THORLABS

Qualification Test Report

980 nm/1310 nm Fiber Wavelength Division Multiplexers Qualification Test Report

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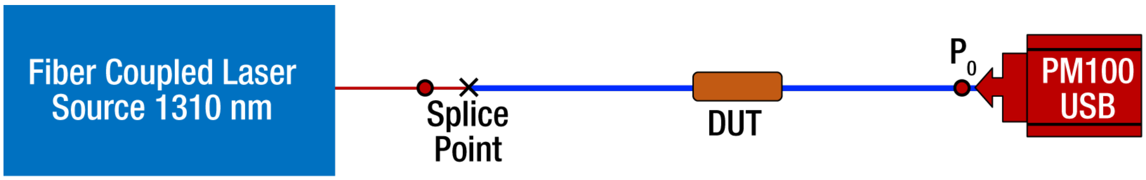
WDM Qualification Test Report



Thorlabs designs and manufactures a line of fiber wavelength division multiplexers (WDMs). In this document, our 1x2 980 nm/1310 nm WDMs undergo a reliability testing program to demonstrate that the component is capable of meeting or exceeding requirements outlined in Telcordia standard GR-1221-CORE.

These WDMs 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; Thorlabs WDMs meet the Telcordia GR-1221 Generic Reliability Assurance Requirements for Passive Optical Components and can be reliably used in uncontrolled environments.

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Introduction

Thorlabs Inc., 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 meeting or exceeding Telcordia requirements 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 a Thorlabs 1x2 980/1310 nm WDM. As shown in Figure 1 below, the WDM consists of two input fibers (Port 1 & 2) and one output fiber (Port 3). They are typically used to combine/multiplex or separate/demultiplex two wavelengths. The WDM under test in this report combines a 980 nm pump wavelength with a signal wavelength at 1310 nm

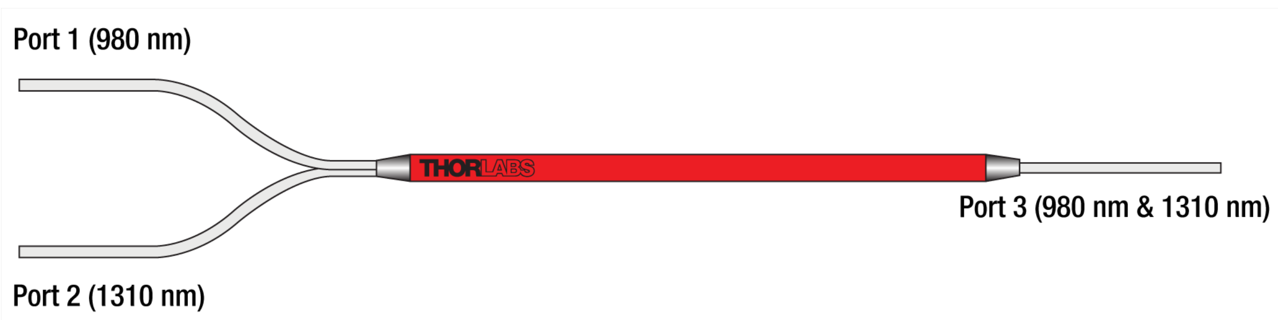

Figure 1 Schematic of a 980 nm/1310 nm WDM

Part 1. Qualification Test

1.1. Test Conditions

This test program is guided by Telcordia standard a "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		
				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) 500 cycles with a pause of 10 minutes at room temperature	20	11	0

Table 1 Qualification Test Conditions

1.2. Pass/Fail Criteria

Parameter	Test Limits
Insertion Loss Change (ΔIL)	≤ 0.2 dB
Isolation	≥ 30 dB

Table 2 Pass/Fail Criteria

1.3. Component Description

The WDMs tested in this qualification program are 1x2 980/1310 nm WDMs (Model Number: WD980-330). 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

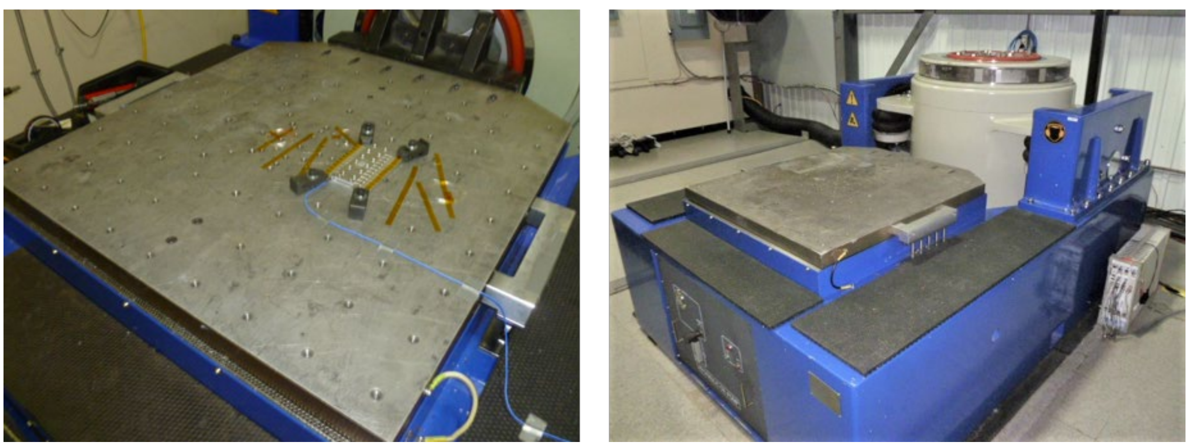

Figure 3 Vibration Test Setup

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).

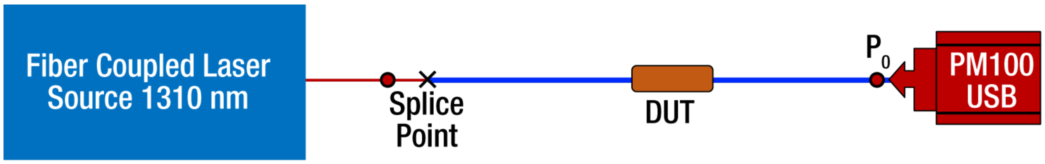

Figure 4 Schematic of Optical Setup

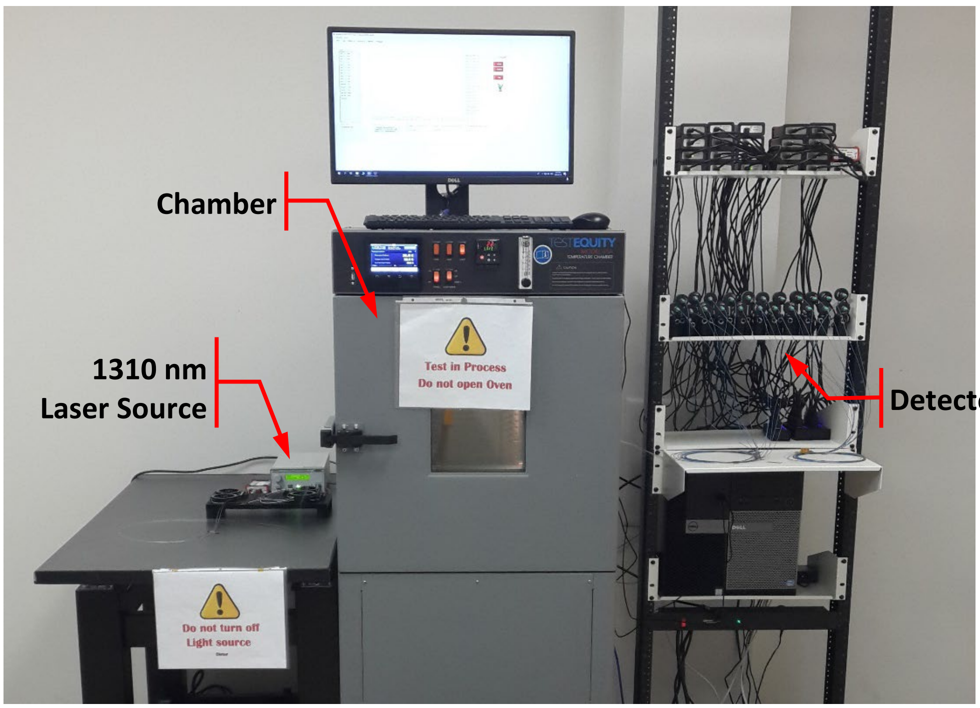

Figure 5 Damp Heat Test Setup

Part 2. Test Results and Discussion

2.1. Group 1: Mechanical Integrity Testing

Eleven devices were submitted to mechanical integrity tests including mechanical shock (impact) and vibration. Optical performance was measured before and after each test. Test results are summarized in Table 3.

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

Component Serial #	Insertion Loss (dB) Initial	Insertion Loss (dB) Post-Shock	Insertion Loss (dB) ΔIL	Result	Insertion Loss (dB) Post-Vibration	Insertion Loss (dB) ΔIL	Result
T048423	**0.167**	0.170	0.003	Pass	0.165	-0.006	Pass
T048531	**0.203**	0.213	0.010	Pass	0.202	-0.011	Pass
T048437	**0.212**	0.189	-0.023	Pass	0.195	0.006	Pass
T048467	**0.132**	0.140	0.008	Pass	0.120	-0.020	Pass
T048486	**0.069**	0.077	0.007	Pass	0.067	-0.009	Pass
T048483	**0.131**	0.151	0.020	Pass	0.136	-0.016	Pass
T048481	**0.164**	0.149	-0.015	Pass	0.155	0.007	Pass
T048477	**0.104**	0.105	0.001	Pass	0.114	0.009	Pass
T048489	**0.164**	0.141	-0.023	Pass	0.125	-0.016	Pass
T048499	**0.044**	0.074	0.029	Pass	0.058	-0.016	Pass
T048494	**0.118**	0.142	0.024	Pass	0.133	-0.010	Pass

Table 3 Insertion Loss (ΔIL) Test Summary for Shock and Vibration Testing

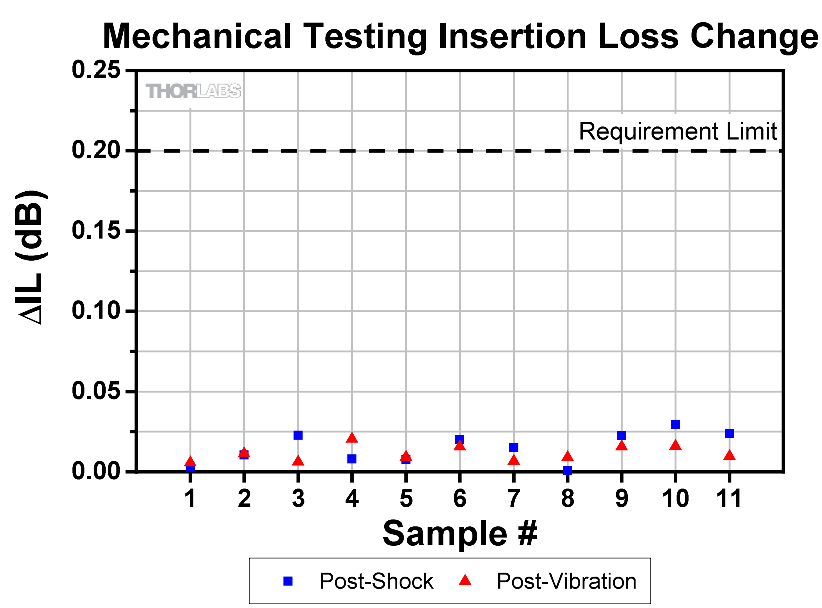

Figure 6 Change in Insertion Lost During Shock and Vibration Testing

Component Serial #	Isolation (dB)		Result
	Post-Shock	Post-Vibration	
T048423	33.8	35.0	Pass
T048531	36.3	35.8	Pass
T048437	32.2	32.3	Pass
T048467	35.5	34.3	Pass
T048486	39.8	38.7	Pass
T048483	34.8	34.3	Pass
T048481	33.2	35.0	Pass
T048477	34.3	34.5	Pass
T048489	33.5	34.0	Pass
T048499	37.6	38.4	Pass
T048494	34.7	35.5	Pass

Table 4 Isolation Test Summary for Shock and Vibration Testing

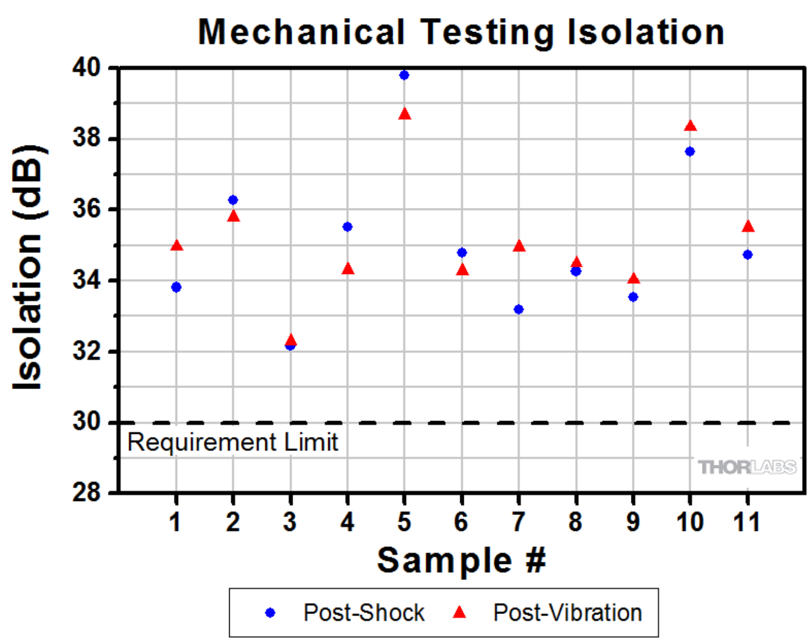

Figure 7 Isolation During Shock and Vibration Testing

Eleven devices were submitted to fiber side pull tests. Optical performance was measured before and after each test. Test results are summarized in Table 5.

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

Component Serial #	Insertion Loss (dB)			Result
	Initial	Post-Side-Pull	ΔIL	
T056004	-0.104	-0.102	-0.002	Pass
T055989	-0.119	-0.112	-0.007	Pass
T055992	-0.182	-0.171	-0.011	Pass
T055998	-0.102	-0.100	-0.002	Pass
T056001	-0.159	-0.159	0.000	Pass
T055980	-0.095	-0.098	0.003	Pass
T056046	-0.232	-0.229	-0.003	Pass
T056051	-0.134	-0.119	-0.015	Pass
T055981	-0.213	-0.210	-0.003	Pass
T056043	-0.095	-0.101	0.005	Pass
T056062	-0.082	-0.084	0.002	Pass

Table 5 Insertion Loss (ΔIL) Test Summary for Fiber Side Pull Testing

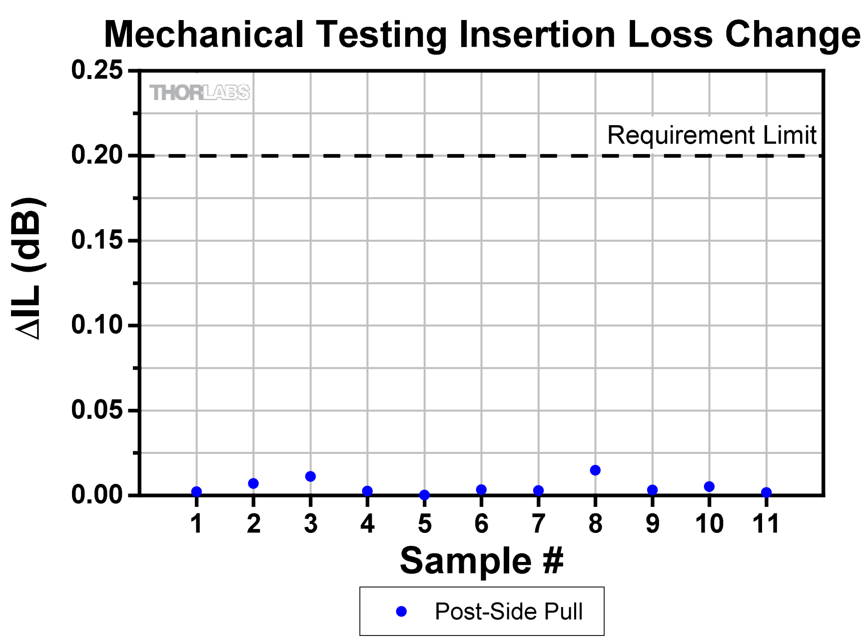

Figure 8 Change in Insertion Lost During Fiber Side Pull Testing

Component Serial #	Isolation (dB) Post-Side-Pull	Result
T056004	35.2	Pass
T055989	30.4	Pass
T055992	30.0	Pass
T055998	36.5	Pass
T056001	31.5	Pass
T055980	30.1	Pass
T056046	38.3	Pass
T056051	31.4	Pass
T055981	30.1	Pass
T056043	34.1	Pass
T056062	37.4	Pass

Table 6 Isolation Test Summary for Fiber Side Pull Testing

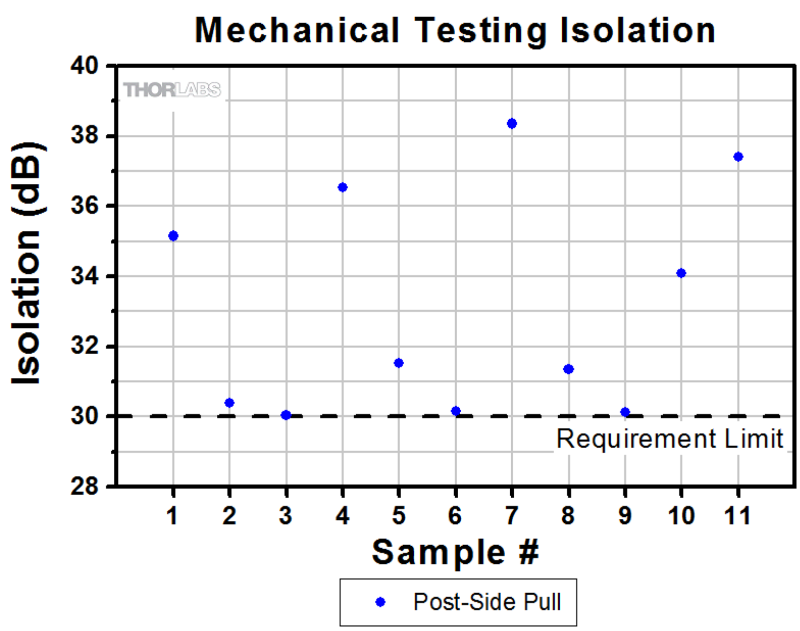

Figure 9 Isolation During Fiber Side Pull Testing

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 show in both ΔIL and Isolation graphs below, the results demonstrate the Thorlabs 1x2 980/1310 nm WDMs successfully passed the damp heat test.

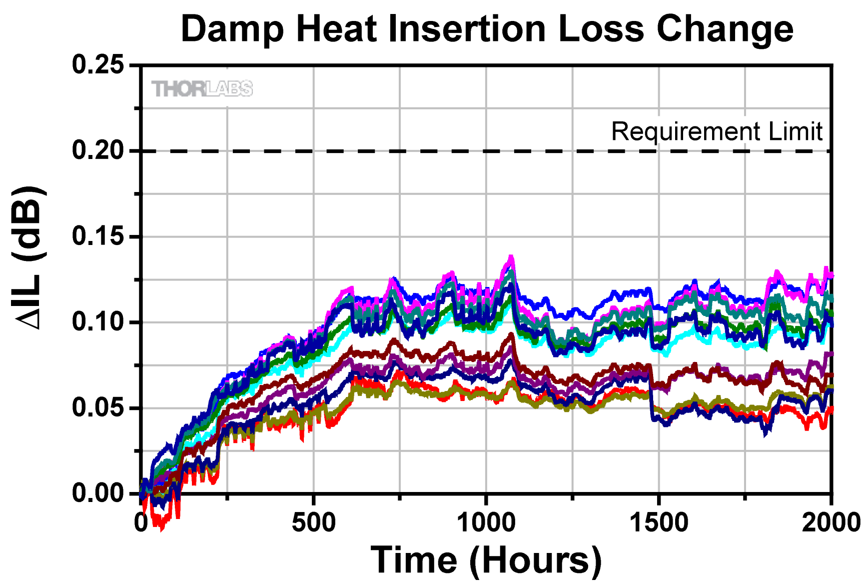

Figure 10 Change in Insertion Lost During Damp Heat Testing

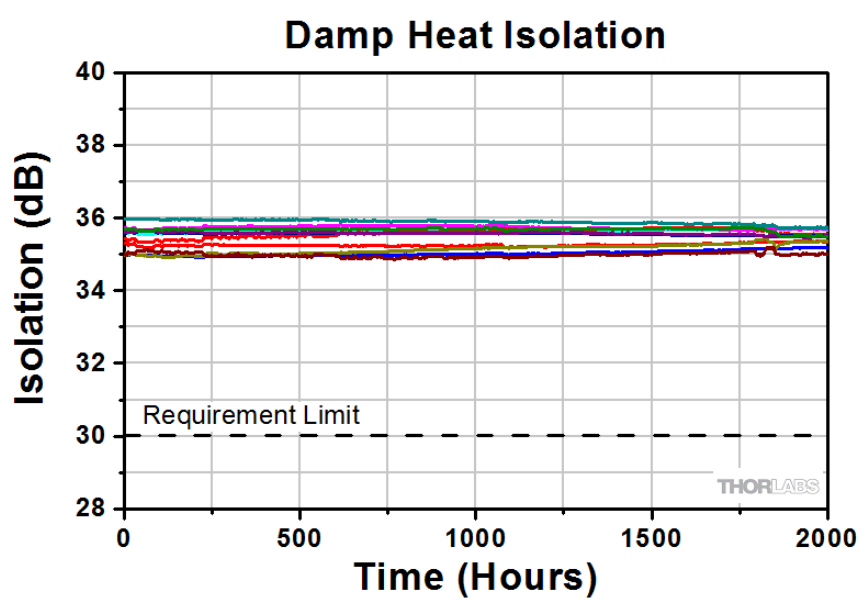

Figure 11 Isolation During Damp Heat Testing

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 both ΔIL and Isolation graphs below, the results demonstrate that Thorlabs 1x2 980/1310 nm WDMs successfully passed the high temperature storage test.

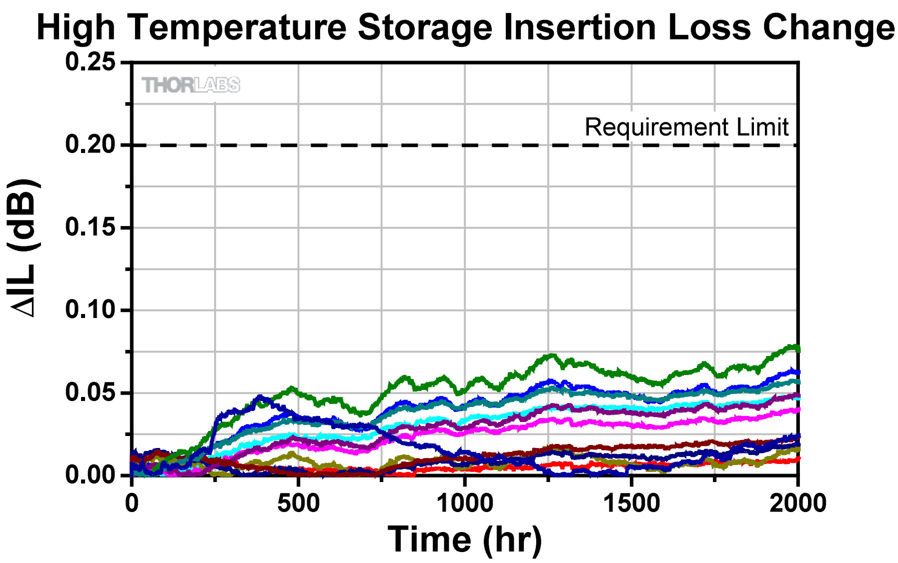

Figure 12 Change in Insertion Lost During High Temperature Storage Testing

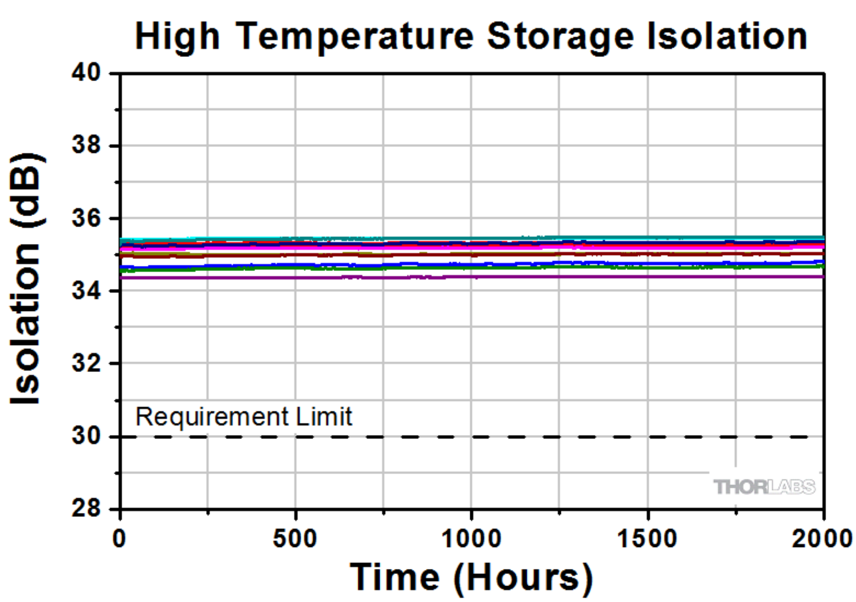

Figure 13 Isolation During High Temperature Storage Testing

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 for every 135 minutes for the duration of the storage. As shown in both ΔIL and Isolation graphs below, the results demonstrate that Thorlabs 1x2 980/1310 nm WDMs successfully passed the low temperature storage test.

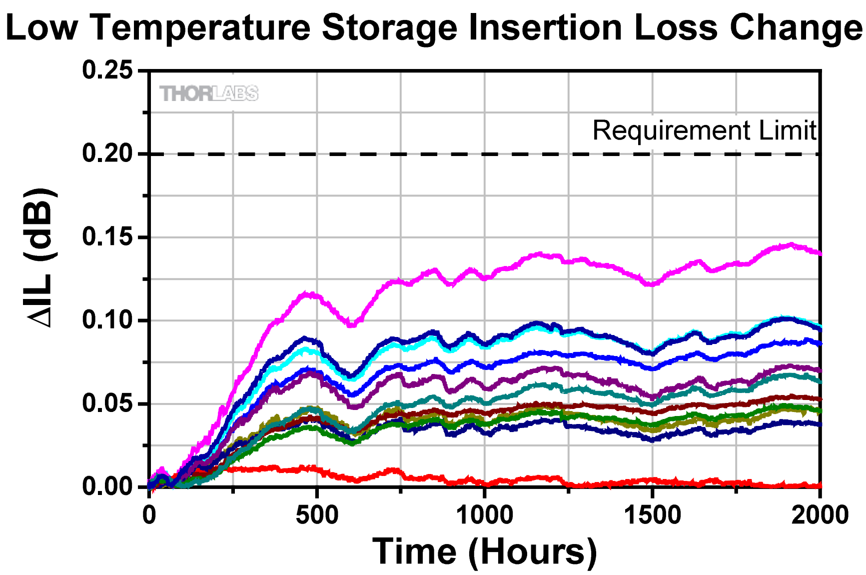

Figure 14 Change in Insertion Lost During Low Temperature Storage Testing

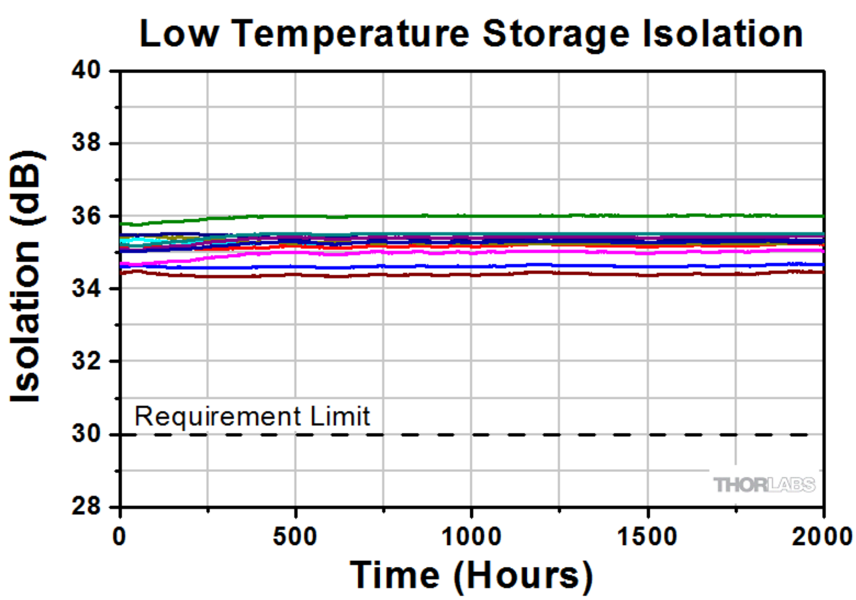

Figure 15 Isolation During Low Temperature Storage Testing

2.5. Group 5: Temperature Cycling

Eleven devices were subjected to a total of 500 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 both ΔIL and Isolation graphs below, the results demonstrate that Thorlabs 1x2 980/1310 nm WDMs successfully passed the temperature cycling test.

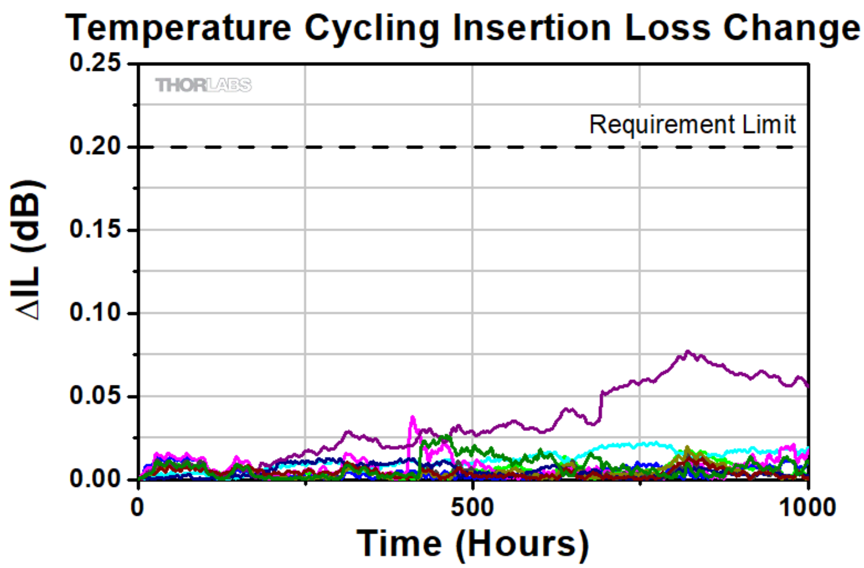

Figure 16 Change in Insertion Lost During Temperature Cycling Testing

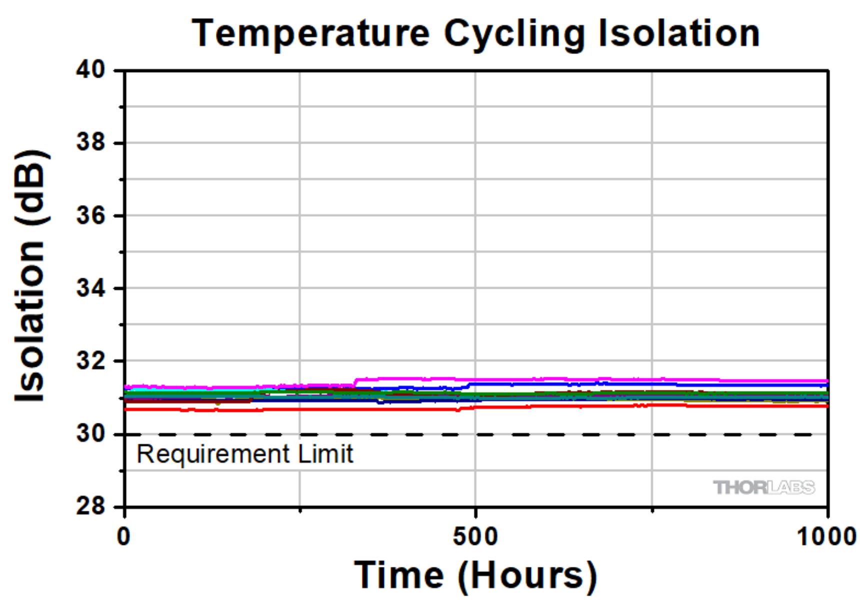

Figure 17 Isolation During Temperature Cycling Testing

Part 3. Conclusion

A total of 65 1x2 980/1310 nm WDMs manufactured by Thorlabs using Thorlabs proprietary fusion & tapering, packaging and assembly technology were submitted to a test program formulated according to Telcordia GR-1221 standard for uncontrolled environment. No failures were observed during this qualification test program. Therefore Thorlabs WDMs meet the Telcordia GR-1221 Generic Reliability Assurance Requirements for Passive Optical Components and can be reliably used in uncontrolled environments. Moreover, after reviewing the WDMs design, manufacturing process and potential failure mechanisms, Thorlabs considers that the test results presented in this report may be applicable to other WDMs made with different fibers and with different wavelength spacings.

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.