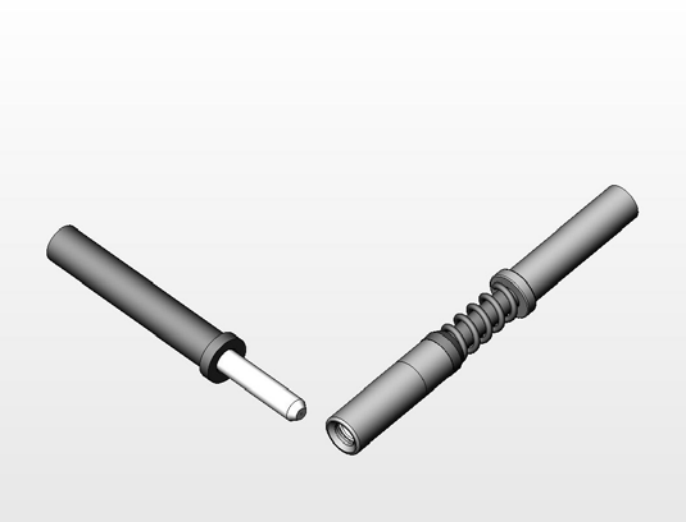
Design Verification and Qualification Test Report M29504 /4 and /5 Optical Terminus System, Style 2 Multi Mode, Report *M29504-1776-06*



1. SCOPE

1.1 Scope. This test report provides summary, raw and processed test data from XiOptics qualification activities for Mil-PRF-29504 /4 and /5, Style 2 removable crimp and epoxy type fiber optic termini for use in M38999 connectors. TICC bands under test are 4220 for the pin, 4249 for the socket. The data and results confirm the ability of XiOptics terminus system to meet all of the qualification requirements of the Mil-PRF-29504 specification. The data and results confirm the ability of XiOptics terminus system to meet all of the qualification requirements of the Mil-PRF-29504 specification. Testing was completed in June of 2013. The data sheets provided within this document provide detailed information regarding the timing and sequences of tests. Revision D of the specification was used as the guiding document for qualification. All of the product and test procedures used are compliant to the Revision D specification, Revision C of the specification was the minimum required revision compliance per the test initiation date.

In order that credible test results are maintained XiOptics procured all non-XiOptics products from commercial distribution points. This included raw fiber optic cable materials, Mil-DTL-38999 QPL

certified connectors and their associated accessory hardware (backshells, clamps, etc…). By using items commercially available except for the termini under qualification XiOptics believes the qualification testing performed fairly represents results that end users can expect with the terminus products.

Cable materials were procured from OFS Corp. Multi-mode core/cladding optical glass (P/N C10027) fiber (50/125) was used for items under consideration in this document.

All test item fabrication (terminus termination and cable assembly) was performed by Coastal Connections in Oxnard California using XiOptics specifications and supplied materials. All endface, cable construction and materials meet the requirements of the current “D” revision of the 29504 specification. Specialized cleaning prior to test and secondary cable performance verification, a quality check, was performed by Silicon Lightwave Technology in Irvine California.

All qualification testing was performed at Experior Laboratories in Oxnard, California. DLA/DSCC has performed the requisite surveys and certified Experior Laboratories to perform the necessary testing prior to initiation of any XiOptics QPL test activities in 2007.

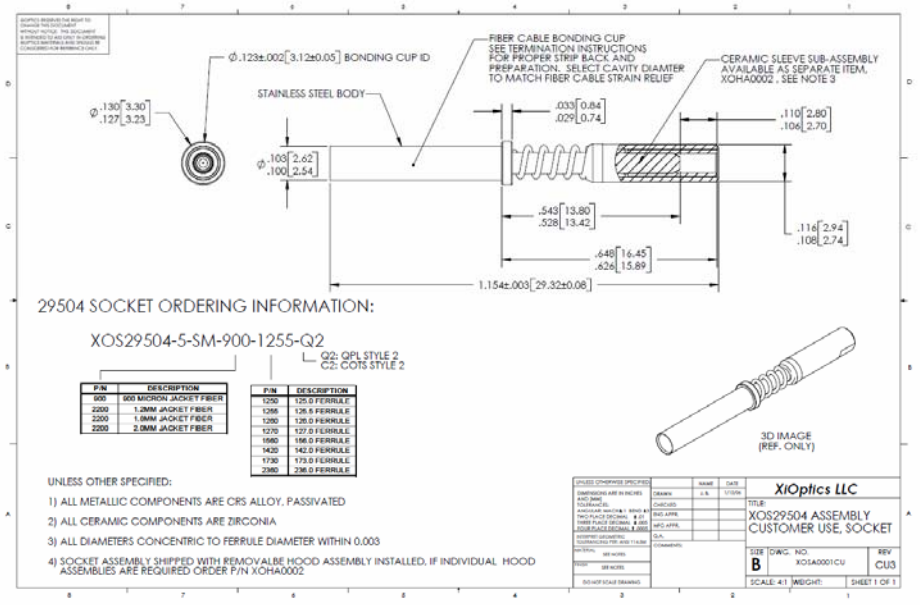
XiOptics performed each group of test as required by the specification using the smallest possible optical core diameters within the allowable cable options. This test report is specifically for multi-mode application optical termini. 50/125 micron optical glass was used with the OFS cabling solution noted above.

Revision Table:

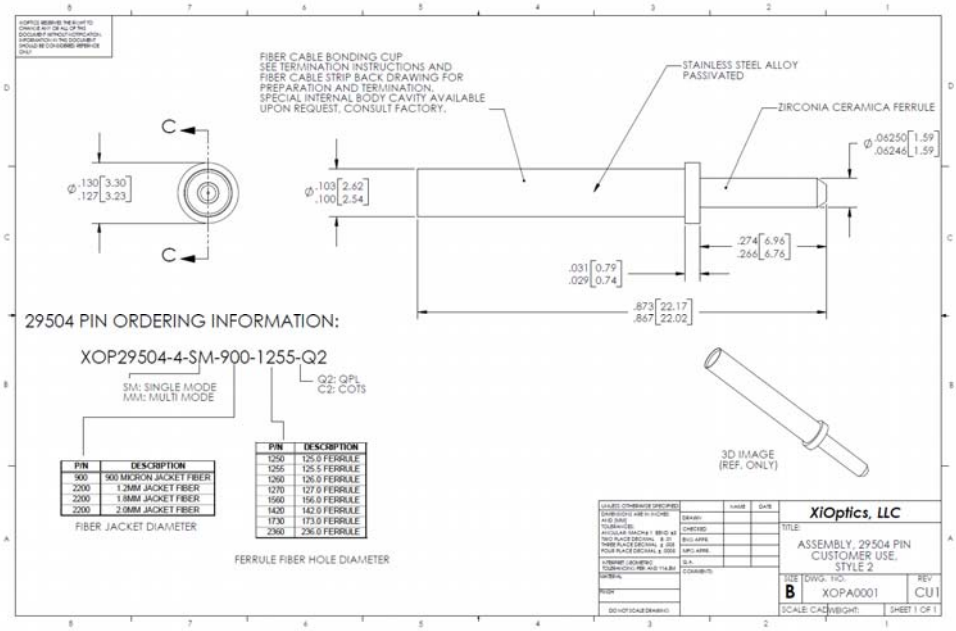
Revision	Date	Approved	Paragraph Impacted	Description Of Change
N/C	TBD	R. Flora	NA	Initial Release
A	7/13	R. Flora	Reworked w/retest data	Retest results w/one piece hood

1.1 Product Configuration Under Test.

1.1.1 Socket Termini: P/N: XOS29504-5-MM-2200-1260-Q2 (TICC marked 4249) termini were utilized for all qualification tests. Ferrule hole diameter meets the requirement of 126.0 +1.0/-0.0 microns. Manufacturing location was at DSCC certified location, 141 Remington Blvd. Ronkonkoma, NY



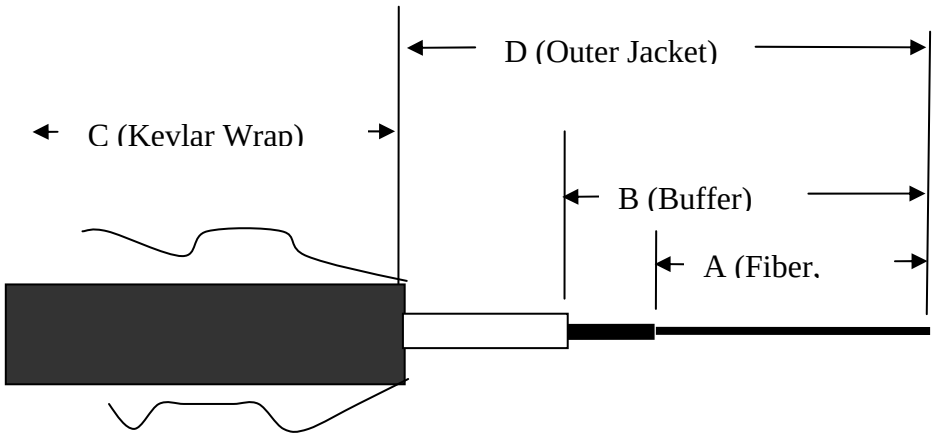
1.1.2 Pin Termini: P/N: XOP29504-4-MM-2200-1260-Q2 (TICC marked 4220) termini were utilized for all qualification tests. Ferrule hole diameter meets the requirement of 126.0 +1.0/-0.0 microns. Manufacturing location was at DSCC certified location, 141 Remington Blvd. Ronkonkoma, NY



1.2 Termination Process Used For Validation. Termini were processed through Group 1 evaluation and supplied to Coastal Connections by Experior Laboratories. Coastal Connections is located at 2368 Eastman Ave, Unit 11, Oxnard, CA 93003 and are certified for production of XiOptics products cables by physical site inspection and submittal of samples to XiOptics prior to initiation of testing. Termination was performed to the requirements stated in the D revision of the Mil-PRF-29504 specification. Secondary termination verification was performed by XiOptics prior to submittal for qualification by having Silicon Lightwave Technology located at 9277 Research Drive, Irvine, Ca. perform verification insertion loss testing, secondary cleaning and end face verification prior to delivery to Experior Laboratories for initiation of actual test sequences that yield the data within this report. XiOptics termination method specified for the pin and socket termini are in compliance with the D revision of 29504, XiOptics provided the specification and also the XiOptics Style 2 termination procedure directly to the cable termination and inspection organizations. The XiOptics solution used is provided below in Figure 1:

CABLE AND FIBER PREPARATION:

NOTE: Refer to XiOptics website at www.xioptics.com for the latest fiber cable preparation information.



NOTE: "A" Dimension for buffer stripped fiber is only critical for operator handling. The recommended length for exposed fiber is 13mm (.5 inch) minimum. Actual strip back may not appear as shown. Kevlar may extend over buffer region and require back fold during stripping.

Figure 1. Cable stripping dimensions.

TABLE 1. Cable stripping dimensions (13mm exposed glass)

Terminus	Cable Constr.	Dimensions mm 1/					
		M29504/4 Pin Terminus			M29504/5 Socket Terminus		
		B	C	D	B	C	D
XO	Tight jacket	16	6	20	18	4.5	27

1/ Tolerances on all dimensions are ± 1mm .

1.3 Test Cable Configuration.

1.4 Connector Configuration. XiOptics procured from authorized distributors M38999 Series III mated connector pairs of the Mil-DTL-38999 QPL plugs and receptacles shell size 17 and larger. Plugs were “pin” front style. Optical pins were placed with applicable plugs. All finishes where nickel or stainless steel to prevent Foreign Object and Debris generation.

Connector materials were selected based on the test environment to minimize the probability of connector influence on final test results. Materials of construction included composite, stainless steel and aluminum.

Manufacturers of the test support connectors included:

- ITT Industries, Cannon
- Deutsch

Connector size, type and manufacturer were selected at the onset of each test sequence to meet the specific test sequence objectives and meet test fixture or equipment limitations. Shell sizes were always size 17 or larger to allow for the requisite number of channels. The largest shell size utilized was 25. Specific connector utilization is noted within the applicable test sequence detailed results.

1.5 DSCC Permission to Test: Form DESC 19P Submitted and Approved 7/31/2006, incremental test period extensions approved through the 2013 period via discussions with DSCC component responsible technical support personnel.

2. APPLICABLE DOCUMENTS

2.1 General/Order of Precedence. The documents listed in this section are specified in sections 3 and 4 of the Mil-PRF-29504 requirements specification. This section may not include all documents cited in other sections of this test report. Test specific documents maintained by XiOptic’s outside test laboratory may be referenced and may be required to reproduce the test results. In the case of a conflict between the text of this document and the applicable specification, the text of this document takes precedence in determining performance and data collected.

2.2 Government Documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto.

2.2.1.1 Government Specifications

MIL-PRF-29504, Rev B., Performance specification termini, fiber optic connector, removable, general specification for

MIL-PRF-29504/4 Rev C.: Termini, fiber optic, connector, removable, environment resisting, pin terminus size 16, rear release, Mil-DTL-38999, Series I, III and IV.

MIL-PRF-29504/5 Rev C.: Termini, fiber optic, connector, removable, environment resisting, socket terminus size 16, rear release, Mil-DTL-38999, Series I, III and IV.

MIL-PRF-29504/4 Rev D.: Termini, fiber optic, connector, removable, environment resisting, pin terminus size 16, rear release, Mil-DTL-38999, Series I, III and IV.

MIL-PRF-29504/5 Rev D.: Termini, fiber optic, connector, removable, environment resisting, socket terminus size 16, rear release, Mil-DTL-38999, Series I, III and IV.

MIL-DTL-38999, Connectors, electrical, circular, miniature, high density, quick disconnect (bayonet, threaded, and breech coupling), environment resistant, removable crimp and hermetic solder contacts general specification for.

2.2.1.2 Government Handbooks

MIL-HDBK-454 - General Guidelines for Electronic Equipment.

2.3 Non-Government publications. The following documents form a part of the general specifications and test requirements document to the extent specified herein. Unless otherwise specified, the issues of the documents that are those listed in the issue of the DoDISS at the time of the test period. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the specification.

Society of Automotive Engineers (SAE):

SAE Aerospace Information Report
AIR1351 Manufacturers' Identification of Aerospace Electrical and Electronic Wiring Devices and Accessories

Telecommunication Industry Association/Electronic Industries Alliance:

(TIA/EIA) EIA-359 - EIA Standard Colors for Color Identification and Coding.

TIA/EIA-455 - Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components.

EIA/TIA-455-6 - Cable Retention Test Procedure for Fiber Optic Cable Interconnecting Devices.

TIA/EIA-455-13 - Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies.

TIA/EIA-455-20 - Measurement of Change in Optical Transmittance.

EIA-455-21 - Mating Durability of Fiber Optic Interconnecting
Devices.

TIA/EIA-455-32 - Fiber Optic Circuit Discontinuities.

TIA/EIA-455-34 - Interconnection Device Insertion Loss Test.

TIA/EIA-455-56 - Test Method for Evaluating Fungus Resistance of
Optical Fiber and Cable

EIA/TIA-455-107 - Return Loss for Fiber Optic Components.

TIA/EIA-455-135 - Measurement of Connector Ferrule Inside and Outside
Diameter Circular Runout.

2.4 Order of Precedence. In the event of a conflict between the text of this test report and the references cited herein, the text of this document takes precedence.

3. REQUIREMENTS

3.1 Specification Sheets. The individual items provided by XiOptics for qualification have been tested to the specification and sheets as specified here-in by a DSCC qualified outside test organization. The selected qualified outside test organization is Experior Laboratories located in Oxnard, CA. Supporting data is supplied to DSCC embedded within the structure of this document. Items under test include Mil-PRF-29504 /4 and /5 Style 2 optical terminus assemblies. In the event of any conflict between the requirements of this document and the specification sheet, the latter shall govern.

3.2 Qualification. XiOptics Mil-PRF-29504 /4 and /5 Style 2 Optical Termini furnished for qualification are products manufactured to the engineering documents provided here-in, assembled with cable and connectors specified here-in and using the processes specified here-in. Specific part numbers under evaluation are:

1) XOP-29504-4-MM-2200-Q2 (TICC: 4220), Multi-mode, 126 micron ferrule pin
2) XOS-29504-5-MM-2200-Q2 (TICC: 4249), Multi-mode, 126 micron ferrule socket

The items under test were manufactured from component parts randomly selected from a single lot and were then randomly assembled for use in the test sequences. All hardware used in the qualification testing was shipped directly from XiOptics New York manufacturing facility to the independent test organization, Experior Laboratories in Oxnard, CA, for verification of compliance to the items below. Subsequent to element level group tests (Group 1), components were forwarded from Experior Laboratories directly to an independent cable assembly company, Coastal Connections in Oxnard, CA for assembly into cable products. Cable products were then either returned to Experior Laboratories for test performance or forwarded to Silicon Lightwave Technology for secondary cleaning and inspection. Items forwarded to Silicon Lightwave Technology were subsequently drop shipped to Experior Laboratories. XiOptics quality personnel monitored the progress of the assembly and test operations to ensure all items meet the specifications of the product. In the event that pre-test cable performance variances were noted at Coastal Connections or in the event that cleaning as allowed by Mil-PRF-29504 was required between test segments XiOptics authorized Experior Laboratories to utilize Silicon Lightwave Technology to perform these cleaning operations using applicators that permit cleaning while maintaining cable assemblies within connectors.

3.3 Materials. Materials selected by XiOptics for component, cable and test item fabrication were selected to meet all of the qualification requirements. Considerations taken during the development of the products included toxicity, chemical and optical compatibility, compatibility in humid/salt laden environments and ensuring that all end products are non-nutrient to fungus growth. All components were manufactured and assembled to the certificates of compliance provided for the parts and reviewed by DSCC prior to initiation of testing. All XiOptics terminus metallic elements are manufactured from corrosion resistant steel alloys. The only other terminus materials inherent in the termini are zirconia ceramic (split sleeves and ferrules). Cable materials, adhesives, connectors and backshell assemblies are considered support items to the qualification of the optical terminus assemblies (per Mil-PRF-29504 /4 and /5). Selection of these materials is within the allowable requirements of the specifications. Only QPL connectors and accessories were selected for use. Cable and adhesive materials were selected based on the environments specified for exposure.

3.3.1 Toxic and Hazardous Products and Formulations. The products used in XiOptics Mil-PRF-29504 /4 and /5 terminus construction do not give off toxic or explosive fumes when exposed to flame. No items are flammable within the termini products under test. Materials used do not have

adverse effect on the health of personnel when used for the intended purpose. Compliance to this requirement is by analysis of the materials of construction of XiOptics products.

3.3.2 Metals. XiOptics optical terminus designs utilize metallic components that are manufactured from corrosion resistant steel alloys and are non-magnetic by composition. Compliance to this requirement is by analysis of the materials of construction of XiOptics products.

3.3.3 Dissimilar Metals. XiOptics has selected materials that that are compatible in composition to provide protection against corrosion cell formation. Compliance to this requirement is by analysis of the materials of construction of XiOptics products.

3.3.4 Nonmetallic Materials. Nonmetallic materials used in XiOptics products under test (Mil-PRF-29504 /4 and /5 optical termini) are limited to zirconia ceramic. This material by nature is non-corrosive, non-toxic and not susceptible to attack by chemicals. Actual hardware subjected to and supportive of the test items includes Mil-C-38999 connectors, OFS Flightguide optical cable and M85049 backshells. There are materials within these components that can be attacked by harsh chemicals, those items are not considered to be under qualification hence were not evaluated.

3.3.4.1 Adhesives. Adhesives are not used directly in the production of the products under test. XiOptics did select a high temperature EpoTek adhesive (353ND) that is specifically designed for use between optical glass media and metallic elements and has an elevated glass transition temperature in order to meet the temperature life test sequence. This adhesive is a required element in the production of cables. The adhesives used are commonly available in the open market as commercial items. Cable production is a necessary support item for the test qualification activity but not considered an item under qualification.

3.3.4.2 Sealing Compounds. The product under test does not require sealing compounds for use.

3.3.5 Fungus Resistance. All materials used in the manufacture of XiOptics termini under test are considered non-nutrient to fungus and non-supportive of fungus growth or formation. All materials are in compliance with guideline 4 of MIL-HDBK-454 for non-nutrient materials. All hardware items are cleaned with 60/40 Alcohol/DI water solvents prior to packaging to ensure organic materials are not packaged with the items. Compliance to this requirement is by analysis of the materials of construction of XiOptics products.

3.3.6 Recycled, Recovered, or Environmentally Preferable Materials. XiOptics considers the use of recycled or recovered materials only in packaging items. No recycled materials are allowed for use within test item fabrication or assembly due to the critical nature of the items end use. Packaging materials for final goods may allow the use of recycled plastics or paper products as applicable. Packaging materials are not subject to the requirements of this qualification.

3.4 Design and Construction. XiOptics termini meet all of the requirements of the sited specification in effect at the time of initiation of qualification testing. Applicable revision control of components and materials is maintained by XiOptics within its factory sited in 1.1.1 and 1.1.2 . Components under test physical dimensions are provided in 1.2. Dimensions were validated against the Mil-PRF-29504 /4 and /5 specification sheets as required by an outside certified testing organization as was workmanship. Group 1 testing results for these elements are reported here-in. Any item not meeting the requirements of the specification was noted during the appropriate Group 1 test and an analysis of that part performed to determine root cause if applicable. All items entering qualification test were compliant to all of the design, construction, marking, dimensional and termination requirements of the applicable specifications.

3.4.1 Optical Termini. XiOptics M29504 optical terminus design enables the terminus to be inserted and removed from M38999 connectors regardless of manufacture without damage to seals, inserts or retaining mechanisms. XiOptics incorporates a heavy chamfer on the leading

edges of all metallic surfaces that run on plastics or composite connector surfaces to prevent gouging and contamination creation. Product under test here-in is Style 2. XiOptics Style 2 terminus extends the rear bonding cup through the rear grommet seal of the D38999 connector. This ensures proper sealing, as well it provide a smooth running surface to for the seal to operate against to prevent tearing damage. Insertion and extraction of the terminus was performed using industry standard Aiconics M81969/14-03 plastic contact insertion/removal tool.

3.4.1.1 Dummy Termini. During testing, all connector cavities not under test were plugged using un-terminated optical contacts of the type specified here-in. This was performed to prevent contaminates and moisture from entering the connector cavity.

3.4.2 Terminus Insertion and Removal Methods. XiOptics M29504 optical termini are rear insertion/rear release items per the Mil-PRF-29504 specifications. XiOptics used industry standard Aiconics tool M81969/14-03 to insert and/or remove the loose termini or cable assemblies.

3.4.3 Finishes. XiOptics uses only corrosion resistant steel alloy metallic components. All elements are passivated for corrosion resistance subsequent to final machining. Xirconia ceramic is used for ferrule and alignment sleeve elements.

3.4.4 Interchangeability. XiOptics optical termini elements have been cross tested with other qualified optical termini to ensure interchangeable performance as well as within XiOptics own product offering. With proper end-face geometry and proper connector installation XiOptics termini may be interchanged with all Mil-PRF-29504 qualified products and all XiOptics parts have shown an ability to be interchanged with other like XiOptics parts without impact. XiOptics typically holds tighter than specification requirements for multi-mode ferrule element concentricity, this ensure superior optical waveguide alignment and reduces rotational sensitivity of the optical terminus assembly.

3.4.5 Intermateability. XiOptics cross mated like test items to ensure cross mate performance. During qualification testing mated pairs were randomly selected from available product. When related to optical performance, the ability to intermate is primarily driven by polish finish and end-face geometry. When properly polished finished and properly installed into connector systems XiOptics Mil-PRF-29504 product may be cross mated interchangeably to any other XiOptics product or to any other qualified M29504 product available on the market as of the time of this test report.

3.4.6 Interoperability. Refer to 3.4.5, XiOptics meets all of the performance and intermate requirements within the Mil-PRF-29504 product family for the applicable /4 and /5 sheets under qualification. Interoperability with other qualified products is performed and certified by DSCC as an element of QPL listing.

3.4.7 Maintainability. XiOptics termini require no preventative maintenance during operation or life of the product per MIL-PRF-29504. XiOptics testing validates the stability of the product across the test environments. XiOptics recommends cleaning of termini using alcohol/water solutions with less than 90% alcohol and cleaning actions taken during testing were as specifically allowed by Mil-T-29504. Reagent grade alcohol was not be used due to thermal shock that may result due to evaporation. Lint free wipes and swabs available from industry standard sources were used where applicable.

3.5 Optical Performance Requirements. XiOptics M29504 products exceed the optical performance characteristics of the stated specifications. Detailed results are provided as a part of each test sequence.

3.5.1 Insertion Loss. When properly terminated and installed in a QPL M38999 connector system the insertion loss of the optical link at the terminus will not exceed values in the table 3.5.1. Data

presented in the indicated table is maximum insertion loss post exposure to qualification environments. Initial loss is typically significantly less. Expected beginning of life maximum optical insertion loss performance, when termination procedure is done for a domed ferrule with a PC polish, is 1.0 dB initial insertion loss for the 50/125 fiber size and 0.75 dB initial insertion loss for the 62.5/125 fiber size. During testing XiOptics used 50/125 for all multi-mode testing. Cable insertion loss values are provided within the detailed test results at each stage of the test process.

Termini with multimode fiber were tested using an optical source at either the 850 nm or the 1,300 nm wavelength.

The initial insertion loss of multimode termini was measured in accordance with method A of TIA/EIA-455-34, using both 70/70 and overfills launch conditions. For subsequent insertion loss tests, a 70/70 launch condition was used.

3.5.2 Discontinuity. During testing requiring monitoring of continuity a continuous sweep measurement was performed to sample variation in power levels. For the multi-mode product being evaluated a discontinuity is considered to be a reduction of optical transmittance of 0.5 dB or more for a duration of 50 microseconds or more. Discontinuity measurements during testing were performed in accordance with TIA/EIA- 455-32. Equipment could resolve discontinuities of duration less than 50 microseconds (µs).

3.5.3 Return Loss. There are no return loss requirements for multi-mode products.

3.5.4 Change in Optical Transmittance. During all testing and post exposure to test environments XiOptics products demonstrated no greater than 0.5 dB insertion loss variation. The change in optical transmittance in test sequences was measured in accordance with TIA/EIA-455-20, utilizing a monitor fiber to evaluate the change in transmittance due to exposure of the terminus to environmental/mechanical and other tests.

3.6 Inspection Requirements. Visual and mechanical examinations were performed on all XiOptics components and assemblies prior to initiating of testing at an outside test facility, XiOptics contracted with Experior Laboratories for these efforts. Measurements were taken in accordance with TIA/EIA-455-13 to verify that the design, construction, physical characteristics, dimensions, marking, and workmanship were in accordance with the specification requirements and this document.

3.6.1 Size. Each terminus entering the qualification test sequence was examined relative to the dimensions specified in the relevant specification sheet for the terminus. Equipment used was typical inspection grade equipment capable of having range, precision and accuracy requirements to the dimensions and tolerances specified. All measurement equipment was calibrated and certified by an outside calibration laboratory using NIST standards. The six critical dimensions on the pin/socket pair were measured for each test item submitted and verified to be compliant to the Mil-PRF-29504 /4 or /5 specification sheets as appropriate. No item under consideration of testing was allowed to move forward within a test sequence without 100% dimensional verification.

3.6.2 Weight. The weight of each terminus entering test was measured prior to integration with cable hardware. Weight validation ensuring less than 1.0 grms per terminus was performed using calibrated scales having the range, precision and accuracy appropriate for the tolerances specified. XiOptics Style 2 pin termini (M29504/4) weigh 0.45 grms, Style 2 socket termini (M29504/5) weigh 0.67 grms at maximum material conditions.

3.6.3 Identification Marking. XiOptics marking characters are visible on the external surface of the termini and are identifiable with the naked eye, optical magnification may be an aid. Reference 3.7 for test verification. Marking includes the applicable TICC number and XiOptics SAE

registered mint mark, Ξ. Marking is accomplished with laser marking of the required information onto the terminus metallic body. The laser marking creates a darkened coloration on the terminus surface that can be formed into the necessary discrete numeric or alpha characters.

3.6.4 Terminus Cleaning. Subsequent to a test sequence if required optical interfaces were cleaned using methods and materials described within this document and as allowed by the specification. In the event of a test support item failure, such as a connector, all channels were removed from the failed support item, the item was replaced and prior to test re-start all optical channels were cleaned and inspected for any damage that may impact on-going test activities.

3.6.5 Circular Run-out. All termini were measured for circular run-out prior to entering the test sequence. All termini were required to meet the total circular run-out specification based on the TICC band item under test. All termini were tested in accordance with TIA/EIA-455-135. Maximum circular run-out allowed in XiOptics product is provided in 3.7.2, due to modern manufacturing methods typical circular run-out for XiOptics products is less than .5 micron.

3.6.6 Terminus Retention. As specified in Mil-PRF-29504 XiOptics products under test were subjected to minimum axial loads of 22 pounds to verify termini shoulder engagement with qualified Mil-C-38999 connector systems. The test was performed by installing termini into test connectors and pushing on the front face of the termini with an Instrom force/displacement measurement system. Termini were monitored for retention within test connector inserts and that as required the total terminus displacement did not exceed 0.015 inch. Socket termini are spring loaded, hence they deflect more than 0.015 inch but it was verified that they returned to within 0.015 inch of original position after load was removed. All applied loads were axial compressive and were applied to the front face of the terminus pushing the terminus to the rear of the connector insert. Axial loads were ramped from an unloaded condition to the maximum value at a rate of 1 lbf per second. The maximum load of 22 lbs was retained for a minimum of five seconds.

3.6.7 Terminus Engagement and Separation Force. XiOptics socket termini were tested for engagement and separation forces as required by the applicable Mil-PRF-29504 specification. XiOptics sockets use split xirconia ceramic alignment sleeves. Sockets were mounted in a Mil-C-38999 test connector and test pins were inserted. A maximum diameter test pin, 0.0625 in., was inserted and removed, the insertion force was measured during the mate cycle. The maximum recorded insertion was 0.8 lbs, the maximum allowable by specification is 1.83 lbs.

3.6.8 Environmental/Mechanical. To qualify XiOptics termini to operate in the expected environments Experior Laboratories. All testing was performed and controlled by Experior Laboratories as indicated within this test report. At the conclusion of each test sequence all XiOptics products were evaluated for evidence of dimensional change, opening of seals, cracking or crazing of components or finishes, identification marking impairment, fusion or seizure of mating parts, breakage of the fiber within the terminus, or other effects detrimental to terminus operation. Due to a design revision to the alignment hood many of the products under test were subject to two full environmental exposures. This extended exposure caused no failure of any XiOptics products and further defined the capability of the termini elements under qualification evaluation.

3.6.9 Terminus Insertion and Removal Forces. XiOptics pin and socket termini under test were inserted and removed from test connector systems. The force required to insert the termini to the point it was locked in position was measured and the force required to unlock and subsequently extract the terminus was measured. Neither was greater than the specified 22 pounds specified in Mil-PRF-29504, termini typically installed using light hand pressure with the appropriate tools.

3.6.10 Fiber Pull Out Force. XiOptics Mil-PRF-29504 pin and socket termini were evaluated for fiber retention once installed into qualification test connectors. Fiber retention was accomplished using a proper fiber/cable/termini preparation process and subsequent installation/bonding of the

terminus to the end of the fiber/cable. XiOptics product is a style 2 terminus system and uses an extended fiber bonding socket on the rear of the terminus. This cup is filled with the appropriate adhesive system along with ensuring full wetting of the ferrule thru hole. Strength is achieved by bonding the fiber strength member to the bonding cup while simultaneously capturing the fiber to the ferrule. Termination procedure verification was performed by testing fiber only pull out strength. This test is not required as a part of qualification as the fiber/cables used for qualification all include strength members.

3.6.11 Cable Pull Out Force. Prior to entering any test sequence XiOptics cables were tested for pull-out strength. The mated termini were installed into test connectors and the Kevlar reinforced cable system was pulled with an increasing load up to 22 pounds. This load was held for 1-minute minimum. Upon completion of the test insertion loss testing per 3.5.4 was performed. The maximum insertion loss met the requirements of Mil-PRF-29504 and was typically less than 0.02 db variation from initiation to conclusion of the testing. Post test load application each terminus was inspected for evidence of cable jacket damage, bond retention failure, distortion from bending of terminus parts or cable disengagement from the structure of the terminus.

3.6.12 Mating Durability. XiOptics termini products under test were tested for 500 mating cycles in accordance with the requirements of Mil-PRF-29504. The 500 mating cycles were accumulated on 2 Mil-C-38999 shell size 17 connector test samples having 8 monitored channels per connector pair. Test connectors were mated and unmated in accordance with EIA/TIA-455-6. The change in optical transmittance was measured every 100 mating cycles and at 500 cycles, the conclusion of the test sequence. The maximum change in value recorded was .45 db, typical change in loss value from pre to post test was 0.15 db. At the conclusion of testing Experior Laboratories performed a full audit of the units under test and certified that there was no evidence of defects which may be detrimental to their mechanical or optical performance. Socket engagement forces were validated post durability testing to validate that no damage had occurred to the sockets. Each socket’s engagement force was measure and none exceeded .98 lbs.

3.6.13 Maintenance Aging. XiOptics pin and socket Mil-PRF-29504 /4 and /5 termini were installed in a qualification connector. Each terminus was cycled for 10 insertion/removal operations using approved tools per Mil-PRF-29504/4 and /5. The maximum insertion and removal forces did not exceed the maximum of 22 lbs specified. Post test verification indicated no visual degradation (chipping, cracking, scratching) of the terminus resulting from these operations.

3.7. Marking. XiOptics marks its termini with permanent laser engraving techniques. The laser application provides a contrasting color to the semi-polished stainless steel outer surface finish. This contrast ensures ease of legibility and since engraving is used it cannot be degraded with chemical or other items found in anticipated applications/environments and is truly permanent. Marking was evaluated by the testing organization and noted as acceptable. Marking includes the applicable TICC number and XiOptics mint mark.

3.7.1 Manufacturer's Symbol or Trademark. XiOptics trademark is registered SAE in accordance with AIR1351. This trademark (Ξ) is applied on the side of each terminus using laser marking techniques. The marking is in the location as specified by the individual terminus specification on the fiber barrel side of the shoulder. During testing the test laboratory validated location, size and legibility of the trademark. Marking of the XiOptics symbol was evaluated by the testing organization and noted as acceptable before and after test sequences.

3.7.2 TICC bands. XiOptics does not use color banding as a means of identifying terminus type. The actual TICC band identification number is laser marked onto the fiber barrel side of the shoulder alongside the XiOptics trademark. Marking of the identified items is per below:

Pin Termini (M29504/4), Style 2:

Multi mode 126 +2/-0 microns, Ceramic ferrule, Concentricity 2 micron, Marking: 4220
Multi mode 127 +2/-0 microns, Ceramic ferrule, Concentricity 2 micron, Marking: 4221
Multi mode 156 +3/-0, Ceramic ferrule, Concentricity 3 micron, Marking: 4222
Multi mode 157 +3/-0 Ceramic ferrule, Concentricity 3 micron, Marking: 4223
Multi mode 142 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4224
Multi mode 145 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4225
Multi mode 10173 +1/-0 Ceramic ferrule, Concentricity 2 micron, Marking: 4294
Multi mode 173 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4226
Multi mode 175 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4227
Multi mode 236 +4/-0 Ceramic ferrule, Concentricity 8 micron, Marking: 4228
Multi mode 286 +4/-0 Ceramic ferrule, Concentricity 8 micron, Marking: 4229
Multi mode 448 +4/-0 Ceramic ferrule, Concentricity 8 micron, Marking: 4230

Socket Termini (M29504/5), Style 2:

Multi mode 126 +2/-0 microns, Ceramic ferrule, Concentricity 2 micron, Marking: 4249
Multi mode 127 +2/-0 microns, Ceramic ferrule, Concentricity 2 micron, Marking: 4250
Multi mode 156 +3/-0, Ceramic ferrule, Concentricity 3 micron, Marking: 4251
Multi mode 157 +3/-0 Ceramic ferrule, Concentricity 3 micron, Marking: 4252
Multi mode 142 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4253
Multi mode 145 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4254
Multi mode 173 +1/-0 Ceramic ferrule, Concentricity 2 micron, Marking: 4297
Multi mode 173 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4255
Multi mode 175 +3/-0 Ceramic ferrule, Concentricity 4 micron, Marking: 4256
Multi mode 236 +4/-0 Ceramic ferrule, Concentricity 8 micron, Marking: 4257
Multi mode 286 +4/-0 Ceramic ferrule, Concentricity 8 micron, Marking: 4258
Multi mode 448 +4/-0 Ceramic ferrule, Concentricity 8 micron, Marking: 4259

3.7.3 JAN and J Marking. XiOptics parts are not current marked with a J leading the indicated TICC band information since the product is not yet qualified. Once certified, the J designation will be added using laser marking techniques as a leading indictor on the TICC band numerics if space is available and it does not impact legibility.

3.8 Workmanship. All of XiOptics products under test were processed within the XiOptic's New York production facility. This facility is ISO9001:2008, AS9100:2009 certified. Further, the site has been audited in 2008 and also in 2011 by DSCC to meet the compliance requirements specific to the product under test in this document. All products are individually inspected for workmanship (FOD, burrs, etc..) prior to leaving the facility. Prior to initiation of any termination or test activities all XiOptics Mil-PRF-29504 /4 and /5 components submitted for qualification were evaluated by Experior Laboratories, all product submitted to Coastal Connectors for cable integration was determined compliant. Tracking of inspected items into their respective test groups is provided by XiOptics terminus mapping table.

3.9 Qualification by Similarity. XiOptics entered most test sequences with both multi-mode and small core single mode cables based on a corporate decision to simultaneously evaluate both optical types. The successful completion of single mode qualification is an illustration of the capability of the product under test.

4.0 Salt Spray. XiOptics pin and socket termini were tested in corrosive salt spray environments per EIA/TIA-455-16, test condition C. Test results were collected for each terminus pair prior to the 48 hour exposure period in the 6.9 ph airborne solution. A Mil-D-38999 series III connector shell size 17 test connector was used. Insertion loss pre and post test was collect and met the requirements of the specification. Change in insertion loss was measured and did not exceed .5 db, actual measured typical insertion loss change was less than .2 db without cleaning required.

A post test visual inspection showed no corrosive effects on the external terminus parts that would be detrimental to the operation of the connector.

4.9.10 Environmental/Mechanical. XiOptics Mil-PRF-29504 /4 and /5 optical termini were installed in applicable Mil-DTL-38999 Series III connectors for each environmental test sequence listed below. All termini completed the requirements of performance before/after and during exposure to the applicable environments of the appropriate specification slash sheets and as required by the specification when changes in optical transmittance and/or optical discontinuity were monitored.

Mechanical. The following mechanical tests were performed; mating durability, hammer shock, mechanical shock and finally mechanical vibration (both sinusoidal and random) test. In each test a discontinuity is considered to be a reduction of optical transmittance of 0.5 dB or more for a duration of 50 microseconds or more (during vibration) or 100 milliseconds or more (during shock).

Mechanical shock. Mated connector assemblies of shell size 17 or larger were joined with XiOptics optical test cables. Each item was visually inspected and then subject to:

> Shock Hammer. Mated connector assemblies with appropriate optical channels installed were tested in accordance with MIL-S-901, grade A, type A, class I.
>
> Mechanical Shock. Mated connector assemblies were tested in accordance with EIA/TIA-455-14, test condition D. Three shocks in each direction shall be applied along the three mutually perpendicular axes of the test sample (18 shocks).

Post testing each sample was visually inspected for loosening of parts, coupling mechanism failures, distortions, wear or any other physical damage. The product under test successfully completed all of these test requirements without any of the above items noted and validation of optical performance before, during and after exposure.

Vibration. Mated connector assemblies of shell size 17 or larger were joined with XiOptics optical test cables. Each item was visually inspected and then subject to:

> Sine vibration in accordance with 4.5.22.2.1 of MIL-DTL-38999 (60 G).
>
> Random vibration in accordance with 4.5.22.2.3 of MIL-DTL-38999 (41.7 G rms at temperature of 125 C).
>
> Random vibration in accordance with 4.5.22.2.4 of MIL-DTL-38999 (49.5 G rms at ambient temperature)

Environmental. The following environmental tests were performed; thermal shock, temperature life. In each test the change in optical transmittance was never greater than 0.5 db over the exposure environment.

Thermal shock. Mated connector assemblies of shell size 17 were joined with XiOptics optical test cables. Each item was visually inspected by test engineers at Experior Laboratories and then subject to a thermal shock profile between -55 degree C (+0, -5 degree C) and +165 degree C (+5, -0 degree C). Two mated connector assemblies with cables were tested in accordance with TIA/EIA-455-71, Schedule C-0 for a total of 5 cycles each. The mated connector assemblies were not unmated then re-mated after the test. The change in optical transmittance was measured during the test at the end of each soak temperature time period and after conclusion of the test. During testing one channel under test experienced an insertion loss of 0.54 db versus the specification allowed 0.50 db on two cold cycles. The channel passed post test insertion loss

variance tests and post test analysis of the channel showed significant end-face contamination due from condensates that typically occur from this type of testing. Cleaning of the endface removed all debris and further reduced the post test insertion loss even though the part had already passed the required testing without cleaning. All other channels monitored successfully met the required maximum insertion loss for all cycles and post test data collection point. XiOptics single mode optical performance data was supplied to DSCC to validate the capability of the terminus to withstand thermal shock environments per approval of DLA/DSCC technical staff.

Temperature life. Temperature life exposed two connector assemblies to high temperature for an extended period of time to measure degradation of the XiOptics products over an accelerated temperature life period. The exposure temperature was 165 degree C (+5/-0 degree C) for a duration of 1000 hours. The test method used was in accordance with TIA/EIA-455-4 for the duration of 1000 hours. Insertion loss test data was collect pre- and post- test to determine any degradation in the item under test. In addition, post test the termini and cables were examined to the extent feasible inside the connector to ensure no damage was apparent. All elements under test successfully survived 2 full 1000 hour exposures without degradation. XiOptics did request that Experior Laboratories continuously monitor performance during testing to fully understand any time-history degradation that might have occurred. During the exposure period no channels varied outside the allowable specification limits. The during test data illustrated that there was no “creep” of IL over the extended time periods.

Multi Mode Product Qualification Test Data

Qualification test data is provided below as processed by Experior Laboratories. Each test sequence was performed per Mil-PRF-29504/Mil-T-29504 /4 or /5 as specified within this document. Test results are provided for each test group and for each sub-group there-in. An event log for each test sequence is included to include the requisite notes per the specification.

Group 1 Unterminated Termini:

Group 1-1 Terminus Dimensional Characteristics

Group 1 testing is intended to validate the physical characteristics of parts prior to entering test sequences:

- Visual **(Passed)**
- Size **(Passed)**
- Weight **(Passed)**
- Identification Marking **(Passed)**
- Workmanship **(Passed)**
- Circular Runout **(Passed)**

Group 1 testing is used to validate the configuration of product going into all test sequences. XiOptics assembled all products per approved engineering documentation and manufacturing instructions at our Ronkonkoma, NY manufacturing facility that has been audited and validated by DSCC inspection. All products entering into formal evaluation was required to successfully pass Group 1-1. Data supporting this was generated at Experior Laboratories.

Group 1-2 Terminus In-Use Functionality

Group 2 testing is intended to validate the following capabilities:

- Terminus retention **(Passed)**
- Terminus engagement and separation force **(Passed)**
- Terminus cleaning **(Passed)**

All termini to be used for qualification were subject to cleaning, subsequently they were tested for insertion and extraction/mating forces versus the specification requirements. Termini entering this sequence had completed Group 1-1 dimensional testing. All products successfully completed Group 1-2 tests. All testing was performed at Experior Laboratories.

Group 2 Termini As A Part Of A Single Cable:

Group 2-1/2 Not Applicable to Items Under Qualification

No testing is performed in these groups.

Group 2-3 Cable Termination Verification

Group 2-3 testing is intended to validate the following capabilities:

- Fiber Pullout **(Not Required)**
- Cable Pullout **(Passed)**

These tests validate the ability of the terminus to be successfully coupled to an Aramid strength member reinforced optical fiber assembly and not demonstrate optical degradation after exposure to extremely high pull loads of 22 pounds minimum. Since the product under qualification is a Style 2 design with an integral strain relief mechanism, fiber pullout testing is not required. All 16 cables under test passed the test sequence and moved into further testing.

Group 2-4 Corrosive Environment (Salt Fog)

Group 2-4 testing is intended to validate the following capabilities:

- Salt Spray **(Passed)**

This test validates the materials of construction and finish properties of the termini and cable construction to withstand exposure to corrosive environments. Cable assemblies were subjected to the specified corrosive salt environment at Experior Laboratories post exposure to Group 2-3 cable pull. All cables successfully passed the test sequence after exposure and no corrosive cells were found that would impact performance of the connectors. All testing was performed at Experior Laboratories.

Group 3 Termini In Multiple Channel Connector (Mechanical Environments):

Group 3-1 *InterOperability Test Group:*

Interoperability testing ensures the units under test will mate and operate with all other items qualified. There are no other qualified 50/125 micron fiber qualified parts list units to mate to so interoperability testing is between XiOptics products only. Testing was performed by the NavSea optical element test laboratory.

- Interoperability Testing **(Passed)**

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Group 3-2a Mechanical Mating Durability Within Connectors

Group 3-2a testing is intended to validate the following capabilities:

- Insertion Loss **(Passed)**
- Mating Durability **(Passed)**
- Cleaning **(Passed)**

XiOptics selected 50/125 OFS FlightGuide fiber for use during qualification. The smaller core fiber was selected to better identify any design deficiencies. All product entering into Group 3 testing has successfully completed Group 1 verification evaluations. XiOptics selected shell size 17 connectors and procured the items under test from qualified parts distributors as would any open market OEM user. All product passed initial insertion loss testing. Product was then moved to mating durability to condition the product prior to shock and vibration testing. The product was tested twice for mating durability for a total exposure of 1000 cycles. Data for the final 500 cycles is provided, the first 500 cycles utilize an alternate alignment hood design that is not under consideration for qualification. The tests clearly showed the ability of the terminus structures to meet or exceed all life cycle expectations and in fact the terminus design demonstrated its ability to continue to function past the usable life of the 38999 connector elements into which is housed. Post test evaluation showed evidence of foreign object debris created during mating durability. During subsequent cleaning and connector inspections it was noted that the connectors and their coupling ring components showed heavily wear patterns at the mating interfaces, this is expected as the connectors are exercised to their end-of-life conditions. No contaminates were found within the optical termini and the product passed the post test IL variance tests without cleaning. Post mating durability these products moved into mechanical shock, hammer shock and vibration test sequences.

Data for the test sequence of insertion loss, 500 cycles of mating and subsequent test/cleaning, were generated. No failures were found during any testing.

Group 3-2b Mechanical Shock Environment Within Connectors

Group 2 testing is intended to validate the following capabilities:

- Mechanical Shock **(Passed)**
- Hammer Shock **(Passed)**

Shock tests are intended to validate mechanical and optical design criteria and interactions between the connector, cable and terminus system. XiOptics performed all mechanical shock testing at Experior Laboratories and all hammer shock testing at Environmental Associates. At Environmental Associates, Experior Photonincs provided the monitoring equipment and test technicians. Environmental Associates provided operations personnel for the shock hammer test.

All mechanical shock and hammer shock testing was performed twice. The first sequence did not have a properly pre-conditioned hood so mating durability was performed after an initial exposure and then the shock exposures were re-performed. All product passed the test sequences and the

dual exposure clearly illustrates the durability of the design by successfully passing the levels of exposure as required by the Mil-PRF-29504 specification twice without damage or degradation.

For mechanical shock XiOptics performed all testing on-site at Experior Laboratories. Of the 8 channels monitored for discontinuity all 8 passed. All 16 channels passed pre/post change in insertion loss testing.

Mil-S-801 Hammer Shock was performed by Experior Laboratories using Mil-S-801 shock hammer facilities at Environmental Associates. XiOptics performed full level hammer shock 3 times per axis per the specification. 8 channels were monitored for discontinuity, all 16 channels under test were evaluated for change in insertion loss. All channels under evaluation passed all tests.

Group 3-2c Mechanical Vibration Exposure Within Connectors

All vibration tests are intended to validate mechanical and optical design criteria in the connector/cable/terminus system.

- Sinusoidal Vibration **(Passed)**
- Random Vibration **(Passed)**
- Engagement/Separation **(Passed)**
- Insertion Loss Verification **(Passed)**

XiOptics performed all mechanical vibration testing at Experior Laboratories. Discontinuity monitoring and pre/post insertion loss testing was for each sequence. 8 channels were continuously monitored for discontinuity; all 16 channels were measured for change in insertion loss during the test sequence. Sinusoidal vibration was performed as an un-interrupted sequence of exposure to all 3 axes. 2 connectors were mounted on the test platform during each axis exposure. Change in insertion loss measurements for all vibration sequences are serial in that connectors were not demated/mated so baseline power evaluation was held through the entire test sequence.

Random vibration sequences were performed with higher level ambient exposure first followed by set-up within an environmental chamber and subsequent exposure at elevated temperature. Connectors remained unmated from the sinusoidal exposures with no cleaning or other preparatory maintenance required. No degradation to the connector test specimens were noted other. Cables were secured with conventional FO capable back shell accessories and secured to test stanchions to prevent handling damage as was previously witnessed on testing of other cables. Post the random vibration sequences all cables were visually inspected and tested for insertion loss and return loss performance. Data for random vibration and vibration spectrum are shown within the Excel workbook contained within this file. Random vibration was performed on sequential days for ambient and subsequently elevated temperature at 125 C.

At the conclusion of mechanical environment exposures all cable channels were visually inspected for damage, separation or other degradation. Verification of optical insertion loss was performed to verify no internal degradation of optical termini, components or termination. Connectors were separated post testing to verify no internal damage. Cables are stored for future reference as required.

Group 4 Termini In Multiple Channel Connector (Thermal Environments):

Group 4 testing focuses on the termini and cables' capability to withstand extreme operational thermal environments. Validation of the design and capability of the design is performed by exposing the product to a combination of thermal tests and monitoring optical performance before, during and after each test sequence.

Group 4.1 Terminus Performance Verification Within Connectors In Thermal Shock

Thermal shock is intended to validate the capability of the product to function while temperature fluctuations at a maximum rate are influencing the product and as well that the product will perform at both extreme high and low temperatures.

- Initial Insertion Loss (not required, performed) **(Passed)**
- Thermal Shock **(Passed)**

Thermal shock testing was performed at Experior Laboratories. Testing was performed on 16 multi-mode channels. The cables and connectors were prepared by Coastal Connectors and inspected by Silicon Lightwave Technology prior to testing. All connectors were shell size 17. All channels successfully completed the testing with most channel have a variance of less than 0.2 db insertion loss after test exposure. The worst channel was 0.47 db post test variance EN2 channel 1. Prior to testing each channel's insertion loss was verified and the connectors cycled 10 times to verify performance post temperature life exposure.

Group 4.2 Terminus Performance Verification Within Connectors, Temperature Life

Group 4.2 exposes the cable, connector and terminus system to extended exposure of extremely elevated temperatures. This temperature life testing is intended to validate the stability of the fiber/terminus joining process and also the connector retention features of the terminus.

- Initial Insertion Loss (not required, performed) **(Passed)**
- Temperature Life **(Passed)**
- Insertion Loss Verification **(Passed)**

For qualification the life test at high exposure temperature was 165 °C +5/-0 °C. Mated connectors with termini and cables were tested in accordance with TIA/EIA-455-4 for the duration of 1000 hours at the high exposure temperature. The change in optical transmittance was measured after the test. The termini and cable assemblies were visually examined after the test to the extent feasible inside the connector. Subsequent to completion of this inspection the cables were removed from the connectors and inspected a second time. Termini were not damaged, and there were no loosening of parts. There was no evidence of separation of bonded surfaces (cable interfaces) or other damage detrimental to the operation of the termini.

Post the temperature life and thermal shock exposures the insertion loss of the cables was tested to verify the ability of the cable, connector and terminus system to operate with a loss of less than 1.5 db as required by the specification. 16 of 16 channels exposed to the testing passed the test. The highest insertion loss was 0.75 db with most channels remaining at 0.5 db or less.

Cables are stored for future reference as required.