

Fiber Optic Cable Assemblies for Space Flight

Thermal and Radiation Effects

Melanie Ott,

Technology Validation Assurance Group,

Swales Aerospace / Goddard Space Flight Center

January 14, 1998

Photonics Page	Previous Slide	Next Slide

Outline

- Justification
- Goals
- Applications
- Terminology
- Lessons Learned
- Radiation effects on optical fiber
- Testing Results:
 - Cable Shrinkage
 - Radiation Effects
- Conclusion

Photonics Page	Previous Slide	Next Slide

Justification

- Corning fiber 100/140 discontinued.
- SMA connectors non repeatable performance, discontinued.
- Research and Development being driven by telecommunications.
- Push for COTS parts for projects to cost cut.

Photonics Page	Previous Slide	Next Slide

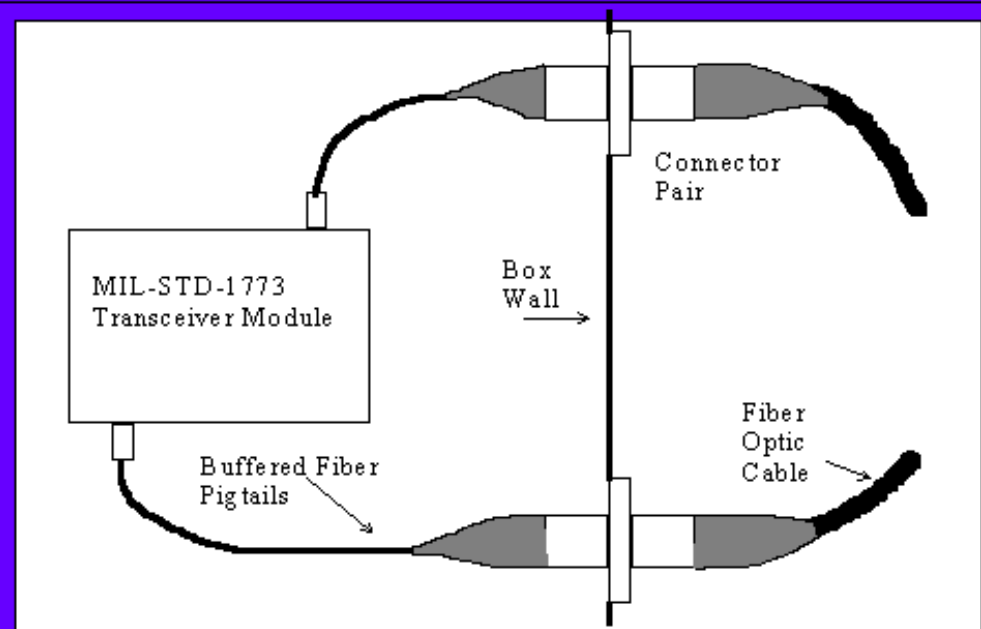
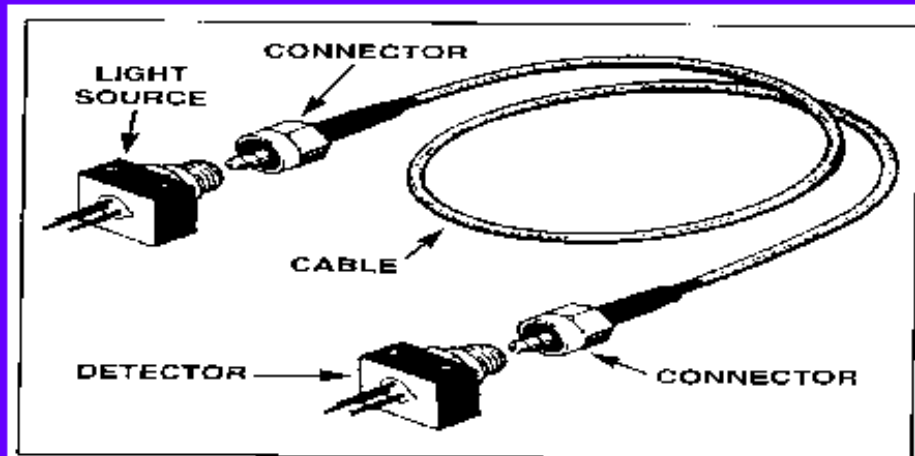
Goals

- NASA wide use.
- Multimode and singlemode applications.
- Cable assembly using Commercial-Off-the-Shelf Technology (COTS).
- Sharing available data.
- Partnerships with vendors.
- Wide variety of products with parameters for usage.

Photonics Page	Previous Slide	Next Slide

Applications

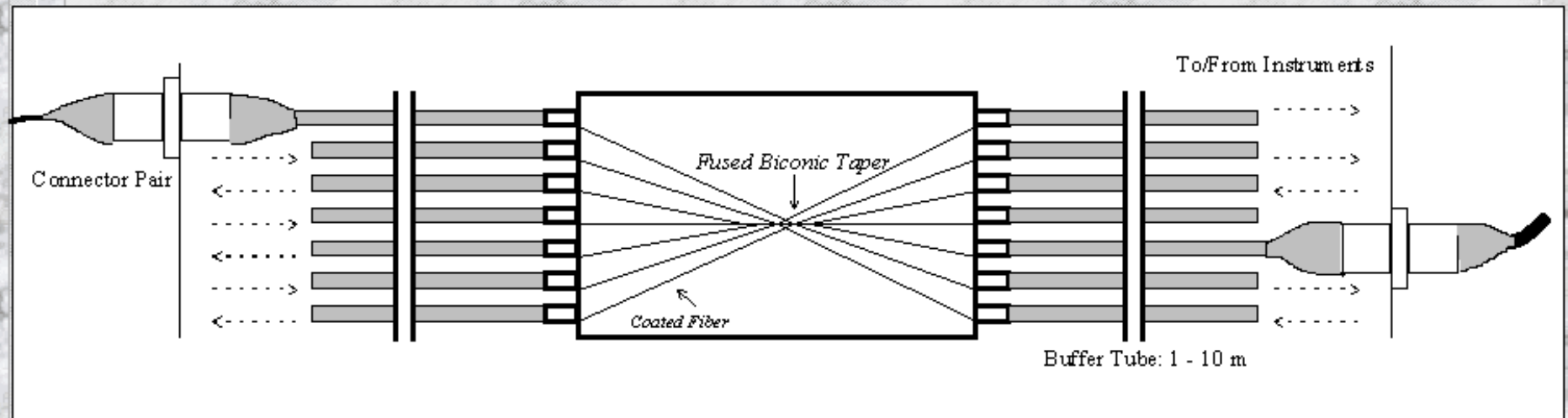
- Point-to-Point Spacecraft (> 10 meters)
- Sub-Box Jumpers (@ 0.5 m)



Photonics Page	Previous Slide	Next Slide

Applications

- Extra Vehicular Harness
- Singlemode and Multimode

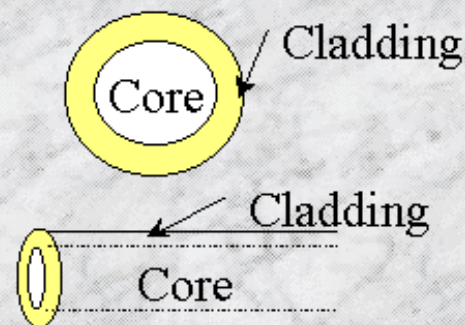
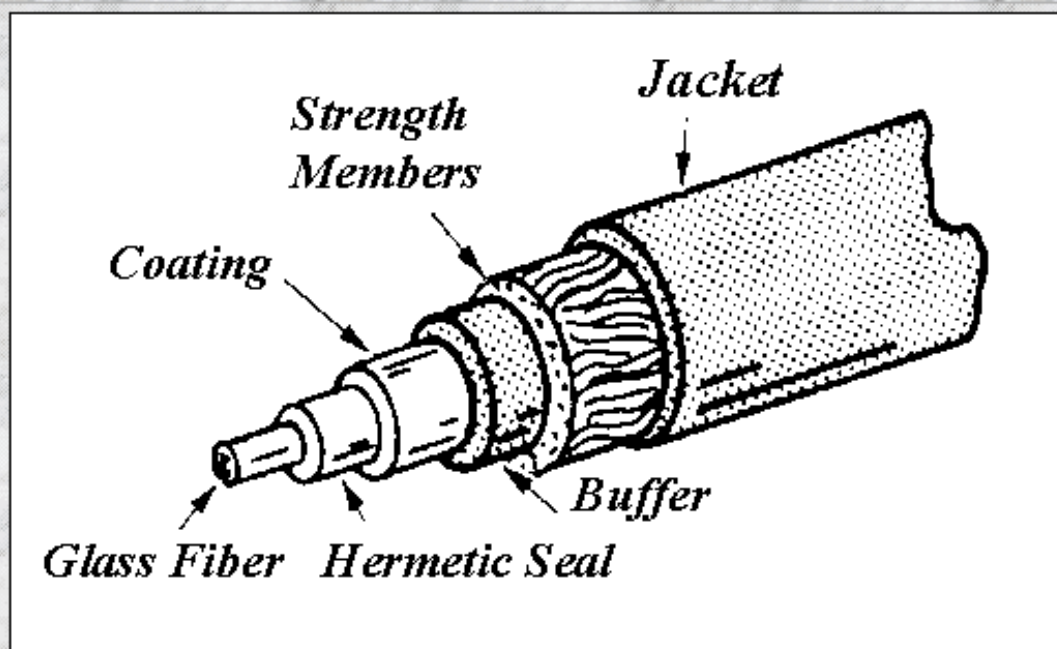


- Couplers
 - coated fiber inside coupler
 - external packaging

Photonics Page	Previous Slide	Next Slide

Terminology of Cable

- Glass Fiber
 - core and cladding
- Hermetic Seal layer
- Coating
- Buffer
 - loose tube, tight tube
- Strength Members
- Jacket



Photonics Page	Previous Slide	Next Slide

Lessons Learned

- Shrinkage of Fluoropolymers: Teflon & Tefzel (TFE, ETFE, PFA, FEP) - causes optical losses.
- Hygroscopic Behavior of Kevlar.
- Strippability of Polyimide Coating.
- Processing Control of Acrylate Material (affect on stripping).
- Outgassing of Acrylate Fiber Coating.
- Contacting Fiber Connection : Pull-Proof.
- Dimensional Compatibilities.
- Hermetic Coating Fabrication.

Photonics Page	Previous Slide	Next Slide

Optical Fiber Behavior in Radiation Environment

- ◆ Attenuation

- mechanism, peak in UV w/ tails extending to IR.
- Transient
- Permanent
- Dependent on many parameters

- ◆ Saturation

- ◆ Recovery

- ◆ Photobleaching

Why focus on these behaviors?

Attenuation is a significant parameter in communications applications.

Photonics Page	Previous Slide	Next Slide

Parameters that Affect Attenuation and Recovery of Optical Fiber

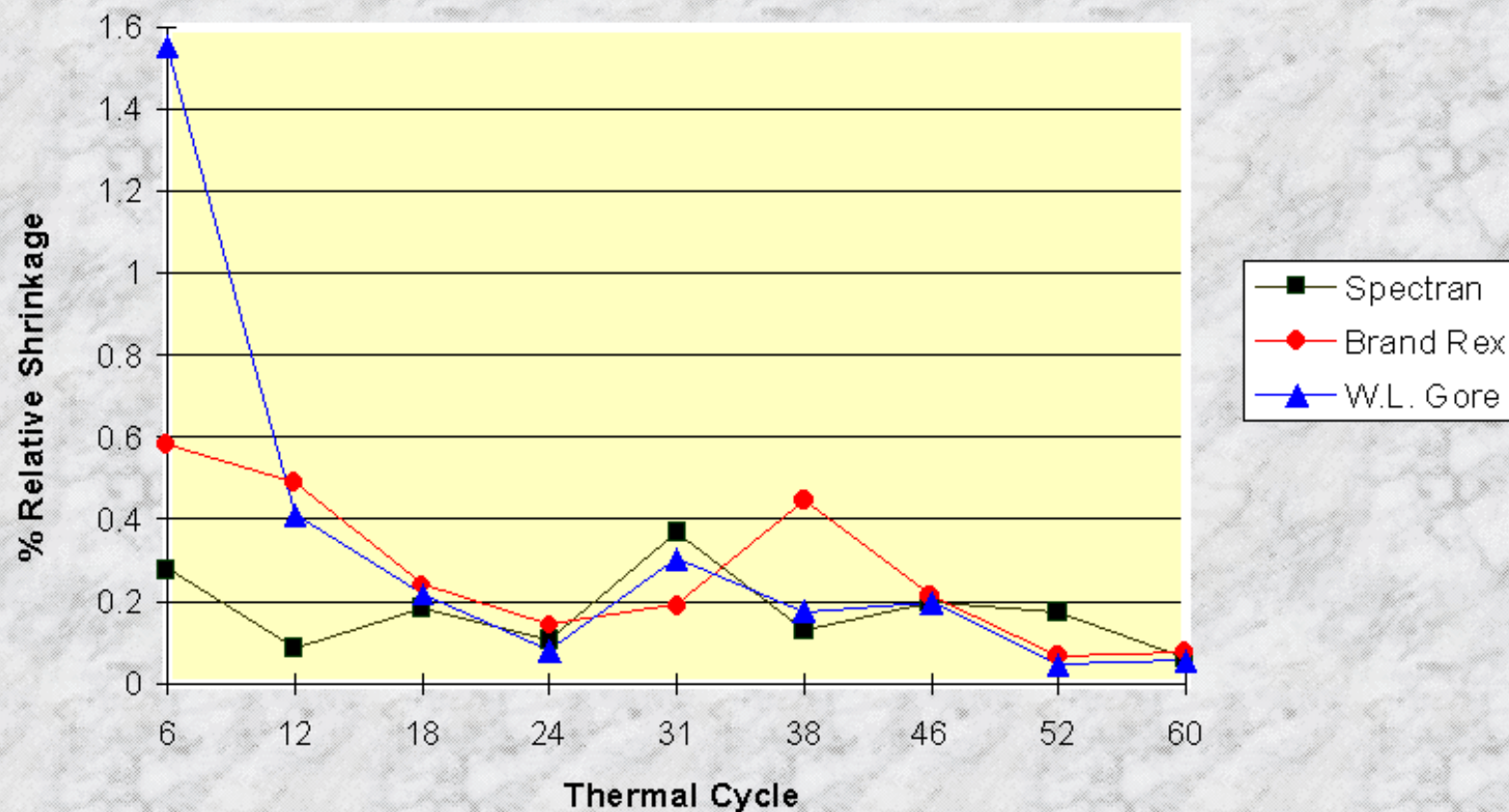
- Operating Wavelength
- Materials used as dopants
- Fabrication procedure
- Fiber Coating Materials
- Temperature of Operation
- Dose Rate
- Total Dose

Photonics Page	Previous Slide	Next Slide

Testing: Cable Component Shrinkage from Temperature Cycling

-30 to 140 degrees C, 1 degree C/min, 5 min dwell at extremes

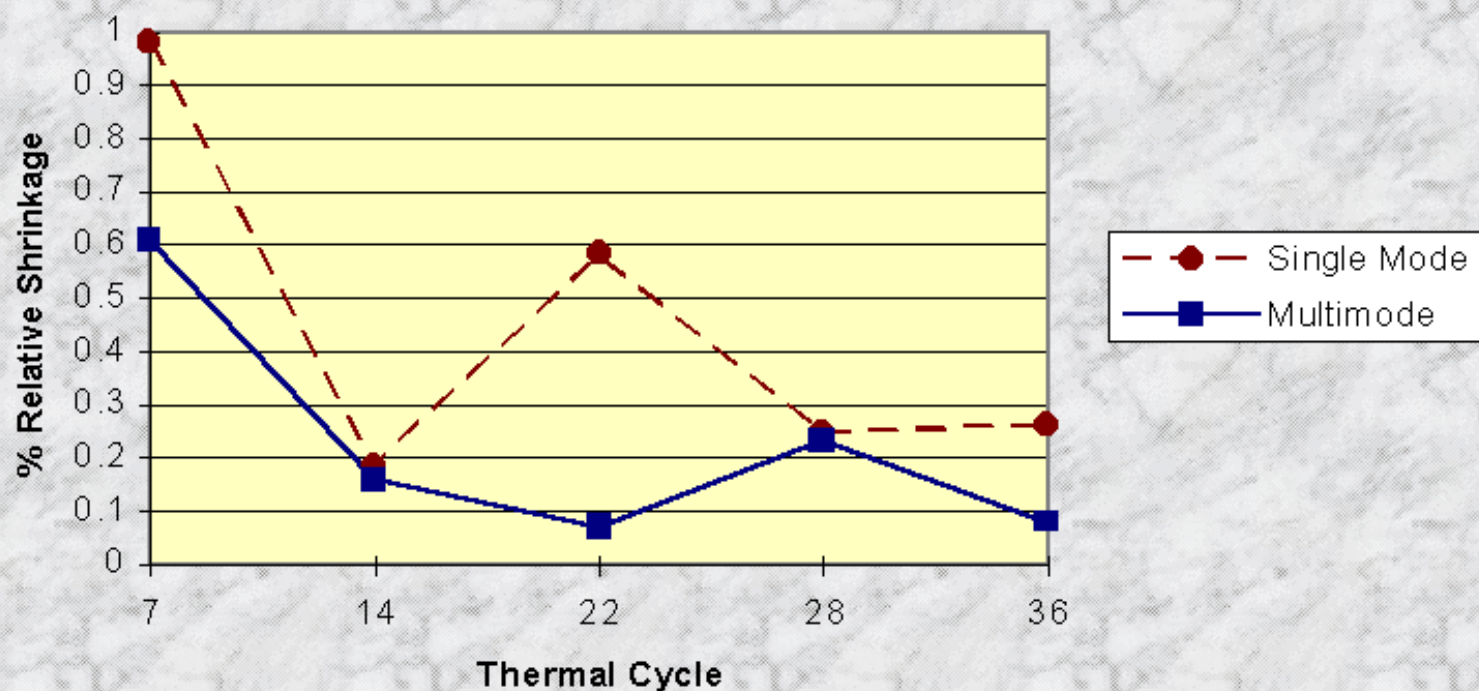
Cable Component Shrinkage vs. Thermal Cycle



Photonics Page	Previous Slide	Next Slide

Shrinkage Behavior of Northern Lights Hytel Coated Optical Fiber Cable,
001-HY-MC-62CFD (Multimode), 001-HY-MC-10C (Single Mode)
Due to Thermal Cycling

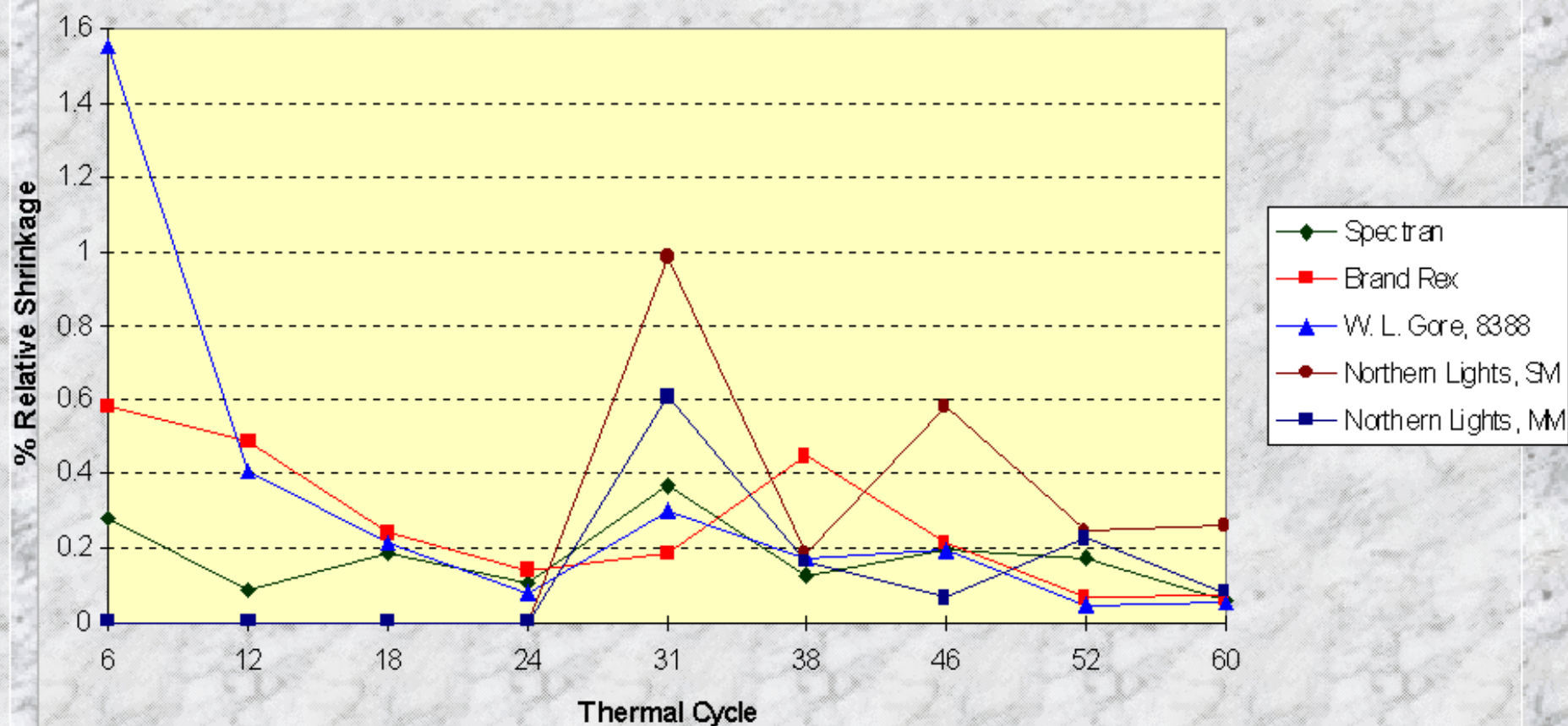
**Cable Component Shrinkage of Northern Lights Hytel
Jacketed Optical Fiber Cable**



Photonics Page	Previous Slide	Next Slide

Shrinkage Results of All Cables Tested

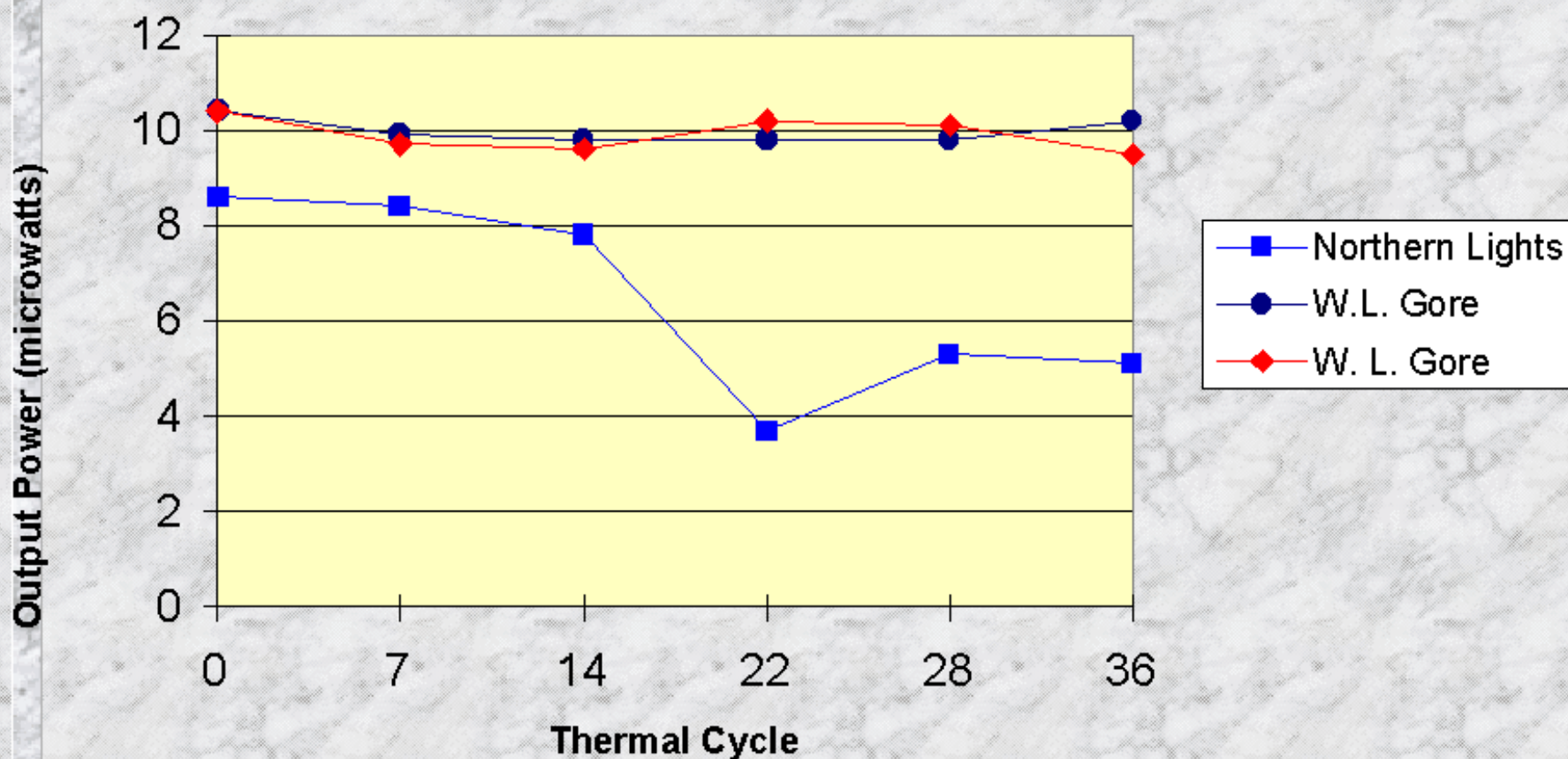
% Relative Shrinkage for All Cable Components vs. Thermal Cycles



Photonics Page	Previous Slide	Next Slide

Optical Testing for Shrinkage

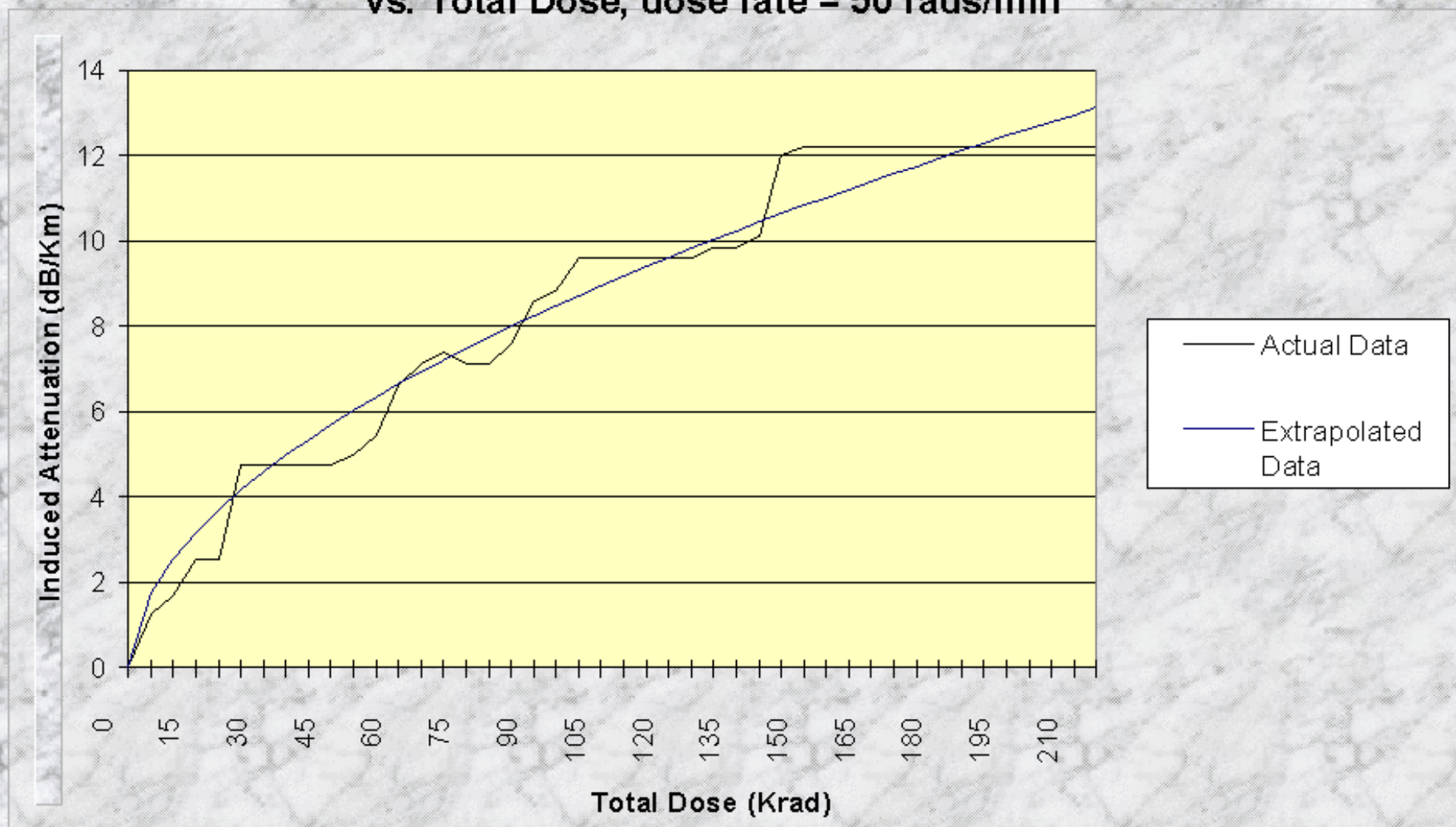
Optical Power Output After Thermal Cycling of Northern Lights Hytrel Cable and W.L. Gore FON 1008



Photonics Page	Previous Slide	Next Slide

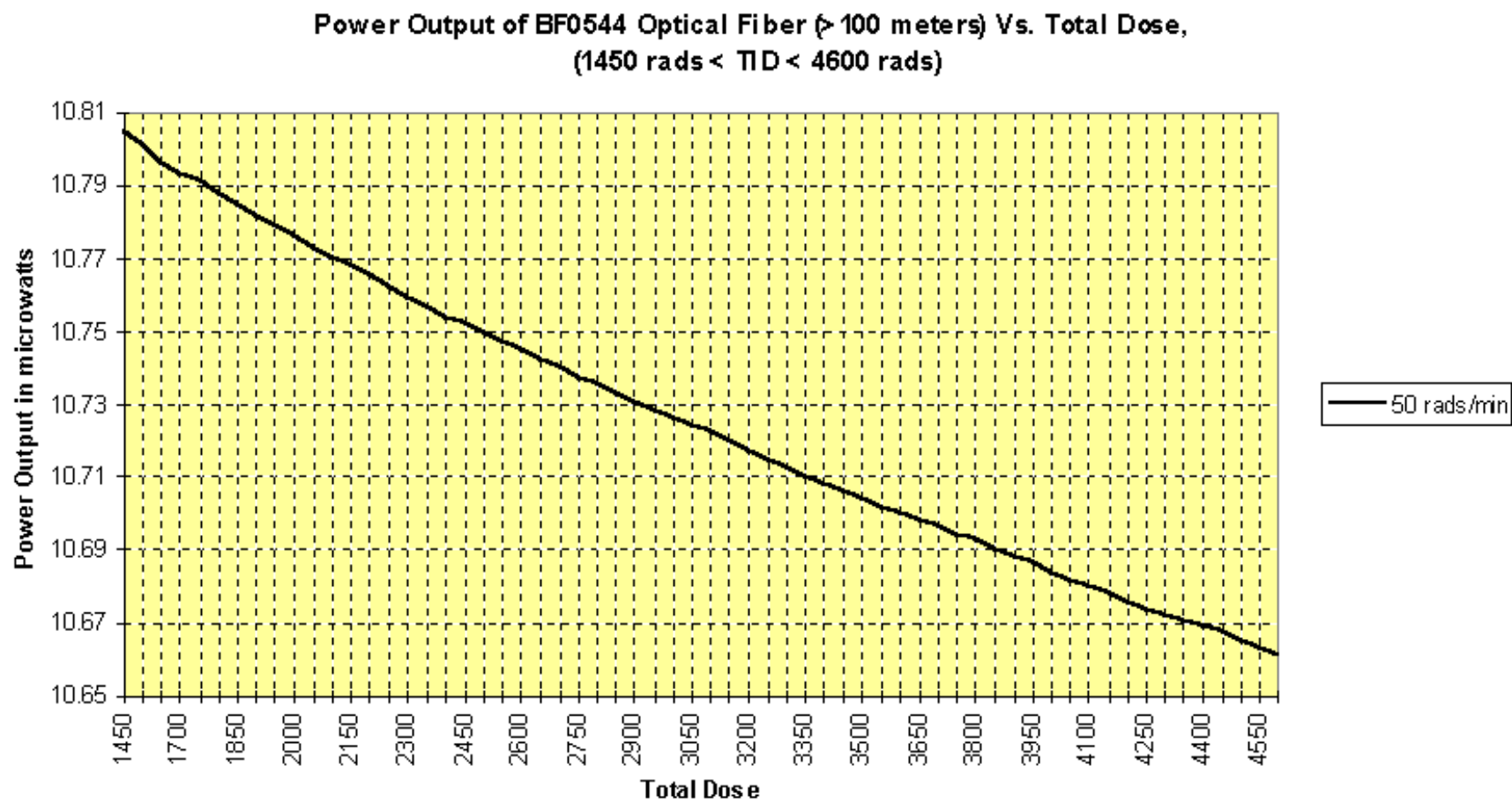
Testing: Radiation Effect on Attenuation of Spectran Hermetic Acrylate
Rad Hard Fiber, BF0544, 0 to 215 Krad dose rate = 50 rads/min

**Induced Attenuation and Extrapolated Induced Attenuation for Spectran
BF0544 Acrylate Hermetic 100/140 Graded Index Multimode Fiber
vs. Total Dose, dose rate = 50 rads/min**



Photonics Page	Previous Slide	Next Slide

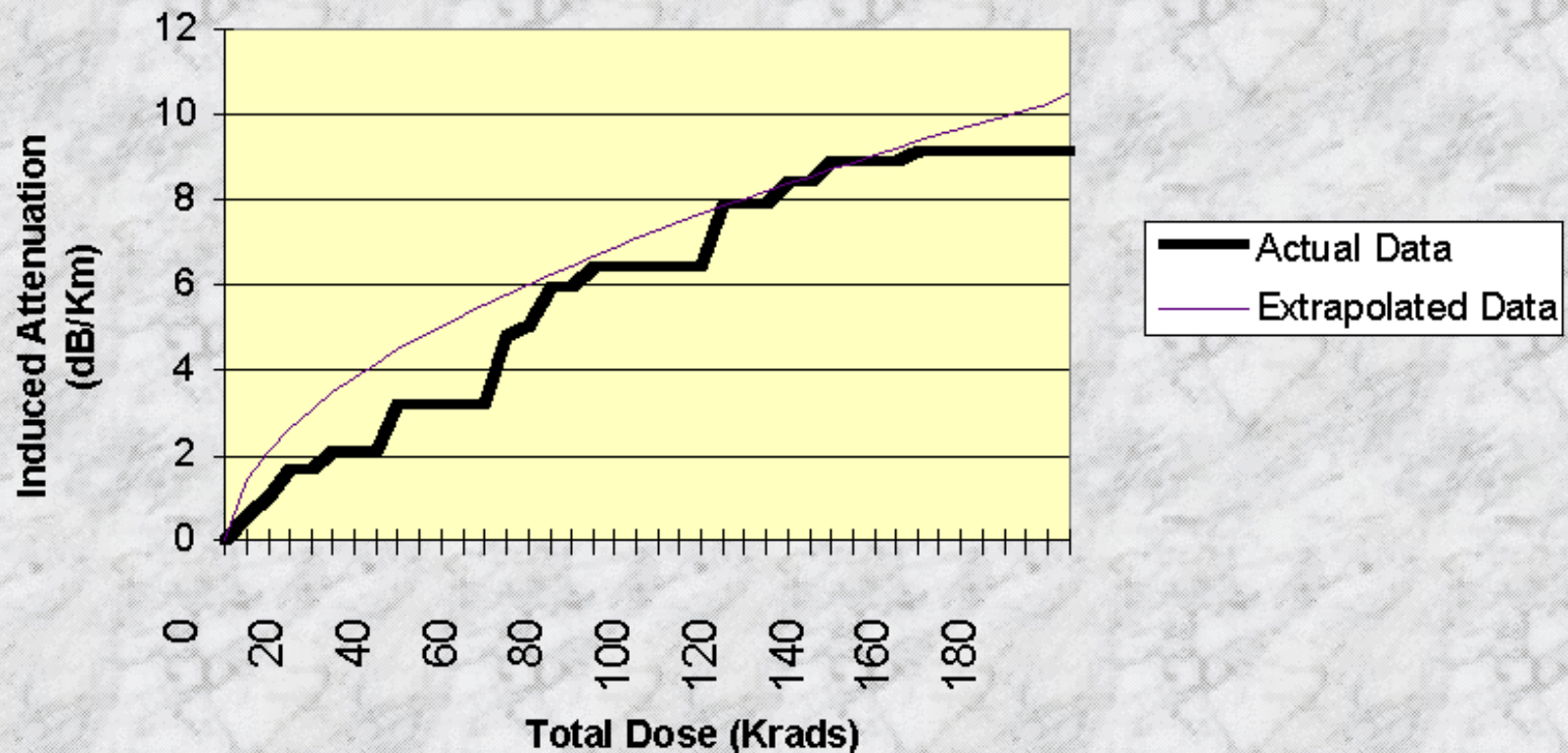
Testing: Radiation Effect on Power Transmission of Spectran Hermetic Acrylate Rad Hard Fiber, BF0544, Range 1450 to 4600 rads, dose rate = 50 rads/min



Photonics Page	Previous Slide	Next Slide

Testing: Radiation Effect on Attenuation of Spectran Hermetic Acrylate Rad Hard Fiber, BF0544, 0 to 200 Krads, dose rate = 34 rads/min

Induced Attenuation and Extrapolated Induced Attenuation for the Spectran BF0544 Hermetic Acrylate 100/140 Graded Index Multimode Fiber vs. Total Dose for 34 rads/min



Photonics Page	Previous Slide	Next Slide

Summary of Test Results and Cable Parameters from Shrinkage Testing

Manufacturer	W.L. Gore	Spectran	Brand Rex	Northern Lights Microcable	Northern Lights Microcable	W. L. Gore
Part Number	8388 Prototype 1	Flightguide	OC 1008	1-HY-MC-62CFD	1-HY-MC-10C	FON 1008
Total samples tested	4	6	4	3	3	2
Length of samples	~ 3 m	~ 3 m	~ 3 m	~ 3, 4 m	~ 3 m	100 m
Measurement	Length	Length	Length	Length, Optical	Length	Optical
Jacket Material	Fluoropolymer	Tefzel	Tefzel	Hytrel	Hytrel	Fluoropolymer
Outer Diameter	2.5 mm	1.8 mm	2.75 mm	.9 mm	.9 mm	1.16 mm
Total Number of cycles	60	60	60	36	36	36
Ave Total % shrinkage	3	1.58	2.43	1.14	2.25	
Total attenuation (28 cycles)	—	—	—	—	—	.25 dB/100m
Total Attenuation (36)	—	—	—	3.6 dB/4 m	—	.084 dB/100m

Photonics Page	Previous Slide	Next Slide

Conclusions

- Preconditioning procedure should be specific to cable configuration.
- “Looser” tube configuration for attenuation sensitive or phase sensitive applications.
- Spectran Flight Guide & W.L. Gore FON 1008, least shrinkage.
- Shrinkage of all cables less than .1% at 60 cycles.
- Larger diameter cables have higher shrinkage.
- Hermetic Acrylate BF0544 Rad Hard Optical Fiber, Radiation Results
 - 50 rads/min, TID 100 Krads, Attenuation = 9.59 dB/Km
 - TID 15 Krads, Attenuation = 2.53 dB/Km
 - TID 150, Saturation @ 12.21 dB/Km
 - 34 rads/min, TID 100 Krads, Attenuation = 6.45 dB/Km
 - TID 15 Krads, Attenuation = 1.69 dB/Km
 - TID 160, Saturation @ 9.18 dB/Km
- Acrylate coating strippable in methylene chloride after 2 minutes immersion.

Photonics Page

Previous Slide