



CGA C-1—2022

METHODS FOR PRESSURE TESTING COMPRESSED GAS CYLINDERS AND TUBES

TWELFTH EDITION

This document licensed for the sole use of the purchaser. It may not be shared with any other person or used after the expiration date without the express written permission of the CGA. Any unauthorized use, reproduction, distribution, or modification of this printed page will result in a \$5,000 liquidated damages fee plus loss of access to CGA publications for one year for your company.

Full document details: CGA C-1-2022

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 20-036
Cylinder Specifications Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendices A, C, D, E, and F (Informative) are for information only.

NOTE—Appendix B (Normative) is a requirement.

TWELFTH EDITION: 2022
ELEVENTH EDITION: 2016
TENTH EDITION: 2009
NINTH EDITION: 2006

© 2022 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., 8484 Westpark Drive, Suite 220, McLean, VA 22102. You may not alter or remove any trademark, copyright or other notice from this work.

Contents	Page
1 Introduction.....	1
2 Scope	1
3 Definitions.....	1
4 Overview	4
4.1 Water jacket method.....	4
4.2 Direct expansion method.....	4
4.3 Proof pressure method.....	4
4.4 Regulatory approval of cylinder requalifier	4
4.5 Visual inspection of cylinders at time of requalification	4
5 Water jacket method	5
5.1 Scope	5
5.2 Requirements	7
5.3 Test system components.....	9
5.4 Calibrated cylinder.....	13
5.5 Test system accuracy verification.....	13
5.6 Test procedure	15
5.7 Cylinder retesting.....	15
6 Direct expansion method.....	16
6.1 Scope	16
6.2 Test system components.....	18
6.3 Calibrated cylinder.....	18
6.4 Expansion determination of test system and components	19
6.5 Test system accuracy verification.....	19
6.6 Test procedure	21
7 Proof pressure method.....	23
7.1 Scope	23
7.2 Test system components.....	24
7.3 Test system accuracy verification.....	24
7.4 Test procedures.....	26
8 References	27
Figures	
Figure 1—Typical schematic diagram of water jacket test apparatus	6
Figure 2—Total expansion	7
Figure 3—Permanent expansion	7
Figure 4—Zero point	8
Figure 5—Adjustment of water level in burette for expansion readings.....	10
Figure 6—Example of burette-style EID requirements.....	10
Figure 7—Typical nonburette EID systems.....	11
Figure 8—Typical microprocessor-based EID systems	11
Figure 9—Typical schematic diagram of direct expansion test apparatus	17
Figure 10—Factors for compressibility of water.....	22
Figure 11—Typical schematic diagram of liquid-based proof pressure test apparatus	23
Appendices	
Appendix A—Sources of regulatory information (Informative)	28
Appendix B—Test system component calibration (Normative).....	29
Appendix C—Marking of cylinders requalified by the water jacket or direct expansion methods (Informative) .	31
Appendix D—Sample forms for cylinder requalification (Informative).....	33
Appendix E—Troubleshooting (Informative)	38
Appendix F—Checklists (Informative).....	43

Appendix figures

Figure C-1—Example of DOT cylinder marking 32

Figure C-2—Example of TC cylinder marking..... 32

Appendices tables

Table D-1—Test apparatus calibration verification data for water jacket volumetric expansion testing 33

Table D-2—Direct expansion hydrostatic requalifying of cylinders 34

Table D-3—Requalification data sheet 35

Table D-4—Requalification retest data sheet for proof testing 36

Table D-5—Test apparatus calibration verification data for proof testing 37

Table F-1—Checklist for accuracy verification of test system (Direct expansion method) 43

Table F-2—Checklist for determining the expansion of test system and components
(Direct expansion method) 44

Table F-3—Checklist for hydrostatic testing of cylinders (Direct expansion method) 45

1 Introduction

Pressure testing of compressed gas cylinders is required for many newly manufactured cylinders and is also an accepted test method for the requalification of cylinders. The referenced edition of the applicable documents, as specified by the U.S. Department of Transportation (DOT) in Title 49 of the U.S. *Code of Federal Regulations* (49 CFR), in Canada by Transport Canada (TC) in CSA B339, *Cylinders, spheres, and tubes for the transportation of dangerous goods*, and CSA B341, *UN pressure receptacles and multiple-element gas containers for the transport of dangerous goods* as referenced by the *Transportation of Dangerous Goods Regulations*, or the authority having jurisdiction shall be available at each facility conducting pressure testing/requalification [1, 2, 3, 4].¹

For the testing/requalification of cylinders manufactured under a special permit or equivalency certificate, a current copy of that special permit or equivalency certificate shall also be available. See Appendix A for addresses of agencies and organizations that produce these documents.

For the manufacturing tests or requalification of a cylinder or tube manufactured under an international standard, pressure testing shall be performed in accordance with the requirements of the relevant cylinder design standard or relevant cylinder requalification standard specified by national or international competent authorities.

2 Scope

This standard contains operating and equipment requirements necessary to properly perform pressure testing of compressed gas cylinders.

NOTE—For purposes of this standard, cylinder(s) also means tubes unless otherwise stated.

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 Accuracy

Degree of conformity of a measured or calculated quantity to its actual (true) value.

3.2.2 Accuracy grade

Inherent quality of the device.

NOTE—Accuracy grade expresses the maximum error allowed for the device at any reading and is expressed as a percentage of the full scale of the device.

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

3.2.3 Actual test pressure

True, recorded pressure applied to a cylinder during a test.

3.2.4 Calibration

Process of adjusting a device to match a known standard so that it indicates to within specified accuracy limits.

NOTE—See Appendix B for information on calibration devices.

3.2.5 Calibration verification

Checking of an individual device or test apparatus by comparison with a given standard to determine the indication error at specified points of the scale.

3.2.6 Calibrated cylinder

Cylinder that has certified calibration points of pressure with corresponding expansion values.

NOTE—It is a secondary, derived standard used for the verification and demonstration of test system accuracy and integrity.

3.2.7 Condemn

Determination that a cylinder is unserviceable for transportation of hazardous materials (dangerous goods).

3.2.8 Cylinder

Any type of pressure vessel designed for a minimum internal pressure of 40 psia (276 kPa, abs) and having a circular cross section.²

NOTE—For purposes of this standard, cylinder(s) also means tubes unless otherwise stated.

3.2.9 Defect

Imperfection requiring a cylinder to be rejected or condemned.

3.2.10 Elastic expansion

Temporary increase in cylinder's volume due to application of pressure that is lost when pressure is released.

NOTE—The calculation for elastic expansion is total expansion minus permanent expansion.

3.2.11 Error

Difference between the indicated value and the true value of the variable being measured.

3.2.12 Expansion indicating device (EID)

Device used to directly or indirectly measure the expansion of a cylinder during the test.

3.2.13 Hydrostatic test

Method of pressure testing a cylinder using liquid as the pressurization media.

3.2.14 Independent Inspection Agency (IIA)

Inspection firm approved by DOT as outlined in 49 CFR 107.803 [1].

3.2.15 Master gauge

Pressure indicating device (PID) used as a calibration standard that has an accuracy grade equal to or better than the requirement for the PID in the test apparatus.

3.2.16 Percent permanent expansion

Ratio of permanent expansion to total expansion, expressed as a percentage.

NOTE—The calculation for percent permanent expansion is permanent expansion divided by total expansion times 100.

3.2.17 Permanent expansion

Increase in cylinder volume due to application of pressure that is not recovered when pressure is released.

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].

3.2.18 Pressure indicating device (PID)

Device used to measure the pressure applied to a cylinder during the test.

3.2.19 Proof pressure test

Cylinder testing procedure consisting of an application of internal pressure without measurement of the cylinder expansion.

3.2.20 Reference gauge

PID used in the daily verification of a proof test system that has an accuracy grade equal to or better than the requirement for the PID to be checked.

NOTE—Also known as referee gauge.

3.2.21 Reference zero point

Zero reading on the EID with a tolerance of $\pm 0.1\%$ of the total expansion or ± 0.1 cc, whichever is greater.

3.2.22 Reject

Determination that a cylinder is not permitted for continued transportation of dangerous goods without repair, requalification, etc.

3.2.23 Requalification

Test(s) required to be performed on a cylinder to determine its suitability for continued service.

3.2.24 Requalifier identification

Code assigned by DOT (requalification identification number [RIN]) or by TC (registered mark) to uniquely identify a cylinder requalification/repair/rebuild facility.

NOTE—See Appendix C for information on marking a RIN or TC registered mark on a cylinder.

3.2.25 Retest

Act of conducting a pressure test again due to equipment failure or operator error.

3.2.26 Service pressure

Rated pressure marked on the cylinder.

3.2.27 Test head

Closure device to seal the water jacket.

3.2.28 Test pressure

Minimum prescribed pressure calculated in accordance with the applicable regulations to verify its fitness for service.

3.2.29 Total expansion

Total increase in a cylinder's volume due to application of the test pressure.

3.2.30 Tube

Seamless container of cylindrical shape with openings at both ends and a water capacity greater than 1000 lb (450 L).

NOTE—Also described by TC's *Transportation of Dangerous Goods Regulations* as a container with a water capacity greater than 450 L, in a seamless cylindrical form, and capable of withstanding an internal service pressure of at least 12.4 MPa [4].

NOTE—For purposes of this standard, cylinder(s) also means tubes unless otherwise stated.

3.2.31 Visual inspection

Internal examination and/or external examination performed as part of the cylinder requalification process.

3.2.32 Volumetric expansion test

Hydrostatic test to determine the total, permanent, and elastic expansion of a cylinder at a given pressure.

NOTE—This test is conducted using the water jacket or direct expansion methods.

3.2.33 Water capacity

Total mass or volume of water a container can hold at 59 °F (15 °C) and at a pressure of 101.325 kPa, abs (14.7 psia).

4 Overview

4.1 Water jacket method

The water jacket method is an acceptable hydrostatic test method when volumetric expansion determinations are required. It consists of enclosing a cylinder filled with liquid into a test jacket filled with water. Internal pressure is then applied to the cylinder, causing the cylinder to expand. The total and permanent volumetric expansions of the cylinder are determined by measuring the amount of water displaced by the expansion of the cylinder when under pressure and after the pressure is released. The elastic expansion is calculated by subtracting the permanent expansion from the total expansion. In accordance with DOT regulations, this is the only hydrostatic testing method that qualifies a cylinder for filling to 10% in excess of the marked service pressure [1].

Information on how to determine if a cylinder qualifies to be filled to a pressure 10% in excess of its stamped service pressure can be found in 49 CFR or CSA B339 as appropriate [1, 2]. See Appendix C for further information.

4.2 Direct expansion method

The direct expansion method is an acceptable hydrostatic test method when volumetric expansion determinations are required. However, it has practical limitations in its use. It consists of forcing a measurable volume of liquid into a cylinder filled with a known weight of liquid at a known temperature, and measuring the volume of liquid expelled from the cylinder when the pressure is released. The permanent volumetric expansion of the cylinder is calculated by subtracting the volume of liquid expelled from the cylinder from the volume of liquid forced into the cylinder. The total volumetric expansion of the cylinder is calculated by subtracting the volume of liquid due to compressibility from the volume of liquid forced into the cylinder to raise the pressure to the desired test pressure. Although this procedure also measures elastic expansion, DOT regulations do not permit this testing method to be used to qualify a cylinder for filling to 10% in excess of the marked service pressure [1].

4.3 Proof pressure method

The proof pressure method is permitted when regulations do not require the determination of total and permanent expansion. It consists of pressurizing a cylinder to test pressure and examining it under pressure for leaks, bulges, and any visible defects. The pump from either a water jacket test apparatus or a direct expansion test apparatus may be used to perform the proof pressure test.

Additionally, appropriate sections of 49 CFR and CSA B339 permit certain cylinders to be requalified by this method when the cylinder is used in noncorrosive service [1, 2].

4.4 Regulatory approval of cylinder requalifier

The test facility and test apparatus used shall be approved as to type and operation. Each facility performing requalification on DOT specification cylinders shall have a Regulation Identification Number (RIN) issued by DOT (49 CFR 107.805) upon the favorable recommendation of an Independent Inspection Agency (IIA) [1].

In Canada, all requalification facilities shall be registered with TC. See CSA B339 and CSA B341, UN pressure receptacles and multiple-element gas containers for the transport of dangerous goods for additional information [2, 3].

4.5 Visual inspection of cylinders at time of requalification

Regardless of the type of requalification test method used in this standard, federal regulations specify that the requalification shall include either an external and internal examination of the cylinder or an external visual examination only of the cylinder. See the applicable regulation for the required visual inspection. In the United

States, a requalifier is required to comply with the visual inspection procedures and the cylinder approval, rejection, and condemnation criteria set forth in the editions of the following CGA publications specifically referenced in 49 CFR [1]:

- C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders* [6];
- C-6.1, *Standard for Visual Inspection of High Pressure Aluminum Alloy Compressed Gas Cylinders* [7];
- C-6.2, *Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders* [8];
- C-6.3, *Standard for Visual Inspection of Low Pressure Aluminum Alloy Compressed Gas Cylinders* [9]; and/or
- C-8, *Standard for Requalification of DOT-3HT, CTC-3HT, and TC-3HTM Seamless Steel Cylinders* [10].

In the case of cylinders requalified in Canada, a requalifier is required to comply with CSA B339 and CSA B341 [2, 3].

Performing a preliminary visual inspection before the pressure test is recommended.

5 Water jacket method

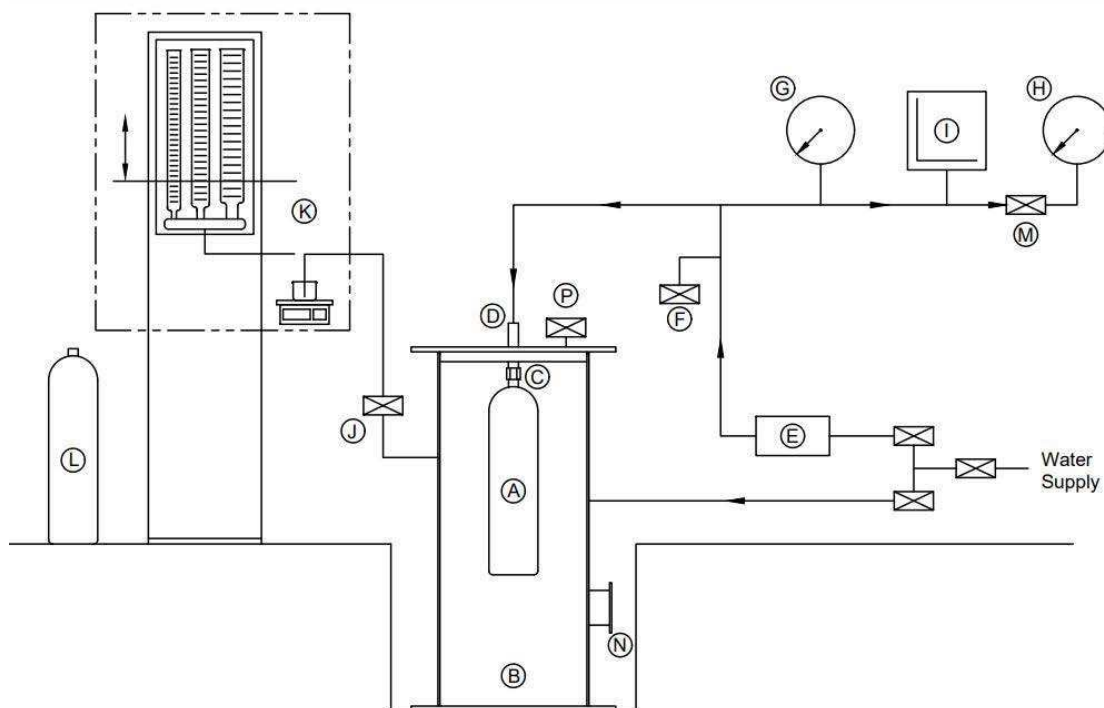
5.1 Scope

The water jacket method is the most common method for pressure testing high pressure cylinders in the compressed gas industry in the U.S. and Canada. It consists of pressurizing a cylinder filled with liquid inside a sealed container filled with water (the water jacket) and measuring the resulting expansion. See Figure 1 for a typical schematic diagram of a water jacket test apparatus.

As the cylinder expands under pressure, the surrounding water in the water jacket is forced out of the water jacket into the expansion indicating device (EID). This displaced volume of water represents the total expansion of the cylinder (see Figure 2). After test pressure is released, the cylinder contracts and the displaced water returns to the water jacket from the EID. Any displaced water remaining in the EID represents the permanent expansion of the cylinder (see Figure 3). The amount of displaced water that returns to the water jacket when pressure is released represents the elastic expansion of the cylinder.

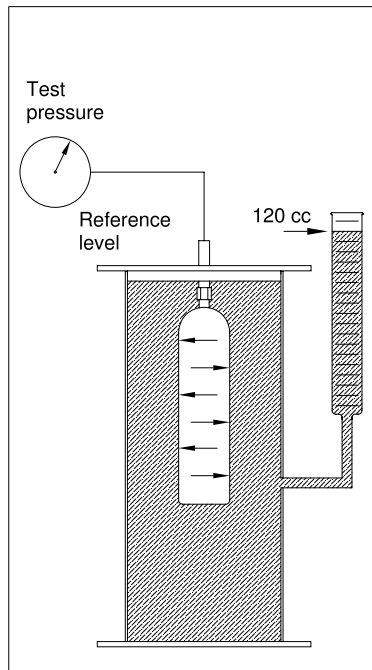
Various devices are used for measuring both the expansion and the pressure. Expansion liquid may be read visually as with a burette or measured electronically by weight. Pressure may be read using an analog gauge or electronically using a digital device.

The test system itself may be operated either manually or computer controlled.



Key	Description
A	Cylinder
B	Water jacket with <u>safety relief port</u> and sealed lid with high/low pressure connections
C	Test adapter
D	Pressure connection
E	Pump (for example, manual, shop air, electric, motor driven)
F	Pressure release valve
G	Pressure indicating device (PID)
H	Master gauge (optional)
I	Pressure recording device (optional)
J	Expansion valve (optional)
K	Expansion indicating device (EID) (burette[s] or scale)
L	Calibrated cylinder
M	Isolation valve
N	Safety relief port
P	<u>Purge valve</u>
⊗	Water/electric/air control valves: operated manually and/or automatically via program-mable logic controller/computer control

Figure 1—Typical schematic diagram of water jacket test apparatus



NOTE—Figures 2 and 3 are for illustrative purposes only. These figures are used to represent cylinder expansion and the rising and falling levels in the EID and are not meant to be literal schematics.

Figure 2—Total expansion

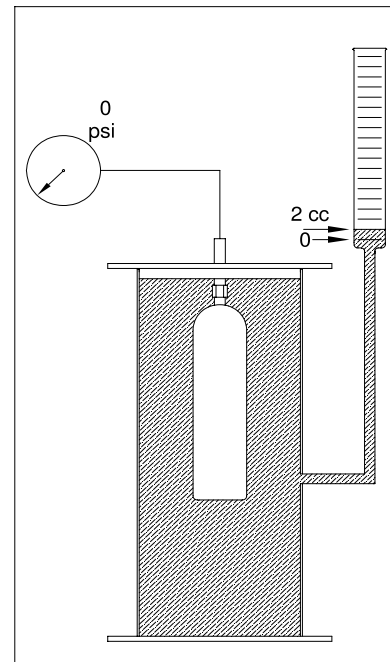


Figure 3—Permanent expansion

5.2 Requirements

Test pressure, regualification period, expansion rejection criteria, 10-year regualification criteria, and marking requirements for DOT and TC specification, special permit, or equivalency certificate cylinders are cited in 49 CFR, CSA B339, and current special permits or equivalency certificates [1, 2].

A DOT 3A, 3AA, 3AX, 3AAX, 3T specification cylinder shall qualify for service at 110% of rated pressure (i.e., + stamp marking) or the extended 10 year regualification (i.e., ★ stamp marking) when:

- elastic expansion does not exceed the limit established by Table 1 in CGA C-5, *Wall Stress Regualification Criteria for High Pressure Seamless Steel Cylinders* [11]; or
- elastic expansion does not exceed the rejection elastic expansion (REE) as marked on the cylinder at the time of manufacture; or
- average wall stress or the maximum wall stress at service pressure does not exceed the wall stress limitations established in 49 CFR 173.302a(b) [11, 1].

Additionally, all other requirements of 49 CFR 173.302a(b) shall be met [1].

A TC 3AM, 3AAM, 3AXM, 3AAXM, 3TM or 3ASM specification cylinder shall no longer qualify for filling to the marked service pressure (i.e., shall be marked with the letter K, immediately following the service pressure marking, to indicate that the service pressure shall be reduced by 10%) or the extended 10 year regualification test (i.e., no ★ stamp marking) when:

- elastic expansion exceeds the limit established by Table 1 in CGA C-5 [11];
- elastic expansion exceeds the REE as marked on the cylinder at the time of manufacture; or
- average wall stress or maximum wall stress exceeds the corresponding limitation in Appendix B of CGA C-5 [11].

Additionally, all other requirements of CSA B339, Clause 24.2.2 shall be met [2].

NOTE—In contrast to the previous DOT specification cylinders, TC 3AM, 3AAM, 3AXM, 3AAXM, 3TM or 3ASM specification cylinders have a marked service pressure that reflects the 110% filling allowance.

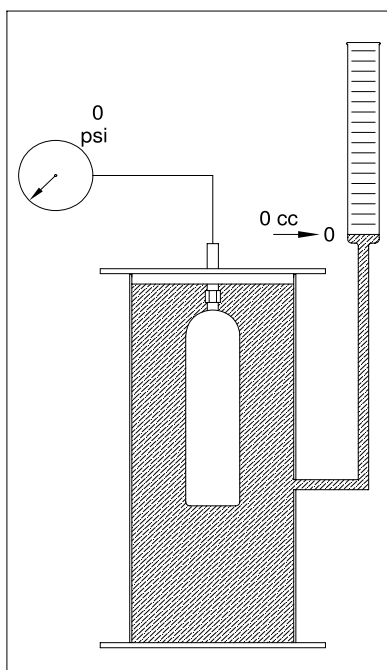
Dual specification cylinders (DOT/TC) tested in Canada will be marked according to the TC specification requirements.

NOTE—An increase in elastic expansion from the time of cylinder manufacture could indicate a reduction in the average wall thickness or a reduced yield strength of the cylinder material (possibly due to overheating of the cylinder).

5.2.1 General

The following shall be performed before opening any pressurization valves:

- Bands and other removable attachments shall be loosened or removed before testing so that the cylinder is free to expand in all directions;
- The water jacket shall be sealed and the EID shall be zeroed with the expansion line open to the water jacket (see Figure 4); and
- The expansion measuring device shall remain at zero for at least 10 seconds before beginning the test.



NOTE—Figure 4 is for illustrative purposes only and is not meant to be a literal schematic.

Figure 4—Zero point

If at time of cylinder requalification the actual test pressure has exceeded 110% of the minimum test pressure (with an allowance of +1%), the requalifier shall either contact the cylinder manufacturer for direction or condemn the cylinder. For dual specification cylinders (DOT/TC), the 110% test pressure limit shall be based on the higher test pressure calculated from the marked service pressures.

The cylinder shall be pressurized to at least the minimum test pressure. The cylinder shall maintain test pressure for at least 30 seconds and as much longer as may be necessary to ensure its complete expansion. The test pressure and total expansion shall be stable by the end of the hold time (no observable change in the readings from either the pressure indicating device (PID) or EID for at least 5 seconds).

If pressure and expansion have not stabilized, the hold time shall be extended or the test aborted. If pressure is added to the cylinder during the hold time, the hold time shall be restarted. Actual test pressure shall be recorded at the end of the hold time.

The cylinder shall be isolated from any pressure source, accumulator, or surge chamber during the hold time.

5.2.2 Calculations

Percent permanent expansion is calculated by dividing the permanent expansion by the total expansion and multiplying by 100. Elastic expansion is calculated by subtracting permanent expansion from total expansion. See the following formulae and examples.

$$\frac{\text{Permanent expansion}}{\text{Total expansion}} \bullet 100 = \text{percent permanent expansion}$$

$$\text{Example 1: } \left(\frac{2.3}{92} \right) \bullet 100 = 2.5\%$$

$$\text{Total expansion} - \text{permanent expansion} = \text{elastic expansion}$$

$$\text{Example 2: } 92 - 2.3 = 89.7$$

Cylinder expansions are measured with an EID such as a burette where the volume of water is measured in cubic centimeters or measured with a weighing scale where the weight of water in grams is converted to cubic centimeters. For the purpose of this standard, 1 g is equivalent to 1 cc. All expansion values are expressed in cc.

See Appendix D for sample test record forms.

5.3 Test system components

5.3.1 Expansion system

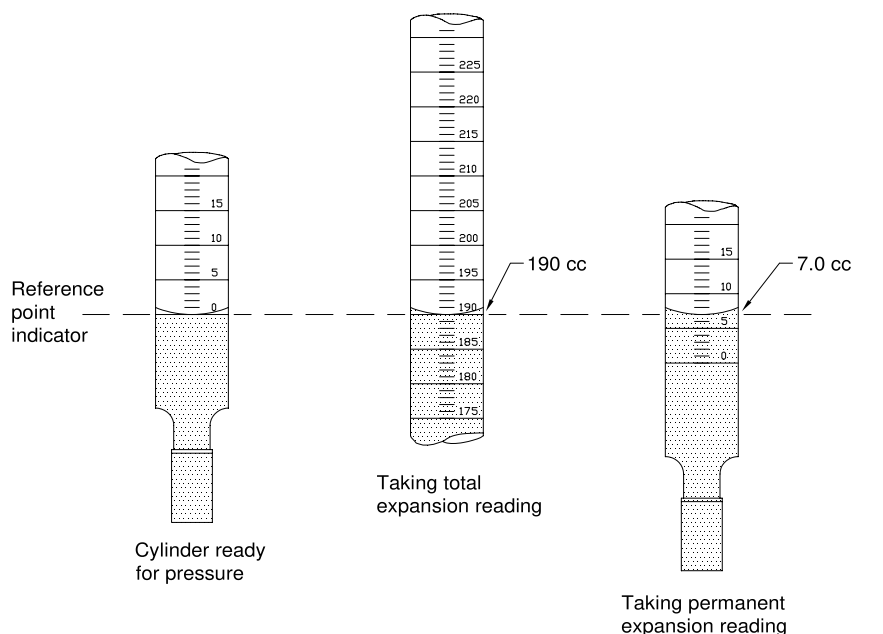
5.3.1.1 Water jacket

The water jacket shall be of sufficient size to allow a cylinder to expand freely in all directions. The water jacket and/or sealing head shall be designed to prevent leakage or air entrapment.

5.3.1.2 Expansion indicating device

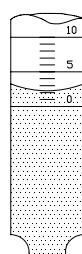
The EID shall be a burette, scale, or other suitable device and shall:

- Permit reading of the cylinder expansion to within 1% of the total expansion of each cylinder tested, or 0.1 cc, whichever is greater. Example: For total expansion readings of less than 10 cc, a reading to 0.1 cc is acceptable. Interpolation to one half of the marked increment is permitted. The device shall give a stable reading;
- Be accurate to within $\pm 1\%$ of the total expansion of any cylinder tested, or 0.1 cc, whichever is greater;
- Be designed to take into account the barometric effect of differing water levels (see Figure 5);
- Be certified as having an accuracy grade of $\pm 0.5\%$ or better. Example: A burette with a full scale of 150 cc and an accuracy grade of 0.5% would be accurate to a reading of 0.75 cc. Therefore, this burette shall not be used for total expansions less than 75 cc in order to maintain a $\pm 1\%$ accuracy of the total expansion (see Figure 6); and
- Be verified periodically in accordance with Appendix B.

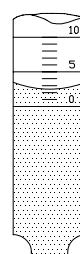


* Burette reading (at bottom of meniscus) is read to the nearest of:

- 1) marked increment; or
- 2) midpoint between marked increments



Bottom of meniscus is above 2.0 and below 2.5 but closer to 2.0
Record as 2.0 cc



Bottom of meniscus half way between 2.0 and 3.0
Record as 2.5 cc

* Select and use burette to ensure total expansion reading can be read to an accuracy of 1%

Figure 5—Adjustment of water level in burette for expansion readings

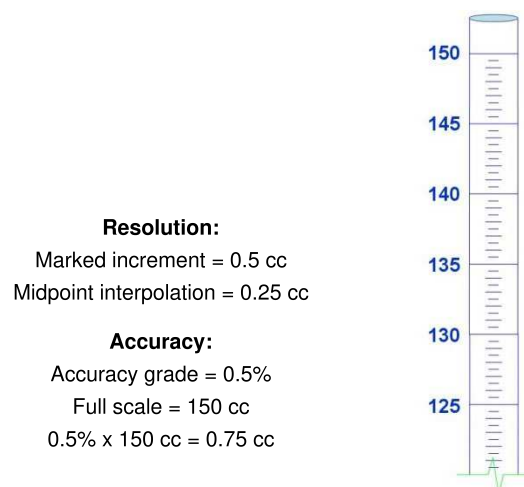


Figure 6—Example of burette-style EID requirements

5.3.1.2.1 Burette systems

For all readings, the adjustable panel shall be moved so the meniscus of the water column in the graduated burette is at the same level as the reference point indicator of the test panel. All measurements shall be taken at the same reference level and from the bottom of the meniscus (see Figure 5).

The reference point indicator should be positioned so measurements can be taken conveniently at eye level. The burette assembly shall be moveable so that the water level in the burette is at the same height when reading zero, total expansion, and permanent expansion. This water level shall be higher than the highest point of water in the water jacket and its connecting piping.

5.3.1.2.2 Nonburette type systems

The EID shall be designed and installed so any change in water level does not affect the required accuracy or cause errors in the expansion readings. Expansion readings can be affected by vibration, wind, and temperature. The EID shall be verified periodically in accordance with Appendix B.

Pictures of typical nonburette and microprocessor-based systems are found in Figures 7 and 8.



Figure 7—Typical nonburette EID systems

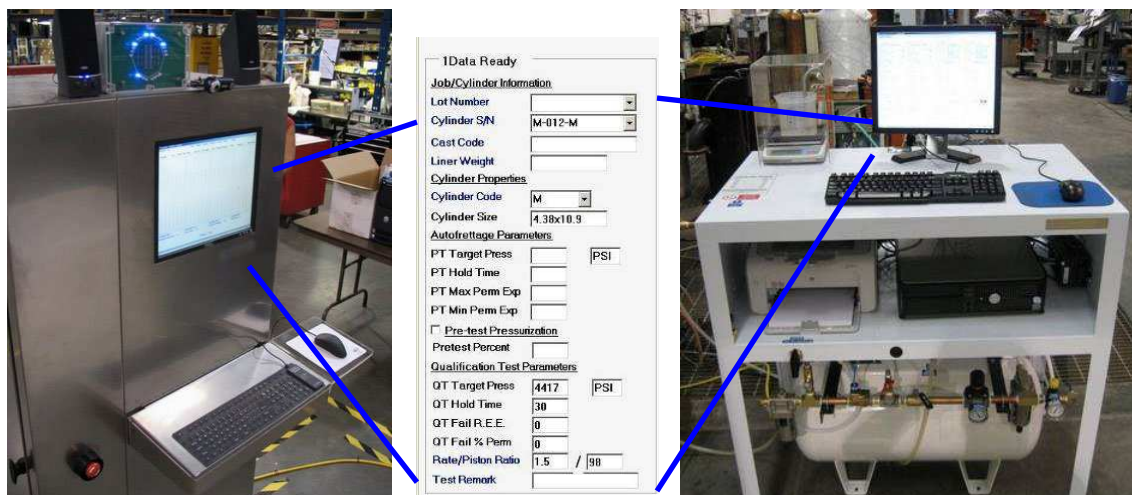


Figure 8—Typical microprocessor-based EID systems