

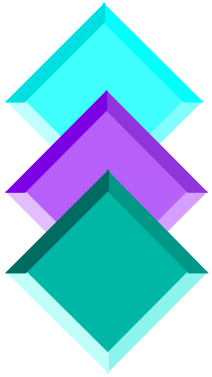
Mechanical Performance of Silica Clad Fiber in the 3M Galaxy Connector

Thomas Hanson
Standards Engineering Manager/Engineering Associate
Corning Incorporated
(607) 974-4530



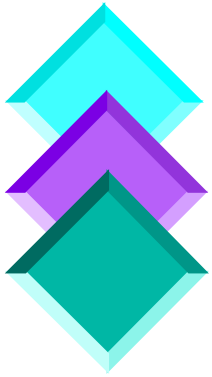
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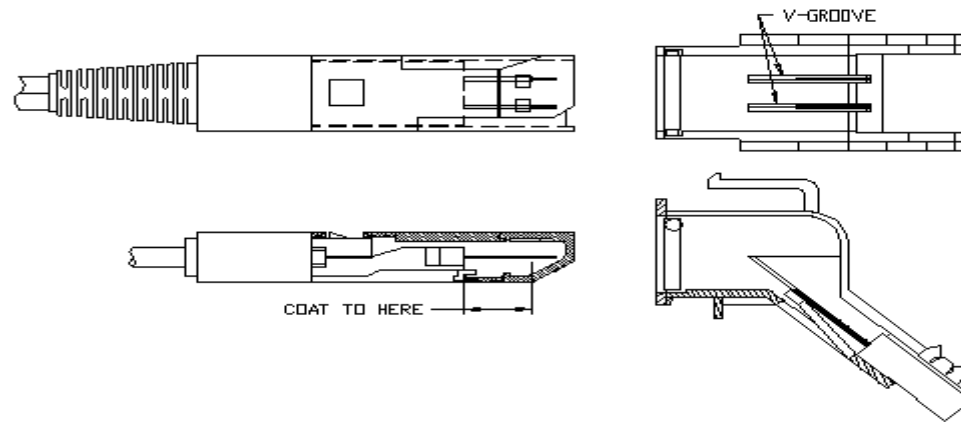


Outline

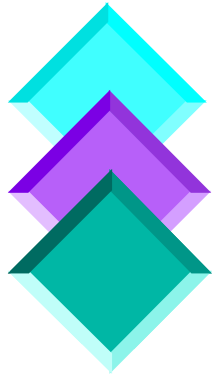
- ◆ Review the design of the 3M connector
- ◆ Discuss impact of connector mechanical requirements on reliability of fiber
- ◆ Determine failure probability of connector based on direct strength measurements
 - as manufactured strength
 - normal field usage wear
 - Failure probability analysis does not take into account extraneous damage due to unforeseen events
 - Dig ups, rodents, non-standard operating procedures, etc.



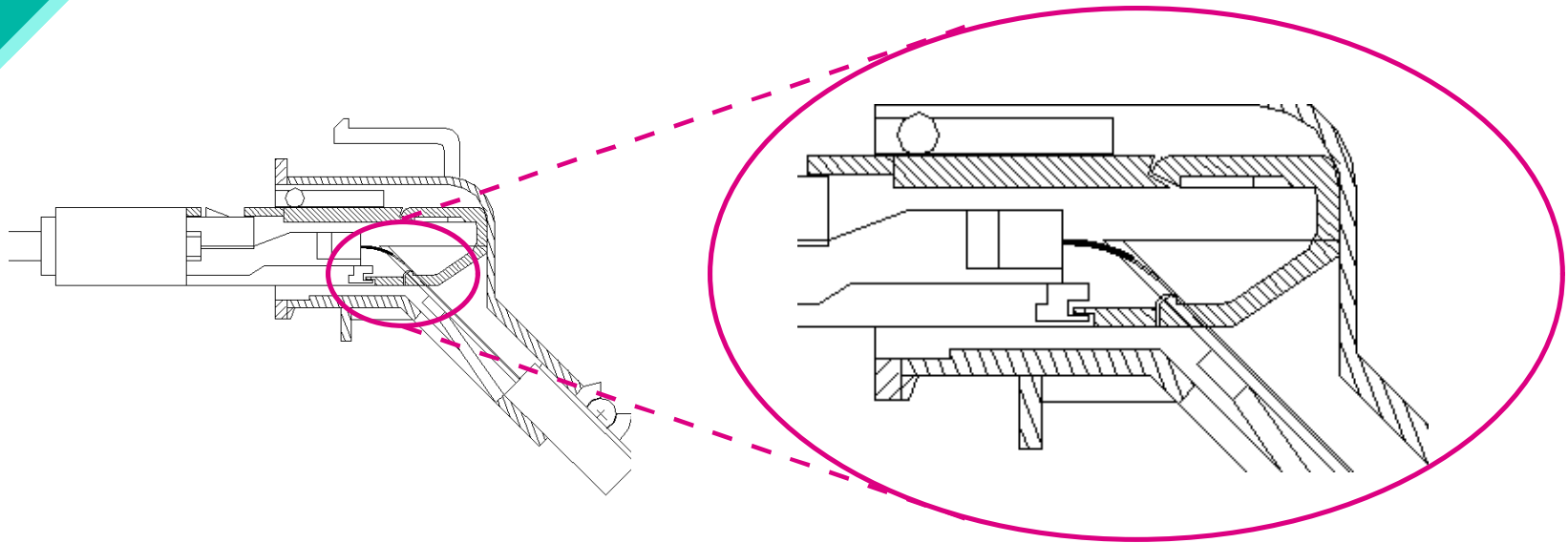
3M Galaxy Interconnect - Observations



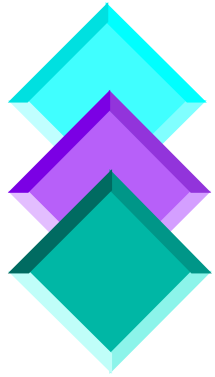
- ◆ Connector is composed of male/female (plug/socket) components prepared in a manufacturing facility
- ◆ Fiber held in connector by clamping mechanisms, assume tensile strain relieved by design
- ◆ Terminated acrylate coated fiber ends extend within plug
- ◆ Approximately 1 cm of fiber end is bare (i.e. acrylate coating has been removed)
- ◆ Plug un-coated fiber ends are contained within a protective shroud



3M Galaxy Interconnect - Observations



- ◆ When plug and socket are mated a portion of **coated** fiber is placed into a permanent bend, quarter turn (0.25) at 10 mm radius
- ◆ Bare plug fiber end is aligned in the socket by direct physical contact with guide groove
- ◆ Bare fiber experiences a static bend condition of ~63 mm radius, < 0.05 turn
- ◆ For 3M interconnect there is a customer concern over the use of bare fiber
 - Repeated interconnects may abrade fiber surface, lead to wear out over time
- ◆ **What is the mechanical performance of standard fiber?**

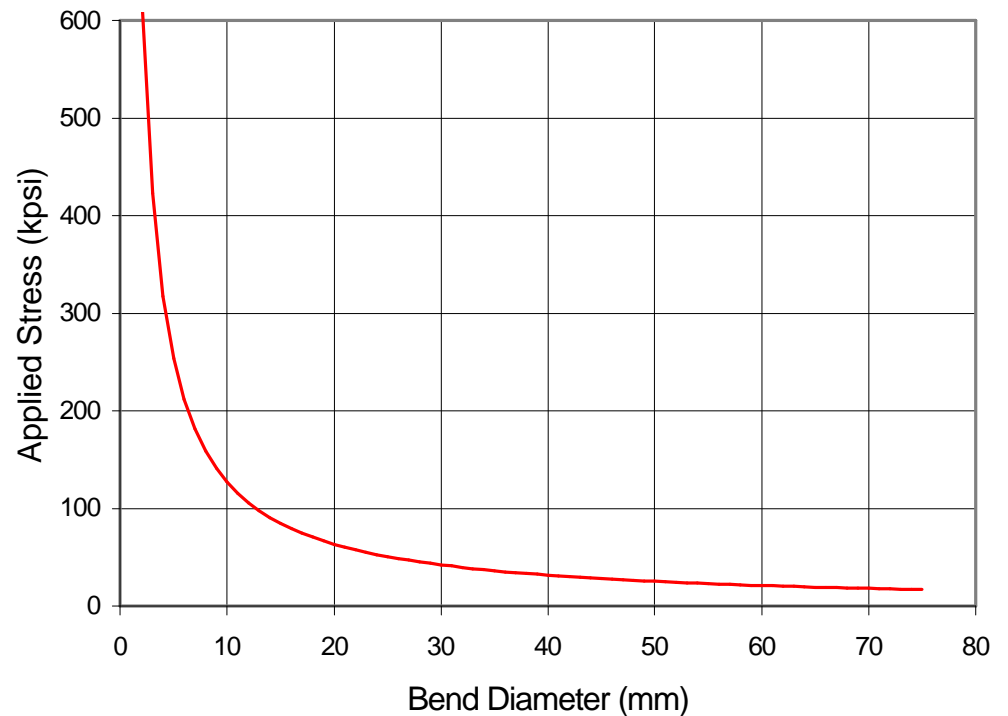


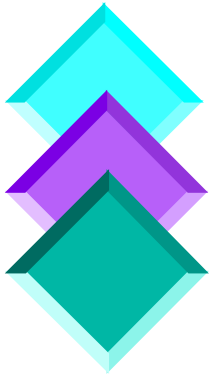
Factors Affecting Mechanical Reliability of Fiber

125 μm Fiber
Silica Clad

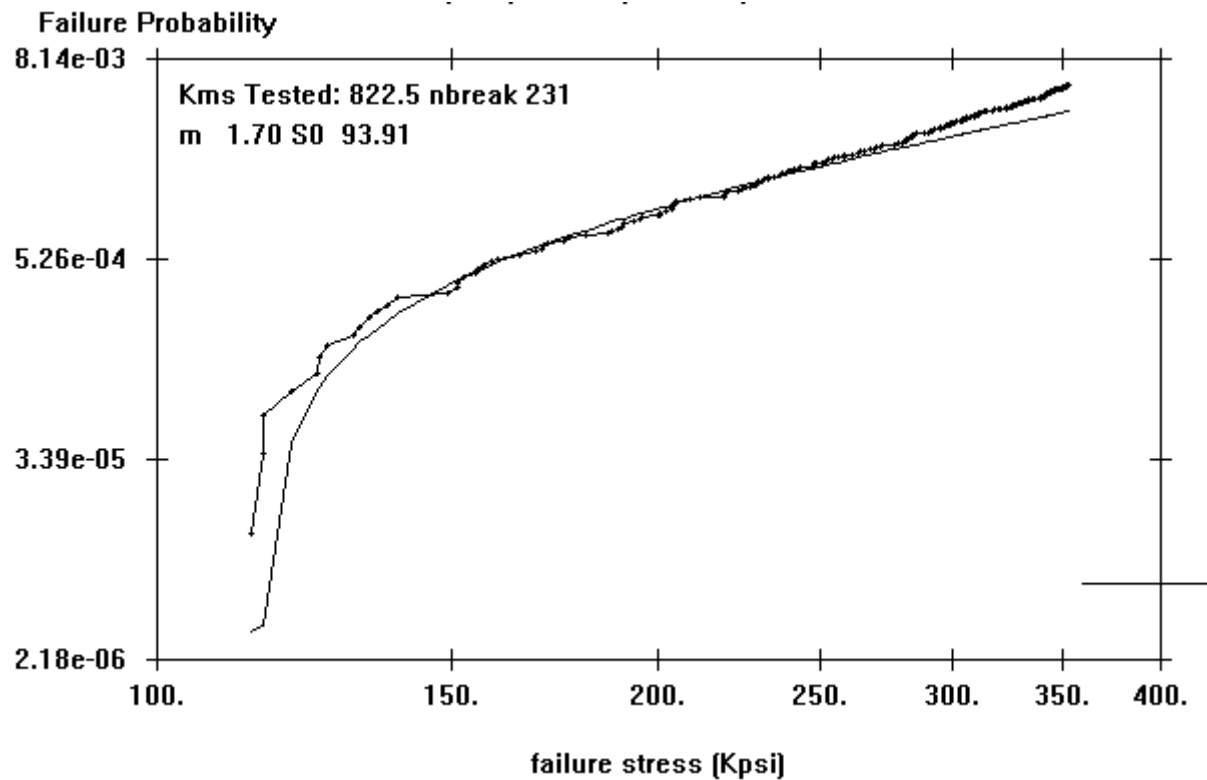
- ◆ Strength of the fiber
 - Size and distribution of flaws on the fiber surface
 - Determined by manufacturing and Handling history
- ◆ Fatigue characteristics of the fiber
 - How the flaws will grow over time in the presence of moisture and applied stress
- ◆ Applied stress on the fiber
 - Tensile
 - Bending

Maximum Applied Stress on Fiber in Bending





Low Strength Distribution of Silica-Clad Fiber - 822 km tested

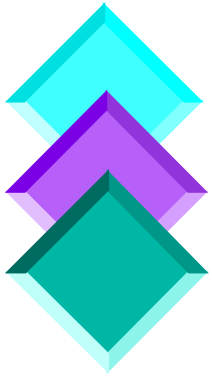


- ◆ Strength distribution of coated fiber
- ◆ Represents the low strength distribution of fiber that experiences 10 mm bend in the connector

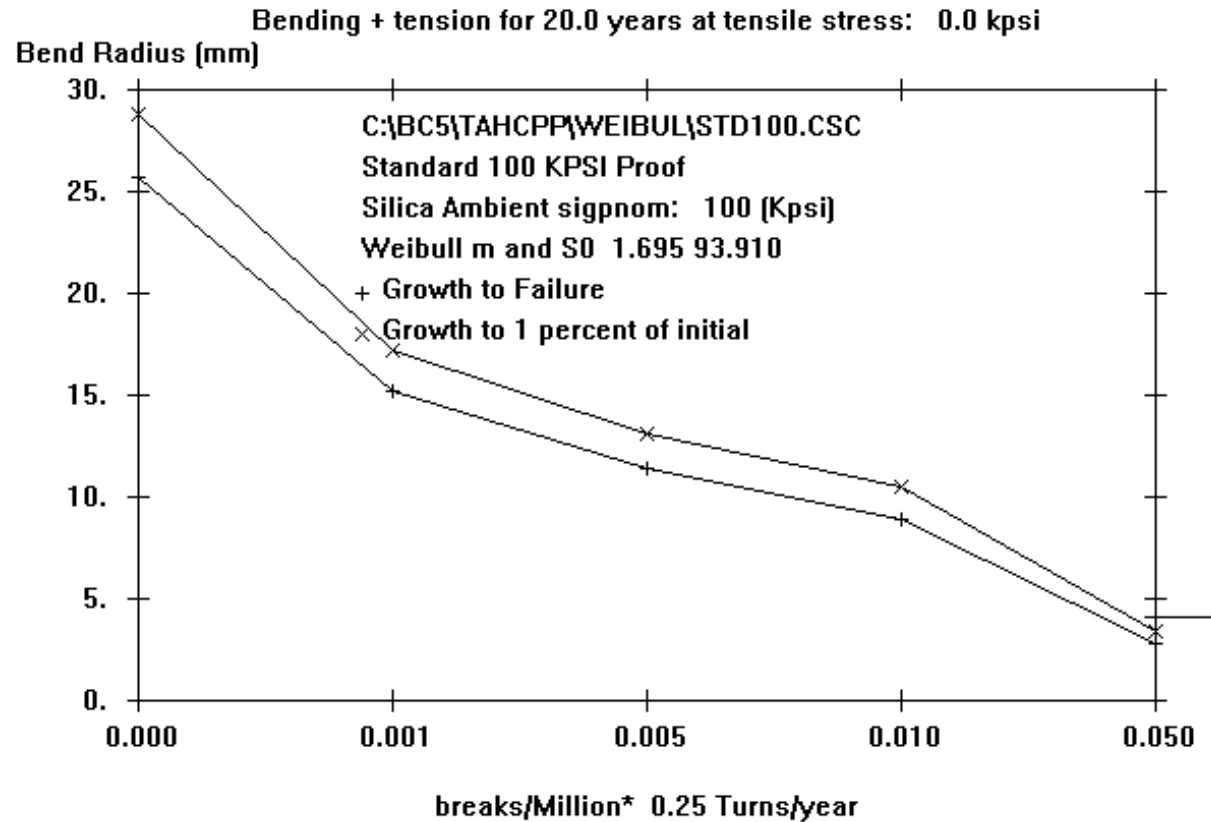


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Failure Rate of Coated Silica Clad Fiber in 1/4 Turn Bend - 20 year life

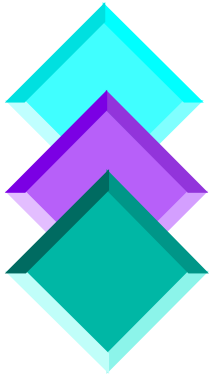


- ◆ For 10 mm bend radius, 0.01 ppm failures per year for 20 years



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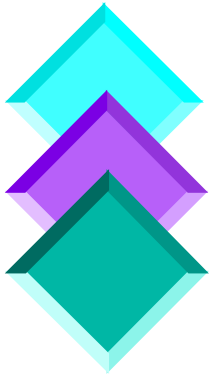
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Measuring the Strength of the Bare Fiber Section

- ◆ Must determine the strength (distribution of flaws) of the bare fiber within the connector
 - As-manufactured strength of terminated fiber
 - Strength of terminated fibers after repeated connections
- ◆ 3M Role
 - Assemble sample connectors
 - silica-clad fiber terminated in plug (as manufactured)
 - silica-clad fiber terminated in plug and cycled through 500 interconnections
- ◆ Corning Role
 - Perform strength testing on the samples
 - Measure the strength of the fiber within the plastic shroud of the interconnect plug
 - Analyze data
 - Reliability modeling

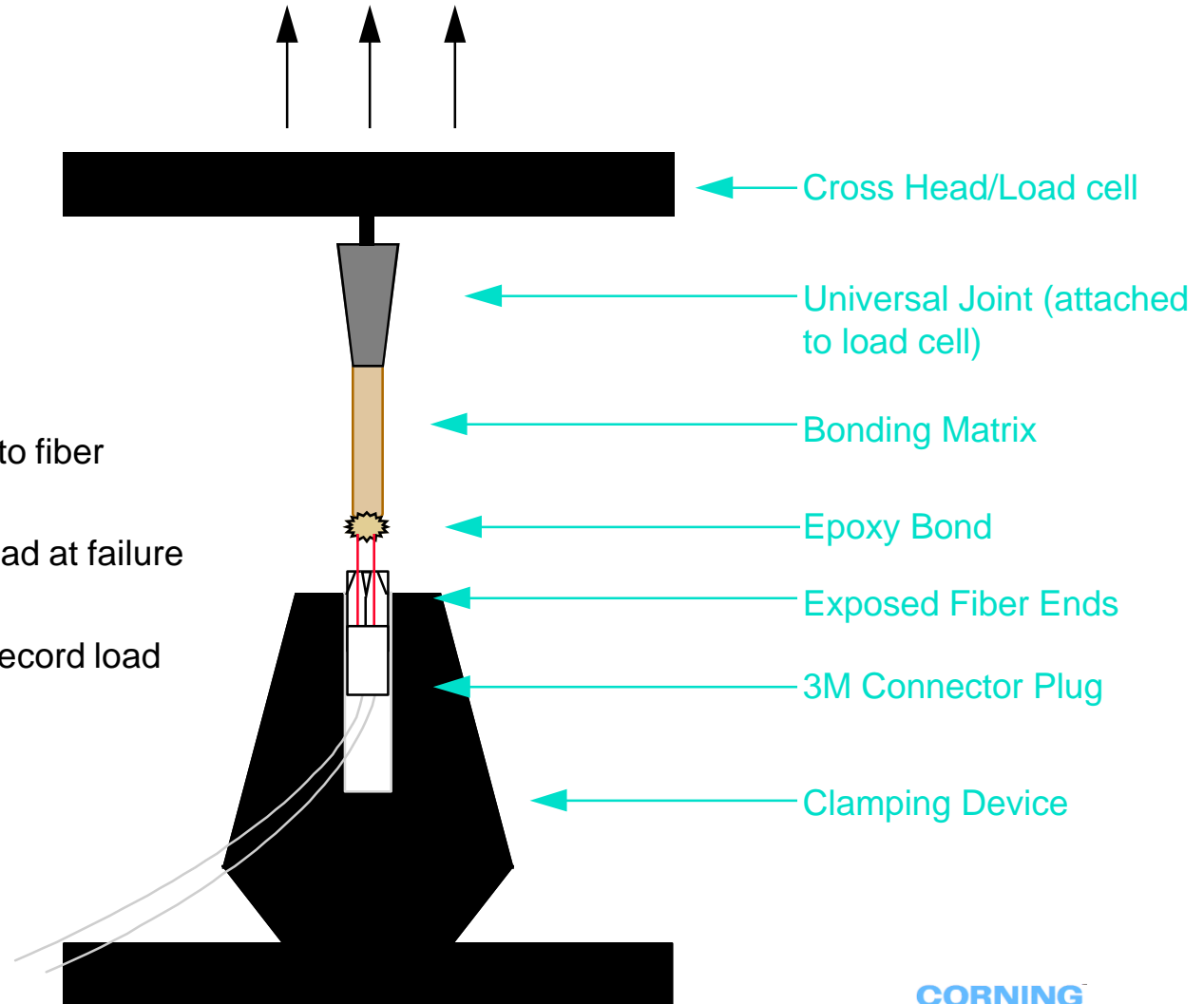


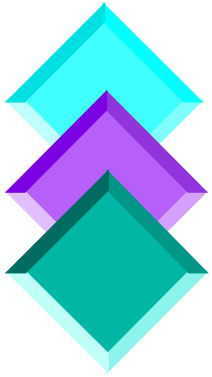


Connector Test Fixture

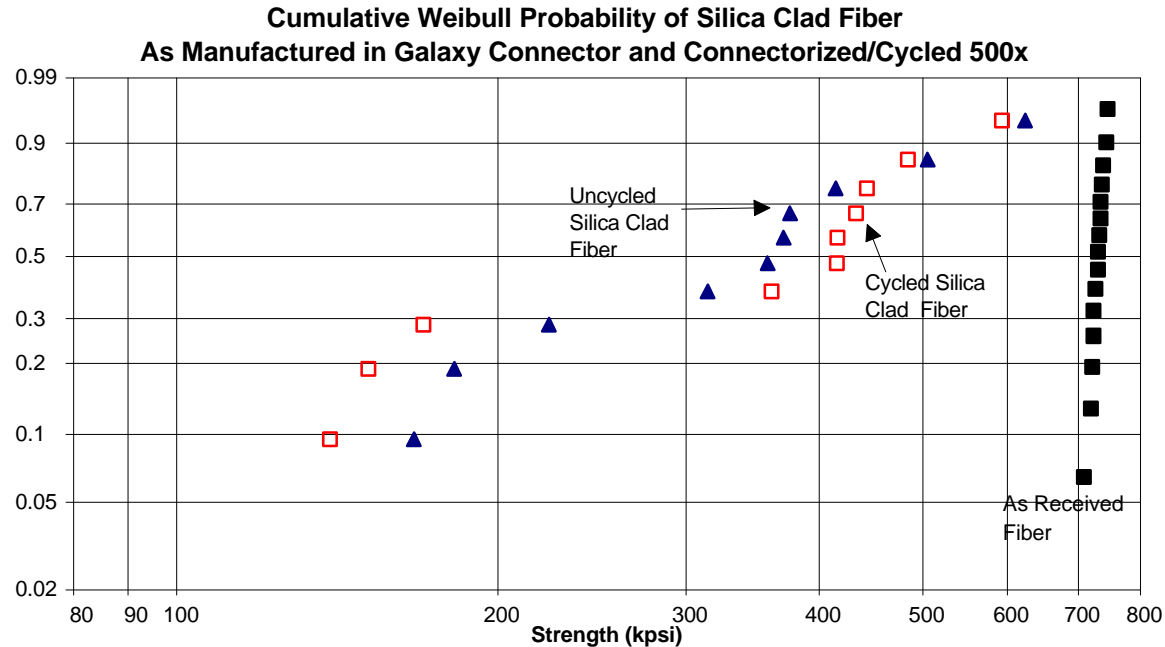
◆ Test Steps

- disassemble Plug
- clamp plug in place
- lower epoxy bead on to fiber
- allow epoxy to cure
- initiate test - record load at failure
- epoxy second fiber
- initiate second test - record load at failure
- unclamp plug



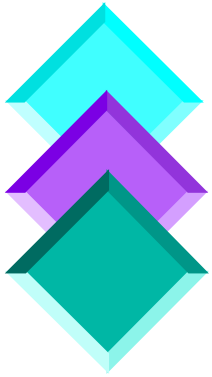


3M Interconnect - Strength Test Results with Corning Silica Clad Fiber

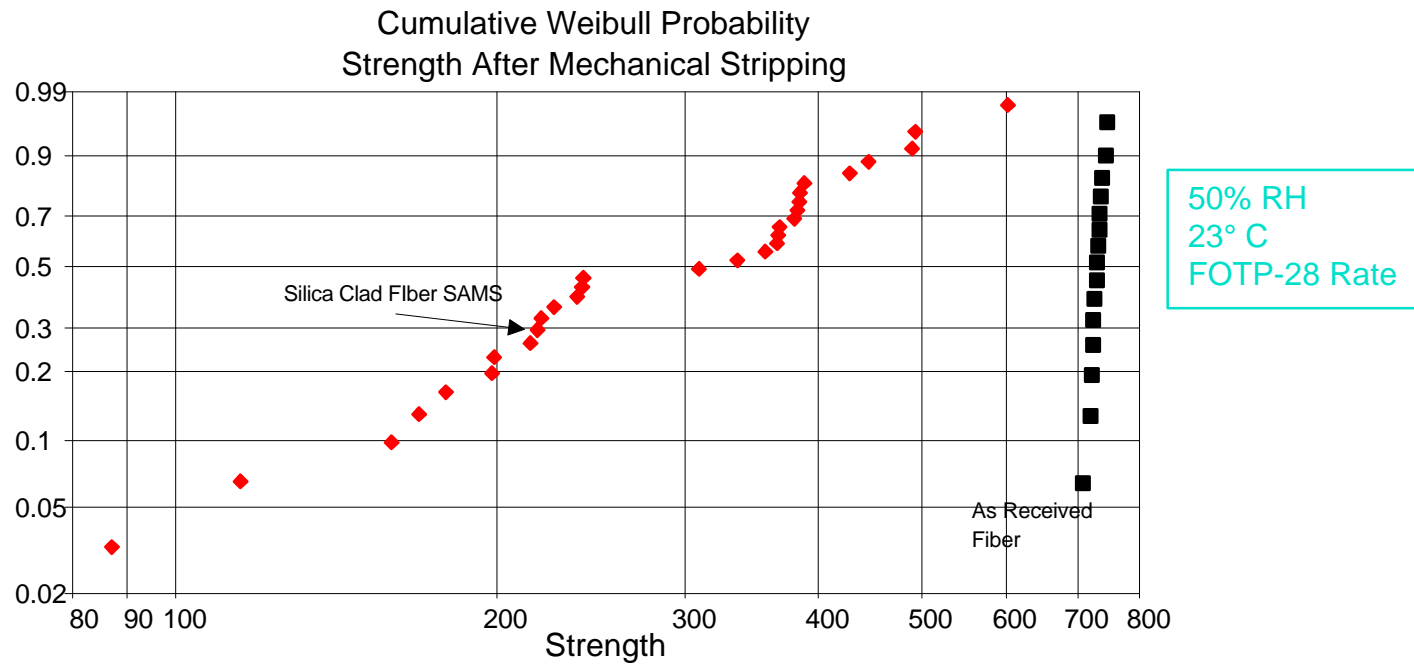


- ◆ Degradation in strength from as-received is observed, and expected for any silica clad fiber, Multimode or Single-mode
- ◆ Repeated mating of the connector does not change the strength distribution of the fiber

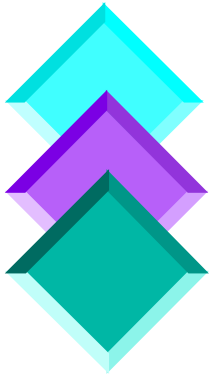




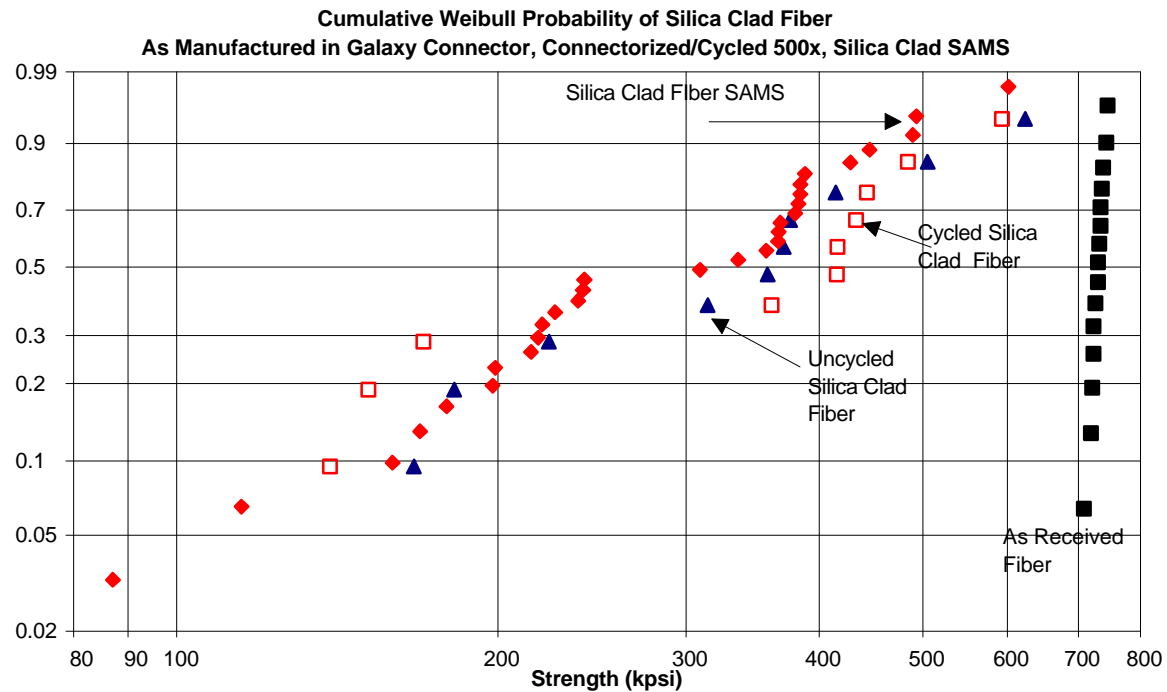
Mechanically Stripped Fiber



- ◆ Strength distribution of standard silica-clad fiber after mechanical stripping (Miller stripping tool)



SAMS Data Compared to Corning Silica Clad Fiber

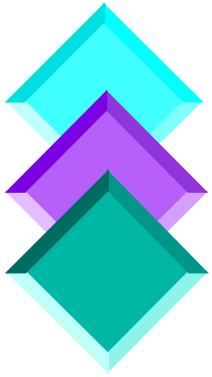


- ◆ SAMS: Strength After Mechanical Stripping
- ◆ The strength distribution of laboratory mechanically stripped fiber overlaps that of the terminated fiber
 - Any strength degradation is similar to common field termination techniques
 - 3M connector fiber strength is not significantly different than fiber in standard connectors



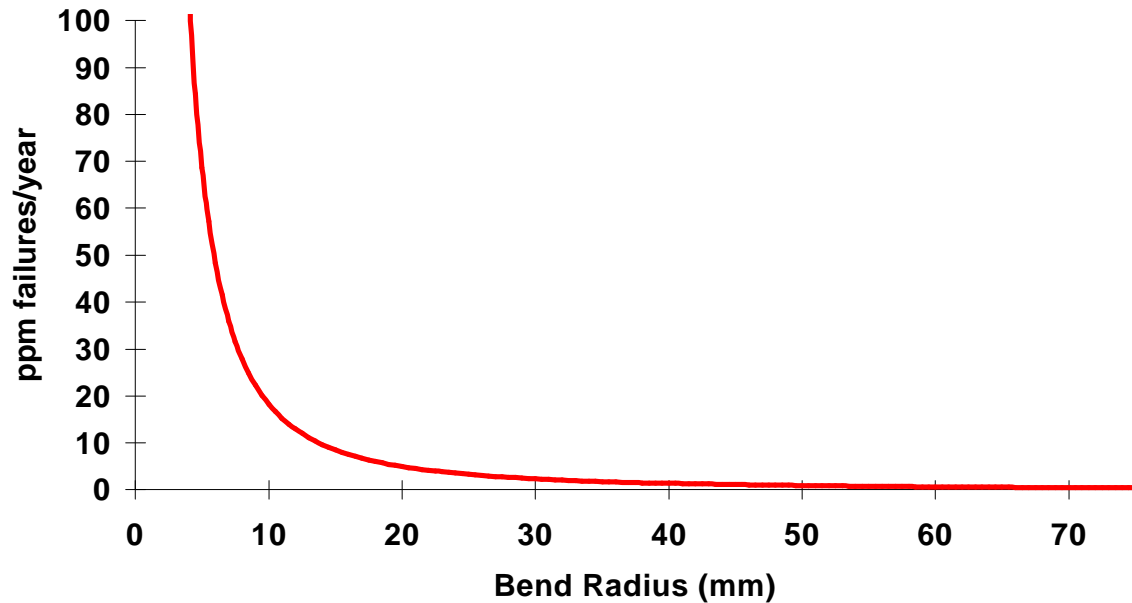
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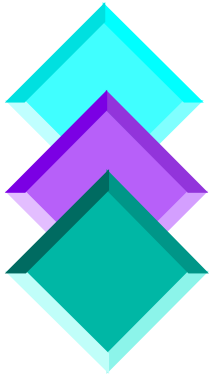


Failure Rate of Uncoated Silica Clad Fiber in Galaxy Connector

Failure Rate of Bare Silica Clad Fiber in 3M Galaxy Connector



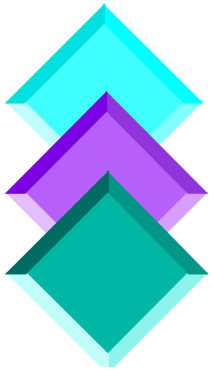
- ◆ Using technique applied to the coated section of fiber under bend the failure rate was determined for the bare fiber section before and after cycling
- ◆ Failure probability for 20 year life of the bare fiber within the connector was calculated to be < 10 ppm



Conclusions

- ◆ The 3M Galaxy Interconnect design is a novel approach to low cost connectorization
- ◆ Fiber strength distribution in the connector is due to limited stripping of the coating
- ◆ No additional damage seen after repeated (500) connector re-mating
- ◆ Data and analysis indicate excellent reliability (<10 ppm failures) over 20 years for standard silica clad fiber (both MM & SM)





Aging of Abraded Silica Clad Fiber in 80°C Water

