



A Furukawa Company

Test Plan and Results

Supplemental Information for Qualified OFS Customer Use

Two-Phase Testing and Analysis of:
and Multi-Fiber Connectorized Constructions of

Low Smoke Zero Halogen Cable

Inclusive of OFS Cable Part Numbers:

**Phase I:
Simplex/Zipcord Connectorized Cables**

C21050 Simplex w/Aramid
C21051 Zipcord w/Aramid
C21058 Simplex no Aramid
C21059 Zipcord no Aramid

**Phase II:
Multi-Fiber Cables**

C21053 4-fiber 2.5 mm w/Aramid no Armor
C21056 4-fiber 2.5 mm w/Aramid w/Aarmor
C21061 4-fiber 2.2 mm w/Aramid no Armor
C21064 4-fiber 2.2 mm w/Aramid w/Aarmor

**Testing Completed
May 2010**

Executive Introduction

The following report outlines testing completed by OFS according to IEC and EIA/TIA standards. This testing was conducted on OFS's line of Low Smoke Zero Halogen Cables in a two-phase process involving first the simplex and zipcord cables connectorized with V-Pin, ST, or SMA connectors. Connector-retention information from the first testing phase was retained and carried over for the multi-fiber testing phase. Duplicate connector testing was unnecessary, because these multiple-fiber cable units use the same subunits.

Internal multi-fiber cable testing was conducted only on the 4-fiber versions of various constructions (e.g. with and without aramid yarn, with and without armoring). According to IEC protocol, the 2-fiber and 6-fiber versions are considered to pass the Smoke, Halogen Gas, and Acid Gas tests where the 4-fiber versions do since the same cable materials are used in all constructions. UL and IEC flame test results on the 4-Fiber cables extend to the 2-Fiber cables, but not the 6-fiber cable constructions. Higher fiber-count versions are an option we make available to customers. If UL Riser rating is required in fiber counts of six or higher, additional testing can be conducted.

Underwriters' Laboratories has conducted its own, separate testing for flame retardance in order to issue a UL-1666 Riser rating for these cables. UL also performed the IEC Flame, Smoke, Halogen Gas, and Acid Gas tests. The complete UL and IEC reports are not available to customers, but the final results are shown for each cable part number on the individual data sheets and summarized on page 36 (3.11 and 3.12) of this report.

Phase I:
Simplex/Zipcord Connectorized Cables
 C21050 Simplex w/Aramid
 C21051 Zipcord w/Aramid
 C21058 Simplex no Aramid
 C21059 Zipcord no Aramid

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1. Introduction

1.1 Summary

This test report summarizes the work performed on 4 types of Low Smoke Zero Halogen Cable and the testing results obtained by OFS Avon Test and Reliability Engineering department. The testing was performed according to the test plan outlined in Table 1.1. Three spools of each cable type were submitted for testing. Table 1.2 summarized the lot numbers submitted.

Table 1.1: Test Plan

Test	Test Description and Procedure
Optical Requirements	
Numerical Aperture	CDT-03, FOTP-007
Spectral Attenuation	CDT-04, FOTP-115
Mechanical Requirements	
Tensile Loading and Bending	FOTP-33
Cable Bend	FOTP-88
Compression	FOTP-41
Cyclic Flex	FOTP-104
Impact	FOTP-25
Twist	FOTP-85
Shrinkage	
Mass per Unit Length	
Thermal Characteristics	
Thermal Induced Attenuation	FOTP-003
Assembly Testing	
V-Pin Retention	CDT-51
A-Series Retention	CDT-51
Other Testing	
Flame, Smoke and Toxicity	Submitted and reported separately

Table 1.2: Lot Numbers

A Series			V-Series		
Part Number	Lot Number	Type	Part Number	Lot Number	Type
C21050	48059	Simplex	C21058	48064	Simplex
	48060			48065	
	48061			48066	
C21051	48422A	Zipcord	C21059	48077A	Zipcord
	48424			48078A	
	48427			48080	

2. Optical Requirements

2.1 Sample List, OTDR Attenuation and Length

Each spool was checked for attenuation, length and point discontinuities on the EXFO OTDR according to CDG-32 (FOTP-59, FOTP-60 and FOPT-61 are used as a reference). The results are summarized in Table 2.1. Data is taken from spool travelers.

Table 2.1: OTDR Results

Part Number	Cable Lot Number	Channel	Attenuation	Length	Point Discontinuities
C21050	48059		4.37	987	None
	48060		3.54	1057	None
	48061		3.83	1397	None
C21051	48422A	Print	4.48	1013	None
		No Print	5.19		None
	48424	Print	4.17	1014	None
		No Print	4.59		None
	48427	Print	3.36	1426	None
		No Print	4.57		None
C21058	48064		3.13	1384	None
	48065		3.51	1419	None
	48066		4.2	1454	None
C21059	48077A	Print	6.62	1105	None
		No Print	7.97		None
	48078A	Print	4.77	1014	None
		No Print	4.89		None
	48080	Print	5.52	1203	None
		No Print	5.60		None

2.2 Spectral Attenuation

Spectral attenuation was measured according to CDT-04 and FOTP-115 (Spectral Attenuation Measurement of Step-Index Multimode Optical Fibers). The spectral scan was from 600nm to 1100nm with a 5nm increment. The attenuation values at 650 and 850 are listed in Table 2.2.

Table 2.2: Spectral Attenuation Results

Part Number	Cable Lot Number	Channel	Attenuation	
			650nm	850nm
C21050	48059		7.87	4.83
	48060		7.82	4.84
	48061		8.10	4.93
C21051	48422A	Print	8.40	5.36
		No Print	8.50	5.63
	48424	Print	8.24	5.08
		No Print	8.64	5.37
	48427	Print	7.47	4.50
		No Print	8.31	5.07
C21058	48064		7.53	4.30
	48065		8.13	5.10
	48066		7.96	4.78
C21059	48077A	Print	9.33	6.64
		No Print	10.74	8.20
	48078A	Print	8.80	5.68
		No Print	8.31	5.39
	48080	Print	8.92	5.98
		No Print	8.29	5.50

2.3 Numerical Aperture

The numerical aperture was measured according to CDT-03 and FOTP-007 (Numerical Aperture of Step-Index Multimode Optical fibers by Output Far-Field Radiation Pattern Measurement), method A. The numerical aperture values are listed in Table 2.3.

Table 2.3: Numerical Aperture Data

Part Number	Cable Lot Number	Channel	Numerical Aperture
C21050	48059		0.356
	48060		0.356
	48061		0.359
C21051	48422A	Print	0.353
		No Print	0.360
	48424	Print	0.356
		No Print	0.356
	48427	Print	0.362
		No Print	0.352
C21058	48064		0.357
	48065		0.363
	48066		0.356
C21059	48077A	Print	0.352
		No Print	0.352
	48078A	Print	0.359
		No Print	0.361
	48080	Print	0.361
		No Print	0.355

3. Mechanical Properties

3.1 Tensile Loading and Bending

Tensile loading and bending was measured on one sample per spool according to FOTP-33. A 10 meter sample was loaded onto the Sintech 5-G tensile bench and the test performed at the loads and mandrel size listed in Table 3.1a. Optical transmittance was monitored during the test and measurements taken after 25 minutes at each load, in addition to a final reading after the tension on the cable was released; data is listed in Table 3.1b.

Table 3.1a: Tensile Loading and Bending Setup Data

Part Number	Cable Lot Number	Load 1	Load 2	Mandrel Diameter
C21050	48059	55lbs	110lbs	76mm
	48060			
	48061			
C21051	48422A	85lbs	165lbs	76mm
	48424			
	48427			
C21058	48064	5lbs	25lbs	30mm
	48065			
	48066			
C21059	48077A	5lbs	25lbs	30mm
	48078A			
	48080			

Table 3.1b: Tensile Loading and Bending Results

Part Number	Cable Lot Number	Channel	Change in Optical Transmittance (dB)			
			Baseline	Load 1	Load 2	No Load
C21050	48059		0.00	-0.12	-0.23	-0.08
	48060		0.00	-0.09	-0.11	0.03
	48061		0.00	-0.12	-0.18	0.00
C21051	48422A	Print	0.00	-0.03	-0.07	0.05
		No Print	0.00	-0.08	-0.18	-0.63
	48424	Print	0.00	-0.21	-0.34	-0.10
		No Print	0.00	-0.15	-0.23	-0.06
	48427	Print	0.00	-0.31	-0.47	-0.02
		No Print	0.00	-0.15	-0.22	0.00
C21058	48064		0.00	0.01	0.01	0.00
	48065		0.00	0.01	0.01	0.02
	48066		0.00	0.03	0.02	0.03
C21059	48077A	Print	0.00	0.06	0.10	0.09
		No Print	0.00	0.03	0.05	0.06
	48078A	Print	0.00	0.02	0.05	0.04
		No Print	0.00	0.04	0.03	0.05
	48080	Print	0.00	0.08	0.08	0.08
		No Print	0.00	0.01	0.05	0.01

3.2 Cable Bend

Cable Bend was tested on one sample per spool according to FOTP-88. The sample was loaded onto the Sintech 5-G tensile bench and the test performed at the loads and mandrel size listed in Table 3.2a. Each load was applied for 2 minutes and optical transmittance was monitored after 1 minute. A final reading was taken after the cable had relaxed. Table 3.2a lists the loads for each cable and Table 3.2b shows the test results.

Table 3.2a: Cable Bend Setup Data

Part Number	Cable Lot Number	Load 1	Load 2	Mandrel Diameter
C21050	48059	55lbs	110lbs	76mm
	48060			
	48061			
C21051	48422A	85lbs	165lbs	76mm
	48424			
	48427			
C21058	48064	5lbs	25lbs	30mm
	48065			
	48066			
C21059	48077A	5lbs	25lbs	30mm
	48078A			
	48080			

Table 3.2b: Cable Bend Results

Part Number	Cable Lot Number	Channel	Change in Optical Transmittance (dB)			
			Baseline	Load 1	Load 2	No Load
C21050	48059		0.00	-0.16	-0.22	0.00
	48060		0.00	-0.06	-0.10	0.02
	48061		0.00	-0.15	-0.21	-0.03
C21051	48422A	Print	0.00	-0.19	-0.28	0.02
		No Print	0.00	-0.12	-0.19	-0.04
	48424	Print	0.00	-0.10	-0.14	-0.01
		No Print	0.00	-0.15	-0.23	0.04
	48427	Print	0.00	-0.16	-0.24	-0.02
		No Print	0.00	-0.11	-0.20	-0.01
C21058	48064		0.00	0.00	-0.05	-0.03
	48065		0.00	0.01	0.01	0.04
	48066		0.00	-0.02	-0.03	-0.05
C21059	48077A	Print	0.00	-0.01	-0.01	0.00
		No Print	0.00	0.01	0.00	0.02
	48078A	Print	0.00	0.00	0.00	0.00
		No Print	0.00	0.01	-0.01	0.00
	48080	Print	0.00	0.01	0.01	0.02
		No Print	0.00	0.01	0.00	0.01

3.3 Compression

Compression was measured on one sample per pool according to FOTP-41. The sample was placed on the Sintech 5-G tensile bench into the compression fixture. The load was increased from 0lbs to 4500lbs in 500lb increments and held for 2 minutes at each load. Optical transmittance was recorded after 1.5 minutes at each load. The data is shown in Table 3.3.

Table 3.3: Compression Results

Part Number	Cable Lot Number	Channel	Compressive Force in lbs										
			0	500	1000	1500	2000	2500	3000	3500	4000	4500	0
C21050	48059		0.00	-0.39	-0.60	-0.67	-0.72	-0.74	-0.77	-0.77	-0.77	-0.78	0.00
	48060		0.00	-0.19	-0.26	-0.32	-0.36	-0.40	-0.46	-0.53	-0.62	-0.75	0.00
	48061		0.00	-0.34	-0.55	-0.71	-0.88	-1.08	-1.40	-1.66	-1.88	-2.08	0.00
C21051	48422A	Print	0.00	-0.09	-0.13	-0.16	-0.19	-0.21	-0.23	-0.25	-0.27	-0.28	0.01
		No Print	0.00	-0.04	-0.09	-0.11	-0.11	-0.12	-0.12	-0.12	-0.12	-0.14	0.03
	48424	Print	0.00	-0.12	-0.22	-0.27	-0.30	-0.32	-0.33	-0.35	-0.37	-0.40	0.00
		No Print	0.00	-0.06	-0.12	-0.15	-0.17	-0.18	-0.20	-0.21	-0.23	-0.24	0.00
	48427	Print	0.00	-0.12	-0.23	-0.34	-0.39	-0.43	-0.48	-0.50	-0.53	-0.56	0.00
		No Print	0.00	-0.08	-0.15	-0.19	-0.22	-0.25	-0.26	-0.28	-0.29	-0.31	0.00
C21058	48064		0.00	-0.32	-0.45	-0.54	-0.57	-0.83	-1.41	-1.66	-1.92	-2.30	-0.07
	48065		0.00	-0.18	-0.28	-0.35	-0.49	-1.13	-1.50	-1.60	-1.59	-1.78	-0.01
	48066		0.00	-0.29	-0.42	-0.53	-0.62	-1.17	-1.53	-1.74	-1.92	-2.23	-0.07
C21059	48077A	Print	0.00	-0.07	-0.13	-0.15	-0.15	-0.15	-0.15	-0.14	-0.15	-0.22	-0.02
		No Print	0.00	-0.04	-0.09	-0.09	-0.09	-0.08	-0.06	-0.24	-0.22	-0.23	0.00
	48078A	Print	0.00	-0.03	-0.13	-0.17	-0.19	-0.19	-0.20	-0.20	-0.20	-0.20	0.01
		No Print	0.00	-0.11	-0.19	-0.20	-0.20	-0.18	-0.17	-0.16	-0.15	-0.15	0.00
	48080	Print	0.00	-0.05	-0.09	-0.12	-0.29	-0.20	-0.24	-0.22	-0.22	-0.21	0.07
		No Print	0.00	0.00	-0.04	-0.01	-0.02	-0.04	-0.19	-0.19	-0.17	-0.24	0.09

3.4 Cyclic Flex

Cyclic flex was tested on one sample per spool according to FOTP-104. The samples were loaded with a 1.5kg mass and bent around a 1” diameter sheave. The samples were flexed for a minimum of 50,000 flexes. Change in optical transmittance and the number of actual flexes were recorded at the end of the test and are listed in Table 3.4.

Table 3.4: Cyclic Flex Results

Part Number	Cable Lot Number	Channel	Number of Flexes	Change in Optical Transmittance
C21050	48059		116,377	0.00
	48060		50,400	0.00
	48061		51,494	-0.01
C21051	48422A	Print	52,868	0.04
		No Print		0.18
	48424	Print	52,977	-0.01
		No Print		-0.02
	48427	Print	50,070	-0.06
		No Print		-0.03
C21058	48064		116,377	-0.02
	48065		50,250	-0.01
	48066		50,250	0.01
C21059	48077A	Print	51,236	-0.01
		No Print		-0.03
	48078A	Print	51,121	-0.03
		No Print		0.00
	48080	Print	52,682	0.05
		No Print		-0.19

3.5 Impact

Impact testing was performed on one sample per spool according to FOTP-25. Samples were placed into the test fixture and the respective mass was dropped and change in optical transmittance was measured. A mass of 500 grams was used on the simplex cables (C21050 & C21058) and a mass of 1kg was used on the zipcord (C21051 & C21059). The data is shown in Table 3.5

Table 3.5: Impact Results

Part Number	Cable Lot Number	Channel	Number of Impacts										
			0	5	10	15	20	25	30	35	40	45	50
C21050	48059		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	48060		0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	48061		0.00	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
C21051	48422A	Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		No Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	48424	Print	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
		No Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	48427	Print	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
		No Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C21058	48064		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	48065		0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	48066		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C21059	48077A	Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		No Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	48078A	Print	0.00	0.00	0.00	-0.04	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
		No Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	48080	Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		No Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.6 Twist

Cable twist was performed on one sample per spool according to FOTP-85. A 2 meter sample was loaded into the test fixture and clamped. The sample was rotated 90 degrees clockwise then 180 degrees counter clockwise then returned to zero. This was repeated for a total of 10 cycles. The change in optical transmittance was measured before and after clamping, after 10 cycles and after the clamps were removed. The data is shown in Table 3.6; the change that was induced due to twisting has been calculated.

Table 3.6: Twist Results

Part Number	Cable Lot Number	Channel	Baseline	Post Clamping	Post 10 cycles	Change due to Twist	Post Clamp removal
C21050	48059		0.00	-0.57	-0.58	-0.01	0.18
	48060		0.00	-0.30	-0.28	0.02	0.10
	48061		0.00	-0.05	-0.05	0.00	-0.04
C21051	48422A	Print	0.00	-0.13	-0.41	-0.28	0.07
		No Print	0.00	-0.15	-0.41	-0.26	0.10
	48424	Print	0.00	-0.21	-0.19	0.02	0.00
		No Print	0.00	-0.24	-0.25	-0.01	0.00
	48427	Print	0.00	-0.16	-0.14	0.02	0.00
		No Print	0.00	-0.56	-0.53	0.03	0.00
C21058	48064		0.00	-0.55	-0.55	0.00	0.00
	48065		0.00	-0.48	-0.46	0.02	0.00
	48066		0.00	-0.47	-0.45	0.02	0.00
C21059	48077A	Print	0.00	-0.12	-0.10	0.02	-0.01
		No Print	0.00	-0.36	-0.35	0.01	0.00
	48078A	Print	0.00	-0.25	-0.23	0.02	0.00
		No Print	0.00	-0.25	-0.24	0.01	0.00
	48080	Print	0.00	-0.25	-0.23	0.02	0.01
		No Print	0.00	-0.46	-0.45	0.01	-0.09

3.7 Shrinkage versus Thermal Cycling

A 1-meter sample from each spool was placed into a thermal chamber and thermal cycled from -20°C to 105°C for a total of 5 cycles. The shrinkage (mm) was measured on an optical comparator and recorded in Table 3.7 below.

Table 3.7: Shrinkage Results

Part Number	Cable Lot Number	Channel	Shrinkage (mm)	Shrinkage (%)
C21050	48059		13.29	1.33%
	48060		12.20	1.22%
	48061		13.22	1.32%
C21051	48422A	Print	13.21	1.32%
		No Print	13.72	1.37%
	48424	Print	13.94	1.39%
		No Print	12.43	1.24%
	48427	Print	13.65	1.37%
		No Print	13.57	1.36%
C21058	48064		0.00	0.00%
	48065		0.00	0.00%
	48066		0.20	0.02%
C21059	48077A	Print	3.16	0.32%
		No Print	2.55	0.26%
	48078A	Print	13.29	1.33%
		No Print	15.30	1.53%
	48080	Print	9.34	0.93%
		No Print	4.90	0.49%

3.8 Mass per Unit Length

Cable mass per unit length was measured on one sample from each spool 1.2 meters long. The mass was recorded in grams and mass per unit length was calculated in grams per meter and kilograms per kilometer.

Table 3.8: Mass per Unit Length Results

Part Number	Cable Lot Number	Sample length	Mass	Grams / Meter	Kilograms / Kilometer
C21050	48059	1.20	7.9958	6.66	6.66
	48060	1.20	8.0039	6.67	6.67
	48061	1.20	8.0029	6.67	6.67
C21051	48422A	1.20	16.4578	13.71	13.71
	48424	1.20	16.5393	13.78	13.78
	48427	1.20	16.3808	13.65	13.65
C21058	48064	1.20	6.7697	5.64	5.64
	48065	1.20	6.6862	5.57	5.57
	48066	1.20	6.6470	5.54	5.54
C21059	48077A	1.20	13.5142	11.26	11.26
	48078A	1.20	13.4985	11.25	11.25
	48080	1.20	13.3296	11.11	11.11

4. Thermal Characteristics

4.1 Thermal Induced Attenuation

Thermal Cycling was conducted according to FOTP-03 (Temperature Cycling for Fiber Optic Cable). One sample from each spool was cut to ~100 meters. The samples were placed inside a thermal chamber and the ends of the fibers exited the porthole of the thermal chamber and were connected to a data acquisition system, which monitored attenuation at 850nm. The samples were cycled from -20°C to 105°C for 5 cycles. Each cycle had a dwell time of four hours at each extreme and at ambient. Table 4.1 shows the maximum and minimum change in attenuation for each sample. Figures 4.1a through 4.1d show the actual thermal response for the samples tested from each cable part number.

Table 4.1: Thermal Cycling Data

Part Number	Cable Lot Number	Channel	Minimum Change in Attenuation	Maximum Change in Attenuation	Permanent Change in Attenuation
C21050	48059		-0.23	2.27	0.02
	48060		-0.16	2.06	0.06
	48061		-0.17	2.16	0.02
C21051	48422A	Print	-0.16	1.86	0.06
		No Print	-0.16	2.68	0.07
	48424	Print	-0.16	2.06	0.05
		No Print	-0.20	3.48	0.09
	48427	Print	-0.20	1.74	0.04
		No Print	-0.23	2.64	0.02
C21058	48064		-0.27	0.25	-0.06
	48065		-0.25	0.15	-0.10
	48066		-0.21	0.24	-0.03
C21059	48077A	Print	-0.48	0.91	-0.10
		No Print	-0.62	1.80	-0.18
	48078A	Print	-0.35	0.80	-0.07
		No Print	-0.50	1.30	-0.14
	48080	Print	-0.33	0.90	0.04
		No Print	-0.26	0.50	-0.03

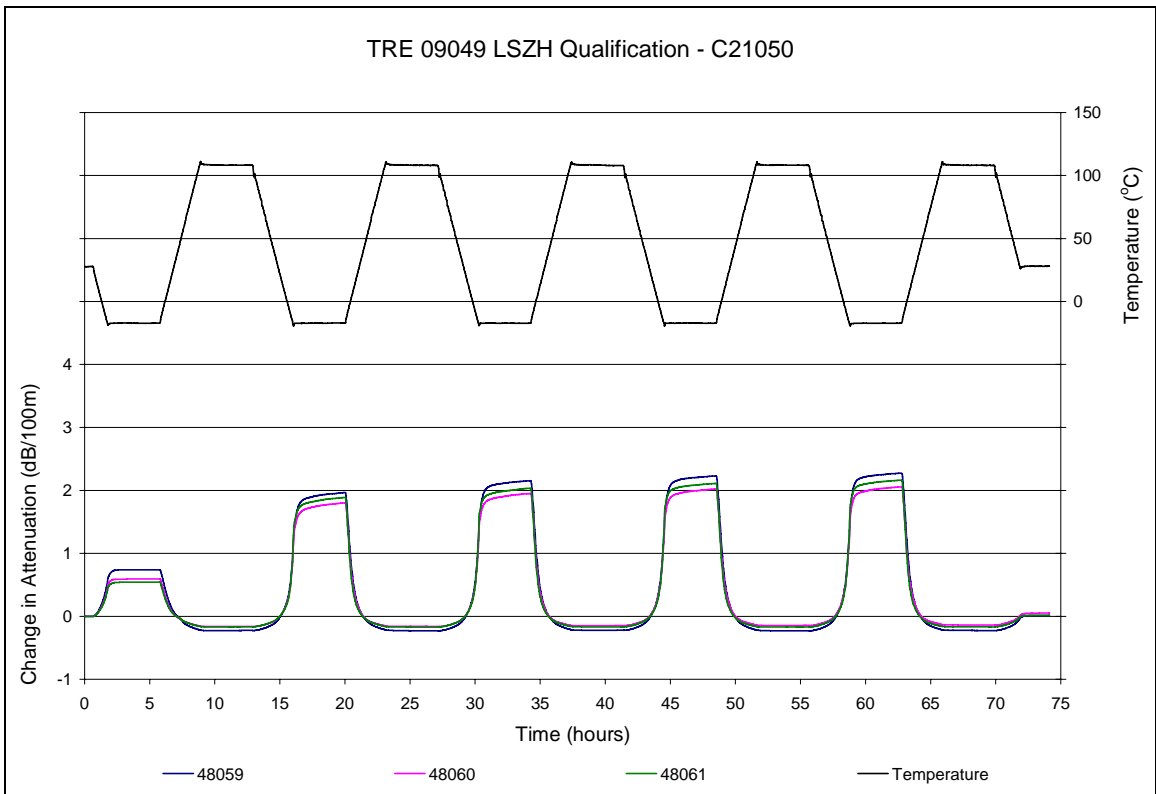


Figure 4.1a: Thermal Cycle Graph – C21050

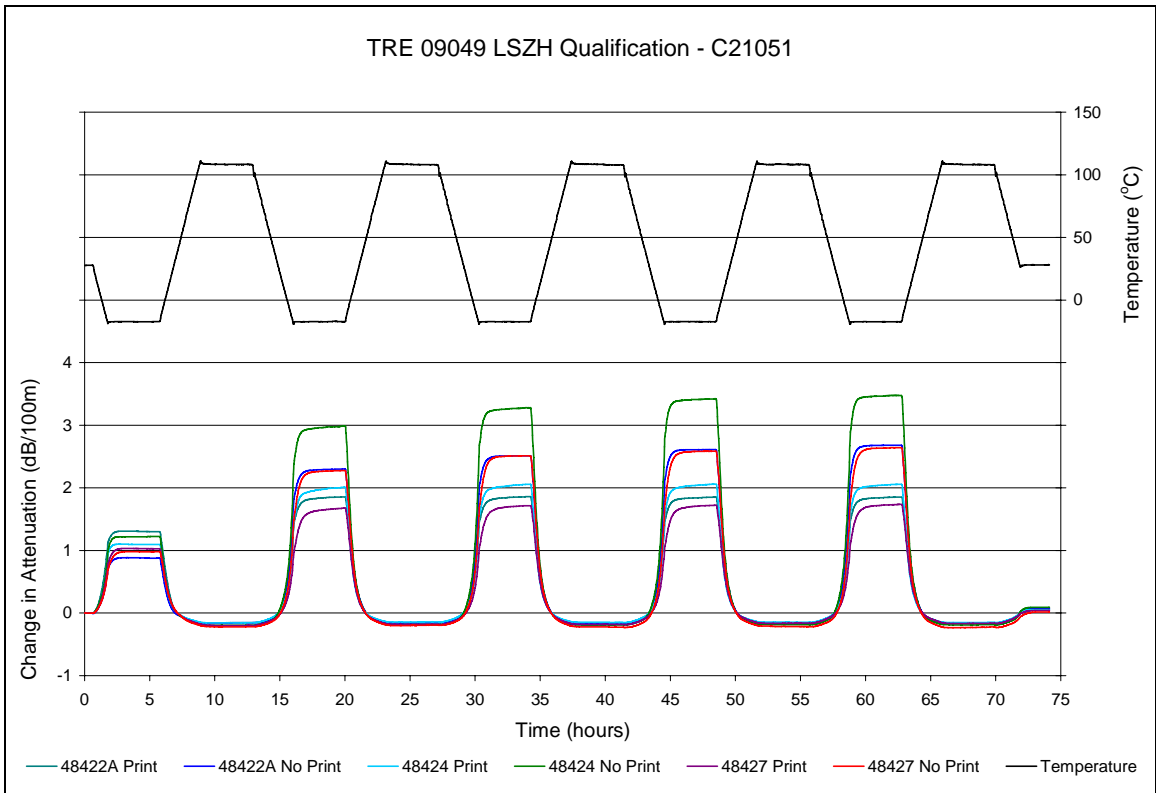


Figure 4.1b: Thermal Cycle Graph – C21051



Figure 4.1c: Thermal Cycle Graph – C21058

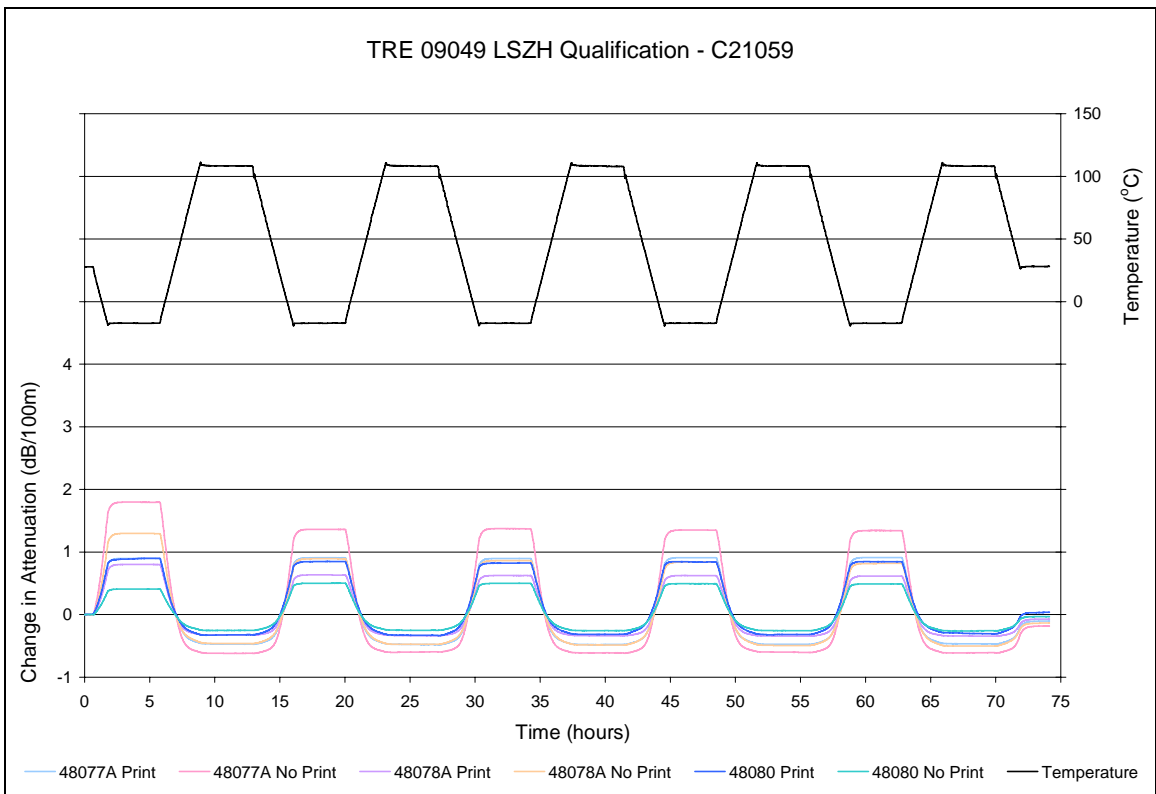


Figure 4.1d: Thermal Cycle Graph – C21059

5. Assembly Characteristics

5.1 V-Pin Assemblies

V-Pin assemblies were made using the V-Series simplex cable part number C21058. Half of the samples were put into a thermal chamber and cycled from -20°C to 80°C for 5 cycles, 2 hour dwell at each extreme. Retention testing was performed on each of the samples and the data recorded in Table 5.1.

Table 5.1: V-Pin Assembly Data

No Thermal Cycling		Thermal Cycled	
Sample #	Retention (lbs)	Sample #	Retention (lbs)
1	14.93	2	11.31
3	14.98	4	11.17
5	14.01	6	10.89
7	14.58	8	11.52
9	14.61	10	11.40
11	15.44	12	11.55
13	14.75	14	11.34
15	14.78	16	11.70
17	15.64	18	11.09
19	14.04	20	11.43
21	14.93	22	10.93
23	15.19	24	11.31
25	14.57	26	11.50
27	14.94	28	10.75
29	15.14	30	10.96
31	15.41	32	11.16
33	14.40	34	11.34
35	15.61	36	11.25
37	15.19	38	11.15
39	15.25	40	11.65
Average	14.92	Average	11.27
St Dev	0.46	St Dev	0.26
Minimum	14.01	Minimum	10.75
Maximum	15.64	Maximum	11.70

5.2 A-Series Assemblies

ST assemblies were made using the A-Series simplex cable part number C21050. Half of the samples were put into a thermal chamber and cycled from -20°C to 80°C for 5 cycles, 2 hour dwell at each extreme. Retention testing was performed on each of the samples and the data recorded in Table 5.1.

Table 5.2: A-Series Retention Data

No Thermal Cycling		Thermal Cycled	
Sample #	Retention (lbs)	Sample #	Retention (lbs)
1	26.52	2	26.48
3	30.47	4	93.67
5	70.42	6	72.25
7	28.47	8	30.23
9	27.82	10	22.53
11	41.24	12	105.96
13	61.82	14	99.32
15	35.86	16	26.76
17	25.89	18	20.50
19	84.16	20	26.48
21	24.40	22	40.88
23	48.90	24	36.04
25	35.49	26	70.27
27	57.83	28	90.39
29	80.48	30	45.11
31	34.57	32	24.43
33	34.60	34	83.32
35	30.00	36	50.93
37	68.41	38	39.96
39	72.52	40	26.99
Average	45.99	Average	51.63
St Dev	20.17	St Dev	29.30
Minimum	24.40	Minimum	20.50
Maximum	84.16	Maximum	105.96

**Phase II:
Multi-Fiber Cables**

- C21053 4-fiber 2.5 mm w/Aramid no Armor
- C21056 4-fiber 2.5 mm w/Aramid w/Aramid
- C21061 4-fiber 2.2 mm w/Aramid no Armor
- C21064 4-fiber 2.2 mm w/Aramid w/Aramid

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1. INTRODUCTION

This report is a summary of the testing completed on four (4) types of multi-fiber Low Smoke Zero Halogen (LSZH) optical cable made with 200µm HSC optical fiber:

- 1) Four (4) fiber A-Series cable, p/n C21053
- 2) Four (4) fiber A-Series cable with Dielectric Armor, p/n C21056
- 3) Four (4) fiber V-Series cable, p/n C21061
- 4) Four (4) fiber V-Series cable with Dielectric Armor, p/n C21064

The testing was performed according to the test plan outlined in Section 2.

Drawings of the optical cables tested are presented in the Appendix.

2. OPTICAL CABLE TEST PLAN

Three lots of each cable type were manufactured for testing.

<u>TEST</u>	<u>TEST SPECIFICATION</u>
• Length	OTDR
• Attenuation at 850nm	FOTP-46, Spectral 850nm
• Numerical Aperture (NA)	FOTP-177
• Temperature Cycling Effects	FOTP-3
• Impact Resistance	FOTP-25
• Tensile Loading and Bending	FOTP-33
• Compressive Loading Resistance	FOTP-41
• Fluid Penetration (Water Blocking)	FOTP-82
• Cable Twist	FOTP-85
• Cable Bend	FOTP-88
• Cable Jacket Shrinkage	CDT-16
• Cyclic Flexing	FOTP-104
• Cable Mass per Unit Length	OFS Test Procedure
• UL & CUL Riser Rating	UL1666
• IEC 60332-3	Flame Test
• IEC 60754-2	Acid Gas Test (Toxicity)
• IEC 61034-2	Smoke Emission Test

2.1 TEST SPECIMENS

Cable p/n	Cable Lot #	Blue Fiber Lot #	Orange Fiber Lot #	Green Fiber Lot #	Brown Fiber Lot #
C21053 A-Series	49300 1,605m	BD0424L	AD0429J	BD04283F	AD04233M
	49301 1,749m	AD04166E	AD04214C	AD04223G	BD04188F
	49302 1,639m	AD04175J	AD04213C	BD04284B1	AD04225G

Cable p/n	Cable Lot #	Blue Fiber Lot #	Orange Fiber Lot #	Green Fiber Lot #	Brown Fiber Lot #
C21056 A-Series Armor	50031 1,568m	AD04221N	AD04225F	BD04272H	AD04216L
	50032 1,560m	AD04215A	AD04219P	AD04205J	AD04232C
	50033 1,607m	AD04227L	AD04219F	AD04215J	AD04204K

Cable p/n	Cable Lot #	Blue Fiber Lot #	Orange Fiber Lot #	Green Fiber Lot #	Brown Fiber Lot #
C21061 V-Series	49201A 1,119m	AD04152I	AD04125G	AD04150I	AD04194J
	49202A 1,580m	BD04164I	BD04266M	AD04114L	BD04194P
	49203 977m	BD04225D	AD04227Q	AD04222P	AD04215G

Cable p/n	Cable Lot #	Blue Fiber Lot #	Orange Fiber Lot #	Green Fiber Lot #	Brown Fiber Lot #
C21064 V-Series Armor	49208 1,092m	AD04226I	AD04219C	BD04263A	BD04264J
	49209 1,177m	AD04219E	AD04219I	BD04275B	AD04219N
	49210 1,262m	AD04221K	AD04216H	AD04208B	AD04207F1

3. TEST RESULTS

3.1 Optical Properties

Each spool of cable was checked for attenuation at 850nm and NA according to FOTP-177. The results are shown in Tables 3.1a and 3.1b. A summary of the data is shown in Table 3.1c.

Table 3.1a Spectral Attenuation at 850nm

Cable Part #	Cable Lot #	Length (m)	Spectral Attenuation dB/km			
			Blue	Orange	Green	Brown
C21053	49300	1605	4.80	4.70	4.70	5.01
	49301	1749	4.54	4.68	4.43	4.53
	49302	1639	4.91	5.00	5.16	5.15
C21056	50031	1568	5.33	5.12	5.39	4.86
	50032	1560	5.87	5.66	5.93	4.62
	50033	1607	5.03	4.86	4.58	6.05
C21061	49201A	1119	6.48	5.14	5.92	7.23
	49202A	1580	4.84	6.15	6.10	5.09
	49203	977	6.00	6.53	4.96	5.57
C21064	49208	1092	5.87	9.43	8.65	7.93
	49209	1177	5.36	5.37	6.47	5.30
	49210	1262	7.67	5.52	8.55	7.54

Table 3.1b Numerical Aperture (NA)

Cable Part #	Cable Lot #	Length (m)	Numerical Aperture			
			Blue	Orange	Green	Brown
C21053	49300	1605	0.359	0.362	0.378	0.359
	49301	1749	0.361	0.365	0.365	0.359
	49302	1639	0.370	0.358	0.376	0.354
C21056	50031	1568	0.361	0.357	0.361	0.366
	50032	1560	0.359	0.361	0.367	0.363
	50033	1607	0.373	0.363	0.368	0.365
C21061	49201A	1119	0.366	0.367	0.368	0.357
	49202A	1580	0.356	0.359	0.360	0.365
	49203	977	0.360	0.360	0.378	0.358
C21064	49208	1092	0.358	0.363	0.357	0.359
	49209	1177	0.357	0.354	0.355	0.355
	49210	1262	0.367	0.366	0.356	0.365

Table 3.1c Attenuation (dB/km) & Numerical Aperture (NA) Summary

	C21053		C21056		C21061		C21064	
	Attn.	NA	Attn.	NA	Attn.	NA	Attn.	NA
Max.	5.16	0.378	6.05	0.373	7.23	0.378	9.43	0.367
Min.	4.43	0.354	4.58	0.357	4.84	0.356	5.30	0.354
Std. Dev.	0.24	0.007	0.51	0.004	0.73	0.006	1.50	0.005

3.2 Temperature Cycling

The effect of temperature cycling on the optical fiber cables was measured in accordance with EIA/TIA-455-3A, FOTP-3 “Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components”.

One, 100 meter long sample from each lot of cable was put into a thermal chamber and cycled 5 times from -20°C to +105°C. The dwell time at each temperature extreme was 4 hours and the ramp rate between temperature extremes was 40°C per minute. The change in attenuation was monitored at 850nm during the temperature cycling.

The range in maximum and minimum change in attenuation (dB/100m) for all the cables under test is shown in Table 3.2.a For each of the cables under test, the maximum change in attenuation occurred at the low temperature of the temperature cycle. A plot of Change in Attenuation vs. Time throughout the temperature cycle for each of the cables tested is shown in Figures 3.2a through 3.2d.

Table 3.2.a Change in Attenuation (dB/100m) During Temperature Cycling

	C21053	C21056	C21061	C21064
Max. Range	0.29 to 1.23	0.33 to 0.68	0.29 to 1.27	0.35 to 2.16
Min. Range	-0.16 to -0.60	-0.60 to -0.18	-0.56 to -0.24	-0.80 to -0.21

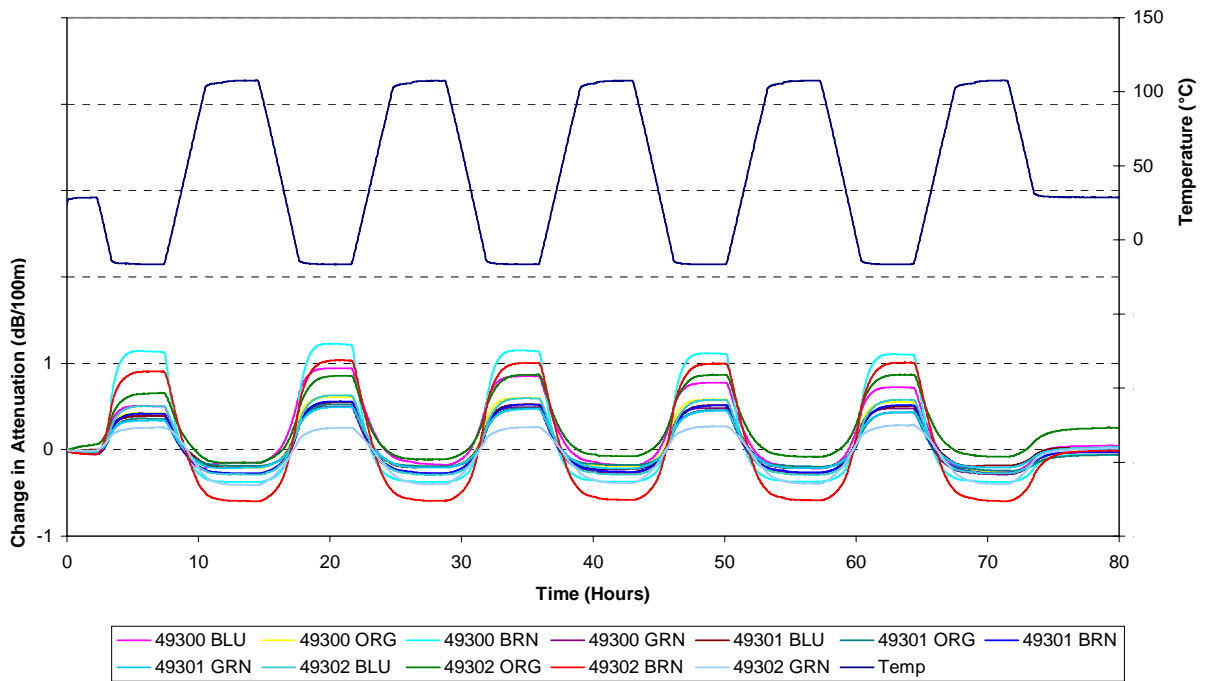


Figure 3.2a C21053, Temperature Cycling -20°C to +105°C

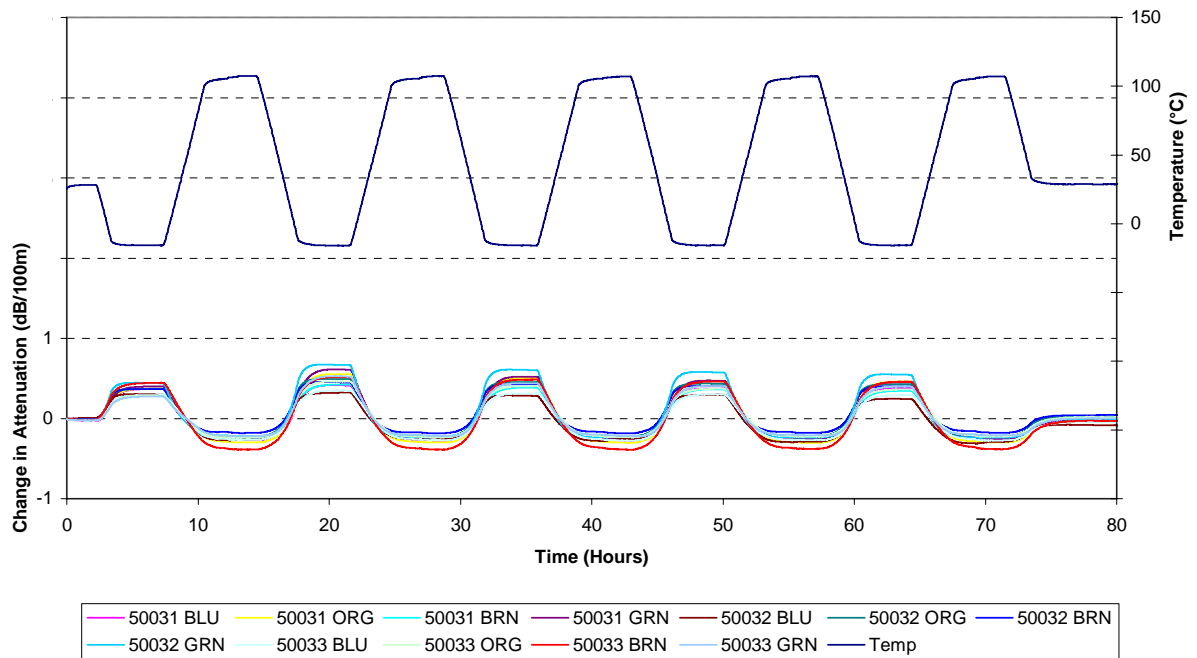


Figure 3.2b C21056, Temperature Cycling -20°C to +105°C

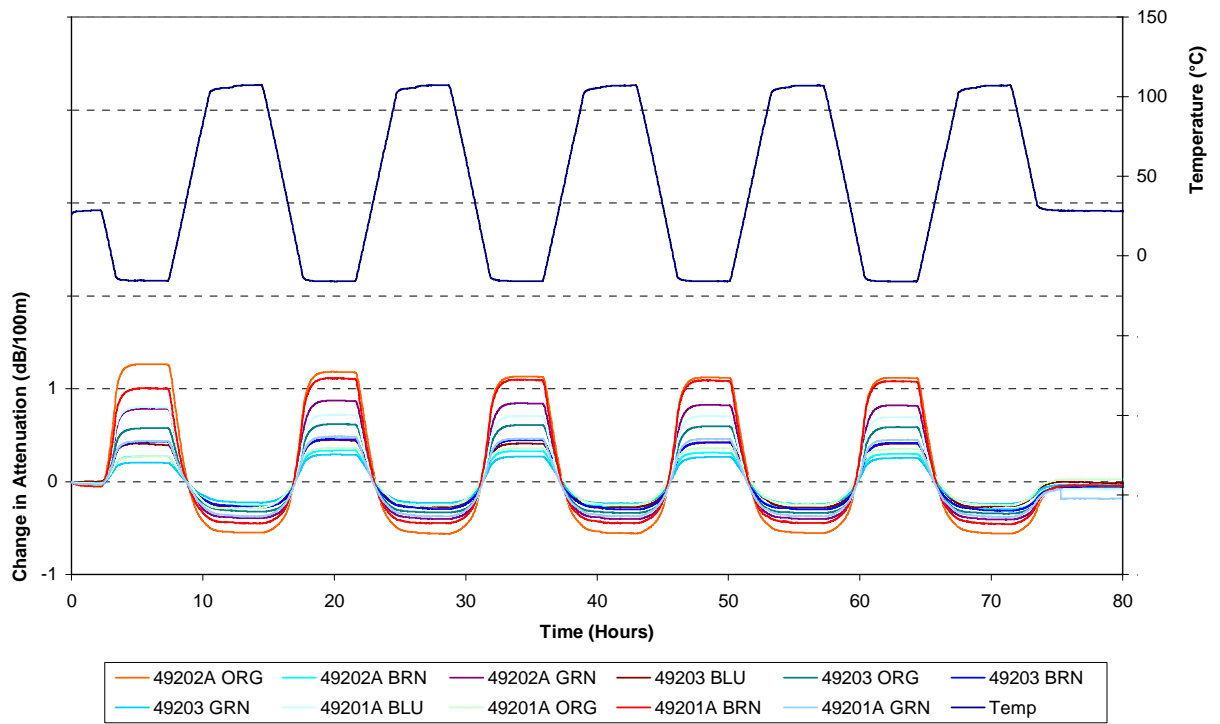


Figure 3.2c C21061, Temperature Cycling -20°C to +105°C

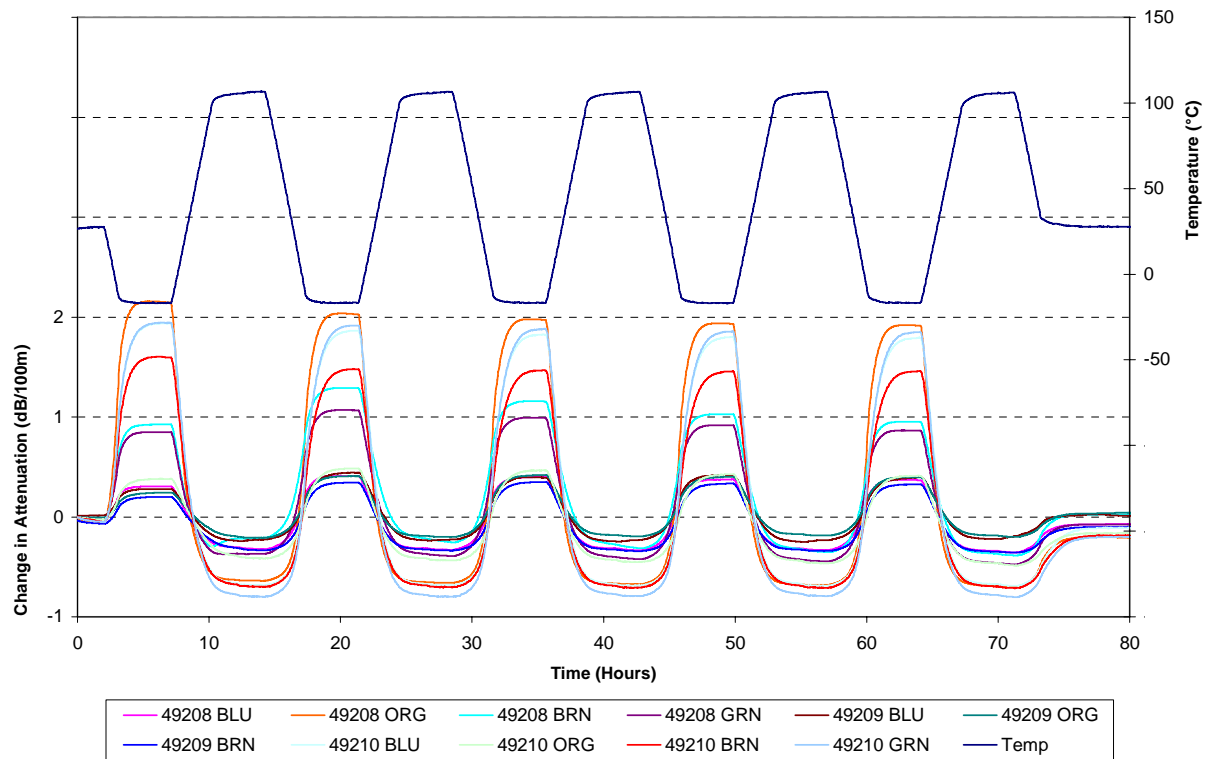


Figure 3.2d C21064, Temperature Cycling -20°C to +105°C

3.3 Impact

The resistance to impact on the optical fiber cables was measured in accordance with EIA/TIA-455-25B, FOTP-25 “Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies”.

One sample of each of the three lots of the four cable types were subjected to 20 repeated impacts of a 2.0kg mass dropped from a height of 15 cm onto the cable.

The change in attenuation (dB) after 20 impacts and 5 minutes after the conclusion of the test is shown in Table 3.3.a. No change in the outer cable jacket was observed after the test.

Table 3.3a Change in Attenuation (dB) After 20 Impacts

	C21053		C21056		C21061		C21064	
	After 20 Impacts	After 5 Minutes	After 20 Impacts	After 5 Minutes	After 20 Impacts	After 5 Minutes	After 20 Impacts	After 5 Minutes
Max.	0.22	0.21	0.95	0.93	0.66	0.72	0.52	0.52
Min.	-0.27	-0.25	-0.10	-0.54	-0.39	-0.38	-0.12	-0.12
Ave.	0.00	0.01	0.17	0.15	0.07	0.11	0.09	0.08
Std. Dev.	0.13	0.13	0.29	0.38	0.26	0.34	0.23	0.23

3.4 Tensile Loading and Bending

Tensile Loading and Bending was conducted in accordance with EIA/TIA-455-33A, FOTP-33 “Fiber Optic cable Tensile Loading and Bending Test”. One sample of each of the three lots of the four cable types was tested.

Cable C21053 was wrapped around a 63.5mm (2.5 inch) radius mandrel, loaded to 265 lbs, held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load. The cable was loaded once again to 530 lbs, held for held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load.

Cable C21056 was wrapped around a 101.6mm (4.0 inch) radius mandrel, loaded to 375 lbs, held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load. The cable was loaded once again to 750 lbs, held for held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load.

Cable C21061 was wrapped around a 63.5mm (2.5 inch) radius mandrel, loaded to 45 lbs, held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load. The cable was loaded once again to 90 lbs, held for held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load.

Cable C21064 was wrapped around a 101.6mm (4.0 inch) radius mandrel, loaded to 150 lbs, held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load. The cable was loaded once again to 300 lbs, held for held for 30 minutes and change in attenuation recorded before the load was released and the attenuation recorded at zero load.

This procedure was used to simulate the cable under going maximum installation load and minimum bend radius during installation, and then maximum operating load and minimum bend radius installed.

The results are recorded in Table 3.4a, Table 3.4b, Table 3.4c, and Table 3.4d.

Table 3.4a Change in Attenuation (dB) C21053

	265 lbs	0 lbs	530 lbs	0 lbs
Maximum	0.30	0.16	0.58	0.42
Minimum	-0.07	-0.01	0.04	-0.06
Average	0.10	0.07	0.31	0.17
Std Dev	0.09	0.06	0.15	0.13

Table 3.4b Change in Attenuation (dB) C21056

	375 lbs	0 lbs	750 lbs	0 lbs
Maximum	0.44	0.34	0.69	0.48
Minimum	-0.02	-0.19	0.15	-0.11
Average	0.13	0.06	0.32	0.15
Std Dev	0.13	0.14	0.16	0.18

Table 3.4c Change in Attenuation (dB) C21061

	45 lbs	0 lbs	90 lbs	0 lbs
Maximum	0.30	0.30	0.49	0.42
Minimum	-0.22	-0.04	-0.25	-0.26
Average	0.00	0.06	0.09	0.08
Std Dev	0.11	0.11	0.20	0.18

Table 3.4c Change in Attenuation (dB) C21064

	150 lbs	0 lbs	300 lbs	0 lbs
Maximum	0.18	0.36	0.18	0.36
Minimum	-0.08	-0.18	-0.08	-0.18
Average	0.03	0.05	0.03	-0.05
Std Dev	0.08	0.16	0.19	0.16

3.5 Compressive Loading

Resistance to compressive loading was tested in accordance with EIA/TIA-455-41A, FOTP41 “Compressive Loading Resistance of Fiber Optic Cables”.

The load was applied to a 3.94 inch plate on the cable. The load was applied in 500 lb increments up to 4,500 lbs for 2 minutes at each increment. The load was released and the final change in attenuation was recorded. One sample from each of the three lots of cable was tested for each cable type.

The results showing the maximum change in attenuation during compressive loading and the return to zero load attenuation of all the cables tested are listed in Table 3.5a,

Table 3.5b and Table 3.5c and Table 3.5d. No change in the outer cable jacket was observed after the test.

Table 3.5a Change in Attenuation (dB) C21053

	Max. Δ	0 lb. Load
Maximum	1.21	1.28
Minimum	-0.13	-0.03
Average	0.69	0.20
Stand. Dev.	0.33	0.35

Table 3.5b Change in Attenuation (dB) C21056

	Max. Δ	0 lb. Load
Maximum	1.99	0.84
Minimum	0.36	-0.27
Average	0.98	0.19
Stand. Dev.	0.48	0.32

Table 3.5c Blue Change in Attenuation (dB) C21061

	Max. Δ	0 lb. Load
Maximum	1.54	1.33
Minimum	-0.07	-0.15
Average	0.41	0.28
Stand. Dev.	0.42	0.42

Table 3.5d Change in Attenuation (dB) C21064

	Max. Δ	0 lb. Load
Maximum	0.78	0.67
Minimum	0.16	0.01
Average	0.41	0.26
Stand. Dev.	0.23	0.23

3.6 Cable Twist

The optical cable's ability to withstand twist was measured in accordance with EIA/TIA-455-85A, FOTP85 "Fiber Optic Cable Twist Test".

One sample from each of the three lots of unarmored cable, C21053 and C21061, was subjected to 10 twist cycles. Each cycle is defined as rotation 180 degrees clockwise, return to starting position. The next cycle is a rotation 180 degrees counter-clockwise and return to starting position. The change in attenuation was recorded after 10 cycles and then after 5 minutes after the test is ended. Any change in attenuation due to clamping the cable in the twist test fixture was zeroed out.

The results showing the change in attenuation after 10 twist cycles and after 5 minutes after the test is completed are listed in Table 3.7a and Table 3.7b. The length of the test specimens was 2-meters. No change in the outer cable jacket was observed after the test.

Table 3.7a Change in Attenuation (dB) C21053

	Post 10 Cycles	5 Minutes After Test
Maximum	0.31	0.32
Minimum	-0.08	-0.05
Average	0.03	0.04
Std. Dev.	0.09	0.11

Table 3.7b Change in Attenuation (dB) C21061

	Post 10 Cycles	5 Minutes After Test
Maximum	0.72	0.67
Minimum	-0.03	-0.03
Average	0.12	0.18
Std. Dev.	0.23	0.25

3.7 Cable Bend

The optical cable's ability to withstand bending under load measured in accordance with EIA/TIA-455-88, FOTP88 "Fiber Optic Cable Bend Test".

One sample from each of the three lots of unarmored cable, C21053 and C21061 was tested. An attenuation measurement was made on each sample prior to the start of the test. 12kg load was applied to the end of the cable test specimen while the cable was bent around a 127mm diameter mandrel. The load was applied to each cable under test for 60 seconds and the change in attenuation from the unloaded condition was recorded. The load was then removed and after 60 seconds the change in attenuation from the start of the test was recorded.

The results showing the change in attenuation under load and after the load is removed are listed in Table 3.7a and Table 3.7b. No change in the outer cable jacket was observed after the test.

Table 3.7a Change in Attenuation (dB) C21053

	12kg Load, 127mm Diameter	0 kg Load
Maximum	0.08	0.28

Minimum	-0.14	-0.37
Average	-0.01	-0.03
Std. Dev.	0.05	0.15

Table 3.7b Change in Attenuation (dB) C21061

	12kg Load, 127mm Diameter	0 kg Load
Maximum	0.10	0.10
Minimum	-0.51	-0.11
Average	-0.04	-0.01
Std. Dev.	0.15	0.07

3.8 Jacket Shrinkage

Jacket shrinkage vs. thermal cycling was conducted according to FOTP-03 (Temperature Cycling for Fiber Optic Cable) and CDT-16 (Shrinkage Test).

One sample from each of the three lots of unarmored cable, C21053 and C21061 was tested. The samples were cut to 1-meter lengths and placed inside a thermal chamber and cycled -20°C to $+105^{\circ}\text{C}$ for a total of 5 cycles with a 4-hour dwell at each extreme. The samples were removed from the chamber and the ends were measured again.

The jacket shrinkage from each end of the sample, relative to the central strength member, was measured and the total % shrinkage calculated. The results are shown in Tables 3.8a and 3.8b.

Table 3.8a Percent Shrinkage (%) C21053

	% Shrinkage
Maximum	0.79
Minimum	0.53
Average	0.67
Std. Dev.	0.00

Table 3.8b Percent Shrinkage (%) C21061

	% Shrinkage
Maximum	1.04
Minimum	0.34
Average	0.60
Std. Dev.	0.00

3.9 Cyclic Flexing

The ability of the cable to withstand cyclic flexing while under load was measured in accordance with EIA/TIA-455-104A, FOTP104 “Fiber Optic Cyclic Flexing Test”.

One sample from each of the three lots of unarmored cable, C21053 and C21061 was tested. The samples were flexed for a minimum of 10,000 flexes over 4 inch diameter sheaves at an average rate of 30 cycles per minute. A cycle is defined as follows: start at zero, bend 90 degrees clockwise, 180 degrees counter clockwise and 90 degrees clockwise. The attenuation was measured at the beginning and end of the test.

The change in attenuation is shown in Table 3.9a and Table 3.9b. A 5.0kg load applied to C21053 and C21061 during the cyclic flexing test. Both cables showed cracks and slits after 1,000 cycles.

Table 3.9a Change in Attenuation (dB) C21053

	Post 10k Cycles
Maximum	0.56
Minimum	0.01
Average	0.19
Std. Dev.	0.26

Table 3.9b Change in Attenuation (dB) C21061

	Post 10k Cycles
Maximum	0.85
Minimum	-0.38
Average	0.19
Std. Dev.	0.34

3.10 Cable Mass per Unit Length

The weight (kg/km) of each cable construction, C21053, C21056, C21061, and C21064 was determined by measuring the weight of a 1 meter length of cable. The results were converted to a mass per km value. One sample from each of three lots of each cable design was measured. The results are shown in Tables 3.10a, 3.10b, 3.10c and 3.10d.

Table 3.10a C21053 Mass per Unit Length

	kg/km
Maximum	62.80
Minimum	62.20
Average	62.53
Stand. Dev.	0.31

Table 3.10b C21056 Mass per Unit Length

	kg/km
Maximum	93.00
Minimum	92.20
Average	92.67
Stand. Dev.	0.42

Table 3.10c C21061 Mass per Unit Length

	kg/km
Maximum	66.20
Minimum	66.00
Average	66.07
Stand. Dev.	0.12

Table 3.10d C21064 Mass per Unit Length

	kg/km
Maximum	96.00
Minimum	95.20
Average	95.67
Stand. Dev.	0.42

3.11 IEC Flame, Smoke and Acid Gas Emission

The multi fiber LSZH cable part number C21064 has been tested by UL and shown to pass IEC 60332-3-24 Vertical Flame Spread, IEC 61034-2 Smoke Density of Burning Cables, IEC 60754-1 & -2 Test of Halogen Acid Content and Degree of Acidity of Gases Evolved During Combustion. Passage of C21064 provides passage by similarity of construction to C21053, C21056, and C21061.

A listing with cable description indicating passage of these tests has been added to OFS's Underwriter's Laboratories file E96635.

The only surface marking that is applied to the cables is "IEC 60332-3" which shows compliance to the flame test. There is no marking available from UL to show compliance to the smoke and toxic acid gas emissions.

3.12 UL and CUL Riser Rating

The multi fiber LSZH cable part numbers C21053, C21056, C21061, and C21064 have been tested by UL and shown to pass the requirements of UL and CUL Type OFNR.

A listing with cable description indicating passage of the OFNR (Riser Rating) test has been added to OFS's Underwriter's Laboratories file E96635.

Appendix I

	89012X0				
MATERIALS:			REVISIONS		
COMPONENT	MATERIAL DESCRIPTION		REV	DATE	BY
FIBER	HCP-M0200T		INITIAL RELEASE	5/09	S.D
STRENGTH ELEMENT	ARAMID YARN WATER BLOCKING		A	02/09-328	S.D
SUBUNIT JACKET	LOW SMOKE ZERO HALOGEN (LSZH)				
SUBUNIT COLORS	BLUE, ORANGE, GREEN, BROWN				
CENTRAL STRENGTH MEMBER	E-GLASS WATER BLOCKING				
TAPE WRAP	WATER BLOCKING BINDER				
RIPCORD	COATED ARAMID CORD				
OUTER JACKET	BLACK UV RESISTANT LOW SMOKE ZERO HALOGEN (LSZH)				

GEOMETRICS:	
SUBUNIT JACKET: OD: 25 ± 0.2 mm	
STRAND LAY: LEFT HAND	
CENTRAL MEMBER: OD: 10mm NOMINAL	
OUTER JACKET: OD: 60 ± 0.4 mm	

ATTENUATION ≤ 8dB/KM AT 850nm BY OTDR OR CUTBACK

JACKET PRINTING: (WHITE INK)
 DFS (3*) www.SpectraLyPhotonics.com (3*) P/N C21053 (3*) HCS@ LSZH OPTICAL CABLE (3*) E90835 (2*) c(ULUS (2*) OFNR RISER (2*) IEC 60332-3 (3*) LOT NO.XXXXXX

* INDICATES NUMBER OF SPACES BETWEEN CHARACTERS.

SPOOL TYPE: UP TO 1.0km: 24" X 14" X 12" WOOD REEL
 1.0km to 2.4km: 30" X 17" X 10" WOOD REEL

CABLE SPECIFICATIONS:

MAX. INSTALLATION LOAD: 2350 N (530 LBS)
 MAX. OPERATING TENSILE LOAD: 1179 N (265 LBS)
 MIN. BEND RADIUS UNDER LOAD: 120mm (4.7 ft)
 MIN. BEND RADIUS UNLOADED: 80mm (3.1 ft)
 CABLE WEIGHT: 45.0 kg/Km (30.2 lb/1000ft)
 OPERATING & STORAGE TEMPERATURE: -20°C TO +105°C
 WATER BLOCKED PER EIA/TIA-455-828, FOTP-92

DO NOT SCALE	LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ±1/64 ±.01 ±.020 ±1°	CX HCP-M0200T-A04ZB 4-FIBER LSZH CABLE CUSTOMER PRINT
MATERIAL	DFS A FURUKAWA COMPANY 55 Dorring Drive, Avon, Connecticut 06001
DRAWN BY: SD DATE: 5/28/10 CHECKED BY: DATE:	APPROVED BY: DATE: 5/28/10 DATE:
APPLICATION: FINISH	SCALE: N/A DATE:
NEXT APP'Y: USED ON:	B Cx21053 PK: A SHEET 1 OF 1

DFS
PROPRIETARY

APPLICATION: FINISH

Appendix I (cont.)

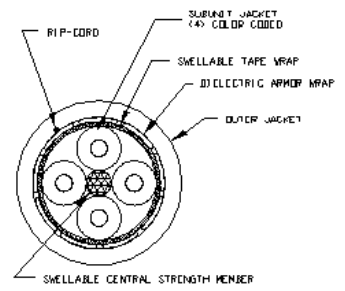
19012X3	8		REVISIONS																												
MATERIALS: <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width:20%;">COMPONENT</th> <th style="width:80%;">MATERIAL DESCRIPTION</th> </tr> </thead> <tbody> <tr> <td>FIBER</td> <td>HCP-M0200T</td> </tr> <tr> <td>SUBUNIT JACKET</td> <td>LOW SMOKE ZERO HALOGEN (LSZH)</td> </tr> <tr> <td>SUBUNIT COLOPS</td> <td>BLUE, ORANGE, GREEN, BROWN</td> </tr> <tr> <td>CENTRAL STRENGTH MEMBER</td> <td>E-GLASS WATER BLOCKING</td> </tr> <tr> <td>TAPE WRAP</td> <td>WATER BLOCKING BINDER</td> </tr> <tr> <td>RIPCORD</td> <td>COATED ARAMID CORD</td> </tr> <tr> <td>OUTER JACKET</td> <td>BLACK UV RESISTANT LOW SMOKE ZERO HALOGEN (LSZH)</td> </tr> </tbody> </table>		COMPONENT	MATERIAL DESCRIPTION	FIBER	HCP-M0200T	SUBUNIT JACKET	LOW SMOKE ZERO HALOGEN (LSZH)	SUBUNIT COLOPS	BLUE, ORANGE, GREEN, BROWN	CENTRAL STRENGTH MEMBER	E-GLASS WATER BLOCKING	TAPE WRAP	WATER BLOCKING BINDER	RIPCORD	COATED ARAMID CORD	OUTER JACKET	BLACK UV RESISTANT LOW SMOKE ZERO HALOGEN (LSZH)	<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width:10%;">REV</th> <th style="width:60%;">DESCRIPTION</th> <th style="width:15%;">DATE</th> <th style="width:15%;">BY</th> </tr> </thead> <tbody> <tr> <td></td> <td>INITIAL RELEASE</td> <td>5/09</td> <td>SD</td> </tr> <tr> <td>A</td> <td>CR2010-21</td> <td>1/10</td> <td>SD</td> </tr> </tbody> </table>		REV	DESCRIPTION	DATE	BY		INITIAL RELEASE	5/09	SD	A	CR2010-21	1/10	SD
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	INITIAL RELEASE	5/09	SD																												
A	CR2010-21	1/10	SD																												
GEOMETRIES: SUB UNIT JACKET: OD: 2.2 ± 0.15 mm CENTRAL MEMBER: .040" NOMINAL STRAND LAY: LEFT OUTER JACKET: OD: 6.0 ± 0.4 mm		<div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="border: 1px solid black; padding: 2px;"> COLOR ORIENTATION BLUE ORANGE GREEN BROWN </div> <div style="border: 1px solid black; padding: 2px;"> (4) SUB UNITS COLOR CODED </div> </div>																													
ATTENUATION: ≤ 10 dB/km AT 850nm BY OTDR OR CUTBACK																															
JACKET PRINTING: (WHITE INK) OFS (3") www.SpecialtyPhotonics.com (3") P/N C21061 (3") HCS® V-SYSTEM® LSZH OPTICAL CABLE (3") E96635 (2") c(L)US (2") OFNR RISER (2") IEC 60332-3 (3") LOT NO.XXXXX		CABLE SPECIFICATIONS: MAX. INSTALLATION TENSILE LOAD: 400 N (90 LBS) MAX. OPERATING TENSILE LOAD: 200 N (45 LBS) MIN. BEND RADIUS UNDER LOAD: 120 mm (4.7 IN) MIN. BEND RADIUS UNLOADED: 80 mm (3.1 IN) CABLE WEIGHT: 50 kg/km (22.6 lb/1000ft) OPERATING & STORAGE TEMPERATURE: -20°C TO +105°C WATER BLOCKED: PER EIA/TIA-455-828, F01P-82																													
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			FINISH	SCALE: 1:1																											

Appendix I (cont.)

REVISIONS		
REV	DATE	BY
B	1/1/0	SD

MATERIALS:	
COMPONENT	MATERIAL DESCRIPTION
FIBER	HCP-M0200T
SUBUNIT JACKET	LOW SMOKE ZERO HALOGEN (LSZH)
SUBUNIT COLORS	BLUE, ORANGE, GREEN, BROWN
CENTRAL STRENGTH MEMBER	E-GLASS WATER BLOCKING
TAPE WRAP	WATER BLOCKING BINDER
GLASS WRAP	RODENT DETERRENT
RIPCORD	COATED ARAMID CORD
OUTER JACKET	BLACK UV RESISTANT LOW SMOKE ZERO HALOGEN (LSZH)

COLOR ORIENTATION
 BLUE
 ORANGE
 GREEN
 BROWN



GEOMETRIES:
 SUBUNIT JACKET: OD 2.2 ± 0.15 mm
 CENTRAL MEMBER: OD: .040" NOMINAL
 STRAND LAY: LEFT HAND
 OUTER JACKET: OD: 9.5mm ± 0.4mm

ATTENUATION: ≤ 10 dB/km AT 850nm BY OTDR OR CUTBACK

CABLE IS DESIGNED FOR SMALL RODENT DETERRENCE AND INDOOR/OUTDOOR INSTALLATIONS.

CABLE SPECIFICATIONS:
 MAX. INSTALLATION LOAD: 1790 N (400 LBS)
 MAX. OPERATING TENSILE LOAD: 890 N (200 LBS)
 MIN. BEND RADIUS UNDER LOAD: 143mm (5.6 in)
 MIN. BEND RADIUS UNLOADED: 95mm (3.7 in)
 CABLE WEIGHT: 65 kg/km (41.7 lb/k-ft)
 OPERATING & STORAGE TEMPERATURE: -20°C TO +105°C
 WATER BLOCKED PER EIA/TIA-455-828, F01P-82

JACKET PRINTING: (WHITE INK)
 QFS (3*) www.SpeedByPhotonics.com (3*) P/N C21064 (3*) HCS (3*) V-SYSTEM (3*) LSZH OPTICAL CABLE (3*) E90635 (2*) (UL)US (2*) OFNR RISER (2*) IEC 60332-3 (3*) LOT NO. XXXXX

* INDICATES NUMBER OF SPACES BETWEEN CHARACTERS.

SPOOL TYPE: UP TO 800m: 24" x 14" x 12" WOOD REEL
 800m TO 1.7km: 30" x 17" x 10" WOOD REEL
 1.7km TO 3.3km: 40" x 24" x 24" WOOD REEL

OFS
 PROPRIETARY

DO NOT SCALE		REV	NO	MATERIAL	DESCRIPTION
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		LIST OF MATERIAL			
FRACTIONS	DECIMALS	C21064			
21/64	± .01 ± .005 ± .1"	HCP-M0200T-V04ZB-OUTDOOR CABLE			
TOLERANCES ARE AS SHOWN		DIELECTRIC ARMOR			
		4-FIBER LSZH CABLE			
		CUSTOMER PRINT			
MATERIAL		DATE	DATE	DATE	DATE
		5/28/10	5/28/10		
FINISH		DATE	DATE	DATE	DATE
APPLICATION		SCALE	NONE	DATE	DATE
		REV	B	REV	B
		DATE	1/1/0	DATE	1/1/0
		BY	SD	BY	SD
		SCALE	1	SCALE	1