THORLABS

Qualification Test Report

1300 nm Wideband Coupler Qualification Test Report

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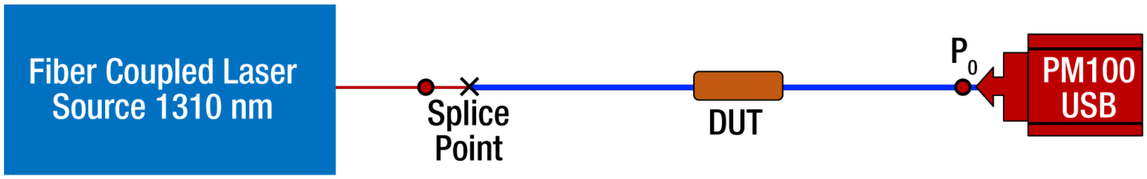
Fiber Optic Coupler Qualification Test Report



Thorlabs designs and manufactures a line of fused couplers. In this document, our couplers undergo a reliability testing program inspired by Telcordia GR-1221 standard for uncontrolled environment. These couplers underwent mechanical integrity testing including mechanical shock, vibration, and fiber side pull. They were also tested in damp heat, during high and low temperature storage, and during temperature cycling.

No failures were found during this test program confirming that they can be reliably used in uncontrolled environments.

Introduction

Thorlabs is an innovative developer and manufacturer of high-performance, high reliability, and cost-effective fiber optical components based on fused bi-conical taper technology. Capitalizing on a portfolio of patents, proprietary and state-of-the-art fiber fusion processes, Thorlabs offers a full line of fused fiber products such as power splitters/combiners, wavelength splitters/combiners (WDM), polarization maintaining (PM) fiber splitters/combiners and finds its products used in a wide range of applications such as telecommunication, OCT, test instrumentation, and in fiber optic sensors.

The purpose of this reliability testing program is to both demonstrate that the component is capable of reliable operation over a variety of environments over an extended period and to qualify the component and its manufacturing process for volume production.

This test report presents the results of a reliability test program performed on Thorlabs fused couplers that have a 90:10 split ratio. As shown in figure 1 below, the 1300 nm Single Mode Fused Fiber Optic Coupler consists of two input fibers (Port 1 & 2) and two output fiber (Port 3 & Port 4). It allows a single fiber input to be split into 2 outputs or vice versa. The 1300 nm Single Mode Fused Fiber Optic Coupler under test in this report injects light into input port 1. Port 3 and port 4 would then be considered the tap and signal outputs, respectively.

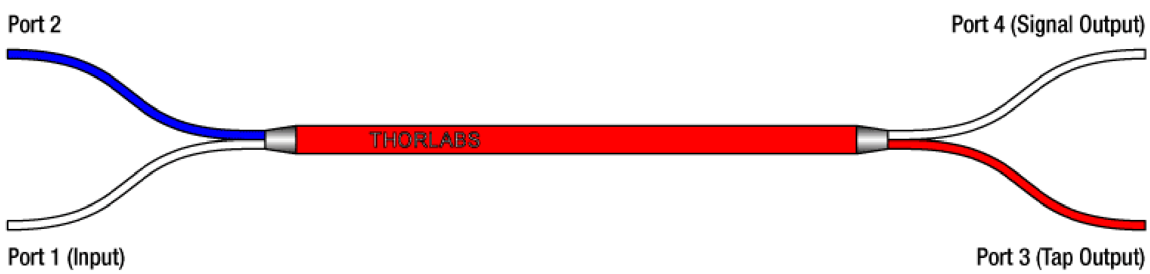


Figure 1 Schematic of a 1300 nm Single Mode Fused Fiber Optic Coupler

Part 1. Qualification Test

1.1. Test Conditions

This test program is inspired by Telcordia standard, "Generic Reliability Assurance Requirements for Passive Optical Components", Issue 2. The test conditions chosen for this test program are those for uncontrolled (UNC) environments, which are some of the most stringent test conditions for passive components. (See Table 1 for detailed test conditions).

Group	Test	Reference	Conditions	Sampling[a]		
				LTPD	SS	C
1	Mechanical Shock	MIL-STD-883, Method 2002	Acceleration: 500 g Pulse width: 1 ms Pulse shape: Half-Sine Number of directions: 6 Number of shocks per direction: 5	20	11	0
	Vibration	MIL-STD-883 Method 2007, Condition A	Acceleration: 20 g Frequency range: 20 to 2000 Hz Duration: 4 minutes/cycle Number of cycles per axis: 4 Axes: X, Y, Z	20	11	0
	Fiber Side Pull	GR-1209-CORE	0.23 kg, 90°, 5 sec, 2 directions	20	11	0
2	Damp Heat	MIL-STD-883 Method 103	85 °C (±2 °C), 85% (±5%) RH for 2000 hrs	20	11	0
3	High Temperature Storage (Dry Heat)	EIA/TIA-455-4A	85 °C (±2 °C), <40% RH for 2000 hrs	20	11	0
4	Low Temperature Storage	EIA/TIA-455-4A	-40 °C (±5 °C), Uncontrolled RH for 2000 hrs	20	11	0
5	Temperature Cycling	MIL-STD-883 Method 1010	-40 °C to 85 °C (±2 °C), 400 cycles with a pause of 10 minutes at room temperature	20	11	0

a. LTPD is Lot Tolerance Percent Defective; SS is Sample Size, and C is Number of Acceptable Failures

Table 1 Qualification Test Conditions

1.2. Pass/Fail Criteria

Parameter	Test Limits
Insertion Loss Change (ΔIL)	≤ 0.2 dB
Coupling Ratio	± 1.5%

Table 2 Pass/Fail Criteria

1.3. Component Description

The couplers tested in this qualification program are 2x2 1300 nm Single Mode Fused Fiber Optic Couplers with a 90:10 split ratio. All these components were manufactured by Thorlabs using Thorlabs proprietary fusion and tapering, packaging and assembly technology.

1.4. Test Summary

As detailed in Table 1, the test program consisted of five test groups, with a sample size (SS) of 11. Both mechanical shock and vibration tests were performed by NTS – Environmental and Mechanical Testing Laboratory, Thorlabs' contract laboratory. All other tests were performed at Thorlabs.

1.5. Test and Measurement Equipment

All test and measurement equipment used for this qualification program are within the manufacturer's suggested calibration period and certified by either the original manufacturer or Thorlabs' external laboratory. The following test and measurement equipment are used for this qualification test program for optical and environmental testing.

Test Equipment:

- **Vibration**: Dynamic Solutions Vibration System DS-220VH/8-10; Vibration Controller VT1436; Accelerometer 356A01
- **Shock**: Avex Mechanical Shock Test Machine SM-105; Accelerometer 3200B4
- **Temperature Cycling**: Test Equity Model 115A Temperature Chamber (S/N 152140)
- **Damp Heat**: Test Equity Model 123H (S/N 230287)

Figure 2 Mechanical Shock Test Setup

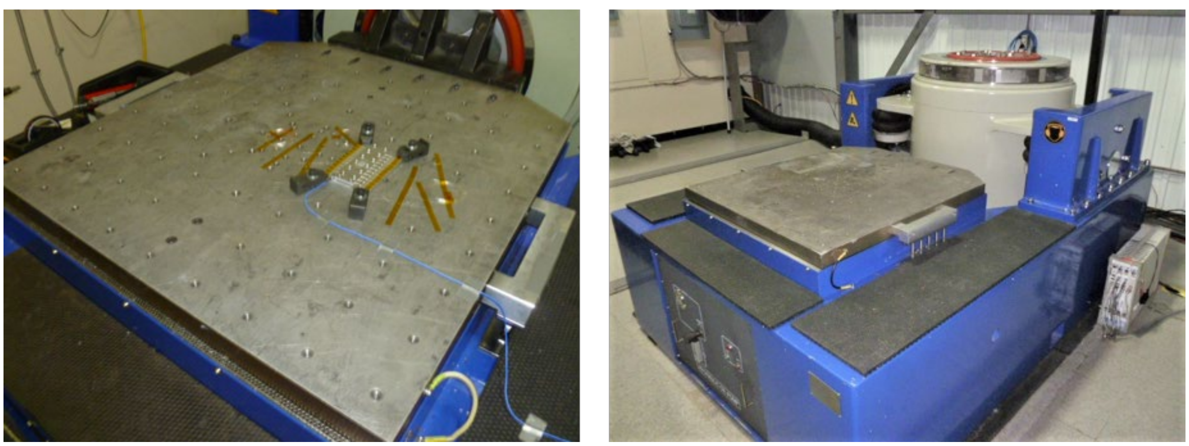


Figure 3 Vibration Test Setup

Measurement Equipment:

- 1310 nm Fiber Coupled Laser Source
- 1 x 16 Waveguide Coupler
- Thorlabs Optical Power Meter (PM100USB), Qty. 22
- Detector Head (S154C), Qty. 22

1.6. Optical Measurement Setup

The cutback technique was used for optical performance measurements during this qualification program. The parameters measured before and after mechanical or environmental tests include change in insertion loss (ΔIL). The change of the insertion loss before and after each test was used to determine the pass or fail of the device under test (DUT).

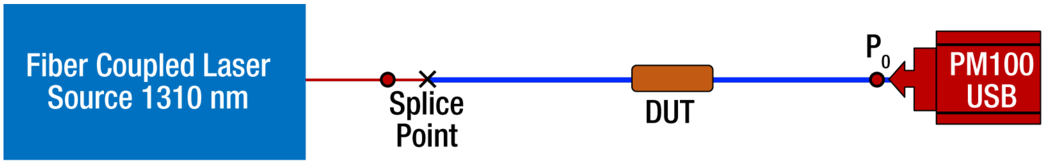


Figure 4 Schematic of Optical Setup

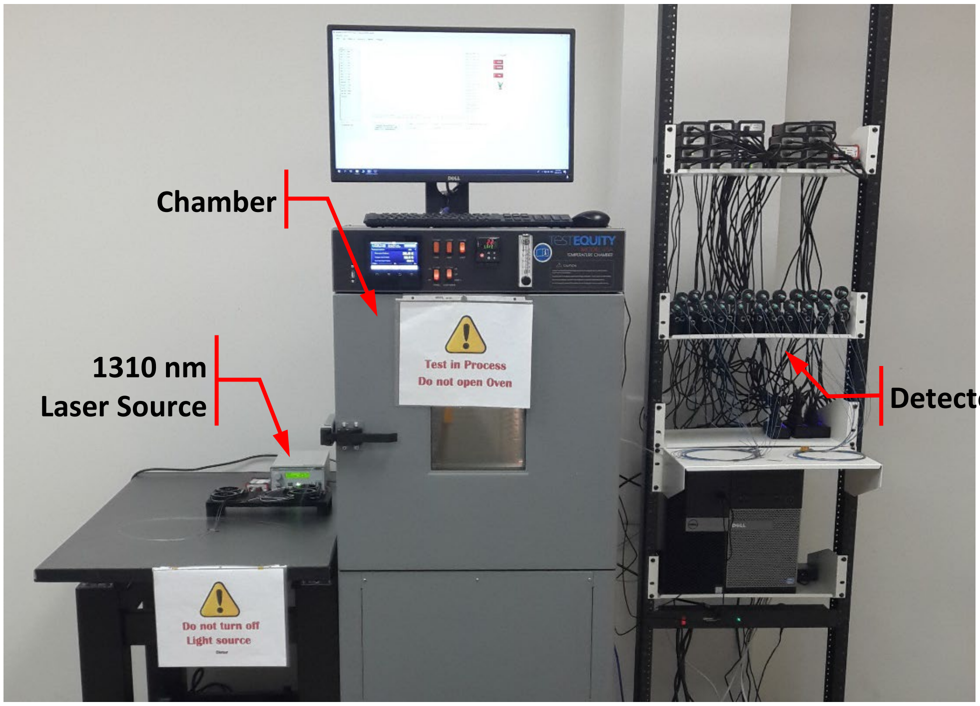


Figure 5 Damp Heat Test Setup

Part 2. Test Results and Discussion

2.1. Group 1: Mechanical Integrity Testing

Eleven devices were submitted to the following mechanical integrity tests: fiber side pull, mechanical shock (impact) and vibration. Optical performance was measured before and after each test. Test results are summarized in Tables 3 and 4.

A repeatability and reproducibility study was conducted and the measurement error was found to be ±0.005 dB.

Component Serial #	Δ Post-side pull (dB)	Δ Post-shock (dB)	Δ Post-vibration (dB)	Result
T055915	0.002	0.034	0.005	Pass
T055919	0.003	0.046	0.006	Pass
T055921	0.018	0.023	0.001	Pass
T055927	0.014	0.045	0.005	Pass
T055929	0.003	0.021	0.002	Pass
T055931	0.004	0.004	0.024	Pass
T055982	0.007	0.019	0.002	Pass
T055985	0.010	0.015	0.003	Pass
T055988	0.005	0.012	0.002	Pass
T055991	0.010	0.037	0.003	Pass
T055993	0.008	0.014	0.004	Pass

Table 3 Test Result Summary for Change in Insertion Loss (ΔIL) (Mechanical Tests)

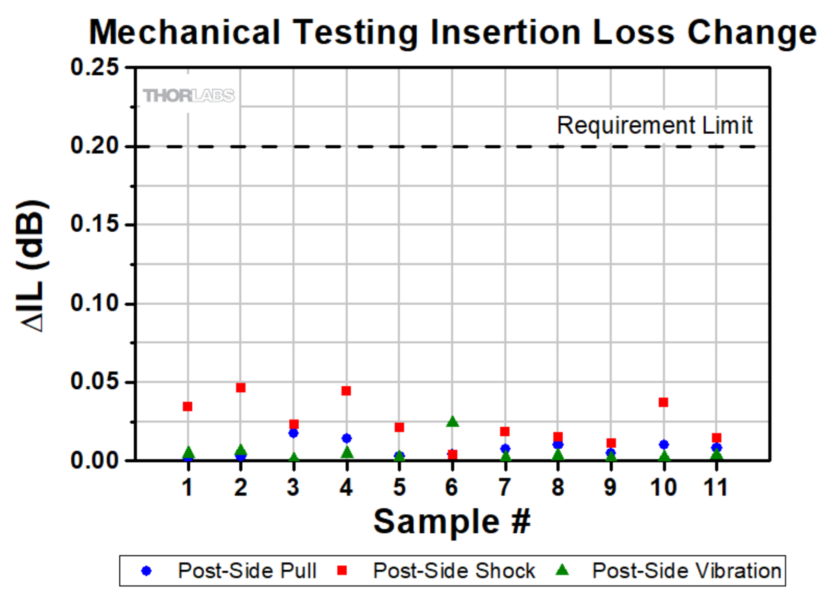


Figure 6 Change in Insertion Loss (Mechanical Tests)

Component Serial #	Post-side pull	Post-shock	Post-vibration	Result
T055915	89.94%	89.83%	89.86%	Pass
T055919	90.56%	90.57%	90.58%	Pass
T055921	89.70%	89.70%	89.69%	Pass
T055927	91.16%	91.17%	91.18%	Pass
T055929	89.04%	89.02%	88.96%	Pass
T055931	89.93%	89.90%	89.92%	Pass
T055982	88.86%	88.87%	88.88%	Pass
T055985	89.39%	89.37%	89.48%	Pass
T055988	90.30%	90.28%	90.25%	Pass
T055991	90.32%	90.31%	90.33%	Pass
T055993	89.26%	89.23%	89.31%	Pass

Table 4 Test Result Summary for Coupling Ratio (Mechanical Tests)

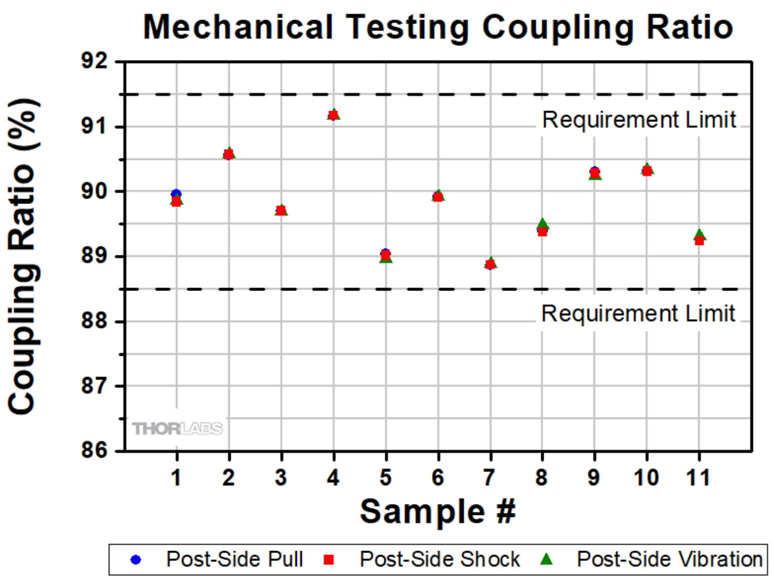


Figure 7 Change in Coupling Ratio (Mechanical Tests)

2.2. Group 2: Damp Heat

Eleven devices were tested for humidity resistance under 85 °C/85 % relative humidity (RH) damp heat conditions for over 2,000 hours. Optical performance data of each device was collected every 135 minutes for the duration of the test. As shown in the ΔIL and coupling ratio graphs below, the results demonstrate the Thorlabs 2x2 1300 nm Single Mode Fused Fiber Optic Coupler successfully passed the damp heat test. Raw data is available upon request.

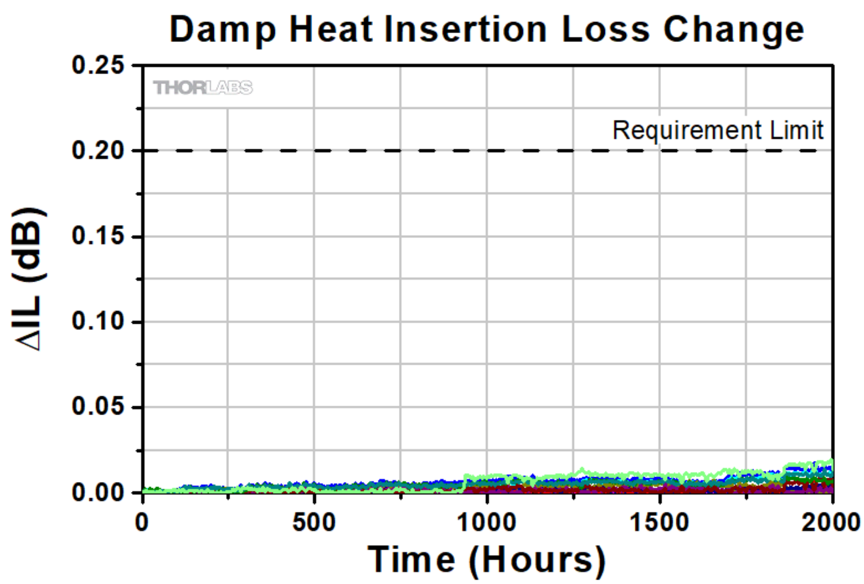


Figure 8 Change in Insertion Loss During Damp Heat Testing

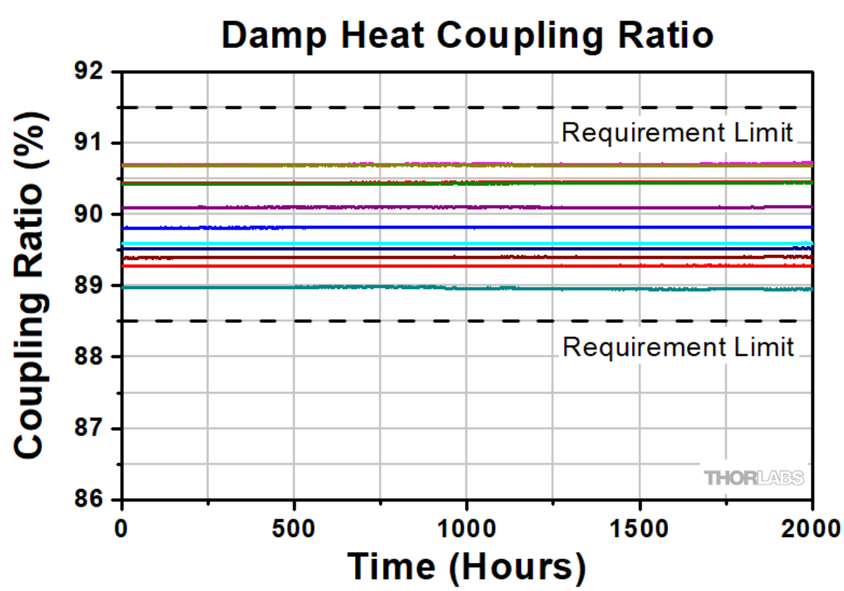


Figure 9 Coupling Ratio During Damp Heat Testing

2.3. Group 3: High Temperature Storage (Dry Heat)

Eleven devices were stored at 85 °C for 2,000 hours. Optical performance data of each device was collected every 135 minutes for the duration of the storage. As shown in the ΔIL and coupling ratio graphs below, the results demonstrate that 2x2 1300 nm Single Mode Fused Fiber Optic Coupler successfully passed the high temperature storage test. Raw data is available upon request.

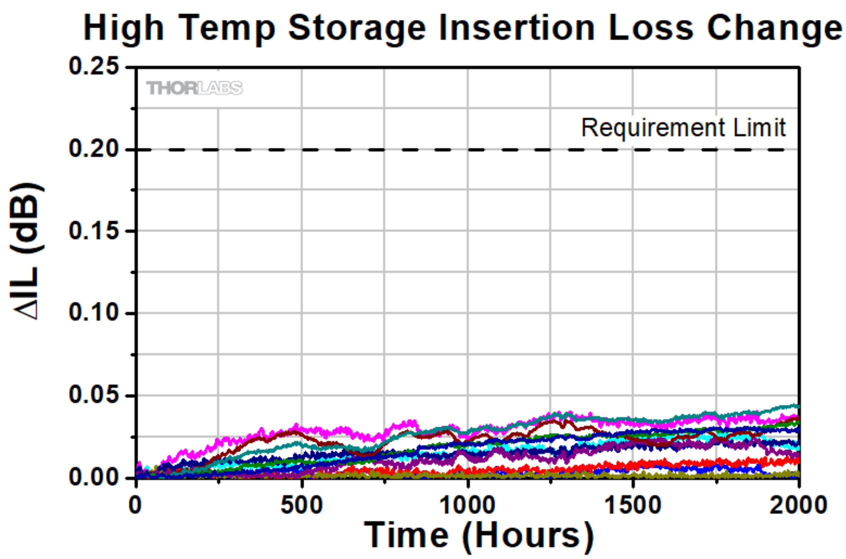


Figure 10 Change in Insertion Loss During High Temperature Storage Testing

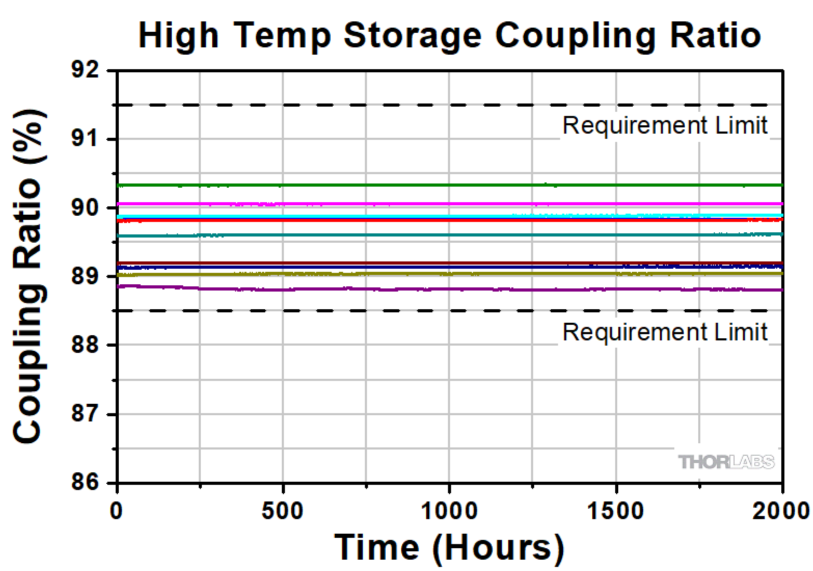


Figure 13 Coupling Ratio During High Temperature Storage Testing

2.4. Group 4: Low Temperature Storage

Eleven devices were stored at -40°C for 2,000 hours. Optical performance data of each device was collected every 135 minutes for the duration of the storage. As shown in the ΔIL and coupling ratio graphs below, the results demonstrate that Thorlabs 2x2 1300 nm Single Mode Fused Fiber Optic Coupler successfully passed the low temperature storage test. Raw data is available upon request.

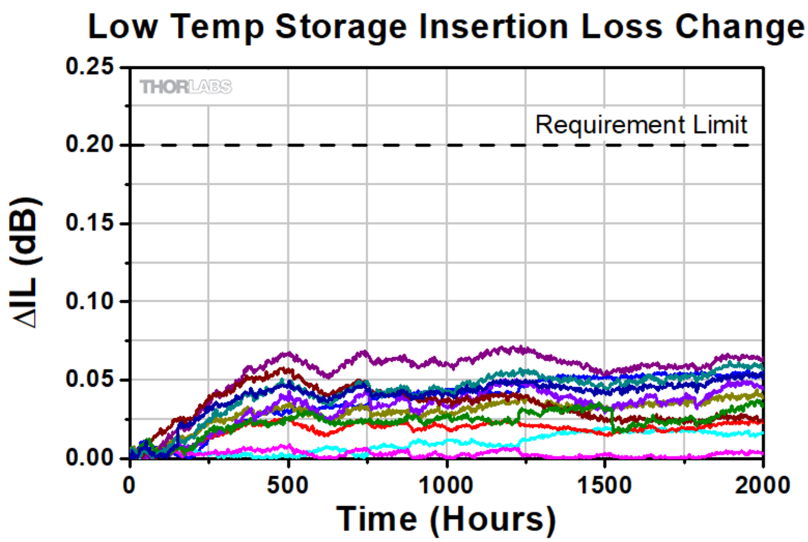


Figure 11 Change in Insertion Loss During Low Temperature Storage Testing

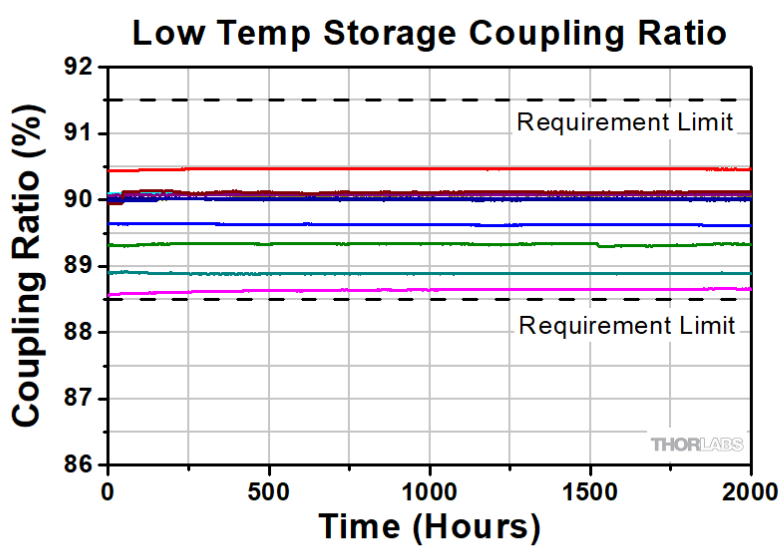


Figure 15 Coupling Ratio During Low Temperature Storage Testing

2.5. Group 5: Temperature Cycling

Eleven devices were subjected to a total of 400 thermal cycles from -40 °C to 85 °C with a 10-minute pause at 22 °C on each upcycle. During this pause, optical performance data of each device was collected. As shown in the ΔIL and coupling ratio graphs below, the results demonstrate that Thorlabs 2x2 1300 nm Single Mode Fused Fiber Optic Coupler fused coupler successfully passed the temperature cycling test. Raw data is available upon request.

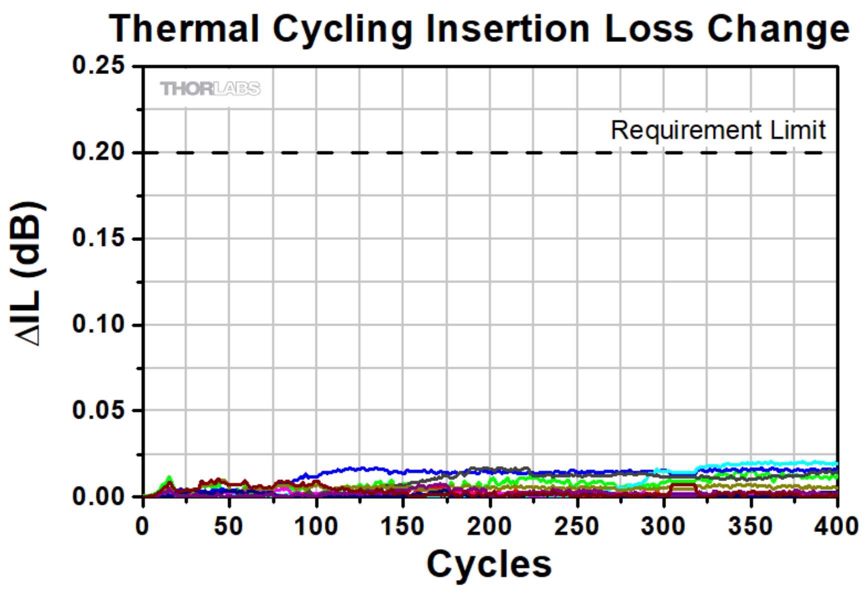


Figure 12 Change in Insertion Loss During Temperature Cycling Testing

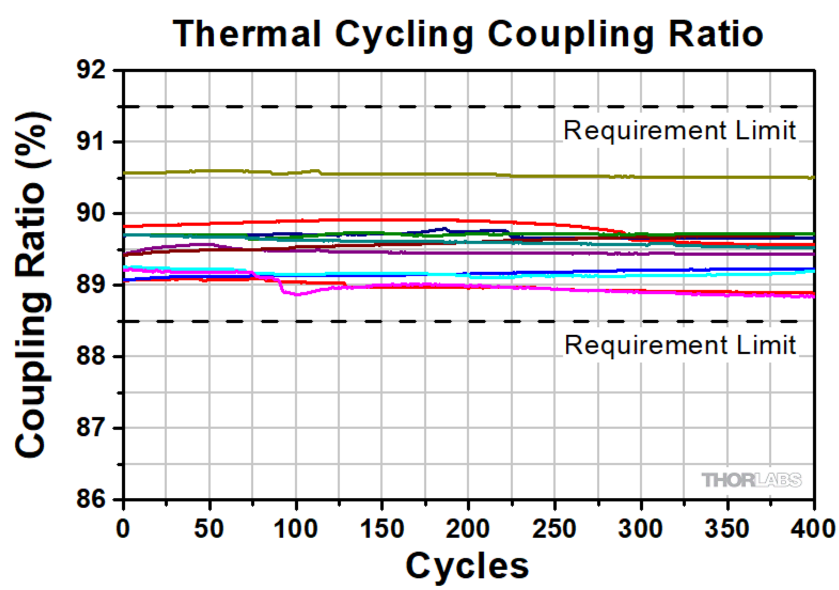


Figure 13 Coupling Ratio During Temperature Cycling Testing

Part 3. Conclusion

A total of 65 2x2 1300 nm Single Mode Fused Fiber Optic Couplers manufactured by Thorlabs using Thorlabs proprietary fusion & tapering, packaging and assembly technology were submitted to a test program inspired by Telcordia GR-1221 standard for uncontrolled environment. No failures were observed during this qualification test program. Therefore, Thorlabs fused couplers can be reliably used in uncontrolled environments. Moreover, after reviewing the coupler design, manufacturing process and potential failure mechanisms, Thorlabs considers that the test results presented in this report may be applicable to both narrowband and wideband couplers made with different fibers and with different coupling ratios.

Part 4. References

1. Telcordia “Generic Reliability Assurance Requirements for Passive Optical Components” GR-1221-CORE, Issue 2, January 1999.
2. Telcordia “Generic Requirement for Passive Optical Components” GR-1209-CORE, Issue 2, January 1999.