gas leakage hazard	43
14.8	Compressor surge	43
14.9	Machine protection systems	43
14.10	Operational inspections	44
14.11	Responsibility transfer documentation	44
14.12	Qualifications and training for operating personnel	44
14.13	Hazard area	44
14.14	Fire drills	44
14.15	Emergency purge and vent systems	44
14.16	Record of machine operation	44
14.17	Tipping devices	45
14.18	Interlock systems	45
14.19	Oil filters	45
14.20	Startup procedures	45

15	Maintenance.....	46
15.1	General.....	46
15.2	Cleanliness during maintenance	47
15.3	Rotor checks.....	47
15.4	Startup after maintenance	47
15.5	Spare parts.....	47
16	Instruction manual.....	48
16.1	General.....	48
16.2	List of minimum information.....	48
16.3	Additional Information.....	48
17	References.....	49

Figures

Figure 1	—Grounding of compressor shafts	13
Figure 2	—Centrifugal oxygen compressor system flow diagram.....	24
Figure 3	—Example of a single shaft gas supply schematic diagram.....	27
Figure 4	—Example of a geared compressor seal gas supply schematic diagram	28
Figure 5a	—Example of a single shaft centrifugal oxygen compressor impact force distribution on barrier (plan and front views).....	35
Figure 5b	—Example of an integrally geared centrifugal oxygen compressor impact force distribution on barrier (plan and front views)	36

Tables

Table 1	—Minimum instrumentation of oxygen compressors	21
Table 2	—Failure modes and operating speeds of system valves.....	23

1 Introduction

This publication has made a significant contribution to the safe compression of oxygen primarily because the manufacturers and users have 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.

Oxygen compression represents a risk in that the compressor can burn violently. This publication defines design and operating parameters for centrifugal oxygen compressors. Compliance with this publication can reduce the likelihood of, and the hazards arising from, a fire in a compressor to a level equal to or less than those commonly accepted in the air separation industry.

The publication requires that all those who build and operate centrifugal oxygen compressors 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 manufacturer shall establish full agreement on the possible and expected modes of compressor operation (for example, specified operating points, normal operating range, startup and shutdown, etc.)

2 Scope and purpose

This publication applies to single shaft horizontally split casing and vertically split casing (barrel) type compressors and integrally geared compressors. Operating experience exists on compressors up to 71 000 Nm³/hr (2 700 000 scfh) at pressures up to 1230 psi (8.5 MPa) for single shaft compressors and up to 650 psi (4.5 MPa) for integrally geared compressors with oxygen purity of 90% or greater and with maximum 10 ppm water (volume basis).^{1,2}

The use of axial compressors in oxygen service is not covered by this publication.

The purpose of this publication is to provide guidance on the design, manufacture, installation, operation, and maintenance of centrifugal oxygen compressors, thereby safeguarding personnel and equipment. Fire in an oxygen compressor can be caused by a variety of reasons, which include mechanical deterioration resulting in excessive vibration and/or loss of running clearances within the compressor, ingress of oil (for example, through the seal system), foreign bodies passing through the machine, and surge.

An oxygen compressor shall be provided with a safety support system that shall minimize the development of a potentially dangerous operating condition in the event of an incident on the compressor that results in combustion of the materials of construction, and safety systems shall be designed to minimize the effect of the fire.

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

2.1 Management of hazards

- identification of the hazard;
- hazard area, safety barriers, and enclosures;
- location of the compressor; and
- emergency procedures.

¹ psi, bar, and kPa/MPa shall indicate gauge pressure unless otherwise noted as (psia; bar, abs; and kPa/MPa, abs) for absolute pressure or (psid; bar, dif; and kPa/MPa dif) for differential pressure. All kPa values are rounded off per CGA P-11, *Guideline for Metric Practice in the Compressed Gas Industry* [1].

² References are shown by bracketed numbers and are listed in order of appearance in the reference section.