CBT2G-19-0077

IEEE P802.3

Multi-Gig Optical Ethernet (OMEGA) Study Group

# Optical Fiber Harness for Multi-XG Automotive Applications

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SUMITOMO ELECTRIC GROUP

# Motivation

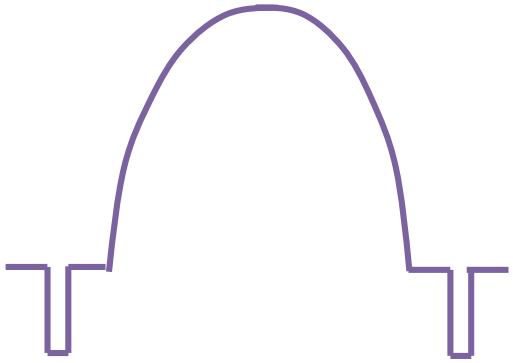
**Can industry provide optical harnesses to meet OMEGA requirement?**

- Support technical feasibility of multi-gigabit optical technology with test result of the optical loss performances and the reliabilities of a possible optical harness for automotive

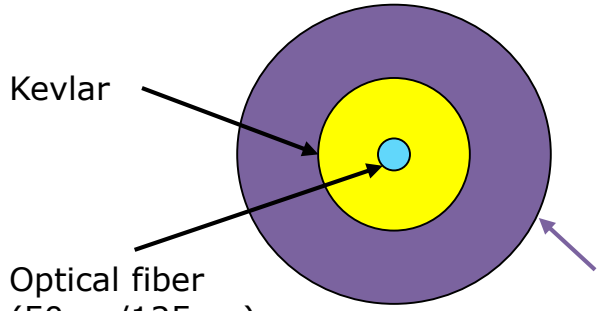
- To estimate the optical loss budget for OMEGA application

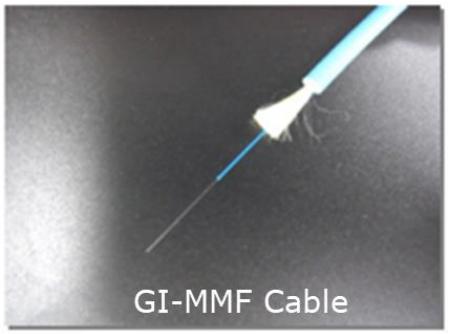
# Optical Harness for Automotive

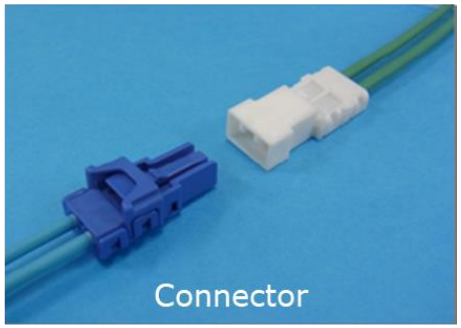
**Tested cable: Sumitomo BIMMF (Bend insensitive multimode fiber) cable**
**Tested connector: Sumitomo original duplex optical connector**



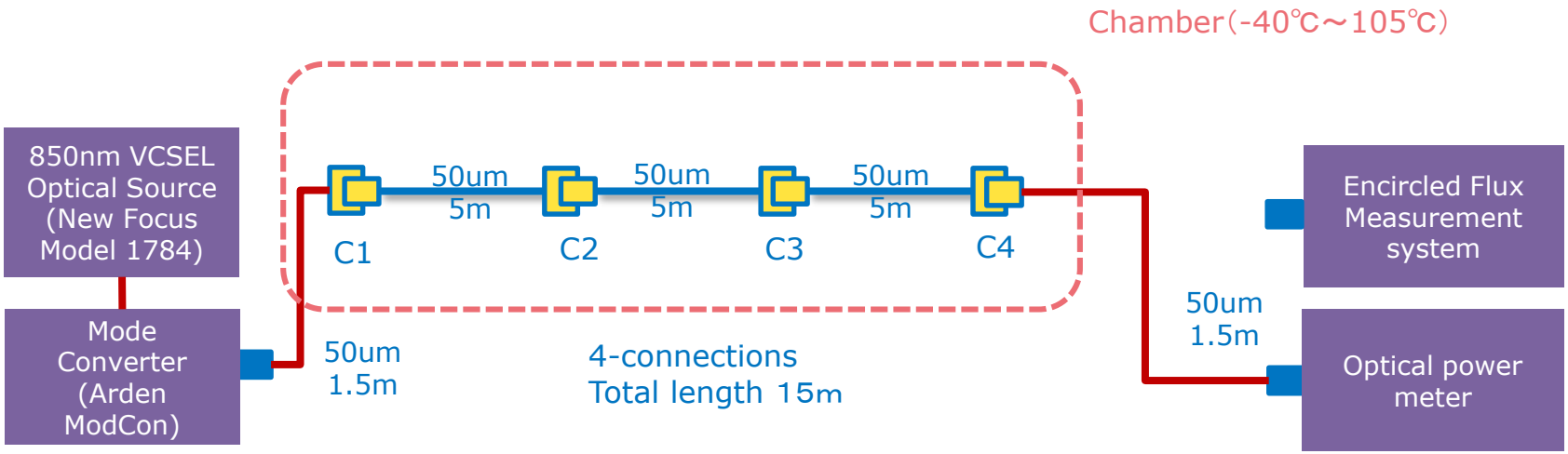
Numerical aperture profile

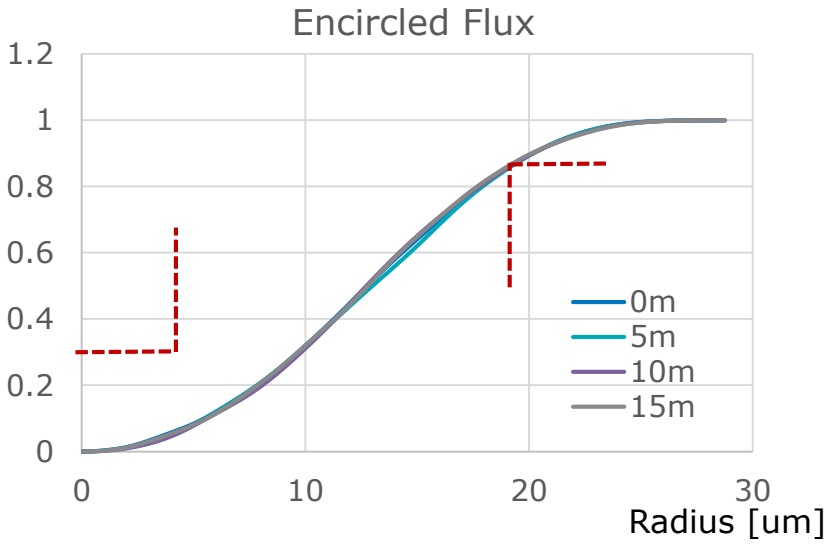


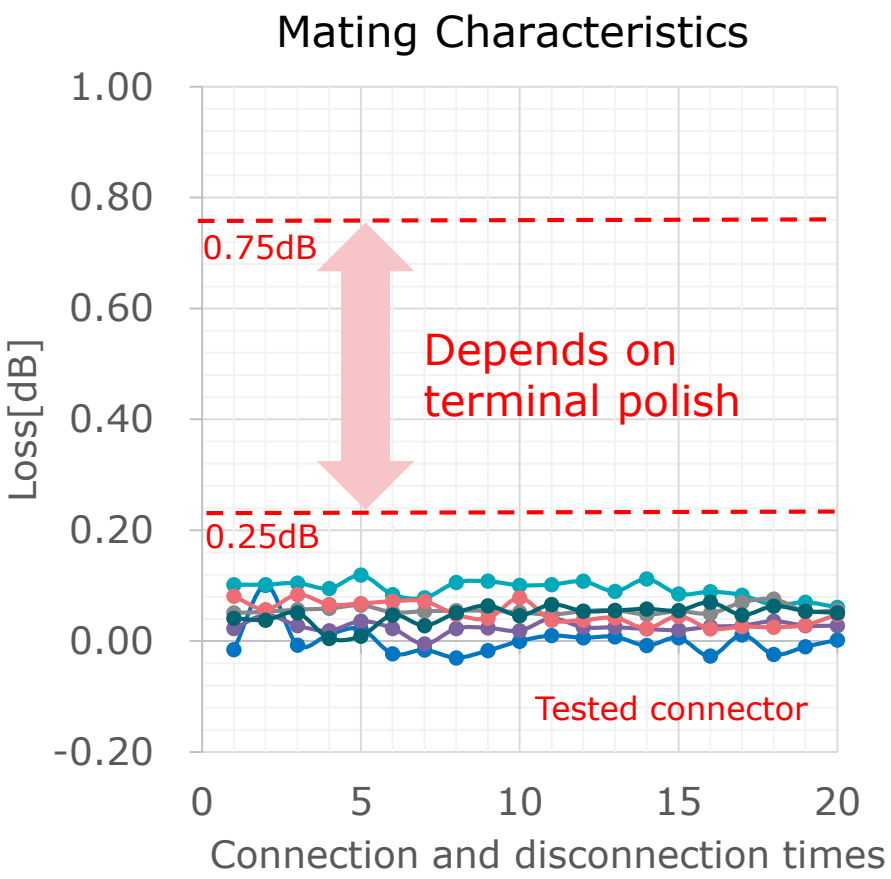
# Evaluation: Input condition



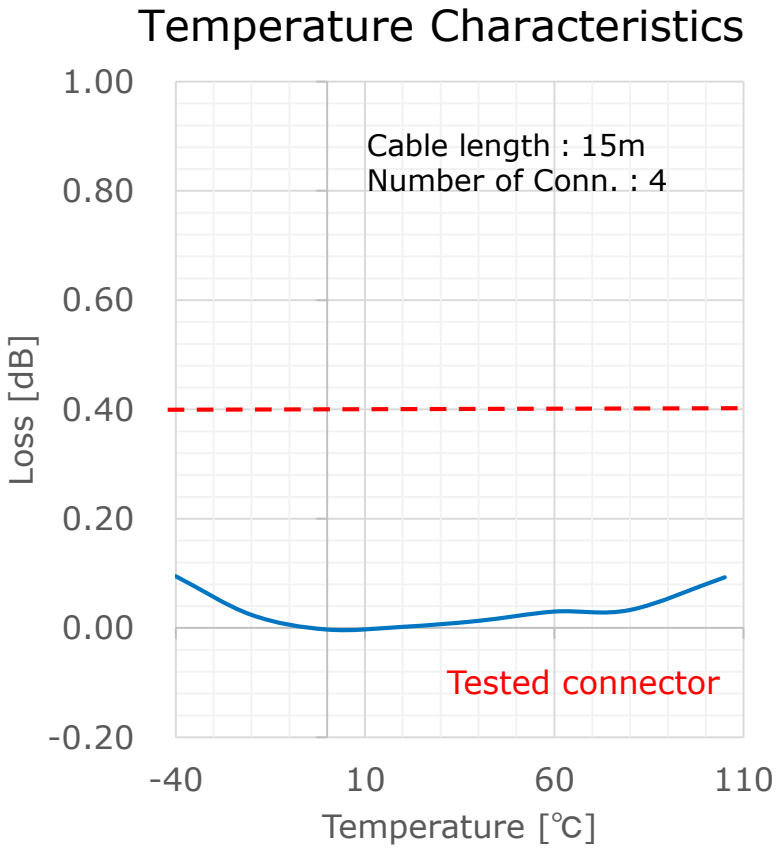




| Input Condition | |
|---|---|
| Encircled Flux | >= 86% @19um<br><=30% @ 4.5um |

# Evaluation: Connection Loss



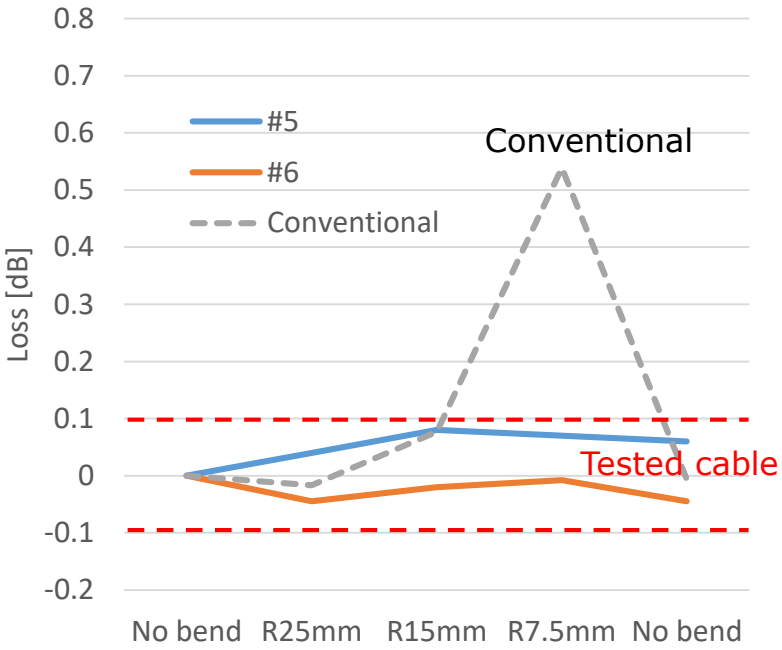

Change of loss: ~0.1dB
(worst ~ 0.75dB:Fiber Channel Grade: Std. Field Polish)




Change of loss:~0.1dB
(worst ~ 0.4dB)

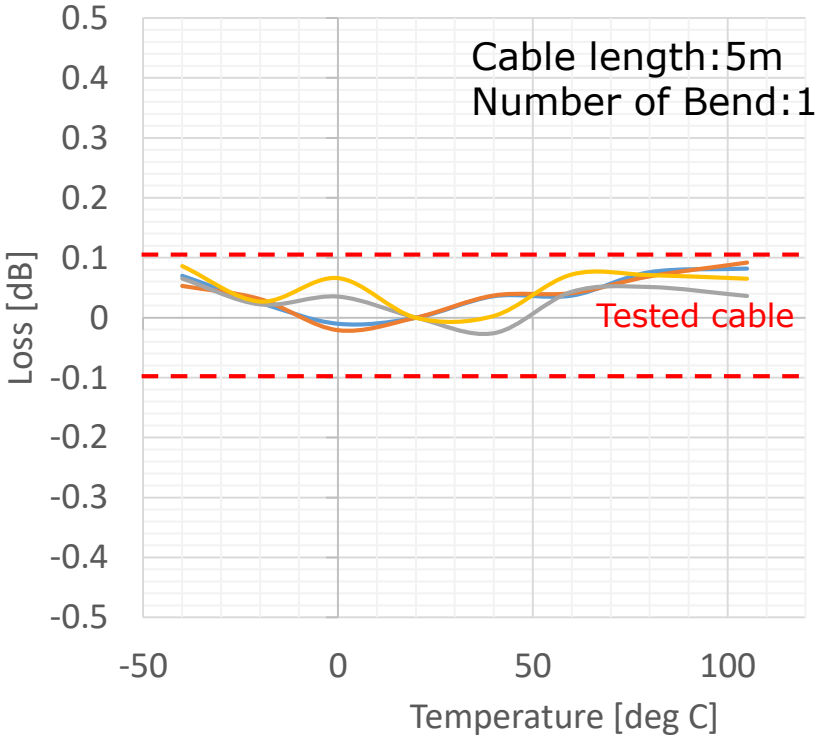
# Evaluation: Bending Loss

Bend Radius：R25, R15, R7.5mm
Condition： 1-turn



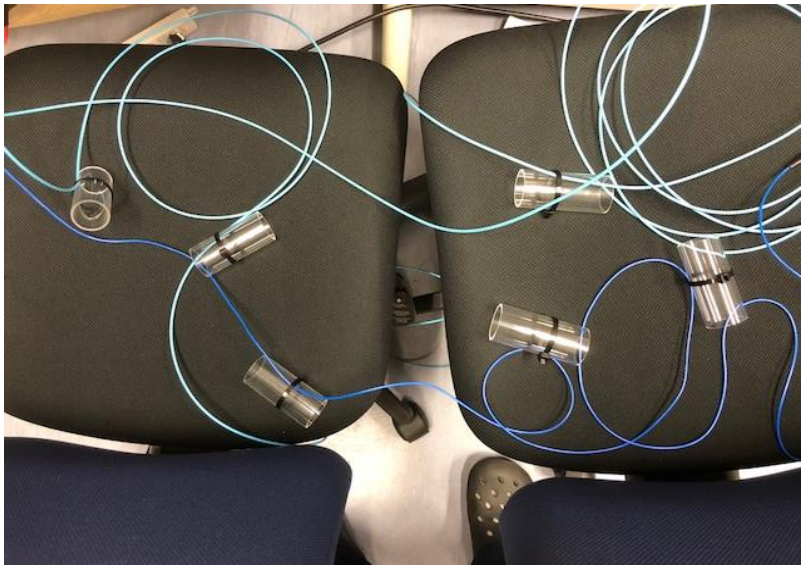

Change of loss: ～0.1dB

Temperature Characteristics
（R=7.5mm）




Change of loss：～0.1dB

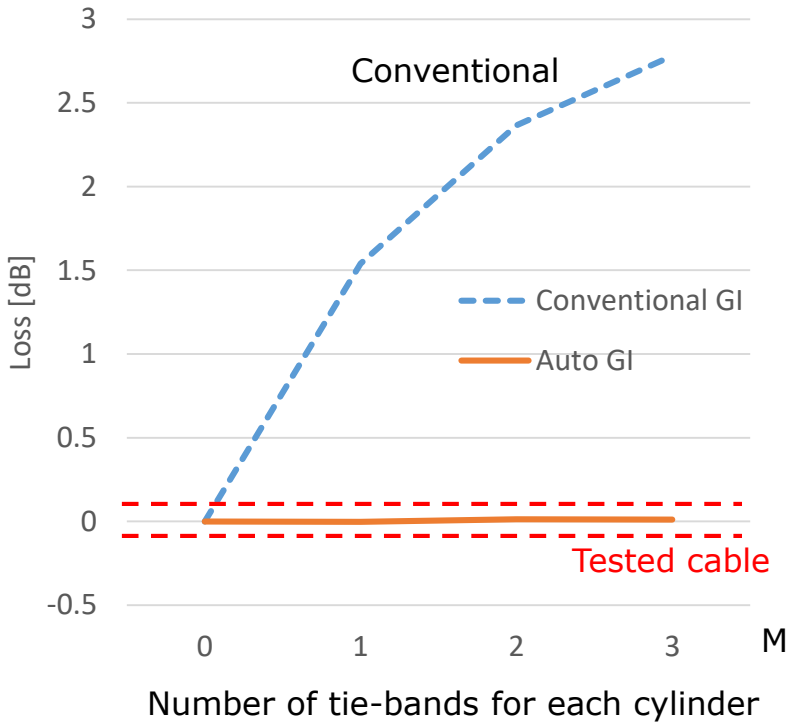
# Evaluation: Tie-band Stress



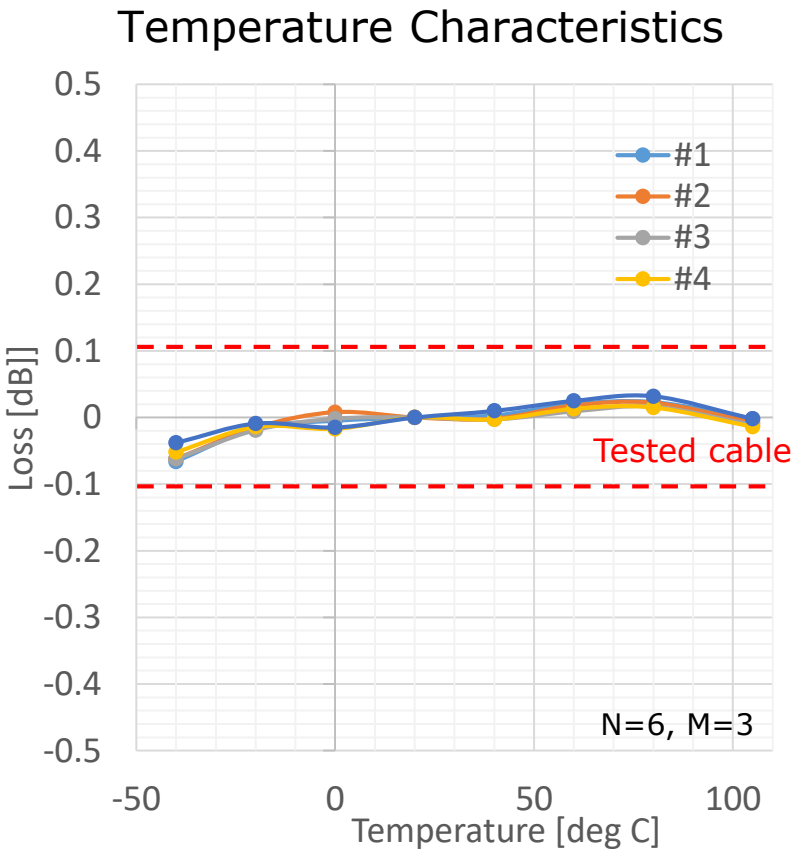
Fixture
Outer diameter: 35mm
Acrylic cylinder: N = 6
Tie-bands for each cylinder: M=1~3


TIEMATE MK9RE-F
Hellermann Tyton
Setting：3.75(～100N)

# Evaluation: Tie-band Stress



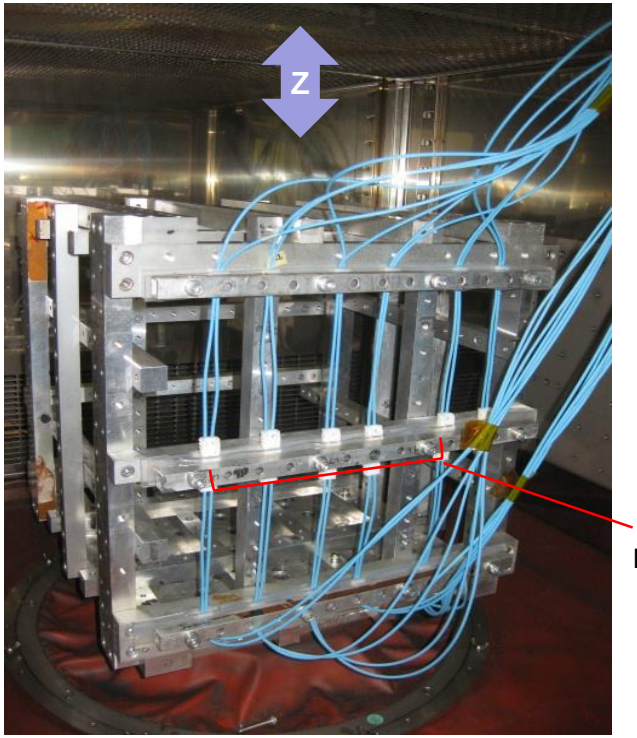

Change of loss: ~0.1dB

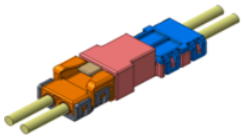


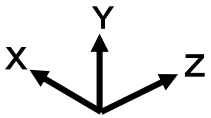

Change of loss：~0.1dB

# Evaluation: Vibration Test

■ Tolerance (Vibration)

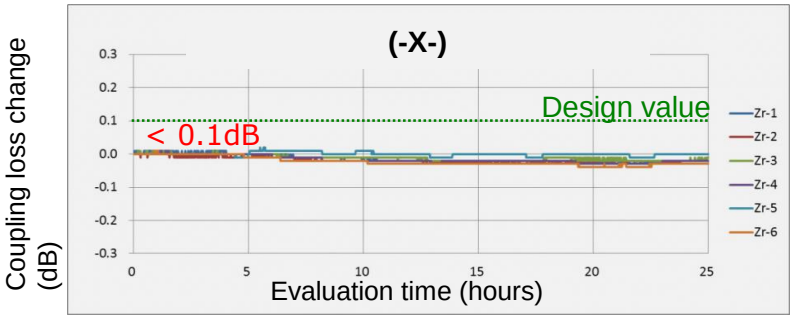


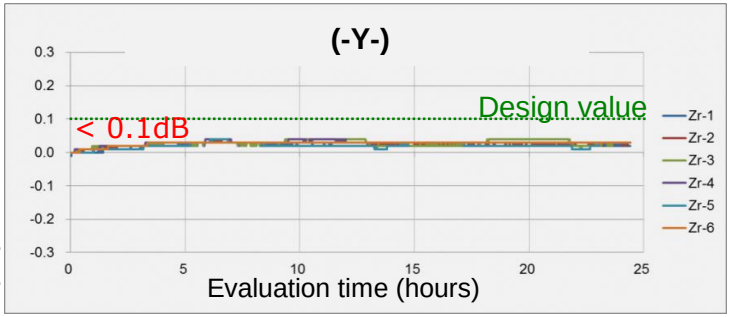



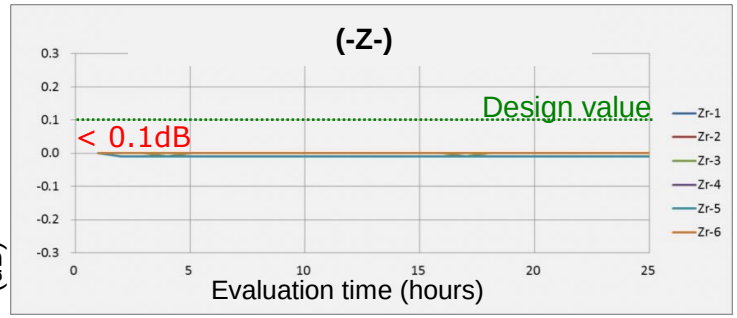



Inline connectors

**Vibration with temperature overlap**



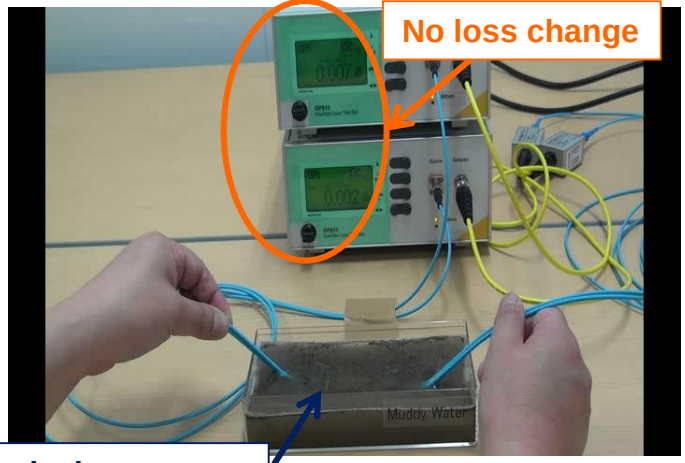



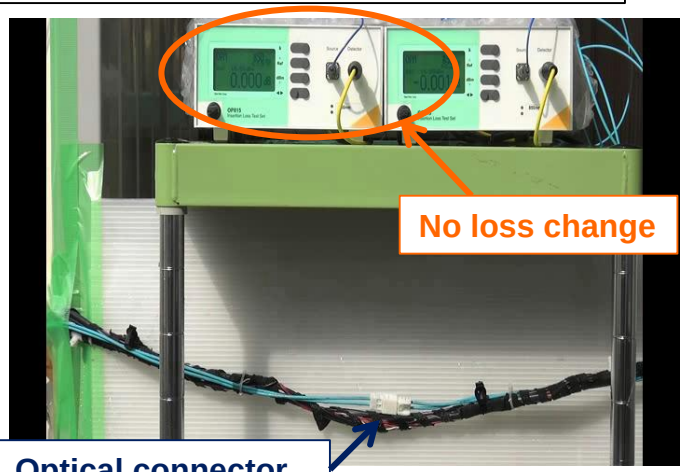

**Change of loss during evaluation was under 0.1dB.**

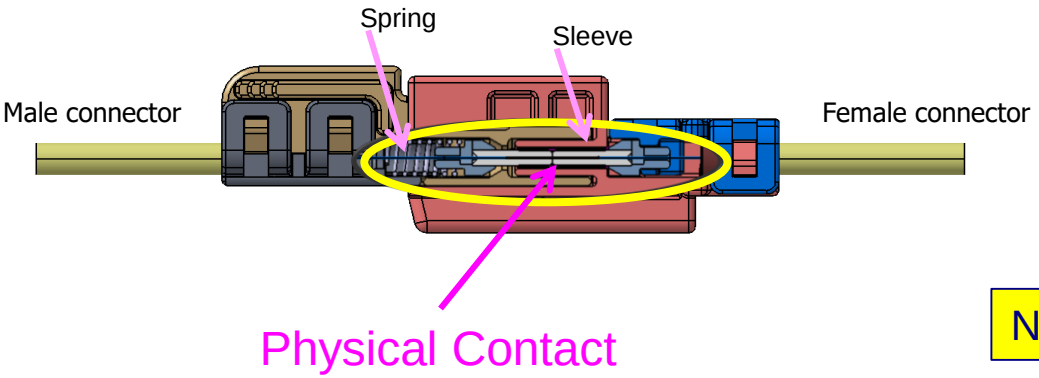
# Evaluation: Water Resistivity

Soak in water




High-pressure washing machine



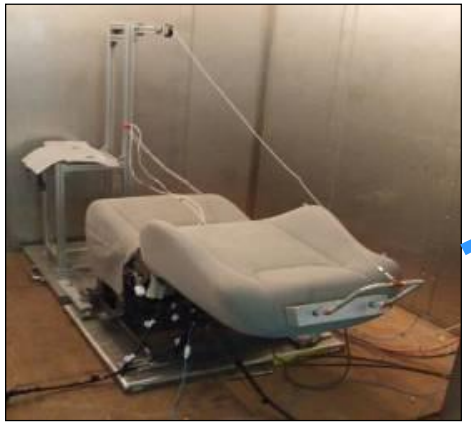



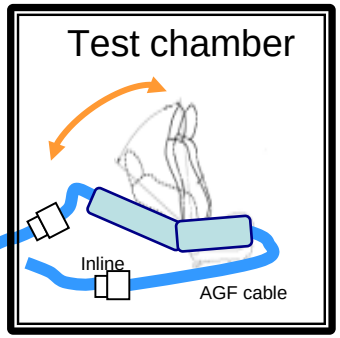

No Loss Change

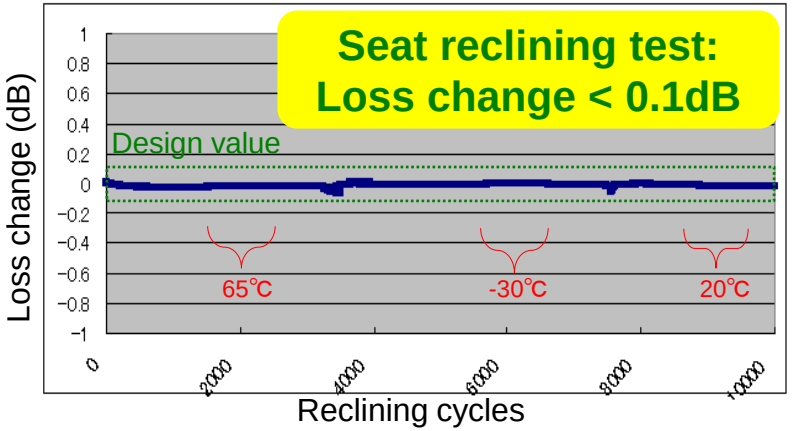
# Evaluation: Seat Stress Test

■ Reliability (Harness layout)

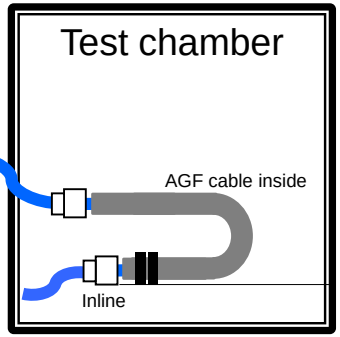
Seat reclining test image

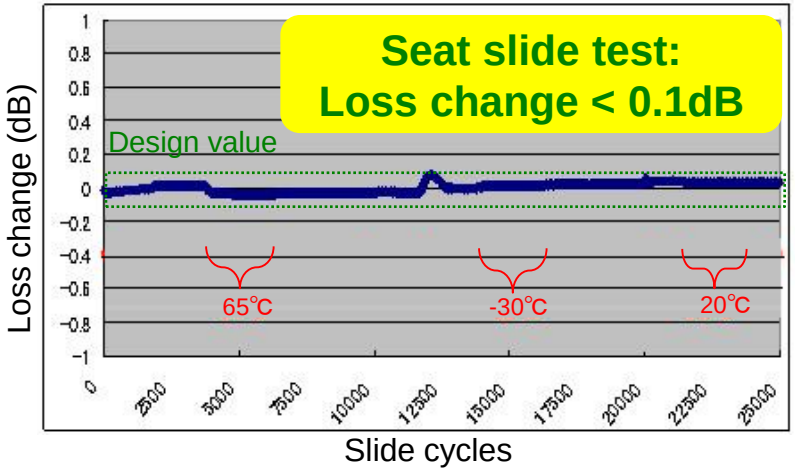




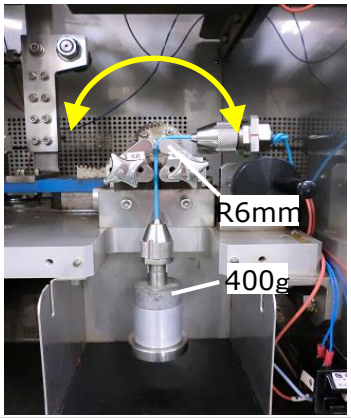




Seat slide test image



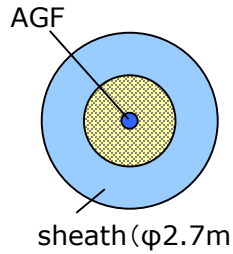
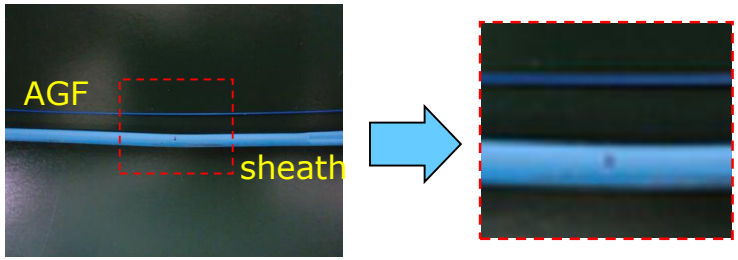
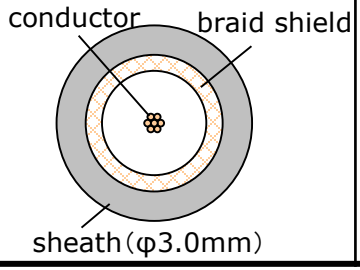
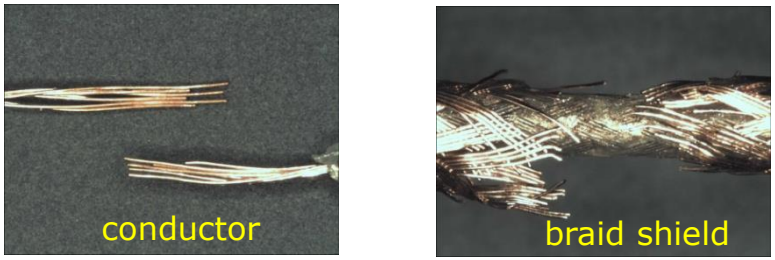



# Evaluation: Bending Test




**Test Condition**

- Bending angle :±90 degree
- Timing : 60cycles/minute
- Mandrel radius : 6mm
- Weight : 400g
- Temperature : 23℃

| Cable | Cycles | Result | |
|---|---|---|---|
| Optical Cable   | 1,000,000 |   | No failure |
| Co-Axial Cable (ref.)   | 10,000 |   | Disconnection of braid shield and conductor |

# Reliability Test Results

Optical Connector

| Test Item | Samples | Result |
|---|---|---|
| Thermal pistoning | 5 | no pistoning |
| Temperature resistance | 5 | max. 0.09dB |
| Temperature change | 5 | max. 0.42dB |
| Temperature stages | 5 | max. 0.42dB |
| Humidity heat cyclic | 5 | max. 0.11dB |
| Temperature shock | 5 | max. 0.25dB |
| Torsion of contacts | 3 | no loss increase |
| Mechanical Shock | 3 | max. 0.01dB |
| Vibration with temperature overlap | 3 | max. 0.03dB |
| Impact test | 3 | no loss increase |
| Dust protection | 3 | max. 0.15dB |
| Plugging frequency | 5 | max. 0.38dB |
| Plug force and pull force | 5 | max. 20.6N |
| Pull-off force of the housing parts | 5 | min. 131.7N |
| Continuous pull/tension at the fiber | 2 | max. 0.05dB |
| Resistance against chemical material | 2 | max. 0.06dB |
| Resistance against noxious gas | 4 | no loss increase |

# Loss Budget : L=15m

Fiber Channel Grade C (Standard Field Polish)

| L=15m | In-line conn. 1pc | In-line conn. 2pcs | In-line conn. 3pcs | In-line conn. 4pcs |
|---|---|---|---|---|
| Connector Insertion Loss Random @ Room Temp. | Mean. <= 0.30dB | Mean. <= 0.60dB | Mean. <= 0.90dB | Mean. <= 1.20dB |
| | Std.Dev. = 0.15dB | Std.dev. = 0.21dB | Std.Dev. = 0.26dB | Std.Dev. = 0.30dB |
| | Max.(3σ) = 0.75dB | Max.(3σ) = 1.23dB | Max.(3σ) = 1.68dB | Max.(3σ) = 2.10dB |
| Connector ΔIL (Temp. Change) | <= 0.4dB | <= 0.8dB | <= 1.2dB | <= 1.6dB |
| Connector ΔIL (total) | <= 1.15dB | <= 2.03dB | <= 1.88dB | <= 3.70dB |
| Harness ΔIL (total) | <= 0.3dB | <= 0.3dB | <= 0.3dB | <= 0.3dB |
| (Aging) Margin | 1.0dB | 1.0dB | 1.0dB | 1.0dB |
| **TOTAL (Worst)** | **2.45dB** | **3.33dB** | **4.18dB** | **5.00dB** |

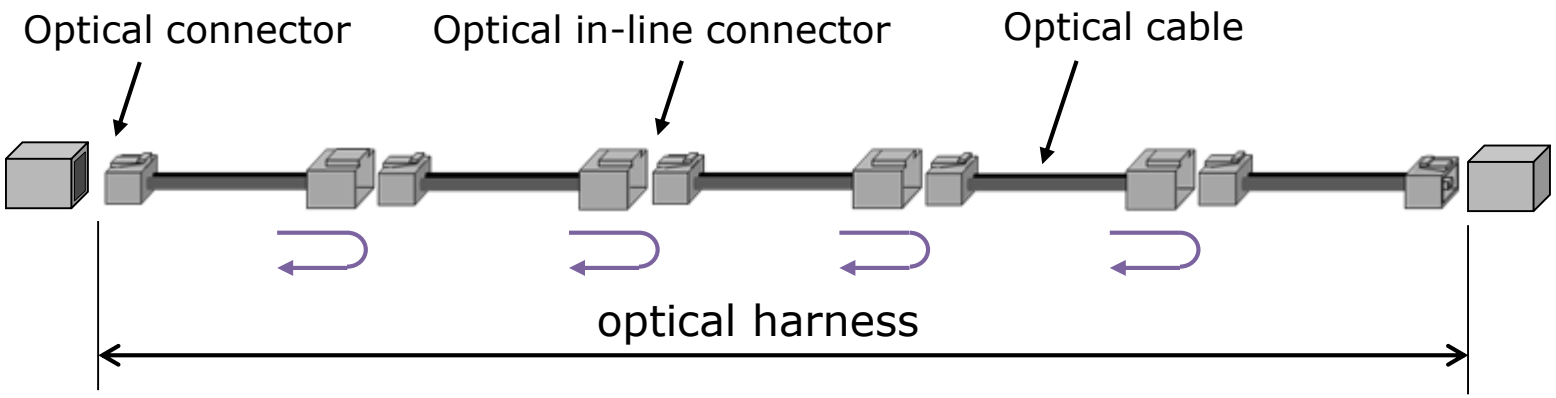
# Loss Budget : L=50m

Fiber Channel Grade C (Standard Field Polish)

| L=15m | In-line conn. 1pc | In-line conn. 2pcs | In-line conn. 3pcs | In-line conn. 4pcs |
|---|---|---|---|---|
| Connector Insertion Loss Random @ Room Temp. | Mean. <= 0.30dB | Mean. <= 0.60dB | Mean. <= 0.90dB | Mean. <= 1.20dB |
| | Std.Dev. = 0.15dB | Std.dev. = 0.21dB | Std.Dev. = 0.26dB | Std.Dev. = 0.30dB |
| | Max.(3σ) = 0.75dB | Max.(3σ) = 1.23dB | Max.(3σ) = 1.68dB | Max.(3σ) = 2.10dB |
| Connector ΔIL (Temp. Change) | <= 0.4dB | <= 0.8dB | <= 1.2dB | <= 1.6dB |
| Connector ΔIL (total) | <= 1.15dB | <= 2.03dB | <= 1.88dB | <= 3.70dB |
| Harness ΔIL (total) | <= 0.9dB | <= 0.9dB | <= 0.9dB | <= 0.9dB |
| (Aging) Margin | 1.0dB | 1.0dB | 1.0dB | 1.0dB |
| **TOTAL (Worst)** | **3.05dB** | **3.93dB** | **4.78dB** | **5.60dB** |

# Return Loss Budget

| | In-line conn. 1pc | In-line conn. 2pcs | In-line conn. 3pcs | In-line conn. 4pcs |
|---|---|---|---|---|
| Connector Return Loss (incl. ΔTemp) | < -20dB | < -17dB | < -15.2dB | < -14dB |



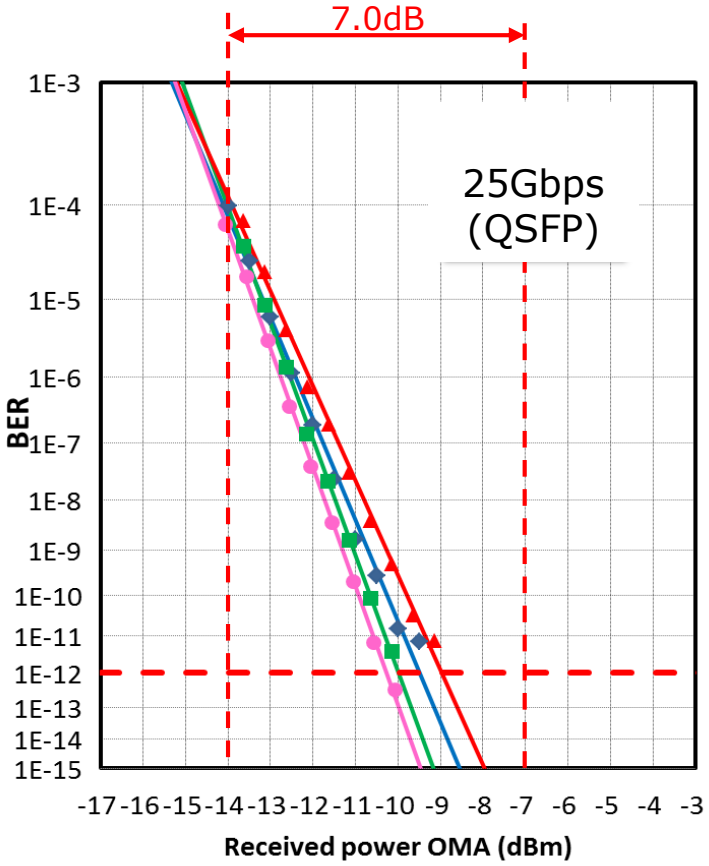
# Summary

Tested BIMMF based optical fiber cable and connector have a good performance and reliability for automotive applications

- Optical attenuation :
  - less than 0.3dB (15m),
  - less than 0.9dB (50m)
- Optical connection loss:
  - less than 3.7dB
    (4 in-line connections)
- Optical return loss :
  - less than -14dB
    (4 in-line connections)

- 15m, 4 inline connections :
  5.00dB (incld. 1.0dB margin)

- 50m, 4 inline connections :
  5.60dB (incld. 1.0dB margin)



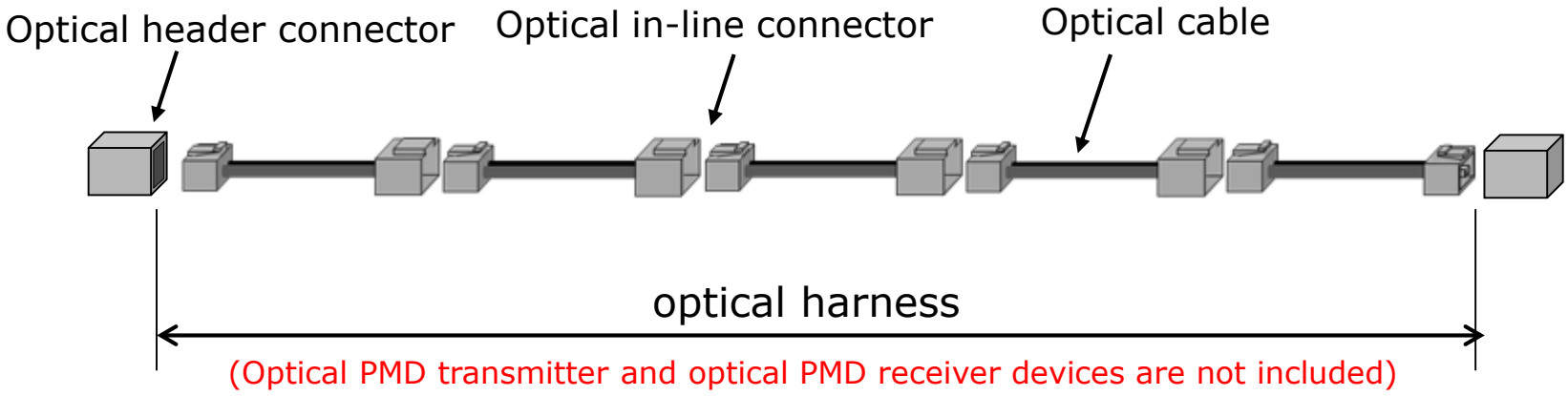

More margin should be necessary to achieve 50Gbit/s or higher data rates

# ISO/PWI 24581

TC22/SC32/WG10 is now working for the standardization of the optical fiber harness for automotive application.

## Title:

**General requirements and test methods of in-vehicle optical harnesses for up to 100Gbit/s communication**



ANTech

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