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Certificate of Registration

This is to certify that: Taylor Wharton Cylinders, 9th and Herr St., Harrisburg, PA U.S.A. pursuant to its application on file with Transport Canada has been granted the registration No. M25 in accordance with the provisions of Special Permit No. 3263 and section 25 of CAN/CSA B339-88 for the purpose of manufacturing compressed gas cylinders under the following limitations:

- 1) The cylinders shall be manufactured in complete accordance with specification 3AA, part 78 of the "Regulations for the Transportation of Dangerous Commodities by Rail", or with the requirements prescribed in appendices "A" or "B" to this certificate.
- 2) The cylinders shall be in accordance with the drawings indicated in the revised list dated August 20, 1990 and corresponding designs and additional information provided with previous applications on file with this Directorate.
- 3) The manufacturing must be supervised by a duly authorized Independent Inspection Agency under inspection procedures conforming to the prescribed requirements and filed with this Directorate.
- 4) The manufacturer's symbol to be marked on the cylinders shall be either "M25" or a symbol prescribed by the U.S. Department of Transportation or any other acceptable mark registered with this Directorate.
- 5) Within two years after the Registration date of this certificate, a quality assurance manual shall be submitted to the Director. The manual shall indicate that the operations in the plant are in accordance with CAN3-Z299.3-85 standard or equivalent.

Not later than 20 days after any changes occur in the information submitted in support of the application, the holder shall advise this Directorate of any such changes.

Failure to comply with the above mentioned requirements or any applicable regulations may result in the suspension or revocation of this certificate of registration.

This Certificate of Registration shall expire on: August 30, 1995 or on such previous date as this Directorate may decide.

Registration Date: Sept 7/90 signed: Jean Bouchard for JRM,
Director, Regulatory Requirements
Transport Dangerous Goods Directorate



Canada


APPENDIX "A" TO CERTIFICATE OF REGISTRATION NO. M25

The following requirements apply to cylinders made in accordance with Taylor Wharton's application and drawing 38380 and additional design and performance data on file with this Directorate.

The cylinders shall comply with CTC specification 3AA except as follows:

1. Compliance and lot definition.
 - (a) Compliance required in all details.
 - (b) Lot definition. In this Appendix, a "lot" means a group of cylinders successively produced and having the same:
 - (1) Size and configuration;
 - (2) Specified material of construction;
 - (3) Process of manufacture and heat treatment;
 - (4) Equipment of manufacture and heat treatment;
 - (5) Conditions of time, temperature and atmosphere during heat treatment.

In no case may the lot size exceed 200 cylinders, but any cylinder processed for use in the required destructive testing need not be counted as being one of the 200.

2. Type, size and service pressure.
 - (a) Seamless, 8.75 inches nominal inside diameter, .260 inch minimum wall thickness, 120 pounds maximum water capacity, 4500 psig maximum service pressure. 
 - (b) Not applicable.

4. Duties of Inspector.

Add: (c)(1) The fracture toughness test need not be witnessed by the Inspector provided the test is performed by a facility specifically identified to and acknowledged in writing by this Directorate and a certified report of test results is furnished by the test facility.

(e) Verify that design qualification tests have been performed with satisfactory results.

5. Authorized steel.

(a) Basic oxygen or electric furnace steel of uniform quality is authorized. The steel analysis must be in conformance with the following:

CHEMICAL COMPOSITION IN WEIGHT PERCENT

<u>Element</u>	<u>Ladle Analysis</u>	<u>Check Analysis Tolerance</u>	
		<u>Under</u>	<u>Over</u>
Carbon	.32/.36	0.01	0.02
Manganese	.60/.90	0.03	0.03
Phosphorus	.025 Max.	--	0.01
Sulphur	.010 Max.	--	0.00
Silicon	.15/.35	0.02	0.03
Chromium	.80/1.10	0.03	0.03
Molybdenum	.15/.25	0.01	0.01
Vanadium	.07/.100	0.01	0.01
Aluminum	.01/.05	--	0.00
Copper	.20/Max.	--	0.00

Note 1: Steel shall be treated with calcium to provide the following J-K microcleanliness rating per ASTM Standard E-45, Method A.

<u>A (Sulfides)</u>		<u>B (Alumina)</u>		<u>C (Silicates)</u>		<u>D (Oxides)</u>	
<u>Thin</u>	<u>Heavy</u>	<u>Thin</u>	<u>Heavy</u>	<u>Thin</u>	<u>Heavy</u>	<u>Thin</u>	<u>Heavy</u>
2.0	1.5	2.0	1.0	1.0	0.5	2.5	1.5

Certificate from the material manufacturer must certify that the material was calcium treated and must include in such certification the J-K microcleanliness rating for each heat of steel.

Note 2: Steel shall be aluminum killed and made by a fine grain deoxidation practice.

8. Manufacture.

- (a) * * *. Metal removal for any purpose other than removal of isolated defects and ~~threading~~ must be done prior to hydrostatic and ultrasonic tests. The thickness of treated areas must be measured and may not be less than the minimum prescribed thickness.
- (b) Each cylinder must be of seamless construction manufactured by the backward extrusion method with integrally formed heads and bottoms.
- (c) The thickness of the bottoms of cylinders is, under no condition, to be less than two times the minimum wall thickness of the cylindrical shell; such bottom thickness to be measured within an area bounded by a line representing the points of contact between the cylinder and floor when the cylinder is in a vertical position.
- (d) Shape and thickness of the cylinder bottom and sidewall adjacent to the bottom must be such that failure during the cyclic pressure test occurs in the sidewall of the cylinder.
- (e) The design authorized herein must be qualified for production by subjecting at least three prototype samples to pressure cycling test and burst tests as follows.

- (1) Cycle test. The cycle test must be performed on the completed cylinder after hydrostatic test by subjecting the cylinder to successive hydrostatic pressurization from the lower cyclic pressure to the upper cyclic pressure at a rate not to exceed 10 cycles per minute. Adequate recording instrumentation shall be provided if equipment is to be left unattended for any period of time. Lower cyclic pressure must not exceed 10 percent of the upper cyclic pressure. Upper cyclic pressure must be at least equal to the minimum prescribed test pressure.
- (2) Burst Pressure Test. The burst pressure test must be performed on the completed cylinder by hydrostatic pressurizing the cylinder to destruction. Rate of pressurization must not exceed 200 psi per second.

9. Welding or brazing.

Welding or brazing for any purpose whatsoever is prohibited.

10. Wall thickness.

- (a) The minimum wall thickness must be such that the wall stress at the minimum specified test pressure does not exceed 67 percent of the minimum tensile strength of the steel as determined by the prescribed mechanical tests. A wall stress of more than 104,000 psi is not permitted. In no case may wall thickness be less than .260 inch.

- (b) Calculation must be made by the formula:

$$S = P(1.3D^2 + 0.4d^2)/(D^2 - d^2)$$

where

S = wall stress in pounds per square inch;
 P = minimum test pressure, at least $3/2$ service pressure;
 D = outside diameter in inches;
 d = inside diameter in inches.

11. Heat treatment.

- (a) The completed cylinder must be uniformly and properly heat treated prior to tests. Heat treatment of cylinders shall be as follows:
- (1) The furnace shall be equipped with recording infrared pyrometers capable of determining cylinder temperature in both the austenitizing and tempering sections at the beginning and end of each soak zone. The furnace should have fault controls providing uniform temperature in each control zone and proper function of the feed mechanism.
 - (2) Each cylinder must be treated and held above the upper critical temperature (Ac_3) for at least one hour per inch of thickness based on the maximum thickness of the cylinder and then quenched in a suitable liquid medium having a cooling rate not in excess of 80 percent of water. The steel temperature on quenching must be above the Ac_3 temperature, but not higher than $1700^{\circ}F$.
 - (3) After quenching, each cylinder must be reheated to a temperature below the transformation range but not less than $1100^{\circ}F$, and must be held at this temperature for at least one hour per inch of thickness based on the maximum thickness of the cylinder. Each cylinder must then be air cooled.

12. Openings.

- (b) All openings must be threaded. Threads must be in compliance with the following:
- (1) Each thread must be clean cut, even, without checks, and to gauge.
 - (2) Taper threads, when used, must be in compliance with one of the following.
 - (i) American Standard Pipe Thread (NPT) type must be in compliance with the requirements of Federal Standard H-28 (1978), Section 7.

(ii) National Gas Taper Thread (NGT) type must be in compliance with the requirements of Federal Standard H-28 (1978), Sections 7 and 9.

(iii) Other taper threads in compliance with other standards may be used provided the length is not less than that specified for NPT threads.

(3) Straight threads when used must be in compliance with one of the following:

(i) National Gas Straight Thread (NGS) type must be in compliance with the requirements of Federal Standard H-28 (1978), Sections 7 and 9.

(ii) Unified Thread (UN) type must be in compliance with the requirements of Federal Standard H-28 (1978), Section 2.

(iii) Controlled Radius Root Thread (UNJ) type must be in compliance with the requirements of Federal Standard H-28 (1978), Section 4.

(iv) Other straight threads in compliance with other recognized standards may be used provided that the requirements in (4) below are met.

(4) All straight threads must have at least 6 engaged threads, a tight fit, and a factor of safety in shear of at least 10 at the test pressure of the cylinder. Shear stress must be calculated by using the appropriate thread shear area in accordance with Federal Standard H-28 (1978), Appendix A5, Section 3.

13. Pressure relief devices and protection for valves and pressure relief devices.

(a) Must be as required by Sections 73.34(d) and 73.301(g)

(b) Pressure relief devices must be in compliance with Section 73.302(c)(1) except as follows:

(i) Cylinders charged with gas mixtures containing gas requiring placards with a square background must not be equipped with any pressure relief device.

- (ii) Cylinders charged with gas mixtures containing no gas requiring placards with a square background may be equipped with a combination rupture disk and fusible plug pressure relief device in compliance with CGA Pamphlet S-1.1.

14. Hydrostatic test.

- (a) Applies except water jacket method only is authorized.
- (b) * * *
- (c) * * *
- (d) Each cylinder must be tested to at least $3/2$ times service pressure.
- (e) A rejection elastic expansion limit (REE) must be developed as specified in CGA Pamphlet C-5. If the elastic expansion of any cylinder, at test pressure, exceeds the limit so developed, that cylinder must be rejected.

15. Toughness and ductility tests.

- (a) Fracture toughness test. At least two plane-strain fracture toughness KIC data point shall be obtained on one cylinder after heat treatment taken from each heat of steel. The valid KIC data shall be obtained via the J-integral test method prescribed in ASTM Standard E813. The specimen shall be so tested at room temperature in the TL orientation as defined in ASTM Standard E399. The specimen must be prepared only from material removed from the cylindrical portion of the cylinder. Flattening of the material without heating is allowed for preparing the test specimens.
- (b) Flattening test. Between knife edges, wedge shaped, 60-degree angle, rounded to $\frac{1}{4}$ inch radius; test 1 cylinder taken at random out of each lot of 200 or less cylinders. Longitudinal axis of the cylinder must be at approximately a 90-degree angle to knife edges.

(c) Impact tests.

(1) Three Charpy impact specimens must be tested from one heat-treated cylinder taken from each 500 or less successively produced.

(2) Each impact specimen must be Charpy V-notch type size 10mm X 4mm or 10mm X 5mm taken in accordance with ASTM Standard A-370-77.

(3) Each specimen must be taken from the sidewall of the cylinder. The longitudinal axis of the specimen must be at 90 degrees to the longitudinal axis of the cylinder.

(d) Hardness measurement. A hardness measurement must be performed on the cylindrical section of each cylinder after heat treatment.

(e) Flawed cylinder pressure test. One cylinder must be selected from each heat of steel and subjected to a preflaw pressure test. A sharp part through longitudinal flaw must be introduced into the test cylinder by a means that will not affect the mechanical or metallurgical properties of the cylinder. The flaw must be at least 2-inches long and have a depth that will cause the cylinder to fail when pressurized to not less than 90 percent and not more than 125 percent of the stress at service pressure. The cylinder must be hydrostatically pressurized to failure at a rate not in excess of 200 psi per second.

17. Ultrasonic examination.

(a) Each cylinder shall be examined after heat treatment by shear wave ultrasonic equipment which has been calibrated to give an indication greater than the equivalent of a 5% of wall thickness by 1" long notch. Procedures must be in accordance with ASTM E-213-83, and supplements S1.1 and S2, using the immersion method.

18. Acceptable results of tests and inspections.

- (a) Fracture toughness test. Each K_{1C} value must be at least 85 ksi in $\frac{1}{4}$.
- (b) Flattening test. Flattening required without cracking to 10 times wall thickness. Maximum degree of flattening attained without cracking must be entered on the inspector's report.
- (c) Impact tests. The Charpy V-notch impact properties for the three impact specimens which must be tested at 0.0°F or colder must not be less than the values shown below:

<u>Size</u> <u>(mm)</u>	<u>Avg. value for</u> <u>acceptance 3</u> <u>specimens</u>	<u>Min. value</u> <u>1 specimen only</u> <u>of the three</u>
10 X 5 or 10 X 4	13.0 ft. lbs.	10.0 ft. lbs.

- (d) Hardness measurement. The tensile strength equivalent of the hardness number obtained may not be more than 182,000 psi; Rc 40 (Brinell 371). When the result of a hardness test exceeds the maximum permitted, two or more retests may be made; however, the hardness number obtained in each retest may not exceed the maximum permitted.
- (e) Flawed cylinder pressure test. The failure must be by leakage without crack extension, or by plastic fracture with visible evidence of bulging.
- (f) Mechanical tests.
- (1) Tensile strength at least 155,000 psi and not more than 175,000 psi.
- (2) Elongation at least 12 percent for gauge length 2 inches with width not over $1\frac{1}{4}$ inches.
- (g) Ultrasonic examination. Any cylinder having a discontinuity greater than the equivalent of a 5 percent of wall thickness by 1 inch long notch must be rejected.

7, 1590 (f)
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- (h) Cycle test. Cylinders subjected to design qualification cycling test must withstand at least 10,000 cyclic pressurizations without distortion or failure. At least one cylinder must be cycled using water as the pressurizing medium.
- (i) Burst tests. Cylinders subjected to design qualification burst tests must withstand a pressure of at least 2.25 times the service pressure without failure. Failure must initiate in the sidewall in a longitudinal direction, and the cylinder must remain in one piece.

19. Rejected cylinders.

- (a) Fracture toughness test. Reheat treatment authorized; subsequent thereto, acceptable cylinders must pass all prescribed tests.
- (b) Flattening test. Reheat treatment authorized; subsequent thereto, acceptable cylinders must pass all prescribed tests.
- (c) Impact tests. Reheat treatment authorized; subsequent thereto, acceptable cylinders must pass all prescribed test.
- (d) Hardness measurement. Rejected cylinders may be reheat treated; subsequent thereto, acceptable cylinders must pass all prescribed tests.
- (e) Flawed cylinder pressure test. Reheat treatment authorized; subsequent thereto, acceptable cylinders must pass all prescribed tests.
- (f) Mechanical tests. Reheat treatment authorized; subsequent thereto, acceptable cylinders must pass all prescribed tests.
- (g) Ultrasonic examination. Rejected cylinders may be requalified subject to the conditions prescribed in this Appendix.

*4
reheat only*

*7 cylinder re-qual.
no metal removed
Reheat follows a test
UT after hydro*

20. Marking.**(a) * * ***

- (1) "TC SP 3263-M25A" in lieu of "CTC 3AA" followed by the service pressure.

Note: This sequence can be placed before the prescribed DOT markings.

- (2) Not applicable.
- (3) A serial number and the manufacturer's symbol.
- (4) * * *
- (5) Rejection elastic expansion (REE) in cubic centimeters near the date of test.

22. Inspector's report.

Applies except that "CTC 3AA" shall be replaced by "TC SP 3263-M25A".

SPECIAL REQUIREMENTS

- (a) The cylinders shall be maintained and used in accordance with applicable sections of the "Regulations for the Transportation of Dangerous Commodities by Rail" and filled only with gases authorized in CTC 3AA specification cylinders except for the following:
- (1) Hydrogen, compressed natural gas, hydrogen sulphide, or carbon monoxide;
 - (2) Any gas mixture containing hydrogen sulphide or other free sulphides, or containing hydrogen or compressed gas;
 - (3) Any gas mixture containing more than ten percent (10%) carbon monoxide;
 - (4) Any gas mixture containing carbon monoxide and having a dew point of minus 52°F or higher at one (1) atmosphere;
 - (5) Any gas or mixture of gases which does not remain in a gaseous state when contained in the cylinder at filling pressure of 70°F; and
 - (6) Any mixture of gases, the quantity of one or more of which is capable of combining chemically with other gases in such mixture or of combining chemically with the cylinder steel so as to significantly reduce the effectiveness of the cylinder.
- (b) Reports
- (1) Prior to the initial shipment of cylinders made to any specific design, a report of the qualification test results shall be submitted to the Director, Regulatory Requirements.
 - (2) The maker of the cylinder under this specification must retain the test reports required by this specification indefinitely as long as these cylinders are authorized.
 - (3) These cylinders may not be used for carriage of gases that would cause hydrogen embrittlement of the steel.

- (4) Filling limits specified in Section 73.302(c) are not authorized. Under no circumstances are these cylinders to be filled to a pressure exceeding the marked service pressure at 70°F.
- (5) A copy of the Inspector's report for each lot produced, shall be submitted to the Director, Regulatory Requirements.
- (6) Each cylinder must be requalified for use every five years in accordance with Section 73.34 as prescribed for CTC-3AA. Cylinders requalified after having been subjected to the action of fire, must be reported to the Director, Regulatory Requirements prior to being placed back in service.
- (7) The Director, Regulatory Requirements shall be advised of any change in design of the cylinder.
- (8) The Director, Regulatory Requirements shall be advised of any incident involving loss of contents and shall be provided with a summary of experience on a yearly basis.

APPENDIX "B" TO CERTIFICATE OF REGISTRATION NO. M25

The following requirements apply to cylinders made in accordance with Taylor Wharton's application and drawing 38385 and additional design and performance data on file with this Directorate.

The cylinders shall comply with CTC specification 3AA except as follows:

1. Compliance and lot definition.

- (a) Compliance required in all details.
- (b) Lot definition. In this Appendix, a "lot" means a group of cylinders successively produced and having the same:
 - (1) Size and configuration;
 - (2) Specified material of construction;
 - (3) Process of manufacture and heat treatment;
 - (4) Equipment of manufacture and heat treatment;
 - (5) Conditions of time, temperature and atmosphere during heat treatment.

In no case may the lot size exceed 200 cylinders, but any cylinder processed for use in the required destructive testing need not be counted as being one of the 200.

2. Type, size and service pressure.

- (a) Seamless, 8.50 inches nominal inside diameter, .339 inch minimum wall thickness, 120 pounds maximum water capacity, 6000 psig maximum service pressure.
- (b) Not applicable.

4. Duties of Inspector.

Add: (c)(1) The fracture toughness test need not be witnessed by the Inspector provided the test is performed by a facility specifically identified to and acknowledged in writing by this Directorate and a certified report of test results is furnished by the test facility.

(e) Verify that design qualification tests have been performed with satisfactory results.

5. Authorized steel.

(a) Basic oxygen or electric furnace steel of uniform quality is authorized. The steel analysis must be in conformance with the following:

CHEMICAL COMPOSITION IN WEIGHT PERCENT

<u>Element</u>	<u>Ladle Analysis</u>	<u>Check Analysis Tolerance</u>	
		<u>Under</u>	<u>Over</u>
Carbon	.32/.36	0.01	0.02
Manganese	.60/.90	0.03	0.03
Phosphorus	.025 Max.	--	0.01
Sulphur	.010 Max.	--	0.00
Silicon	.15/.35	0.02	0.03
Chromium	.80/1.10	0.03	0.03
Molybdenum	.15/.25	0.01	0.01
Vanadium	.07/.100	0.01	0.01
Aluminum	.01/.05	--	0.00
Copper	.20/Max.	--	0.00

Note 1: Steel shall be treated with calcium to provide the following J-K microcleanliness rating per ASTM Standard E-45, Method A.

<u>A (Sulfides)</u>		<u>B (Alumina)</u>		<u>C (Silicates)</u>		<u>D (Oxides)</u>	
<u>Thin</u>	<u>Heavy</u>	<u>Thin</u>	<u>Heavy</u>	<u>Thin</u>	<u>Heavy</u>	<u>Thin</u>	<u>Heavy</u>
2.0	1.5	2.0	1.0	1.0	0.5	2.5	1.5

Certificate from the material manufacturer must certify that the material was calcium treated and must include in such certification the J-K microcleanliness rating for each heat of steel.

Note 2: Steel shall be aluminum killed and made by a fine grain deoxidation practice.

8. Manufacture.

- (a) * * *. Metal removal for any purpose other than removal of isolated defects and threading must be done prior to hydrostatic and ultrasonic tests. The thickness of treated areas must be measured and may not be less than the minimum prescribed thickness.
- (b) Each cylinder must be of seamless construction manufactured by the backward extrusion method with integrally formed heads and bottoms.
- (c) The thickness of the bottoms of cylinders is, under no condition, to be less than two times the minimum wall thickness of the cylindrical shell; such bottom thickness to be measured within an area bounded by a line representing the points of contact between the cylinder and floor when the cylinder is in a vertical position.
- (d) Shape and thickness of the cylinder bottom and sidewall adjacent to the bottom must be such that failure during the cyclic pressure test occurs in the sidewall of the cylinder.
- (e) The design authorized herein must be qualified for production by subjecting at least three prototype samples to pressure cycling test and burst tests as follows.

- (1) Cycle test. The cycle test must be performed on the completed cylinder after hydrostatic test by subjecting the cylinder to successive hydrostatic pressurization from the lower cyclic pressure to the upper cyclic pressure at a rate not to exceed 10 cycles per minute. Adequate recording instrumentation shall be provided if equipment is to be left unattended for any period of time. Lower cyclic pressure must not exceed 10 percent of the upper cyclic pressure. Upper cyclic pressure must be at least equal to the minimum prescribed test pressure.
- (2) Burst Pressure Test. The burst pressure test must be performed on the completed cylinder by hydrostatic pressurizing the cylinder to destruction. Rate of pressurization must not exceed 200 psi per second.

9. Welding or brazing.

Welding or brazing for any purpose whatsoever is prohibited.

10. Wall thickness.

- (a) The minimum wall thickness must be such that the wall stress at the minimum specified test pressure does not exceed 67 percent of the minimum tensile strength of the steel as determined by the prescribed mechanical tests. A wall stress of more than 104,000 psi is not permitted. In no case may wall thickness be less than .339 inch.

- (b) Calculation must be made by the formula:

$$S = P(1.3D^2 + 0.4d^2)/(D^2 - d^2)$$

where

S = wall stress in pounds per square inch;
 P = minimum test pressure, at least $\frac{3}{2}$ service pressure;
 D = outside diameter in inches;
 d = inside diameter in inches.

11. Heat treatment.

- (a) The completed cylinder must be uniformly and properly heat treated prior to tests. Heat treatment of cylinders shall be as follows:
 - (1) The furnace shall be equipped with recording infrared pyrometers capable of determining cylinder temperature in both the austenitizing and tempering sections at the beginning and end of each soak zone. The furnace should have fault controls providing uniform temperature in each control zone and proper function of the feed mechanism.
 - (2) Each cylinder must be treated and held above the upper critical temperature (Ac3) for at least one hour per inch of thickness based on the maximum thickness of the cylinder and then quenched in a suitable liquid medium having a cooling rate not in excess of 80 percent of water. The steel temperature on quenching must be above the Ac3 temperature, but not higher than 1700°F.
 - (3) After quenching, each cylinder must be reheated to a temperature below the transformation range but not less than 1100°F, and must be held at this temperature for at least one hour per inch of thickness based on the maximum thickness of the cylinder. Each cylinder must then be air cooled.

12. Openings.

- (a) Openings are permitted in cylinder head only.
- (b) All openings must be threaded. Threads must be in compliance with the following:
 - (1) Each thread must be clean cut, even, without checks, and to gauge.
 - (2) Taper threads, when used, must be in compliance with one of the following.
 - (i) American Standard Pipe Thread (NPT) type must be in compliance with the requirements of Federal Standard H-28 (1978), Section 7.

(ii) National Gas Taper Thread (NGT) type must be in compliance with the requirements of Federal Standard H-28 (1978), Sections 7 and 9.

(iii) Other taper threads in compliance with other standards may be used provided the length is not less than that specified for NPT threads.

(3) Straight threads when used must be in compliance with one of the following:

(i) National Gas Straight Thread (NGS) type must be in compliance with the requirements of Federal Standard H-28 (1978), Sections 7 and 9.

(ii) Unified Thread (UN) type must be in compliance with the requirements of Federal Standard H-28 (1978), Section 2.

(iii) Controlled Radius Root Thread (UNJ) type must be in compliance with the requirements of Federal Standard H-28 (1978), Section 4.

(iv) Other straight threads in compliance with other recognized standards may be used provided that the requirements in (4) below are met.

(4) All straight threads must have at least 6 engaged threads, a tight fit, and a factor of safety in shear of at least 10 at the test pressure of the cylinder. Shear stress must be calculated by using the appropriate thread shear area in accordance with Federal Standard H-28 (1978), Appendix A5, Section 3.

13. Pressure relief devices and protection for valves and pressure relief devices.

(a) Must be as required by Sections 73.34(d) and 73.301(g)

(b) Pressure relief devices must be in compliance with Section 73.302(c)(1) except as follows:

(i) Cylinders charged with gas mixtures containing gas requiring placards with a square background must not be equipped with any pressure relief device.

- (ii) Cylinders charged with gas mixtures containing no gas requiring placards with a square background may be equipped with a combination rupture disk and fusible plug pressure relief device in compliance with CGA Pamphlet S-1.1.

14. Hydrostatic test.

- (a) Applies except water jacket method only is authorized.
- (b) * * *
- (c) * * *
- (d) Each cylinder must be tested to at least $3/2$ times service pressure. ✓
- (e) A rejection elastic expansion limit (REE) must be developed as specified in CGA Pamphlet C-5. If the elastic expansion of any cylinder, at test pressure, exceeds the limit so developed, that cylinder must be rejected.

15. Toughness and ductility tests.

- (a) Fracture toughness test. At least two plane-strain fracture toughness KIC data point shall be obtained on one cylinder after heat treatment taken from each heat of steel. The valid KIC data shall be obtained via the J-integral test method prescribed in ASTM Standard E813. The specimen shall be so tested at room temperature in the TL orientation as defined in ASTM Standard E399. The specimen must be prepared only from material removed from the cylindrical portion of the cylinder. Flattening of the material without heating is allowed for preparing the test specimens.
- (b) Flattening test. Between knife edges, wedge shaped, 60-degree angle, rounded to $\frac{1}{4}$ inch radius; test 1 cylinder taken at random out of each lot of 200 or less cylinders. Longitudinal axis of the cylinder must be at approximately a 90-degree angle to knife edges.

(c) Impact tests.

(1) Three Charpy impact specimens must be tested from one heat-treated cylinder taken from each 500 or less successively produced.

(2) Each impact specimen must be Charpy V-notch type size 10mm X 4mm or 10mm X 5mm taken in accordance with ASTM Standard A-370-77.

(3) Each specimen must be taken from the sidewall of the cylinder. The longitudinal axis of the specimen must be at 90 degrees to the longitudinal axis of the cylinder.

(d) Hardness measurement. Hardness tests must be performed on each cylinder after the heat treatment is completed. At a minimum, one reading must be taken in the cylindrical section, and one reading at about 1.5 inches above the base of the cylinder. The results must be recorded.

(e) Flawed cylinder pressure test. One cylinder must be selected from each heat of steel and subjected to a preflaw pressure test. A sharp part through longitudinal flaw must be introduced into the test cylinder by a means that will not affect the mechanical or metallurgical properties of the cylinder. The flaw must be at least 2-inches long and have a depth that will cause the cylinder to fail when pressurized to not less than 90 percent and not more than 125 percent of the stress at service pressure. The cylinder must be hydrostatically pressurized to failure at a rate not in excess of 200 psi per second.

17. Ultrasonic examination.

(a) Each cylinder shall be examined after heat treatment and hydrostatic proof testing by shear wave ultrasonic equipment which has been calibrated to give an indication greater than the equivalent of a 5% of wall thickness by 1" long notch. Procedures must be in accordance with ASTM E-213-83, and supplements S1.1 and S2, using the immersion method. Ultrasonic test results must be recorded by individual cylinder serial numbers and maintained as long as the cylinders are in service.

18. Acceptable results of tests and inspections.

- (a) Fracture toughness test. Each K_{1C} value must be at least 85 ksi in $\frac{1}{4}$.
- (b) Flattening test. Flattening required without cracking to 10 times wall thickness. Maximum degree of flattening attained without cracking must be entered on the inspector's report.
- (c) Impact tests. The Charpy V-notch impact properties for the three impact specimens which must be tested at 0.0°F or colder must not be less than the values shown below:

<u>Size</u> <u>(mm)</u>	<u>Avg. value for</u> <u>acceptance 3</u> <u>specimens</u>	<u>Min. value</u> <u>1 specimen only</u> <u>of the three</u>
10 X 5 or 10 X 4	13.0 ft. lbs.	10.0 ft. lbs.

- (d) Hardness measurement. The tensile strength equivalent of the hardness number obtained may not be more than 182,000 psi; Rc 40 (Brinell 371). When the result of a hardness test exceeds the maximum permitted, two or more retests may be made; however, the hardness number obtained in each retest may not exceed the maximum permitted.
- (e) Flawed cylinder pressure test. The failure must be by leakage without crack extension, or by plastic fracture (fully ductile fracture) with visible evidence of bulging.
- (f) Mechanical tests.
- (1) Tensile strength at least 155,000 psi and not more than 175,000 psi.
 - (2) Elongation at least 15 percent for gauge length 2 inches with width not over $1\frac{1}{2}$ inches.
- (g) Ultrasonic examination. Any cylinder having a discontinuity indication greater than the equivalent of a 5 percent of wall thickness by 1 inch long notch must be rejected. Any cylinder with rejectable ID indication shall be scrapped and destroyed.

- (h) Cycle tests. Cylinders subjected to design qualification cycling test must withstand at least 10,000 cyclic pressurization without distortion or failure. At least one cylinder must be cycled using water as the pressurizing medium.
- (i) Burst tests. Cylinders subjected to design qualification burst tests must withstand a pressure of at least 2.25 times the service pressure without failure. Failure must initiate in the sidewall in a longitudinal direction, and the cylinder must remain in one piece.

19. Rejected cylinders.

If any lot in an already accepted heat fails any of the prescribed physical tests of this appendix that lot may be subjected to one repeated heat treatment. Any lot subjected to second heat treatment is considered as equivalent to new heat and, therefore, must meet at a minimum, the requirements specified below. If any lot subjected to a second heat treatment fails any of the prescribed mechanical tests, the cylinders from that lot shall not be used under the terms of the present certificate.

(1) Lot re-qualification.

- (a) The second heat treatment procedure shall be in accordance with that prescribed in section 11 of this appendix.
- (b) The lot is identified in the heat treatment records appropriately indicating repeated heat treatment.
- (c) Fracture toughness test. Acceptable lot must pass all prescribed tests per sections 15(a) and 18(a) of this appendix.
- (d) Flattening test. Acceptable lot must pass all prescribed tests per sections 15(b) and 18(b) of this appendix.
- (e) Impact tests. Acceptable lot must pass all prescribed tests per sections 15(c) and 18(c) of this appendix.

- (f) Hardness measurement. Acceptable lot must pass all prescribed tests per sections 15(a) and 18(a) of this appendix.
- (g) Flawed cylinder test. At a minimum one cylinder must pass the tests prescribed per sections 15(e) and 18(e) of this appendix.
- (h) Mechanical tests. Acceptable lot must pass all prescribed tests per sections 15(f) and 18(f) of this appendix.

(2) Cylinder re-qualification.

- (a) Metal removal for any purpose is not permitted.
- (b) Each cylinder must be subjected to hydrostatic test to ³/₂ times rated service pressure as prescribed in section 14 of this appendix.
- (c) Elastic and plastic expansion at the proof test pressure shall not exceed rejectable limits as prescribed in section 14(e) of this appendix.
- (d) Following hydrostatic proof testing, each cylinder shall pass ultrasonic examination as prescribed in section 17(a) of this appendix.

20. Marking.

(a) * * *

- (1) "TC SP 3263-M25B" in lieu of "CTC 3AA" followed by the service pressure.
Note: This sequence can be placed before the prescribed DOT markings.
- (2) Not applicable.
- (3) A serial number and the manufacturer's symbol.
- (4) * * *
- (5) Rejection elastic expansion (REE) in cubic centimeters near the date of test.

22. Inspector's report.

Applies except that "CTC 3AA" shall be replaced by "TC SP 3263-M25B".

SPECIAL REQUIREMENTS

- a) The cylinders shall be maintained and used in accordance with applicable sections of the "Regulations for the Transportation of Dangerous Commodities by Rail" and filled only with gases authorized in CTC 3AA specification cylinders except for the following:
- (1) Hydrogen, compressed natural gas, hydrogen sulphide, or carbon monoxide;
 - (2) Any gas mixture containing hydrogen sulphide or other free sulphides, or containing hydrogen or compressed gas;
 - (3) Any gas mixture containing more than ten percent (10%) carbon monoxide;
 - (4) Any gas mixture containing carbon monoxide and having a dew point of minus 52°F or higher at one (1) atmosphere;
 - (5) Any gas or mixture of gases which does not remain in a gaseous state when contained in the cylinder at filling pressure of 70°F; and
 - (6) Any mixture of gases, the quantity of one or more of which is capable of combining chemically with other gases in such mixture or of combining chemically with the cylinder steel so as to significantly reduce the effectiveness of the cylinder.
- (b) Reports
- (1) Prior to the initial shipment of cylinders made to any specific design, a report of the qualification test results shall be submitted to the Director, Regulatory Requirements.
 - (2) The maker of the cylinder under this specification must retain the test reports required by this specification indefinitely as long as these cylinders are authorized.
 - (3) These cylinders may not be used for carriage of gases that would cause hydrogen embrittlement of the steel.

- (4) Filling limits specified in Section 73.302(c) are not authorized. Under no circumstances are these cylinders to be filled to a pressure exceeding the marked service pressure at 70°F.
- (5) A copy of the Inspector's report for each lot produced, shall be submitted to the Director, Regulatory Requirements.
- (6) Each cylinder must be requalified for use every five years in accordance with Section 73.34 as prescribed for CTC-3AA. Cylinders requalified after having been subjected to the action of fire, must be reported to the Director, Regulatory Requirements prior to being placed back in service.
- (7) The Director, Regulatory Requirements shall be advised of any change in design of the cylinder.
- (8) The Director, Regulatory Requirements shall be advised of any incident involving loss of contents and shall be provided with a summary of experience on a yearly basis.