CGA C-6.1—2019

STANDARD FOR VISUAL INSPECTION OF HIGH PRESSURE ALUMINUM ALLOY COMPRESSED GAS CYLINDERS

SEVENTH EDITION

CGA
Compressed Gas Association
The Standard For Safety Since 1913

AVA Documents
Document Sharing Hub

Full document details: CGA C-6.1-2019

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 regulations.

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 18-006
Cylinder Specifications Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendices A, B, and C (Informative) are for information only.

SEVENTH EDITION: 2019
SIXTH EDITION: 2013 (corrected 4/14/2015)
FIFTH EDITION: 2006
FOURTH EDITION: 2002
© 2019 The Compressed Gas Association, Inc. All rights reserved.
All materials contained in this work are protected by United States and international copyright laws. No part of this work may be reproduced or transmitted in any form or by any means, electronic or mechanical including photocopying, recording, or any information storage and retrieval system without permission in writing from The Compressed Gas Association, Inc. All requests for permission to reproduce material from this work should be directed to The Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly VA 20151. You may not alter or remove any trademark, copyright or other notice from this work.

Documents
Document Sharing Hub

Full document details: CGA C-6.1-2019

Contents **Page**

1 Introduction 1

2 Scope 2

3 Definitions 3

4 Preparation for inspection 7
4.1 Inspection equipment 7
4.2 Valve removal and venting 8
4.3 Aluminum alloy cylinder identification 8
4.4 Cleaning 8

5 Inspection criteria 9
5.1 Ultrasonic examination visual inspections 9
5.2 Markings 9
5.3 Corrosion limits 10
5.4 Cuts, digs, and gouges 10
5.5 Wall loss 11
5.6 Dents 11
5.7 Leaks and holes 11
5.8 Bulges 11
5.9 Fire and thermal damage 11
5.10 Neck defects 13
5.11 Threads and valving 15
5.12 Bow 15

6 Condemning a cylinder 15

7 References 16

8 Additional references 16

Figures

Figure 1—Exemption marked cylinder 2
Figure 2—3AL marked exemption cylinder 2
Figure 3—Cylinder with pitting corrosion 4
Figure 4—Gouged cylinder 4
Figure 5—Dented cylinder 5
Figure 6—Fold 5
Figure 7—Cylinder characteristics 6
Figure 8—Valley 6
Figure 9—Light and mirror used to inspect threads and crown 7
Figure 10a—Neck crack 13
Figure 10b—Neck crack 14
Figure 11—Tool stop mark 14

Appendices

Appendix A—Eddy current devices (Informative) 17
Appendix B—Sustained load cracking (SLC) (Informative) 18
Appendix C—Heat exposure and condemning aluminum alloy cylinders (Informative) 20

Documents
Document Sharing Hub
Full document details: CGA C-6.1-2019

This page is intentionally blank.

Documents
Document Sharing Hub

Full document details: CGA C-6.1-2019

1 Introduction

Unless otherwise provided for by special permit, equivalency certificate (formerly called permit of equivalent level of safety), or regulations, U.S. Department of Transportation (DOT) and Transport Canada (TC) require that cylinders used for the transportation of compressed gases are requalified periodically by visual inspection followed by hydrostatic testing if they are to remain in service (see CGA C-1, *Methods for Pressure Testing Compressed Gas Cylinders*) [1].[1] However, a cylinder that was charged or filled before the requalification becomes due may remain in service until it has been emptied. U.S. regulations in Part 180 Subpart C of Title 49 of the *Code of Federal Regulations* (49 CFR) and equivalent Canadian regulations in Clause 24 of Canadian Standards Association (CSA) B339, *Cylinders, spheres, and tubes for the transportation of dangerous goods*, identify the inspection and hydrostatic testing requirements for most cylinders [2, 3]. Cylinders fabricated in accordance with DOT, TC, or the former Canadian Transport Commission (CTC) permits, equivalency certificate/permit of equivalent level of safety, or exemptions/special permits shall be requalified as specified in the exemption/special permit, equivalency certificate/permit, or CTC permit. These documents can be obtained from DOT, TC, or the manufacturer.

The approval of the 3AL specification in 49 CFR 178.46 (July 2, 1982) consolidated the majority of the exemptions and special permits for aluminum alloy cylinders into one manufacturing regulation [2]. Canadian specification TC-3ALM also consolidates specification CTC-3AL and permits for aluminum alloy cylinders into regulations [3, 4].

Both DOT and TC have provisions in their regulations for introduction of new cylinder designs, materials, and fabrication techniques. Before implementation of CTC/DOT specification 3AL and TC specification 3ALM, aluminum alloy cylinders were manufactured under special permits and/or exemptions E 6498, E 7042, E 8107, E 8364, E 8422, CTC SP 890, or CTC SP 922. Permit or exemption numbers are stamped on the shoulder of the cylinder. These cylinders may be continued in use in Canada. In the United States, these cylinders (with the exception of CTC SP 922) may be continued in use but shall be remarked in compliance with 49 CFR 173.23 at the time of the first retest following July 2, 1982 [2]. Such remarking is not authorized for all permitted cylinders.

In the United States, DOT exemptions E 6498, E 7042, E 8107, E 8364, and E 8422 were previously issued, which identified the manufacturing, usage, and inspection requirements of these cylinders. These exemptions have been superseded by DOT specification 3AL and copies of the exemptions are no longer required. Cylinders marked with “S.P.” preceding the previously noted exemption numbers, designating special permits, are also covered by DOT specification 3AL. Some cylinders with the previously noted markings may be preceded by “CTC” indicating compliance with the CTC requirements, for example, CTC/DOT E 6498-1800. Exemption and special permit cylinders shall be remarked at the time of the first hydrostatic testing occurring after July 2, 1982. Requirements for remarking can be found in 49 CFR 173.23(c), which states that after July 2, 1982, a seamless aluminum alloy cylinder manufactured in conformance with and for use under DOT exemption E 6498, E 7042, E 8107, E 8364, or E 8422 may be continued in use if marked before or at the time of the next retest with the specification identification 3AL immediately above the exemption number, or if the DOT mark (i.e., DOT-3AL 1800) is added in proximity to the exemption marking [2]. See Figures 1 and 2 for examples of exemption marked cylinders.

Experience in the inspection of cylinders is an important factor in determining the acceptability of a given cylinder for continued service. Inspectors evaluating cylinders shall consult the manufacturer or other knowledgeable sources.

Existing regulatory markings shall remain intact.

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

Documents
Document Sharing Hub

Full document details: CGA C-6.1-2019

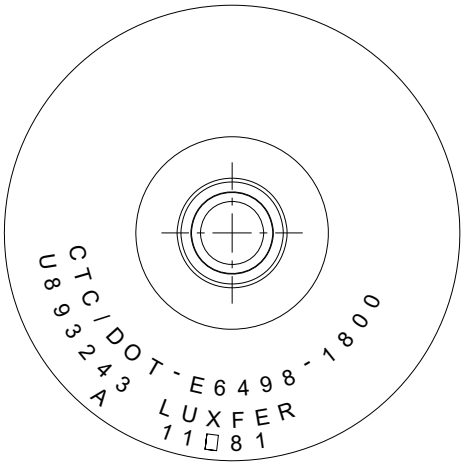

Figure 1—Exemption marked cylinder

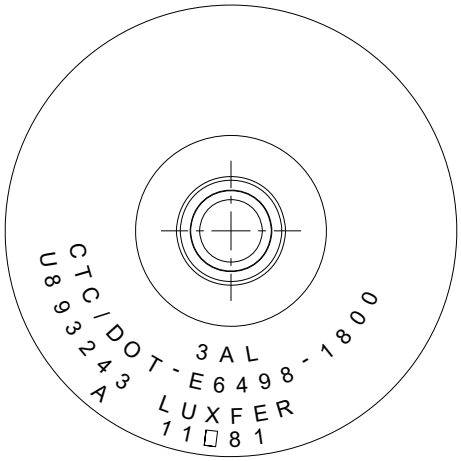

Figure 2—3AL marked exemption cylinder

2 Scope

This standard has been prepared for the visual inspection of aluminum alloy compressed gas cylinders with service pressures of 1800 psi (12 410 kPa) or greater.[2] This standard does not address all cylinder manufacture defects. Cylinders authorized by regulation may require testing by ultrasonic examination (UE) or pressure testing. This standard does not include testing that may be required by regulation. UE of aluminum alloy cylinders shall meet the requirements of CGA C-20, *Requalification Standard for Metallic, DOT and TC 3-Series Gas Cylinders and Tubes Using Ultrasonic Examination* [6]. Pressure testing shall meet regulatory requirements. CGA C-6.3, *Standard for Visual Inspection of Low Pressure Aluminum Alloy Compressed Gas Cylinders* shall be followed for cylinders with lower service pressures [7].

Additional publications and standards prepared by the Compressed Gas Association, Inc. (CGA) that can be helpful include:

- CGA C-1 [1];
- CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders* [8];

[2] 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, *Guideline for Metric Practice in the Compressed Gas Industry* [5].

Documents
Document Sharing Hub
Full document details: CGA C-6.1-2019

- CGA C-6.2, *Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders* [9];
- CGA C-6.3 [7];
- CGA C-20 [6];
- CGA V-11, *Guideline for the Installation of Valves into High Pressure Aluminum Alloy Cylinders* [10];
- CGA P-38, *Guideline for Devalving Cylinders* [11]; and
- CGA S-1.1, *Pressure Relief Device Standards—Part 1—Cylinders for Compressed Gases* [12].

3 Definitions

For the purpose of this standard, 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 Bow
Cylinder manufactured with a curve in it like a banana shape.

3.2.2 Bulge
Visible swelling of the container.

3.2.3 Condemned
No longer fit for service. A condemned cylinder is required to be removed from service.

3.2.4 Corrosion
Loss of metal thickness by some corrosive media.

NOTE—Corrosion of aluminum appears as a roughened and discolored area with a white deposit sometimes associated with the corrosion. There are several kinds of corrosion to be considered as defined in 3.2.4.1, 3.2.4.2, and 3.2.4.3.

3.2.4.1 General corrosion
Corrosion that covers considerable surface areas of the cylinder.

3.2.4.2 Line corrosion
Series of pits closely spaced as to appear to be in a line.

NOTE—This condition is considered more serious than isolated pitting.

Documents
Document Sharing Hub
Full document details: CGA C-6.1-2019

3.2.4.3 Pitting corrosion

Pits can be small and localized or larger and scattered.

NOTE—Small, isolated pits have very little effect on the strength of the cylinder but the degree of pitting and concentration of the pits determine if the cylinder may continue in service, see Figure 3.

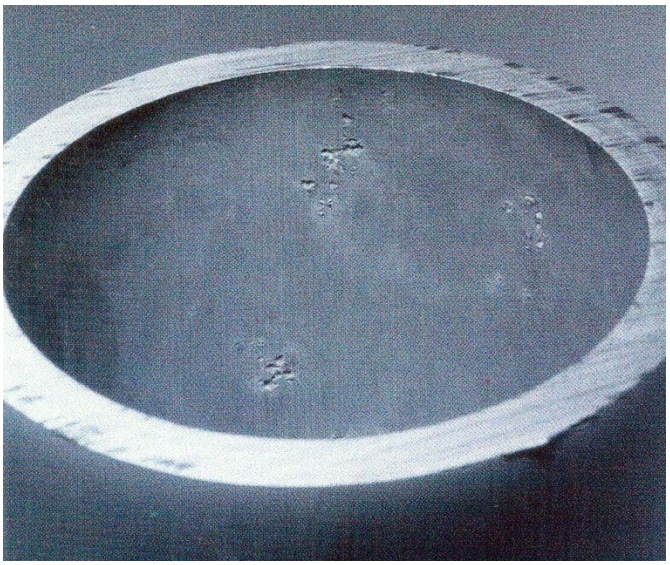

Figure 3—Cylinder with pitting corrosion

3.2.5 Crack

Split or rift in the metal.

3.2.6 Cuts, digs, and gouges

Defects that are indicated by removed or upset metal.

NOTE—These defects are associated with loss of wall thickness and are usually caused by a sharp object, see Figure 4.

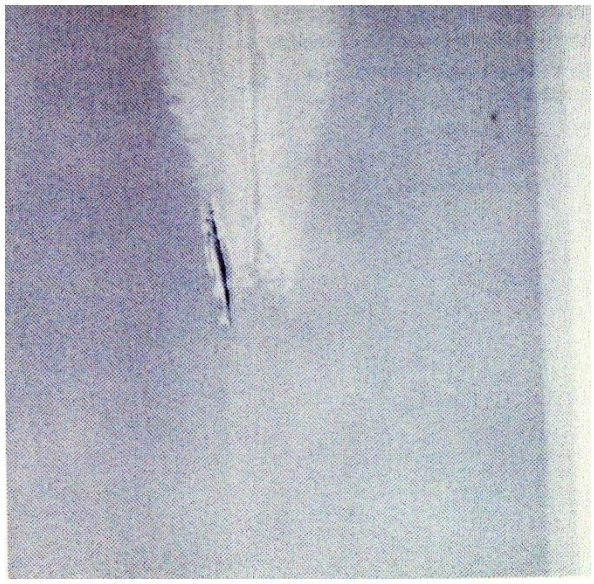

Figure 4—Gouged cylinder

Documents
Document Sharing Hub
Full document details: CGA C-6.1-2019