

Comparison Between ISO & DOT Cylinder (Design Requirements During Manufacturing)

ISO Standard 11119/2-'98

Composite Fully Wrapped with Load Sharing Metal Liners

DOT Standard CFFC, Rev 3

DOT Exemption N/A

Criteria	ISO	DOT	Exemption
Safety Margin (Burst/Test) [burst/ser.]	Carbon 2 [3.34] Aramid 2.1 [3.51] Glass 2.4 [4.01]	2.04 [3.4]	N/A
Minimum Wall thickness Requirement			
Max. Allowable Tensile (psi)		Liner @ $P_o \leq 60\%$ Yield Filament @ $P_o \leq 30\%$ Liner 262,001 kPa (38 ksi) Carbon 5,171,068 kPa (750 ksi) S-glass 2,757,903 kPa (400ksi) E-glass 1,378,951 kPa (200ksi)	
Yield/Tensile		1.09	
Elongation (min.) Coupon size		14% 2" x 1.5" - 5.1 x 3.8 cm gage; 4 dia.; 24tx6t for $t \leq 3/16$ " (0.48 cm)	
Charpy (@ BF) Requirement			
Flattening Test Requirement			

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<p>Other tests (e.g. cycling) Ambient Temp Cycling</p>	<p>For 15 YEAR LIFE CYLCE 2 for 7,500 cycles @ ≤ 10cpm from 10% $P_h - P_h$ No leakage or burst for 0-3750 cycles Leakage OK, No Burst for 3750-7500 cycles *12,000 cycle testing = 30 year life span then requalfified per std</p>	<p>15 YEAR LIFE CYCLE 2 for 10,000 cycles @ 10cpm from 10% $P_o - P_o$ $w \geq 1.2$ sec dwell time then 30 cycles from 0-P_h $w \geq 1.2$ sec dwell time. No visual leaks or damage growth. Then Burst test per std to \geq 90P_b None max 15 year life span</p>	
<p>Environmental Cycling</p>	<p>same 1 for 5,000 from 0-2/3P_h, samesame then 5,000 at - 58to-76$^{\circ}$F(-50 to -60$^{\circ}$C) from 0-2/3P_h. Same, then 30 cycles ambient to 2/3P_h Burst @ 72.5 psi/sec (5bar/sec)to 80%P_b No corrosion of liner</p>	<p>Condition 48 hrs, 0psig, 140$^{\circ}$F(60$^{\circ}$C), 95%RH 2 for 5,000 cycles from 0- P_o, at above condition. Stabilize, then 5,000 cycles at $\leq 60^{\circ}$F, from 0- P_o. Stabilize, then 30 cycles at ambient, 0- P_h. None No distortion, deterioration or failure</p>	
<p>Thermal Cycling</p>	<p>NONE</p>	<p>2 for 10,000 cycles from 0- P_o at ambient & 20 cycles @ P_o from 200$^{\circ}$F(93.3$^{\circ}$C) to - 60 $^{\circ}$F(-51.6 $^{\circ}$F) w min 10 minutes at each temp. Burst @ uniform rate to 90%P_b (3.4 P_o) Thermal, no visual damage, distortion, leakage.</p>	

**Other tests (continued)
Gunfire**

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Bonfire

Salt water immersion test

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<p>Flaw test</p>	<p>P_o fill *same? same</p> <p>same *Cylinder dia ≤ 120 mm, 5.6mm shell *Cylinder dia >120 mm, 7.62mm shell</p> <p>1 vertical, 1 horizontal either service</p> <p>Air or Nitrogen fill to 2/3 P_h No direct impingement on cylinder or valve May leak through PRD or cylinder wall or other Burst to failure</p> <p>2, for 45 days @ 2/3 P_h then 45 days 0 pressure. 1 burst per std P_b ≥ 2 P_h 1 ambient cycle tested per std</p> <p>2, w 1 mm width longitudinal cut ≥ 0.5t_{composite} deep, 5x t_{composite}. 1, Burst to ≥ .66P_b 1, ≥ 1,000 cycles from 0 – 2/3 P_h. Leakage > 1,000 cycles OK, Burst No Go</p>	<p>P_o fill 30 cal., 2800fps (853m/s) @ ≤ 50 yds (45.7m) for 45degree impact No fragmentation.</p> <p>2, vertical test (non- liquefied gas or liquified gas?) Air or Nitrogen fill to P_o.</p> <p>NONE</p> <p>Vent only through PRD</p> <p>NONE</p> <p>NONE</p> <p>NONE</p> <p>NONE</p>	
<p>NDE (Type such as UT) Requirement</p>			

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<p>Drop Test (height “ft”) Requirement</p>	<p>3.94 ft (1.2 m) 2 fill 50% water & plugged @ 1.2 m. vertical, 45⁰, 90⁰, 180⁰, 270⁰, Twice. 1 for 7,500 cycles @ ≤10cpm from 10% P_h - P_h No leakage or burst for 0-3750 cycles Leakage OK, No Burst for 3750-7500 cycles. 1 Burst to 100% P_b per std. w P_{b carbon} = 2x P_h ; P_{b aramid} = 2.1x P_h ; P_{b glass} = 2.4x P_h</p>	<p>9.84 ft (3 m) 1 empty? w valve @ 3 m. vertical, horizontal, horizontal angle iron. 1000 cycles @ 10cpm from 10% P_o - P_o w ≥ 1.2 sec dwell time. No visual leaks or damage growth. Then Burst test per std to ≥ 90% P_b For 2, 1 as above, other Burst w pressurization ≤ 1379 kpa/sec</p>	
<p>Maximum Wall Stress (psi)</p>			

Other Criteria

Liner material

Overwrap

Resin Matrix

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<p>Quality</p> <p>Size</p> <p>Cylinder Lifespan</p>	<p>Seamless Steel-ISO 9809/1 or 2</p> <p>Seamless Stainless -prEN 1964-3</p> <p>Seamless Aluminum -ISO 7886, others</p> <p>All mfg to ISO 11114 Part1</p> <p>same</p> <p>Aramid</p> <p>Glass</p> <p>Mixtures of Above</p> <p>Polymers-Epoxy or Modified Epoxy with Amine or Anhydride curing agents.</p> <p>Vinyl esters and Polyesters</p> <p>NONE</p> <p>Material certification by mat'l mfg per batch</p> <p>≤ 450 L(992 lbs), ≤ [650 bar test] 433 bar service (6283psi)</p> <p>30+ years w continuation</p>	<p>N/A</p> <p>N/A</p> <p>6061 or 6351 alloy T6 temper</p> <p>Per std</p> <p>Carbon</p> <p>N/A</p> <p>Type S or E (400ksi ; 200ksi strand strength)</p> <p>N/A</p> <p>Same</p> <p>NONE</p> <p>NONE</p> <p>NONE</p> <p>Shear strength 34,474kPa (5ksi) min.</p> <p>Material cert by cylinder mfg</p> <p>≤ 90.7 L(200lbs), ≥ 62bar (900 psi) ≤ 344.8 bar (5,000 psi) @ 21.1C(70F)</p> <p>15 years max</p>	
<p>Recommendations (i.e. accept as is, accept conditionally, reject)</p>			