

Reliability Qualification Test Report

SWLD-CWDM and DWDM DFB Lasers (Select Wavelength Laser Diodes)

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I. Introduction

This document presents the qualification plan for the Agiltron Lasers Select Wavelength Laser Diodes (SWLD) product family. SWLD-1550 devices will be chosen as reference. The purpose of this Qualification Test Report is to provide a structured, rational and thorough method that will guide our effort to achieve the goal of delivering defect-free reliable Select Wavelength Laser Diodes (SWLD) that meet or exceed the Agiltron Lasers product specifications and customer's requirements.

The products are manufactured on the qualified production line with confirmed bill of materials (BOM) and standard operation processes (SOP) supported by our work instruction (WI). The production line is qualified through verification of work instructions, in-line monitors and quality protocols in each and every production step. Following established manufacturing procedures, randomly selected SWLD lasers from this production line are used to perform the qualification testing for the entire manufacturing environment for all the designs. In the manufacturing process and prior to final measurement, every SWLD device undergoes standard burn-in and screening process to guarantee that Agiltron Lasers ships the highest standard of components to our customers. The screening process consists of burn-in of the laser operation at 85 °C for 48hrs and 10 temperature cycles between –40°C and +85°C. These help to eliminate the components that have any instability in the optical alignment or have built-in mechanical stresses due to incorrect assembling process or incorrect way to execute the process step. SWLD qualification requirements are drawn from Telcordia GR-468-CORE “Generic Reliability Assurance Requirements for Optoelectronic Devices Used In Telecommunications Equipment”. The testing methods are specified in the GR-468 with detail description of testing methodologies and used equipment.

Product Description: Agiltron Lasers Select Wavelength Laser Diodes (SWLD) are specifically developed laser sources for different Wavelength Division Multiplexing (WDM) systems, where it is used as a wavelength specific source in combination with an external modulator or direct modulation lasers. The select wavelength laser diodes comply with ITU recommendations, both in range from 1527.61nm to 1610.06nm and in channel definitions ranging from the wavelength from 1260nm to 1660nm,.

SWLD series laser is fabricated in a hermetically sealed 14-pin butterfly package that contains a laser diode, thermoelectric cooler (TEC), thermistor, monitor photodiode, optical isolator and unique pigtail system with fiber grating wavelength stabilizer with very accurate wavelength control. Customized packages of the laser sources with the same performance and qualification can also be manufactured. SWLD series lasers have a high-side-mode suppression-ratio (SMSR), very low relative intensity noise (RIN), and narrow laser linewidth. The output power is up to 100mW. The lasers meet or exceed Telcordia GR-468-CORE reliability qualification requirement as the testing results recorded in this testing report.

Key Features

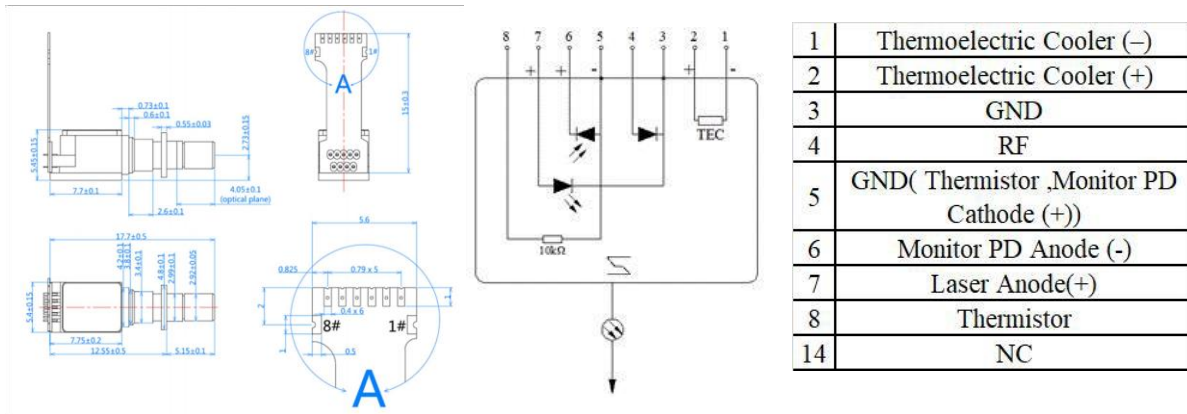
- ITU and customized wavelengths available; Up to 100mW

- ## Specifications

	Symbol	Min.	Typical	Max.	Unit
CW output power (at 25°C)	Pf	5	---	10	mW
Threshold current	Ith	---	35	---	mA
Operating drive current	If	---	120	--	mA
Forward voltage	Vf	---	2.0	3.0	V
Wavelength	λ_c	ITU grid ± 0.08			nm
Linewidth	L	---	500	--	KHz
Monitor current	Im	---	100	---	μA
Monitor dark current(Vr=-5V)	Id	--	--	100	nA
Isolation	Iso	-30	--	--	dB
Thermistor resistance (at 25°C)	Rth	9.5	10	10.5	k Ω
TEC current	Ic	--	1.2	--	A
TEC voltage	Iv	--	3.0	--	V
Operating temperature range	To	-20	--	65	°C
Storage temperature	Tstg	-40	--	85	°C

Laser forward current	If	20 0	mA
Laser revers voltage	Vf	2.5	V
TEC current	Ic	2.0	A
TEC voltage	Vc	3.3	V
Photo reverse voltage	Vrp d	5	V
Lead Soldering Temp.	--	26 0	°C
Fiber Bend Radius	--	30	mm

Pi	Function	Pin	Function
1	PD Anode	8	TEC(+)
2	PD Cathode, GND	9	NC
3	NC	10	Thermistor, GND
4	NC	11	Thermistor
5	NC	12	LD(+), GND
6	NC	13	LD(-)



9-PIN TOSA DFB and EML Lasers

II. TELCORDIA GR-468 Qualification Test

1. Sample flow chart and number of allowed failures

The following table shows the qualification flow chart used to evaluate FBFD according to Telcordia GR-468. The sample size has been divided in 12 groups to perform the tests in parallel.

Group No.	Type of Test	Samples Size	Number of Allowed Failures
1	Mechanical Shock	11	0
2	Vibration Test	11	0
3	Thermal Shock	11	0
4	Solderability	11	0
5	Fiber Pull	11	0
6	Damp Heat	11	0
7	Temperature Cycling	11	0
8	High Temperature Storage	11	0
9	Low Temperature Storage	11	0
11	Internal Moisture	Not test	0
12	ESD Threshold	Not test	0

2. Optical parameters: The following performance parameters will be tested with required change defined by

The following optical performances will be tested and monitored during the tests:

- Laser output power and output power change
- Back PIN PD monitor current
- Lasing threshold current
- Laser output center wavelength
- SMSR

3. Pass/Fail criteria

Parameter	Parameter	Pass/Fail Criteria
Laser Output Power change	ΔP	$\leq 10\%$ or 0.5dB
Center Wavelength change	$\Delta \lambda$	$\leq 0.1\text{nm}$
SMSR change	Δ	$\leq 5\text{dB}$
Device Dimension		Within the tolerance
Physical Damage		None

4. Telcordia GR-468 qualification summary

Tests for laser modules include all tests listed in following table, unless stated there as an objective (in which case they should be performed)

Heading	Type of Test	Test Condition	Reference
Mechanical Integrity	Mechanical Shock	5 times/axis with TEC 500g, 1.0ms; w/o TEC 1,500g, 0.5ms,	MIL-STD-883 Method 2002
	Vibration Test	Condition A, 20g, 20 – 2,000Hz, 4 min./cycle, 4 cycles/axis.	MIL-STD-883 Method 2007
	Thermal Shock	$\Delta T = 100^\circ\text{C}$, 0°C to 100°C	MIL-STD-883, Method 1011
	Solderability	245°C, 5 seconds	MIL-STD-883, Method 2003
	Fiber Pull	1 kg, 5 sec, 3 times	N/A
Endurance	Accelerated Aging (Life Test)	For central office: Ts/Tp=25°C/70°C, rated power, 2000hours min., 5000 hours info. For un-control Environment: Ts/Tp=25°C/85°C, rated power, 2000hours min., 5000 hours info.	GR-468 (R)-453 Section 5.18
	High Temperature Storage	85°C or max. storage temperature 2000 hours	EIA/TIA-455-4A
	Low Temperature Storage	-40°C or min. storage temperature 2000 hours	EIA/TIA-455-4A
	Temperature Cycling	For central office: -40°C to 70°C 100 cycles for pass/fail, 500 cycles for information. For un-control Environment: -40°C to 85°C 500 cycles for pass/fail, 1,000 cycles for information	GR-468 Section 5.20
	Damp Heat	85°C, 85%RH, 1000 hours	MIL-STD-202, Method 103

Special Test	Internal Moisture	Max. 5000ppm water vapor	MIL-STD-883, Method 1018
	ESD Threshold	TR-NWT-000870, >500 volts	GR-468 Section 5.22

5. Test definitions

- **Mechanical Shock:** The above test method is based on MIL-STD-883, Method 2002, with the following conditions:
 - If the laser module has TEC, use following condition:
 - Number of Shocks: 5 times per direction for 6 directions (on 3 axes)
 - Shock Level: 500G,
 - Duration: 1ms.
 - If the laser module has not TEC, use following condition:
 - Number of Shocks: 5 times per direction for 6 directions (on 3 axes)
 - Shock Level: 1,500G,
 - Duration: 0.5ms.

After test, each SWLD is to be carefully examined for evidence of any physical damage and measure the optical performance.

Testing Results of Mechanical Integrity-Mechanical Shock (Condition: 1500G, 0.5ms, 5 times/axis)										
No.	Product No.	Wavelength (nm)			Output power (dBm)			SMSR (dB)		
		Initial	After MS	$\Delta\lambda$	Initial	After MS	ΔP	Initial	After MS	$\Delta SMSR$
1	SWLD-1552.2	1552.21	1552.23	0.02	10.00	10.12	0.12	47.5	47.9	0.40
2	SWLD-1555.7	1555.73	1555.75	0.02	10.00	9.88	0.12	48.5	48.6	0.10
3	SWLD-1554.5	1554.52	1554.51	0.01	10.00	9.66	0.34	45.2	45.9	0.70
4	SWLD-1555.3	1555.32	1555.32	0.00	10.00	9.85	0.15	44.9	45.3	0.40
5	SWLD-1552.8	1552.83	1552.84	0.01	10.00	9.82	0.18	45.8	46.5	0.70
6	SWLD-1555.1	1555.14	1555.15	0.01	10.00	9.91	0.09	49.1	48.5	0.60
7	SWLD-1554.5	1554.56	1554.53	0.03	10.00	9.95	0.05	48.2	48.7	0.50
8	SWLD-1553.5	1553.59	1553.57	0.02	10.00	9.96	0.04	47.9	48.3	0.40
9	SWLD-1542.3	1542.37	1542.37	0.00	10.00	9.78	0.22	48.5	47.8	0.70
10	SWLD-1536.5	1536.57	1536.58	0.01	10.00	9.99	0.01	47.8	48.2	0.40
11	SWLD-1538.1	1538.18	1538.19	0.01	10.00	9.75	0.25	45.2	45.6	0.40
		Max.	$\Delta\lambda$	0.03	Max.	ΔP	0.34	Max.	$\Delta SMSR$	0.70

- **Vibration:** The variable frequency vibration test is performed to evaluate the mechanical integrity of SWLD and is based on MIL-STD-883, Method 2007, with the following conditions:
 - Condition: Condition A
 - Acceleration: 20 G maximum acceleration
 - Frequency: 20-2,000 Hz
 - Duration: 4 min per cycle and 4 cycles per axis

After Vibration, each SWLD is to be carefully examined for evidence of any physical damage and measure the optical performance.

Testing Results of Mechanical Integrity-Vibration (Condition: 20G, 20~2000Hz, 4 min/cycle, 4 cycles/axis)										
No.	Product No.	Wavelength (nm)			Output power (dBm)			SMSR (dB)		
		Initial	After Vibration	$\Delta\lambda$	Initial	After Vibration	ΔP	Initial	After Vibration	$\Delta SMSR$
1	SWLD-1550.2	1550.23	1550.26	0.03	10.00	9.77	0.23	45.6	46.2	0.60
2	SWLD-1535.6	1535.58	1535.55	0.03	10.00	9.86	0.14	51.2	51.5	0.30
3	SWLD-1534.2	1534.22	1534.22	0.00	10.00	9.74	0.26	48.5	48.1	0.40
4	SWLD-1533.3	1533.32	1533.28	0.04	10.00	10.02	0.02	47.2	47.8	0.60
5	SWLD-1532.5	1532.53	1532.49	0.04	10.00	9.95	0.05	46.5	45.8	0.70
6	SWLD-1532.1	1532.14	1532.09	0.05	10.00	9.9	0.10	44.3	44.6	0.30
7	SWLD-1534.9	1534.86	1534.81	0.05	10.00	9.87	0.13	45.2	45.3	0.10
8	SWLD-1533.8	1533.79	1533.79	0.00	10.00	9.76	0.24	46.9	47.2	0.30
9	SWLD-1541.5	1541.52	1541.55	0.03	10.00	9.82	0.18	41.8	41.6	0.20
10	SWLD-1543.5	1543.51	1543.54	0.03	10.00	9.69	0.31	42.9	42.5	0.40
11	SWLD-1537.2	1537.18	1537.22	0.04	10.00	9.81	0.19	45.6	45.8	0.20
		Max.	$\Delta\lambda$	0.05	Max.	ΔP	0.31	Max.	$\Delta SMSR$	0.70

- **Thermal Shock Test:** The thermal shock test is based on MIL-STD-883 Method 1011 with the following conditions:
Temperature Range: $\Delta T = 100^{\circ}\text{C}$ (0°C to 100°C), liquid-to-liquid
Dwell Times: ≥ 5 minutes at temperature extremes (typical 20min.)
Transfer Time: ≤ 10 seconds
Number of Cycles: 15

After test, each SWLD is to be carefully examined for evidence of any physical damage and measure the optical performance. The optical test is made after the components are stabilized at room conditions for at least 2 hours.

Testing Results of Mechanical Integrity-TS (Condition: $\Delta T = 100^{\circ}\text{C}$, $0-100^{\circ}\text{C}$, MIL-STD-883E, Method 1011.9)										
No.	Product No.	Wavelength (nm)			Output power (dBm)			SMSR (dB)		
		Initial	After TS	$\Delta\lambda$	Initial	After TS	ΔP	Initial	After TS	$\Delta SMSR$
1	SWLD-1547.2	1547.24	1547.29	0.05	10.00	9.83	0.17	43.3	44.2	0.90
2	SWLD-1545.9	1545.89	1545.82	0.07	10.00	9.69	0.31	44.8	44.9	0.10
3	SWLD-1543.5	1543.46	1543.48	0.02	10.00	9.86	0.14	45.6	45.1	0.50
4	SWLD-1543.3	1543.33	1543.31	0.02	10.00	10.06	0.06	48	47.8	0.20
5	SWLD-1542.8	1542.82	1542.86	0.04	10.00	9.58	0.42	51.2	49.9	1.30
6	SWLD-1542.9	1542.91	1542.95	0.04	10.00	9.71	0.29	40.8	41.2	0.40
7	SWLD-1545.6	1545.57	1545.63	0.06	10.00	9.81	0.19	38.5	39.7	1.20
8	SWLD-1553.7	1553.72	1553.66	0.06	10.00	9.68	0.32	39.2	40.5	1.30
9	SWLD-1561.2	1561.17	1561.11	0.06	10.00	9.8	0.20	41.5	42	0.50
10	SWLD-1555.3	1555.33	1555.38	0.05	10.00	9.71	0.29	41.9	42.4	0.50
11	SWLD-1558.6	1558.61	1558.69	0.08	10.00	9.88	0.12	45.5	45.9	0.40
		Max.	$\Delta\lambda$	0.08	Max.	ΔP	0.42	Max.	$\Delta SMSR$	1.30

- **Solderability:** The solderability test is based on MIL-STD-883 Method 2003, the general solderability test procedure consists of the following steps: 1) proper preparation of the samples as defined by the acquisition document, but which must not include wiping, cleaning, scraping, or abrasive cleaning of the terminations to be tested; 2) aging of the samples in a steam ager, which consists of exposing the surfaces to be tested to water vapor for 8 hours and drying them either by baking at 100°C for no more than 1 hour in a dry atmosphere or air drying them at ambient temperature for a minimum of 15 minutes; 3) proper application of flux to the terminations; 4) solder dipping, which consists of immersing the terminations in

static solder at a uniform temperature of $245 \pm 5^{\circ}\text{C}$, 5 seconds and 5) examination of the terminations at 10-15X.

After test, the main criterion for acceptable solderability is 95% coverage of the dipped portion of the terminations by a new and continuous solder coating. Thus, pinholes, voids, porosity, non-wetting, or de-wetting must not exceed 5% of the total dipped area.

Testing Results of Mechanical Integrity-S (Condition:MIL-STD-883, Method 2003)										
No.	Product No.	Wavelength (nm)			Output power (dBm)			SMSR (dB)		
		Initial	After S	$\Delta\lambda$	Initial	After S	ΔP	Initial	After S	ΔSMSR
1	SWLD-1310.2	1310.23	1310.23	0.00	10.00	10	0.00	46.6	47.2	0.60
2	SWLD-1335.1	1335.14	1335.16	0.02	10.00	9.96	0.04	42.5	43.6	1.10
3	SWLD-1372.1	1372.08	1372.12	0.04	10.00	9.95	0.05	47.7	48	0.30
4	SWLD-1308.4	1308.43	1308.45	0.02	10.00	9.89	0.11	46.3	45.9	0.40
5	SWLD-1309.5	1309.51	1309.54	0.03	10.00	10.02	0.02	46.2	45.5	0.70
6	SWLD-1330.1	1330.1	1330.12	0.02	10.00	9.9	0.10	45.8	45.9	0.10
7	SWLD-1312.7	1312.73	1312.75	0.02	10.00	9.89	0.11	43.9	46.2	2.30
8	SWLD-1314.8	1314.78	1314.75	0.03	10.00	9.84	0.16	42.1	43.1	1.00
9	SWLD-1311.5	1311.52	1311.56	0.04	10.00	9.85	0.15	40.6	41.2	0.60
10	SWLD-1307.8	1307.82	1307.86	0.04	10.00	9.89	0.11	41.2	43.5	2.30
11	SWLD-1372.3	1372.32	1372.31	0.01	10.00	9.86	0.14	48.5	49.7	1.20
		Max.	$\Delta\lambda$	0.04	Max.	ΔP	0.16	Max.	ΔSMSR	2.30

- **Fiber Pull:** The purpose of the fiber pull test is to ensure that attachment of the fiber pigtail to the package. The load is applied 1kg during 10 seconds, the SWLD lasers may not incur physical damage, including
 - ✓ Fiber Breakage
 - ✓ Package Cracks
 - ✓ Fiber Pullout
 - ✓ Fiber Jacket Damage
 - ✓ Failure of the Fiber-terminus Joint
 - ✓ Seal Damage.

The load is to be applied to the secured fiber at a minimum distance of 10 cm (4 inches) from the end of the fiber, at a rate of 400 micrometers (0.016 in.) per second until attaining the maximum load, which is to be maintained for 5 seconds. Measure the optical performance after the load is applied for at least 3 times.

Testing Results of Mechanical Integrity-Fiber Pull (Condition: 1 kg, 10 sec, 3 times)											
No.	Product No.	Wavelength (nm)			Output power (dBm)			SMSR (dB)			
		Initial	After FP	$\Delta\lambda$	Initial	After FP	ΔP	Initial	After FP	Δ MSR	
1	SWLD-1390.8	1390.78	1390.79	0.01	10.00	10.00	0.00	43.5	44.6	1.10	
2	SWLD-1392.5	1392.54	1392.52	0.02	10.00	9.96	0.04	43.2	42.5	0.70	
3	SWLD-1391.6	1391.61	1391.64	0.03	10.00	9.78	0.22	42.9	42.1	0.80	
4	SWLD-1393.2	1393.23	1393.26	0.03	10.00	10.06	0.06	43.5	43.8	0.30	
5	SWLD-1388.9	1388.89	1388.87	0.02	10.00	9.91	0.09	44.2	44.9	0.70	
6	SWLD-1390.8	1390.83	1390.8	0.03	10.00	9.96	0.04	44.9	43.5	1.40	
7	SWLD-1390.6	1390.62	1390.62	0.00	10.00	9.88	0.12	42.5	43.1	0.60	
8	SWLD-1389.5	1389.51	1389.52	0.01	10.00	9.86	0.14	41.6	41.9	0.30	
9	SWLD-1390.7	1390.71	1390.73	0.02	10.00	9.85	0.15	42.2	41.7	0.50	
10	SWLD-1392.2	1392.22	1392.21	0.01	10.00	9.87	0.13	44.2	45.6	1.40	
11	SWLD-1391.5	1391.54	1391.55	0.01	10.00	9.92	0.08	45.2	44.3	0.90	
		Max.	$\Delta\lambda$	0.03	Max.	ΔP	0.22	Max.	Δ MSR	1.40	

- **Damp Heat:** The high temperature storage (damp heat) test is based on the procedure stated in MIL-STD-883 Method 103, with the following conditions:

Temperature: 85°C(±2°C)

Humidity: 85%(±5%) RH

The test samples are subjected to a temperature resistance test at a modified test temperature of +85°C with a relative humidity of 85%, and shall be taken initially and at the end, as well as interim measurements, at 100/168/500/1000/2000 hour intervals, 2000 hrs for qualification and will continue testing at 5000 for information. The optical test is made after the components are stabilized at room conditions for at least 2 hours.

Testing Results of Endurance-Damp-Heat (Condition: 85°C, 85% RH, 2000 hrs)																			
No.	Product No.	Wavelength (nm)										Output power (dBm)							
		Initial	168	$\Delta\lambda$	336	$\Delta\lambda$	500	$\Delta\lambda$	1000	$\Delta\lambda$	2000	$\Delta\lambda$	Initial	168	ΔP	336	ΔP	500	ΔP
1	SWLD-1291.4	1291.41	1291.43	0.02	1291.45	0.04	1291.48	0.07	1291.44	0.03	1291.47	0.06	10.00	9.69	0.31	9.63	0.37	9.61	0.39
2	SWLD-1292.3	1292.32	1292.3	0.02	1292.33	0.01	1292.33	0.01	1292.32	0	1292.36	0.04	10.00	9.72	0.28	9.69	0.31	9.73	0.27
3	SWLD-1292.1	1292.07	1292.03	0.04	1292.08	0.01	1292.06	-0.01	1292.06	0.01	1292.1	0.03	10.00	9.85	0.15	9.91	0.09	9.86	0.14
4	SWLD-1291.8	1291.78	1291.82	0.04	1291.86	0.08	1291.85	0.07	1291.85	0.07	1291.86	0.08	10.00	9.91	0.09	9.93	0.07	9.7	0.3
5	SWLD-1290.9	1290.91	1290.87	0.04	1290.82	0.09	1290.88	-0.03	1290.89	0.02	1290.85	0.06	10.00	9.96	0.04	10.12	0.12	9.91	0.09
6	SWLD-1290.6	1290.6	1290.55	0.05	1290.51	0.09	1290.56	-0.04	1290.58	0.02	1290.59	0.01	10.00	9.75	0.25	10.2	0.2	9.93	0.07
7	SWLD-1290.5	1290.53	1290.59	0.06	1290.53	0	1290.57	0.04	1290.6	0.07	1290.48	0.05	10.00	9.76	0.24	9.63	0.37	9.58	0.42
8	SWLD-1291.6	1291.56	1291.58	0.02	1291.49	0.07	1291.58	0.02	1291.52	0.04	1291.51	0.05	10.00	9.68	0.32	9.66	0.34	9.68	0.32
9	SWLD-1292.0	1292.02	1292.09	0.07	1292.03	0.01	1292.06	0.04	1292.02	0	1292.06	0.04	10.00	9.82	0.18	9.59	0.41	9.61	0.39
10	SWLD-1291.5	1291.54	1291.49	0.05	1291.59	0.05	1291.47	-0.07	1291.52	0.02	1291.53	0.01	10.00	9.9	0.1	9.73	0.27	9.71	0.29
11	SWLD-1291.2	1291.22	1291.25	0.03	1291.28	0.06	1291.28	0.06	1291.29	0.07	1291.27	0.05	10.00	9.84	0.16	9.81	0.19	9.66	0.34
		Max.	$\Delta\lambda$	0.07	$\Delta\lambda$	0.09	$\Delta\lambda$	0.07	$\Delta\lambda$	0.07	$\Delta\lambda$	0.08	Max.	ΔP	0.32	ΔP	0.41	ΔP	0.42

- **Temperature cycling:** The temperature cycling test is based on the procedures stated in MIL-STD-883, Method 1010, with a minimum temperature ramp rate of 10°C/min., with the following conditions:

Temperature: -40°C to 70°C (±2°C) for CO

-40°C to 85°C (±2°C) for RT/UNC

Dwell Time at Extremes: ≥15 minutes

Temperature Ramp Rate: ≥ 10°C per minute.

Number of Cycles: 100 pass/fail, 500 for information for CO

500 pass/fail, 1000 for information for RT/UNC

Samples will be put into the chamber to a temperature cycle from +85±2°C to -40±2°C. The test was started with the high temperature. The temperature rate of change was kept constant at 10°C per minute; the dwell time at highest and lowest temperature is 30 minutes. Samples will be taken initially and at the end, as well as interim measurements,

at 50, 100, and 500 intervals, 100 cycles for qualification and 500 for information. The optical test is made after the components are stabilized at room conditions for at least 2 hours.

Testing Results of Endurance-Damp-Heat (Condition: -40°C to +85°C, 500 cycles P/F)															
No.	Product No.	Wave length (nm)							Output power (dBm)						
		Initial	50	Δλ	100	Δλ	500	Δλ	Initial	50	ΔP	100	ΔP	500	ΔP
1	SWLD-1450.2	1450.21	1450.23	0.02	1450.25	0.04	1450.26	0.05	10.00	9.69	0.31	9.66	0.34	9.61	0.39
2	SWLD-1452.1	1452.12	1452.15	0.03	1452.1	0.02	1452.16	0.04	10.00	9.85	0.15	9.79	0.21	9.72	0.28
3	SWLD-1451.2	1451.17	1451.14	0.03	1451.16	0.01	1451.18	0.01	10.00	9.69	0.31	9.66	0.34	9.59	0.41
4	SWLD-1452.2	1452.18	1452.16	0.02	1452.23	0.05	1452.22	0.04	10.00	9.72	0.28	9.78	0.22	9.65	0.35
5	SWLD-1452.8	1452.82	1452.78	0.04	1452.85	0.03	1452.86	0.04	10.00	9.71	0.29	9.76	0.24	9.58	0.42
6	SWLD-1451.6	1451.63	1451.66	0.03	1451.66	0.03	1451.65	0.02	10.00	9.92	0.08	9.88	0.12	9.72	0.28
7	SWLD-1451.5	1451.52	1451.56	0.04	1451.57	0.05	1451.56	0.04	10.00	9.86	0.14	9.75	0.25	9.8	0.2
8	SWLD-1452.2	1452.21	1452.23	0.02	1452.26	0.05	1452.26	0.05	10.00	9.76	0.24	9.71	0.29	9.61	0.39
9	SWLD-1453.2	1453.18	1453.18	0	1453.22	0.04	1453.19	0.01	10.00	9.66	0.34	9.61	0.39	9.52	0.48
10	SWLD-1453.1	1453.09	1453.11	0.02	1453.07	0.02	1453.12	0.03	10.00	9.85	0.15	9.77	0.23	9.55	0.45
11	SWLD-1450.8	1450.78	1450.75	0.03	1450.82	0.04	1450.74	0.04	10.00	9.59	0.41	9.72	0.28	9.59	0.41
		Max.	Δλ	0.04	Δλ	0.05	Δλ	0.05	Max.	ΔP	0.41	ΔP	0.39	ΔP	0.48

- **Accelerated Aging:** The high temperature aging test was conducted to confirm the reliability of the fully assembled modules. Although SWLD package can be checked with various methods, accelerated aging provides information on median lifetime of the whole modules instead of the laser diode and photodiode only. The aging condition will be biased to achieve 10dBm output power at environment temperature of -40 °C or 85°C, the laser wavelength and output power as well as laser side-mode-suppression-ratio will be monitored online and all data are recorded in data base per Telcordia testing standard required.
- **High Temperature storage:** The high temperature storage (dry heat) test is based on the procedures stated in EIA/TIA-455-4A, with the following conditions:
Temperature: 85°C ($\pm 2^\circ\text{C}$) or the maximum storage temperature
Humidity: <40% RH
Test Duration: 2,000 hrs for qualification and 5,000 hrs for information

Test samples are subjected to a temperature resistance test at a modified test temperature of +85°C with a relative humidity less than 40%, and data shall be taken initially and at the end, as well as interim measurements, at 168/336/500/1000/2000 hours intervals for qualification. The optical test is made after the components are stabilized at room conditions for at least 2 hours.

Testing Results of Endurance-Low Temperature Storage (Condition: -40°C, 2000 hrs)																							
No.	Product No.	Wavelength(nm)										Output power(dBm)											
		Initial	168	Δλ	336	Δλ	500	Δλ	1000	Δλ	2000	Δλ	Initial	168	ΔP	336	ΔP	500	ΔP	1000	ΔP	After FP	ΔP
1	SWLD-1392.5	1392.51	1392.53	0.02	1392.53	0.02	1392.56	0.05	1392.54	0.03	1392.55	0.04	10.00	9.83	0.17	9.88	0.12	9.82	0.18	9.77	0.23	9.75	0.21
2	SWLD-1391.1	1391.1	1391.16	0.06	1391.15	0.05	1391.11	0.01	1391.14	0.04	1391.13	0.03	10.00	9.96	0.04	10.21	0.21	9.96	0.04	9.71	0.29	9.81	0.19
3	SWLD-1390.7	1390.72	1390.75	0.03	1390.76	0.04	1390.77	0.05	1390.71	0.01	1390.76	0.04	10.00	9.92	0.08	10.06	0.06	9.92	0.08	9.69	0.31	9.76	0.23
4	SWLD-1391.6	1391.57	1391.59	0.02	1391.61	0.04	1391.6	0.03	1391.61	0.04	1391.62	0.05	10.00	9.93	0.07	10.21	0.21	9.96	0.04	9.61	0.39	9.61	0.39
5	SWLD-1392.1	1392.11	1392.14	0.03	1392.08	0.03	1392.14	0.03	1392.1	0.01	1392.14	0.03	10.00	9.85	0.15	9.96	0.04	9.91	0.09	9.92	0.08	9.65	0.33
6	SWLD-1390.8	1390.78	1390.75	0.03	1390.82	0.04	1390.82	0.04	1390.83	0.05	1390.81	0.03	10.00	9.88	0.12	9.76	0.24	9.72	0.28	9.91	0.09	9.9	0.10
7	SWLD-1391.6	1391.64	1391.66	0.02	1391.69	0.05	1391.64	0	1391.66	0.02	1391.69	0.05	10.00	9.86	0.14	9.72	0.28	9.68	0.32	9.88	0.12	9.52	0.44
8	SWLD-1391.4	1391.42	1391.41	0.01	1391.46	0.04	1391.45	0.03	1391.47	0.05	1391.47	0.05	10.00	9.87	0.13	9.73	0.27	9.66	0.34	9.75	0.25	9.71	0.24
9	SWLD-1391.5	1391.49	1391.49	0	1391.52	0.03	1391.55	0.06	1391.52	0.03	1391.55	0.06	10.00	9.92	0.08	9.71	0.29	9.59	0.41	9.71	0.29	9.82	0.13
10	SWLD-1390.7	1390.66	1390.63	0.03	1390.69	0.03	1390.63	-0.03	1390.61	0.05	1390.63	0.03	10.00	9.83	0.17	9.72	0.28	9.75	0.25	9.65	0.35	9.68	0.33
11	SWLD-1392.2	1392.23	1392.26	0.03	1392.28	0.05	1392.21	-0.02	1392.26	0.03	1392.28	0.05	10.00	9.92	0.08	9.85	0.15	9.76	0.24	9.66	0.34	9.62	0.33
		Max	Δλ	0.06	Δλ	0.05	Δλ	0.06	Δλ	0.05	Δλ	0.06	Max	ΔP	0.17	ΔP	0.29	ΔP	0.41	ΔP	0.39	ΔP	0.39

- **Low Temperature storage:** The low temperature storage test is based on the procedures stated in EIA/TIA-455-4A with the following conditions:
Temperature: -40°C ($\pm 5^\circ\text{C}$)
Humidity: Uncontrolled

Test Duration: 2,000hrs for qualification with testing interval of 168hrs, 336hrs, 500hrs, 1000hrs and 2000hrs

The test samples are subjected to a temperature resistance test at a modified test temperature of -40°C, and data shall be taken initially and at the end, as well as interim measurements, at 168, 336, 500, 1000, 2000hrs intervals, and 2000hrs for qualification. The optical test is made after the components are stabilized at room conditions for at least 2 hours.

Testing Results of Endurance-High Temperature Storage (Condition: +85°C, 2000 hrs)																							
No.	Product No.	Wavelength (nm)										Output power (dBm)											
		Initial	168	Δλ	336	Δλ	500	Δλ	1000	Δλ	2000	Δλ	Initial	168	ΔP	336	ΔP	500	ΔP	1000	ΔP	2000	ΔP
1	SWLD-1493.2	1493.22	1493.26	0.04	1493.24	0.02	1493.26	0.04	1493.27	0.05	1493.23	0.01	10.00	9.77	0.23	9.71	0.29	9.6	0.4	9.56	0.44	9.53	0.47
2	SWLD-1492.2	1492.21	1492.25	0.04	1492.23	0.02	1492.22	0.01	1492.16	0.05	1492.25	0.04	10.00	9.82	0.18	9.69	0.31	9.63	0.37	9.58	0.42	9.61	0.39
3	SWLD-1491.8	1491.79	1491.75	0.04	1491.77	0.02	1491.72	0.07	1491.73	0.06	1491.72	0.07	10.00	9.88	0.12	9.83	0.17	9.78	0.22	9.77	0.23	9.72	0.28
4	SWLD-1490.5	1490.47	1490.49	0.02	1490.51	0.04	1490.42	0.05	1490.51	0.04	1490.49	0.02	10.00	9.9	0.1	9.86	0.14	9.69	0.31	9.68	0.32	9.73	0.27
5	SWLD-1492.2	1492.21	1492.21	0	1492.24	0.03	1492.25	0.04	1492.26	0.05	1492.2	0.01	10.00	9.93	0.07	10.06	0.06	9.82	0.18	9.88	0.12	9.81	0.19
6	SWLD-1491.1	1491.12	1491.15	0.03	1491.1	0.02	1491.16	0.04	1491.09	0.03	1491.16	0.04	10.00	9.71	0.29	9.66	0.34	9.72	0.28	9.85	0.15	9.82	0.18
7	SWLD-1489.6	1489.62	1489.6	0.02	1489.66	0.04	1489.66	0.04	1489.55	0.07	1489.65	0.03	10.00	9.66	0.34	9.68	0.32	9.59	0.41	9.62	0.38	9.61	0.39
8	SWLD-1490.3	1490.33	1490.35	0.02	1490.37	0.04	1490.38	0.05	1490.36	0.03	1490.37	0.04	10.00	9.69	0.31	9.66	0.34	9.55	0.45	9.61	0.39	9.66	0.34
9	SWLD-1492.3	1492.31	1492.28	0.03	1492.33	0.02	1492.36	0.05	1492.28	0.03	1492.36	0.05	10.00	9.63	0.37	9.58	0.42	9.58	0.42	9.59	0.41	9.59	0.41
10	SWLD-1490.8	1490.82	1490.79	0.03	1490.79	0.03	1490.84	0.02	1490.76	0.06	1490.88	0.06	10.00	9.65	0.35	9.63	0.37	9.69	0.31	9.71	0.29	9.61	0.39
11	SWLD-1491.5	1491.49	1491.52	0.03	1491.52	0.03	1491.43	0.06	1491.43	0.06	1491.54	0.05	10.00	9.66	0.34	9.61	0.39	9.63	0.37	9.73	0.27	9.58	0.42
		Max.	Δλ	0.04	Δλ	0.04	Δλ	0.07	Δλ	0.07	Δλ	0.07	Max.	ΔP	0.37	ΔP	0.42	ΔP	0.45	ΔP	0.44	ΔP	0.47

- **Internal Moisture:** The purpose of this test is to measure the water vapor contents of hermetically sealed modules. Excessive moisture levels coupled with ionics (such as from process chemicals, organic adhesives etc.) inside the package enclosures can potentially results in corrosion type failures over time. This is a destructive test, and is performed per MIL-STD-883. The specified moisture level is 5000 ppm of water vapor. Long-term reliability studies for some FCP modules (such as ceramic oscillators) with moisture levels exceeding this threshold have not shown any adverse impact on product reliability from the water vapor. Therefore method 1018 requirements are currently used as an objective, and the IM test is performed for information only unless required by customer application.

--Not tested

- **ESD Threshold:** ESD-damage threshold was determined at room temperature on finished devices. The devices for this test were subjected to normal incoming inspection and screening procedures. All operators wore grounding strap when handling the modules and the modules were transported with conductive foam. Test condition applied to these modules was based on the human-body model (HBM), 100pF, 1.5kΩ, ±500V and ±1000V, 5 times/each polarity, and is in reference to TR-NWT-000870.

--Not tested

6. Test Results-Summary of GR-468 Qualification Testing as following:



SWLD laser GR468-qualification report 2021-03-16

Telcordia GR468 Qualification Results (99pcs SWLD samples)								
Test Category	Type of Test	测试种类	Sample	Testing Condition	Max. λ -Change nm	Max. Power-Change dB	Max. SMSR-Change dB	Status
Mechanical integrity 机械完整性测试	Mechanical Shock	机械冲击	11	1500G, 0.5ms, 5 times/axis	0.03	0.34	0.70	Pass
	Vibration	机械震动	11	20G, 20-2000Hz, 4 min/cycle, 4 cycles/axis	0.05	0.31	0.70	Pass
	Thermal Shock	热冲击	11	$\Delta T=100^{\circ}\text{C}$, 0-100 $^{\circ}\text{C}$. MIL-STD-883E, Method 1011.9	0.08	0.42	1.30	Pass
	Solderability	焊锡特性测试	11	MIL-STD-883, Method 2003	0.04	0.16	2.30	Pass
	Fiber Pull	光纤拉力测试	11	1 kg, 10 sec, 3 times	0.03	0.22	1.40	Pass
Endurance 耐力测试项目	Damp/heat	高温高湿测试	11	85 $^{\circ}\text{C}$, 85% RH, 2000 hrs	0.08	0.44	< 5	Pass
	Temp Cycling	温度循环测试	11	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$, 500 cycles P/F 1000 cycles Information	0.05 0.08	0.48 0.49	< 5 < 5	Pass Pass
	Low Temp Storage	低温存储测试	11	-40 $^{\circ}\text{C}$, 2000 hrs, started 12/18/2004	0.06	0.48	< 5	Pass
	High Temp Storage	高温存储测试	11	85 $^{\circ}\text{C}$, 2000 hrs, started 12/18/2004	0.07	0.47	< 5	Pass
			99					
All the lasers tested wavelength change of less than 0.1nm using Agilent 86120B/C wavelength meter at fixed operation conditions								

Reference

1. GR-468-CORE, "Generic Reliability Assurance Requirements for Optoelectronic Devices Used In Telecommunications Equipment", Telcordia Technologies Generic Requirements Issue 2, September 2004.