Section	CFFC	ISO 11119-2	FRP-1
CFFC-2 **<u>Type, size and Service Pressure</u>**	Liner: seamless aluminum Max. Water Capacity: 90.7 Liters (200 Lbs.) Max. Service Pressure: 34,474 kPa (5000 psi) Test Pressure: $P_h = \frac{5}{3} \times P_{service}$ Max. Test Pressure: 575 bars (8333 psi) Min. Safety Factor: 3.4 Overwrap fiber: carbon, glass (Only Type S or E) Overwrap matrix: epoxy Winding pattern: combination of helical and hoop	Liner: seamless metallic Max. Water Capacity: 450 Liters (992 Lbs.) Max. Service Pressure: 43,334 kPa (6285 psi) Test Pressure: $P_h = \frac{3}{2} \times P_{service}$ Max. Test Pressure: 650 bars (9428 psi) Min. Safety Factor: 3.0 Overwrap fiber: carbon, aramid, glass Overwrap matrix: polymer suited to application Winding pattern: longitudinal and hoop	Liner: seamless aluminum Max. Water Capacity: 90.7 Liters (200 Lbs.) Max. Service Pressure: 34,474 kPa (5000 psi) Test Pressure: $P_h = \frac{5}{3} \times P_{service}$ Max. Test Pressure: $P_h = 1.15 \times p_h$ = 9583 psi Min. Safety Factor: 3.0 Overwrap fiber: glass (Only Type S or E) Overwrap matrix: epoxy or modified epoxy Winding pattern: helical, in-plane, hoop
CFFC-3 **<u>Service Life</u>**	- 15 years (from manufacture date) - 30 years (Administrator approval required)	- Varies: 10 to 38 years* - 38 years defined as Unlimited Life - 38 years if P_h > 60 bars (870 psi) * Requalification recommended if design life > 15 years.	- 15 years* * The service life is clearly defined in all special permits for FRP-1 cylinder designs.
CFFC-4 **<u>Inspection By Whom & Where</u>**	- Inspection and verification performed by an approved Independent Inspection Agency (IIA) - Chemical analysis must be approved for each batch - Fiber mechanical properties must be verified and approved by IIA	- Performed in accordance with regulations established in the country of use - Cylinders must be inspected and tested to ensure compliance with the standard; focus areas include Cylinder Materials, Design & Manufacture, Type Approval Procedures and Batch Inspection & Testing - Performed by an independent inspector recognized in the country of use	- Inspection and verification performed by an approved Independent Inspection Agency (IIA) - Chemical analysis and tests must be performed in the US unless approved

CFFC-5 **<u>Duties of Inspector</u>**	- Obtain and retain design type documentation - Determine if materials/components comply with the standard - Verify conformance, consistency and quality of: o Chemical composition for each liner heat o Fiber materials o Resins & other chemicals o Completed liners o Filament winding & curing procedures o Completed cylinders - Witness & retain documentation for all tests and pressurizations performed on completed cylinders with acceptable results - Complete Inspector's report - Verify that design qualification testing has been performed on new designs with acceptable results prior to initial shipment	- Obtain and retain design type documentation - Certify that the design, manufacture and testing were carried out in accordance with the standard - Verify conformance of: o Fiber materials o Resin matrix materials o Completed liners o Completed cylinders - Supervise type approval testing - Determine that all materials conform with the standard before releasing for manufacture	- Determine that all materials conform with the standard before releasing for manufacture - Verify conformance of: o Chemical composition of each liner heat o Fiber system o Resin system o Filament winding process o Completed cylinders - Witness & retain documentation for all tests and pressurizations; report volumetric capacity, permanent expansion and completed cylinder weight - Complete inspector's report - Verify that design qualification testing has been performed on new designs with acceptable results prior to initial shipment
CFFC-6 **<u>Authorized Materials</u>** **(Liner)**	Liner: 6061-T6 aluminum Min. Yield Strength: 241,316 kPa (35,000 psi) Min. Tensile Strength: 262,001 kPa (38,000 psi) Min. Elongation for 5.1 cm (2") gage: 14% Min. Elongation for 24t × 6t: 6% Other Authorized Materials: N/A - Liner ends must be concave to pressure - Liner exterior surface must be protected from galvanic corrosion # of Physical Test Specimens: 2 Max. Lot Size: 200	Liner: 6061A aluminum (see ISO 7866) Min. Yield Strength: 241,316 kPa (35,000 psi) Min. Tensile Strength: 262,001 kPa (38,000 psi) Min. Elongation for 5.1 cm (2") gage: 14% Min. Elongation for 24t × 6t: 6% Other Authorized Materials: 6351A aluminum (see ISO 7866), steel (see ISO 9809-1, 9809-2), stainless steel (see EN 1964-3) - Protective coating applied to liner prior to wrapping to prevent corrosion # of Physical Test Specimens: 1 Max. Lot Size: 200	Liner: 6061-T6 aluminum Min. Yield Strength: By ASTM Standard E8 Min. Tensile Strength: By ASTM Standard E8 Min. Elongation for 5.1 cm (2") gage: 14% Min. Elongation for 24t × 6t: 10% Other Authorized Materials: 6351 aluminum - Liner ends must be concave to pressure - Protective coating applied to liner prior to wrapping to prevent corrosion # of Physical test specimens: 2 Max. Lot Size: 200

CFFC-6 **<u>Authorized Materials</u>** **(Filaments)**	- Must be polyacrylonitrile based carbon fiber tows - Tensile strength: 5,171,068 kPa (750 ksi) - Tested in accordance with ASTM D-2343-95	- Must be carbon, aramid or glass; or any mixture	- Must be Type S or Type E - Tensile strength: Type S (400 ksi), Type E (200 ksi) - Tested in accordance with ASTM D-2343-79
CFFC-6 **<u>Authorized Materials</u>** **(Resins)**	- Must be epoxy or modified epoxy	- A suitable polymer (e.g. epoxy or modified epoxy)	- Must be epoxy or modified epoxy
CFFC-7 **<u>Design Criteria</u>**	- Reliable model of cylinder required - Model must account for non-linear behavior - Only cylindrical region must be analyzed - Max. stresses in domes < Stresses in cylinder body - Model & analysis procedure must be documented - In the fibers: $\sigma_{max} < 0.30\,\sigma_{fiber,burst}$ - At service pressure $\sigma_{max} < 0.60\sigma_{Y,liner}$ - $0.60\sigma_{Y,liner} < \sigma_{comp} < 0.95\sigma_{Y,liner}$ - Net loading sharing capacity of galvanic liner protection < 15% of the total pressure load in cylinder at burst pressure - Burst must initiate in cylinder sidewall	- Calculate stresses using stress analysis software - Model must account for non-linear behavior - Stress analysis must be documented -	- Stresses must be calculated using the NASA CF-72124 code or other suitable technique - At service pressure $\sigma_{max,liner} < 0.60\sigma_{Y,liner}$ - At service pressure $\sigma_{max,fiber} < 0.30\sigma_{fiber,burst}$
CFFC-8 **<u>Openings, Valves & Pressure Relief Devices</u>**	- Openings in heads only - Centerline of opening must coincide with cylinder centerline - Threads designed in compliance with FED-STD-H28, Appendix A5 - Tapered threads not permitted - Straight threads having at least 6 threads must have a calculated factor of safety in shear of at least 10 at the test pressure; threads must extend completely through neck	- Cylinders can have a maximum of 2 openings - Openings along central axis only - Parallel threads shall extend completely through neck or have sufficient threads to allow full engagement of the valve	- Openings in heads only - Centerline of opening must coincide with longitudinal axis of cylinder - Tapered threads not permitted - Straight threads conforming with NGS thread standard are authorized - Straight threads having at least 6 engaged threads are authorized if the calculated shear strength is at least 10 times the test pressure of the cylinder - Pressure relief devices conform to 49 CFR 173.34(d) and 173.301(g)

CFFC-9 **<u>Design Type and Authorization</u>**	Cylinder **IS** a new design if: - Change in diameter > 10%; or, - Change in service pressure > 10%; or, - Change in water capacity > 30%; or, - Significant change material properties; or, - Significant change in manufacturing process, quality assurance, or winding pattern	Cylinder **IS** a new design if: - Change in diameter or > 50%; or, - Change in test pressure > 60%; or, - Change in water capacity > 30%; or, - Significant change in overwrap materials; or, - Significant change in manufacturing process; or, - Significant change in liner manufacture or design Cylinder is a design **VARIANT** if: - Change in length; or, - Change in diameter < 50%; or, - Change in autofrettage pressure by 5% or 10 bars, whichever is greater; or, - Change in base profile and/or base thickness of liner relative to cylinder diameter and min. wall thickness	Cylinder **IS** a new design if: - Change in diameter ≥ 10%; or, - Change in service pressure ≥ 10%; or, - Any change in material
CFFC-10 **<u>Design Qualification Tests</u>** **(Resin System)**	- Test coupon of composite overwrap - Test in accordance with ASTM D-2344-89 - Min. sheer strength: 34,474 kPa (5000 psi)	N/A	- Test coupon of composite overwrap - Test in accordance with ASTM D-2344-67 - Min. sheer strength: 34,474 kPa (5000 psi)
CFFC-10 **<u>Design Qualification Tests</u>** **(Burst test)**	Min. Safety Factor: 3.4 Min. # of Cylinders: 3 Min. Hold Time: 60 sec. Max. Pressurization Rate: 1379 kPa/sec (200 psi/sec) - Failure must occur in cylinder sidewall	Min. Safety Factor: 3.0 Min. # of Cylinders: 3 Min. Hold time: 60 sec. Max. Pressurization rate: 5 bars/sec (72.5 psi/sec)	Min. Safety Factor: 3.0 Min. # of Cylinders: 1 Min. Hold Time: 60 sec. Max. Pressurization Rate: 1379 kPa/sec (200 psi/sec) - Failure must occur in cylinder sidewall - Cylinder must remain in one piece

CFFC-10 **<u>Design Qualification Tests</u>** **(Drop test)**	Min. # of cylinders: 1 Contents: empty (but valve is attached) Drop Height: 3 meters (10 feet) # of Drops: 1 per cylinder Impact Surfaces: concrete, angle iron Drop Positions: vertical, horizontal, angled **<u>If 1 Cylinder is Drop Tested</u>:** - Post-drop cycle to 1000 pressure cycles - Pressure Range: $0.10\,P_{service} \geq P \geq P_{service}$ - Max. pressurization rate: 10 cycles/min - Min. dwell between 90-100% of $P_{service}$: 1.2 sec - No observable leakage or damage growth - Burst tested after cycling - Residual strength ≥ 90% of required min. burst **<u>If 2 Cylinders are Drop Tested</u>:** - Post-drop cycle 1st cylinder to 1000 cycles then burst - Burst test 2nd cylinder in accordance with CFFC-10 - Residual strength ≥ 90% of required min. burst	**<u>For Water Capacity ≤ 50 Liters</u>:** Min. # of Cylinders: 2 Contents: 50% filled with water (opening plugged) Drop Height: 1.2 meters (4 feet) # of Drops: 2 per cylinder Impact Surface: steel plate Drop Positions: 5 positions (vertical, horizontal, angled) - Burst test 1st cylinder - Residual strength ≥ 100% of min. required burst - Cycle 2nd cylinder using ambient cycle test **<u>For Water Capacity > 50 Liters</u>:** Min. # of Cylinders: 1 Contents: empty (opening plugged) Drop Height: 1.8 meters (6 feet) # of Drops: 5 Impact Surface: concrete Drop Positions: 5 positions (vertical, horizontal, angled) - Cycle to 12,000 cycles using ambient cycle test - Pressure Range: $0.067\,P_h \geq P \geq 0.67P_h$ - Cylinder must withstand at least 12,000 cycles without leakage or burst	N/A

CFFC-10 **<u>Design Qualification Tests</u>** **(Ambient Temperature Cycling)**	Min. # of cylinders: 2 Pressure Range: $0.10\,P_{service} \geq P \geq P_{service}$ Max. Pressurization Rate: 10 cycles/min Min. Dwell between 90-100% of P_s: 1.2 sec Min. # of Service Pressure Cycles: 10,000 Min. Dwell between 90-100% of P_h: 1.2 sec Min. # of Test Pressure Cycles: 30 - No observable leakage or damage growth - Burst test second cylinder in accordance with CFFC-10 - Min. Residual Strength: 90% of $P_{b,min}$	Min. # of cylinders: 2 Pressure Range: $0.10\,P_h \geq P \geq P_h$ Max. Pressurization Rate: 15 cycles/min Min. Dwell between 90-100% of P_s: N/A Min. # of Service Pressure Cycles: N_d (if P_h > 60 bars) Min. Dwell between 90-100% of P_h: N/A Min. # of Test Pressure Cycles: N (if P_h > 60 bars), or 12,000 otherwise **If P_h > 60 bars:** - Cylinders must withstand N cycles to P_h where: o $N = y \times 250\ cycles\ per\ year$ - Or, N_d cycles to P_{max} , where: o $N_d = y \times 500\ cycles\ per\ year$ - No failure by leakage or burst - Cylinders must then pass an additional N or N_d cycles without burst **If P_h < 60 bars:** - Cylinders must withstand 12,000 cycles to P_h	Min. # of cylinders: 1 Pressure Range: $0 \geq P \geq P_{service}$ (with 30 bar max.) Max. Pressurization Rate: 4 cycles/min Min. Dwell between 90-100% of P_s: N/A Min. # of Service Pressure Cycles: 10,000 Min. Dwell between 90-100% of P_h: N/A Min. # of Test Pressure Cycles: 30 - No evidence of distortion, deterioration or failure - Burst test cylinder in accordance with 178.AA-18(e)(1) - Min Residual Strength: 100% of $P_{b,min}$
CFFC-10 **<u>Design Qualification Tests</u>** **(Environmental Cycling)**	Min. # of Cylinders: 2 Max. Cycling rate: 10 cycles/min Max. Dwell between 90-100% of P_s: 1.2 sec - Step 1: 0 psi, 60 °C (140 °F), 95 % rel. hum for 48 hrs - Step 2: Apply 5000 cycles from 0 to P_s for at 60 °C and 95% relative humidity - Step 3: Stabilize cylinder and apply 5000 cycles from 0 to P_s at -60 °F. - Step 4: Stabilize and apply 30 cycles from 0 to P_s - Step 5: Burst cylinder - No evidence of damage, distortion or leakage - Min. Residual Strength: 90% of $P_{b,min}$	Min. # of Cylinders: 1 Max. Cycling rate: 5 cycles/min Max. Dwell between 90-100% of P_s: 1.2 sec - Step 1: 0 psi, 60 °C (140 °F), 95 % rel. hum for 48 hrs Step 2: Apply 5000 cycles from 0 to P_s for at 60 °C and 95% relative humidity - Step 3: Stabilize cylinder and apply 5000 cycles from 0 to P_s at -60 °F - Step 4: Stabilize and apply 30 cycles from 0 to P_s - Step 5: Burst cylinder - Min. Residual Strength: 70% of $P_{b,min}$	Min. # of Cylinders: 1 Max. Cycling rate: N/A Max. Dwell between 90-100% of P_s: N/A - Step 1: 0 psi, 60 °C (140 °F), 95 % rel. hum for 48 hrs - Step 2: Apply 5000 cycles from 0 to P_s for at 60 °C and 95% relative humidity - Step 3: Stabilize cylinder and apply 5000 cycles from 0 to P_s at -60 °F. - Step 4: Stabilize and apply 30 cycles from 0 to P_s - No evidence of corrosion, deterioration or failure

CFFC-10 **<u>Design Qualification Tests</u>** **(Thermal cycling)**	Min. # of Cylinders: 2 Max. Cycling Rate: 10 cycles/min Max. Dwell between 90-100% of P_h: 1.2 sec Min. Temperature Dwell Time: 10 min - Step 1: 10,000 cycles between 0 and P_s - Step 2: Pressurize to P_s and apply 20 thermal cycles between 200 °F and -60 °F - Step 3: Burst cylinder - No evidence of damage, distortion or leakage - Min. Residual Strength: 90% of $P_{b,min}$	N/A	Min. # of Cylinders: 1 Max. Cycling Rate: N/A Max. Dwell between 90-100% of P_h: 1.2 sec Min. Temperature Dwell Time: 10 min - Step 1: Apply 10,000 cycles between 0 and P_s - Step 2: Apply 30 cycles between 0 and P_h - Step 3: Pressurize to P_s and apply 20 thermal cycles between 200 °F and -60 °F - Step 4: Burst test cylinder - No evidence of damage, distortion or leakage - Failure must occur in cylinder sidewall - If P_s < 2200 psi, cylinder must remain in one piece - Min. Residual Strength: 100% of $P_{b,min}$
CFFC-10 **<u>Design Qualification Tests</u>** **(Gunfire test)**	Min. # of Cylinders: 1 Cylinder Charge Pressure: P_s Projectile caliber: 0.30 (armor piercing) Projectile velocity: 853.4 m/sec (2800 ft/sec) Impact angle: 45° Distance to impact point: 45.7 m (150 ft) - Cylinder must be charged with nitrogen or air - Cylinder must not fragment - Impact and exit penetration sizes must be recorded	Min. # of Cylinders: 1 Cylinder Charge Pressure: P_s Projectile caliber: 7.62 mm (0.30 AP), if D > 120 mm 5.56 mm AP, if D ≤ 120 mm Projectile velocity: 853.4 m/sec (2800 ft/sec) Impact angle: 45° Distance to impact point: 45 m (147.6 ft) - Cylinder must be charged with nitrogen or air - Bullet must penetrate at least one wall of cylinder - Cylinder must not fragment - Impact and exit penetration sizes must be recorded AP – armor piercing	Min. # of Cylinders: 1 Cylinder Charge Pressure: P_s Projectile caliber: 0.30 (armor piercing) Projectile velocity: 2800 ft/sec (853.4 m/sec) Impact angle: 45° Distance to impact point: 50 yds (150 ft) - Cylinder must be charged with nitrogen or air - Cylinder must not fragment - Impact and exit penetration sizes must be recorded

CFFC-10 **<u>Design Qualification Tests</u>** **(Bonfire test)**	Min. # of Cylinders: 2 Cylinder Charge Pressure: P_s Test Positions: vertical Heat Source: Kerosene soaked wood Min. Temperature: N/A Distance from Source to Cylinder: N/A - Expose to fire until contents are completely vented - Venting must occur predominately thru PRD - Cylinder must be intact upon test completion - Alternate test method: Chimney Test Method	Min. # of Cylinders: 1 Cylinder Charge Pressure: P_s Test Positions: horizontal, vertical Heat Source: Wood, Gas, Hydrocarbon fuel Min. Temperature: 590 °C (1094 °F) Distance from Source to Cylinder: 0.1 m (4 inches) - Expose to fire until contents are completely vented - Cylinder may vent thru PRD or other surfaces - Cylinder and valve must be fully exposed to fire - PRD must be shielded from flame - Cylinder must not burst during 2 min period from start of test	Min. # of Cylinders: 3 (LPG service), 2 (non-LPG service) Cylinder Charge Pressure: P_s Test Positions: vertical, horizontal Heat Source: Kerosene soaked wood, Gasoline, JP-4 Min. Temperature: N/A Distance from Source to Cylinder: 4 inches - Expose to fire until contents are completely vented - Venting must occur **ONLY** thru PRD - Flame impingement on PRD is prohibited - PRD shielding is allowed - Cylinder must be intact upon test completion - Burst test after passing fire test
CFFC-11 **<u>Qualification Requirements for Design Change</u>**	See Appendix 1 & 2	See Appendix 1 & 2	N/A
CFFC-12 **<u>Manufacturing, Quality Assurance and Lot Qualification Tests</u>**	Manufacturer must: - Be responsible for total compliance with the standard - Ensure that all aspects of manufacture conform to processes used for the manufacture of design qualification cylinders - Retain production data and test results - Maintain a quality assurance system for each design - Establish compliance procedures for all design control features Max. Lot Size: 200 **<u>Lot Qualification Tests</u>** - Burst (1 cylinder per lot) - Ambient Temperature Cycling (1 cylinder per lot) **<u>Lot Acceptance Criteria</u>:** - Cylinders that fail the Lot Qualification Tests must be rejected - If a cylinder fails, 5 randomly chosen cylinders may be selected for testing; if more than one of these fails then the lot must be rejected	Manufacturer must: - Be responsible for total compliance with the standard - Ensure that all aspects of manufacture conform to those used for the manufacture of design qualification cylinders - Retain production data and test results - Maintain a quality assurance system for each design - Establish compliance procedures for all design control features Max. Lot Size: 200 **<u>Lot Qualification Tests</u>** - Burst - Pressure Cycling **<u>Lot Acceptance Criteria</u>:** - Cylinders that fail the Lot Qualification may be retested if there is evidence of an error; an additional cylinder may be tested if the cause of the error is indeterminate - If a cylinder fails, 5 randomly chosen cylinders may be selected for testing; if more than one of these fails then the lot must be rejected	Max. Lot Size: 200 **<u>Lot Qualification Tests</u>** - Burst - Pressure Cycling **<u>Lot Acceptance Criteria</u>:** - Cylinders that fail the Lot Qualification may be retested if there is evidence of an error; an additional cylinder may be tested if the cause of the error is indeterminate - If a cylinder fails either of the Lot Qualification Tests the lot must be rejected

CFFC-13 **Production Tests**	**Hydrostatic Test** Min. Hold Time: 60 sec Gauge Accuracy: ±%1 in 80-120% of - Test using water jacket method - Pressurize to test pressure - Reject if evidence of leakage or distortion **Visual Inspection & Marking** - All cylinders must be visually inspected for quality and for conformance to marking requirements	**Hydraulic Proof Pressure Test** Min. Hold Time: 30 sec Gauge Accuracy: N/A - Pressurize to test pressure - Reject if there are leaks, failure to hold pressure or visible permanent deformation **Volumetric Expansion Test** Min. Hold Time: 30 sec Gauge Accuracy: N/A - Pressurize to test pressure - Reject if there are leaks, failure to hold pressure or if permanent expansion at 0 pressure exceeds 5% of total expansion	**Hydrostatic Test** Min. Hold Time: 60 sec Gauge Accuracy: ±%1 - Test using water jacket method - Pressurize to test pressure - Reject if evidence of leakage or distortion **Visual Inspection & Marking** All cylinders must be visually inspected for quality and for conformance to marking requirements
CFFC-14 **Marking**	—	—	—
CFFC-15 **Inspector's Reports**	—	—	—
CFFC-16 **Retention of Reports**	—	—	—

APPENDIX 1

Type of Test or Requirement	New Design	Design Changes																	
		Length (ΔL)				Diameter (ΔD)				Pressure (ΔP)				Water Capacity (ΔV)					
		ISO		CFFC		ISO		CFFC		ISO		CFFC		ISO		CFFC			
		≤ 50%	> 50%	N/A	N/A	≤ 20%	> 20%	10–20%	> 20%	≤ 20%	> 20%	10-20%	> 20%	N/A	N/A	30-50%	> 50%		
Resin shear	ISO																		
Liner material	ISO																		
Composite material	ISO																		
Hydraulic Pressure	ISO CFFC	ISO	ISO			ISO	ISO	CFFC	CFFC	ISO	ISO	CFFC	CFFC			CFFC	CFFC		
Liner burst	ISO		ISO			ISO	ISO				ISO[B]								
Cylinder burst	ISO	ISO	ISO			ISO	ISO			ISO	ISO								
Cycling – Ambient temp	ISO CFFC	ISO	ISO			ISO	ISO	CFFC	CFFC	ISO	ISO	CFFC	CFFC			CFFC	CFFC		
Cycling - Environmental	ISO CFFC								CFFC				CFFC				CFFC		
Cycling - Thermal	CFFC								CFFC				CFFC				CFFC		
Flaw	ISO						ISO												
Drop	ISO CFFC						ISO	CFFC	CFFC		ISO	CFFC	CFFC			CFFC	CFFC		
Gunfire	ISO CFFC						ISO	CFFC	CFFC		ISO	CFFC	CFFC			CFFC	CFFC		
Fire resistance (Bonfire)	ISO CFFC		ISO				ISO[D]	CFFC	CFFC		ISO	CFFC	CFFC			CFFC	CFFC		
Salt water	ISO																		
Torque	ISO																		
High temperature creep	ISO						ISO[B]				ISO[B]								
Stress Analysis	CFFC							CFFC	CFFC			CFFC	CFFC				CFFC		

A – Also applies for changes in autofrettage pressure
B – Where burst pressure to test pressure ratio of design
C – Conducted with a liner thickness decrease only

D – Test to be conducted for reduction in diameter only

APPENDIX 2

Type of Test or Requirement	New Design	Design Changes									
		Material		Liner Thickness Change		Manufacturing Facility		Neck Thread		Composite Thickness or Pattern Change	
		ISO	CFFC	ISO	CFFC	ISO	CFFC	ISO	CFFC	ISO	CFFC
		Any Change	Any Change	Any Change	Any Change	N/A	Any Change	Any Change	N/A	Any Change	N/A
Resin shear	ISO		CFFC								
Liner material	ISO	ISO[1]		ISO							
Composite material	ISO	ISO[2,3]								ISO	
Hydraulic (Hydrostatic) Pressure	ISO CFFC	ISO[1,2]	CFFC	ISO	CFFC		CFFC			ISO	
Liner burst	ISO	ISO[1]		ISO						ISO[B]	
Cylinder burst	ISO	ISO[1,2]		ISO						ISO	
Cycling – Ambient temp	ISO CFFC	ISO[1,2]	CFFC	ISO	CFFC		CFFC			ISO	
Cycling - Environmental	ISO CFFC		CFFC				CFFC				
Cycling - Thermal	CFFC		CFFC				CFFC				
Flaw	ISO										
Drop	ISO CFFC	ISO[2]	CFFC	ISO[C]	CFFC		CFFC				
Gunfire	ISO CFFC		CFFC	ISO[C]			CFFC				
Fire resistance (Bonfire)	ISO CFFC		CFFC	ISO[C]			CFFC				
Salt water	ISO										
Torque	ISO							ISO			
High temperature creep	ISO									ISO[B]	
Stress Analysis	CFFC		CFFC		CFFC						

A – Also applies for changes in autofrettage pressure
B – Where burst pressure to test pressure ratio of design

1 – Equivalent liner
2 – Equivalent fiber

C – Conducted with a liner thickness decrease only
D – Test to be conducted for reduction in diameter only

3 – Equivalent matrix