

American National
Standard for
**Compressed Natural Gas
Vehicle Fuel Containers**



Fourth Edition - 2007



Approved
June 20, 2007
American National Standards Institute, Inc.

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March 19, 2008

Erratum to
American National Standard for
Compressed Natural Gas Vehicle Fuel Containers
ANSI NGV 2-2007

The fourth edition of American National Standard for Compressed Natural Gas Vehicle Fuel Containers, NGV 2-2007, was recently published. There are errors in Table II, Test Requirements For Designs And Design Changes, the references were incorrect. Attached is a corrected page.



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Erratum to American National Standard for Compressed Natural Gas Vehicle Fuel Containers, ANSI NGV 2-2007, March 19, 2008

Table II

Test Requirements For Designs And Design Changes

Test	Fiber Material or Manufacturer	Resin System Material	Liner or Metal Container Material	Dia. <20% Change (7)	Dia. >20% Change (7)	Service Pressure <20% Change (7)	Length <50% Change	Length >50% Change	Integral Mounting Brackets & Valve Protection Shrouds	Pressure Relief Devices or Valves	External Coating	Boss
Ambient Cycling Test (Section 16.3)	X(1)		X	X(5)	X	X(5)			X(5)			X(5)
Environmental Test (Section 16.4) (4)	X	X(10)	X(2)								X	
Extreme Temperature Cycling (Section 16.5) (4)	X	X(10)	X		X							
Hydrostatic Burst Test (Section 16.6)	X	X	X	X(5)	X	X(5)	X(5)	X(5)	X(5)			X(5)
Composite Flaw Tolerance Test (Section 16.7) (4)	X(1)	X(10)	X(2)		X							
Drop Test (Section 16.8) (4)	X	X(10)	X(11)		X			X				
Bonfire Test (Section 16.9)	X(1)		X(2)		X		X(3)	X		X(8)		
Accelerated Stress Rupture Test (Section 16.10) (4)	X(1)	X	X(11)									
Penetration Test (Section 16.11)	X(1)	X(10)	X(2)	X(9)	X							
Permeation Test (Section 16.12) (6)			X									
Natural Gas Cycling Test (Section 16.13) (6)			X(11)									X(12)
Leak Before Break (Section 16.14)	X(1)		X		X							

Notes For Table 2:

- (1) Test required only when fiber type is changed.
- (2) Tests required only when liner material type is changed, e.g., steel to aluminum or metal to polymer.
- (3) Fire test not required provided safety relief devices or device configuration passed the required fire test on a container with equal or greater internal water volume.
- (4) Test required only on composite reinforced containers.
- (5) Only one unit required for qualification.
- (6) Test required only for Type 4 containers.
- (7) When changes in diameter or pressure are made the structural wall elements must be operating at the same or lower nominal stress levels as the original design (e.g., if pressure or diameter increase, the wall thickness must increase proportionally.)
- (8) Required if the new valve design has reduced relief channel flow area compared with previously qualified valves or if the mass of the valve and PRD increase by more than 30%, or when pressure relief device is changed.
- (9) Test required only if diameter decreases.
- (10) Test not required when chemically equivalent materials are substituted.
- (11) Test required only when change is made to polymer.
- (12) Test required for Type 4 containers when the boss to liner interface is affected by design changes.

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Preface

This publication represents a standard for safe operation, substantial and durable construction and performance testing of containers for the on-board storage of compressed natural gas for vehicle operation, within limitations given below and in the scope of this standard.

This standard is based on engineering principles, research and the combined expertise of gas utilities, manufacturers, users, and others having specialized experience.

Nothing in this standard is to be considered in any way as indicating a measure of quality beyond compliance with the provisions it contains. It is designed to allow compliance of products which may exceed that specified in the provisions herein. In its preparation, full recognition has been given to possibilities of improvement through ingenuity of design. This standard is subject to revision as further experience and investigation may show it is necessary and desirable.

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EFFECTIVE DATE: An organization using this standard for product evaluation as a part of its certification program will normally establish the date by which all products certified by that organization should comply with this standard.

History Of Development Of ANSI NGV 2

(This history is informative and is not part of the standard.)

NOTE: This edition of NGV 2 incorporates changes to the 2000 edition and addenda thereto. Changes, other than editorial, are denoted by a vertical line in the margin.

In 1988 a group of U.S. gas utility companies formed the Natural Gas Vehicle (NGV) Coalition (the Coalition) to promote widespread use of natural gas as a vehicle fuel. The Coalition organized committees to address technical, marketing and legislative issues which would affect future expansion.

The Coalition recognized that an important consideration in the successful commercialization of natural gas as a vehicle fuel was the issue of codes and standards (or the lack of codes and standards, or harmonized codes and standards) pertaining to both fuel stations and vehicle fuel systems. The Coalition's Technology Committee undertook the goal of establishing a program for the development of an organized family of coordinated codes, standards and regulations addressing natural gas vehicles and fueling stations.

One of the major technical obstacles to the above goal concerned the on-board fuel container. It was acknowledged that lack of a design standard and certification program for light-weight composite vehicle fuel supply containers was a major obstacle to wider use of compressed natural gas as a vehicle fuel. U.S. Department of Transportation (DOT) regulations and exemptions do not address the use of cylinders as vehicle fuel containers. Such government regulations only cover cylinders which are approved for use in interstate transport.

The Standards and Standardization Subcommittee's On-Board Fuel Containers Working Group established a task group to prepare a draft standard addressing NGV on-board fuel containers.

The Fuel Cylinder Task Group initiated a proposed draft standard for NGV on-board fuel containers, which was (1) based on existing standards, (2) had no limitation on materials or method of construction, (3) considered the internal and external container environment, and (4) incorporated a certification process for design, manufacturing and quality control. The draft standard was initially based on the format of U.S. DOT cylinder regulations and exemptions (e.g., *DOT FRP-1 for Fiber Reinforced, Full Composite Cylinders Using a Seamless Aluminum Liner*).

The draft NGV fuel container standard was processed as an American National Standard under the canvass method in accordance with procedures of the American National Standards Institute (ANSI).

On June 30 1997, the Canadian Standards Association (CSA) acquired International Approval Services (IAS) which was until then a joint venture of the American Gas Association (A.G.A.) and the Canadian Gas Association (CGA). Under this agreement CSA acquired the complete range of IAS standards administration, certification and registration products and services for appliances and accessories fueled by natural and liquefied petroleum gases.

The revisions contained in the third edition of NGV 2-2000 were originally proposed to be published as an "a" addenda to the 1998 edition. In response to industry requests these revisions were incorporated in the base document and were released as a new edition of NGV 2. The third edition of the NGV fuel containers standard was approved by the American National Standards Institute, Inc. on March 3, 2000.

This the fourth edition of the NGV fuel container standard was approved by the American National Standards Institute, Inc. on June 20, 2007.

Previous editions of this standard, and addenda thereto, approved by the American National Standards Institute are as follows:

NGV 2-1992

NGV 2-1998

NGV 2-2000

NGV 2a-2001

The following identifies the designation and year of the fourth edition of the standard:

ANSI NGV 2-2007

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American National Standard For Compressed Natural Gas Vehicle Fuel Containers

1. Scope

1.1 General

This standard contains requirements for the material, design, manufacture and testing of serially produced, refillable Type NGV 2 containers intended only for the storage of compressed natural gas for vehicle operation. These containers are to be permanently attached to the vehicle. Type NGV 2 containers shall not be over 1000 liters (35.4 ft³) water capacity.

Where the word “shall” is used in this standard, it indicates a requirement .

1.2 Container Type

Type NGV 2 containers are designated as follows:

Type 1. Metal.

Type 2. Resin impregnated continuous filament with metal liner with a minimum burst pressure of 125 percent of service pressure. This container is hoop-wrapped.

Type 3. Resin impregnated continuous filament with metal liner. This container is full-wrapped.

Type 4. Resin impregnated continuous filament with a non-metallic liner.

1.3 Alternative Construction or Materials

All specifications as to construction or materials set forth herein may be satisfied by the construction or materials actually prescribed or such other construction or materials as will provide at least equivalent level of performance. Additional tests may be required to evaluate potential failure modes that pertain to the new construction or materials that are not specifically addressed in this standard.

2. Service Conditions

2.1 General

2.1.1

Standard Service Conditions

The standard service conditions specified in this section are provided as a basis for the design, manufacture, inspection, testing, and approval of containers that are to be mounted permanently on vehicles and used to store natural gas for use as a fuel on the vehicles. Containers are intended to be

installed on vehicles in accordance with *The Vehicular Fuel Systems Code, ANSI/NFPA 52, Fuel System Integrity of Compressed Natural Gas Vehicles, FMVSS No. 303, (49CFR571.303), Compressed Natural Gas Fuel Container Integrity, FMVSS No. 304, (49CFR571.304),* or other equivalent standards.

2.1.2

Service Life.

The service life for the container(s) shall be specified by the manufacturer. The specified life shall not be less than ten years or greater than 25 years.

2.1.3

Periodic In-Service Inspections.

Any requirements for periodic re-qualification by inspection or testing during the service life shall be specified by the container designer on the basis of use under service conditions specified herein. Each container shall be visually inspected at least every 36 months, or at the time of any re-installation, for external damage and deterioration.

Prior to visual inspection, the container surface shall be exposed by the removal of protective shields and covers, unless the vehicle or container manufacturer recommends against such removal.

The inspection shall be performed by a qualified container inspector in accordance with (1) the manufacturer's recommendations and (2) the inspection procedures provided in *the Method for External Visual Inspection of Natural Gas Vehicle Fuel Containers and Their Instalations, CGA C-6.4*. Inspections shall be documented by the inspector and the documentation shall be made available to the authority having jurisdiction upon request. Alternatively, containers may be inspected as installed using a non-destructive test method approved by the container manufacturer.

Containers without labels containing mandatory information, or with labels containing mandatory information which is illegible in any way, shall be removed from service. If the container can be positively identified by manufacturer and serial number, a replacement label supplied by the manufacturer may be applied to the container, and it may remain in service.

2.1.4

Conditions Requiring Immediate Inspections

Containers which have been involved in collisions, accidents, fires or other events, for a more comprehensive list see the *Methods for External Visual Inspection of Natural Gas Vehicle Fuel Containers and Their Installations, CGA C-6.4*, that may cause damage shall be subjected to inspection procedures provided in CGA C-6.4. Containers which have not experienced any rejectable damage may be returned to service; otherwise, the container shall be destroyed per CGA C-6.4 or returned to the manufacturer for evaluation.

2.1.5

Overpressurization.

Any container which is believed to have been subjected to a pressure greater than 1.25 times service pressure shall be depressurized and removed from service.

After inspection by an agency authorized by the manufacturer and, if required, by the authority having jurisdiction, the container may be returned to service if it is determined that the container has not suffered any damage that might reduce its service life. A record of any such incident shall be sent to and retained by the manufacturer according to the provisions of Section 13, Record of Manufacture.

2.2 Pressures

2.2.1

Service Pressure

The manufacturer shall specify the Service Pressure of the container.

Note: The service pressures in common usage are 20 700 kPa (3000 psi) and 24 800 kPa (3600 psi) at 21°C (70°F).

2.2.2

Maximum Pressures.

Containers are designed to be filled to a pressure not exceeding any of the following conditions:

- a. A pressure that would settle to 1.0 times the service pressure at a settled temperature of 21°C (70°F);
- b. A settled pressure of 1.25 times the service pressure at 57°C (135°F); or
- c. 1.25 times the service pressure immediately after filling, regardless of temperature.

Note: The fill pressure shall be temperature compensated to prevent pressures from exceeding the maximum pressures that are defined.

2.3 Maximum Number of Filling Cycles

Containers are designed to be filled to pressures not exceeding the requirements of section [2.2.2](#), Maximum Pressures, for a maximum of 750 times the service life of the container in years.

2.4 Temperature Range

2.4.1

Settled Gas Temperatures.

Settled temperature of gas in containers may vary from a low of -40°C (-40°F) to a high of 57°C (135°F).

2.4.2

Container Temperatures.

The temperature of the container materials may vary from -40°C to 82°C (-40°F to 180°F).

2.4.3

Transient Temperatures.

Transient temperatures during filling and discharge may vary beyond the limits described in Section [2.4.1](#), Gas Temperatures, and Section [2.4.2](#), Container Temperatures.

Note: During filling and discharge localized transient gas temperatures of limited duration between -110 °C (148°F) and +90°C (194°F) have been recorded.

2.4.4

Test Temperatures.

Unless otherwise specified, all tests shall be conducted at 24 ± 14°C (75 ± 25°F).

2.5 Gas Composition

Containers made to this standard are designed to be used with gas complying with the *Recommended Practice for Compressed Natural Gas Vehicle Fuel*, SAE J1616, or the *Canadian General Standards Board Standard for Natural Gas for Vehicles*, CGSB 3.513; or an equivalent national standard. Methanol and/or glycol shall not be deliberately added to the natural gas at the fueling station. Recognizing that the gas supplied to the vehicle may not always be in compliance with these documents, containers should be designed to tolerate being filled with natural gas meeting both of the following conditions:

- a. Dry Gas - Water vapor would normally be limited to less than 32 mg/m³ (2 lbs/MMscf), a pressure dewpoint of -9°C (16°F) at 20 700 kPa (3,000 psi). There would be no maximum constituent limits for dry gas, except for:
 1. Hydrogen Sulfide.....23 mg/m³
 2. Oxygen 1.0 percent by volume
 3. Hydrogen 2.0 percent by volume
- b. Wet Gas - Gas that contains 32 mg/m³ (2 lbs/MMscf) of water or more normally meets the following maximum constituent limits:
 1. H₂S and other soluble sulfides.....23 mg/m³ (1 gr/100scf)
 2. Total Sulfur 115 mg/m³ (5 gr/MMscf)
 3. Oxygen 1 percent by volume
 4. CO₂ 3 percent by volume
 5. Hydrogen 0.1 percent by volume

Under wet gas conditions, a minimum of 1 mg of compressor oil per kilogram of gas (0.007 grains of compressor oil per pound of gas) is necessary to protect metallic containers, liners, and bosses.

2.6 External Surfaces

Container external surfaces shall be designed to be resistant to environmental conditions outlined in [Section 16.4, Environmental Test](#). Containers are not designed for exposure to leakage from cargo that may be carried on vehicles.

2.7 Gas Permeation

Containers may be located in enclosed spaces for extended periods of time. Permeation of gas from the container shall be considered in the design, as outlined in [Section 16.12, Permeation Test](#).

2.8 Installation Requirements

The installer shall be responsible for the protection of container valves, pressure relief devices, and connections as required by the Standard for *Vehicular Fuel Systems Code*, ANSI/NFPA 52, or the Standard for *Natural Gas For Vehicles Installation Code*, CAN/CGA-B109; *Fuel System Integrity of Compressed Natural Gas Vehicles*, or *Transport Canada/TC, Motor Vehicle Safety Regulations*, FMVSS No. 303; *Section 301.2 of Schedule*

IV, "CNG Fuel System Integrity." If this protection is mounted to the container, the design and method of attachment shall be approved by the container manufacturer. Factors to be considered include the ability of the container to support the transferred impact loads and the effect of local stiffening on container stresses and fatigue life.

Containers shall be protected from accidental cargo spillage and from mechanical damage. This standard contains no requirements for container integrity in a vehicle collision. Container locations and mountings should be designed to provide adequate impact protection to prevent container failure in a collision.

3. Compliance

3.1 General

Compliance is required in all details, without exception. If there is evidence of a fault in carrying out a test or an error in measurement, another test shall be performed. If the results of this test are satisfactory, the results of the prior test shall not be a basis for rejection.

3.2 Retroactivity

Containers qualified under previous edition(s) of this standard may remain in service for their designated lifetime.

4. Material Qualification Tests And Requirements

4.1 General

All structural materials shall be traceable to their original manufacturer's certified test reports. The materials shall be of uniform quality. Materials not in compliance with the manufacturer's design specifications are not authorized.

Materials shall be selected according to the following criteria (See 4.2. Metal Containers and Metal Liners, through [4.7, Bosses for Type 4 Containers](#)).

4.2 Metal Containers and Metal Liners

4.2.1

Material Properties.

Steels shall be aluminum killed and produced to predominantly fine grain practice. The chemical composition of all steels shall be declared and defined at least by:

- a. Carbon, manganese, aluminum, and silicon contents in all cases, and
- b. Nickel, chromium, molybdenum, boron, vanadium, or any other elements that are deliberately added.

The following limits shall not be exceeded in the cast analysis:

	For Steels with Tensile Strength	
	950 MPa (135 Ksi) or less	Greater than 950 MPa (135 Ksi)
Sulfur	0.020%	0.010%
Phosphorus	0.020%	0.015%
Sulfur and Phosphorus	0.030%	0.020%

Aluminum alloys shall be quoted in line with Aluminum Association practice for a given alloy system. The impurity limits for lead and bismuth in any aluminum alloy shall not exceed 0.010 percent. Excess silicon 6xxx series aluminum alloys with yield strengths above 250 MPa (36,250 psi) (e.g., 6351 and 6082) shall not be used in fuel containers or liners.

4.2.2

Impact Test for Steel.

The impact properties of the steel in the finished container or liner shall be determined in general accordance with The *Charpy Impact Test (V-Notch)*, ISO 148, or *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*, ASTM E23. The impact test pieces shall be taken from the wall of the container in the transverse direction. The notch plane orientation shall be in the CL direction (i.e. perpendicular to the circumference and along the length). Test pieces with a width of less than 5 mm (0.2 in) shall be taken from the longitudinal direction. If the wall thickness does not permit a final test piece width of 10 mm (0.4 in), the width shall be as near as practicable to the nominal thickness of the container wall. All impact tests shall be conducted at -40°C (-40°F). Impact values shall not be less than that indicated as follows:

Width of test piece (mm)	5.0 - 7.5	7.5 - 10.0
(in)	0.2 - 0.3	0.3 - 0.4
Impact Strength - (J/cm ²)	44	50
(ftlb/in ²)	210	240

- Impact values for test pieces of width less than 5 mm (0.2 in) shall be based on special studies of particular materials and particular specimens.
- Required average results of three specimens.
- Not more than one specimen shall break at less than the average value required and no single specimen shall break at less than 80 percent of the average value.

4.2.3

Sulfide Stress Cracking Resistance for Steels.

The ultimate tensile strength of the steel from a finished container shall not exceed 1200 MPa (175,000 psi). If the upper limit of the ultimate tensile strength exceeds 950 MPa (138,000 psi), the steel shall be tested in accordance with the procedures described in Method A - NACE Standard Tensile Test of NACE Standard for *Laboratory Testing of Metals for Resistan*, TM0177-96, except as noted in this section. Tests shall be conducted on tensile specimens with a gauge diameter of 3.81 mm (0.150 in) machined from the wall of a finished container or liner. The specimens shall be placed under a constant tensile load equal to 60 percent of the specified minimum yield strength of the steel, immersed in a solution of distilled water buffered with 0.5 percent (wt/wt) sodium acetate trihydrate and adjusted to an initial pH of 4.0 using acetic acid. The solution shall be continuously saturated at room temperature and pressure with 0.414 kPa

(0.06 psia) hydrogen sulfide (balance nitrogen). Three specimens shall be tested and none shall fail within the 144 hour duration of the test. Specimens that fail outside the gauge length are considered invalid tests.

4.2.4

Tensile Tests for Metals.

Tensile strength methods shall be as prescribed by the *Standard Test Methods for Tension Testing of Metallic Materials (Metric)*, ASTM E8, and shall meet the requirements of the designs. Alternatively, tensile tests shall be carried out in accordance with *Gas Cylinders - Refillable Seamless Steel Gas Cylinders - Design, Construction and Testing, ISO 9809-1, - Part 1: Quenched and Tempered Steel Cylinders with Tensile Strength Less Than 1100 MPa*, for steels, and *Gas- Cylinders-Refillable Seamless Aluminum Alloy Gas Cylinders, ISO 7866, —Design, Construction and Testing*, for aluminum.

4.2.5

Sustained Load Cracking (SLC) Test for Aluminum.

The resistance to SLC shall be determined in accordance with Annex B of *Gas Cylinders, Refillable Seamless Aluminum Alloy Gas Cylinders, ISO 7866, —Design, Construction and Testing*, and shall meet the requirements therein.

4.2.6

Corrosion Tests for Aluminum.

Corrosion tests for aluminum alloys shall be carried out in accordance with Annex A of *Gas Cylinders, Refillable Seamless Aluminum Alloy Gas Cylinders, ISO 7866, —Design, Construction and Testing*, and shall meet the requirements therein.

4.3 Ultraviolet Resistance of External Coatings

Protective coatings required to meet [Section 16.4, Environmental Test](#), shall be evaluated for resistance to ultraviolet effects using a minimum 1000 hours exposure using a UVA 340 lamp in accordance with Standard Practice for *Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials, ASTM G154*. There shall be no evidence of blistering, cracking, chalking or softening.

4.4 Fibers

Structural reinforcing filament material types shall be glass fiber, aramid fiber or carbon fiber. If carbon fiber reinforcement is used, the design shall incorporate means to prevent galvanic corrosion of metallic components of the fuel container.

4.5 Resins

The material for impregnation may be thermosetting or thermoplastic resin. Examples of suitable matrix materials are epoxy, modified epoxy, polyester and vinylester thermosetting plastics, and polyethylene and polyamide thermoplastic material. Resin system materials shall be tested on a sample test panel, representative of the composite overwrap, in accordance with *Standard Test Method for Short-Beam Polymer Matrix Composites Materials and Their Laminates, ASTM D2344*. Following a 24 hour water boil, the composite shall have a minimum shear strength of 13.8 MPa (2000 psi).

4.6 Nonmetallic Liners (Type 4)

The nonmetallic liner material shall be compatible with the service conditions specified in Section 4, Service Conditions.

The tensile yield strength and ultimate elongation shall be determined in accordance with *Standard Test Method for Tensile Properties of Plastics, ASTM D638*. Tensile or impact testing shall be conducted on samples of the nonmetallic liner material to demonstrate that the material fails in a ductile, rather than brittle, mode at temperatures down to and including -50°C (-58°F).

The softening temperature shall be at least 90°C (194°F), and the melting temperature at least 100°C (212°F), when tested in accordance with the method described in *Plastics - Thermoplastic Materials - Determination of Vicat Softening Temperature, ISO 306*, or using an equivalent alternative method.

4.7 Bosses for Type 4 Containers

Materials shall be compatible with the liner and the intended environment and shall be resistant to stress corrosion cracking.

Acceptable materials include steel alloys, stainless steel alloys, nickel alloys, and aluminum alloys. Steel and stainless steel alloys shall meet the requirements of Section 4.2.3, Sulfide Stress Cracking Resistance for Steel. Austenitic stainless steels shall be tested for resistance to chloride stress corrosion cracking.

Aluminum alloys must meet the requirements of Sections 4.2.5, Sustained Load Cracking (SLC) Test for Aluminum, and 4.2.6, Corrosion Tests for Aluminum.

5. Wall Thickness

5.1 Type 1 Containers

The minimum wall thickness shall be sufficient to comply with all applicable qualification tests within this specification. Welded Type 1 Containers shall have a minimum burst/service pressure ratio of 3.5.

5.2 Liners for Type 2, Type 3, and Type 4 Containers

Minimum thickness of the liner shall be such that the required qualification test requirements of this specification are met.

5.3 Composite Reinforcement for Type 2, Type 3, and Type 4 Containers

5.3.1

Stress Analysis.

Stresses in the liner and composite reinforcement shall be computed using suitable analysis techniques which have been demonstrated to adequately predict the stresses and strains in both the liner and the composite overwrap at the following pressures: autofrettage, zero (after autofrettage), service, hydrostatic, and minimum burst.

5.3.2

Stress Ratios.

The composite overwrap shall be designed for high reliability under sustained loading and cyclic loading. This reliability shall be achieved by meeting or exceeding the following composite reinforcement stress ratio values shown below.

Material	Stress Ratio		
	Type 2	Type 3	Type 4
E-Glass	2.65	3.5	3.5
S-Glass	2.65	3.5	3.5
Aramid	2.25	3.0	3.0
Carbon	2.25	2.25	2.25

5.3.3

Modified Stress Ratio Test

At the option of the manufacturer, or for designs in which the required minimum container burst pressure may not be sufficient to cause tensile failure in the fiber, a modified burst test procedure may be used to verify that the fiber stress ratio at service pressure is achieved. The stress ratio requirements (2.65) for E-glass and S-glass, reinforced Type 2 containers, may be demonstrated by meeting a minimum hold time at a specified pressure during the burst tests conducted under [Section 11.5, Burst Test](#), or 11.3, Hydrostatic Burst Test. Acceptable alternative combinations of hold times and pressures are as follows:

1 minute at 2.50 times service pressure; or

1 hour at 2.25 times service pressure.

As an alternative, the strength of the fiber may be verified by the testing of containers, with the composite thickness reduced by no more than 50 percent, to assure failure initiation in the composite.

5.3.4

Hybrid Designs.

Hybrid construction (using more than one type of reinforcing fiber) is permitted. The strength of the individual types of fibers used in hybrid construction may be verified by testing of containers reinforced with a single type of fiber. In a hybrid construction, the applicable stress ratio requirements must be met in one of the two following ways:

- If load sharing between the various fiber reinforcing materials is considered a fundamental part of the design, each fiber must meet the stated stress ratio requirements.
- If load sharing between fibers is not considered as a fundamental part of the design, then one of the reinforcing fibers must be capable of meeting the stress ratio requirements even if all other fiber reinforcing materials are removed.

5.4 External Loads on Containers

Containers with greater than 450 liters (15.93 ft³) water capacity and all containers employing integral mounts or valve protection (as permitted by [Section 8.9, Mounting and Protection](#)), shall consider the external loads imposed on the container as a function of the service conditions and mounting provisions. This would include bending and torsional stresses.

6. Threaded Openings

Threads shall be clean cut, even, and to gauge.

All threads shall comply with a recognized international or national standard.

Tapered threads are only permitted on steel containers, steel liners and steel bosses.

7. Inspection Requirements

7.1 Inspection During Qualification

All design qualification tests shall either be conducted or witnessed by a representative of a nationally recognized testing agency or an independent inspection agency. The nationally recognized testing agency shall be accredited [e.g., by the American National Standards Institute (ANSI), or the Standards Council of Canada (SCC)]. The independent inspection agency shall comply with the requirements of Section 15.2(a) [Independent Inspection (Option 2)]. Chemical analysis and tests as specified shall be made within the United States or Canada unless otherwise approved in writing by the approving agency or independent agency.

7.2 Inspection During Manufacturing

If the manufacturer's quality system is approved in accordance with Section 15.1, Quality Assurance, General, - Option 1 (Approved Quality System), the manufacturer may perform all inspections and verifications during manufacturing, subject to monitoring by the accredited registrar.

If the manufacturer's quality system is in accordance with Section 15.1, Quality Assurance, General, - Option 2 (Independent Inspection) and section 15.2, Quality Assurance, Independent Inspection, all inspections and verifications during manufacturing must be performed by a representative of a qualified independent inspection agency. The independent inspection agency shall comply with the requirements of Section 15.2(a) [Independent Inspection (Option 2)].

7.2.1

Duties of Inspector During Manufacturing.

7.2.1.1

Duties Performed by All Manufacturing Inspectors.

The following duties apply during manufacture to the inspectors employed by a manufacturer with an approved quality system in accordance with Section 15.1, Quality Assurance, General, - Option 1 (Approved Quality System), or to third party inspectors employed by manufacturers operating quality systems in accordance with Section 15.1, Quality Assurance, General, - Option 2 (Independent Inspection) and 15.2, Quality Assurance, Independent Inspection.