



**Verizon NEBS™ Compliance: Hardened
Fiber Optic Connectors (HFOC)
Verizon Technical Purchasing Requirements
VZ.TPR.9418
Issue 6, May 2011**





CHANGE CONTROL RECORD:

Version	Date	Action*	Reason for Revision
1	11/2/2007	New	New Document.
2	2/27/2008	Change	Section 4.3.5 Durability – dropped 50°C requirement
3	5/2/2008	Change	Multiple updates throughout document
4	8/11/2008	Change	Multiple updates throughout document
5	03/10/11	Change	Flammability R3-10, Clarified sample size, UL746 as an alternate test method
			Corrected Omission of Fungus Resistance
			Section 4.4.1 Performance of New Product, Added Clarification
			Freeze thaw, Clarified Sample size
			Impact Changed test method
			Section 4.4.3, Corrected Temperature cycling Dwell Time
			Dust, Salt Spray, Airborne, Clarified Sample size
			Section 4.4.9 Immersion, Defined first measurement
			Optical Measurements, CIT and CIR defined as A-B., added clarifications
			Added Clarification to BR/IL increase.
			Optical Requirements, removed the 2 dB RL change criterion.
			Corrected table one.
			Clarified End of Test Measurements
			Note 3: Clarified testing per preferred bend direction.
			Extended Thermal Cycling: Re-defined measurement times
6	05/18/11	Change	Clarified Test Sequence Impact Durability Seal Under Load
			Updated Impact Test following Chemical Resistance Exposure Test.
*New, Add, Delete, Change, Reissue			

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1.0 PURPOSE

The purpose of this Verizon Technical Purchasing Requirement (VZ.TPR) document is to provide the FOC testing requirements for Hardened Fiber Optic Connectors. This requirement is based on GR-3120 Generic Requirements for Hardened Fiber Optic Connectors and GR-326 Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies.

2.0 SCOPE

Hardened Fiber Optic Connectors (HFOC)

3.0 REFERENCES

ASTM G21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
GR-209-CORE, Issue 5, February 2006	Generic Requirements for Product Change Notices (PCNs)
GR-326-CORE, Issue 3, September 1999	Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies
GR-1221-CORE, Issue 2, January 1999	Generic Reliability Assurance Requirements for Passive Optical Components
GR-3120-CORE, Issue 1, October 1994	Generic Requirements for Hardened Fiber Optical Connectors
FOC Memo # 3 GR-771 2005	Applicable to GR-771 Test Conditions
FOC Memo # 3 Rev.1 2005	Applicable to Fiber Monitoring
FOC Memo # 3 Rev.2 2005	Applicable to optical test and criteria clarification
FOC Memo # 9, 2005	Applicable to punch list
FOC Memo # 9, Rev. 1 2005	Applicable to punch list
FOC Memo # 9, Rev. 2 2005	Applicable to punch list
FOC Memo # 9, Rev. 3 2005	Applicable to Freeze/Thaw Test
FOC Memo # 9, Rev. 3 2005	Applicable to HFOC Intermateability
FOC Memo # 9, Rev. 4 06/06	Applicable to GR-3120 Hardened Connector Punch List
FOC Memo # 9, Rev. 4 2006	Applicable to HFOC Intermateability
FOC Memo # 18, Rev 1	Applicable to Intermatability testing
FOC Memo # 18, Rev 1 2005	Applicable to Intermatability testing
FOC Memo # 18, Rev 2	Applicable to Intermatability testing
FOC Memo # 43	Applicable to Extended Thermal Cycling test



IEC 60874-14-6	Connectors for optical fibers and cables - Part 14-6: Detail specification for fiber optic connector - Type SC-APC 9° untuned terminated to single-mode fiber Type B1
IEC 60874-14-7	Connectors for optical fibers and cables - Part 14-6: Detail specification for fiber optic connector - Type SC-APC 9° tuned terminated to single-mode fiber Type B1:
IEC 61300-3-23	Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-23: Examination and measurements - Fiber position relative to ferrule endface
VZ.TPR.9405	Generic Reliability Assurance Requirements for Passive Optical Components
VZ.TPR.9407	Freeze/Thaw Test Setup and Procedure
VZ.TPR.9409	Singlemode Optical Connectors and Jumper Assemblies
VZ.TPR.9430	Optical Fiber and Optical Fiber Cable

4.0 ACRONYMS

A	After
B	Before
CIR	Change in Reflectance
CIT	Change in Transmittance
D	During
DUT	Device Under Test
FOC	Fiber Optic Components
HFOC	Hardened Fiber Optic Connector
IL	Insertion Loss
ITL	Independent Test Laboratory
RL	Return Loss
TPR	Technical Purchasing Requirement



5.0 TEST REQUIREMENTS FOR HARDENED FIBER OPTIC CONNECTORS (HFOC)

Verizon purchases Hardened Fiber Optic Connectors for various applications. Hardened Optical Connectors shall meet the requirements specified in the following tables, which are based on to the requirements specified in Telcordia document GR-3120: Generic Requirements for Hardened Fiber Optic Connectors and GR-326: Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies. All the testing must be completed by a Verizon approved ITL.



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
3.0 Detailed Requirements					
3.1 Product Samples		R3-1			Production Samples
		R3-2			Manufacturer's name, model or part number and date code
		R3-3			Identified with the closure/terminal model number in which they are used
3.2 Product Change		R3-4			PCN per GR-209
3.3 Safety and Reliability Considerations		R3-5			No defects, sharp edges, burrs, etc.
		R3-6			Per GR-3120
		R3-7			No hazardous materials
					No Index Matching Gels
3.4 Plastic Materials		R3-8	5 test bars x 11 chemicals		Saturate test bars with



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		CR3-9			chemicals (1 chemical per test bar set), store in plastic bag for 30 days. No cracks, stripping, molting, texture or color change allowed.
		R3-10	<i>“A minimum of ten test specimens, 125+/-5mm long by 13+/-0.5mm wide, and provided in the minimum and maximum thicknesses for each type of polymeric material used in the DUT. The maximum thickness of the test samples is not to exceed 13mm. See UL 94 for additional sample preparation information.”</i>		The exterior housing shall have a Flammability rating of 94-V0 If test bars are not available, testing can be performed using UL 746 "End Product Flame Testing" as an alternative to the material UL 94 tests.
Fungus Resistance		R3-11			Fungus Resistance per ASTM-G21-70, Rating of 0.
3.5 Optical Connectors		R3-12			VZ.TPR.9409 compliant



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771& 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
3.6 Cable Media		R3-13			VZ.TPR.9430 compliant
3.7 Documentation		R3.14			Per GR-3120
		CR3-15			Detailed Training packages as required
3.8 Marking, Packaging, and Shipping		R3-16			HFOC and its shipping container shall be readily identifiable and marked with Manufacturer, model number, date of manufacture (Month and Year) and serial Number
		R3-17			Marking minimum of 3/4" in height
		R3-18			Packaging shall prevent damage during shipping. (Small components shall be shipped in sealed packages)
3.9 Quality		R3-19			TL 9000
		R3-20			On-Site Quality Surveillance Program



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
3.10 Intermateability					
Intermateability		R3-21	5 jumpers/5 mating adapters		Measure Manufacturer's product geometry to production print.
Keying		R3-22			Connector plug should be keyed
4.0 Application-Specific Requirements					
4.1 Geometry Requirements					
4.1.1 Ferrule Endface Geometry for Non-Angled Physical Contact Connectors	A-1	R4-1			Fiber Undercut and Protrusion: Per GR-3120 and IEC 60874-14-n (n = applicable standard in the series)
		R4-2			Ferrule Endface Radius: Between 7mm and 25mm
		R4-3			Apex Offset: <50um



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.1.2 Endface Geometry Requirements for Angled Physical Contact (APC) Connectors	A1	R4-4			IEC 60874-14-6 for 8° untuned connector and IEC 60874-14-7 for 8° tuned connector: To be conducted before and after all environmental and mechanical testing
4.1.3 Endface Geometry Measurement Areas	A1	R4-5			To be conducted before and after all environmental and mechanical testing, shall meet the requirements specified in IEC 61300-3-23 for measuring radius of curvature and fiber undercut/protrusion.



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120 (Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.1.4 Performance of New Product	A-2	R4-2	All	IL	Table 1: New Product (Max Loss - Requirement) The performance of New Product measurements are performed DUT connector mated to DUT bulkhead terminal receptacle as configured for service life tests. No measurements against a reference connector are required.)
		O4-3		IL	Table 1: New Product (Max Loss - Objective)
		R4-4		IL	Table 1: New Product (Mean Loss - Requirement)
		O4-5		IL	Table 1: New Product (Mean Loss - Objective)



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		R4-6		RL	Table 2: New Product (Max Reflectance - Requirement)
4.2 Environmental Performance					
4.2.1 Temperature, Humidity and Condensation Tests					
4.2.1.1 Thermal Age Testing	A3	R4-6 thru O4-7	16 pigtailed pair, 10 hot spares	IL/RL (B/D/A); CIT/CIR	85°C/168h
4.2.1.2 Thermal Cycle Test	A4	R4-8 thru O4-9	16 pigtailed pair, 10 hot spares	IL/RL (B/D/A); CIT/CIR	-40°C to +75°C; 7 days; Dwell Time: 1 hour (per GR-326, Figure 4-3) - see note1
4.2.1.3 Humidity Aging Test	A5	R4-10 thru O4-11	16 pigtailed pair, 10 hot spares	IL/RL (B/D/A); CIT/CIR	75° C / 95% RH, 7 days - Measurements every 6hrs minimum
4.2.1.4 Humidity/Condensation Cycling Test	A6	R4-12 thru O4-13	16 pigtailed pair, 10 hot spares	IL/RL (B/D/A); CIT/CIR	-10°C to +65°C, 90% - 100% RH; 7 days; (per GR-326, Figure 4-4) - see note2
4.2.1.5 Dry-Out Step	A7		16 pigtailed pair, 10 hot spares		24 hrs @ 75°C, uncontrolled humidity
4.2.1.6 Post-Condensation Thermal Cycle Test	A8	R4-14 thru O4-15	16 pigtailed pair, 10 hot spares	IL/RL (B/D/A); CIT/CIR	-40°C to +75°C; 7 days; Dwell Time: 1 hour (per GR-326, Figure 4-3) - see note1



**FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC)
based on GR-326, 771 & 3120(Task references from GR-326)**

Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.2.2 Vibration Test	A9	R4-16 thru O4-17	16 pigtailed pair, 10 hot spares	IL/RL (B/A); CIT/CIR	10 - 55 Hz, 45 Hz/min, 2 hours @ amplitude of 1.5mm; X/Y/Z Axis (Measurements before and after each axis).
4.2.3 Freeze Thaw	A10	R4-18 thru R4-19	16 pigtailed pair, 10 hot spares, 11 connectors mated to a closure/terminal and 5 connectors fitted with dust caps.	IL/RL (B/A); CIT/CIR	10 cycles of Freeze Thaw per VZ.TPR.9407; No water intrusion. (Optical Monitoring During at 1625 only)
4.2.4 Water Resistance	A11	R4-20*	16 pigtailed pair, 10 hot spares	None Required	No Water Intrusion after 7 days, 10ft water head.
4.3 Mechanical Performance					
4.3.1 Flex Test	A12	R4-21 thru O4-22	16 pigtailed pair, 10 hot spares	IL/RL (B/A); CIT/CIR	8 flex cycles @ 0°, 90°, 0°, -90°, 0°; - 10.0 lbf load; -30°C and 40°C.
4.3.2 Cable Torsion	A13	R4-23 thru R4-25	16 pigtailed pair, 10 hot spares	IL/RL (B/A); CIT/CIR	10 Torsion cycles @ 0°, 90°, 0°, -90°, 0°; - 30°C and 40°C; Twist 1 meter back.



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.3.3 Proof Test	A14	R4-26 thru CO4-28	16 pigtailed pair, 10 hot spares	IL/RL (B/A); CIT/CIR	Requirement: Plug/Cap Straight Pull: 100 lbs for 60 seconds, wait 10 seconds and perform optical measurements @ -30°C and 40°C
					Objective: Plug/Cap Straight Pull: 167 lbs for 60 seconds, wait 10 seconds and perform optical measurements@ - 30°C and 40°C
					Requirement: Plug/Adapter 90° Side Pull: 15 lbs for 60 seconds, wait 10 seconds and perform optical measurements@ - 30°C and 40°C



**FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC)
based on GR-326, 771 & 3120(Task references from GR-326)**

Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
					Objective: Plug/Adapter 90° Side Pull: 25 lbs for 60 seconds, wait 10 seconds and perform optical measurements @ -30°C and 40°C
					Requirement: Plug/Adapter-Tensile Load: 25 lbs for 60 seconds, wait 10 seconds and perform optical measurements @ -30°C and 40°C
					Objective: Plug/Adapter-Tensile Load: 50 lbs for 60 seconds, wait 10 seconds and perform optical measurements @ -30°C and 40°C
4.3.4 Transmission With Applied Tensile Load	A15	R4-29 thru O4-31	16 pigtailed pair, 10 hot spares	IL/RL (B/D/A); CIT/CIR	30 minutes @ 10 lbs: -30°C and 40°C at 0, 90 & 135 degree angles
4.3.6 Impact	A16		16 pigtailed pair, 10 hot spares	IL/RL (B/A); CIT/CIR	1. Test is performed at –



**FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC)
based on GR-326, 771 & 3120(Task references from GR-326)**

Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		R4-40			40°C. 2. Test Jacks from first 8 samples and Plugs from second 8 samples. 3. Test are performed with HMFOC endcaps installed on DUT 4. Impact hammer surface shall be rigid (concrete or steel) flat surface approximately 10"x10" Mass = 2 lbs (mass) 5. Impact velocity 9.46 m/s 6. Impact Method – Spring Impact 7. Connector Plug is aligned such that center of hammer surface is aligned with the center of the connector plug



**FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC)
based on GR-326, 771& 3120(Task references from GR-326)**

Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		R4-41			8. The hammer surface shall be perpendicular to the motion of the hammer prior to striking the DUT surface 9. DUT is suspended vertically with 1 meter of cable, cable end is fixed, the connector end is free to swing. 10. Five Impacts at – 40°C Impact 4 times, every 90° around connector axis and one on the end. (Connector suspended horizontally for end impact.) 11. Inspect for Damage.



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771& 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		R4-40			If DUT does not comply at -40°C perform test at -20°C,
		R4-41			
		R4-40			If DUT does not comply at -20°C perform test at 0°C.
		R4-41			
4.3.5 Durability	A17		16 pigtailed pair, 10 hot spares	IL/RL (B/D/A); CIT/CIR	50 cycles durability, @ -18°C, clean every 10 mating. Measurements @ 9,19,29,39,49 without cleaning. Measurements @ 10,20,30,40,after 1 side cleaning. Measurements @ 25 and 50 after 2 sided cleaning. Perform Seal Under Load, Change Seal, Repeat Durability for 40°C, Perform Seal Under Load.



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		R4-34			1 sided or 2 sided cleaning - 90% shall meet requirements
		O4-35			1 sided or 2 sided cleaning - 95% shall meet objectives
		O4-36			Without cleaning - 90% shall meet Requirements
		R4-37			After 50 Insertions, shall meet Requirements
		O4-38			After 50 Insertions, shall meet Objectives
		O4-39			Cleanability Objective: Not met if recleaning required
4.3.7 Seal Under Load	A18	R4-42	16 pigtailed pair, 10 hot spares	None Required	7 days @ 23°C: 10ft water head; 2.5lb (Req) - 90°; No damage.
		O4-43			7 days @ 23°C: 10ft water head; 5lb (Obj) - 90°; No damage.



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.3.10 End of Test Criteria	A19	VZR-1	16 pigtailed pair, 10 hot spares	IL/RL/CIT/CIR	Optical Requirements "End of Test" (see Table 1 & 2)
		VZR-2			Optical Objectives "End of Test" (see Table 1 & 2)
		R4-1 thru R4-5			Geometry (R4-1 to R4-5)
		VZR-3			No damage that would impair the performance of either the connector plug or the adapter.
4.3.8 Crush Test	B	R4-44	16 pigtailed pair	None Required	300 lbs for 15 minutes: 8 @ -40°C and 8@ 40°C If not met, provide matrix for pass levels.
		O4-45			
4.3.9 Rodent Resistance/Rockwell Hardness	C	CR4-46	5 Test Bars	None Required	Rockwell hardness (R87)
Facilities for Product Testing					
Ambient Laboratory Conditions					Temperature:23°C +2°C Humidity: less than 75%RH



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
Optical Measurements					Per VZ.TPR.9405 (system validation)
Reliability Test					
4.4 Reliability Performance Testing					
4.1.1 Ferrule Endface Geometry for Non-Angled Physical Contact Connectors	All	R4-1	All as required		Fiber Undercut and Protrusion: Per GR-3120 and IEC 60874-14-n (n = applicable standard in the series)
		R4-2			Ferrule Endface Radius: Between 7mm and 25mm
		R4-3			Apex Offset: <50um
4.1.2 Endface Geometry Requirements for Angled Physical Contact (APC) Connectors	All	R4-4	All as required		IEC 60874-14-6 for 8° untuned connector and IEC 60874-14-7 for 8° tuned connector: To be conducted before and after all environmental and mechanical testing



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.1.3 Endface Geometry Measurement Areas	All	R4-5	All as required		To be conducted before and after all environmental and mechanical testing, shall meet the requirements specified in IEC 61300-3-23 for measuring radius of curvature and fiber undercut/protrusion.
4.1.4 Performance of New Product	A-2	R4-2	All	IL	Table 1: New Product (Max Loss - Requirement)
		O4-3		IL	Table 1: New Product (Max Loss - Objective)
		R4-4		IL	Table 1: New Product (Mean Loss - Requirement)
		O4-5		IL	Table 1: New Product (Mean Loss - Objective)
		R4-6		RL	Table 2: New Product (Max Reflectance - Requirement)



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.1 High Temperature Storage Test (Dry Heat)	D	R4-47 and R4-49 thru R4-51	44 Pigtailed Assemblies and 44 Mating Adapters (LTPD 10%)	IL/RL (B/D/A)	85°C (±5°C), <40% RH, 2,000 hrs. For qualification and ≥ 5000 hrs (optional) for information. IL measurements initially, and then at 168- (optional), 500-, 1000-, and 2000-hour intervals. Per GR-1221, section 6.24
4.4.2 High Temperature Storage Test (Damp Heat)	E	R4-52 and R4-54 thru R4-56	44 Pigtailed Assemblies and 44 Mating Adapters (LTPD 10%)	IL/RL (B/D/A)	75°C (±5°C), 95% (± 5%) RH, 2,000 hrs. For qualification and ≥ 5000 hrs (optional) for information. IL measurements initially, and then at 168- (optional) 500-, 1000-, 2000-hour intervals. Per GR-1221, section 6.25



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771& 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.3 Temperature Cycling Test (Extended Thermal Cycling)	F	R4-57 and R4-59 thru R4-61	44 Pigtailed Assemblies and 44 Mating Adapters (LTPD 10%)	IL/RL (B/D/A)	- 40°C to 85°C (± 2°C) ≥ 30 minutes dwell time at extremes, 125 cycles pass/fail, 500 cycles pass/fail, 1000 cycles (optional) for information for RT/UNC. Per attached profile - see below
4.4.4 Salt Spray	G	R4-62 thru R4-65	10 assemblies ¹ ; 5 mated-pair assemblies; 5 plugs with dust caps; 5 receptacles with dust caps.	IL/RL (B/A)	Perform testing per GR-326, section 4.4.4.4 (Closure: 5 samples each, with mated plugs and with dust cap)
4.4.5 Airborne Contaminants	H	R4-66 thru R4-68	10 assemblies; 5 mated-pair assemblies; 5 plugs with dust caps; 5 receptacles with dust caps.	IL/RL (B/A)	Perform testing per GR-326, section 4.4.4.3 (Closure: 5 samples each, with mated plugs and with dust cap)
4.4.6 UV Resistance	I	R4-70	10 test bars	None Required	90 days, no damage, Tensile/Elongation greater than 20% - per ASTM G-154

¹ For the Dust Test, Salt Spray Test, and Airborne Contaminants Tests an “assembly” is an HFOC Plug mated to a HFOC receptacle on a closure.



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.7 Fungus Resistance	J	R4-71	10 test bars	None Required	Per ASTM G21, rating of 0 required
4.4.8 Dust Test	K	R4-72 thru O4-76	10 assemblies; 5 mated-pair assemblies; 5 plugs with dust caps; 5 receptacles with dust caps.	IL/RL (B/A)	Perform testing per GR-326, section 4.4.4.1 (Closure: 5 samples each, with mated plugs and with dust cap)
4.4.9 Groundwater Immersion	L	R7-15*	24	IL/RL (I/D/E)	Configure as: Closure/Connector (chemical only). Test three Config.; Plug/Dust; Plug/Adapter; Adapter/Dust Cap. 2 samples in each fluid. 4 immersion media's (organism not required), 22°C ±2°C for 7 days: Measure before immersion, Initially (upon immersion), after 24 hours, after 7 days (while in fluid)



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
GR-326 4.4.3.9 End of Test Criteria	ALL	VZR-1	16 pigtailed pair, 5 hot spares	IL/RL/CIT/CIR	Optical Requirements "End of Test" (see Table 3 & 4)
		VZR-2			Optical Objectives "End of Test" (see Table 3 & 4)
		R4-1 thru R4-5			Geometry (R4-1 to R4-5)
		VZR-3			No damage that would impair the performance of either the connector plug or the adapter.
4.4.10 Chemical Resistance - Material Degradation	M	R4-78	5 test bars/ material/chemical 2.5" x 0.5" x 0.125"		Smear samples with appropriate chemical, place in 3-point fixture (0.04" deflection) for 24 hrs. No evidence of cracking of material



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Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.11 Chemical Resistance - Immersion	N-1	R4-79 thru R4-81	3 dogbone samples and 3 pigtailed samples per chemical		Immerse 3 dogbones and 3 pigtailed samples in each chemical for 7 days. No change in weight > 10% or tensile and elongation > 20% for dogbones allowed. No damage to pigtails.
4.3.8 Crush Test	N-2	R4-44	12 pigtailed pair		300 lbs for 15 minutes: 8 @ -40°C and 8@ -40°C If not met, provide matrix for pass levels.
		O4-45			
4.3.6 Impact	N-3	R4-40	16 pigtailed pair, 10 hot spares	IL/RL (B/A); CIT/CIR	<ol style="list-style-type: none"> Test is performed at – 40°C. Test Jacks from first 8 samples and Plugs from second 8 samples. Test are performed with HMFOC endcaps



**FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC)
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Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
					installed on DUT 4. Impact hammer surface shall be rigid (concrete or steel) flat surface approximately 10"x10" Mass = 2 lbs (mass) 5. Impact velocity 9.46 m/s 6. Impact Method – Spring Impact 7. Connector Plug is aligned such that center of hammer surface is aligned with the center of the connector plug 8. The hammer surface shall be perpendicular to the motion of the hammer prior to striking the DUT surface 9. DUT is



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		R4-41			<p>suspended vertically with 1 meter of cable, cable end is fixed, the connector end is free to swing.</p> <p>10. Five Impacts at -40°C Impact 4 times, every 90° around connector axis and one on the end. (Connector suspended horizontally for end impact.)</p> <p>11. Inspect for Damage.</p>
		R4-40			If DUT does not comply at -40°C
		R4-41			perform test at -20°C,



FOC Test Criteria for HARDENED Fiber Optical Connectors (HFOC) based on GR-326, 771 & 3120(Task references from GR-326)					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
		R4-40			If DUT does not comply at -20°C perform test at 0°C.
		R4-41			
4.3.7 Seal under Load	N-4	R4-42	12 pigtailed pair	None Required	7 days @ 23°C: 10ft water head; 2.5lb (Req) - 90°; No damage.
		O4-43			7 days @ 23°C: 10ft water head; 5lb (Obj) - 90°; No damage.
4.5 Intermateability Test					See Testing listed below
8.0 Reliability Assurance Program					
8.2 Manufacturing and Process Control					Per VZ.TPR.9445
Repeatability & Accuracy requirement					Bench Top Optical System Switch-Based Optical System End Face Geometry



Optical Measurements

- 100% of channels to be monitored
- B – Before IL & RL Optical Testing @ (1310, 1490, 1550 & 1625 nm)
- D – During IL & RL Optical Testing @ (1310, 1490, 1550 & 1625 nm)
- A – After IL & RL Optical Testing @ (1310, 1490, 1550 & 1625 nm)
- I – Initial (under load) IL & RL Optical Testing @ (1310, 1490, 1550 & 1625 nm)
- E – End of test (under load) IL & RL Optical Testing @ (1310, 1490, 1550 & 1625 nm)
- CIT (Change in Transmittance)² Calculation - $CIT = A^{IL} - B^{IL}$
- CIR (Change in Reflectance)³ Calculation - $CIR = A^{RL} - B^{RL}$
- No measurements are required on hot spares until they become replacements.
- Concatenation of test samples is not allowed.

Damage Criteria:

- At the completion of the respective test the connector plugs and adapters shall be inspected for damage that might impair the performance of the connector. This inspection shall include inspections for:
 - Distortion of housing parts, as indicated by difficulty in insertion, improper snap-fits, etc.
 - Distortion of ferrules and sleeves, as indicated by change in mating force,
 - Changes in endface geometry, etc.
 - Cracks
 - Presence of debris, shavings, etc.
 - Corrosion or residue
 - Other potentially service-affecting damage
 - Permanent Loss Increase of more than 0.5 dB from the New Product Measurement
 - Permanent Reflectance Increase of more than 5 dB from the New Product Measurement.
- Permanent is defined as having the specified level of increase in loss or reflectance at the end of all tests performed on connector assemblies. The connector assemblies may be cleaned up to 2 times, using the specified Cleaning Procedure, at the supplier's option, in an attempt to bring their increases below the criteria level.
- Examination shall also include inspection of the polished end of the ferrule under a magnification of 100 power for cracks, chips, or scratches.

²Only increases in Insertion Loss are a concern. A decrease in Insertion Loss is not a concern.

³Only increases in reflectance are an issue. A decrease in reflectance is not a concern.



Testing Sequences:

The following table will define the test sequences for the Service Life testing requirements.

Table 1 (Service Life)			
Sample Group	Test Sequence	Title	Section
A	1	Ferrule Endface Geometry	4.1
A	2	New Product Measurement	4.1.4
A	3	Thermal Age Test	4.2.1.1
A	4	Thermal Cycling	4.2.1.2
A	5	Humidity Age	4.2.1.3
A	6	Humidity / Condensation Cycling Test	4.2.1.4
A	7	Dry-out Step	4.2.1.5
A	8	Post-Condensation Thermal Cycle	4.2.1.6
A	9	Vibration	4.2.2
A	10	Freeze Thaw	4.2.3
A	11	Water Resistance	4.2.4
A	12	Flex Test	4.3.1
A	13	Cable Torsion	4.3.2
A	14	Proof Test	4.3.3
A	15	Transmission With Applied Tensile Load	4.3.4
A	16	Impact	4.3.6
A	17	Durability	4.3.5
A	18	Seal Under Side Load	4.3.7
A	19	End of Test Criteria (Optical, Ferrule Geometry and Damage)	4.3.10
B		Crush Test	4.3.8
C		Rockwell Hardness	4.3.9

Testing is to be performed sequentially as defined in the above table.



The following table will define the test sequences for the Reliability testing requirements.

Table 2 (Reliability)			
Sample Group	Title	Section	Sample Type
ALL	Ferrule Endface Geometry (Initially and at the end of testing - all samples)	4.1	
A	New Product Measurement	4.1.4	All
D	Extended Thermal Age	4.4.1	Assembly and adapter/Terminal or Closure
E	Extended Humidity Age	4.4.2	Assembly and adapter/Terminal or Closure
F	Extended Thermal Cycling	4.4.3	Assembly and adapter/Terminal or Closure
G	Salt Spray	4.4.4	Pigtail Assembly
H	Airborne Contaminants	4.4.5	Pigtail Assembly
I	UV Resistance	4.4.6	Test Bars
J	Fungus resistance	4.4.7	Test Bars
K	Dust	4.4.8	Pigtail Assembly
L	Ground Water Immersion	4.4.9	Pigtail Assembly
ALL	End of Test (IL/RL, Geometry, Damage)		ALL
M	Chemical Resistance - Material Degradation	4.4.10	Test Bars
N-1	Chemical Resistance - Immersion	4.4.11	Assembly and adapter/Terminal or Closure
N-2	Crush Test	4.3.8	Assembly and adapter/Terminal or Closure
N-3	Impact	4.3.6	Assembly and adapter/Terminal or Closure
N-4	Seal Under load	4.3.7	Assembly and adapter/Terminal or Closure

Testing is to be performed per the sequences defined in the above table.

- Initially, all samples must meet the new product measurement requirements as defined in Tables 1 and 2 and the End Face Geometry requirements as defined in section 4.1 above and in GR-326.
- At the completion of test, all samples must the optical requirements as specified in Tables 1 and 2, the Damage requirements as specified in this document and the Endface Geometry requirements as specified in section 4.1 above and in GR-326.



Optical Requirements:

Insertion Loss Criteria

Table 3: Summary of Optical Performance Criteria: Loss						
Test	Maximum Loss		Mean Loss		Loss Increase	
	(R)	(O)	(R)	(O)	(R)	(O)
New Product	0.4	0.2	0.2	0.15	---	---
During Test, Not Under Load	0.5	0.3	0.3	0.2	0.3	0.2
During Test, Under Load	---	---	---	---	0.5	0.3
End of Test	0.5	0.3	0.3	0.2	---	---

Reflectance Criteria

Table 4: Summary of Optical Performance Criteria: RL		
Test	Reflectance	Increase in Reflectance
	(R)	(R)
New Product	-65	---
During Test, Not Under Load	-65	5
During Test, Under Load	-65	5
End of Test	-65	5

Notes:

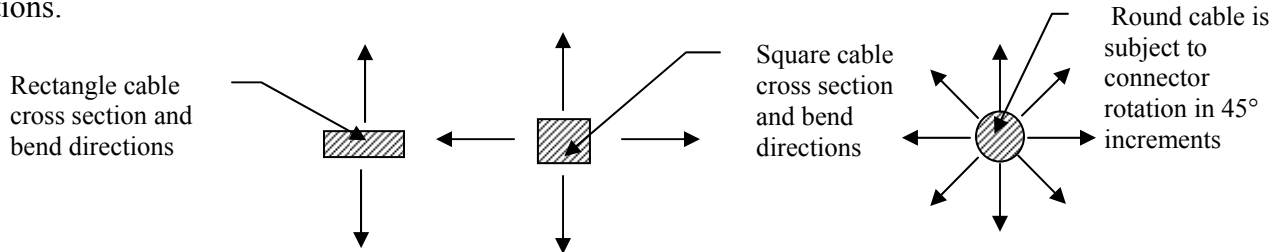
Note 1: Measurement to be performed at every plateau - wait minimum of 30 minutes into cycle before starting. (Cycle may be modified by decreasing transition time and increasing hold times if need to complete measurements)

Note 2: Humidity is only controlled above freezing (0°C)



Note 3: (Service Life) The tensile test fixturing is to be designed with a bracket to hold the coupling adapter in angular increments of 45° about the axis of the connector. During testing, the sample of product is to be rotated as evenly as possible between the eight angular positions to ensure all angles are tested. (i.e. - sample 1 @ 0°, sample 2 @ 45°, sample3 @ 90°, etc.). The sample rotation criterion applies to Flex, Twist, Proof and Transmission with Applied Load. The 45° connector rotation criterion is only applicable to assemblies that utilize round cable. For assemblies that utilize rectangular cable, the connector cable assembly is to be tested with the cable in its two preferred bend direction. Square cable is to be tested in the four flat edged directions.

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Note 4: Decrease in reflectance is not of concern. Note that the definition of “reflectance” is that of a negative number, as opposed to Optical Return Loss, which is a positive number. The terms “greater than” and “less than” are applied to the numerical values of the reflectance, and not the absolute values of these numbers. Thus, a -50 dB reflectance is greater than a -60 dB reflectance

Note 5: RL readings of >65 dB are usually outside of the test set-ups capability and the resultant delta value may be outside the allowable range, thus technically interpreted as a failure. Since the value is excellent and readings are not reliable above the 65 dB level for many set-ups, the delta should not be considered as a failure.

Note 6: Optical readings - during are to be taken at the maximum sampling rate.

Note 7: The most stringent criteria is to be used as the pass/fail criteria i.e.: GR criteria, Verizon specifications, or supplier's specifications. The suppliers spec sheet is to be included in the test plan and report in the product description section of the document.

Note 8: For Service Life Environmental Tests, recommended using adapter with Hardened Connector but use of a closure and/or other mounting arrangements is acceptable.



Extended Thermal Cycling (Reliability) Test

The test conditions for the Extended Thermal Cycle Test are shown in Figure 1 below.

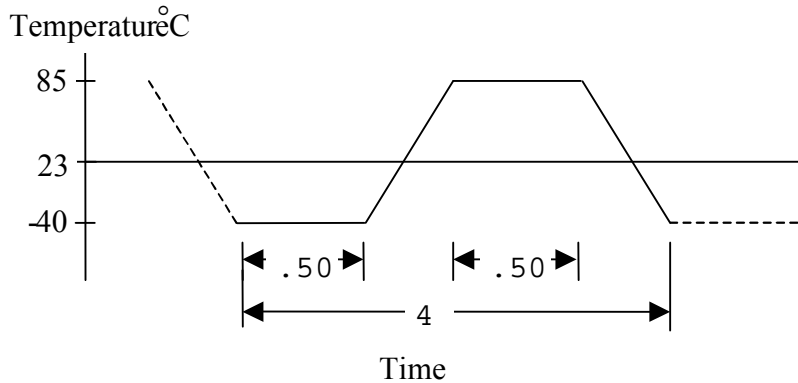


Figure 1: Temperature Profile for Extended Thermal Cycle Test

Extended Thermal Cycle Test Conditions

Temperature: Cycle in Figure 1 (-40°C to 85°C).
All ramp times are 1.4°C per minute, all plateaus are 30 minutes

Humidity: Uncontrolled

Duration: 500 cycles in 2000 hours

Measurement of Insertion Loss and Reflectance: Data shall be taken initially, and then at the completion of 125 cycles and at the completion of 500 cycles.



Intermateability Testing of SC-APC HFOC Connectors and Adapters

Executive Summary:

The objective of this proposed test program is to provide detailed insight regarding the interconnecting ability of connector and adapters from different suppliers. Using a modified test plan and test protocol from GR-3120-CORE Issue #1, tests and conditioning will be performed on an inter-mated group of connector assemblies. Insertion loss and reflectance readings will be determined before, during and after specific conditionings. The intent of this program is to determine the suitability and interchangeability of connector and adapters of participating vendors and manufacturers.

Connector Intermateability

Test Requirements:

- **Endface Geometry Readings**
Initial endface readings of all connectors under test will be taken.
- **Insertion Loss and Reflectance Testing**
Insertion Loss and Reflectance readings are conducted for New Product, during the test and End of Test Criteria at four wavelengths (1310 nm, 1490 nm, 1550 nm, and 1625 nm). New Product measurements are conducted with each manufacturer's HFOC connector and adapter. The appropriate manufacturer's launch cable (reference jumper) will be used for each connector. Please see Figure 2.
- **Environmental Cycle (Modified)**
Please refer to Figure 3 for the temperature profile and data acquisition times.
- **Vibration Test.**
Conducted in accordance with this TPR.
- **Proof Test**
Conducted in accordance with this TPR.
- **Durability Test**
Conducted in accordance with this TPR.
- **Seal Under Load Test**
Conducted in accordance with this TPR.
- **End of Test Criteria**
Insertion Loss, Reflectance, and Endface readings will only be conducted on nonconforming samples. The appropriate manufacturer's launch jumper cable assemblies (same as Step #1 above) will be used for each assembly, if necessary.

- NOTE 1: All test samples will be tested sequentially to the test list above.
- NOTE 2: Each combination of HFOC connector, adapter, and SC APC pigtail will have a total sample lot as defined in Table 3.
- NOTE 3: All testing to be performed at 1310 nm, 1490 nm, 1550 nm, and 1625 nm wavelengths except where noted.



NOTE 4: ITL will use the manufacturer’s service provider specific cleaning procedures for the HFOC connector/adapter. Only this specific cleaning procedure will be used on the DUT (Device Under Test). As an example Alcohol and Kim-Wipes and/or Cleatops will be used on surfaces not undergoing testing.

NOTE 5: The manufacturer’s HFOC specific installation and maintenance instructions shall be provided prior to testing.

- Samples:

Sample Requirements for Program Participation: The number of samples required for participating in the HFOC Intermateability test program is given in Table 3. Sample configurations are based on the connector definitions given in figure 4 of this document and assume two initial participants. Each succeeding program candidate (connector) is tested against the two most recently approved connectors in reverse chronological⁴ order for a maximum of 3 participants per test program. Each test program requires Ten (10) full connectors + 5 hot spares of the new participant test samples and five (5) samples + 3 hot spares of each of the two veteran participants.

Table 3 Program Sample Requirement

Order of Participation	Manufacturer	Test Combination HFOC → Adapter	Number of Test Samples
Initial 2 participants	A	A → B	A - 10 + 5 for Hot Spares
	B	B → A	B - 10 + 5 for Hot Spares
3 rd participant	A	A → C - 5 per	A-5 + 3 for Hot Spares
	B	B → C - 5 per	B-5 + 3 for Hot Spares
	C	C → A - 5 per C → B - 5 per	C - 10 + 5 for Hot Spares
4 th participant	B	B → D - 5 per	B - 5 + 3 for Hot Spares
	C	C → D - 5 per	C - 5 + 3 for Hot Spares
	D	D → B - 5 per D → C - 5 per	D - 10 + 5 for Hot Spares
5 th participant	C	C → E - 5 per	C - 5 + 3 for Hot Spares
	D	D → E - 5 per	D - 5 + 3 for Hot Spares
	E	E → C - 5 per E → D - 5 per	E - 10 + 5 for Hot Spares

⁴ If A, B, and C are already approved and D wishes to participate, then D is tested against B and C.



The following list of samples and supplies are required from each supplier participating in the program:

- Four (4) – (Test Equipment Connector) to SC-APC 1-meter launch cable. The manufacturing process and end face geometry on the SC-APC launch cable connector shall be representative of all other test samples.
- New Participant samples requirements - 15- test connector to HFOC SC APC jumper cable assemblies. Please see Figure 1, page 3 of 7 for HFOC SC-APC jumper assembly details. (10 required with 5 spares).
- Veteran Participant Sample Requirements: 8- test connector to HFOC SC APC jumper cable assemblies. Please see Figure 1, page 3 of 7 for HFOC SC-APC jumper assembly details. (5 required with 3 spares for each participant).
- To prevent water seepage through the length of the cable during the seal under load test sequence, the drop cable portion of the HFOC connector may be sealed with silicone or other appropriate means as shown in Figure 1 below. Alternatively, if equipped with water blocking capability, lengthening the HFOC drop cable may be used as a method for preventing cable water seepage during the “Seal under load” test. See Insertion loss and reflectance testing of this document for the cable length impact on “Back Reflectance Test Results”.
- (15)-Rookie (10 required with 5 spares), (8)-Veteran (5 required with 3 hot spares) - HFOC adapters
- (15)-Rookie (10 required with 5 spares), (8)-Veteran (5 required with 3 hot spares)– GR-326 approved test connector to SC APC 3-meter jumper cable assemblies.
- Supplies and specific instructions on the cleaning system for the HFOC connector and/or adapter
- Specific Instructions for installing and maintaining the HFOC connector and/or adapter.

- One extra set of O-rings/seals for each connector under test.

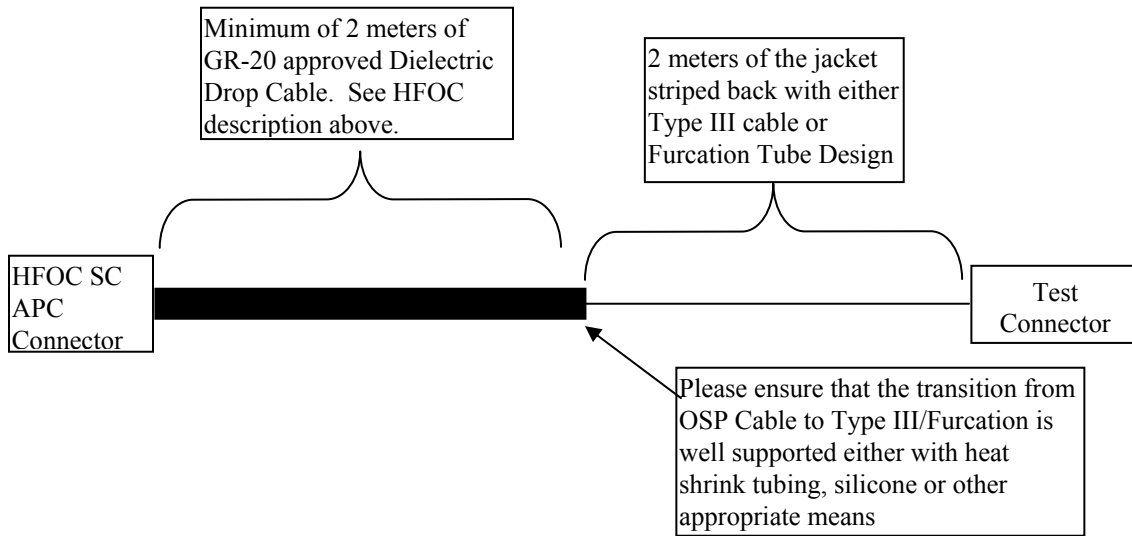


Figure 1: Required Configuration of HFOC Jumper Cable Assemblies

Test Specifics:

- **Endface Geometry Readings**

Endface geometry readings will be done on all DUT samples (HFOC and SC APC) as an out of the box “New Product”.

- **Insertion Loss and Reflectance Testing**

New Product Insertion Loss and Reflectance readings will be conducted on all HFOC jumpers utilizing the appropriate launch cable. Please refer to Figure 2 for configuration specifications.

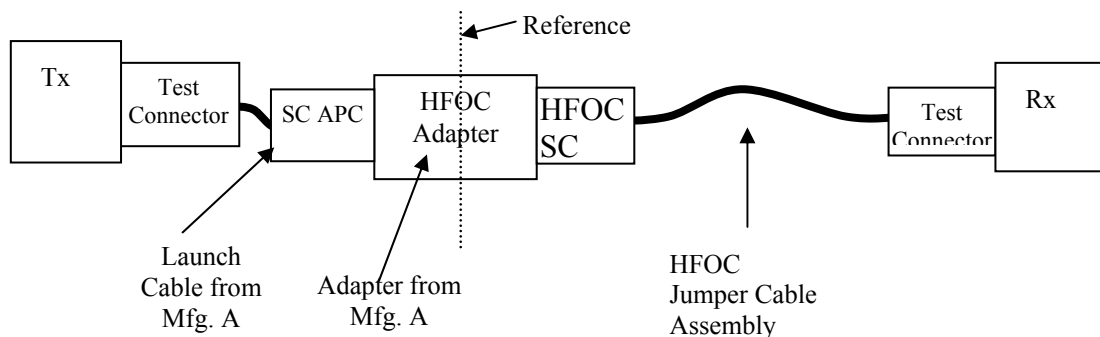


Figure 2: Test Setup

If the length of the HFOC drop cable is increased beyond the required minimum (such as to prevent cable water seepage), then the back reflectance measurements conducted during the intermatability test sequence may be adjusted to compensate for the added reflectance of the additional HFOC fiber length. All correction factors and data calculations shall be included in the test report.



- **Environmental Cycle (modified)**

Jumper assemblies and spare O-rings from each of the participating manufacturers will be placed in a conditioning chamber and subjected to the temperature profile shown in Figure 3. Insertion Loss and Reflectance Readings shall be taken every two hours throughout the test.

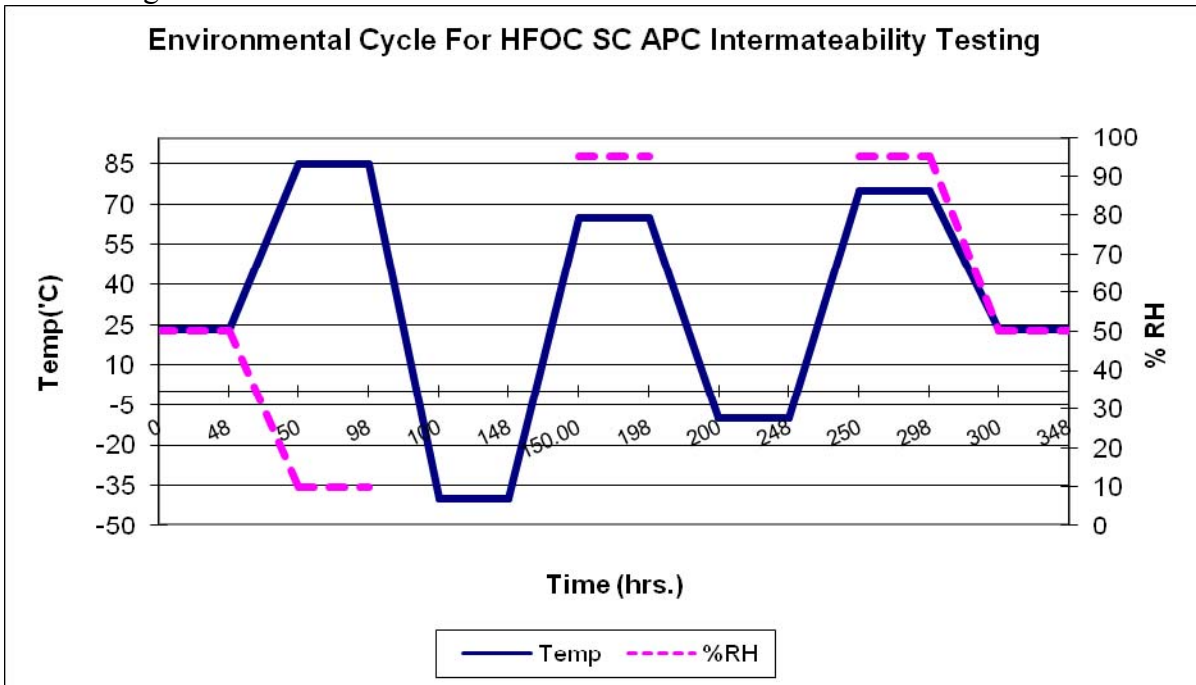


Figure 3: Environmental Cycle for HFOC SC APC Intermateability Testing

- **Vibration Testing {GR-3120, Section 4.2.2}**

Conducted in accordance with this TPR on all combinations. Please note that the samples will not be monitored during the actual vibration sweeps.

- **Proof Test**

Conducted in accordance with this TPR.



- **Durability Test**

Conducted in accordance with this TPR. Fifty cycles will be performed at -18°C (0°F) and at 46°C (115°F) as per the combinations shown in Table 3. The cleaning procedure will follow GR-3120, Issue #1, Section 4.3.5.

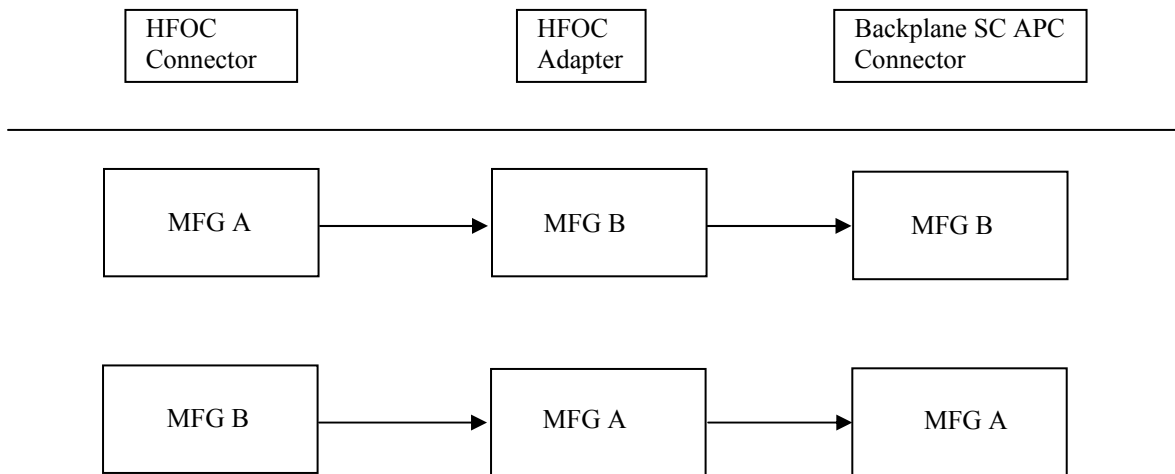


Figure 4: Combination for the Durability Test

- a. The required number of connector assemblies as shown in the Table 3 shall be tested.
- b. The connectors shall then be conditioned at -18° C for two hours.
- c. Each connector shall be disconnected and re-connected.
- d. Insertion loss and reflectance are measured at 1310 nm, 1490 nm, 1550nm and 1625 nm wavelength after each disconnect and re-connect operation.
- e. The test sequence is continued until all connectors have been cycled (removed and inserted) 50 times. Clean using the service provider instructions every 10 mating/cycles and optically monitor. A seal under load test is performed at the end of the 50th cycle. See section 1.3.7 below. The O-rings shall not be replaced prior to the seal under load test.
- f. The test sequence is repeated with a spare (aged) set of O-rings and a test environment of 46°C.



- **Seal Under Load Test {GR-3120, Section 4.3.7}**
Conducted in accordance with this TPR. The test will follow the latest service provider punch-list where the HFOC connector shall be tested in two orthogonal cable orientations and a 2.5-lb load shall be placed on the cable approximately 6-8 inches from the end of the boot.
- **End of Test Criteria**
On nonconforming samples, endface geometry shall be re-measured as described in Section 1.3.1 above. Final measurements for Insertion Loss and Reflectance will be repeated using the same methods as described in #2 above.

Acceptance Criteria

- **End Face Geometry**
As per this TPR.
- **Initial and Final Loss Measurements**
As per this TPR. Connectors shall meet the Requirements listed Table 1 and 2 of this document.
- **Environmental Conditioning**
Custom temperature profile, please refer to Figure 2. Connectors shall meet the Requirements listed Table 1 and 2 of this document.
- **Vibration Test**
As per this TPR, Connectors shall meet the Requirements listed Table 1 and 2 of this document.
- **Proof Test**
As per this TPR, Connectors shall meet the Requirements listed Table 1 and 2 of this document.
- **Durability Test**
As per this TPR, Connectors shall meet the Requirements listed Table 1 and 2 of this document.
- **Seal Under Load Test**
As per this TPR, samples will be checked for water leaks for a “Pass/Fail” criteria.
- **End of Test Criteria**
As per this TPR, Connectors shall meet the Requirements listed Table 1 and 2 of this document. Endface Geometry as per this TPR.