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# *Hard Clad Fibers for Automotive Applications*

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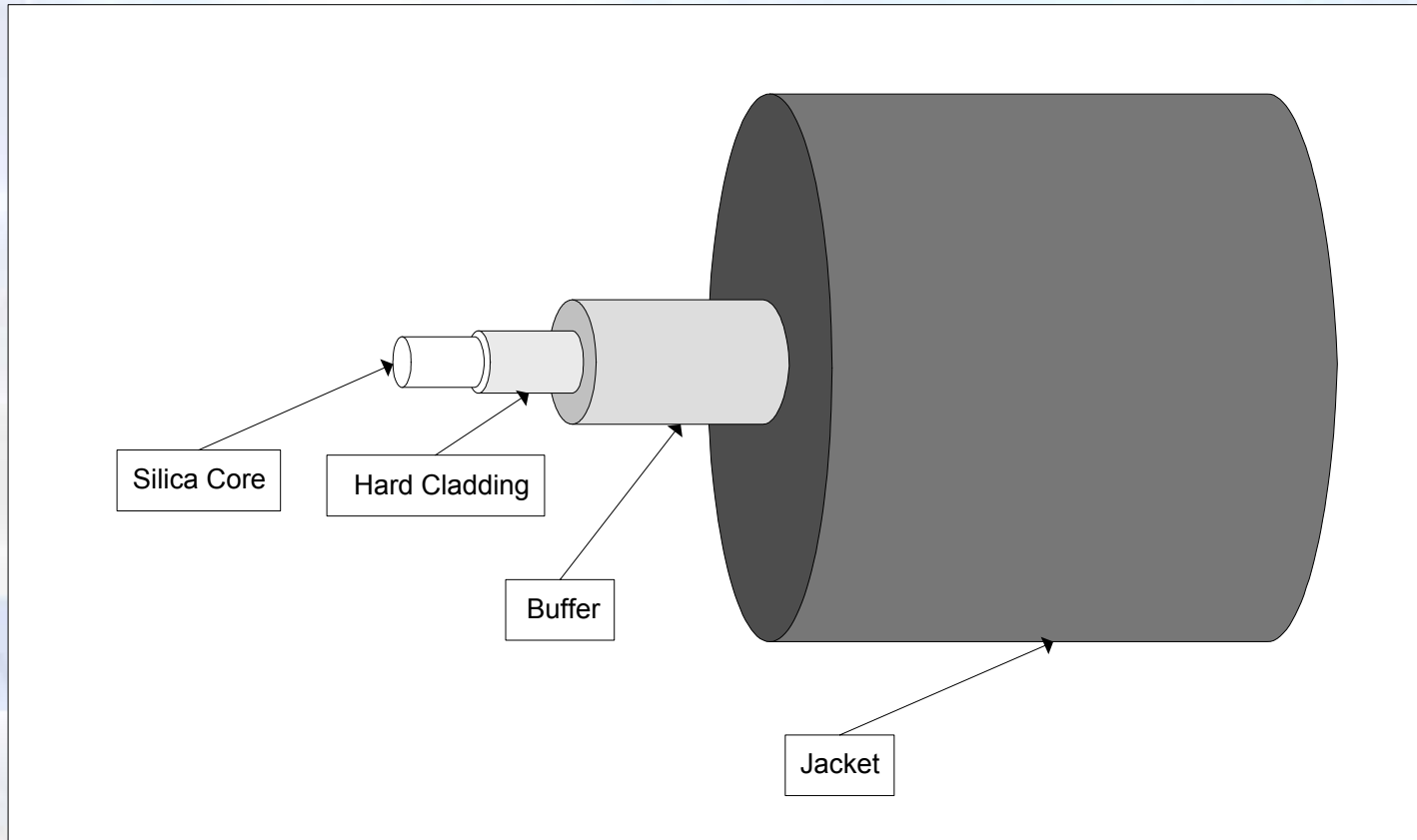


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# Automotive Hard Clad Fiber



# Fiber Draft Specs

## Materials:

Core	synthetic fused silica
Clad	fluorinated polymer
Buffer	Tefzel (ETFE fluoropolymer)
Jacket	Santoprene (TP elastomer)

## Geometry:

Core Diameter	200 ± 5 µm
Clad Diameter	230 +0/-10 µm
Buffer Diameter	500 ± 30 µm
Jacket Diameter	2200 ± 100 µm

Clad Offset	5 µm max.
Buffer Conc.	70% min.
Jacket Conc.	70% min.

## Optical:

Attenuation	7 dB/km @ 850nm max
Bandwidth	20 MHz-km min.
Index Profile	Step Index
NA	0.37 ± 0.02 @ 850nm

## Other:

Proof test	100 kpsi min.
Weight	5 kg/km max.
Flammability	UL HB or better
Temp. Range	-40 to 125°C

# Why Hard Clad?

- Low Optical Loss
- Stable to 125°C
- $\geq 20$  MHz-km Bandwidth
- Compact Size
- High Strength
- Low Flammability
- Low Cost

# Critical Parameters

- Termination Technique
  - Crimp/cleave vs. epoxy/polish
  - Temperature, fluid, vibration durability
  - Cost
- Temperature Range
  - 125°C durability
  - -40 to 125°C attenuation change
- Buffer and Jacket Selection

# Buffer Options

- Nylon
  - Good temp & adhesion properties
- Tefzel
  - High shrinkage & cost; flame retardant
- Silicone
  - Good temp cycling & low cost
- Hytrel
- Others possible

# Jacket Options

- Santoprene
  - Commonly used in automotive
- Nylon
- Tefzel
- PE
- Polyolefin
- Also, Tight or Loose Tube

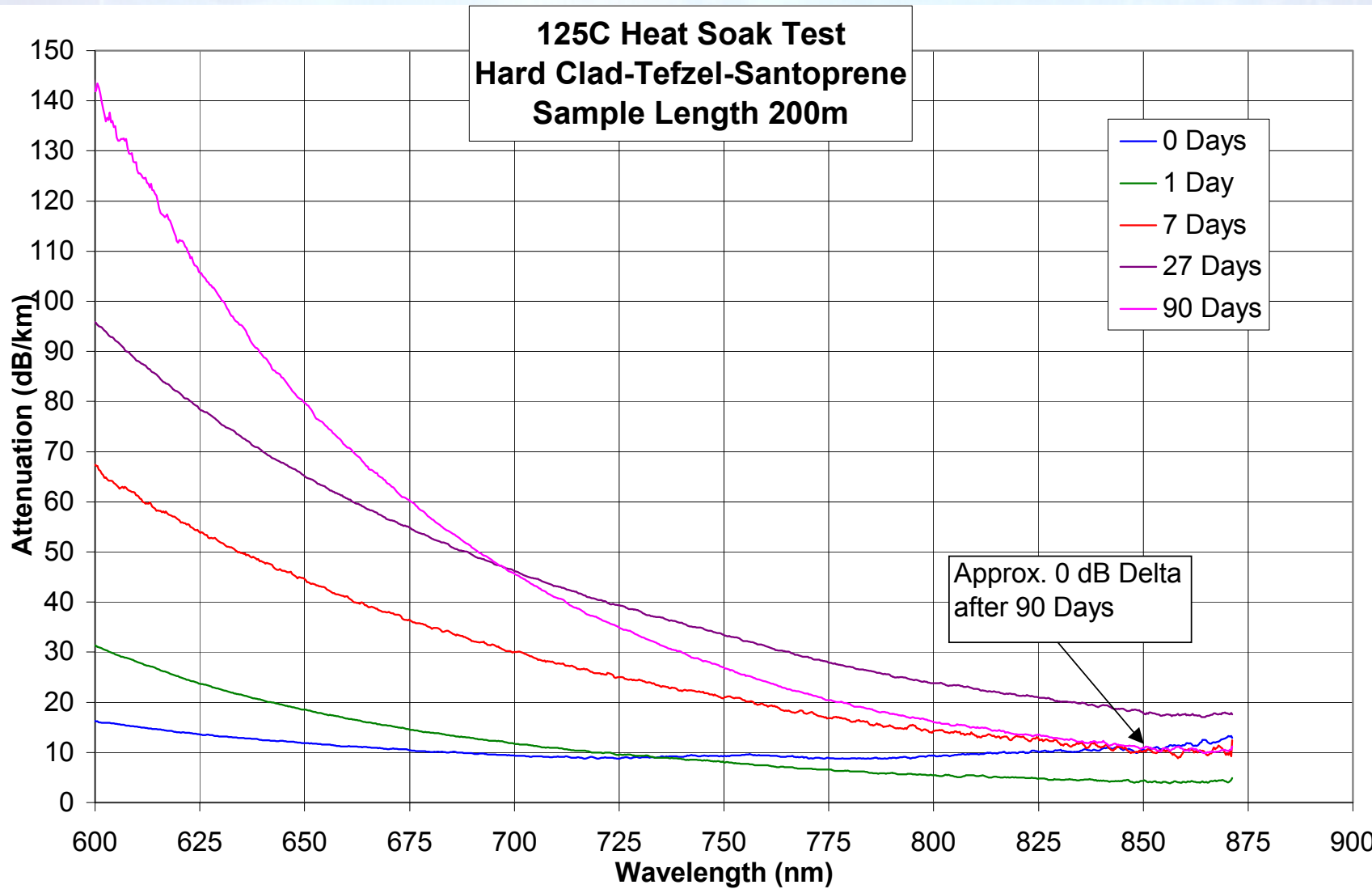
# Buffer/Jacket Combinations

- Dependent primarily on:
  - Adhesive location/securing of connector
  - 125°C performance
  - Termination processing costs
  - Flammability & Fluids

Currently under  
evaluation:

<b>Buffer</b>	<b>Jacket</b>
Nylon	Santoprene
Nylon	Nylon
Silicone	Santoprene
Tefzel	Santoprene
Hytre	Santoprene

# Atten. vs. 125°C Soak

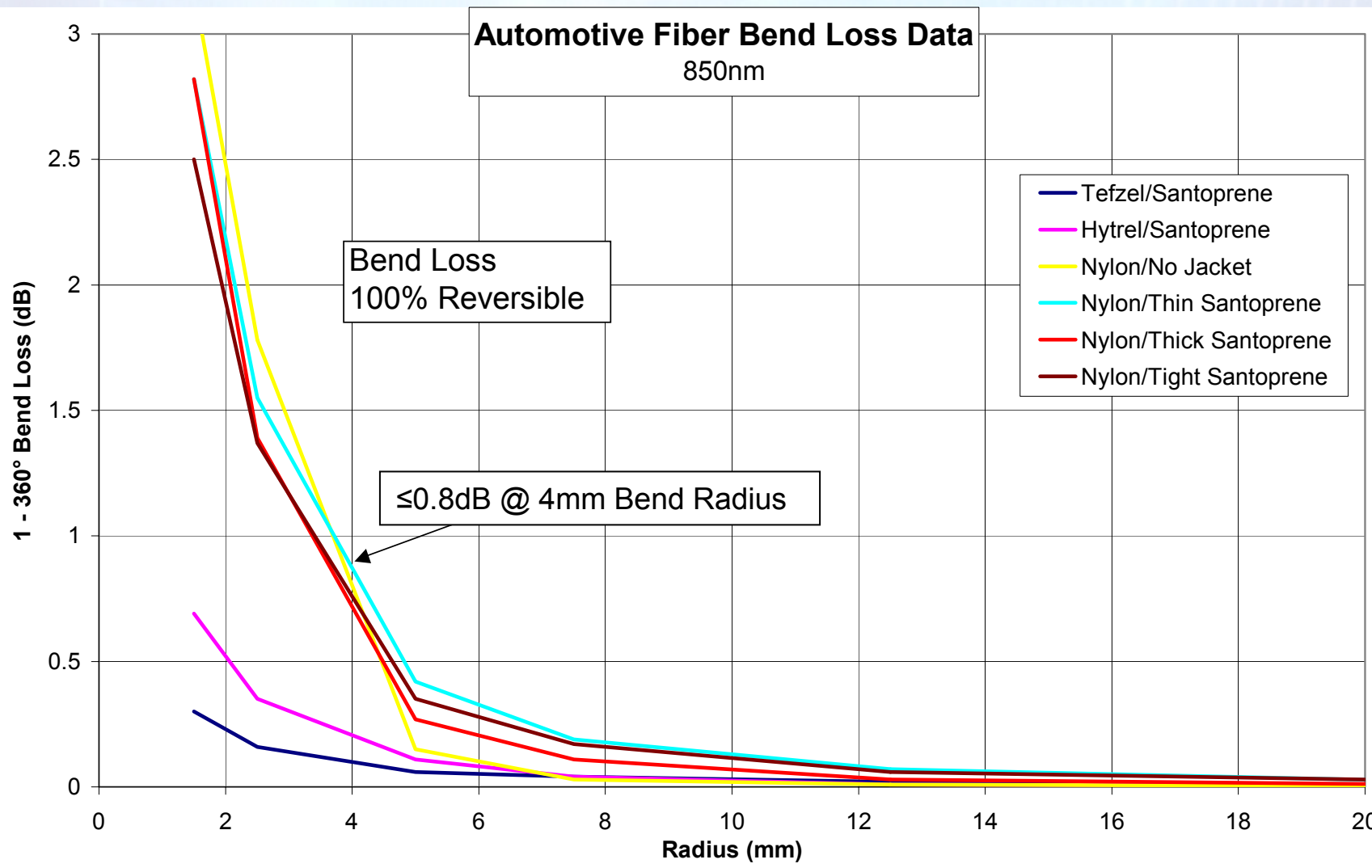


# Temp Cycle

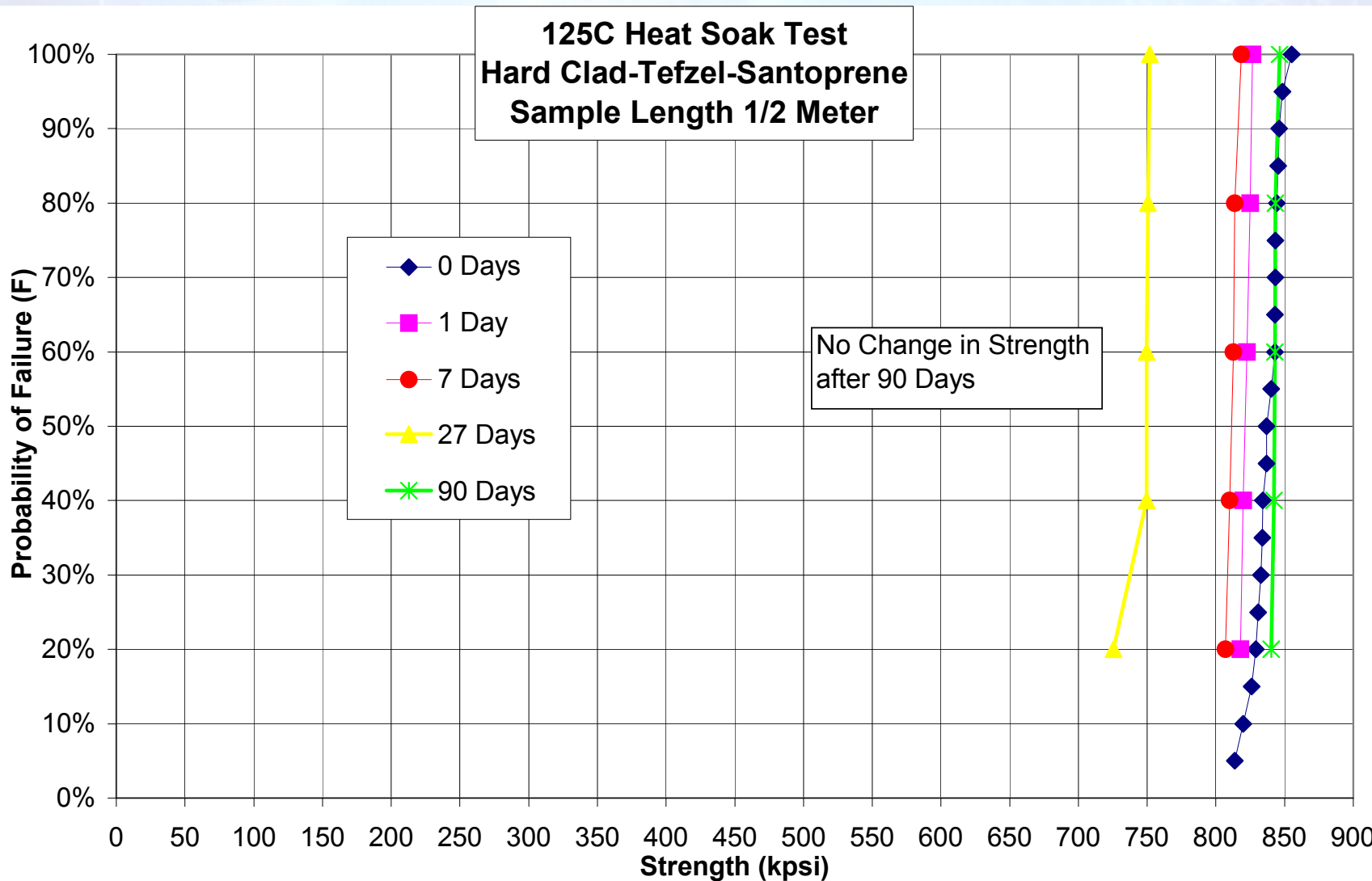
Cycles	Cold to Hot Max. Power Variation (dB/25m)
1	0.24
5	0.21
25	0.26

- Cycle of -40 to 125°C with 1 hour dwell time
- 200m samples
- No cumulative loss; loss reversible

# Bending Loss (850nm)



# Strength vs. Temp Soak

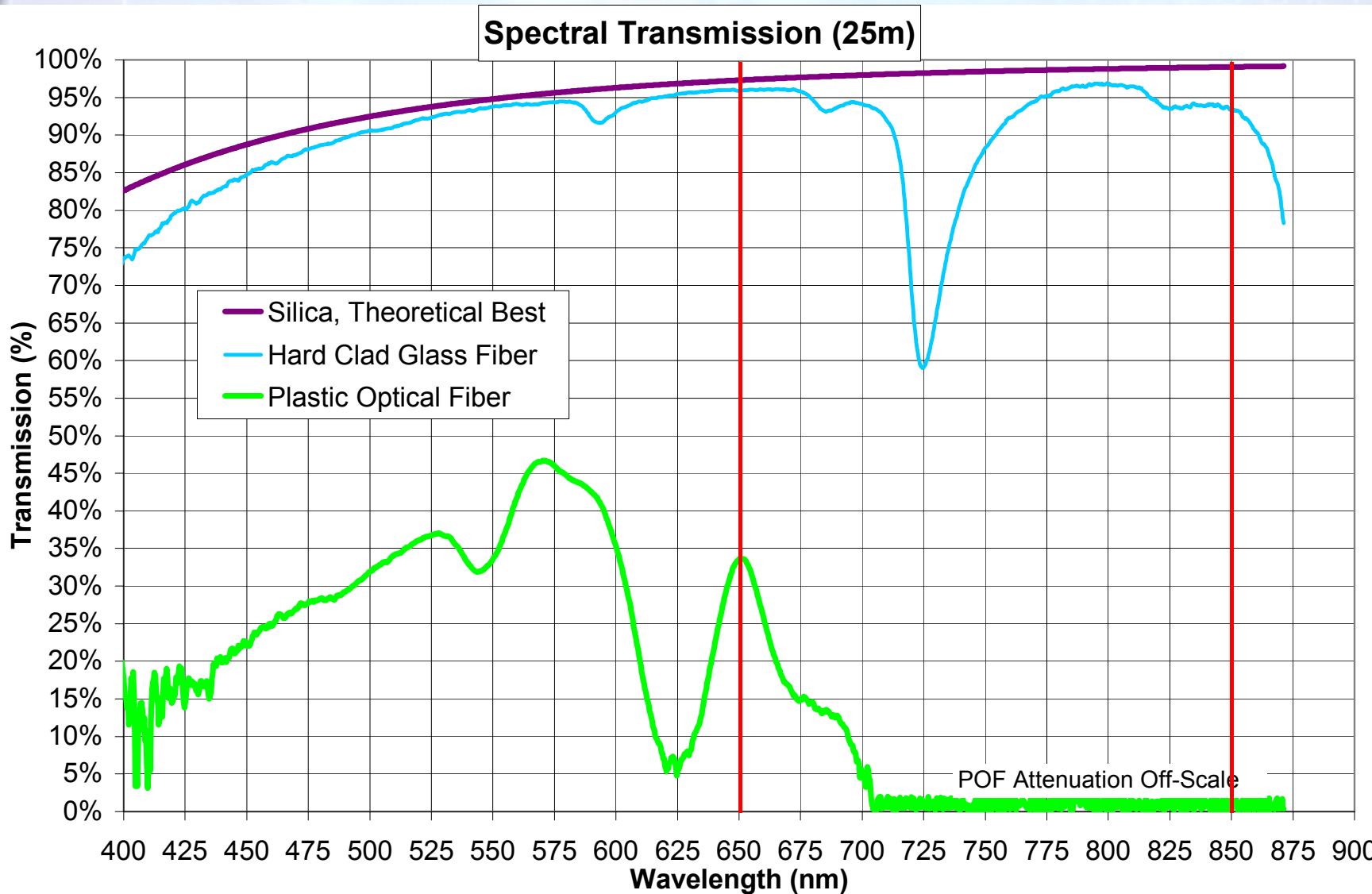


# Hard Clad vs. POF

	Attenuation (dB/25m)	BW (MHz-km)	NA	Max. Temp.	Flamm- ability	Flexibility
POF	1.1	4	0.6	90°C	high	High
Hard Clad	<0.5	20	0.37	125°C	low	Moderate

	Ease of Termination	Chem. Durab.	Strength	Weight	Min. Volume	Cost
POF	Easy	Low	Moderate	<5kg/km	3.8 cm <sup>3</sup> /m	Low
Hard Clad	Moderate	High	High	<5kg/km	0.2 cm <sup>3</sup> /m	Moderate

# Transmission



# Fiber Output

## Output of Fibers Illuminated by Metal Halide Light Source

200 ft Hard Clad #2

200ft PMMA  
Fiber

200 ft Hard Clad #1

# Termination

- ***Critical in Selection of Fiber Design!!***
  - Adhesion Technique
    - Epoxy or crimp or both
  - Fiber End Preparation
    - Cleave or polish

# Epoxy/Polish vs. Crimp/Cleave

	<b>Advantages</b>	<b>Disadvantages</b>
<b>Epoxy/ Polish</b>	Repeatable/reliable Yields Bulk processing Economical in factory Blocks fluids	Cure time Polishing time Uses (wet) slurries Not good for field/ repairs
<b>Crimp/ Cleave</b>	No curing Good with cleave Good for field/ repairs Fast process Potential mirror endface	Less consistent/repeatable Yields/reliability concerns Sensitive to tooling wear Crimp damage to hard clad Angled/chipped endface Pistoning/fluid ingress

# Cost Considerations

- Epoxy/Polish
  - Bulk processing
  - Consistent yields/repeatable/reliable
  - *Practical for factory environment*
- Crimp/Cleave
  - Fast/easy
  - Less consistent yields/repeatability/reliability
  - *Practical for field installations/repairs*

# Epoxy/Cleave??

- Maybe best of both worlds
- Fiber protrusion maybe problem
- Needs some development

# Next Steps

- Determine Termination Technique
  - Work with customer
  - Performance vs. temp/vibration/fluids
  - Adhesive compatibility with coatings/jackets
  - Cost effectiveness
- Establish Testing/Qualification Guidelines

# Next Steps (con't)

- Determine Optimum Jacket
  - Termination compatibility
  - Temperature range capability
  - Fluid resistance
  - Flammability
  - Processability/Cost
- Further Qualification Testing
- Initial Production of Cable



# Thank You!!

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