

Verizon NEBS™ Compliance: Single-mode Optical Connectors and Jumper Assemblies

Verizon Technical Purchasing Requirements

VZ.TPR.9409

Issue 8, March 2020

CHANGE CONTROL RECORD:

Version	Date	Action*	Reason for Revision
1	10/15/2007	New	New Document.
2	10/30/2007	Change	4.4.2.3 Humidity Aging Test changed to 95% RH
3	03/06/2008	Change	Corrected Test Conditions for Section 4.4.2.6 Corrected Test Conditions for Section 4.4.3.2 Corrected Test Conditions for Section 4.4.3.3
4	4/22/2010	Add	Added Intermateability test requirements from FOC memo # 33 and several other modifications
5	8/20/10	Change	Correct Criteria Table
			Clarified Samples for flammability
			Clarified DUT Mated Pair Only Measurements for New Product, Section 4.4.1
			Corrected Dwell Time for Extended Thermal Cycling
			Clarified Measurement before Immersion, Section 4.4.4.6
			Clarified Measurement Rational for Jumper Cable Assembly
			Updated/Corrected Table 2
			Clarified Note 5
			Identified the 100 hour and 168 hour measurements as optional for Extended Thermal Cycle.
6	10/5/2012	Change	Modified the scope to include factory splices in the connector assembly.
		Add	Added Section for Wavelength Dependant Loss testing between Section 3 and 4.
		Change	Update references to latest GRs and remove references to FOC Memos
		Change	Update Requirement and Objective Number to match GR-326.
		Change	Use "reflectance" instead of "return loss"
		Change	Maximum SC & LC Loss to 2 significant figures
		Change	Deviations / changes from GR-326 highlighted in bold italic
		Add	Comment regarding fungus growth on cable in Test Plan table
		Change	Flammability per GR-326
		Remove	3.3.2 – Cleanability removed - (removed from GR-326, addressed via dust test and salt spray testing)
		Change	Only pigtail pairs go through entire service life sequence. Cable assembly pairs go through service life thermal aging and service life thermal cycle.
		Change	Adopt GR-326 Twist Test requirement and objective for Type 2 Media
		Change	4.4.3.5 – Added verification of fiber bend during side load
		Change	4.4.4.5 – Removal of requirement for "core dissolution" test
		Change	Clarify the RL measurements are made as part of extended thermal age, extended humidity, and extended thermal cycle
		Change	Remove CO option for Extended Thermal Cycling
		Change	Modify Extended Thermal Cycling comments to indicate cycle numbers for measurement rather than hours.
		Change	Modify salt spray to agree with GR-326

		Change	Clarify sample description for 4.4.2 to match GR-326
		Delete	Redundant Extended Thermal Cycling (Reliability) section after the Notes removed.
		Add	High Power Test
		Add	MPI (Multi-path Interference)
7	01/22/13	Add	Added Section 4.4.3.10 and 4.4.3.11.
8	3/9/2020	Revise	Renumber 4.4.5.3 to 4.4.5.4 to agree with GR-326 numbering
		Revise	Add new line for 4.4.5.3 with IEC 61755-3-1 & 61755-3-2
		Delete	Wording after table 2 on page 22 for Reliability
* 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 summarize and provide additional and/or overriding FOC testing requirements to those specified in GR-326-CORE Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies.

2.0 SCOPE

Factory terminated Singlemode Optical Connectors and Jumper Assemblies.

3.0 REFERENCES

GR-326-CORE, Issue 4, February 2010	Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies
GR-1221-CORE, Issue 3, September 2010	Generic Reliability Assurance Requirements for Passive Optical Components

4.0 ACRONYMS

A	After
B	Before
CIR	Change in Reflectance
CIT	Change in Transmittance
D	During
FOC	Fiber Optic Components
IL	Insertion Loss
ITL	Independent Test Laboratory
RL	Reflectance

5.0 TEST REQUIREMENTS FOR SINGLEMODE OPTICAL CONNECTORS AND JUMPER ASSEMBLIES

Verizon purchases Singlemode Optical Connectors and Jumper Assemblies for various applications. This Technical Purchasing Specification includes Factory Terminated Connectors that may be assembled utilizing a fusion splice inside the connector and boot assembly. However, any connector so manufactured must also meet the wavelength dependent loss criteria included in this document. Additionally, all Factory Terminated Single Mode Optical Connectors and Jumper assemblies, including those incorporating a fusion splice behind the boot, must meet all the requirements specified in the following tables. These criteria are based on the requirements specified in Telcordia document GR-326-CORE: Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies. All the testing must be completed by a Verizon approved ITL:

The tests of GR-326 are outlined in this document. Where Verizon additions and/or clarifications are made and where Verizon criteria differ from those in the GR, we have attempted to indicate such by ***Bold, Italic*** type. Note that any text in this document which differs from GR-326 applies, even if not highlighted.

NOTE: The IL/RL pass/fail requirements are presented below. ***These differ from those of GR-326-CORE.***

Loss Criteria

Test	Maximum Loss SC & LC, APC mated connector	Maximum Loss SC & LC, UPC mated connector	Loss Increase SC & LC, APC mated connector	Loss Increase SC & LC, UPC mated connector
	(R)	(R)	(R)	(R)
New Product	0.30	0.25	---	---
During Test, Not Under Load	0.40	0.30	0.30¹	0.20²
During Test, Under Load	---	---	0.40	0.30
End of Test	0.40	0.30	---	---

¹ Loss increase is not a concern as long as Max Loss is not exceeded during or at the end of the test.

² Loss increase is not a concern as long as Max Loss is not exceeded during or at the end of the test.

Return Loss Criteria

Test	Maximum Reflectance SC & LC, APC mated connector	Maximum Reflectance SC & LC, UPC mated connector
	(R)	(R)
New Product	-65	-55
During Test, Not Under Load	-65	-55
During Test, Under Load	-65	-55
End of Test	-65	-55

- Increase in reflectance need not be evaluated in maximum requirement is met

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
3.0 General Requirements					
3.1 Documentation					
Test Reports		R3-1 [1]			
Product Documentation		R3-2 [2]			
3.2 Packaging and Shipping		R3-3 [3]			Samples shall be packaged and shipped to the ITL as shipped to the field
3.3 Design Features					
3.3.1 Materials					
Metallic Elements		R3-4 [4]			Verified from Salt Fog and Thermal Cycling/Humidity results
Index Matching Fluid or Gel		R3-5 [5]			Non-used
Fungus Resistance		R3-6 [6]	5 plugs & adapters		ASTM-G21-70. Rating of 0 Fungus also not allowed on cables. Exception for cables in GR-326 does not apply Rating of 1 may be considered based on the application
Flammability		R3-7 [7]	<i>“A minimum of ten test specimens, 125+/-5mm long by 13+/-0.5mm wide, and provided in the minimum and maximum thickness 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> <i>or 5 pigtail samples</i>		Per GR-326

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
Cable Media Type		R3-8 [8]			GR-20 and/or GR-409 cable
3.4 Intermateability					
Intermateability		CR3-9 [10]	5 jumpers/5 mating adapters		FOCIS-n (new product and after service live)
Ferrule Extension Contact Force		R3-10 [11]	5 jumpers (plugs)		Per FOCIS-n doc.
Length Requirements		R3-11 [212]	5 jumpers/5 mating adapters		Per FOCIS-n doc.
Adapter Sleeve/Ferrule Friction Forces		R3-12 [213]	5 mating adapters		Force to remove pin gage from adapter sleeve per FOCIS-n doc.
Adapter Sleeve Latch Spacing		R3-13 [214]	5 jumpers/5 mating adapters		Latch spacing per FOCIS-n
Glass Transition		R3-14 [215]	5 jumpers/5 mating adapters		Glass Transition > 100°C
3.4.1 Latching Intermateability		CO3-15 [216]	288 plugs & 144 adapters		Push-Pull Type Connectors only: $\geq 30\%$ of connectors fail test; Insertion Force between 5 and 6 lbs, Extraction Force < 5lbs. (see procedure listed below)
3.5 Product Marking and Packaging					
Product Marking		R3-16 [12]			Per GR-326: Supplier, model or series, vintage code (adapters - 6 months; plugs - 3 months)
Color Code		O3-17 [13]			per Table 3-1; GR-326
Color Code APC		CR3-18 [14]			APC - Green Plug body or Green Boot
3.5.1 Keying					
Presence		O3-19 [15]			
Visible		O3-20 [16]			

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
3.6 Safety					
Radiation Hazard		R3-21 [17]			Documentation Review
Cleaning Materials		R3-22 [18]			Documentation Review
VZ Specific - Wavelength Dependent Loss³	11	GR-1081; 4.2 Wavelength Dependency	N=20 Ten mated pairs of DUT connectors mated to each other. Ten mated pairs (DUT w/fusion) mated with standard factory terminated connector		<ul style="list-style-type: none"> This test is highly recommended for all connectors GR-1081 4.2 requires measurements from 1260nm to 1630 at all wavelengths, with peak-to-peak variation not to exceed 0.1 dB. This test shall be conducted with > minimum fiber length on the transmit side and = to minimum fiber length on the receive side. Refer to the Note at the end of this table for test setup
4.0 Connector Tests and Criteria (Service Life)					
4.2.2.5 Handling of Nonconformance					
4.4.5 Geometry Requirements					

³ Applicable only to those factory terminated connectors utilizing a splice within the connector and/or boot assembly.

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.5.1 Ferrule Endface Geometry for Non-Angled Physical Contact Connectors	1-A	R4-65 [80] -R4-67 [82]	All		Per GR-326, section 4.4.5.1
4.4.5.2 Endface Geometry Requirements for Angled Physical Contact (APC) Connectors	1-A	R4-68 [222]	All		Per GR-326, section 4.4.5.2 (APC only)
4.4.5.3	1-A	IEC 61755-3-1 (UPC) & IEC 61755-3-2 (APC)	All		If any of R4-65 through RF-68 are not met, provide evaluation against the limits in IEC. Verizon will review against IEC values.
4.4.5.4 Endface Geometry Measurements Areas	1-A	R4-69 [223]	All		Per GR-326, section 4.4.5.4
4.4.1 Performance of New Product	1-B	R4-1 [19] thru O4-6 [25]	All	IL/RL	Per Tables 4-2 and 4-3 (New Product) Measurement must be taken against a mated pair (DUT mated to DUT, no measurements against reference connector required.) Note Verizon Criteria outlined before this table
4.4.2 Temp/Hum/Cond Test					
4.4.2.1 Thermal Age Testing	1-C	R4-7 [26] and O4-8 [27]	15 pigtailed pair, 5 hot swap pigtailed pair and 5 cable assembly pair	IL/RL (B/A); CIT/CIR	85°C/168h
4.4.2.2 Thermal Cycle Test	1-D	R4-9 [28] and O4-10 [29]	15 pigtailed pair, 5 hot swap pigtailed pair and 5 cable assembly pair	IL/RL (B/D/A); CIT/CIR	-40°C to +75°C; 7 days; Dwell Time: 1 hour (per GR-325, Figure 4-3) - see note ¹
4.4.2.3 Humidity Aging Test	1-E	R4-11 [30] and O4-12 [31]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/D/A); CIT/CIR	75° C / 95% RH, 7 days - Measurements every 6hrs min.

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.2.4 Humidity/Condensation Cycling Test	1-F	R4-13 [32] and O4-14 [33]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/A); CIT/CIR	-10°C to +65°C, 90% - 100% RH; 7 days; (per GR-326, Figure 4-4) - See note ²
4.4.2.5 Dry-Out Step	1-G		15 pigtailed pair, 5 hot swap pigtailed pair		24 hrs @ 75°C, uncontrolled humidity
4.4.2.6 Post-Condensation Thermal Cycle Test	1-H	R4-15 [34] and O4-16 [35]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/A); CIT/CIR	-40°C to +75°C; 7 days; Dwell Time:1 hour (per GR-325, Figure 4-3) - see note ¹
4.4.3 Mechanical Tests					
4.4.3.1 Vibration Test	1-I	R4-17 [36] and O4-18 [37]	15 pigtailed pair, 5 hot swap pigtailed pair	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)
4.4.3.2 Flex Test	1-J	R4-19 [38] - CO4-21 [218]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/A); CIT/CIR	100 flex cycles @ 0°, 90°, 0°, 90°, 0°: Media Type 1 only - 2.0 lbf load, reduce load to 1.3 lbf for small form factor connectors. Product shall not uncouple during test.
4.4.3.3 Twist Test	1-K	R4-22 [40] and O4-23 [41]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/A); CIT/CIR	Twist Cycles (per Table 4-8 of GR-326), Media Type 1: 3.0lbf, X= 2.5 turns, Y=5 turns Media Type 2: 1.65lbf X= 1.5 turns, Y=3 turns Media Type 3: 1.1lbf X= 1.5 turns, Y=3 turns Product shall not uncouple during test. For Media Type 2: The objective load of

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
					0.75 kgf (1.65 lbf) is preferred but the requirement of 0.5 kgf (1.1 lbf) applies
4.4.3.4 Proof Test	1-L	R4-24 [42] - CO4-26 [219]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/A); CIT/CIR	Media Type 1 Only: per GR-326, section 4.4.3.4
4.4.3.5 Transmission With Applied Tensile Load	1-M	R4-27 [44] - CO4-34 [221]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/D/A); CIT/CIR	Per GR-326, section 4.4.3.5 During 90° side load, also verify that boot ensures fiber minimum bend radius is not violated. For LC connectors recommend 7.5 mm.
4.4.3.7 Impact	1-N	R4-35 [50] and O4-36 [51]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/A); CIT/CIR	Impacted @ 1.5 meter height - 8 impacts
4.4.3.8 Durability	1-O	R4-37 [52] - O4-42 [57]	15 pigtailed pair, 5 hot swap pigtailed pair	IL/RL (B/D/A); CIT/CIR	200 cycles durability, per GR-326, section 4.4.3.8
4.4.6 Connector installation	1-P	R4-70 [224] - O4-73 [226]	5 pigtails	IL/RL (B/D/A); CIT/CIR	Perform testing per GR-326, section 4.4.6
4.4.3.9 End of Test Criteria	1-Q	R4-43 [58] - R4-46 [61]	15 pigtailed pair, 5 hot swap pigtailed pair and 5 cable assembly pair	IL/RL/CIT/CIR	Optical Measurements, Endface Geometry and Damage
4.4.3.10 Assembly Strength Test (Small Form Factor Assemblies – Connector)	1-R		5 pigtail assemblies (pair)	None	Samples shall be pre-conditioned beginning with 4.4.2.1 and continuing through 4.4.3.3. Test is performed as per 4.4.3.4 with the following modification. The test is to be performed at 0 degrees only. Test per TIA 455-6. Add load at a rate of 10 mm per minute. Increase load until failure occurs. Failure is defined

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
					<p>when one of the following events occurs:</p> <ol style="list-style-type: none"> 1. Connector pulls out and/or mechanically fails; 2. Media breaks. <p>Report the failing point load.</p> <p>Failure is expected to occur at loads greater than fifteen (15) lbf.</p> <p>Alternatively (if not able to apply load at a constant rate): Starting at 3 lbf. the load is applied to each sample in increments of 150% X (previous load), until failure occurs.</p>
4.4.3.11 Media Strength Test. (For all media)	1-S	R6-55 GR-409 Issue 1	5 lengths of media	During	<p>Repeat test of 4.4.3.1 with test applied to the cable media instead of connector interface. Minimum gauge length is 0.5 m.</p> <p>The rated cable residual load is applied and held for 30 minutes. IL is monitored during application of the load. Load is increased at 5 mm/min until IL change exceeds 0.05 dB. At this point, the value of the load is recorded. Continue the test until the cable media fails. Failure is defined as $IL \geq 0.5$ dB (permanent) or the media breaks. Record IL and load at the point where permanent failure occurs.</p> <p>An IL increase >0.05 dB is expected to occur at a load that is at least 2x the rated residual load of the cable media. Failure of the cable media ($IL > 0.5$ dB or media</p>

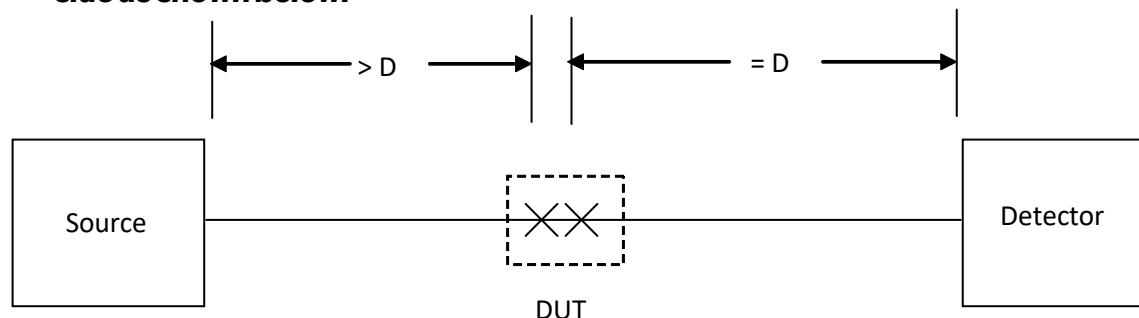
FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
					breaks) is expected to occur at a load that is at least 1.5x the rated installation load. Alternatively (if not able to apply load at a constant rate): Load is increased in steps [150% X (Previous Load)] and held for 15 minutes. Test continues until IL change exceeds 0.05 dB. At this point, the value of the load is recorded. Continue the test until the cable media fails. Failure is defined as IL ≥ 0.5 dB (permanent) or the media breaks. Record IL and load at the point where permanent failure occurs.
VZ Specific - High Power	12		5 mated pigtail pairs	IL/RL (B/A) Visual Inspection	Optional Test Expose mated connectors to +32 dBm for 72 hours and measure IL/RL with conventional power levels. Inspect endface. Measure EFG.
VZ Specific - MPI (Multi-path interference)	13		TBD	TBD	Optional Test Discuss with Verizon
5.0 Facilities for Product Testing					
5.1 Ambient Laboratory Conditions					Temperature: 23°C +/- 2°C Humidity: less than 75%RH
5.2 Optical Measurements					Per VZ.TPR.9405 & GR-326 Section 5.2
6.0 Service Life Test					
6.1 Service Life Test					See Table 1
7.0 Reliability Test					
7.1 Description of Reliability Test					See Table 2
4.4.5 Geometry Requirements	All				

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.5.1 Ferrule Endface Geometry for Non-Angled Physical Contact Connectors	All	R4-65 [80] -R4-67 [82]	All		Per GR-326, section 4.4.5.1
4.4.5.2 Endface Geometry Requirements for Angled Physical Contact (APC) Connectors	All	R4-68 [222]	All		Per GR-326, section 4.4.5.2 (APC only)
4.4.5.3	All	IEC 61755-3-1 (UPC) & IEC 61755-3-2 (APC)	All		If any of R4-65 through R4-68 are not met, provide evaluation against the limits in IEC. Verizon will review against IEC values.
4.4.5.4 Endface Geometry Measurements Areas	All	R4-69[223]	All		Per GR-326, section 4.4.5.4
Extended Thermal Age	2	GR-1221, section 6.2.4	22 Jumper Cable 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/RL measurements initially, and then at 168- (optional), 500-, 1000-, and 2000-hour intervals
Extended Humidity	3	GR-1221, section 6.2.5	22 Jumper Cable Assemblies and 44 Mating Adapters (LTPD 10%)	IL/RL (B/D/A)	75°C (±5°C), 90% (± 5%) RH, 2,000 hrs. for qualification and ≥ 5000 hrs (optional) for information. IL/RL measurements initially, and then at 168- (optional) 500-, 1000-, 2000-hour intervals.
Extended Thermal Cycling	4	GR-1221, section 6.2.7	22 Jumper Cable Assemblies and 44 Mating Adapters (LTPD 10%)	IL/RL (B/D/A)	-40°C to 85°C (± 2°C) for RT/UNC, ≥ 30 minutes dwell time at extremes , 500 cycles pass/fail, and 1000 cycles (optional) for information for RT/UNC. IL/RL measurements initially, and then at 100 cycles, 250 cycles, and 500 cycles.
4.4.4.1 Dust Test	5	R4-47 [62] - O4-51 [66]	22 Pigtail Assemblies and 22 Mating Adapters (LTPD 10%)	IL/RL (B/A)	Perform testing per GR-326, section 4.4.4.1

FOC Test Plan for Singlemode Optical Connectors and Jumper Assemblies – based on GR-326					
Task	Test Group	Reference Spec.	Samples	Optical Monitor	Comments
4.4.4.2 Adhesive Testing	6	R4-52 [67]	5 Pigtailed Assemblies or 5 Ferrule Blanks and 5 Plugs	Fiber undercut, radius and apex offset	Endface Geometry before and after testing. 65°C, 7 days, 2 lb load.
4.4.4.3 Airborne Contaminants	7	R4-53 [68] - R4-56 [71]	22 Pigtail Assemblies and 22 Mating Adapters (LTPD 10%)	IL/RL (B/A)	Perform testing per GR-326, section 4.4.4.3
4.4.4.4 Salt Spray	8	R4-57 [72] - R4-61 [227]	22 Pigtail Assemblies and 22 Mating Adapters (LTPD 10%) plus 5 additional plugs for disassembly and inspection for internal corrosion after exposure	IL/RL (B/A)	Perform testing per GR-326, section 4.4.4.4
4.4.4.5 Immersion/Corrosion Test	9	R4-62 [76]	8 Pigtail Assemblies	Radius of Curvature	85°C for 2 weeks, 0.015mm change from initial (8 mated pigtails for ferrule deformation); testing of O4-63 [77] regarding fiber dissolution not required
4.4.4.6 Groundwater Immersion	10	CR4-64 [78]	20 Pigtail Assemblies /5 per Fluid and 20 Mating Adapters	IL/RL (I/D/E)	4 immersion media's (organism testing not required), 22°C ±2°C for 7 days: Measure before immersion, Initially (upon immersion), after 24 hours, after 7 days (while in fluid)
End of Reliability			All		Endface Geometry and Damage
8.0 Reliability Assurance Program					
8.2 Manufacturing and Process Control					
					Per VZ.TPR.9445/9404

1. Notes: Wavelength Dependency Test (group N): This test is designed to measure the MPI and wavelength dependency of the splice on connectors

This test shall be conducted with > minimum fiber length on the transmit side and = to minimum fiber length on the receive side as shown below:



- ***DUT = Mated Factory Terminated Connector with imbedded fusion splice.***
- ***Where D = minimum length of fiber that is required to avoid any higher order modes in the fiber from a source to the detector (specified by the manufacturer)***

Examination of WDL results against the ITU DWDM grid (100 GHz, 50 GHz, or 25 GHz) is also recommended.

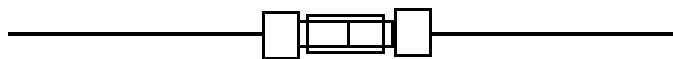
Determination of WDL shall be made on a per band basis (S, C, and L). The 0.1 dB limit applies for the C and L bands. For the S-band, larger values are permitted but test results should be reported.

Optical Measurements

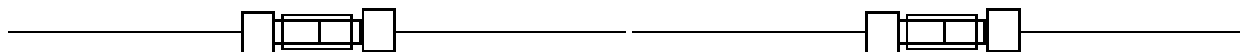
- Loss
 - B – Before IL & RL Optical Testing @ (1310, 1550 & 1625 nm)
 - D – During IL & RL Optical Testing @ (1310, 1550 & 1625 nm)
 - A – After IL & RL Optical Testing @ (1310, 1550 & 1625 nm)
 - I initial (under load) IL & RL Optical Testing @ (1310, 1550 & 1625 nm)
 - E – End of test (under load) IL & RL Optical Testing @ (1310, 1550 & 1625 nm)
 - CIT (Change in Transmittance)⁴ Calculation - $CIT = A^{IL} - B^{IL}$
 - CIR (Change in Reflectance)⁵ Calculation - $CIR = A^{RL} - B^{RL}$
 -
 - Jumper Cable Assembly Measurements: (It is desirable that optical measurements for jumper assemblies be taken on the individual mated pairs. However, during the service life tests for jumper assemblies measured with a CW type optical switching measurement systems or OTD systems, where the OTDR resolution cannot separate the DUT optical performance values from the switch parameters the following set of criteria apply.)
 - Loss, Loss Increase - Divide the measured value of the complete assembly, both connector pairs, by 2 and apply the appropriate criteria.
 - Reflectance - Subtract 3.0 dB from each measurement of the complete assembly and apply the respective criteria
 - All test configuration must ensure adequate range and accuracy is achieved to meet the measurement requirements. In-Situ monitoring test systems utilizing coupler based Reflectance measurement methods should not be connectorized since this will limit the dynamic range and accuracy of your measurements.

Sample Configurations:

- **Pigtail assembly** consists of two connector plugs mated with an adapter with unterminated leads as shown in the following figure. Each of the unterminated leads should be 3 ± 0.5 meters long so that the splices may be located outside of the environmental test chamber.



- **Jumper cable assembly** consists of a jumper cable terminated with plugs on each end connected with adapters to two additional connector plugs with unterminated leads on either end as shown in the figure below. The jumper cable shall be 3 ± 0.5 meters. Each of the unterminated leads should also be 3 ± 0.5 meters long so that the splices may be located outside of the environmental test chamber.



⁴ Only increases in Insertion Loss are a concern. A decrease in Insertion Loss is not a concern.

⁵ Only increases in reflectance are an issue. A decrease in reflectance is not a concern.

- **Plug**, consist of a connectorized pigtail assembly only.
- **Mating Adapter (coupling adapter)**, adapter utilized to join to connector plugs to make a connector assembly containing one connector interface. (See pigtail assembly diagram)

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 100X for cracks, chips, or scratches.

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
1	a	Ferrule Endface Geometry	4.4.5
1	b	New Product Measurement	4.4.1
1	c	Thermal Age Test	4.4.2.1
1	c	Thermal Cycling	4.4.2.2
1	e	Humidity Age	4.4.2.3
1	f	Humidity / Condensation Cycling Test	4.4.2.4
1	g	Dry-out Step	4.4.2.5
1	h	Post-Condensation Thermal Cycle	4.4.2.6
1	l	Vibration Test	4.4.3.1
1	j	Flex Test	4.4.3.2
1	k	Twist Test	4.4.3.3
1	l	Proof Test	4.4.3.4
1	m	Transmission With Applied Tensile Load	4.4.3.5
1	n	Impact Test	4.4.3.7
1	o	Durability	4.4.3.8
1	p	Connector Installation Test	4.4.6
1	q	End of Test Criteria (Optical, Ferrule Geometry and Damage)	4.4.3.9 & 4.4.5

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

The following table lists the tests for the Reliability testing requirements.

Table 2 (Reliability)

Sample Group	Title	Section	Sample Type
ALL	Ferrule Endface Geometry (Initially - all samples) and all of the new product measurement	4.4.5	
2	Extended Thermal Age	GR-1221, Section 6.2.4	Jumper Cable Assembly
3	Extended Humidity Age	GR-1221, Section 6.2.5	Jumper Cable Assembly
4	Extended Thermal Cycling	GR-1221, Section 6.2.7	Jumper Cable Assembly
5	Dust	4.4.4.1	Pigtail Assembly
6	Adhesive	4.4.4.2	5 plugs
7	Airborne Contaminants	4.4.4.3	Pigtail Assembly
8	Salt Spray	4.4.4.4	Pigtail Assembly
9	Immersion/Corrosion Test	4.4.4.5	Pigtail Assembly & Plugs
10	Ground Water Immersion (Organism testing not required)	4.4.4.6	Pigtail Assembly
ALL	Ferrule Endface Geometry (Finals - all samples) and all of the new product measurement	4.4.5	

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°, sample 4@90°, etc.). Tensile Testing encompasses Flex, Twist, Proof and Transmission with Applied Load.

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 readings that exceed the max change criterion should not be considered as a failure, provided that the change does not cause the max RL to exceed -65 dB.

Note 6: 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.

Intermateability Testing of SC APC Connectors, Adapters and Jumper Assemblies

Executive Summary:

The objective of this proposed test program is to provide detailed insight regarding the interconnecting ability of connectors, adapters, and jumper assemblies from different suppliers. Using a modified test plan and test protocol from GR-326-CORE Issue #3, 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 connectors, adapters, and jumper assemblies of the tested manufactures.

Test Requirements:

Endface Geometry Readings

Initial endface readings of the connectors under test will be taken.

Insertion Loss and Reflectance Testing (modified)

Insertion Loss and Reflectance measurements are conducted for the New Product, during specific conditioning (during test) and the End of Test Criteria. The appropriate manufacturer's launch cable assembly (reference jumper) will be used for the New Product measurements. Please see Figure 1. Insertion loss and reflectance measurements are also taken with the interconnection of each of the other participating manufacturers as shown in Table 1.

Environmental Cycle (modified)

Please refer to Figure 2 for the temperature profile and data acquisition times.

Vibration Test (modified)

Test conducted in accordance with GR-326-CORE with modifications.

Durability Test

Test conducted in accordance with GR-326-CORE with modifications.

End of Test Criteria

End of Test Criteria will only be applied to samples found to be noncompliant with the tests listed above. Insertion loss and Reflectance readings will be conducted with the interconnection of each of the other participating manufacturers. The appropriate manufacturer's launch jumper cable assemblies (reference jumper) will be used for each assembly.

- NOTE 1: All test samples will be tested sequentially to the test list above.
- NOTE 2: Each test combination of jumper cables and adapters will have a total sample lot of 10 mated pairs. Five of the ten pairs will be tested from "A" to "B" and remaining five pairs will be tested from "B" to "A".
- NOTE 3: All testing to be performed at four wavelengths (1310 nm, 1550 nm, 1625 nm).
- NOTE 4: The standard cleaning procedures as defined in GR-326, Issue #3, will be used. Only this specific cleaning method 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.

Samples:

Sample Requirements for Program Participation: The number of samples required for participating in the SC-APC Intermateability test program is given in Table 1. Sample configurations are based on the connector definitions given in Figure 3 of this document and assume two initial participants. Each succeeding program candidate (connector) is tested against the two most recently approved connectors in reverse chronological⁶ order for a maximum of 3 participants per test program. See Table 1 and Section 1.4.1 below for sample size requirements.

Table 1 Program Sample Requirement

Order of Participation	Manufacturer	Test Combination Plug → Adapter → Plug	Number of Test Samples
Initial 2	Veteran 1 – V ₁ Veteran 2 – V ₂	V ₁ → V ₂ → V ₂ -10 per	V ₁ - Ten (10) Jumpers + two (2) hot spare jumpers V ₂ - Ten (10) jumpers + two (2) hot spare jumpers V ₂ - Ten (10) adapters + two (2) hot spare adapters
		V ₂ → V ₁ → V ₁ -10 per	V ₂ - Ten (10) Jumpers + two (2) hot spare jumpers V ₁ - Ten (10) jumpers + two (2) hot spare jumpers V ₁ - Ten (10) adapters + two (2) hot spare adapters
		V ₁ → V ₂ → V ₁ -10 per	V ₁ - 20 jumpers + four (4) hot spare jumpers V ₂ - Ten (10) adapters + two (2) hot spare adapters
		V ₂ → V ₁ → V ₂ -10 per	V ₂ - 20 jumpers + four (4) hot spare jumpers V ₁ - Ten (10) adapters + two (2) hot spare adapters

⁶ If V₁, V₂, and V₃ are already approved and R wishes to participate, then R is tested against V₂ and V₃.

Order of Participation	Manufacturer	Test Combination Plug → Adapter → Plug	Number of Test Samples
3	Rookie – R Veteran 1 – V ₁ Veteran 2 – V ₂	V ₁ → R → R – 10 per	V ₁ – Ten (10) Jumpers + two (2) hot spare jumpers R – Ten (10) adapters + two (2) hot spare adapters R – Ten (10) Jumpers + two (2) hot spare jumpers
		V ₂ → R → R – 10 per	V ₂ – Ten (10) Jumpers + two (2) hot spare jumpers R – Ten (10) adapters + two (2) hot spare adapters R – Ten (10) Jumpers + two (2) hot spare jumpers
		R → V ₁ → V ₁ – 10 per	R – Ten (10) Jumpers + two (2) hot spare jumpers V ₁ – Ten (10) Adapters + two (2) hot spare adapters V ₁ – Ten (10) jumpers + two (2) hot spare jumpers
		R → V ₂ → V ₂ – 10 per	R – Ten (10) Jumpers + two (2) hot spare jumpers V ₂ – Ten (10) Adapters + two (2) hot spare adapters V ₂ – Ten (10) Jumpers + two (2) hot spare adapters
		V ₁ → R → V ₁ *	V ₁ – 20 jumpers + four (4) hot spare jumpers R – Ten (10) adapters + two (2) hot spare adapters

Sample Size

The following is the recommended total shipped sample size which includes required test lots, hot spares, and pre-screens. Sample size is based on 3 participants, one “rookie” or “new” participant and 2 “veteran” or “previous” participants. Initial program sample size assumed 2 participants.

- “Rookie” samples: 58 - SC APC to SC APC 8-meter jumpers (40 required, 8 hot spares, and 10 extra from pre-screen)

* May use either V₁ or V₂

- “Rookie” samples: 41 - SC APC or SC Adapters. The adapters shall be identical to the adapters that have undergone the GR-326-CORE, Issue #3 testing prior. (30 required, 6 hot spares and 5 pre-screen)
- “Veteran 1” samples: 51 - SC APC to SC APC 8-meter jumpers (40 required, 6 hot spares, and 5 pre-screen)
- “Veteran 1” samples: 23 - SC APC or SC Adapters. The adapters shall be identical to the adapters that have undergone the GR-326-CORE, Issue #3 testing prior. (10 required, 8 hot spares and 5 pre-screen)
- “Veteran 2” samples: 29 - SC APC to SC APC 8-meter jumpers (20 required, 4 hot spares, and 5 pre-screen)
- “Veteran 2” samples: 17 - SC APC or SC Adapters. The adapters shall be identical to the adapters that have undergone the GR-326-CORE, Issue #3 testing prior. (10 required, 2 spares and 5 pre-screen)

Test Specifics:

Endface Geometry Readings

Endface Geometry measurements will be conducted on each device under test (DUT) as an out of the box “New Product”.

Insertion Loss and Reflectance Testing

“New Product Test” for Insertion Loss and Reflectance shall be performed on all interconnected jumpers utilizing the appropriate adapter and launch cable. Please refer to Figure 1 for configuration specifics.

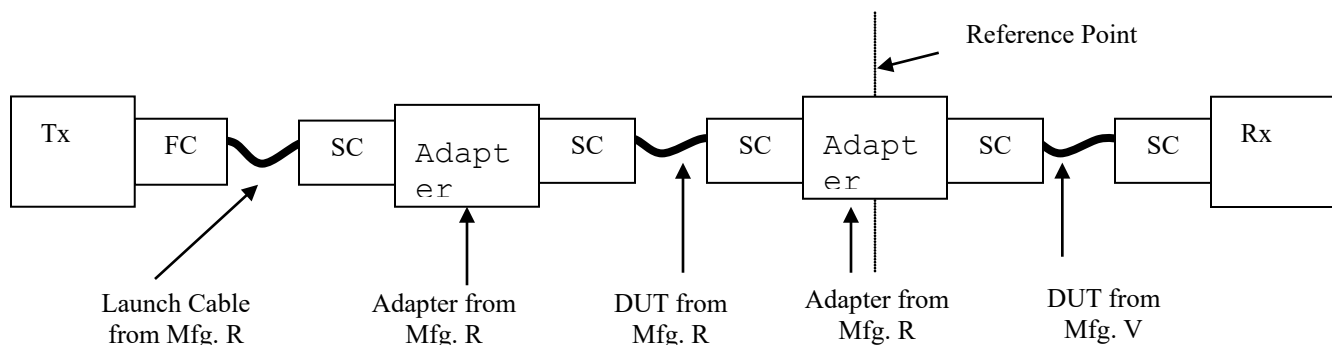


Figure 1: Test Setup

Environmental Cycle (modified)

Jumper assemblies from each of the participating manufacturers will be placed in a conditioning chamber and subjected to the following temperature profile:

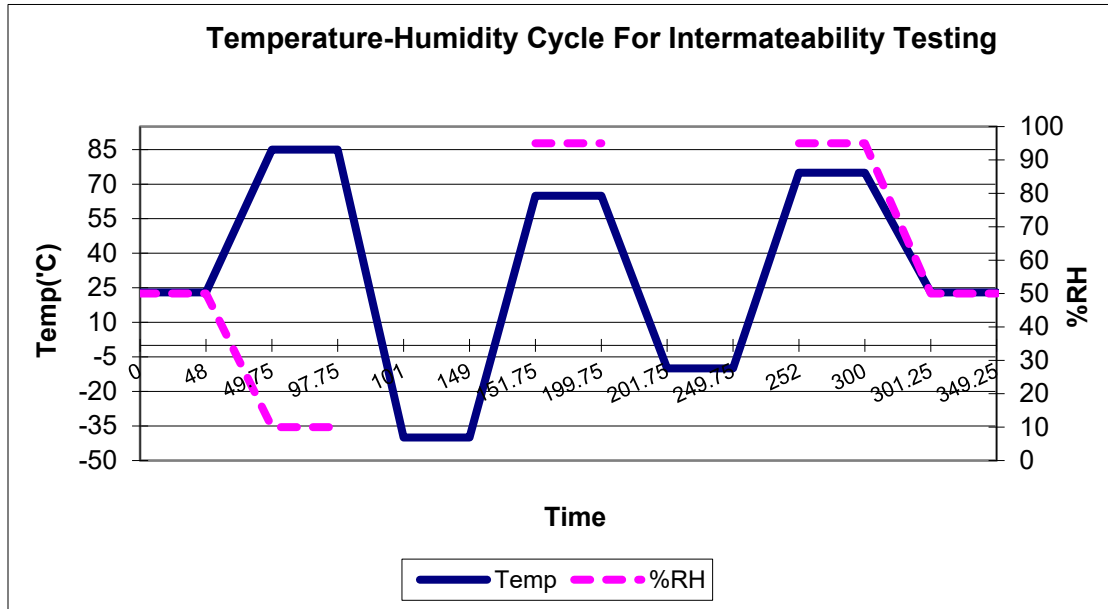


Figure 2: Temperature-Humidity Profile for Intermateability Testing

The intermateability environmental test profile has been derived from the environmental profiles of GR-326. The profile uses seven plateaus starting at 23C @ 30%RH, followed by 85C @ 10%RH, followed by -40C @ uncontrolled humidity, followed by 65C @ 95% RH, followed by -10C @ uncontrolled humidity, followed by 75C @ 95%RH, concluding with 23C @ 50%RH. See appendix A for additional cycling details and for measurement interval times. Final readings will be taken one hour after temperature stabilization. Each combination will have a sample lot of 10-mated pairs.

Vibration Testing

Test conducted in accordance with GR-326 CORE, Section 4.4.3.1 on all combinations. The following exception will be employed; initial readings will be taken prior vibration of all three axes (X, Y and Z) of the connector and final readings will be taken after all vibration cycles have been completed. Please note that the samples will not be monitored during the actual vibration sweeps.

Durability Test

Test conducted in accordance with GR-326-CORE, Section 4.4.3.8 on all combinations, as specified in Figures 3. Two hundred cycles will still be performed with varying heights retained. Passive components are “cycled” as part of Durability Testing. Each configuration will be tested once (200 cycles). If a connector configuration fails, that particular configuration will be replaced with five new samples and re-tested (200 cycles). All five (5) connectors must comply with the requirements.

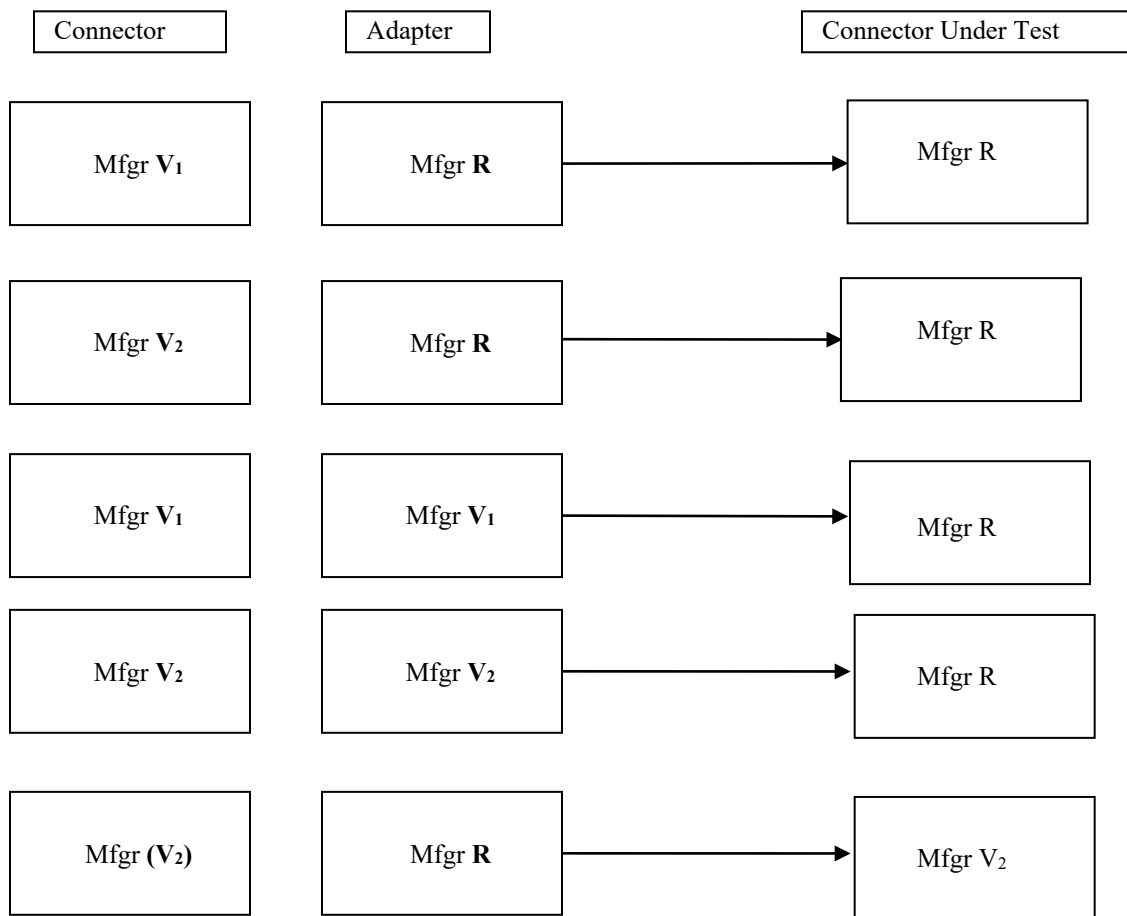


Figure 3: Combination for the Durability Test

End of Test Criteria

On nonconforming samples, end-face geometry shall be re-measured as described in 1.3.1 above. For noncompliant samples only, final measurements for IL and RL will be repeated using the same methods as described above for Insertion Loss and Reflectance Testing (see O, above).

Acceptance Criteria

End Face Geometry

Standard GR-326 Requirements apply.

Initial Measurements with Interconnection of Suppliers (modified)

Standard GR-326 Requirements apply (Table 4-2 and 4-3 of GR-326) with the exception that the maximum Reflectance shall not be greater than -65dB

Thermal Cycle Test (modified)

Standard GR-326 Requirements apply (Table 4-2 and 4-3 of GR-326) with the exception that the maximum Reflectance shall not be greater than -65dB

Vibration Test (modified)

Standard GR-326 Requirements apply (Table 4-2 and 4-3 of GR-326) with the exception that the maximum Reflectance shall not be greater than -65dB

Durability Test (modified)

Standard GR-326 Requirements apply (Table 4-2 and 4-3 of GR-326) with the exception that the maximum Reflectance shall not be greater than -65dB

End of Test Criteria (modified)

Standard GR-326 Requirements apply with the exception that the maximum Reflectance shall not be greater than -65 dB

Appendix A

Modified Environmental Cycle for the Intermateability Program

1. Initial readings will be taken after a minimum of 6 hours at 23°C, 50% RH and will be completed a minimum of 12 hours before the first ramp cycle.
2. The first Ramp cycle (23°C, 50% RH to 85°C, 10% RH) will last for 1 hour and 45 minutes.
3. IL and Reflectance will be taken at 85°C, 10% RH after 24 hours of temperature and humidity stabilization. The plateau will be for 48 hours at 85°C, 10% RH.
4. The second ramp (85°C, 10% RH to -40, uncontrolled humidity) will last for 3 hours and 15 minutes.
5. IL and Reflectance will be taken at -40°C after a minimum of 24 hours of temperature stabilization. The plateau will last for 48 hours at -40°C, uncontrolled humidity.
6. The third ramp (-40°C, uncontrolled humidity to 65°C, 95% RH) will last for 2 hours and 45 minutes.
7. IL and Reflectance will be taken at 65°C, 95% RH after minimum of 24 hours of temperature and humidity stabilization. The plateau will last for 48 hours plus an additional 16 hours totaling 64 hours at 65°C, 95% RH.
8. The fourth ramp (65°C, 95% RH to -10°C, uncontrolled humidity) will last for 2 hours.
9. IL and Reflectance will be taken at -10°C after 24 hours of temperature stabilization. The plateau will last for 48 hours at -10°C, uncontrolled humidity.
10. The fifth ramp (-10°C, uncontrolled humidity to 75°C, 95% RH) will last for 2 hours and 15 minutes.
11. IL and Reflectance will be taken at 75°C, 95% RH after a minimum of 24 hours of temperature and humidity stabilization. The plateau will be for 48 Hours at 75°C, 95% RH.
12. The sixth ramp (75°C, 95% RH to 23°C, 50% RH) will last for 1 hour and 30 minutes.
13. IL and Reflectance will be taken at 23°C, 50% RH after a minimum of 24 hours of temperature and humidity stabilization. The plateau will be held for the duration of the final readings.