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DEPARTMENT OF DEFENSE
STANDARD PRACTICE

INSPECTION AND MAINTENANCE OF COMPRESSED GAS CYLINDERS

AMSC N/A FSC 8120

FOREWORD

1. This standard practice is approved for use by all departments and agencies of the Department of Defense (DoD).

2. MIL-STD-1411, "Inspection and Maintenance of Compressed Gas Cylinders", presents definitions, general requirements, and detailed procedures for the inspection, maintenance, and recharging of government-owned cylinders for the procurement of compressed gases. The standard presents guidelines that recognize and define precise variations from plant to plant. It is a standard practice for the inspection and maintenance of compressed gas cylinders, which are defined in procurement specifications that may present confusing or unclear inspection and maintenance methods. It is intended to resolve problems encountered by compressed gas suppliers and government procurement and inspection activities in agreeing on acceptable procedures for servicing compressed gas containers.

3. MIL-STD-1411 addresses receiving and serviceability inspection and sets standards for acceptance and rejection of gas cylinders. It establishes procedures for internal and external maintenance. It classifies and details the recharging of cylinders and the purging and evacuating of air and residual gas from previous charging. Details are presented as guidelines for cylinder handling.

4. Instructions are given for condemnation and disposal of cylinders declared to be unfit for further use as pressure vessels.

5. The intent of this document is to provide government agencies and the compressed gas industry supporting the government with a standard practice for cylinder inspection and maintenance that is compatible with government requirements as well as industry practice.

6. This revision has resulted in many changes to standard format, but the most significant ones are:

a. Included references and maintenance instructions for ISO cylinders to accommodate the increasing use of ISO standards in industry and military use.

b. Reorganized sections on periodic testing (3.25, 5.1.1.8, and 5.3.1) to improve readability.

c. Updated CFR references throughout document.

d. Added references to AMedP-1; Titles 14, 46, and 49 of the CFR; DD forms 250 and 1191; DOT-SP 14313; DLAR (JP) 4145.25; DLM 4000.25-2; CGA C-6.1, C-6.2, C-6.3, C-7, C-8, C-13, and G-1.9; and AMS-STD-595. Removed references to DOD-P-15328 (replaced with TT-C-490). Updated titles and addresses of references.

e. Added definitions for filled or charged cylinders, high and low pressure cylinders, proof pressure testing, United Nations (UN) cylinders, and volumetric expansion testing.

f. Updated the temperature ranges for cryogenic fluids and liquefied gases (3.11 and 3.26).

g. Updated definition of LPGs and list of medical gases in accordance with DLAR 4145.25 (3.21 and 3.22).

h. Clarified "low pressure" rejection criteria for cylinders to be filled (5.2.1).

i. Specified hammer tests are only to be performed on steel cylinders per the guidance of CGA C-6 (5.2.6.1).

j. Moved the section "Solvent adjustment of acetylene cylinders" from 5.3.3 to 5.2.6.5.

k. Removed the table "k factor and maximum elastic expansion (EE)" (previously Table III) and replaced it with a reference to CGA C-5.

l. Added a section on cylinder markings (5.3.1.2) to assist in labeling and reading cylinders.

7. Comments, suggestions, or questions on this document should be addressed to DLA Aviation, VEB, 8000 Jefferson Davis Highway, Richmond, VA 23297-5616 or emailed to STDZNMGT@dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST database at https://assist.dla.mil/.

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l. SCOPE

1.1 Scope. This standard defines the requirements and procedures for the inspection, maintenance, and charging of government-owned cylinders by gas suppliers. This standard is intended to ensure that the cylinders are serviced to meet safety standards and to ensure that the quality of the gas supplied is not degraded by a government container. This standard is also applicable to cylinders that require reconditioning, repair, and rebuilding to ensure a level of renewal that meets the needs of the government and industry in gas handling. This standard is also to be a guide when cylinders are sorted, graded, and classified for storage, salvage, or disposal in depot facilities.

1.1.1 Procedures. Procedures are as follows:

a. Receiving inspection.

b. Serviceability inspection.

c. Cylinder and valve maintenance and repair.

d. Cylinder purging and recharging.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in Sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INTERNATIONAL STANDARDIZATION AGREEMENTS

AMedP-1.19 - Cross-Servicing of Medical Gas Cylinders

FEDERAL SPECIFICATION

TT-C-490 - Chemical Conversion Coatings and Pretreatments for Metallic Substrates (Base for Organic Coatings)

COMMERICAL ITEM DESCRIPTIONS

A-A-3165 - Lacquer, Gloss, for Aircraft Use

A-A-58092 - Tape, Antiseize, Polytetrafluorethylene
A-A-59860 - Valves, Cylinder, Gas (for Compressed or Liquefied Gases)

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-C-8514 - Coating Compound, Metal Pretreatment, Resin-Acid
MIL-DTL-17376/1 - Caps and Flanges, Compressed-Gas Cylinder: Caps
MIL-DTL-17376/3 - Caps and Flanges, Compressed-Gas Cylinder: Flanges, High Pressure
MIL-PRF-25567 - Leak Detection Compound, Oxygen Systems
MS26545 - Cylinders; Steel; Compressed Gas; Non-Shatterable; Seamless; 1800 PSI, and 2100 PSI

DEPARTMENT OF DEFENSE STANDARD

MIL-STD-101 - Color Code for Pipelines and for Compressed Gas Cylinders

(Copies of these documents are available online at https://quicksearch.dla.mil/)

2.2.2 Other government publications. The following other government publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

CODE OF FEDERAL REGULATIONS (CFR)

14 CFR - Aeronautics and Space
46 CFR - Shipping
49 CFR - Transportation

(Copies of these documents are available online at https://gov.ecfr.io/cgi-bin/ECFR)

DEPARTMENT OF DEFENSE FORMS

DD Form 250 - Material Inspection and Receiving Report
DD Form 1191 - Medical Oxygen Equipment, Warning Tag For Medical Equipment

(Copies of these documents are available online at https://www.esd.whs.mil/Directives/forms/)

DEPARTMENT OF TRANSPORTATION (DOT)

DOT-SP 14313 - Adoption of Special Permits, Pipeline & Hazardous Materials Safety Administration, Cylinders – NDT/Aerosols

(Copies of this document are available online at https://phmsa.dot.gov/)

JOINT SERVICE REGULATIONS

DLAR (JP) 4145.25 - Storage and Handling of Liquefied and Gaseous Compressed Gases and Their Full and Empty Cylinders

(Copies of this document are available online at https://issuances.dla.mil/)

DEFENSE LOGISTICS MANUAL

DLM 4000.25-2 - Military Standard Transaction Reporting and Accountability Procedures (MILSTRAP)

(Copies of this document are available online at https://www.dla.mil/HQ/InformationOperations/DLMS/eLibrary/Manuals/publications/dlm/dlm_pubs/)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA-STD-6001 - Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion

(Copies of this document are available online at https://standards.nasa.gov/)

2.3 Non-government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM D2029 - Standard Test Methods for Water Vapor Content of Electrical Insulating Gases by Measurement of Dew Point

ASTM D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces

(Copies of these documents are available from https://www.astm.org/)

COMPRESSED GAS ASSOCIATION, INC. (CGA)

CGA C-1 - Methods for Pressure Testing Compressed Gas Cylinders

CGA C-5 - Wall Stress Requalification Criteria for High Pressure Seamless Steel Cylinders

CGA C-6 - Standards for Visual Inspection of Steel Compressed Gas Cylinders

CGA C-6.1 - Standards for Visual Inspection of High Pressure Aluminum Alloy Compressed Gas Cylinders

CGA C-6.2 - Standards for Visual Inspection and Requalifications of Fiber Reinforced High Pressure Compressed Gas Cylinders

CGA C-6.3 - Standards for Visual Inspection of Low Pressure Aluminum Alloy Compressed Gas Cylinders

CGA C-7 - Guide to Classification and Labeling of Compressed Gases
CGA C-8 - Standard for Requalification of DOT-3HT, CTC-3HT, and TC-3HTM Seamless Steel Cylinders CGA C-13 - Guidelines for Periodic Visual Inspection and Requalification of Acetylene Cylinders
CGA C-20 - Requalification Standard for Metallic, DOT and TC 3-Series Gas Cylinders and Tubes Using Ultrasonic Examination
CGA G-1.9 - Recommended Practices for Maintaining the Proper Solvent Level in Acetylene Cylinders
CGA G-4.1 - Cleaning of Equipment for Oxygen Service
CGA S-1.1 - Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases
CGA TB-17 - Test Methods for Evaluating Paints and Coatings on Refillable Steel Compressed Gas Cylinders
CGA V-1 - Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections

(Copies of these documents are available from https://www.cganet.com/)

MASTER PAINTERS INSTITUTE (MPI)

MPI #9 - Alkyd, Exterior Gloss (MPI Gloss Level 6)

(Copies of this document are available from https://www.paintinfo.com/)

SAE INTERNATIONAL

AMS-STD-595 - Colors Used in Government Procurement

(Copies of this document are available from https://www.sae.org/)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Acetylene cylinders. DOT acetylene cylinders are fabricated in accordance with DOT 8 or DOT 8AL specifications. ISO acetylene cylinders are fabricated in accordance with ISO 9809-1, 9809-3, and 3807. Both are low-pressure cylinders limited in service pressure to 250 psig and equipped with pressure relief devices (PRDs) that will melt at 212 °F to relieve internal pressure in case of excessive heat or fire. Acetylene is a flammable gas that will detonate on impact. Because of this property, the compressed acetylene gas must be finely divided and cushioned if safe handling is to be achieved. An efficient way to meet this requirement is to dissolve acetylene gas in a liquid. Acetone is the solvent of choice. For increased safety and to guard against separation of a volume of acetylene, the steel cylinder is filled with a porous inert

material. An acetylene cylinder charged with acetone, under 250 psig pressure, will absorb up to 400 times the volume of the liquid acetone in acetylene gas.

3.2 Authorized repair and rebuild facilities. 49 CFR 100-180 limits repair and rebuild activities very specifically. Repair and rebuilding can only be performed by a manufacturer of these types of DOT cylinders or by a repair facility approved by the Associate Administrator for Hazardous Materials Safety, Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington, DC 20590-0001. (https://www.phmsa.dot.gov/hazmat/pressure-vessels-approvals/cylinder-requalifiers)

3.3 Borescope. A borescope is an inspection device that can be of great assistance in inspecting questionable cylinders. This optical device, which is similar to a periscope, can, by a camera or system of lenses, mirrors, and high intensity light, effectively place the eye inside the cylinder and even magnify the surface under inspection.

SAFETY PRECAUTION: Any light source that enters the cylinder must be one designed for use in an explosive environment.

3.4 Calibrated cylinder. A calibrated cylinder is a device used to ensure that measurements made by cylinder testing equipment are accurate to an established standard. A calibrated cylinder is an instrument of calibration and must be handled with care to guard against dents, over-pressurizing, and corrosion.

3.4.1 Calibrated cylinder for hydrostatic testing. The calibrated cylinder used in hydrostatic testing is a cylinder that has been pre-stressed until the expansion pattern becomes reproducible up to a given predetermined pressure. A cylinder with known expansion characteristics for given pressures is used as a standard to calibrate a hydrostatic test setup.

3.4.2 Calibrated cylinder for ultrasonic examination (UE). The calibrated cylinder used in UE is typically a section of an actual cylinder that is used as a means of providing ultrasonic reflections of known characteristics. This is accomplished by precisely machining specified defects into the selected cylinder that simulate areas of corrosion, isolated pits, line corrosion, and cracks. Cylinders with these simulated defects are used for the calibration of the UE system.

3.5 Color code. The government has developed its own system of color-coding for its ground based piping systems and compressed gas cylinders under MIL-STD-101. Adherence to MIL-STD-101 does not exempt the compressed gas cylinder from required marking and stamping requirements in accordance with DOT regulations. These color identification codes are mandatory along with the name of the gas, as applicable, stenciled longitudinally and opposite on the exterior surfaces of a government-owned cylinder. When vendor-owned cylinders are used, markings may be in accordance with Compressed Gas Association (CGA) C-7 or MIL-STD-101. Regulations for the color coding of all medical gas cylinders can be found in NATO AMedP-1.19.

3.6 Composite and fiberglass containers. Composite containers are generally cylindrical in design with enough metal in the sidewalls and heads to withstand the longitudinal stress of internal pressure ratings. The hoop stress of the cylinder is shared with fiberglass wrappings closely adhering to the exterior walls. High strength-to-density ratios are achieved by adding

multiple layers of fiberglass filament at controlled tension and bonded into a composite unit with epoxy resin. The whole structure must be protected against moisture penetration to ensure a stable design and extended life. The composite must undergo hydrostatic testing intact because removal of the fiberglass reinforcement would destroy the strength designed into the vessel. Fiberglass containers are also manufactured with gas-tight liners in which the liners are not depended upon to ensure the integrity of the pressure vessel.

3.7 Compressed Gas Association (CGA). The CGA is an industry association that is actively involved in preparing safety standards for the handling and shipping of compressed gases.

3.8 Compressed gas cylinder. A gas cylinder or tank is a pressure vessel for storage and containment of gases above atmospheric pressure. Inside the cylinder the stored contents may be in a state of a compressed gas, vapor over liquid, supercritical fluid, or dissolved in a substrate material, depending on the physical characteristics of the contents. Compressed gas cylinders are closely regulated by specification for construction and test in accordance with 49 CFR 100-180.

3.9 Compressed gases. Compressed gases are elements, compounds, or mixtures of the two that are contained in the gaseous state at elevated pressure. The exact pressure threshold to be considered a compressed gas is dependent on both temperature and the type of gas and is as laid out in 49 CFR 173.115.

3.10 Condemned cylinders. Condemned cylinders include cylinders that are degraded by damage, corrosion, exposure to fire, cylinders specifically listed by government or industry standards as not in accordance with current DOT regulations, or cylinders that have failed hydrostatic testing or UE. Condemned cylinders also include the rejected cylinder that cannot be maintained or repaired and returned to useful service. Condemned government owned cylinders will be disposed of in accordance with the DLAR 4145.25 section entitled “Disposal of Compressed Gas Cylinders”. Non-Government owned gas cylinders will be returned to their rightful owners.

3.11 Cryogenic fluids. Cryogenic fluids are defined as permanent compressed gases that have been cooled below their boiling point (below -130 °F) and liquefied. Evaporation of the integral fluid and insulated containers maintain the stability of cryogenic fluids in storage. Examples are liquid oxygen, nitrogen, and argon.

3.12 Cylinder service pressure and proof pressure. The service pressure of DOT cylinders is permanently marked on the cylinder immediately following the DOT specification (e.g., DOT 3AA 2015 or DOT 4BA 240). The service pressure is the maximum pressure for a given cylinder in normal gas service. The proof pressure is the pressure at which a cylinder is hydrostatically tested. The proof pressure is usually 5/3 of the service pressure however. Exceptions to this, such as that low-pressure cylinders may be proof tested at two times the service pressure in accordance with the modified hydrostatic test method, are listed in 49 CFR 178.814. At manufacture, each cylinder is tested at its proof pressure. The working pressure of cylinders charged with permanent gases will drop as the contents are released. Cylinders charged with liquefied gas will hold a constant working pressure related to the temperature and the vapor pressure for the specific liquefied gas as long as liquid remains in the cylinder.

3.13 Cylinders subjected to fire. Government cylinders subjected to fire may not be returned to service, however, commercial cylinders neither over 0.25 percent carbon nor over 0.90 percent manganese may if they pass hydrostatic retest. They do not need to be reheat-treated. Acetylene cylinders neither over 0.25 percent carbon nor over 0.90 percent manganese are to be inspected for damage to the porous filler if subjected to fire. If no damage is found in the shell and the porous filler is undamaged, the cylinder may be returned to service without reheat treatment or hydrostatic test. All other cylinders are reheat-treated, reconditioned, and tested in accordance with 49 CFR 180 before returning to gas service.

3.14 Department of Transportation (DOT). DOT is the federal agency responsible for the requirements of shipping hazardous materials, including compressed and liquefied gases. In this capacity, DOT maintains Title 49 of the Code of Federal Regulations (CFR), which covers most of the detailed shipping requirements for compressed gases. Additional regulations for air and sea shipments are included in Titles 14 and 46, respectively. Government cylinders are considered subject to the CFR by this standard, however, the CFR provides special allowance for emergency military shipments. Special privilege in no way relieves the military of certifying the safety of these shipments. The responsibility for 49 CFR, formerly maintained by the Interstate Commerce Commission (ICC), has been transferred to the Pipeline and Hazardous Materials Safety Administration, which is part of the Department of Transportation. Therefore, all ICC prefixes for cylinder specifications remain acceptable and all new cylinders will be marked with DOT prefixes (see 5.1.1.2). Prefix, specification, and service pressure (e.g., ICC 3AA 2015 or DOT 3AA 2015) will be marked in accordance with the current issue of 49 CFR 178, as applicable.

3.15 Disposable cylinders. Disposable cylinders are fabricated for a specific gas distribution. They are fabricated and used in accordance with the DOT 39 specification. Disposable cylinders are low-pressure containers and are tested at the vapor pressure of the gas of intended use at 130 °F or at 180 psig, whichever is greater. Cylinders of each lot are pressure tested to destruction, which cannot occur at less than two times the test pressure in any application. Disposable cylinders are fabricated for one-trip use from the commodity supplier to utilization by the user.

3.16 Dissolved gas. A dissolved gas is defined as a compressed gas that is absorbed or dissolved in a liquefied medium. Acetylene gas dissolved in acetone is a system that will dissolve as much as 400 volumes of acetylene gas in one volume of acetone liquid under 250 psig of gas pressure at 70 °F.

3.17 Filled or charged cylinder. A cylinder is filled (or charged) when gas is present or introduced in the vessel.

3.18 Filling density. The term "filling density" designates the percent ratio of the weight of gas in a container to the weight of water (water capacity) the container will hold at 60 °F. Maximum percent filling densities for specific liquefied gases can be found in 49 CFR 173.304(a). To determine the actual filling density (amount of gas that will safely fill a specific cylinder), the water capacity of the cylinder is multiplied by the decimal equivalent of the percent filling density for the gas of intended use. This filling density will protect a cylinder against the excessive pressures of thermal expansion up to 130 °F, either from the increased pressure from the gaseous state or from the fluid expansion of the liquid state, as applicable.

For example, the critical temperature for carbon dioxide with a filling density of 68 percent is 87.8 °F. Below 87.8 °F carbon dioxide will liquefy, but above 87.8 °F a liquid state cannot exist regardless of pressure. The filling density has been carefully selected for each liquefied gas to take into account potential safety hazards.

3.19 High and low pressure cylinders. High pressure cylinders herein refers to cylinders with marked service pressures of 900 psi (6210 kPa) or greater. Low pressure cylinders refers to cylinders with marked service pressures of less than 900 psi (6210 kPa).

3.20 Hydrostatic testing. Hydrostatic pressure tests must be performed periodically on most cylinders to determine fitness for continued use. During hydrostatic testing, a cylinder is stressed with water pressure to a value determined by the cylinder specification, the marked service pressure, and testing method. The fitness of the cylinder is then assessed by measuring the elastic expansion (volumetric expansion testing see 3.34) or by examining it for bulges, leaks, or other defects (proof pressure testing see 3.29). Hydrostatic pressure test procedures are defined under 49 CFR 180.203 and the frequency of testing in 49 CFR 180.209. 49 CFR 107.805 requires that each hydrostatic test facility be registered with the DOT and receive a Requalifier Identification Number (RIN) before the facility may requalify cylinders.

3.21 Liquefied petroleum gas (LPG). The liquefied petroleum gases are butane, isobutane, propane, propylene (propene), butylenes (butenes) and any mixtures of these hydrocarbons as defined by the National Fire Protection Association (NFPA), DOT, or other authority. They are flammable, colorless, and noncorrosive. Most are odorless, so an odorant such as ethyl mercaptan is added to warn of the presence of the gas. (Propylene and butylenes have a foul odor.) High concentrations of LPG in air may cause central nervous system depression with symptoms including light-headedness, drowsiness, unconsciousness, and possibly death.

3.22 Medical gases. Gases used by the government medical services for medical purposes include United States Pharmacopeia grade carbon dioxide, carbon dioxide and oxygen mixtures, ethylene oxide and nonflammable gas mixtures, helium and oxygen mixtures, methoxyflurane, nitrogen, nitrogen and oxygen mixtures, nitrous oxide, and oxygen. Whenever appropriate in this standard, the term "medical gas" should alert the contractor to certain necessary precautions, particularly concerning materials employed for oxygen service.

3.23 Nonshatterability identification. Nonshatterability is the property of the metal in a cylinder that causes it to remain in one piece rather than to fragment when a cylinder bursts from excessive pressure or when pierced by a high velocity projectile. The term as used herein refers only to specification 3A and 3AA high pressure cylinders made of high grade steel. This designation is not considered applicable to specification 4 or 8 cylinders. This type of cylinder is required in all aircraft and shipboard applications where fragmentation must be controlled to minimize loss of life and damage to vital systems. Specific cylinders to be stamped as nonshatterable are listed in 5.1.1.5.

3.24 Office of Hazardous Materials Safety. Important assignments for the compressed gas industry are the approval of cylinder repair, rebuild, remanufacture, and testing facilities, the approval of hydrostatic test and UE facilities for cylinder testing, the approval of pressure relief device (PRD) designs for pressure vessels, and the control of cylinder identification markings.

These responsibilities are assigned to the Associate Administrator for Hazardous Materials Safety, Office of Hazardous Materials Safety, Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation under 49 CFR 100-180 (see 3.2).

3.25 Periodic test status. Cylinders must be periodically tested by hydrostatic test procedures, UE, external visual examination or other approved methods as authorized in 49 CFR 180 or by the Associate Administrator for Hazardous Materials Safety of the Office of Hazardous Materials Safety. These tests are to be conducted according to 49 CFR 180 and as specified in this document.

3.26 Permanent and liquefied gases. A permanent gas is defined as a compressed gas that will not liquefy between 25 psig and 2500 psig at 70 °F. These gases have boiling points below -150 °F. Examples are oxygen, nitrogen, and hydrogen. A liquefied gas is a gas which when packaged under pressure for transportation is partially liquid at temperatures above −50 °C (−58 °F). Further subcategories of liquefied gases can be found in 49 CRF 173.115. Examples are chlorine, propane, and fluorocarbon refrigerants.

3.27 Pressure relief device (PRD). The PRD is a pressure sensitive or a temperature sensitive mechanism that will protect the container against rupture by controlled release of the compressed gas. Release may be due to pressure rupture of a rupture disk or by pressure activating a spring-loaded relief valve. Release in the case of a fusible metal plug will be due to heat in the immediate environment greater than the melting point of the base metal (165 °F or 212 °F). A combination device made up of a disk backed with fusible metal is designed to be used where container contents will not be released unless the necessary heat to activate the fusible metal and pressure in the burst range of the disk exist at the same time. This provides better control over inadvertent loss of contents. A combination PRD is never used on containers approved for charging 10 percent above marked service pressure (see 5.3.1.1). Approved PRDs and applications are detailed in the CGA S-1.1. A-A-59860 outlines PRDs in government applications as identified in Table I.

TABLE I. PRD designations.

PRD #	CGA S-1.1	Type and description
0	-	None required
1	CG-1	Rupture disk PRD-Service (cylinder) pressure of 1800 psig (12400 kPa)
2	CG-1	Rupture disk PRD-Service (cylinder) pressure of 2015 psig (13890 kPa)
3	CG-1	Rupture disk PRD-Service (cylinder) pressure of 2265 psig (15620 kPa)
4	CG-1	Rupture disk PRD-Service (cylinder) pressure of 2400 psig (16550 kPa)
5	CG-1	Rupture disk PRD-Service (cylinder) pressure of 3000 psig (20680 kPa)
6	CG-1	Rupture disk PRD-Service (cylinder) pressure of 3500 psig (24130 kPa)
7	CG-1	Rupture disk PRD-Service (cylinder) pressure of 4000 psig (27580 kPa)
8	CG-1	Rupture disk PRD-Service (cylinder) pressure of 4500 psig (31000 kPa)
9	CG-1	Rupture disk PRD-Service (cylinder) pressure of 6000 psig (41350 kPa)
10	-	Prohibited[1]
11	CG-2	Fusible plug PRD for service (cylinder) pressures through 500 psig (3450 kPa), 165 °F (74 °C) nominal
12	CG-3	Fusible plug PRD for service (cylinder) pressures through 500 psig (3450 kPa), 212 °F (100 °C) nominal

13	CG-4	Combination rupture disk and fusible plug PRD for service (cylinder) pressures of 1800 psig (12400 kPa) through 2265 psig (15616 kPa), 165 °F (74 °C)
14	CG-5	Combination rupture disk and fusible plug PRD for service (cylinder) pressures of 1800 psig (12400 kPa) through 2265 psig (15616 kPa), 212 °F (100 °C)
15	CG-7	Spring loaded, reseating PRD[2]--Service (cylinder) pressure 225 psig (1550 kPa)
16	CG-7	Spring loaded, reseating PRD--Service (cylinder) pressure 240 psig (1653 kPa)
17	CG-7	Spring loaded, reseating PRD--Service (cylinder) pressure 260 psig (1790 kPa)
18	CG-7	Spring loaded, reseating PRD--Service (cylinder) pressure 300 psig (2066 kPa)
19	CG-7	Spring loaded, reseating PRD--Service (cylinder) pressure 400 psig (2755 kPa)

[1] The use of PRDs is prohibited in certain gas service applications by 49 CFR 173.301.
[2] A spring loaded, reseating PRD (CG-7) is also known as a pressure relief valve (PRV).

3.28 Product item description (PID). When a government agency procures a commodity, it must first be identified by a PID and be included as an approved Federal Item Identification arranged in narrative or tabular form determined appropriate. The PID includes specification and other reference numbers, when applicable. Unless specification numbers are qualified by a suffix or note, the item complies with the latest revision or amendment.

3.29 Proof pressure testing. Proof pressure testing, also called modified hydrostatic testing, is performed at two times the service pressure and involves no expansion measurements, only an examination for leaks or other harmful defects. Additional details for proof pressure testing procedures are presented in CGA C-1.

3.30 Spun cylinders. Spun cylinders are fabricated from seamless tube stock of a diameter and wall thickness of the specified cylinder. A predetermined length is placed in a lathe and spun, and both ends are closed by heating and shaping. In shaping, the side wall is flowed inward until all the slag and edge stock are brought to the center of the cylinder top and bottom. The top shoulder is shaped and handled much like a drawn cylinder. It is drilled and tapped for proper valve inlet threads. The bottom is bumped back for standing stability and the center is broached free of slag and oxides. In a controlled atmosphere, the metal is again flowed inward and closure is completed by inert welding. If a failure in closure occurs, the bottom, which is heavier than the side walls due to inward flow of steel, will be drilled, tapped, and plugged to effect an acceptable closure in accordance with 49 CFR 178.36 (n). Spun cylinders are in general use in the government system in DOT 3A and DOT 3AA applications.

3.31 Tare weight (TW). The tare weight of a compressed gas cylinder is the weight of the empty cylinder with its valve, paint, and other permanent attachments, but does not include the valve protection cap. Tare weight is used to determine the quantity of gas commodity required to charge a cylinder by weight. For liquefied gases, tare weight is generally marked in pounds and tenths of pounds, following the letters "TW". The tare weight of cylinders in acetylene service is required to be permanently marked on the cylinder, flange, or cylinder collar. The tare weight of cylinders in acetylene service includes the cylinder shell, porous mass, fusible metal pressure relief devices, solvent, saturation gas, and valve. Tare weight markings on acetylene cylinders are generally indicated by a whole number for pounds and a whole number in 4-ounce increments. Acetylene cylinders 10 cubic feet or less are marked with a whole number for pounds and the exact whole number for ounces.

3.32 Ultrasonic examination (UE). UE tests are usually performed every five years on cylinders for which it is an acceptable requalification method in order to determine fitness for future use. Cylinders that undergo UE testing must follow the same periodic retesting schedule in accordance with 49 CFR 180.29 as cylinders of the same type and gas service undergoing hydrostatic testing. The test facility must also have a RIN in accordance with 49 CFR 107.805 and receive a special permit for UE testing. During the UE test, the entire side wall of a cylinder is scanned using ultrasonic transducers at various angles to measure the wall thickness and detect defects described as area corrosion, pits, line corrosion or cracks. During the scan, the wall thickness and any defects are recorded. A proper UE test can form the basis for acceptance or condemnation of a cylinder. An acceptable cylinder will have a wall thickness equal to or greater than the minimum wall thickness as defined by the manufacturer, and no critical defects as they are defined by the criteria of the authoritative agency. General UE test methods are described in CGA C-20. More specific details for UE test procedures can be found in DOT-SP 14313.

3.33 United Nations (UN) cylinders. Transportable pressure receptacles with a water capacity not exceeding 150 L that have been marked and certified as conforming to relevant ISO standards and in accordance with 49 CFR 178.69-71. For transportation in the United States these cylinders must be marked with either “USA” or “CAN” showing they have been approved by the United States as being in accordance with Title 49 of the CFR or by Canada as being in conformance with Transport Canada TDG Regulations unless otherwise allowed for in 49 CFR 171.23.

3.34 Volumetric expansion testing. In volumetric expansion testing, the total expansion of the cylinder and the value of permanent expansion after the pressure is released are recorded. The permanent expansion is subtracted from the total expansion to calculate the elastic expansion. An acceptable cylinder will have a permanent expansion less than ten percent of its total expansion (except DOT 4E aluminum cylinders which may have up to twelve percent expansion). The amount of volumetric expansion can be measured using two different methods: direct expansion and water jacket. The water jacket method consists of enclosing a cylinder filled with water in a chamber filled with water. The water in the cylinder is then compressed and the amount of water displaced from the chamber while under pressure and after the pressure has been released are measured. The direct expansion method only requires filling the cylinder with water and consists of measuring the amount of water forced into a cylinder at test pressure, adjusted for the compressibility of water, as a means of determining the expansion. Further details on these methods and their differences can be found in CGA C-1. A proper volumetric expansion test is the basis for a valid estimate of the average wall thickness of the cylinder, and therefore a measure of the erosion of the walls in corrosion processes.

3.35 Water capacity. Water capacity defines the internal volume of a cylinder. Water capacity is an optional marking on government-owned cylinders. High-pressure cylinders for permanent gases (3A and 3AA) are generally made to a standard displacement in cubic inches and at given conditions will contain a specific volume of gas. Charging is limited by the service pressure permanently marked on the cylinder. To determine the contents of a cylinder of standard nominal capacity, determine the pressure and temperature of the gas and find the corresponding capacity in cubic feet at standard conditions from an approved pressure/temperature/capacity chart. A standard 9-inch x 51-inch cylinder with a water capacity of 2640 cubic inches will contain 200 cubic feet of oxygen compressed to 2015 psig at 70 °F. Water capacity for low pressure liquefied gases (DOT 4BA, DOT 4BW, and DOT 4E cylinders)

is the weight of water at 60 °F required to completely fill the cylinder. This weight is used to calculate the filling density for a specific gas from limits specified in 49 CFR 173.304a.

3.36 Welded and brazed cylinders. Welded and brazed cylinders are fabricated in accordance with DOT 3, 4, and 8 specifications. These cylinders are intended for use in low pressure applications in service pressures up to a maximum of 500 psig. Specifications DOT 4BA, 4BW, 4E, and 4B cylinders fall in this grouping. A longitudinal seam may or may not be allowed depending on the specification. In the latter case, two shells are drawn into cups and a single circumferential welded or brazed seam closes their joining edges. Maintenance of DOT series 4 cylinders by welding is permitted throughout their useful life by repair and rebuild shops that have been certified and issued a RIN by the Associate Administrator for Hazardous Materials Safety, Office of Hazardous Materials, Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation as defined in 49 CFR 107.805.

3.37 Wire wrapped cylinders. Wire wrapped cylinders use up to three layers of steel wire over its outside surface to provide nonshatterability in high pressure application. The wire wrapping must be removed for the cylinder to undergo hydrostatic testing.

4. GENERAL REQUIREMENTS

4.1 Standard procedures. The general requirements for handling government-owned cylinders cover the procedures for inspection, maintenance, and recharging required to ensure that the container used with a gas commodity will maintain the purity set forth in the applicable commodity specification and that the compressed gas can be safely handled by personnel. Procedures for cylinder handling are listed in Table II and shall be in accordance with 49 CFR 100-180. When an established procedure, such as the CGA C-1 and C-6 is applicable, it shall be followed. A compressed gas or cylinder service contract will include a PID with the applicable gas specification. In addition, the level of cylinder reconditioning required will be specified. Unless otherwise specified in the contract or work order, maintenance will include valve maintenance, internal cylinder maintenance, periodic requalification, external cylinder maintenance as required, and cylinder evacuation to a minimum of 3 inches of mercury (1.5 PSIA) as detailed in 5.3. When specified, a contractor shall be qualified to perform or supply authorized repair and rebuild functions (see 3.2) in order to qualify as an acceptable contractor of gas commodity or cylinder service, as applicable by this standard.

4.1.1 Receiving inspection. Government-owned cylinders shall be inspected to ensure conformance to the PID provided in the shipping document. Cylinders received by a contractor for reconditioning, recharging with a specific gas, or received by a government agency for grading and storage shall be inspected for legible and accurate identifications, markings, dimensions, color-coding, and stenciling. Inspection shall ensure the presence of a valve protection cap, as applicable, the proper cylinder, valve, and valve outlet, and that the cylinder appropriate for the gas service as specified.

4.1.1.1 Rejection and condemnation. At receiving inspection, all cylinders shall be accepted for serviceability inspection and cylinder maintenance as required, except as follows:

a. Cylinders with dimensions or capacities not as specified in the item description shall be rejected and returned to the government.

b. Cylinders with other than government ownership markings shall be rejected and returned to the government for disposition.

c. Any cylinder that cannot be upgraded within a supplier's authorized capability for maintenance, repairing, or rebuilding shall be rejected and returned to the government.

d. Cylinders damaged and unworthy of repair or rebuild procedures shall be rejected and metal stamped "condemned" and returned to the government.

NOTE: All condemned cylinders, as defined above, shall be metal stamped "condemned" with a justification and returned to the government for disposition as described in 3.10.

e. Occasionally a cylinder will be unidentifiable and filled with gas. Caution must be used as the gas may be flammable or toxic to personnel. These cylinders shall be rejected or condemned and returned to the government for disposal.

4.1.2 Serviceability inspection. Each cylinder accepted at receiving inspection shall be inspected for serviceability in reference to the PID, the applicable DOT or ISO regulations, the assigned gas service, and as specified herein (see Table II). Accepted cylinders shall be forwarded for charging. Records of scheduled maintenance shall be made on DD Form 250. For detailed serviceability requirements, see 5.2.

4.1.2.1 Rejection and condemnation. Cylinders not meeting service inspection shall be scheduled for proper maintenance in accordance with 5.3. Cylinders shall meet serviceability standards before being forwarded for recharging. Cylinders that cannot be repaired or upgraded by maintenance shall be rejected, tagged, and returned to the government. Any cylinder found to require condemnation by standards presented in 5.2.7 shall be metal stamped "condemned" with justification and shall be returned to the government for disposal as described in 3.10.

TABLE II. Inspection and maintenance procedure.

Cylinder gas service	Detailed requirements	Acetylene	Fuel gas mix	Air - human respiration	Air - industrial	Argon - inert	Butane - propane	Carbon dioxide	Carbon monoxide	Chlorine	Fluorocarbons	Helium - inert	Hydrogen	Inert nitrogen O.F.	Inert nitrogen O.T.	Oxygen - ABO	Oxygen - technical	Oxygen - medical	Methyl bromide	Sulfur hexafluoride	Ammonia anhydrous	Detailed requirements
Detailed requirements	5.																					5.
Receiving inspection complete except as listed	5.1	5 1.1.5 5 1.1.7 5 1.6	5.1.1.5	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.5	5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.5	5.1.1.5	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.6 5.1.1.7	5.1.1.5	5.1.1.7	5.1.1.5	5.1
Serviceability inspection	5.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2
Residual gas and moisture control	5.2.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.1
External inspection	5.2.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.2
Paint inspection	5.2.2.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.2.1
Valve protection cap inspection	5.2.2.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.2.2
Valves and PRDs	5.2.3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.3
PRDs	5.2.3.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.3.1
Inspection of flanges	5.2.4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.4
Inspection of footrings	5.2.5	X	X				X			X	X								X		X	5.2.5
General internal cylinder evaluation	5.2.6		X	X	X	X		X	X	X		X	X	X	X	X	X	X		X		5.2.6
Hammer test	5.2.6.1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.6.1
Odor test	5.2.6.2			X	X	X						X		X	X	X	X	X				5.2.6.2
Sulfur hexafluoride cylinder internal inspection	5.2.6.3																			X		5.2.6.3
Chlorine cylinder internal insp.	5.2.6.4									X												5.2.6.4
Solvent adjustment of acetylene cylinders	5.2.6.5	X																				5.2.6.5
Rejection and condemnation	5.2.7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.7
Recording required services	5.2.8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.2.8
Cylinder maintenance[2]	5.3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3
Periodic testing	5.3.1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.1
Cylinder Markings	5.3.1.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.1.2

TABLE II. Inspection and maintenance procedure - Continued.

Cylinder gas service	Detailed requirements	Acetylene	Fuel gas mix	Air - human respiration	Air - industrial	Argon - inert	Butane - propane	Carbon dioxide	Carbon monoxide	Chlorine	Fluorocarbons	Helium - inert	Hydrogen	Inert nitrogen O.F.	Inert nitrogen O.T.	Oxygen - ABO	Oxygen - technical	Oxygen - medical	Methyl bromide	Sulfur hexafluoride	Ammonia anhydrous	Detailed requirements
General cylinder maintenance	5.3.2			X	X	X		X	X			X	X	X	X	X	X	X				5.3.2
Neck threads cleaning	5.3.2.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.2.1
Droplight or borescope testing	5.3.2.2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.2.2
Cylinder structural maintenance	5.3.2.3		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.2.3
Internal cylinder surface cleaning	5.3.2.4		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.2.4
Internal cylinder drying	5.3.2.5		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.2.5
Valves and PRDs	5.3.2.6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.2.6
Chlorine cylinder maintenance	5.3.3									X												5.3.3
Special handling	5.3.4									X	X			X		X				X		5.3.4
External cylinder surface maint.	5.3.5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.5
Cylinder valve protection caps	5.3.5.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.5.1
Paint, decal, and rust removal	5.3.5.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.5.2
Metal surface pretreatment	5.3.5.3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.5.3
Prime coating	5.3.5.4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.5.4
Finish coating	5.3.5.5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.5.5
Touch-up painting	5.3.5.6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.3.5.6
Cylinder charging	5.4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.4
Permanent gases	5.4.1			X	X	X			X			X	X	X	X	X	X	X				5.4.1
Liquefied gases	5.4.2		X				X	X		X	X								X	X	X	5.4.2
Ammonia gas	5.4.2.1																				X	5.4.2.1
Chlorine gas	5.4.2.2									X												5.4.2.2
Fluorocarbon refrigerants	5.4.2.3										X											5.4.2.3
Liquefied petroleum gases	5.4.2.4						X															5.4.2.4
Fuel gas mixtures	5.4.2.5		X																			5.4.2.5
Carbon dioxide gas	5.4.2.6							X														5.4.2.6

TABLE II. Inspection and maintenance procedure - Continued.

Cylinder gas service	Detailed requirements	Acetylene	Fuel gas mix	Air - human respiration	Air - industrial	Argon - inert	Butane - propane	Carbon dioxide	Carbon monoxide	Chlorine	Fluorocarbons	Helium - inert	Hydrogen	Inert nitrogen O.F.	Inert nitrogen O.T.	Oxygen - ABO	Oxygen - technical	Oxygen - medical	Methyl bromide	Sulfur hexafluoride	Ammonia anhydrous	Detailed requirements
Sulfur hexafluoride gas	5.4.2.7																			X		5.4.2.7
Acetylene gases	5.4.3	X																				5.4.3
Leakage test	5.4.4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5.4.4
Leak testing for ABO cylinders	5.4.4.1															X						5.4.4.1

NOTES:
[1] Cylinders manufactured in accordance with MS26545, due to physical characteristics, are not well suited for industry standard UE techniques. Therefore, when applicable, these cylinders should be requalified using hydrostatic testing.
[2] Maintenance requirements for a specific cylinder shall be established during receiving or serviceability inspection or in the contract.

4.1.3 Maintenance. Cylinders that have been scheduled for maintenance procedures shall be serviced in accordance with this standard. Heat treatment, repair, and rebuilding of cylinders shall only be performed by authorized repair and rebuild entity as stated in 3.2. After maintenance, each cylinder shall pass the applicable detailed serviceability requirements of 5.2 before returning to compressed gas service. For detailed maintenance requirements, see 5.3.

4.1.3.1 Rejected and condemned cylinders. See 4.1.2.1.

4.1.4 Cylinder charging. Each cylinder shall be evacuated before charging except for acetylene, LPGs, and other fuel gas mixtures. For these services, the weight of residual gas is retained and becomes a part of the functional base weight for determining the weight of gas required for charging. Charging shall follow immediately after evacuating or purging without opening the manifold to atmospheric air to minimize contamination of the specified gas commodity. Cylinder charging shall be handled in accordance with 5.4.

4.1.4.1 Rejection and condemnation. Any cylinder that leaks at the inlet threads or through a damaged valve body shall have its gas pressure exhausted and be returned to maintenance for necessary repair. Any valve leak that can be sealed by normal tightening of the stem seal or packing gland shall be acceptable for charging. Any cylinder, except for chlorine service (see 5.3.3), with oversized neck threads causing leakage with a standard valve shall be rejected and condemned. Cylinders that display any instability of structure such as bulging or leakage in any way shall be exhausted, rejected, metal stamped "condemned", and returned to the government for disposal (see 3.10).

4.2 Special procedures. When a gas commodity contract is written to include the servicing of government cylinders on a cost per unit of volume or unit of weight base, the only additional expense allowed shall be the cost of returning government property to the procuring agency. This procedure has been established in servicing fluorocarbon contracts. The government cylinder shall be inspected and serviced in accordance with the requirements of 49 CFR 100-180 and the CGA pamphlets referenced herein. The contractor shall exercise the same procedures and practices used in maintaining contractor owned cylinders.

5. DETAILED REQUIREMENTS

5.1 Receiving inspection. The supplier shall inspect the government-owned cylinders received for charging or reconditioning in accordance with the PID. The number of acceptable cylinders shall be recorded to identify a specific contract. Cylinders not acceptable shall be returned to the government agency. The receiving inspection is intended to limit the handling of cylinders that are not reclaimable for use in a contractor work order. Procedural outlines for receiving inspection may be incorporated in a comprehensive serviceability inspection at the discretion of the contractor.

5.1.1 Cylinder identification permanent markings. Each cylinder shall have its permanent markings inspected for proper identification, legibility, and accuracy. Permanent markings shall be embossed, stamped, or etched into the shoulder of DOT 3A or DOT 3AA cylinders and into a place of high visibility on low-pressure DOT 4 and DOT 8 cylinders. Cylinders with improper

markings, illegible markings, or inaccurate markings shall be scheduled for maintenance as applicable, or shall be rejected and returned to the government agency.

5.1.1.1 Serial number. The serial number on the cylinder shall be inspected for legibility as the identification number for the specific cylinder. The serial number is placed on the cylinder at the time of manufacture and is registered with the Associate Administrator for Hazardous Materials Safety of the Office of Hazardous Materials Safety. Duplicates are never issued and numbers shall display no sign of tampering or change.

5.1.1.2 Specification and service pressure. The cylinder's DOT or ISO specification and service pressure markings shall be inspected to ensure that the cylinder is compatible with the requirements of the PID or contract. The cylinder shall be in accordance with 49 CFR 100-180 for intended use. The service pressure is related to the sidewall thickness and the level of proof testing at fabrication, and is used as an index for hydrostatic testing throughout the cylinder life. Nonconforming cylinders shall be returned to the government agency for disposition.

5.1.1.3 Identification symbol. The cylinder shall be inspected for its identification symbol, which identifies the manufacturer, the actual owner, or the user of the cylinder, as applicable. The responsible party is registered with the Associate Administrator for Hazardous Materials Safety of the Office of Hazardous Materials Safety and is a source of technical information regarding the date, material, and process of manufacture for the cylinder. This information is necessary for rebuilding and maintenance of the cylinder throughout its useful life.

5.1.1.4 Government ownership. The cylinder shall be inspected for markings denoting government ownership. Markings identifying government ownership are as follows: U.S. Government, U.S. Property, WD, AF DA, USA, USN, N, US, or the name of a DoD or other government agency impressed into the shoulder of the cylinder or embossed on the neck ring. A military or federal specification number impressed into the shoulder of the cylinder will also establish government ownership. Cylinders not identified as U.S. Government property shall be returned to their point of origin for proper disposition.

5.1.1.5 Nonshatterability (NONSHAT). When nonshatterability is specified, each cylinder shall be inspected for identification markings or fabrication assuring the nonshatterable properties of the steel used to make the vessel. Nonshatterable properties shall be ensured when the following markings are established:

a. Permanent marking: NONSHAT, SHATTERPROOF, or NONSHATTERABLE.

b. Any cylinder fabricated to DOT specification 3A with the following permanent specification markings on the shoulder: SPS 843 (INT), SPS 1022 INT, 51-C-26 (INT), 51-C-41 (INT), 51-C-26, or 51-C-27. In addition, cylinders dated after June 1944 and stamped 51-C-31 or 51-C-31 (INT).

c. Any cylinder fabricated to DOT specification 3AA from ASA 4130X steel shall be considered nonshatterable.

NOTE: Cylinders that are found to be nonshatterable by these guidelines, but not permanently marked as in (a) above, shall be scheduled for marking "NONSHAT" by stamping or etching with a template. Letters shall be not less than 3/8 inch high and deep enough to be legible through the finish coat of paint. Changes in NSNs or Condition Codes that result from reidentifying cylinders from shatterable to non-shatterable will be reported to DLA Aviation in accordance with DLM 4000.25-2, Military Standard Transaction Reporting and Accounting Procedures (MILSTRAP).

5.1.1.6 Tare weight. Each cylinder used in liquefied gas service shall be weighed before each charging. Cylinders without permanently marked tare weights shall be scheduled for weighing and marking at maintenance.

5.1.1.7 Water capacity. Water capacity is an optional marking on government-owned cylinders (see 3.35).

5.1.1.8 Cylinder requalification period. Government-owned cylinders shall be inspected for valid or expired periodic test dates (Table III). Cylinders with expired inspection dates shall be grouped and tested in accordance with 5.3.1. Cylinders filled before the requalification becomes due may remain in service until emptied. The requalification period for most cylinders is by default, 5 years. Under specific circumstances outlined in 49 CFR 180.209, some cylinders may be requalified on a ten year basis. These cylinders shall be marked with a five point star to indicate this. When specified in the contract, other government-owned cylinders may also be approved for ten-year test periods in accordance with 49 CFR 180.209. This privilege should only be used when the history of a cylinder is known, or by special testing. Historic information is not generally available for government-owned cylinders. Special applications may also justify ten-year retesting, such as overseas service. DOT 3HT cylinders shall be requalified every 3 years in accordance with CGA C-8. Acetylene cylinders shall have their shell visually inspected every 10 years and their filler requalified at least every 20 years. Most gas cylinders used as fire extinguishers in accordance with 49 CFR 173.309 are to be tested every 12 years, though some require requalification every 7 years after the initial 12 year requalification. All cylinders not exceeding an outside diameter of 2 inches and a length of 2 feet, and all cylinders designated 3E and 4C are exempted from hydrostatic requalification. UN cylinders shall be requalified every 10 years except when a 5 year requalification is necessary as outlined in 49 CFR 180.207.

TABLE III. Cylinder Marking symbols.

Symbol	Requalification period (years)	Cylinder types	Procedure	Reference in 49 CFR
None	5		Volumetric expansion	180.209
	5-10	UN	Water jacket	180.207
	10	DOT 3A, 3A480X, 4AA480, 4B, 4BA, 4BW, or 4E	Volumetric expansion	180.209(e) or (h)
	10[1]	DOT 3A, 3AA, 3B, 4BA, or 4BW	Volumetric expansion and internal visual	180.209(f)
	12	Fire extinguishers	Water jacket	180.209(j)
★ (five-point star)	10	DOT 3A or 3AA	Volumetric expansion	180.209(b)
+[2]		DOT 3A, 3AX, 3AA, 3AAX, or 3T	Water jacket	173.302a
S	5,7, 10, or 12		Proof pressure	180.209(d), (e), or (j)
E	5		External visual inspection	180.209(g)
S	10	DOT 8 series	Shell requalification	180.209(i)
FS	5-20	DOT 8 series	Shell and porous filler requalification	180.209(i)
AE			Acoustic emission	
UE			Ultrasonic emission	
VE	5	DOT 3AL	Eddy current combined with visual inspection	180.209(m)

[1] Cylinders must be internally and externally inspected every 5 years.
[2] Cylinders with this marking have been approved for special filling limits at 10% above the marked service pressure (see 5.3.1.1).

5.1.2 Dimensions. Government-owned cylinders shall be inspected for cylinder dimensions or capacity in accordance with the PID. Cylinders rejected for excessive variation with the PID shall be reported to the government agency from which they originated.

5.1.3 Color code, paint, and stenciling. The cylinders shall be inspected for proper color coding (see 3.5) and stenciling in accordance with MIL-STD-101 as specified in the PID. Cylinders with improper color, peeling paint, or improper or illegible stenciling shall be scheduled for external maintenance.

5.1.4 Cylinder valve protection cap. Each cylinder designed for a protection cap shall be inspected for the presence of a valve protection cap that will run free on its threads and be free of cracks or dents. Cylinders lacking caps or with damaged caps shall have them replaced or scheduled for necessary maintenance. Per 49 CFR 173.301(h), the following cylinders do not

require cylinder valve protection: cylinders containing only a Division 2.2 material without a Division 5.1 subsidiary hazard; cylinders containing a Class 8 liquid corrosive only to metals; a cylinder containing oxygen with a water capacity of 293 in^3 (4.8 liters) or less; a cylinder containing liquid / cryogenic oxygen; medical Grade E cylinders with a water capacity of 300 in^3 (4.9 liters) or less; fire extinguishers; or “B” style cylinder with a capacity of 40 ft^3 (1.13 m^3) or an “MC” style cylinder with a capacity of 10 ft^3 (0.28 m^3) carrying acetylene.

5.1.5 Cylinder valves. Each cylinder shall be inspected for a functional valve threaded into its neck threads. Broken valves or obviously nonfunctional valves shall be scheduled for replacement at maintenance.

5.1.6 Change in service. When specified in the contract, cylinders at receiving inspection that have an acceptable DOT or ISO specification and service pressure in accordance with the requirements of the PID, but in a different noncorrosive gas service, shall be scheduled for change of service procedures.

5.1.7 Damaged cylinders. Cylinders shall be inspected for bent or worn footrings in low pressure applications and for loose flanges in DOT 3A or DOT 3AA applications. These types of defects shall be scheduled for maintenance in general metal working shops where the pressure bearing portion of the cylinder is not subject to the heat of welding activity. Repair work requiring independent welds of less than three inches or rebuild work requiring welds greater than three inches in length on the pressurized portion of the cylinder shall be scheduled for maintenance in authorized repair and rebuild entities as stated in 3.2. Cylinders showing evidence of being subjected to fire shall be condemned and returned to the government agency for disposal. When proper repair, rebuild, or remanufacture is not available, a cylinder requiring such maintenance shall be rejected and returned to the government agency.

5.1.8 Foreign cylinders. Foreign made cylinders are acceptable only if the cylinders are manufactured to DOT or ISO specifications as outlined in 49 CFR 100-180 and all recorded data required by the specification is available upon request. A DOT assigned manufacturer's code shall be steel stamped into the shoulder of the cylinder.

5.1.9 Nonconforming cylinders. Cylinders that are listed by government agencies or in industrial publications declaring them in nonconformance to 49 CFR 100-180 shall be rejected, marked "condemned", and returned to the government agency for disposition.

5.1.10 Recording of services at receiving inspection. Receiving inspection should include the number of cylinders received on a DD Form 250 indicating acceptance or rejection.

5.2 Serviceability inspection.

5.2.1 Residual gas and moisture control. Each cylinder shall be inspected for residual gas pressure. For general applications, the minimum acceptable pressure for evacuation and refilling shall be 5 psig or great enough to produce an audible hiss when the valve is slightly cracked open. If the audible hiss method is used, a slip of paper shall be placed in front of the valve opening to ensure that any sound is due to a positive pressure and not a vacuum. Cylinders with

low pressure (< 5 psig), negative pressure, or with open valves shall be scheduled for cleaning, drying, and/or purging at maintenance, as applicable. Any cylinder suspected of containing water shall be inverted, drained of its contents for not less than 10 minutes, and considered an open cylinder. Cylinders such as acetylene, LPG, or fuel gas mixtures may be returned partially filled with gas that is of value to the government. This gas shall be retained and included with the cylinder tare weight to make up the base weight for cylinder charging. All other cylinders partially filled with gas shall have their contents bled off and disposed of in accordance with current environmental requirements. The residual gas shall be considered waste by the government and may be reclaimed at the discretion of the gas supplier.

5.2.2 External inspection. Each cylinder shall be inspected externally by placing the cylinder in a good light, tilting to reflect light, and slowly rolling in a vertical position for a complete revolution. The entire surface shall be inspected for excessive denting, pitting, gouges, bulging, cracks, leaks, thermal damage, or corrosion. Rejection shall be in accordance with the contractor's standard practice, but damage shall not exceed rejection levels established in the applicable CGA guidelines: C-6 for steel and nickel cylinders, C-6.1 for seamless aluminum cylinders, C-6.2 for fiber reinforced composite special permit cylinders, C-6.3 for low pressure aluminum cylinders, C-8 for DOT 3HT cylinders, and C-13 for DOT 8 series cylinders. Particular attention should be given to identifying cylinders with an arc-burn generally found in the welding trade. This type of damage is hazardous and cannot be repaired. Condemnation of cylinders with an arc-burn is mandatory. Evidence of grinding out a defect on a cylinder after manufacture shall be cause for rejection. It should be noted that the manufacturers of high-pressure cylinders often grind the shoulder areas after necking to remove ridges or tooling marks solely for appearances. Some cylinder drawing processes are exposed to the atmosphere and oxides may form on surface cracks while cooling. These cracks show up in x-ray examination of the cylinder shell. A longitudinal grinding of several mils depth removes the offending oxide and allows inspection of the base metal. These grinding marks will be exposed when the cylinder is stripped and are identified by their longitudinal pattern, but are not cause for rejection or condemnation.

5.2.2.1 Paint inspection. The condition of the paint on each cylinder shall be inspected for peeling or chalking. The cylinder color shall be in accordance with MIL-STD-101 and the specific PID, as outlined in 3.5. Cylinders displaying a random pattern of chipping or peeling shall be stripped and repainted. Cylinders displaying localized chipping from a specific use pattern may be spot painted to seal the denuded metal. When a cylinder requires coverage of more than 10 percent of its area, stripping and repainting will be justified. Protective caps shall be considered a part of the cylinder package to be repainted with a cylinder needing paint in the maintenance process.

NOTE: Prior to examination, cylinders undergoing UE shall be shot-blasted as necessary to ensure proper acoustic coupling between the ultrasonic transducers and the cylinder wall. After successfully qualifying to return to service, these cylinders shall be repainted in accordance with MIL-STD-101 and the specific PID, and inspected in accordance with this paragraph.

5.2.2.2 Valve protection cap inspection. Each valve protection cap shall be inspected for cracks, dents, or a mismatch in size. Caps with internal threads that are stripped or damaged,

making hand mounting on the cylinder impractical after a wire brush removal of rust and corrosion, shall be rejected. Hydrocarbon lubrication is not allowed on cap or flange threads, however, fire resistant fluorocarbon or silicon lubricants are permissible and recommended for cylinders subject to weather or high humidity conditions.

5.2.3 Valves and PRDs. Each valve shall be inspected for damaged hand wheels, bent or leaking stems, and damaged or nicked outlet seats and threads. Further inspection shall be made for dirt, grease, or insect residue. Packing nuts shall be snug to control leakage and bonnet nuts shall be locked tight. Valve inlet threads should expose more than one thread between the cylinder neck and the wrenching boss of the valve. The valve shall be functional and shall control the gas flow at the valve seat when residual gas is checked. Valve outlets shall be in accordance with A-A-59860 as specified in the PID. Damaged or faulty valves shall be scheduled for maintenance or replacement.

5.2.3.1 PRDs. PRDs shall be inspected for compliance with CGA S-1.1. Rejected or faulty PRDs shall be scheduled for maintenance or replacement. PRDs that are integral with the cylinder (acetylene or chlorine) shall be inspected for leaks or extruded fusible metal. Faulty devices shall be rejected and scheduled for maintenance or replacement. Fusible plugs integral with a valve body found faulty at inspection shall require valve rejection and shall be replaced.

5.2.3.1.1 PRD CG-1 (rupture disk). Cylinder valves with CG-1 type PRDs shall be inspected for evidence of leakage and burst limits in accordance with the service pressure identification markings on the cylinder. Faulty disks shall be scheduled for replacement with a manufacturer's complete unit (cap, washer, and disk), as applicable.

5.2.3.1.2 PRD CG-2 and CG-3 (fusible plug). Cylinder valves with CG-2 and CG-3 type PRDs shall be inspected for leakage or extrusion of the fusible metal. Faulty or rejected fusible plugs shall be scheduled for replacement in accordance with the PID (temperature range) and requirements specified in the CGA S-1.1.

5.2.3.1.3 PRD CG-4 and CG-5 (combination rupture disk-fusible plug). Cylinder valves with CG-4 and CG-5 type PRDs shall be inspected for signs of extrusion of the fusible metal at the relief holes. Unstable devices shall be rejected and scheduled for replacement with a new complete PRD CG-4 or CG-5 when required or with the proper PRD CG-1 in accordance with A-A-59860. Combination PRDs are required by the government for hydrogen, carbon monoxide, sulfur, hexafluoride, and medical gas services. Combination devices are acceptable in high pressure applications on cylinders with marked service pressures from 1800 psig to 2400 psig. Combination devices are prohibited on cylinders to be filled 10 percent above the marked service pressure. These cylinders are marked with a "+" sign following the last periodic test date, and shall be equipped with an CG-1 type PRD with a rated burst pressure not to exceed the minimum required test pressure of the cylinder with which the device is used.

5.2.3.1.4 PRD CG-7 (spring loaded, reseating PRD). Cylinders with CG-7 type PRDs shall be inspected for evidence of leakage. CG-7 type PRDs are utilized in government service on cylinders in LPG and fluorocarbon gas service. Faulty PRDs shall be cause for valve rejection and shall be replaced.

5.2.4 Inspection of flanges.

5.2.4.1 Flanges (high pressure). Flanges on high-pressure cylinders shall be inspected for tightness of fit. These flanges are either pressed into place, sweat fit, or peened tight. Heat cannot be applied to the cylinder in resweating these accessories due to the possibility of annealing. Flanges shall be scheduled for peening, or for flange replacement when peening would deform the cylinder neck to fill a stretched flange. Any cracked flange or a flange with damaged threads shall be replaced in cylinder maintenance.

5.2.4.2 Flanges (low pressure). Flanges on low-pressure cylinders, including acetylene cylinders, are welded to the base metal of the cylinder shell. Acetylene cylinder flanges provide drilled and tapped holes for removable PRDs in their shoulders (see 5.2.3.1). The removal and repair of flanges on low-pressure cylinders shall be a major rebuild operation carried out by an authorized repair and rebuild entity as stated in 3.2. When approved services are not available to the contractor, the cylinder shall be rejected, tagged, and returned to the government agency empty for repair or disposal.

5.2.5 Inspection of footrings. DOT and ISO specifications provide for welded or brazed seams in the fabrication of low-pressure cylinders, and due to the thin construction in the bottom areas they are provided with footrings welded in place. Footrings shall be inspected and scheduled for maintenance when they are deformed or when rings are cracked or broken in any place where the seam is not a part of the cylinder proper. Welding or brazing of the footring is permissible so long as the cylinder is only subject to heat controlled by water or steam. Welded seams on the cylinder proper shall be repaired only by an authorized repair and rebuild entity as stated in 3.2. If authorized repair or rebuild services are not offered by or available to the contractor, the cylinder shall be rejected, tagged, and returned to the government agency.

NOTE: High-pressure cylinders are not provided with footrings, as welding or brazing is not allowed in DOT specifications 3A or 3AA for cylinders with service pressures above 500 psig. These cylinders have round bottoms and require fixtures to hold them in upright position, or the crown of their bases are bumped back to provide a ring at the side wall as a standing surface for upright stability. Seamless 3A and 3AA cylinders of thin wall construction with service pressures under 500 psig are provided with welded footrings for cylinder bottom protection and shall be repaired only by authorized services or by a manufacturer of similar cylinders.

5.2.6 General internal cylinder evaluation. At general internal evaluation, cylinders accepted at receiving inspection not requiring valve removal, shall be inspected for serviceability by the following procedures.

5.2.6.1 Hammer test. Steel cylinders shall be subjected to a hammer test prior to refilling to ensure viable structural integrity and that internally the surface is free of liquids or heavy corrosion residue. Cylinders to be inspected shall be empty, unpressurized, and standing vertically without touching other cylinders or objects that might deaden the sound. A pigtail connecting the cylinder to a manifold is allowable. This test shall not be performed on cylinders which do not need to be emptied prior to filling (such as acetylene cylinders). Each cylinder shall

be given a light blow with a one-half pound machinists ball peen hammer, wrench, or similar tool on the side wall one-half or two-thirds down the cylinder. The blow must be light, as all cylinders will ring if hit hard enough. If there is a thud instead of a ring or if the ring dies out quickly (in one or two seconds), the cylinder shall be set aside for closer examination. A "dead" cylinder can best be simulated by filling an empty cylinder without valve with several inches of dry sand. This cylinder can be used as a periodic check for the sound of a "dead" cylinder. If the ring of any cylinder is substantially different in tone or quality from the ring of other cylinders of the same size being hammer tested, the cylinder shall be rejected.

5.2.6.2 Odor test. This test shall be limited to cylinders for compressed air, argon, nitrogen, helium, oxygen, and gas mixtures containing only those gases. It can only be used for cylinders in flammable gas service if the flammable gas is carefully purged out and replaced with an odor-free inert gas or dry air before the inspection is performed. It is normally not performed on cylinders from which the valve is to be removed. This test shall not be performed on any cylinder in poisonous or toxic gas service. If a residual pressure is not present, then an odorless inert gas must be introduced into the cylinder being inspected in order to carry out an odor test. Odor bearing cylinders shall be scheduled for devalving, cleaning, and drying at maintenance, as applicable.

CAUTION: Do not place the nose directly into the venting gas stream and do not take deep breaths. Discontinue sniffing any gas at the first indication of irritation of the nasal passages or at any sign of physical discomfort. Some contaminants are extremely irritating, poisonous, or toxic and can cause physical injury. Do not perform this test alone. If improperly performed, this test could cause asphyxia.

5.2.6.2.1 Odor test procedure. Standing at arm's length from the cylinder to be tested and with the valve pointing to the left (to the right for left-handed individuals), crack the valve for the briefest possible moment and immediately reclose it. The valve must point away from the hand and arm used to operate the valve. Sniff cautiously without approaching the cylinder. If no odor is detected, slowly open the valve until a gas flow is heard or felt (pass the hand rapidly past the outlet) and proceed to the next step. Be prepared at all times to close the valve quickly. With the valve open to a slight flow of gas, place a cupped hand in the gas stream, close the cylinder valve, and cautiously sniff the cupped hand. If no foreign odor is detected, proceed to the next step. Reopen the valve to a slight flow and, with a quick fanning motion of the hand, fan the gas from the cylinder toward the nose. If no order is detected, continue the fanning motion and move progressively nearer the cylinder.

5.2.6.2.2 Classification of odor. If at any time during the inspection process an odor is detected, an attempt should be made to classify it using terms such as "acrid", "sweet", "rotten egg", "glue-like", or similarly descriptive terms, as this will help in the selection of the appropriate cleaning process.

5.2.6.2.3 Odor detection personnel. The ability to detect and classify odors is important in the detection and identification of contaminants. Persons assigned this task must be able to detect foreign odors in gases vented from cylinders. Such persons should be questioned as to their ability to detect odors. The ability to pick out a cylinder with a known contaminant, from a group

of contaminated cylinders, shall be demonstrated by test. Persons temporarily unable to detect or classify odors because of head colds, hay fever, or similar conditions, shall be excluded from the assignment of inspecting cylinders for the presence of odorous contaminants.

5.2.6.3 Sulfur hexafluoride cylinder internal inspection. Each cylinder in sulfur hexafluoride service shall be bled to zero pressure (0 psig) in accordance with environmental requirements, devalved (see 5.3.2.1), and subjected to internal inspection by droplight (see 5.3.2.2). Internally, sulfur hexafluoride cylinders shall be free of oil, grease, and rust to the reduced metal level and shall be equivalent to the rust free examples in ASTM D2200. Cylinders requiring internal cleaning shall be scheduled for maintenance procedures in accordance with 5.3.4(c) and (d).

5.2.6.4 Chlorine cylinder internal inspection. Each chlorine cylinder shall be bled to zero pressure (0 psig) in accordance with environmental requirements and shall have its valve removed (see 5.3.2.1). It shall then be internally inspected. Before charging, the cylinder shall be subjected to internal inspection by droplight test to ensure that corrosion has not damaged the integrity of the cylinder wall, bottom, or its neck inlet threads (see 5.3.2.2). Before charging, the chlorine cylinder shall be subjected to a hammer test (see 5.2.6.1). Cylinders with corroded sidewalls, cylinders with eroded female neck threads, and cylinders with a dull response or unusual sound at hammer testing shall be rejected and scheduled for applicable maintenance. Cylinders rejected for general internal corrosion shall pass hydrostatic testing or UE when permitted, after corrosion products have been removed and before returning to regular gas service.

5.2.6.5 Solvent adjustment of acetylene cylinders. The solvent level of each acetylene cylinder shall be inspected and compared to the tare weight in accordance to CGA G-1.9 or equivalent. Excessive weight is indicative of water absorption by the acetone in the filler. Poor acetylene absorption is another indication of water vapor trapped in the porous filler. A low tare weight may indicate excessive corrosion and wasting of the steel cylinder or loss of acetone by fast withdrawal of the acetylene by the user. Prior to filling, the acetone level shall be adjusted as follows:

a. Cylinders under weight will require adjustment of the acetone in quantities up to 20 percent of the authorized weight of the acetone charge. Cylinders with greater deficiencies shall be rejected and returned to the government for disposition.

b. Cylinder over weight may be handled by the contractor's standard practice for removing excess acetone or small accumulations of moisture. Cylinders with excess moisture heavy enough to inhibit the absorption of acetylene shall be rejected and returned to the government for disposition.

c. When specified in the work order or contract, cylinders rejected for low weight deficiency of acetone or for heavy weight due to excessive moisture require bleeding of the acetylene gas, heat evaporation of the acetone, baking dry the porous filler, and recharging with dry acetone to the tare weight of the cylinder.

5.2.7 Rejection and condemnation. At serviceability inspection each cylinder received will have been examined for charging, maintenance, and repair, or for storage in accordance with the PID. Cylinders shall be accepted for service with a specified gas commodity application when the integrity of the cylinder is ensured to be in accordance with the applicable DOT or ISO specification and the cylinder is ensured to maintain the purity level of the gas of specified use. Cylinders not acceptable by this standard shall be processed for applicable maintenance to restore acceptability in accordance with the PID. Cylinders that cannot be restored by approved maintenance procedures shall be condemned and returned to the government agency in accordance with 3.10. Unrepairable valves are government property and shall be returned to the government agency.

5.2.8 Recording of required services at serviceability inspection. Serviceability inspection requires the listing of the number of cylinders inspected on the DD Form 250 indicating acceptance, rejection, and required maintenance. The DD Form 250 shall identify all involved activities affected in transporting cylinders requiring maintenance.

5.3 Cylinder maintenance. Cylinders received and found to be deficient at inspection or at charging shall be scheduled for necessary maintenance before returning to compressed gas service. A record of maintenance shall be kept current on the DD Form 250. After scheduled maintenance has been performed, the cylinder shall pass inspection in accordance with 5.1 and 5.2 of this standard. Cylinders should be grouped as follows:

a. Periodic testing.

   (1) Cylinders requiring hydrostatic testing or UE.

   (2) Cylinders requiring visual examination.

b. General cylinder maintenance.

c. General acetylene cylinder maintenance.

d. Chlorine cylinders.

e. Cylinders requiring special handling.

f. Cylinders requiring external surface maintenance.

5.3.1 Periodic testing. Cylinders in maintenance for periodic testing are generally cylinders with expired or invalid periodic test dates. Exceptions would be a requirement for 100 percent testing specified in a reconditioning contract, a cylinder that has undergone rebuild procedures, or a cylinder showing evidence of damage as outlined in 49 CFR 180.205(d). Unless specified in this document, 49 CFR 180, or approved by the associate administrator, cylinders shall be subjected to volumetric expansion testing for periodic testing (See Table III). The pressure at which a cylinder is tested shall be at least the minimum required pressure as outlined in 49 CFR 180.209. The hydrostatic test shall always be preceded by a droplight test (see

5.3.2.2). Any cylinder displaying contamination such as grease, corrosion, or oxidation deposits shall be scheduled for cleaning or mechanical removal of the offending deposits before hydrostatic testing. Proof pressure testing may be performed instead of hydrostatic testing at two times the marked service pressure on some cylinders as outlined in 180.209(d), (e), and (j). UE may be performed in lieu of volumetric expansion testing for DOT 3A and DOT 3AA cylinders when allowed by the DOT special permit for the test facility, with the exception of cylinders manufactured in accordance with MS26545. The UE testing criteria shall at a minimum meet that of DOT-SP 14313. Visual inspection may be performed in lieu of hydrostatic testing for cylinders used exclusively for service of specific gases as outlined in 49 CFR 180.209(g). Visual inspection shall also be used in lieu of hydrostatic testing on acetylene cylinders which shall be inspected in accordance with 49 CFR 180.209(i). DOT-3AL cylinders manufactured from 6351-T6 aluminum alloy and used for breathing apparatus or oxygen service shall be tested by visual inspection and eddy current examination in addition to hydrostatic testing as outlined in 49 CFR 180.209(m). Methods for requalifying UN cylinders are outlined in 49 CFR 180.207. Cylinders that fail droplight test procedures, hydrostatic test requirements, or any other kind of periodic test requirements shall be rejected, marked condemned, and returned to the government agency for disposal. Cylinders passing internal visual examination and cylinders approved in hydrostatic testing shall be drained and dried in accordance with 5.3.2.5 and immediately revalved or sealed with a plug and gasket.

5.3.1.1 Special filling limit test. DOT 3A, 3AA, 3AX, 3AAX, and 3T cylinders that meet the requirements of the 49 CFR 173.302a(b) may be marked with a "+" sign and filled to a pressure 10 percent above the marked service pressure. These requirements, including a wall stress analysis, shall be made at each retest of a given cylinder. In order to approve a cylinder for this special filling limit using UE, the cylinder must meet or exceed the pertinent requirements stated in the special provisions of DOT-SP 14313. Approved cylinders shall be marked permanently by a "+" sign following the last periodic hydrostatic test or UE date. If a cylinder has been in service at the special filling limit and marked with a "+" sign and fails to meet the requirements of 49 CFR 173.302a(b) or the special provisions in DOT-SP 14313 section 8d.(2) when retested but meets all other requirements for service, the "+" sign shall be removed and it shall be returned to service at the marked service pressure. Government cylinders specified for special filling limit shall be restricted to cylinders manufactured after 1960, except for cylinders made by Taylor Wharton or Harrisburg Steel Co., which shall be limited to cylinders made since 1920. The practice of testing for special filling limits should be reserved for use only when justification for the additional capacity is made by the procuring agency. Each manufacturer controls their production by a given "K" factor and a maximum EE at hydrostatic testing. This value can either be obtained from the manufacturer or determined from the table or equations in CGA C-5. K factors shall be used to calculate the average or the maximum wall stress when a corresponding cylinder is retested to be approved for filling 10 percent above the marked service pressure.

5.3.1.2 Cylinder markings. Cylinders which pass periodic inspection shall be marked in accordance with 49 CFR 180.213. Unless otherwise approved, this marking shall include the month and year of requalification, the RIN in a square pattern between the month and year, and a symbol at the end identifying the type of requalification which was performed, as outlined in Table III or 49 CFR 180.213.

5.3.2 General cylinder maintenance. General cylinder maintainance shall be performed on cylinders that require repair, cleaning, external maintenance, and/or valve/PRD repair or replacement as necessary.

5.3.2.1 Neck threads cleaning. When a valve is removed from a cylinder for any reason, the mating neck threads of the cylinder shall be cleaned of extraneous debris, such as thread tape remnants, anti-seize compounds, rust and corrosion, prior to any other procedure. Care must be taken that materials removed from the neck threads do not end up in the cylinder. Any material that does go into the cylinder must be removed prior to installation of a valve. Note that rust or corrosion found in the neck threads is indicative of a more serious problem and requires a thorough inspection of the blind area of the cylinder neck (see 5.3.2.2.3).

5.3.2.2 Droplight or borescope testing. Any time that a valve is removed from a cylinder for any reason, the interior of the cylinder shall be inspected using an internal droplight or borescope.

5.3.2.2.1 Light source. The light source shall have sufficient intensity to clearly illuminate the interior walls.

NOTE: For safety, this light should be low (3-12) voltage with an isolation transformer (no common ground) and the bulb should be protected with some form of a safety shield. (If the bulb should break, it could ignite flammable liquids or vapors in the cylinder, resulting in possible damage to the eyes and face.) A fiber-optic light with its remote light source removed from the area of potentially flammable liquids or vapors is acceptable.

5.3.2.2.2 Test procedure. Before introducing the light, purge the cylinder thoroughly of all residual vapors with dry nitrogen or dry, oil-free air then invert it to remove all loose rust, scale, and liquid contaminants. Set the cylinder upright and guide the light into the cylinder slowly, positioning the light and the cylinder so that the entire inside surface of the cylinder, except for the blind area just below the neck, can be examined. Tilt the cylinder several degrees from vertical to get the best view of the cylinder wall. Stop the movement of the light as required to permit prolonged inspection of suspect areas. Hold the light so that it first shines directly on a subject area and then so that any irregularities will produce shadows to improve the examiner's perception of the suspected area. Continue the examination while the light is being withdrawn from the bottom of the cylinder as some defects show up best at this time.

5.3.2.2.3 Inspection of blind area. The wall thickness in the blind area just below the cylinder neck is heavier than the rest of the cylinder and, because of its location, seldom corrodes as fast as the other interior portions of the cylinder. Contamination in this area can be inferred by an examination of the cylinder neck threads near the bottom of the neck opening and of the visible portions of the upper areas of the cylinder.

5.3.2.2.4 Interpretation of visual inspection. The interpretation of the visual internal inspection must be left to experience. Surface irregularities may appear greater in height or depth than they really are because of the shadows they cast. Harmless mill scale and metal discoloration

can be misinterpreted as heavy contamination. If the examination discloses substantial internal deposits that make it impossible to inspect the cylinder wall itself, these deposits shall be removed in accordance with mechanical restoration (see 5.3.2.4.4). The cylinder shall be reinspected after the deposits are removed in accordance with 5.3.1. When in doubt, the safe and desirable procedure is to clean by a procedure appropriate to the nature of the apparent impurity. When significant corrosion or possible flaws are suspected, the cylinder shall be further inspected in accordance with the requirements of CGA C-5.

5.3.2.3 Cylinder structural maintenance. Cylinder structural deficiencies shall be grouped as follows: neck, flange and threads, collar and foot ring, sidewalls, shoulder and bottom heads.

5.3.2.3.1 Government cylinders DOT 3A and DOT 3AA. DOT 3A and DOT 3AA cylinders greater than 625 cubic inches in water capacity are supplied with a neck flange in accordance with MIL-DTL-17376/3. The flange is installed by press fit or by peening into place. Heat cannot be applied to the cylinder, either in removal of the flange or in replacement, as the temper of the steel in the DOT 3A or DOT 3AA cylinder may be changed. Flanges shall be peened tight when found to be loose. Flanges stretched by abuse shall be replaced in accordance with MIL-DTL-17376/3. Any permanent markings on a replaced flange shall be permanently marked in the steel of the shoulder of the same cylinder. DOT 3A and DOT 3AA cylinders with service pressures over 500 psig are seamless in construction, and welding or heating the cylinder is prohibited. DOT 3A and DOT 3AA cylinders with service pressures up to 500 psig are often equipped with welded foot rings to protect the bottom areas and to provide a flat surface for upright stability. Repair of DOT 3A or DOT 3AA cylinders shall be restricted to authorized repair and rebuild entities as stated in 3.2.

5.3.2.3.2 Government cylinders DOT 4 and DOT 8. DOT 4 and DOT 8 cylinders requiring maintenance shall be grouped into those requiring repair maintenance and those requiring rebuild maintenance. These services shall be performed only by authorized repair and rebuild entities as stated in 3.2.

5.3.2.3.3 Heat treatment of cylinders. Whenever reheat treatment of a cylinder is proposed, it shall be in accordance with the specifications in Title 49 of the CFR which cover the manufacture of the cylinder in question. Data from the original manufacturing reports for the cylinder shall be available. DOT 3A and DOT 3AA specifications require quenching, annealing, and tempering of the drawn cylinder. The temper of the steel is relative to the strength of the high-pressure cylinder and any change by heat will render the vessel unfit for high pressure service. DOT 4 and DOT 8 specifications require heat treatment and annealing of the major components to relieve the stresses of drawing the shells and shaping the sidewalls. These steels are selected for welding properties and therefore, repair and rebuild must be properly done by an authorized repair and rebuild entity as stated in 3.2 and in accordance with 49 CFR 189.59 and 49 CFR 180.211. Heat treatment of UN cylinders shall be performed in accordance with the ISO specifications which outline their construction and maintenance.

5.3.2.4 Internal cylinder surface cleaning. Cylinders that require cleaning of the internal surface of contamination, rust, or corrosion or removal of a degraded lining material shall be processed to restore the cylinder for use to contain the gas specified in the contract or work order.

5.3.2.4.1 Aqueous solution detergent washing. Cylinders can be cleaned by use of aqueous detergent solutions to remove most water and oil based contaminants. All detergent residue must be removed by rinsing and the cylinder must be dried to a dew point less than 40 °F (see 5.3.2.5). Detergent solutions are frequently used to remove organic materials from cylinder interiors. The most effective cleaners are alkaline-based solutions of potassium or sodium hydroxide with concentrations roughly equivalent to 1.4 molar (56 and 79 grams/liter for sodium hydroxide and potassium hydroxide respectively). Solutions are used hot and can cause severe irritation on skin contact, or extensive damage if contact is made with the eyes or mucous membranes. Protective clothing shall be worn to protect personnel from the caustic activity of these solutions. Alkaline or detergent solutions do not dissolve oil, grease, or other organic contaminants, but they function by emulsifying them. The cleaning agents attack films of oil or grease, and break them into globules or particles. Each particle of insoluble liquid or solid material is surrounded by a film of closely adhering detergent, and allows it to float free in the liquid. Heat and agitation enhance cleaning action and thorough rinsing washes the free particles away with the wastewater. Clean hot water must be used to prepare an effective cleaning solution. Exceptionally hard water will form insoluble precipitates with the mineral salts in the water and when used will require filtration to prevent clogging of sprayer heads and nozzles. The strength of the solution should be no greater than required for effective cleaning.

5.3.2.4.1.1 Procedure.

a. Cleaning the outside of a cylinder: If inspection shows that oil or grease is confined to the exterior surface of a cylinder below the neck ring skirt and none is on the neck ring or valve, remove all external oil by washing with the alkali solution. A stiff brush or rag may be used on the parts difficult to clean. After all contamination is removed, rinse the cylinder thoroughly with clean running warm water and return it to service.

b. Cleaning the inside of a cylinder: Never use the same alkali solution or container for internal washing that has previously been used for external washing. Prepare a fresh batch and proceed as follows:

(1) Fill the cylinder to a little over half its capacity with a solution of hot alkali, and plug the end of the cylinder with a flanged plug and a gasket.

(2) Lay the cylinder on the floor and roll it back and forth for about 15 minutes. If a cylinder roller is available, adjust it so the cylinder is horizontal and allow the cylinder to rotate for 15 minutes.

(3) Immediately upon completion of the rolling, stand the cylinder up, remove the plug, and completely fill the cylinder with clean tap water. Be sure the cylinder is full, as the interior walls must be kept wet until the cylinder is rinsed.

(4) When ready to rinse, empty out the solution. While the cylinder is on its side or slightly inclined with the neck down, rinse the inside with fresh, clean running tap water, making

sure that the rinse water reaches all interior surfaces. Continue rinsing until all traces of the cleaning solution are removed. This will require a rinsing period of at least 10 minutes.

5.3.2.4.1.2 Alternate procedure. There are several alternates to this procedure as listed below. Contractor's proven systems that have been approved by the contracting officer for equivalent cleaning will also be acceptable.

a. In one modification, a steam lance is inserted to the bottom of the cylinder, which has been filled with an alkali cleaning solution similar to the one given in the primary procedure. Clean oil-free steam is injected into the solution through the lance to keep it boiling from 15 to 30 minutes. During the boiling process, enough excess boiling water or steam is injected through the lance so that the solution overflows the cylinder carrying away the contaminants that have floated to the surface. When cleaning is completed, rinse the cylinder as specified in 5.3.2.4.1.1 (b) (4).

b. In another procedure, the cylinder is positioned with its valve opening down. A mixture of high-pressure steam and a cleaning solution such as the one given in the primary procedure is injected into the cylinder through a steam lance. The lance should be moved up and down and sideways so that the cleaning fluid will contact the entire inside surface of the cylinder. Rotating the cylinder is helpful.

c. Some contaminants can be removed with steam alone without the cleaning compound.

5.3.2.4.2 Organic solvent washing. Organic solvent washing involves pouring a liquid organic solvent into the cylinder and rotating it so that all surfaces are contacted by the solvent. Experience has indicated more than 90 percent of all cylinders that are oil or hydrocarbon contaminated can be cleaned adequately with organic solvents to render the cylinder suitable for use in oxygen or any other service. Cleaning depends upon the ability of the solvent to dissolve organic materials in a short period of time, the ability of the solvent to leave only a small amount of nonvolatile residue on the walls of a cylinder, and upon the solvent not reacting chemically with the cylinder material. Many commercial solvents meet these requirements and do a good job of cleaning. CGA G-4.1 provides considerable information about solvents and their characteristics. Almost all solvents are harmful if breathed to excess. Cylinder cleaning with these solvents should be done only in an area with positive ventilation and only by persons wearing adequate equipment to protect the eyes and skin. Care should be taken not to subject any cylinder with water soluble contamination to solvent cleaning, as such treatment may change the contamination into insoluble gums. Identification of the contamination in a cylinder can usually be made by examination with a droplight or by filling a cylinder with water and then, after the water has been in the cylinder for 24 hours, examining the surface of the water in the neck opening of the cylinder for the presence of oil or other light hydrocarbons. When both water soluble and water insoluble compounds are found, the cylinder shall first be washed with an alkaline solvent in accordance with 5.3.2.4.1 and then washed with organic solvents in accordance with this procedure. Pour clean solvent into the neck of the cylinder until the cylinder is from 1/10 to 1/4 full. Plug the neck opening with a flanged, gasketed plug, lay the cylinder on its side, and rotate it for approximately 15 minutes. The cylinder can be rotated either with a mechanical rotating machine or by rolling back and forth on the floor. It should be rocked from

side to side periodically so as to contact all interior surfaces. Empty the cylinder and observe the discharge solvent. If the solvent is dirty, repeat the cleaning procedure using fresh solvent. Do not use the original solvent as it could redeposit contaminants. When a solvent reclaiming procedure is available, some solvents may be reclaimed by boiling and condensing the vapors. Otherwise, the solvent shall be discarded. After cleaning, the cylinder shall be dried and purged to remove all residual solvent. This is especially important for cylinders in oxygen service, as residual organic solvents pose a serious safety concern.

5.3.2.4.3 Vapor degreasing of cylinders. Solvent cleaning by vapor degreasing uses a tank with immersed heaters to vaporize the solvent. The solvent vapor is discharged through an injection tube over which a cylinder is placed. The hot vapors condense on the internal walls of the cylinder being cleaned, dissolve the oil contamination, and return to the tank by gravity. The solvent thus becomes contaminated with oil and the boiling temperature of the mixture of solvent and oil increases slightly. Even though the solvent becomes contaminated, the vapor driven off by heating is clean solvent. The cylinder is thus cleaned at all times with clean solvent.

5.3.2.4.3.1 Procedure for vapor degreasing.

a. The cylinder should be rinsed with water internally and externally and then thoroughly dried.

b. Invert cylinder with an appropriate hanger and lower it over the injection tube of the vapor degreaser cleaner. The injection tube must almost reach the base of the cylinder. Various sizes of tubes should be available for use with each unit.

c. The cylinder should be left on the cleaner for 15 to 45 minutes after vapor starts to issue from the neck of the cylinder. The time required depends upon the type and quantity of the contamination.

d. Remove the cylinder from the vapor degreaser and immediately purge it with at least 100 cubic feet of oil-free compressed air or nitrogen. Exhaust the cylinder to the outside of the building.

e. Immediately dry the cylinder thoroughly to avoid the possibility of corrosion. Avoid hazardous concentrations of the degreasing vapor in the area.

5.3.2.4.4 Mechanical cylinder cleaning. When the internal surfaces of a cylinder have become oxidized or corroded to the extent that an internal inspection cannot be made, the oxidized material shall be removed by iron based abrasives, by shot blast, or by uses of a spinning mandrel and a steel chain.

5.3.2.4.4.1 Shot blast. A shot blast system utilizes high-pressure air to drive particles of iron or steel of a uniform size against the internal surface of the cylinder. The action will cut coatings, rust, scale, or corrosive build-up free from the reduced steel of the cylinder. A free exhausting of air and debris through the narrow neck of a cylinder is a controlling factor in a shot blasting system. Care shall also be exercised not to cut away reduced steel, thereby excessively

reducing the wall thickness. Resulting surfaces are of high quality and, after removal of fine particles, are generally acceptable for charging with gas commodity without danger of contamination.

5.3.2.4.4.2 Rolling iron abrasives. For cylinders with light scale or rust or pitting and corrosive build-up, a cleaning process can be achieved by placing a quantity of iron based abrasives in the cylinder and rotating it on a mechanical rolling table. Such a system will abrade lightly and produces an excellent surface in which pit depths can be readily inspected. Cylinders coated heavily with scale and corrosive build-up respond very slowly to the rolling systems as the oxidation residue promptly cushions the cutting action of the abrasives and the system loses efficiency.

5.3.2.4.4.3 Mandrel and chain. A mandrel and chain system utilizes a spinning shaft long enough to reach the bottom of a cylinder with a chain attached at the very end and at intervals along its useful length. The chain must be longer than the radius of the cylinder. As wear on the chain progresses, links at the ends must be replaced. The shaft shall be turned in both directions to effect an acceptable metal surface. While the cylinder bottom cannot be cleaned by this system, the internal shoulder area responds very well as the spinning chain approaches the neck of the cylinder. The oxidation and corrosive products are wiped into the pits and dents of a cylinder by the spinning chain. Pitting depths are very hard to judge at internal inspection after a chain and mandrel process. Aqueous solution cleaning is often needed to remove losened particles.

5.3.2.4.5 Heat treatment cleaning. There are certain types of contaminants that cannot be removed by either organic solvent cleaning or inorganic solution cleaning. The only practical method of removing these contaminants is to burn them out. Since this procedure involves heating the cylinder very close to or to the temperature at which its physical properties are modified, the procedure should be carried out by an agency completely familiar with the properties of the cylinder and in possession of the original manufacturing report for the cylinder. The cylinder is heated to a temperature dependent upon the original heat treatment of the cylinder, and held at this temperature while air is injected into it through a lance inserted nearly to the cylinder bottom. The stream of air is continued until all evidence of combustion such as flame, smoke, etc., has stopped.

5.3.2.4.5.1 Procedure. Temperatures are precise (see following guidelines).

a. Quenched and tempered cylinders -- minimum temperature: 1150 °F; maximum-tempering temperature as shown in manufacturing report.

b. Normalized cylinders -- temperatures as shown in manufacturing report.

c. If possible, the agency performing this type of cleaning should be the cylinder manufacturer.

d. After the heating, all applicable DOT or UN inspections, including retest, shall be performed.

5.3.2.5 Internal cylinder drying. Each cylinder that has accumulated water or has had water introduced for maintenance purposes shall be inverted and drained free of water and dried until the dew point of effluent gas is less than 40 °F when tested in accordance with ASTM D2029 or by equivalent method. When preservation of the internal surfaces is required for periods of storage, for high purity conditions, or for aviator's breathing oxygen (ABO) cylinders, heat shall be applied to the cylinder or hot gas shall be passed through the cylinder until 180 °F surface temperature is reached. The cylinder shall be immediately valved closed or sealed with a plug and gasket. Medical gas cylinders shall be dried with the gas of intended use or with dry air.

5.3.2.5.1 Ambient air drying. This procedure is widely used in cylinder processing to achieve a dew point of 40 °F on the effluent side. Drying characteristics will vary widely with relative humidity and temperature. Controlled systems must be proven or constantly monitored by dew point testing or by equivalent analysis.

5.3.2.5.2 Hot nitrogen gas drying. Heated nitrogen is forced through a lance that is inserted to within one inch of the bottom of the cylinder. Hot nitrogen is passed through the cylinder until the external cylinder surface at the open end reaches 180 °F. The cylinder must be valved closed or plugged at this elevated temperature to ensure its dry interior condition.

5.3.2.5.3 Vacuum and heat drying. The cylinder is dried by a vacuum drawn on a cylinder immersed in a 180 °F water. A vacuum of not less than 3 inches of mercury (1.5 PSIA) absolute pressure must be maintained for 30 minutes. Without access to ambient air, the cylinder should be pressurized to not less than 5 psig with nitrogen gas or the gas of intended use and valved closed.

5.3.2.6 Valves and PRDs. Each cylinder valve requiring maintenance shall be repaired as applicable. Valves should be in accordance with A-A-59860 and may remain in service as long as they are functional, clean, and free of damage. PRD systems shall meet the requirements of 49 CFR 173.301 and shall be tested in accordance with CGA S-1.1. All materials used in fabrication of government medical valves shall pass tests specified in NASA-STD-6001 (see Table I).

5.3.2.6.1 Valve maintenance. Valves shall be cleaned free of insects, webs, dirt, paint, corrosion, oil, or grease. Valves may be effectively cleaned using a solvent in accordance with CGA G-4.1 or a commercial oxygen equipment cleaning solvent safe at ambient temperatures.

5.3.2.6.1.1 Hand wheels, packing glands, bonnet nuts, and valve seats. The use of salvaged hand wheels is acceptable whenever a match in drive can be made. Packing glands must be tightened to ensure a gas-tight seal on the stem. Bonnet nuts must be locked tight. The valve seat must seal gas-tight when hand closed, and the stem must backseal when in the full open position. Damaged stems or plugs and integral seats shall be replaced with a manufacturer's kit.

5.3.2.6.1.2 Valve inlet and outlet connections. Valves with less than one thread previously mated in cylinder installation shall be rejected and replaced (see 5.3.2.1). Valve outlets must have smooth seats that are free of nicks or dents on the sealing surfaces. Threads

will be free running in the mated connections. Outlets shall be in accordance with the CGA V-1 and the contract or work order.

5.3.2.6.1.3 Valve outlet caps and plugs. Outlet caps or plugs shall be provided for toxic gas service in accordance with A-A-59860 and the applicable associated specification sheet. When specified in the contract or work order for nontoxic service, caps or plugs shall be provided in accordance with A-A-59860.

5.3.2.6.2 PRDs. The PRD for each valve shall be in accordance with A-A-59860 and for the service specified in the PID. Mismatched, leaking, or extruded PRDs shall be replaced as complete units (cap, disk, and washer). A faulty PRD, which is integral to the valve body, is cause for replacement of the valve. The combination rupture disk, burst pressure 2,700-3,000 psig, backed with fusible metal (CG-4 or CG-5) as applicable, is an authorized PRD for cylinders with marked service pressures 1,800 through 2,400 psig. This PRD meets all requirements of the DOT and the recommendations of the CGA for compressed high-pressure gas applications when used in accordance with A-A-59860. The combination PRD shall not be used for cryogenic liquid sample cylinders or with any cylinder that has been tested and stamped with a "+" sign after the last hydrostatic test or UE date. The "+" sign indicates that the cylinder may be filled to a pressure 10 percent above the marked service pressure, and therefore the use of a rupture disk PRD is mandatory regardless of whether the cylinder is pressurized to a higher level or only to the marked service pressure. An CG-1 rupture disk for the specific service pressure marked on the cylinder, when applicable, is the preferred PRD.

5.3.2.6.3 Valve installation. All valves shall be installed in cylinders using thread tape. The use of anti-sieze thread compounds is authorized for cylinders in hydrogen or helium service where molecular size may diminish the capability of thread tape to effect a proper seal. All oxygen valves and high-pressure valve services shall be installed with one to three turns of polytetrafluoroethylene tape conforming to A-A-58092. Prior to applying tape or thread compound, the valve's inlet threads shall be cleaned of possible cylinder contaminants. One thread should remain exposed at the lead end of the inlet threads when applying tape or thread compound to ensure against cylinder contamination. Fluorocarbon lubricants that are stable in oxygen atmospheres may be used to increase the effectiveness of the polytetrafluoroethylene tape. Hydrocarbon lubricants are prohibited in compressed gas service. All valves should be installed and torqued until a maximum of five and not less than one full thread shows above the cylinder. New valves should have as near five threads showing as is possible to effect a tight seal. When a valve is reinstated in its mated cylinder, a reliable seal can be achieved by torquing the valve one-half to one full thread into the cylinder beyond its previous installation. Used valves should seal displaying one to two threads less than with any previous installation. If a gas-tight seal cannot be achieved through a reasonable application of the above guidelines, the cylinder shall be rejected and marked condemned for enlarged neck threads. Except for chlorine service, oversized valve inlet threads are not approved in the government system.

5.3.2.6.4 Valve replacement and disposal. Improper or rejected valves that cannot be reconditioned shall be condemned and replaced (see 5.3.2.1) with valves in accordance with A-A-59860. Condemned valves shall be returned to the government for disposal. A simple

control may be achieved by tying the unrepairable valve to the installed new valve to be returned with the service cylinder.

5.3.2.6.5 Cylinder plugs in lieu of valve. When specified by the PID, tapered plugs or plugs with flange and gasket shall be installed in the cylinder neck opening. Plugs shall have national gas threads (see CGA V-1) provided with wrench flats for easy removal. The plug must effect an airtight seal to preserve the internal surfaces of the cylinder from oxidation and corrosion in storage.

5.3.3 Chlorine cylinder maintenance. Each chlorine cylinder shall have its valve removed (see 5.3.2.1), the residual chlorine gas purged with atmospheric air, and shall be internally inspected by droplight test (see 5.3.2.2). Cylinders rejected for internal corrosion must be subjected to a cleaning process to remove any corrosion residue for a determination of internal cylinder damage. Cylinders with excessive erosion require hydrostatic testing or UE before returning to chlorine gas service regardless of the periodic test status of the cylinder. The cylinder rejected for eroded neck threads must be retapped with the applicable national gas tapered (NGT) threads (see CGA V-1) to a depth of up to 4 threads according to need for full roots and crests in the female thread forms. Such a cylinder shall be refitted with a valve having inlet threads machined from one to four threads oversized as applicable and in accordance with valve designation AA59860-040 as specified by A-A-59860. Chlorine cylinders are the only cylinders that are authorized to be fitted with valves with oversized inlet threads by A-A-59860. Neither chlorine liquid nor gas will corrode iron or steel unless a slight amount of water is trapped within the cylinder. When moisture is present, the water will hydrolyze with the chlorine to produce small amounts of hypochlorous and hydrochloric acid. The dilute acid can attack any spot on the cylinder, but shows an affinity for sharp edges or points. As a result, the restored chlorine cylinder must be thoroughly dried before it is returned to chlorine service after any maintenance or hydrostatic test procedure.

5.3.4 Special handling. When specified in the contract or the PID, each cylinder shall be prepared by special handling. Each cylinder shall have a valid periodic test date or will be scheduled for test or examination as applicable. Each cylinder with a valid test must have its valve removed (see 5.3.2.1) and must be subjected to a droplight examination to determine the condition of its internal surface (see 5.3.2.2). The cleaning of the cylinder internally shall be in accordance with the following procedures as applicable, unless otherwise specified in the contract or work order:

a. When the commodity is a permanent gas, the cylinder wall shall be free of oil and grease or any contamination that will volatilize in the compressed gas, as the impurity will be carried along with the gas as it is withdrawn. Generally, any odor in a cylinder is indicative of such contamination. Cleaning will require detergent application followed by hydrocarbon solvent application in very stubborn cases. Oil and grease will generally respond to hot detergent cleaning. Generally, oxide corrosion of the steel sidewall will not contaminate a permanent gas unless the corrosion is progressive enough to trigger failure by hammer test. Rust particulate matter will not contaminate the effluent gas from a permanent gas cylinder, however, accumulations greater than 1.5 grams identified by droplight or by inverting and dumping shall

dictate removal by mechanical cleaning, aqueous cleaning, high-pressure air, or steam, as applicable.

b. When the commodity is a liquefied gas to be withdrawn as a liquid or a gas through a diptube, the sidewall shall be free of oil and grease and loose, fine particle corrosion. This corrosion residue may be removed by mechanical methods or by forced flushing. Tight scale, shallow pitting, and sidewall rust stain are generally acceptable when diptube withdrawal is utilized.

c. When the commodity is a liquefied gas to be withdrawn as a liquid of high purity by inversion of the cylinder, the sidewalls, bottom, and shoulders shall be free of all contamination, rust, and corrosion to the reduced metal level. The cleaning procedure of choice is iron shot blast. Other mechanical or chemical methods may be used if residues from processing can be removed in accordance with ASTM D2200.

d. Special handling cylinders shall be immediately dried in accordance with 5.3.2.5.2 or 5.3.2.5.3 so the corrosion level will remain static until the cylinder is charged. Cylinders prepared in special handling must be charged immediately or they must be preserved with dry inert gas and closed by revalving or by plug and gasket.

5.3.5 External cylinder surface maintenance. The cylinder requiring external surface maintenance shall have the valve masked against stripping solutions and paint spray. The valve protection cap will be turned hand tight onto the cylinder flange. The cylinder must be cleared of decals and stickers, all old paint should be stripped, and the rust removed to the reduced metal. The cylinder shall be refinished in accordance with MIL-T-704, Type C, and as specified herein. The materials supplied to paint government cylinders shall be in accordance with or equal to MPI #9. Lacquer materials acceptable for painting government cylinders shall be in accordance with A-A-3165. Cylinders and valve protection caps shall be color coded and stenciled in accordance with MIL-STD-101. Paint shall be uniform in colors conforming to SAE AMS-STD-595.

5.3.5.1 Cylinder valve protection caps. Replace the cap on the cylinder flange. If the threads are not free running, clean both the cap and flange threads with a wire brush to remove rust or chase the threads with tap or dye as applicable. Cap threads that cannot be cleaned to run free shall be cause for rejection and replacement with a new cap in accordance with MIL-DTL-17376/1. Cylinders under 625 cubic inches in water capacity are not required to have flanges and valve protection caps unless the cylinder is provided with a threaded flange.

5.3.5.2 Paint, decal, and rust removal. Before painting a government cylinder, the old paint, any decals, and oxidation shall be removed to the reduced metal in accordance with TT-C-490. Decals and stickers must be removed before stripping, either by chemical or by mechanical systems. Chemical stripping systems using caustic or phosphate solutions perform well in removing paint, but do not attack the oxidized surfaces of denuded metal. This oxidation must be removed by chemical reducing agents, mechanical abrasives, or a combination of both. Shot blasting is an effective means for removing hard paint without severe erosion of the metal cylinder

wall in controlled processes. Shot blasting can also remove rust without needing to dry or rinse residue off the cylinder as would be the case with chemical processes.

5.3.5.2.1 Release of compressed gas in 150 °F stripping solution. DOT service pressure regulations are based on expansion limitations at 130 °F maximum. If cylinders containing compressed gas or liquefied gas residuals are subjected to temperatures in excess of 130 °F during stripping or drying, PRD limits may be exceeded and contained gas will be released into the paint stripping area.

5.3.5.2.2 Caustic stripping. Paint can be stripped from cylinders in caustic (sodium hydroxide) solutions of varying concentrations depending on the working temperature and mechanical agitation.

a. Cold caustic solutions of 25 weight percent at ambient temperatures (60 to 80 °F) will strip paint from submerged cylinders in approximately 4 hours. This process does not lend itself to production throughput as saturated flanges will drain for extended periods of time over newly painted surfaces.

b. Hot caustic solutions of 25 weight percent heated to 150 °F ± 20 °F will strip old paint from a submerged cylinder in 10 to 12 minutes. Agitation of the solution will increase the general effectiveness of the stripping procedure more than it will decrease the stripping time. A long narrow tank of depth equal to cylinder height will lend itself to continuous monorail application.

c. Hot caustic solutions of 15 weight percent heated to 150 °F ± 20 °F, circulated through a coarse filter, screen, or a settling process and directed uniformly in pressure spray against the cylinder wall will strip old paint to the base metal in 10 to 12 minutes. Cylinders hanging from a monorail that will rotate as they pass through an enclosed spray cabinet for the allotted time yields effective throughput.

5.3.5.2.3 Water rinsing of caustic solutions. Cold water rinsing is possible but the caustic solutions will require volumes of fresh water for flooding and must then be forced-air dried to control surface oxidation. When the caustic solution is rinsed away by hot water with a temperature of 150 °F ± 20 °F, it will leave a residual heat in the cylinder that will allow the cylinder surface to evaporate to dryness in the ambient air. Ambient drying can be controlled by circulating room air about the cylinders and exhausting a portion to control the relative humidity.

5.3.5.3 Metal surface pretreatment. The reduced metal surface shall be treated and passivated to ensure adhesion and refinishing is achieved. The surface of a cylinder recently cleared of old paint and rust displaying the reduced metal condition will oxidize very quickly if it is not immediately protected. The metal cylinder surface should be sealed with an impervious deoxidizing prime coat, or coated with either type I zinc phosphate or type II iron phosphate chemical agents conforming to TT-C-490. Surfaces may be prepared by wash primers conforming to TT-C-490 or MIL-C-8514.

5.3.5.4 Prime coating. A prime coat shall be applied over treated metal surfaces as soon as possible in normal processing. Only primed cylinders are to be held in storage. After extended storage, the surfaces must be freed of oil, grease, dust, and stains before finishing. The prime coat shall be compatible with the proposed finish coat. The paint must dry hard, creating an impervious moisture seal over the base metal with a thickness of 1.0 to 1.5 mil. For continuous operations where a minimum of time elapses (less than one hour), a deoxidizing primer such as a combination of basic zinc chromate and phenolic vinyl butyral may be used to combine the metal surface preparation and the prime coating in one operation. If such a deoxidizing primer is used, the finish paint shall be compatible with the hard prime base and react with inseparable adhesive properties when curing is completed.

5.3.5.5 Finish coating. The finish coat of exterior paint shall be sprayed over a cured prime paint to a thickness that will ensure smooth and even flow that will be free of pits and achieve a sealed glossy surface. Excessive thickness will be regarded as an inferior quality. A heavy buildup of cured paint residue promotes chipping and scratching.

5.3.5.6 Touch-up painting. Touch-up painting may be applied to cylinders displaying localized chipping, such as chipping from an anchoring chain, or when specified in the contract or the delivery order. Excessive chipping will require stripping and refinishing the cylinder completely (see 5.2.2.1).

5.4 Cylinder charging. Except for acetylene, butane, propane, anhydrous ammonia, and carbon dioxide, each cylinder shall be evacuated to an absolute pressure of 3 inches of mercury (1.5 PSIA) or greater and maintained for a minimum of 2 minutes before charging begins. The cylinder shall be charged with the applicable gas equivalent to the marked service pressure or with liquefied gas to its authorized weight in accordance with the cylinder design. Any gas bled from cylinders must be disposed of in accordance with current environmental requirements.

5.4.1 Charging cylinders with permanent gas (oxygen, nitrogen, hydrogen, argon, helium, air, and carbon monoxide). These cylinders arrive at the charging station with residual pressure from previous use or are filled with air and dried to a dewpoint of approximately 40 °F. Each cylinder shall be evacuated to a minimum absolute pressure of 3 inches of mercury (1.5 PSIA) and maintained for 2 minutes before filling begins. High purity gases (oxygen, helium, argon, and nitrogen) and other gases with purity levels above 99.95 percent shall be prepared for charging by double evacuation. ABO cylinders shall undergo three evacuation cycles, of 25 inches of mercury (12.28 PSIA) adjusted for altitude, in preparation for charging. Cylinders with residual gas shall be evacuated to a minimum absolute pressure of 3 inches of mercury, pressurized with the gas of intended use to not less than 10 psig, and again evacuated to a minimum absolute pressure of 3 inches of mercury (1.5 PSIA) for 2 minutes before actual charging begins. Each cycle of evacuation will reduce any residual gas remaining in a cylinder to approximately 10 percent of its previous level. Each cylinder shall be charged with the applicable gas in accordance with the PID to a pressure level equivalent to the marked service pressure at 70 °F. Equivalent pressure/temperature tables will be found in the applicable commodity specification.

5.4.2 Charging cylinders with liquefied gases. Liquefied gases include LPG, fuel gas mixtures, fluorocarbon refrigerants, ammonia, chlorine, and sulfur hexafluoride. The cylinders for these gases are DOT 3-series seamless specification or DOT 4-series welded specification, as applicable for the particular gas and its maxium vapor pressure at 130 °F. Each service will provide specific control of the quality of the commodity contained. The cylinders for each service must be handled to preserve the properties of the commodity specification as applicable. The authorized weight and the nominal capacity presented in the PID for a cylinder in a specific liquefied gas service shall be equivalent values but shall never exceed the maximum permitted filling density in accordance with 49 CFR 173.304 (see 3.18).

5.4.2.1 Charging ammonia cylinders. At a charging station, ammonia cylinders will contain slightly more than one atmosphere of ammonia gas pressure or one atmosphere of dry ambient air when the cylinder is new or requires maintenance. Ammonia may be filled to a density not greater than 54 percent of the cylinder water capacity by weight in accordance with 49 CFR 173.304a. Cylinders with residual ammonia gas and cylinders filled with ambient air can be handled together. Check and record the marked tare weight. Attach the ammonia cylinder to the ammonia recharging line and allow the pressure head to flow liquefied ammonia into the cylinder to the authorized weight of the cylinder. Close the valve and disconnect the recharging line. If the cylinder is filled over the authorized weight, bleed the excess liquefied ammonia as gas to the net product weight. Record the quantity of ammonia filled. Charged anhydrous ammonia cylinders that contain one atmosphere of dry ambient air shall be adjusted by the escape of not less than 5 cubic feet of gas to ensure the preferential release of most of the trapped air.

5.4.2.2 Charging chlorine cylinders. At a charging station, chlorine cylinders will contain approximately one atmosphere of dry air or nitrogen. Place the chlorine cylinder on a manifold capable of drawing a vacuum and introducing a pressure head of liquid chlorine without exposure to ambient air. The chlorine cylinder shall first be evacuated to 3 inches of mercury (1.5 PSIA). After gate valves are switched to the liquefied chlorine head, the cylinder shall be slowly filled. A chlorine container is approved for a filling density of 125 percent times the container's water capacity by weight. Record the tare weight and fill the cylinder to its authorized weight. If the cylinder is filled over the authorized weight, adjust the chlorine for net product weight of the cylinder. Record the quantity of chlorine filled.

5.4.2.3 Charging fluorocarbon refrigerant cylinders. At a charging station, government fluorocarbon refrigerant cylinders will have been subjected to an internal inspection and necessary maintenance, followed by drying to a dewpoint not greater than 40 °F with ambient air. The cylinder shall be weighed to determine its specific tare weight and recorded. Before charging, the cylinder shall be evacuated to 3 inches of mercury (1.5 PSIA), and without access of ambient air the cylinder shall be charged to the authorized weight with a specific refrigerant. Each fluorocarbon refrigerant cylinder shall be charged to a filling density not greater than that specified in 49 CFR 173.304a multiplied by the water capacity of the cylinder for its authorized weight. At a final weighing, the contents of the cylinder shall be adjusted for net product weight for the cylinder as applicable.

5.4.2.4 Charging cylinders with LPG. At a charging station, a LPG cylinder will be empty and will have the same weight as its tare weight, or it will contain liquefied gas and its base weight will be somewhat heavier than its marked tare weight. Record the base weight of each LPG cylinder to be recharged. LPG cylinders may be in accordance with 49 CFR 173.304a(d). Connect the valve outlet to the LPG charging line and fill the cylinder. Cylinders filled with air will block filling at some point short of being full, as the pressure of the compressed air reaches the recharging head pressure. To prevent pressure block, the cylinder valve outlet connection must be cracked periodically during recharging to allow the trapped air to escape. Government LPG cylinders are made to contain the authorized weight as specified in the PID and shall be charged to its authorized weight. The base weight recorded for the specific cylinder shall be subtracted from the gross weight and recorded as the net product weight of LPG required for recharging.

5.4.2.5 Charging cylinders with fuel gas mixtures. Fuel gas mixtures are supplied to the government as proprietary products. Government cylinders are provided for filling to nominal weights, such as 7.5 pounds for portable applications or 70 pounds for stationary or mobile applications. These gases are an inhibited mixture of gases that are readily liquefied under pressure and should be handled like liquefied petroleum in charging. The fuel gas cylinder shall be weighed to determine its tare weight, which shall then be recorded. The cylinder is charged to its authorized weight with liquefied commodity. The net product weight is determined to be the gross weight less the recorded tare weight.

5.4.2.6 Charging carbon dioxide cylinders. Carbon dioxide cylinders arrive at the charging station with residual pressure from previous filling or contain one atmosphere of gas from drying at 180 °F. When a cylinder contains residual carbon dioxide, it shall be bled down to one atmosphere of pressure. Connection shall be made with the carbon dioxide supply manifold and charging shall follow. When a cylinder has been dried at 180 °F and closed, a negative pressure will be developed on cooling. Connect the valve outlet to the carbon dioxide supply manifold with a gas-tight seal before the cylinder valve is opened to prevent the contamination of the cylinder with atmospheric moisture. Carbon dioxide should be purchased by weight. The net product weight of carbon dioxide supplied in each cylinder is the difference between the filled weight and the unfilled weight of the cylinder. Carbon dioxide cylinders shall never be charged above 68 percent filling density.

5.4.2.7 Charging sulfur hexafluoride cylinders. At the charging station, sulfur hexafluoride cylinders will be inspected according to 5.2.6.3. Each cylinder shall be weighed and recorded for tare weight. The cylinder shall be evacuated to an absolute pressure of 3 inches of mercury (1.5 PSIA) and maintained for a minimum of 2 minutes before filling begins. Each cylinder shall be weighed and recorded for tare weight. The cylinder shall be charged with hexafluoride to its authorized weight. Each cylinder may be charged to a filling density not greater than 120 percent of the water capacity of the cylinder. The net product weight is determined to be the gross weight less the recorded tare weight.

5.4.3 Charging cylinders with acetylene. An acetylene cylinder at charging will ordinarily have a residual amount of acetylene dissolved in its solvent carrier and will have a heavier base weight than its marked tare weight, or cylinders devalved for inspection or solvent adjustment

will have a base weight corresponding to the tare weight. Base weights shall be recorded and the cylinder shall be connected to the acetylene manifold. A given source of acetylene in cubic feet capacity per hour must be mated with a bank of cylinders capable of absorbing all the acetylene generated. Differential conditions can be varied at higher pressure (400 psig maximum) or at lower temperature (cooling closets) until a cylinder settled pressure of 250 psig at 70 °F or equivalent is achieved. Weigh the charged cylinder. With the base weight, calculate the quantity of the dissolved gas by weight and its equivalent cubic footage using the conversion factor of 14.7 cubic feet of acetylene per pound of gas weight. Record the number of cubic feet required to charge the cylinder. The dissolved weight of acetylene shall never exceed a cylinder's capacity in cubic feet divided by the conversion factor.

5.4.4 Leakage test. Each cylinder that is charged with compressed gas in accordance with the contract or work order shall be inspected and tested for leakage. Testing shall be carried out by immersion in water or by use of a soap solution or an equivalent leak detection agent, except for ABO cylinders (see 5.4.4.1). Cylinders with valves leaking at the seats or stems shall be tightened to establish leak free seals. Never loosen the bonnet nut or the packing nut of a charged cylinder valve. Cylinders with leaking valves or leaking valve inlet threads shall be relieved of internal pressure, inspected and scheduled for applicable maintenance. Cylinders with leaking inlet neck threads that are oversized (except for chlorine cylinders) shall be marked "condemned" and returned to the government agency for disposal.

5.4.4.1 Leak testing for ABO cylinders. Leak testing of charged ABO cylinders shall use a tube or outlet connected pig-tail with the extremity under a liquid to test for valve seat leakage without valve outlet contamination. ABO cylinder valve leak testing shall use leak detection compounds in accordance with MIL-PRF-25567.

5.4.5 Special tag for filled cylinders procured by the military medical services. A paper tag shall be attached to each filled cylinder. Marking shall include the name of the specified gas, serial number of the cylinder, and necessary precautionary markings. The statement, "CAUTION: Federal law prohibits dispensing without prescription", shall appear on the tag if it does not appear on the cylinder. Tags shall be furnished with metal eyelet and stringing wire. Wire shall be tinned, annealed, or galvanized. Tag colors shall be as follows:

Background - Same color as cylinders
Print - Black

or

Background - White
Print - Same color as cylinders

In addition, the bottom of the tag shall be designed with a three-part legend, marked on both sides of the tag as follows:

"EMPTY"

"IN USE"

"FULL"

A perforation shall be placed between the words "FULL" and "IN USE" and between the words "IN USE" and "EMPTY" in order that these legends may be removed by tearing when they are no longer applicable.

The government will furnish DD Form 1191, “Warning Tag for Medical Oxygen Equipment”, for placement on oxygen cylinders.

NOTE: Filled cylinders shall be packed and marked as specified in the applicable specification for the cylinder, except that any reference that cylinders are empty shall not apply.

In addition, each filled ethylene oxide-dichlorodifluoromethane mixture cylinder shall be marked with the legend:

"STORE IN A COOL PLACE (50 °F - 80 °F)"

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The cylinders covered by this standard are intended for use by government agencies in various compressed gas applications.

6.2 Subject term (key word) listing.

acetylene	drawn seamless	nitrogen
air	fiberglass	nonshatterable
ammonia	flourocarbon refrigerant	oxygen
argon	fuel gas mix	propane
brazed	helium	sulfur hexaflouride
carbon dioxide	hydrogen	ultrasonic
carbon monoxide	hydrostatic	welded
chlorine	medical	
cryogenic	methyl bromide	

6.3 Changes from previous issue. The margins of this standard are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.4 DOT references. Specificiations for all DOT cylinders can be found in 49 CFR 178.

Custodians:	Preparing Activity:
Army - EA	DLA - GS7
Navy - SH	
Air Force - 68	(Project 8120-2020-002)
DLA - GS	

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST database at https://assist.dla.mil/.