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# LC Connector

## A High Density Fiber Optic Network Solution

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TIA 41.8.1 Working Group  
August, 1997

# LC Connector Outline

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- ◆ Design Background and Goals
- ◆ Product Family Overview
- ◆ Features
- ◆ Feature Advantages
- ◆ Adapters, Transceivers, Cordage
- ◆ Standards, Licensing and Availability
- ◆ Performance
- ◆ Summary & Conclusion

# LC Connector Background

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- ◆ Bell Labs was challenged with developing a **next generation optical connection product family** that would meet the changing needs of **both the singlemode and multimode** markets
- ◆ MM and SM teams developed similar conclusions
- ◆ Developed design criteria based on market trends
  - Lower system complexity
  - Smaller size
  - User friendliness
  - Excellent mechanical and optical performance

# LC Connector Design Goals

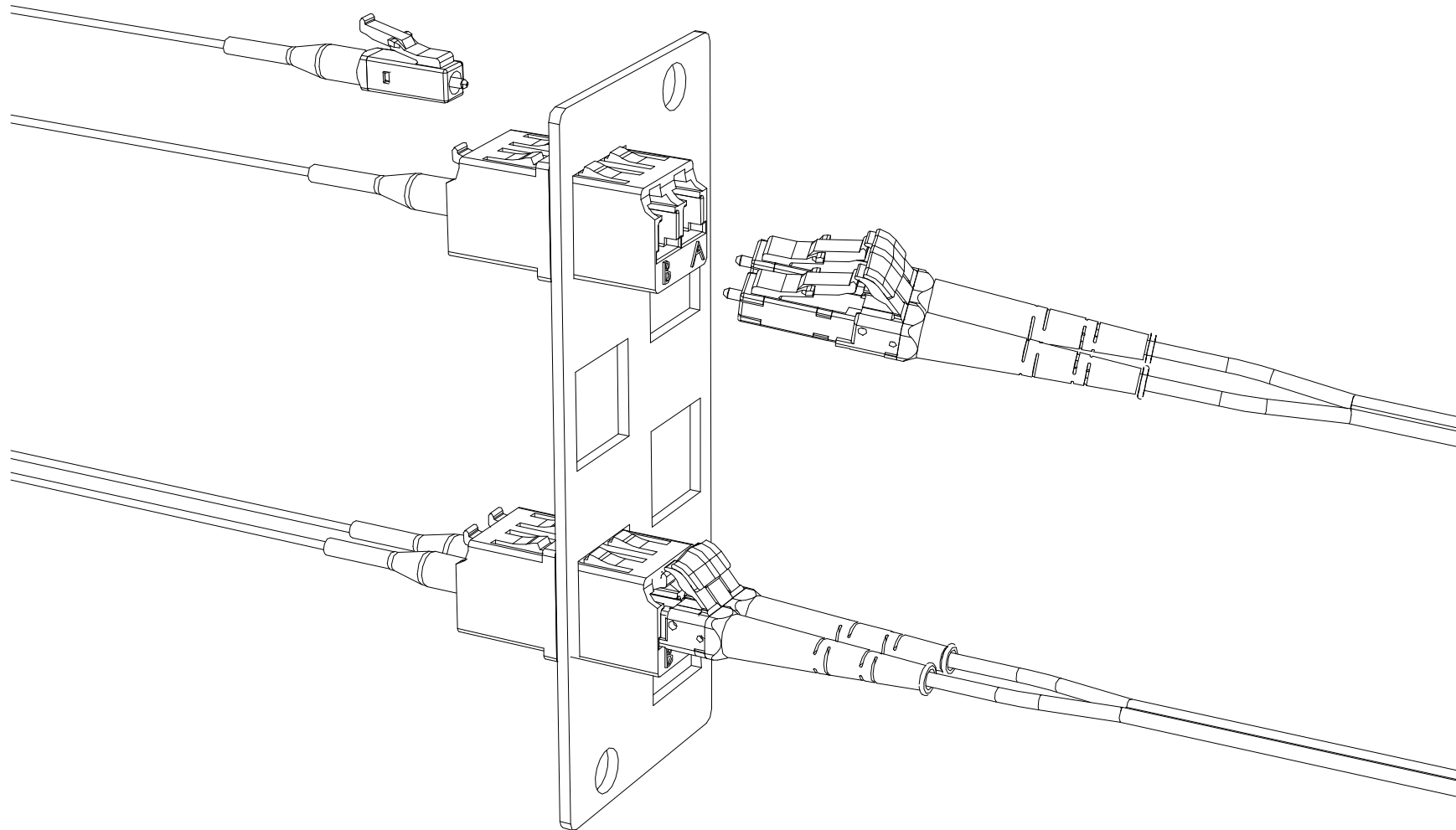
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- ◆ Develop one connector/optical interface for **ALL** applications in the network
  - High volume = low complexity
  - Fewer equipment designs
    - » lower complexity
    - » less R&D expense for xcvr. manif. and OEMs
  - Specialty connectors traditionally not successful
    - » high complexity for network
    - » low volume, not accepted by total market
- ◆ No complexity shifting to **ANY** network components!
- ◆ Develop a complete product family
- ◆ Broadly license for multiple sources

# LC Connector Product Family

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LC Connector

# LC Product Family

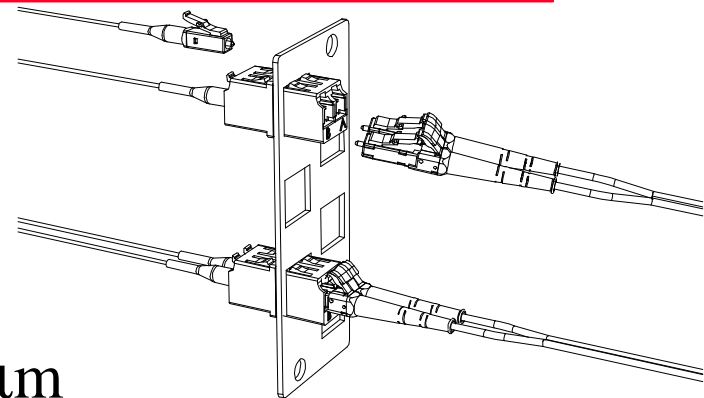
## Multimode and Singlemode

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### Initial Product Offering

- ◆ Patch Cords and pigtails
  - Duplex and simplex
  - MiniCord™ (1.6 mm) and 900 μm
  - Hybrid Patch Cords
- ◆ Field-mountable on buffered-fiber & cordage
- ◆ Duplex adapters
  - standard and reduced height
- ◆ Panels for outlets and cabinets
- ◆ Mounting Collar for RJ-45 cutout



# LC Connector Features

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- ◆ RJ-45 Style
- ◆ Small Size
- ◆ Polarized
- ◆ Color Coded
- ◆ Pull-Proof
- ◆ Cable Compatible
- ◆ Excellent Performance
- ◆ High Reliability

# LC Connector Feature Advantages

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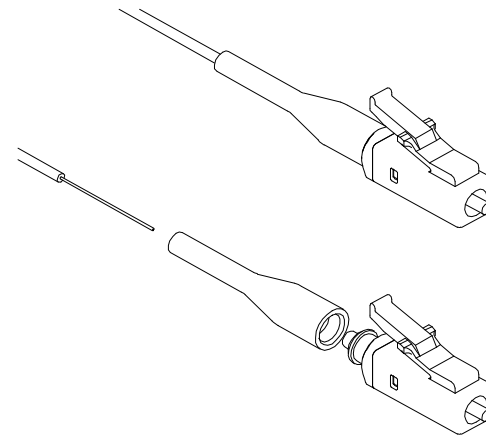
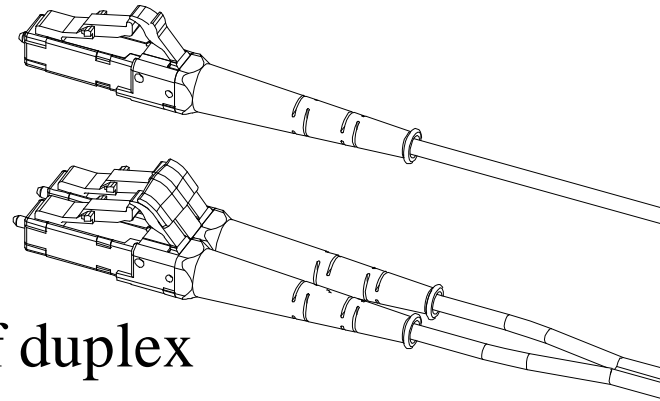
- ◆ RJ-45 Style
  - User friendly (intuitively obvious operation)
  - Familiarity with copper modular plugs
  - No tools
  - Easy insertion and extraction
  - Audible click assures full insertion
  - Low-complexity plastic housing
  - Improved anti-snag latch

# LC Connector Latch Enhancements

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- ◆ Patch Cords
  - Anti-snag feature on latch
  - Easy to disengage
  - Simultaneous disengagement of duplex
  
- ◆ Buffered Fiber Connector and Pigtail
  - Finger catch on latch
  - Extended latching beam
  - Easy to locate and disengage
  
- ◆ Robust Latch
  - Flex tested 1000 times



# LC Connector Feature Advantages

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## ◆ Small Size

- Smaller than RJ-45
- Half size of duplex SC
- PCI mezzanine compliant for NICs
- Lower system complexity
  - » double density panels and hubs
  - » fewer panels and racks, less floor and closet space
  - » same interface for MM and SM
  - » designed for automated manufacturing
  - » alternate ferrule and sleeve materials
  - » no complexity shift

# LC Connector Feature Advantages

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## ◆ Polarized

- Obvious orientation to adapter
- Installs in only one orientation
- Maintains Tx/Rx directions
- No keying
- Repeatable performance
- A / B polarity markings
- Meets TIA 568-A and ISO 11801

# LC Connector Feature Advantages

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- ◆ Color Coded
  - Meets TIA 568-A and ISO 11801
    - » SM blue
    - » MM beige
  - Easily identifiable fiber type
- ◆ Pull-proof
  - Side and axial load tolerant
  - Eliminates accidental disconnections
  - Increases reliability

# LC Connector

## Feature Advantages

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- ◆ Cable Compatible
  - Works readily with installed base
    - » 900  $\mu\text{m}$  buffered (indoor cable)
    - » 250  $\mu\text{m}$  coated (ribbon, loose tube OSP)
    - » standard strength fiber
  - Special fiber or cable **not** required
  - Easy to mount
    - » buffered fiber or cordage
    - » familiar procedure
    - » less polishing
  - Lower complexity
    - » no complexity shifting

# LC Connector

## Feature Advantages

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### ◆ Excellent Performance

- Meets industry opt., mech. and env. standards
  - » TIA 568-A
  - » ISO 11801
  - » Bellcore GR-326
- Design guarantees end-face contact
  - » easily meets 20 / 26 dB return loss
- Pull-proof

# LC Connector

## Feature Advantages

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- ◆ High Reliability
  - Proven technology
  - No inherent fiber bends
  - Durable materials
    - » 500 re-matings
    - » 1000 latch flexures
  - Easily cleaned
  - Low Risk means Lower complexity

# LC Adapters

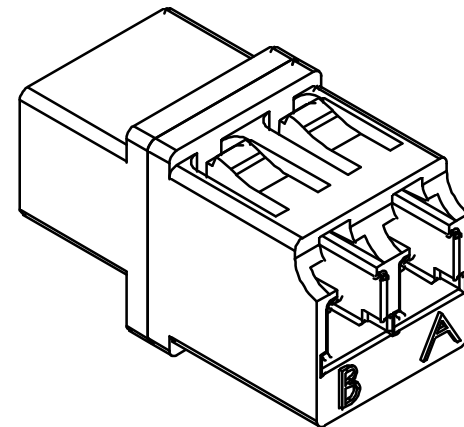
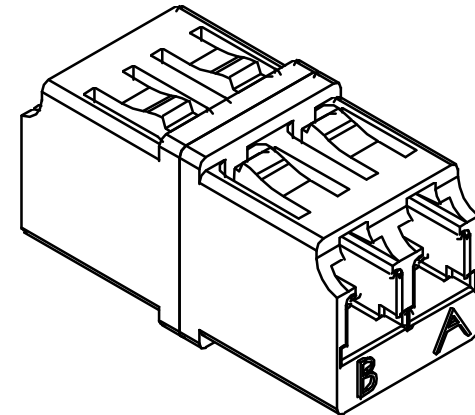
## Features and Advantages

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- ◆ Self adjusting panel latch
  - Adapts to panel thickness
- ◆ Square cross section
  - Choice of mounting orientation
- ◆ Compact duplex designs
  - Panel and board mount
  - 4-piece snap assembly
- ◆ Fits standard RJ-45 cutout
  - M81 LC mounting collar
- ◆ Labeled polarity
  - Meets TIA 568A and ISO 11801



# LC Connector Transceiver Interface

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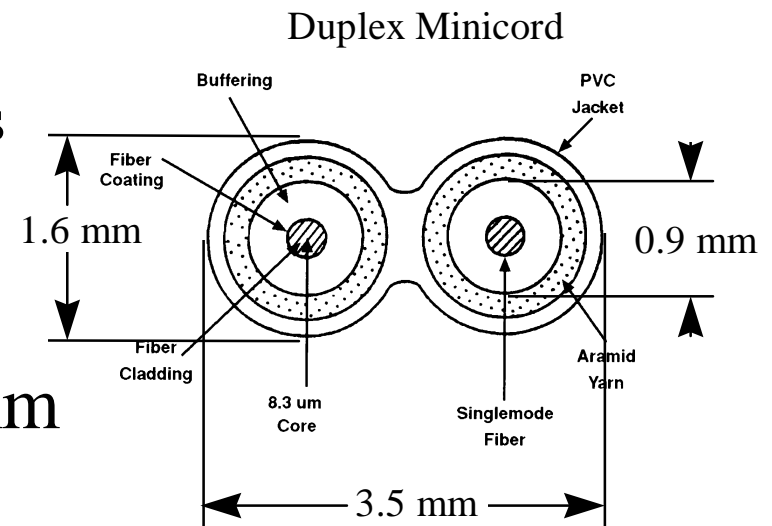
- ◆ Maximize hub density
  - Needs less panel space than UTP jack
- ◆ PCI mezzanine compliant
  - Compatible with PC NICs
- ◆ No complexity shifting
  - Familiar, miniaturized design
- ◆ Low insertion and withdrawal force
- ◆ LC transceiver suppliers
  - Finisar
  - Working with others

# LC Connector MiniCordage

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- ◆ Small diameter - 1.6 mm simplex
  - Alleviates trough congestion
  - Simplex, duplex zipcord, and quad
  - Duplex size 66% of 2.9 mm ribbon cord
- ◆ Excellent performance
  - Made for pull-proof connectors
  - Tight bend radius (1 inch)
  - GR- 409 Bellcore compliant
- ◆ Lower complexity than 3.0 mm zipcord



# LC Standards, Licensing and Availability

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- ◆ Standards
  - Actively working standards
    - » TIA FO6.3 FOCIS work item approved
    - » IEC 86B WG 6: submission approved by USTAG
- ◆ Broadly Licensing
  - Actively negotiating with several companies
- ◆ Availability - **NOW**
  - Limited production since September 1996
  - Full Production since August 1, 1997
  - 5 beta sites in progress (>50,000 connectors)

# LC Performance

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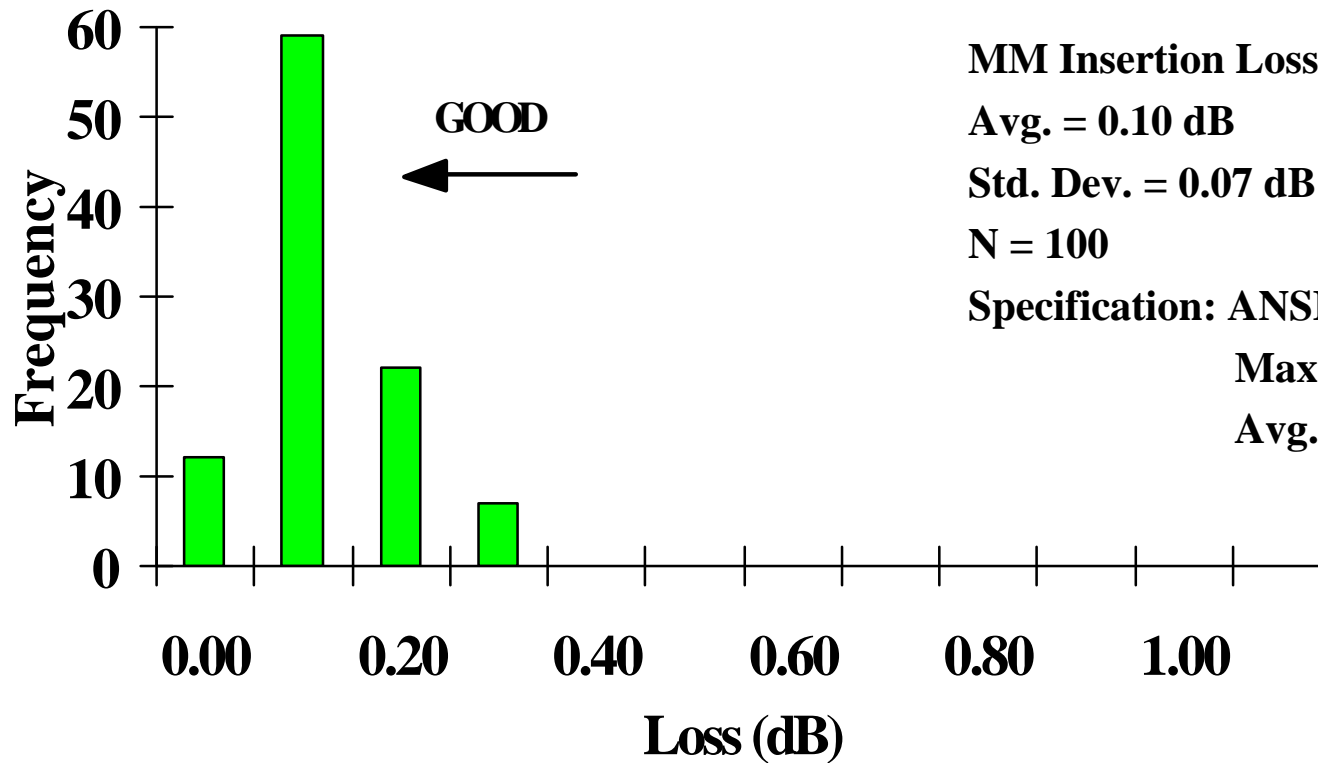


- ◆ Optical
- ◆ Environmental
- ◆ Mechanical

# Optical Performance

## Multimode - Insertion Loss

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**MM Insertion Loss**

**Avg. = 0.10 dB**

**Std. Dev. = 0.07 dB**

**N = 100**

**Specification: ANSI/TIA/EIA-568-A**

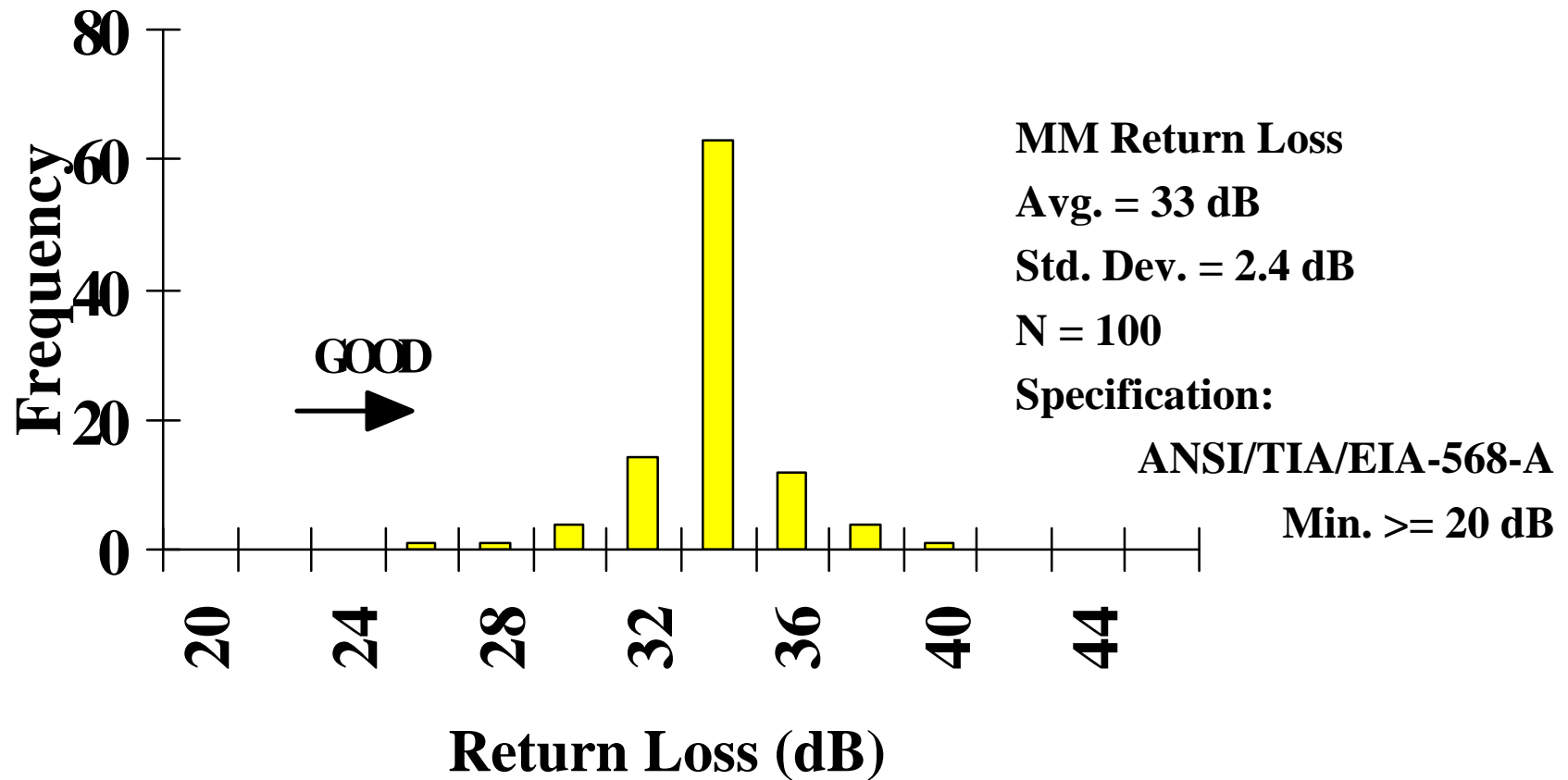
**Max.  $\leq$  0.75 dB**

**Avg.  $\leq$  0.5 dB**

# Optical Performance

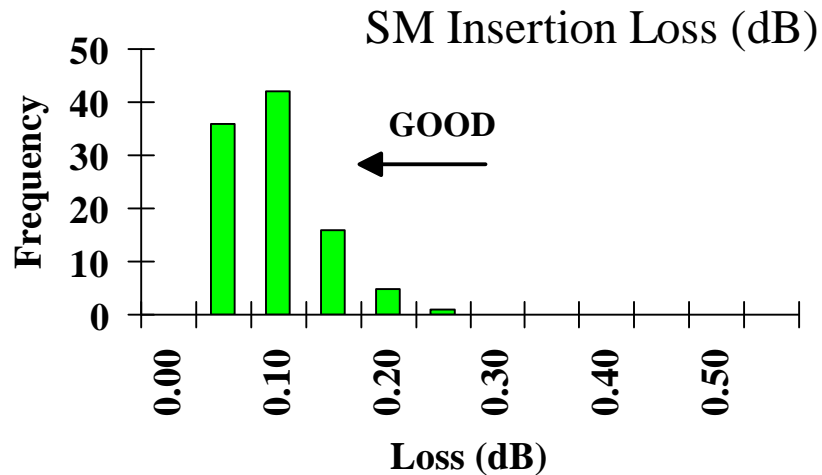
## Multimode - Return Loss

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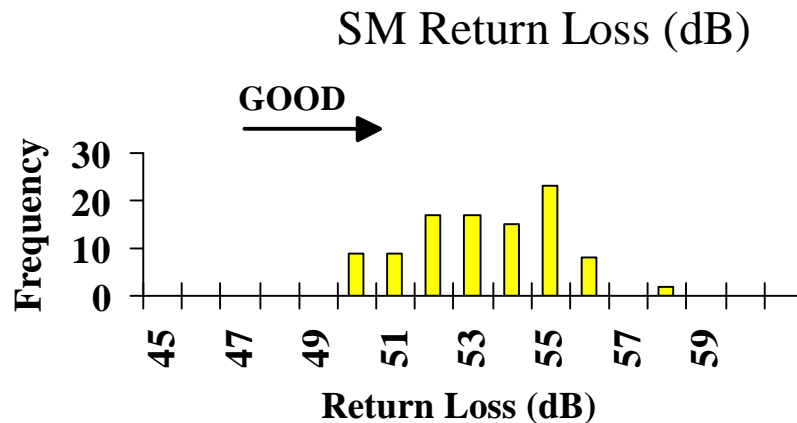


# Optical Performance Singlemode

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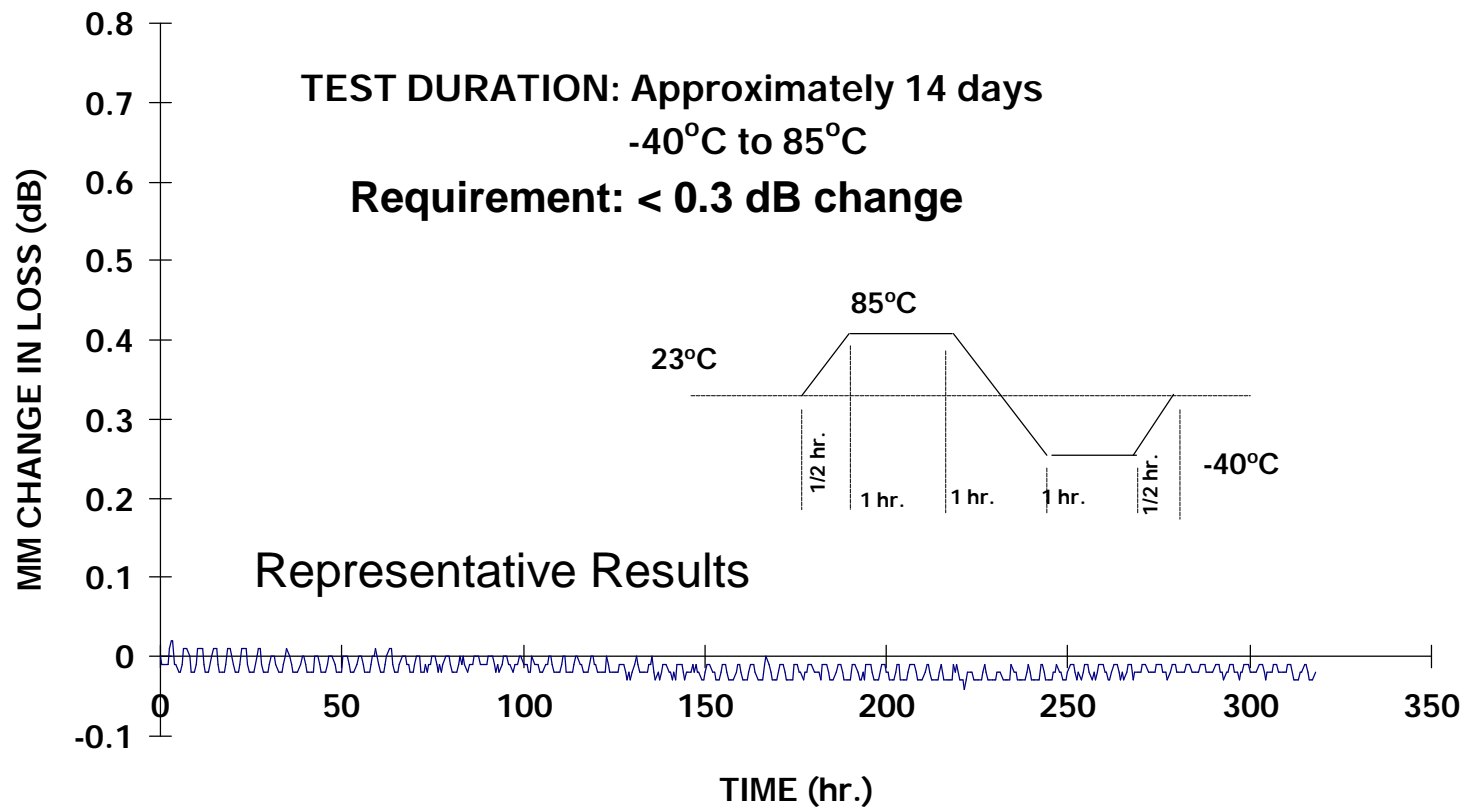
**SM Loss**  
Avg. = 0.09 dB  
Std. Dev. = 0.05 dB  
N = 100  
Specification :  
ANSI/TIA/EIA-568-A  
Max.  $\leq$  0.75 dB  
Avg.  $\leq$  0.5 dB



**SM Return Loss**  
Avg. = 53 dB  
Std. Dev. = 1.9 dB  
N = 100  
Specification :  
ANSI/TIA/EIA-568-A  
Min.  $\geq$  26 dB

# Environmental Performance Multimode

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# Mechanical Performance

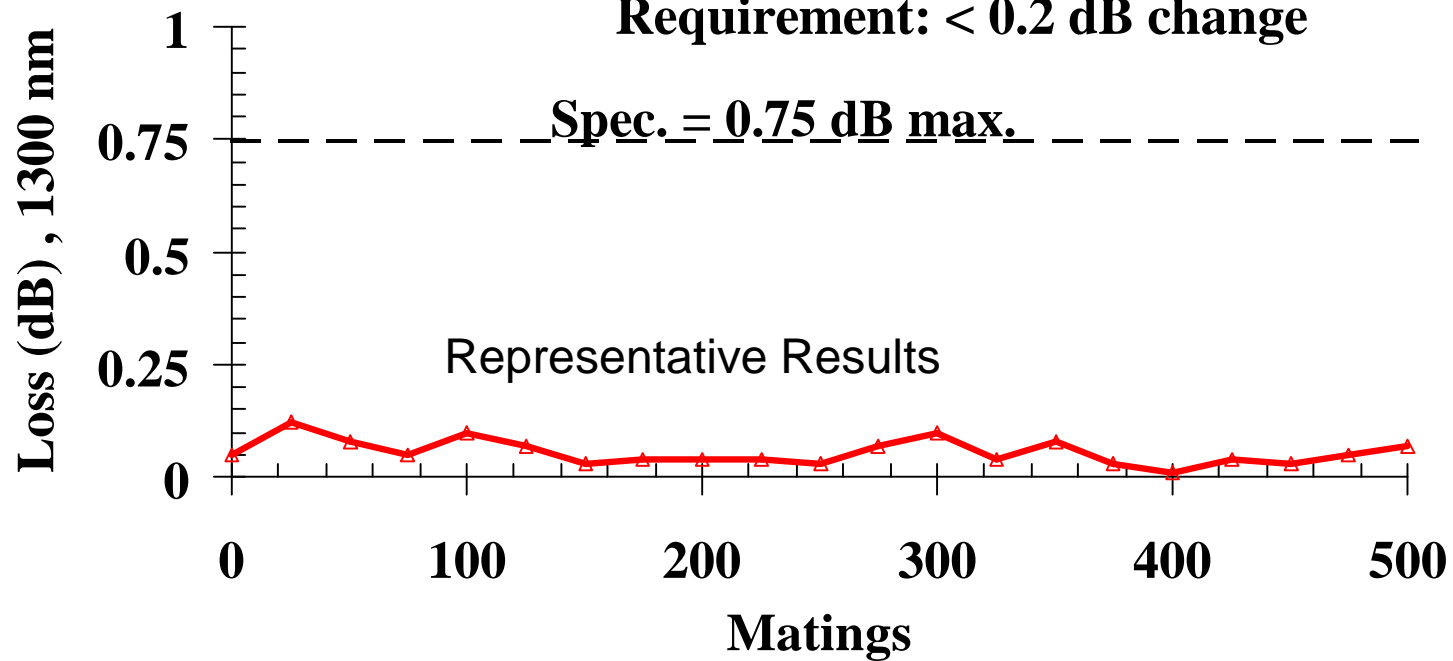
## Mating Durability

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### Multimode 62.5 Micron Fiber

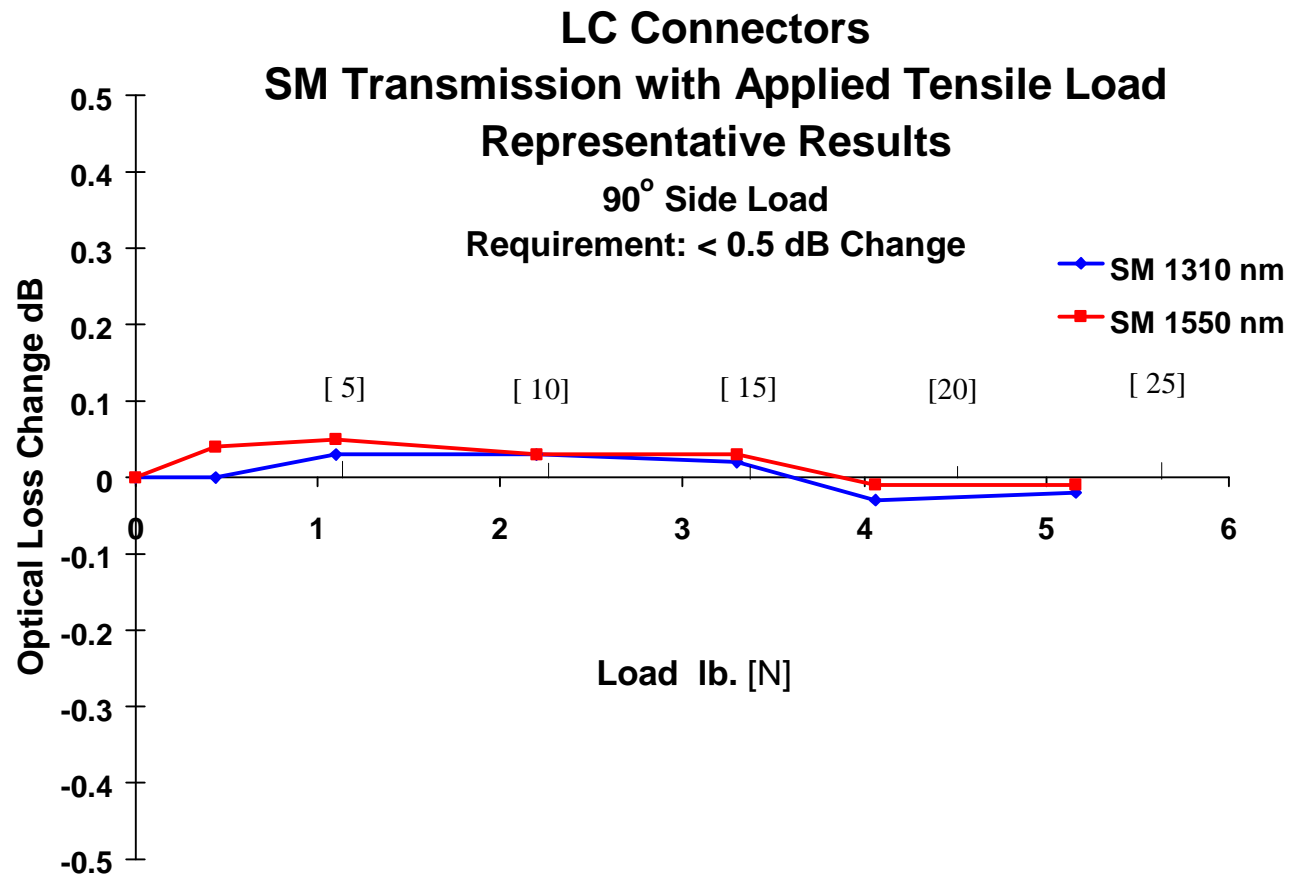
Requirement:  $< 0.2$  dB change



# Mechanical Performance

## Tensile Load - Singlemode

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# Performance Specification

## Multimode

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- ◆ Insertion Loss
  - 0.10 dB average, 0.10 dB standard deviation
- ◆ Return Loss
  - 33 dB average
- ◆ Temperature Cycling
  - -40 to +85 C; loss change < 0.30 dB
- ◆ Mating Durability
  - 500 matings; loss change < 0.2 dB
- ◆ Tensile Loading
  - 0 deg, 10 lbs < 0.2 dB
  - 90 deg, 5 lbs < 0.2 dB

# Performance Specification

## Singlemode

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- ◆ Insertion Loss
  - 0.10 dB average, 0.07 dB standard deviation
- ◆ Return Loss
  - 50 dB minimum
- ◆ Temperature Cycling
  - -40 to +85 C; loss change < 0.30 dB
- ◆ Mating Durability
  - 500 matings; loss change < 0.2 dB
- ◆ Tensile Loading
  - 0 deg, 10 lbs < 0.2 dB
  - 90 deg, 5 lbs < 0.2 dB

# LC Connector Summary

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- ◆ Lower system complexity
- ◆ RJ-45 housing
  - The most user friendly
  - 1/2 size of duplex MM SC
- ◆ Proven, reliable technology
- ◆ Compatible with embedded fiber base
- ◆ Will broadly license
- ◆ Actively working standards

# LC Connector Conclusion

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- ◆ Bell Labs invented the ST connector
  - Standard for 10BASE-F
  - Grandfathered in TIA 568-A and ISO 11801
  - Most popular optical connector in the world
- ◆ Bell Labs also invented the modular plug
  - Most prevalent copper connector worldwide
- ◆ The LC combines the best of both
  - Proven technology of the ST
  - Miniaturized and embodied in a modular plug
- ◆ Examine all facts from a total system perspective
  - The LC is the best choice