

## METRIC

MIL-PRF-49291/11A

22 July 2011

SUPERSEDING

MIL-PRF-49291/11

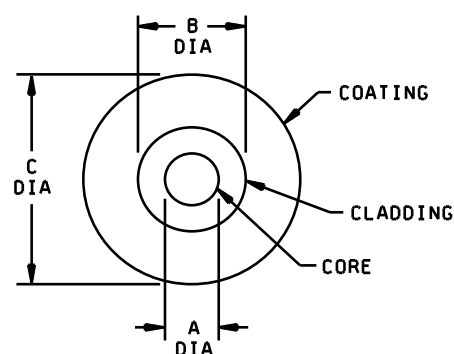
27 August 2009

## PERFORMANCE SPECIFICATION SHEET

## FIBER, OPTICAL, TYPE II, CLASS 5, SIZE II, COMPOSITION A, WAVELENGTH D, RADIATION RESISTANT, ENHANCED PERFORMANCE CHARACTERISTICS (METRIC)

This specification is approved for use by all departments and Agencies of the Department of Defense.

The requirements for acquiring the product described herein shall consist of this specification sheet and MIL-PRF-49291.

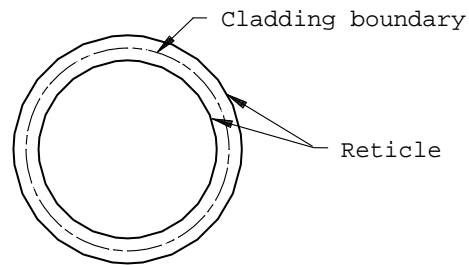


PIN	Dimensions		
	A (μm)	B (μm)	C (μm)
M49291/11-01 M49291/11-01A	<u>1/</u>	<u>3/</u>	125 ± 0.7 <u>2/</u>
M49291/11-02 M49291/11-02A	<u>1/</u>	125 ± 0.7	245 ± 10 <u>4/</u>

- 1/ Core diameter is not a specified attribute. Refer to the mode field diameter specifications.
- 2/ Overall dimension includes a non-strippable coating (or surface treatment). Cladding along with this coating shall conform to C diameter. Use C dimension in lieu of cladding to determine cladding ovality, core-to-cladding offset and cladding dimensions.
- 3/ Cladding diameter remains unspecified with condition that optical fiber must meet specified requirements.
- 4/ Integrated fiber and cable manufacturing process may exceed this diameter. When this condition occurs, then this configuration shall conform to cabling specification in addition to this specification sheet.

FIGURE 1. Dimensions and configuration of optical fiber construction.

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Circle (solid)	Diameter ( $\mu\text{m}$ )
Inner	124.3
Second	125.7

FIGURE 2. Tolerance fields.

Part or identifying number (PIN). (See figure 1 and table II):

M49291/11-01  
M49291/11-01A  
M49291/11-02  
M49291/11-02A

## REQUIREMENTS:

Dimensions and configuration:

Diameter: See figure 1 and figure 2.

Ovality:

Core: Not applicable.  
Cladding:  $\leq 1$  percent.

Offset:

Core-to-cladding:  $\leq 0.7 \mu\text{m}$ .

Fiber-to-coating:

Coating-cladding concentricity error:  $\leq 12.0 \mu\text{m}$ .  
Overall coating concentricity ratio (OCCR or coating noncircularity):  $\geq 0.70$  for  $250 \mu\text{m}$  diameter coatings.

Fiber curl:  $\geq 4.0 \text{ m}$  when measured in accordance with TIA-455-111.

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## Optical parameters:

Mode field diameter: The mode field diameter shall be within the range from 8.2 to 9.5 at 1,310 nm and from 9.4 to 10.5 at 1,550 nm.

Splices within the optical fiber: Splices within the optical fiber are not allowed.

Proof test: 1.38 GPa (200 kpsi).

Fiber mass/unit length: 0.1 kg/km maximum.

Change in optical transmittance: Measurements to be made at 1,550 nm  $\pm$  20 nm.

Maximum attenuation rate: Spectral attenuation shall be performed at a sufficient number of wavelengths to cover the applicable optical transmission windows and sources for attenuation. Sufficient coverage includes the optical transmission windows (850, 1,300, 1,310 and 1,550 nm), ultraviolet absorption band (600 to 870 nm), Rayleigh scattering losses (800 to 1,200 nm), OH impurity absorption peaks (945, 1,249 and 1,383 nm) and infrared absorption (1,600 to 1,700 nm). Use of a source and power meter to perform this measurement is not acceptable.

Maximum attenuation rate over the wavelength range from 1,250 nm to 1,650 nm shall be less than 0.5 dB/km. Attenuation rate for wavelengths of operation shall not exceed 0.35 dB/km at 1,310 nm  $\pm$  20 nm, 0.22 dB/km at 1,550 nm  $\pm$  20 nm and 0.25 dB/km at 1,625 nm  $\pm$  20 nm.

Attenuation uniformity: Applicable except perform at 1,310 nm and 1,550 nm. There shall be no discontinuities in attenuation along the length greater than 0.1 dB.

Numerical aperture: Not applicable.

Bandwidth: Not applicable.

Chromatic dispersion: Applicable except chromatic dispersion shall be  $\leq 3.0$  ps/nm-km at 1,310 nm  $\pm$  20 nm and  $\leq 20$  ps/nm-km at 1,550 nm  $\pm$  20 nm. Zero dispersion wavelength shall be 1312 nm  $\pm$  12 nm. The value of the slope at the zero dispersion wavelength shall be not greater than 0.092 ps/nm<sup>2</sup>-km.

Cutoff wavelength: Applicable except the cutoff wavelength shall be  $\leq 1,260$  nm.

Transient attenuation: Not applicable.

Macrobend attenuation: Applicable except the test shall be performed in accordance with TIA-455-62, method B, with the macrobend attenuation obtained for each row in table I. The macrobend attenuation shall not exceed the maximum values listed in table I.

Polarization mode dispersion: The polarization mode dispersion shall be  $\leq 0.2$  ps/ $\sqrt{\text{km}}$  when measured in accordance with either TIA-455-122 or TIA-455-124.

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TABLE I. Macrobend attenuation test parameters.

Mandrel diameter mm (inch)	Number of turns around mandrel	Measurement Wavelength (nm)	Macrobend attenuation (dB)
76 ± 1 (3.0 ± .04)	100	1,310 ±20	0.1
76 ± 1 (3.0 ± .04)	100	1,550 ±25	1.0
30 ± 1 (1.2 ± .04)	10	1,310 ±20	0.03
30 ± 1 (1.2 ± .04)	10	1,550 ±25	0.03
30 ± 1 (1.2 ± .04)	10	1,625 ±25	0.1
20 ± 1 (.79 ± .04)	1	1,310 ±20	0.1
20 ± 1 (.79 ± .04)	1	1,550 ±25	0.05
20 ± 1 (.79 ± .04)	1	1,625 ±25	0.1
15 ± .5 (.59 ± .02)	1	1,310 ±20	0.1
15 ± .5 (.59 ± .02)	1	1,550 ±25	0.1
15 ± .5 (.59 ± .02)	1	1,625 ±25	0.4

## ENVIRONMENTAL:

Temperature range: See table II.

Fluid immersion aging: Not applicable.

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TABLE II. Temperature range. 1/

PIN	Operating °C (°F)	Nonoperating °C (°F)	Storage °C (°F)
M49291/11-01 M49291/11-02 2/	-55 to +165 (-67 to 329)	-40 to + 85 (-40 to 185)	-40 to +85 (-40 to 185)
M49291/11-01A M49291/11-02A 3/	-46 to +85 (-51 to 185)	-55 to +85 (-51 to 185)	-55 to +85 (-51 to 185)

1/ Temperatures are specified in degrees Centigrade, Fahrenheit equivalents are specified in parentheses.

2/ Temperature ranges in row 2 conform to those specified for other MIL-SPEC fiber optic cabling components for aircraft applications.

3/ Temperature ranges in row 3 conform to those specified for other MIL-SPEC fiber optic cabling components for standard applications (such as the telecommunication industry).

Mechanical strippability: Applicable except, in addition, each individual optical fiber shall comply with the following diameter and residue requirements and test methods:

Diameter requirement. Requirement that the stripped optical fiber complies with diameter B in figure 1 shall be verified by successful insertion and removal of each optical fiber stripped end into a ring gauge/die/ferrule with a hole diameter of 125 +1/-0 micron. It is in the interest of the implementer to choose a gauge closer to 126 micron than 125 microns.

Residual requirement. Requirement that no residual coating material remains on fiber shall be verified by the performance of a fiber pullout test. The end of each stripped length of optical fiber shall be terminated onto the end of a MIL-PRF-29504 terminus (or other suitable fiber optic connector if approved by the qualifying activity prior to test sample fabrication). Fabrication shall be performed as specified in NAVSEA Drawing 8283255. A copy of this document can be obtained at web site: <https://fiberoptics.nswc.navy.mil/> in the NAVSEA Drawing section under component Information. The fiber pull out force shall be tested by applying a 14.0 N (3.1 pounds) axial tensile load between the optical fiber and the terminus for a minimum duration of one minute. At the completion of the test, the optical fiber shall be visually examined and length measured to verify that no fiber pull out occurred.

Splicing compatibility: Six 10 meter (32.8 feet) lengths of optical fiber conforming to the requirements of this specification sheet shall be spliced, (using either a fusion splicer or mechanically splice) and connectorized (using MIL-PRF-29504/4 and MIL-PRF-29504/5 termini) to optical fiber conforming to MIL-PRF-49291/7. Three sample lengths are to be used for each splice or connector. An insertion loss measurement shall be performed in accordance with Method B of TIA/EIA-455-34. The insertion loss shall not exceed 0.2 dB per splice and 0.5 dB per connector mated pair when performed at a wavelength of 1,310 nm.

Dynamic tensile strength: Applicable.

Fungus: Applicable.

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## Thermal shock:

Applicable as specified for M49291/11-01A and M49291/11-02A.

Applicable for M49291/11-01 and M49291/11-02, except that the temperatures of  $-55^{\circ}\text{C} +0^{\circ}\text{C}/-5^{\circ}\text{C}$  ( $-67^{\circ}\text{F} +0^{\circ}\text{F}/-8^{\circ}\text{F}$ ) and  $165^{\circ}\text{C} +5^{\circ}\text{C}/-0^{\circ}\text{C}$  ( $329^{\circ}\text{F} +8^{\circ}\text{F}/-0^{\circ}\text{F}$ ) shall be used for the low and high soak temperatures, respectively. Test shall be performed in accordance with TIA-455-71, schedule C-0 (5 cycles). The change in optical transmittance shall be measured during (towards the end of each soak temperature) and after the test.

Storage temperature: Applicable.

## Temperature cycling:

Applicable as specified for M49291/11-01A and M49291/11-02A.

Applicable for M49291/11-01 and M49291/11-02 except for the optical fiber with a  $-55^{\circ}\text{C}$  to  $165^{\circ}\text{C}$  ( $-67^{\circ}\text{F}$  to  $329^{\circ}\text{F}$ ) temperature range, perform the following in lieu of the specified temperature cycling test. Optical fiber shall be tested in accordance with TIA-455-3 using the number of cycles, test condition schedule, and soak times in accordance with table III. The change in optical transmittance shall be measured during and after the test. At a minimum for the "during test" measurements, an optical transmittance measurement shall be performed towards the end of each soak period (maintain action in table III) after every cycle. A post test visual examination of the test specimens shall reveal no surface impairment or any damage detrimental to the operation of the test specimens. The operating temperature range shall be as specified herein. Test fixtures, if used, must be of minimum mass and approved by the qualifying activity. No other mass (item that causes significant thermal lag) shall be added inside the chamber. This test shall be performed both after temperature-humidity cycling and after temperature life (for M49291/11-01 and M49291/11-02).

TABLE III. Temperature cycling steps.

Step	Cycle	Action	Temperature $^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )	Duration <sup>1/</sup>
1	1	Maintain	$25 \pm 2$ ( $77 \pm 4$ )	4 hours (minimum)
2		Ramp to	$-55 +0/-3$ ( $-67 +0/-5$ )	7.5 minutes
3		Maintain	$-55 +0/-3$ ( $-67 +0/-5$ )	15 minutes (minimum)
4		Ramp to	$165 +3/-0$ ( $329 +5/-0$ )	22 minutes
5		Maintain	$165 +3/-0$ ( $329 +5/-0$ )	15 minutes (minimum)
6	2	Ramp to	$-55 +0/-3$ ( $-67 +0/-5$ )	22 minutes
7		Maintain	$-55 +0/-3$ ( $-67 +0/-5$ )	15 minutes (minimum)
8		Ramp to	$165 +3/-0$ ( $329 +5/-0$ )	22 minutes
9		Maintain	$165 +3/-0$ ( $329 +5/-0$ )	15 minutes (minimum)
10	3-10	Repeat steps 6 thru 9, 8 additional times, for a total of 10 cycles.		
11	Post 10	Ramp to	$25 \pm 2$ ( $77 \pm 4$ )	6 minutes
12		Maintain	$25 \pm 2$ ( $77 \pm 4$ )	4 hours (minimum)

<sup>1/</sup> Ramp rate is  $10^{\circ}\text{C}$  per minute or faster, soak time (maintain step) is 15 minutes.

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Life aging (temperature life):

Applicable as specified for M49291/11-01A and M49291/11-02A.

Applicable for M49291/11-01 and M49291/11-02 except that the high exposure temperature shall be 165°C +5°C, -0°C (329°F +8°F/ -0°F). Test samples shall be tested in accordance with TIA/EIA-455-4 for the duration of 1,000 hours at the high exposure temperature. The change in optical transmittance shall be measured after the test. The optical fiber shall be visually examined after the test to the extent feasible. Optical fiber shall not be damaged, and there shall be no distortion, cracking of coating, or other damage detrimental to the operation of the optical fiber. The requirement for the change in optical transmittance shall be met after the test. Performance of a cable/fiber retention test is not required as part of the final inspection for this test.

Nuclear radiation resistance: Nuclear radiation resistance requirements and test conditions shall be as shown below and in table IV and table V:

Light launch conditions: In accordance with TIA-455-78.

Wavelength: 1,310 nm ± 25 nm.

Source type: Laser diode with FWHM spectral width ≤ 10 nm.

TABLE IV. Steady state gamma radiation test conditions.

Test temperature (°C)	Dose rate rad (Si)/sec	Total dose (rad (Si))
-28 ± 2 +25 ± 2 +85 ± 2	50 +0, -20	Classified

(Some nuclear radiation resistance characteristics of this optical fiber are classified and shall be obtained from the qualifying activity. Application to receive these requirements must be made through the Department of the Navy, Naval Surface Warfare Center, Dahlgren Division, ATTN: Code B35, 17320 Dahlgren Road, Dahlgren, VA 22448-5100. Information concerning security clearance classification and "need to know" must be detailed in the request.)

TABLE V. Radiation test requirements.

Maximum induced attenuation (dB/km)	Attenuation at specified recovery time (dB/km)	Specified recovery time (sec)
≤ 50 <u>1/</u>	≤ 15 at -28°C (-18 °F) ≤ 5 at 25°C (77°F) ≤ 5 at 85°C (185°F) <u>1/</u>	1,000

1/ The radiation induced loss for a given threat. The total dose associate with the threat is classified and not necessarily equal to the test total dose.

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## CONFORMANCE:

Test samples for qualification: Reels of optical fiber produced for initial qualification and quality conformance shall be from at least two different preforms (see 4.5.1).

Qualification: Qualification shall consist of performing testing specified in table VI.

TABLE VI. Qualification inspections.

Test performed	Initial qualification
Initial uncoiling preparation	
Group 1 (3 spools-2km each) <u>1/</u>	
Visual and mechanical	X
OTDR tests:	
Fiber length	X
Attenuation uniformity	X
Parameter tests:	
Attenuation rate	X
Numerical aperture (MM only)	
Core diameter (MM only)	
Cutoff wavelength(SM only)	X
Mode field diameter (SM only)	X
Transient attenuation (MM only)	
Macrobend attenuation	X
Bandwidth-overfill (MM only)	
Bandwidth-RML/EMBc (MM only)	
Chromatic Dispersion	X
Polarization mode dispersion (SM only)	X
Fiber curl (SM only)	X
Mass/unit length	X
Geometry tests:	
End view:	
Core ovality (MM only)	
Cladding diameter	X
Cladding ovality	X
Core to cladding offset	X
Side view:	
Coating diameter	X
Coating-cladding concentricity error	X
Overall coating concentricity ratio	X
Group 2(samples off 3 spools) <u>1/</u>	
Tensile proof	X

See footnotes at end of table



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TABLE VI. Qualification inspections - Continued.

Test performed	Initial qualification
Mechanical strippability	X
Dynamic tensile strength	X
Splice compatibility	X
Group 3 (same 3 spools-2km ea <u>1/</u> , <u>2/</u> , <u>5/</u> , <u>6/</u> )	
Thermal shock <u>3/</u>	X
Storage temperature <u>4/</u>	X
Temperature humidity cycling <u>4/</u>	X
Mechanical strippability (post TH cycling)	X
Temperature cycling <u>4/</u>	X
Life aging (temperature life) <u>4/</u> =daily <u>7/</u>	X
Mechanical strippability (post Temp life)	X
Group 4(samples off 3 spools)	
Nuclear radiation resistance <u>4/</u>	X
Fungus resistance	X

## NOTES:

- 1/ See table I in basic specification (MIL-PRF-49291) for specimen lengths.
- 2/ OOT = Change in optical transmittance. Perform in accordance with TIA-455-20 for transmitted power adhering strictly to the setup and test procedure specified in Measurement 2102 of MIL-STD-1678-2.
- 3/ Perform OOT after the test only.
- 4/ Perform OOT both during and after the test.
- 5/ Sample lengths: Recommend to prepare before group 1. For mechanical strippability, place in pans and remove from chamber after specified environmental test.  
 Mechanical strippability: each spool, 2 samples, 91.4 cm (3 ft) long.  
 Mechanical strippability-post temp/humidity: each spool, 2 samples, 91.4 cm (3 ft) long.  
 Mechanical strippability-post life aging: each spool, 2 samples, 91.4 cm (3 ft) long.  
 Dynamic tensile strength: each spool, 30 samples, 198.1 cm (6.5 ft) long (no humidity).  
 Nuclear radiation resistance: each spool, 1 sample, 200 meters (165.1 ft) long on spool.  
 Fungus resistance: each spool, 1 sample, 30.5 cm (1 ft) long.
- 6/ Prepare in loose coils and place in pans. Recommend to terminate with single ferrule connectors (such as ST connectors) on the fiber ends (for attachment to test instrumentation optical ports – to obtain more stabilized measurements).
- 7/ Measurements requested daily for informational purposes.

In group A testing, single-mode fiber attenuation may be measured using TIA-455-78.

In group C testing the mechanical strippability test may be omitted if the optical fiber coatings have not changed from when the mechanical strippability test was last performed. The manufacturer shall provide a certificate of compliance for mechanical strippability in the group C test report.

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Qualification by similarity:

Change in glass:

Manufacturers who are qualified under this specification sheet and whose optical fiber with a change in the glass (composition or profile) passes the tests specified in table VII are qualified under this specification sheet for the optical fiber with changed glass.

TABLE VII. Change in glass.

Visual and mechanical
Fiber length
Attenuation uniformity
Attenuation rate
Cutoff wavelength
Mode field diameter
Macrobend attenuation
Chromatic dispersion
Temperature cycling
Nuclear radiation resistance

Change in coating:

Manufacturers who are qualified under this specification sheet and whose optical fiber with a change in the coating (composition or thickness) passes the tests specified in table VIII are qualified under this specification sheet for the optical fiber with changed coating.

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TABLE VIII. Change in coating.

Visual and mechanical
Fiber length
Attenuation rate
Macrobend attenuation
Coating diameter
Coating noncircularity
Mechanical strippability
Dynamic tensile strength
Thermal shock
Storage temperature
Temperature humidity cycling
Temperature cycling
Life aging
Fungus resistance

Referenced documents: In addition to MIL-PRF-49291, this specification sheet references the following documents:

MIL-STD-1678-2	TIA-455-3	TIA-455-78
MIL-PRF-29504	TIA/EIA-455-4	TIA-455-111
MIL-PRF-29504/4	TIA-455-20	TIA-455-122
MIL-PRF-29504/5	TIA/EIA-455-34	TIA-455-124
MIL-PRF-49291/7	TIA-455-62	
NAVSEA Drawing 8283255	TIA-455-71	

Changes from previous issue: Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

MIL-PRF-49291/11A

Custodians:

Army - CR  
Navy - AS  
Air Force - 85  
DLA – CC  
NASA – NA

Preparing activity:

DLA – CC

(Project 6010-2010-002)

Review activities:

Navy - SH  
Air Force – 02, 13, 19, 33, 93, 99  
DIA - DI

NOTE: The activities listed above were interested in this document on the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <https://assist.daps.dla.mil>.