Renesas Radiation Hardened QML-P Equivalent Screening and QCI Flow

This document outlines the production flow and lot assurance testing for Renesas Radiation Hardened QML-P Equivalent Products for space applications. Refer to the datasheet for each device for more information specific to that device.

Contents

1. Introduction

The production flow detailed in this document is in accordance with MIL-PRF-38535. Products that refer to this document are produced, screened, and tested to MIL-PRF-38535 Class P standards, except for the wafer fabrication facility audit. The wafer fabrication facility audit is the only deviation from MIL-PRF-38535 Class P standards.

Note: Renesas does not support source inspection (pre-cap or final) on die or packaged parts.

2. Production Flow

This section outlines the production flow that Renesas Radiation Hardened QML-P Equivalent parts receive after assembly. This production flow, group, and sub-group names are in accordance with MIL-PRF-38535.

After parts have been assembled, all units go through the Production Screening Procedure, detailed further in the Production Screening Procedure section. After the ICs pass the Production Screening Procedure, sample selection for Quality Conformance Inspection (QCI) occurs, discussed further in Quality Conformance Inspection. The remaining ICs go on quality hold pending QCI recommendation. Finally, when QCI has passed, the ICs placed on quality hold move into inventory and become orderable. If the sampled ICs fail QCI, the ICs on quality hold are scrapped and can never be ordered.

The flowcharts in this document are used as a visual representation of the production screening and QCI flow. All tests shown are performed in accordance with MIL-PRF-38535; however, the order of the tests is subject to change based on manufacturing needs.

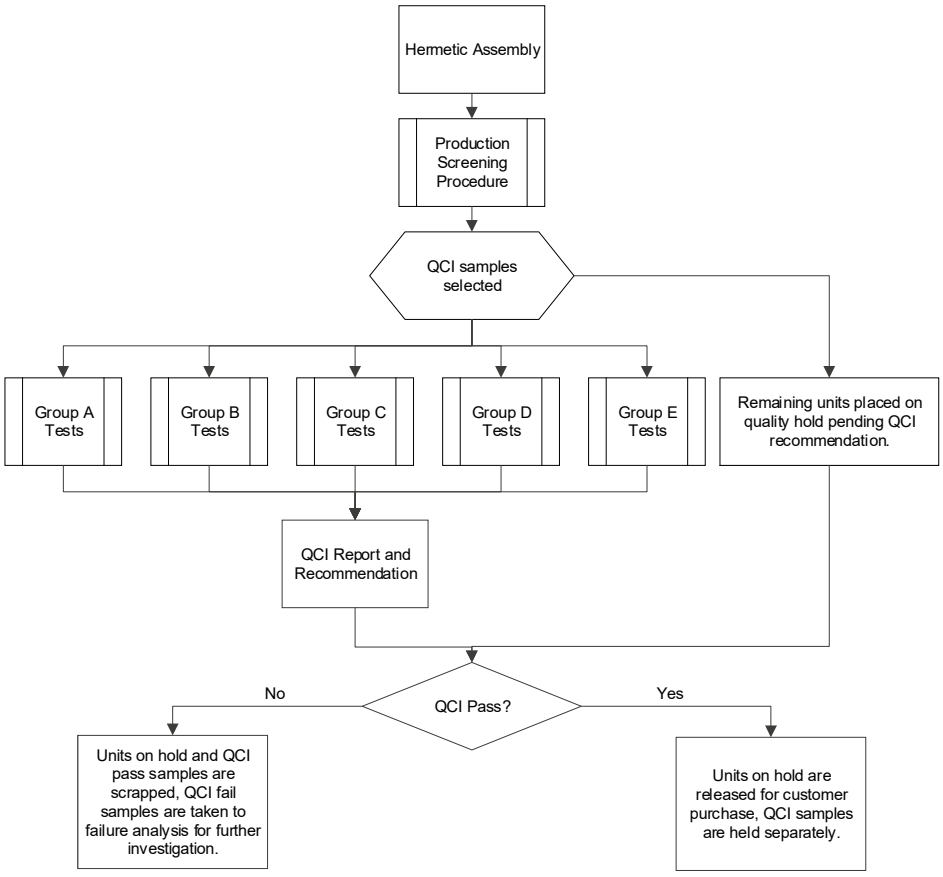

Figure 1. Radiation Hardened QML-P Equivalent Production Flow Chart

3. Production Screening Procedure

This section outlines the production screening that 100% of Renesas Radiation Hardened QML-P Equivalent units receive. This production screening follows MIL-PRF-38535 Table 1A.

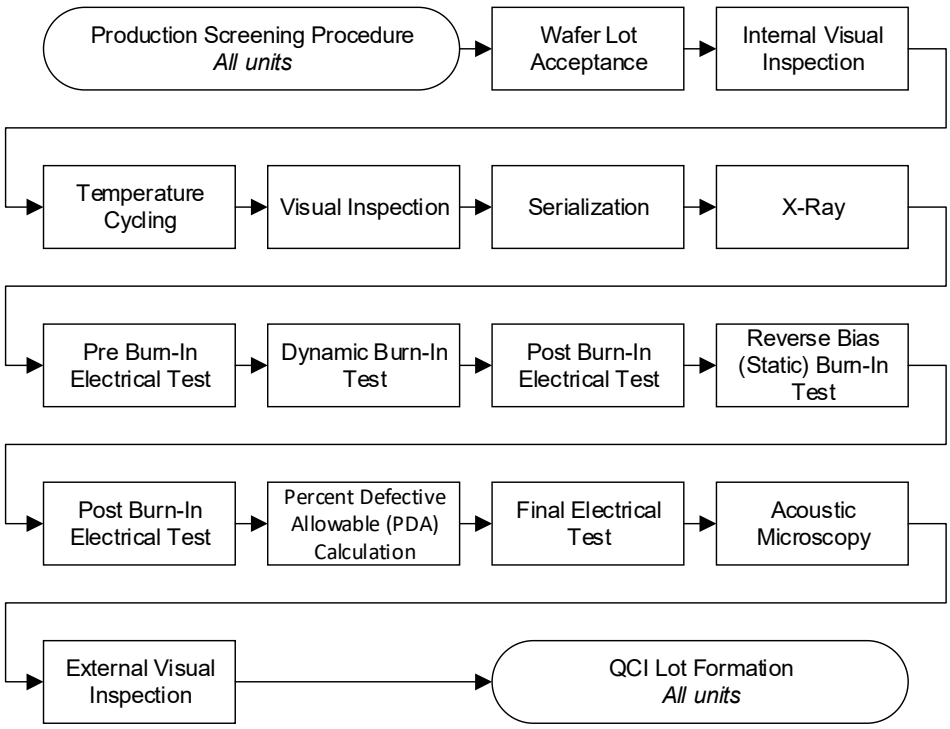

Figure 2. Production Screening Procedure Flow Chart

Table 1. Production Screening Test Procedure Method Descriptions[1]

Test	Test Method	Notes
Wafer Lot Acceptance	MIL-STD-883 TM5007	-
Internal Visual Inspection	MIL-STD-883 TM2010	Condition A
Temperature Cycling	MIL-STD-883 TM1010	Condition B, -55 to 125 °C, 15 cycles
Visual Inspection	100%	-
Serialization	100%	-
X-Ray	MIL-STD-883 TM2012	-
Pre Burn-In Electrical Test	Per device specification, read and record	-
Dynamic Burn-In Test[2]	MIL-STD-883 TM1015	Condition D, 240 hours at 125°C or 180 hours at 135°C
Post Burn-In Electrical Test	Per device specification, read and record at 25°C	-
Reverse Bias (Static) Burn-In Test[2]	MIL-STD-883 TM1015	Condition A, 144 hours at 125°C or 108 hours at 135°C
Percent Defective Allowable (PDA) Calculation	5% PDA, 3% PDA for functional parameters at 25°C including deltas	-
Final Electrical Test	Per device specification	25°C, min., and max. operating temperatures

Table 1. Production Screening Test Procedure Method Descriptions[1] (Cont.)

Test	Test Method	Notes
Acoustic Microscopy	J-STD-020, J-STD-035	-
External Visual Inspection	MIL-STD-883 TM2009	-

1. From *MIL-PRF-38535 Table 1A, Footnote 26*: For QML-P Equivalent microcircuit devices, Renesas shall perform some variant of part-average testing (PAT) that meets the intent of the guideline. Renesas determines the sample sizes and acceptance criteria. If these tests are not possible for a given part, then the supplier shall provide justification to the Qualifying Activity. The PAT requirements may be performed in any sequence (e.g. at wafer sort and/or final test) in the screening flow.
2. From *MIL-PRF-38535 Table 1A, Footnote 16*: The reverse bias burn-in is a requirement only when specified in the applicable device specification and is recommended only for a certain MOS, linear or other microcircuits where surface sensitivity may be a concern. When reverse bias burn-in is not required, interim post burn-in electrical parameter measurements shall be omitted. The order of performing the burn-in test and the reverse bias burn-in test may be inverted. Static burn-in may be substituted for high temperature reverse bias burn-in based on device technology and must be approved by the QA. Moreover, burn-in time-temperature regression table I of TM1015 of MIL-STD-883 can be used for determination of reverse bias burn-in time and temperature.

4. Quality Conformance Inspection

This section outlines the Quality Conformance Inspection testing that follows the production screening procedure.

After units undergo the production screening procedure outlined in Production Screening Procedure, samples are selected for Quality Conformance Inspection (QCI). The ICs not selected for QCI are held for customer purchase, pending QCI recommendation.

QCI testing is completed in accordance with MIL-PRF-38535, which includes the test methods used, the number of samples selected, and the frequency of testing. Group and sub-group names are also in accordance with MIL-PRF-38535.

Table 2. QCI Sampling Quantities and Frequencies

Test	Minimum Number of Samples (Allowed Fails)	Frequency
Group A Tests	116 (0)	Every inspection lot
Group B Tests (Subgroup 1)	3(0)	Every inspection lot
Group B Tests (Subgroup 2a)	4(0)	Every inspection lot
Group B Tests (Subgroup 2b)	3(0)	Every inspection lot
Group B Tests (Subgroup 3)	3(0)	Every inspection lot
Group C Tests	45(0)	Every wafer lot
Group D Tests (Subgroup 1)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 2)	3(0)	Per package type, every 6 months
Group D Tests (Subgroup 3b)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 3c)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 5)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 7)	3(0)	Per package type, every 6 months
Group D Tests (Subgroup 8)	5(0)	Per package type, every 6 months
Group E Tests (Subgroup 2)	4(0)	Every wafer

4.1 Group A Tests

As a part of QCI, Group A Tests (*Electrical Tests*) are performed, shown in Figure 3. These tests are in accordance with MIL-PRF-38535 Table 3.

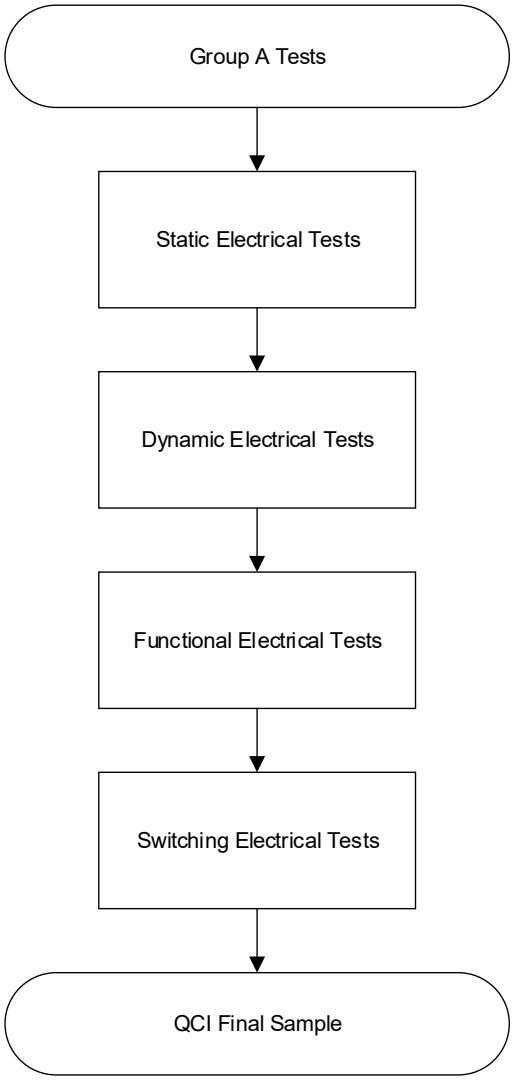

Figure 3. Group A Testing Flow Chart

Table 3. Group A Test Method Descriptions

Test	Test Method	Notes
Static Electrical Tests	Per device specification	25°C, min., and max. operating temperatures
Dynamic Electrical Tests	Per device specification	25°C, min., and max. operating temperatures
Functional Electrical Tests	Per device specification	25°C, min., and max. operating temperatures
Switching Electrical Tests	Per device specification	25°C, min., and max. operating temperatures

4.2 Group B Tests

As a part of QCI, Group B Tests (*Mechanical and Environmental Tests*) are performed, shown in Figure 4. These tests are in accordance with MIL-PRF-38535 Table 2.

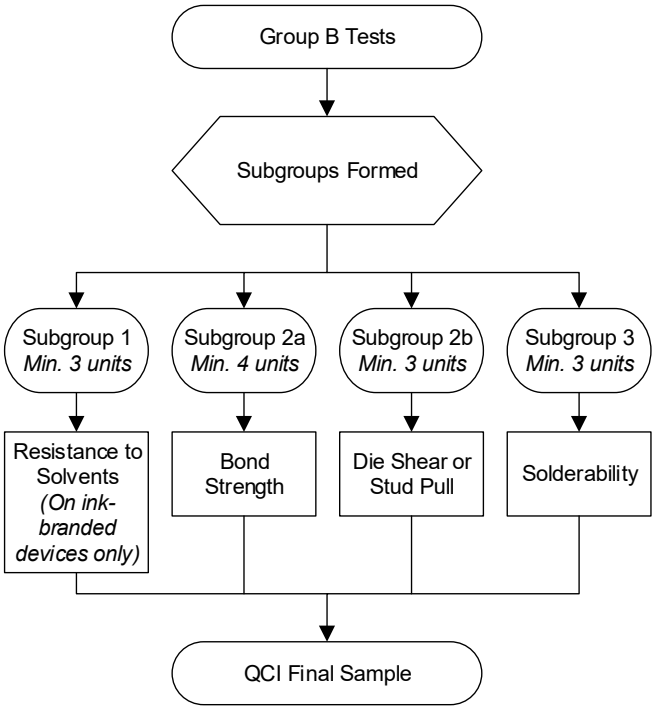

Figure 4. Group B Testing Flow Chart

Table 4. Group B Test Methods

Test	Test Method	Notes
Resistance to Solvents	MIL-STD-883 TM2015	-
Bond Strength	MIL-STD-883 TM2011	Sample size for thermocompression or ultrasonic test is 22 bond pulls from a minimum of 4 devices, sample size for beam lead test is 22 dice. The decision between thermocompression, ultrasonic, or beam lead test is dependent on the die characteristics of the sample. Refer to *MIL-PRF-38535 Table 2, Footnote 7* and *MIL-STD-883 TM2011* for more information.
Stud Pull	MIL-STD-883 TM2027	The decision between performing Stud Pull or Die Shear is based on the die characteristics of the sample. Refer to *MIL-STD-883 TM2019* and *MIL-STD-883 TM2027* for more information.
Die Shear	MIL-STD-883 TM2019	
Solderability	MIL-STD-883 TM2003	22 leads from a min. of 3 devices, solder temperature +245°C ± 5°C

4.3 Group C Tests

As a part of QCI, Group C Tests (*Life Tests*) are performed, shown in Figure 5. These tests are in accordance with MIL-PRF-38535 Table 4.

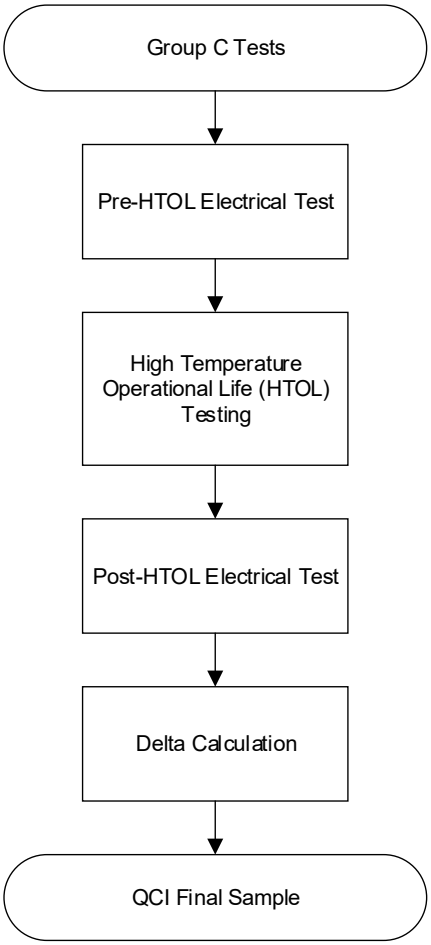

Figure 5. Group C Testing Flow Chart

Table 5. Group C Test Method Descriptions

Test	Test Method	Notes
Pre-HTOL Electrical Test	Per device specification	25°C, min., and max. operating temperatures
High Temperature Operational Life (HTOL) Testing	MIL-STD-883 TM1005	Condition D, T_A = 125° C, 1000 hours min. or T_A = 135° C, 800 hours min.
Post-HTOL Electrical Test	Per device specification	25°C, min., and max. operating temperatures
Delta Calculation	-	25°C

4.4 Group D Tests

As a part of QCI, Group D Tests (*Package Related Tests*) are performed, shown in Figure 6. These tests are in accordance with MIL-PRF-38535 Table 5.

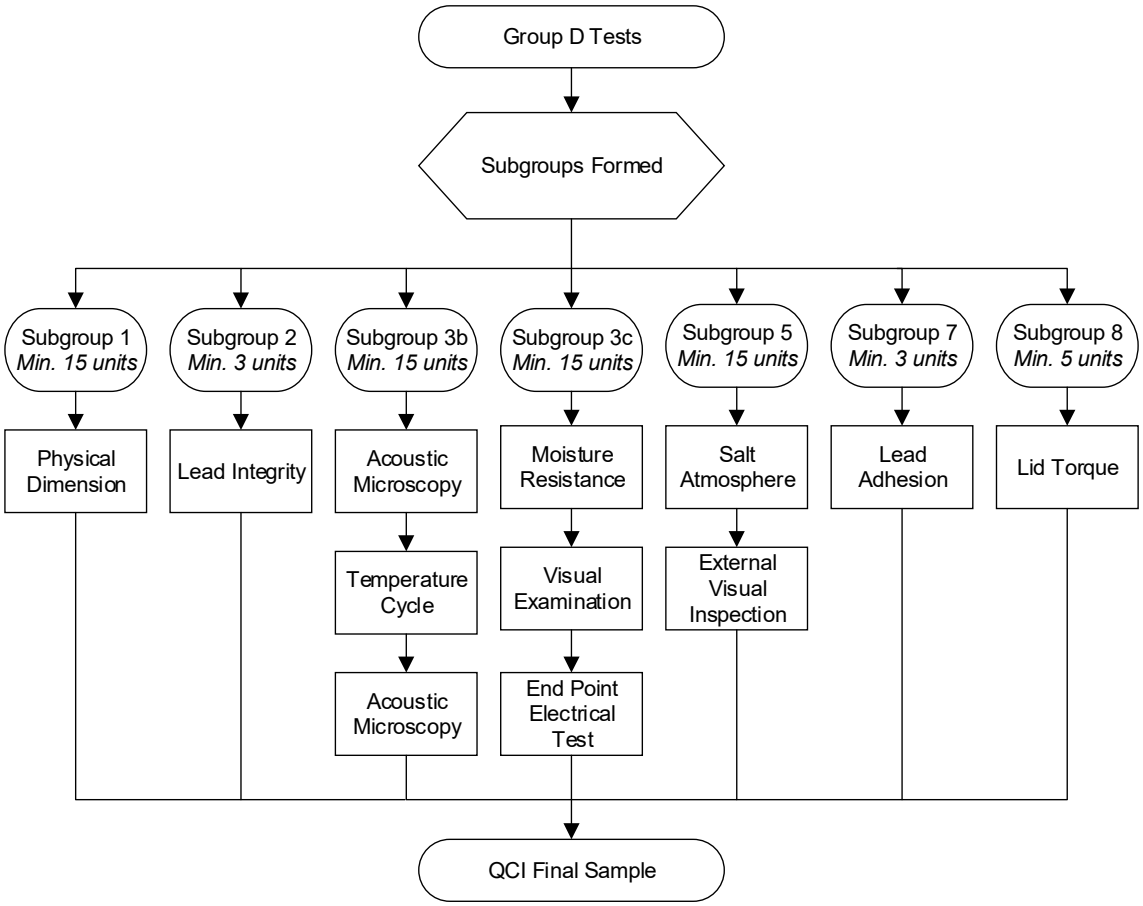

Figure 6. Group D Testing Flow Chart

Table 6. Group D Test Method Descriptions

Test	Test Method	Notes
Physical Dimension	MIL-STD-883 TM2016	-
Lead Integrity	MIL-STD-883 TM2004 and/or MIL-STD-883 TM2028	Sample size is 45 leads with zero failure from a minimum of 3 devices. For LLC packages only, sample size is 15 leads from a minimum of 3 devices.
Acoustic Microscopy	J-STD-020, J-STD-035	-
Temperature Cycle	MIL-STD-883 TM1010	Condition B, 150 cycles
Moisture Resistance	JESD22-A118 Unbiased HAST Condition B and/or JESD22-A110 Biased HAST Condition B	-
Visual Examination	MIL-STD-883 TM1004 or MIL-STD-883 TM1010	-
End Point Electrical Test	Per device specification	-
Salt Atmosphere	MIL-STD-883 TM1009	Condition A (min.)

Table 6. Group D Test Method Descriptions (Cont.)

Test	Test Method	Notes
External Visual Inspection	MIL-STD-883 TM1009	-
Lead Adhesion	MIL-STD-883 TM2025	Sample size is 15 leads with zero failure from a minimum of 3 devices.
Lid Torque	MIL-STD-883 TM2024	-

4.5 Group E Tests

As a part of QCI, Group E Tests (*Radiation Hardness Assurance Tests*) are performed, shown in Figure 7. These tests are in accordance with MIL-PRF-38535 Table C-1.

For Group E tests, the radiation levels that a given device is qualified to can be found on its respective datasheet and radiation reports.

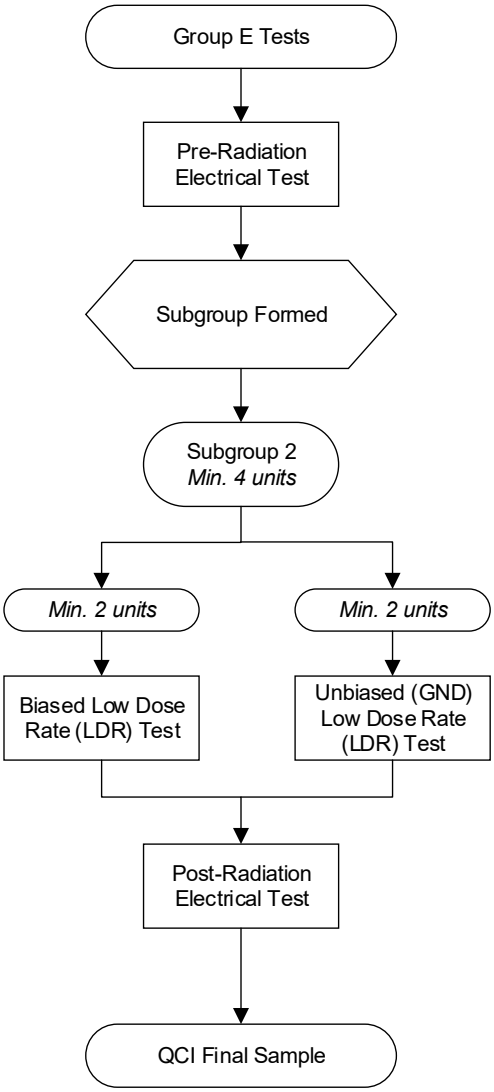

Figure 7. Group E Testing Flow Chart

Table 7. Group E Test Method Descriptions

Test	Test Method	Notes
Pre-Radiation Electrical Test	Per device specification, read and record	-
Biased Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Unbiased (GND) Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Post-Radiation Electrical Test	Per device specification, read and record	-

5. Up-Front Characterization and Qualification

This section outlines the one-time, up-front characterization and qualification that products receive. These tests are only performed during initial qualification or after any major design and/or process change, and are in accordance with MIL-PRF-38535. These tests are performed in addition to the standard production screening flow and quality conformance inspection.

Table 8. Up-Front Characterization Samples

Test Group	Test	Minimum Number of Samples
Package Related Tests	Moisture Resistance Testing MSL1 Test Procedure	22(0)
Package Related Tests	Moisture Resistance Testing MSL2 Test Procedure	22(0)
Package Related Tests	Moisture Resistance Testing MSL3 Test Procedure	22(0)
Package Related Tests	Biased HAST Test	80(0)
Package Related Tests	Unbiased HAST Test	80(0)
Package Related Tests	High-Temperature Storage Test	80(0)
Package Related Tests	Temperature Cycling	80(0)
Device Related Tests	Human Body Model (HBM) Electrostatic Discharge (ESD) Sensitivity Test	3(0)
Device Related Tests	Charge Device Model (CDM) Electrostatic Discharge (ESD) Sensitivity Test	3(0)
Device Related Tests	Latch-Up Test	3(0)
Device Related Tests	HTOL Test	3(0)
Radiation Related Tests	Biased Low Dose Rate (LDR) Test	10(0)
Radiation Related Tests	Unbiased (GND) Low Dose Rate (LDR) Test	10(0)
Radiation Related Tests	Destructive Single Event Effects (DSEE) Test	4(0)
Radiation Related Tests	Single Event Transient (SET) Test	4(0)

5.1 Package Related Tests

As a part of one-time, up-front characterization, specific package-related tests are performed, as shown in Figure 8.

These tests ensure the package is built reliably and no defects exist. Before these tests, a preconditioning procedure takes place, detailed further in Preconditioning Procedure.

The Moisture Sensitivity Level (MSL) is first determined through Moisture Resistance Testing to perform the correct preconditioning procedure based on the package's characteristics, detailed further in Moisture Resistance Testing. After the MSL is determined, the appropriate preconditioning procedure can occur. This preconditioning procedure occurs before every other package-related test.

For package-related tests, electrical tests are performed at 25°C and the maximum operating temperature to maximize mechanical stress after the package stress, based on AEC-Q100.

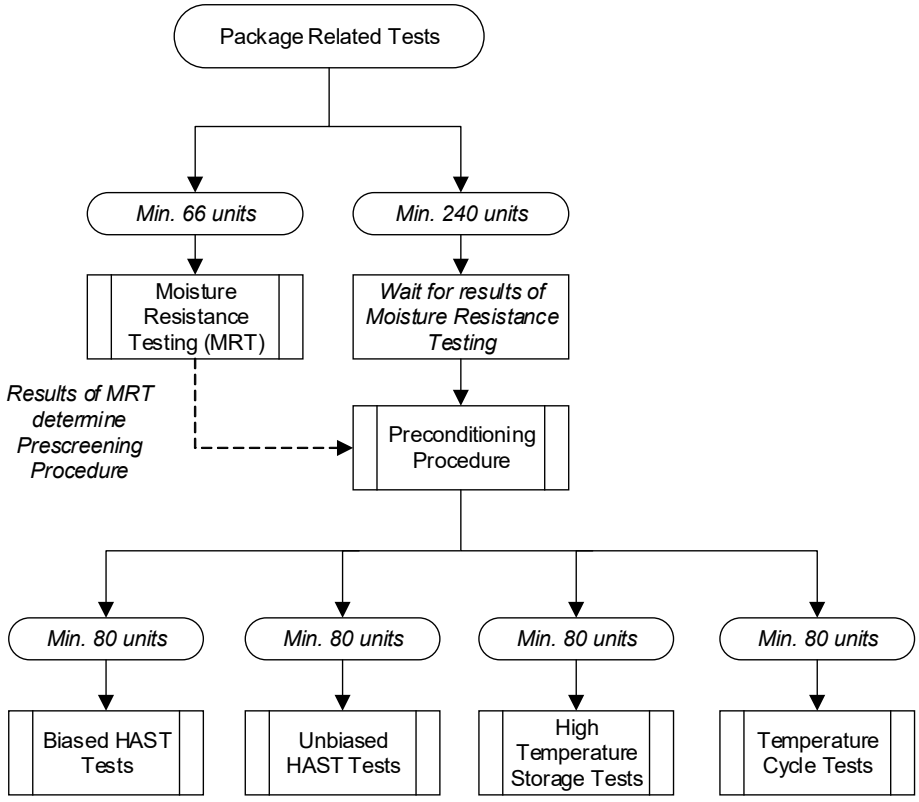

Figure 8. Package-Related Tests Flow Chart

5.1.1 Moisture Resistance Testing

The MSL is determined through Moisture Resistance Testing to determine the correct preconditioning procedure. To ensure less stringent handling requirements for end users, Renesas Radiation Hardened QML-P Equivalent ICs, at worst, have an MSL of 3.

Three parallel test flows are performed based on the three targeted MSLs (Figure 9) to determine the MSL of an IC. After these tests are complete, an engineering review of electrical test results and acoustic microscopy images takes place to assign MSL classification based on J-STD-020.

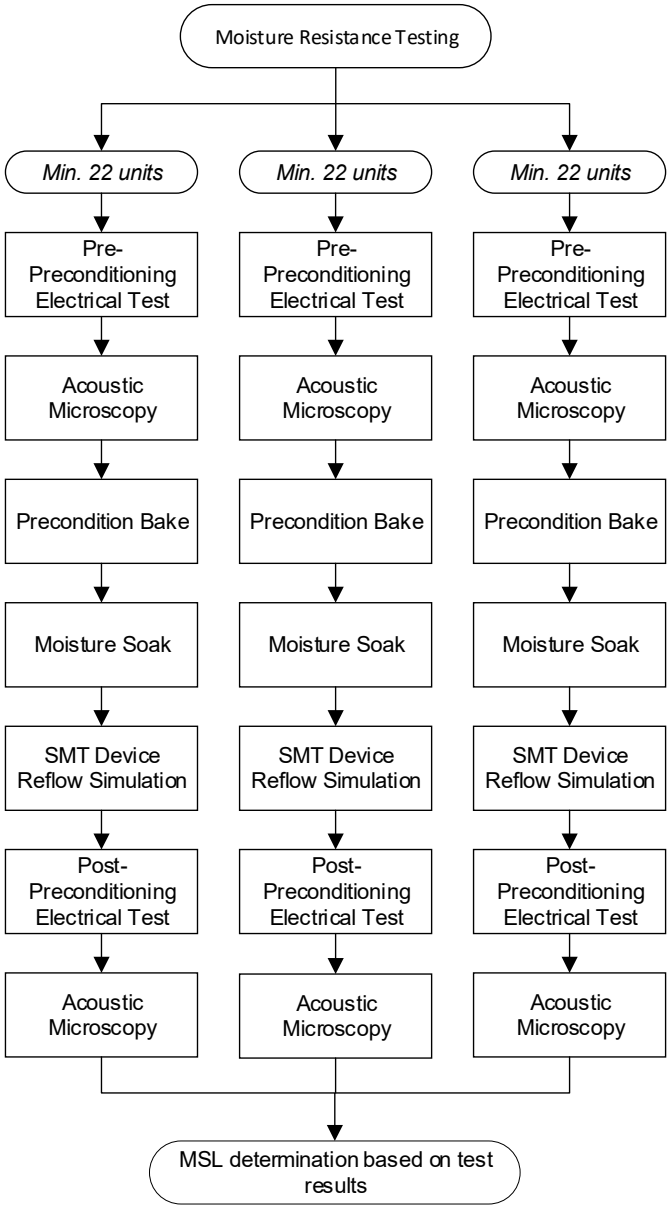

Figure 9. Moisture Resistance Testing Flow Chart

Table 9. Moisture Resistance Testing Test Methods

Test	Test Method	Notes
Pre-Preconditioning Electrical Test	Per device specification	25°C and max. operating temperature
Acoustic Microscopy	J-STD-020, J-STD-035	-
Precondition Bake	-	125°C +5°/-0°C for 4 hours minimum
Moisture Soak: MSL 1	JESD22-A113, paragraph 4.5 per applicable moisture sensitivity level (MSL) per J-STD-020	85°C, 80% RH 168 Hours
Moisture Soak: MSL 2	JESD22-A113, paragraph 4.5 per applicable moisture sensitivity level (MSL) per J-STD-020	85°C, 60% RH 168 Hours
Moisture Soak: MSL 3	JESD22-A113, paragraph 4.5 per applicable moisture sensitivity level (MSL) per J-STD-020	30°C, 60% RH 192 Hours
SMT Device Reflow Simulation	JESD22-A113, paragraph 4.6 through 4.9	Peak solder reflow temperature +235°C
Post-Preconditioning Electrical Test	Per device specification	25°C and max. operating temperature

5.1.2 Preconditioning Procedure

All samples selected for Package-Related Tests are exposed to a preconditioning procedure. This preconditioning procedure mimics the stresses the package receives in a space environment, as shown in Figure 10.

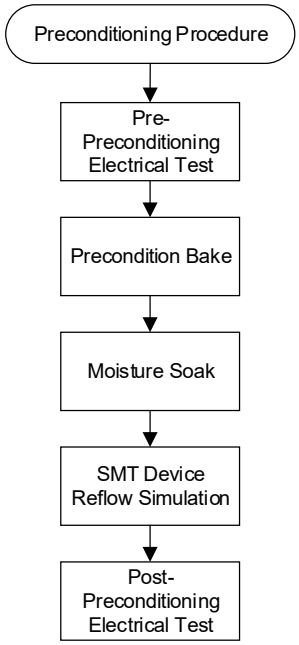

Figure 10. Preconditioning Procedure Flow Chart

Table 10. Preconditioning Procedure Test Methods

Test	Test Method	Notes
Pre-Preconditioning Electrical Test	Per device specification	25°C and max. operating temperature
Precondition Bake	-	125°C +5°/-0°C for 4 hours minimum

Table 10. Preconditioning Procedure Test Methods (Cont.)

Test	Test Method	Notes
Moisture Soak	JESD22-A113, paragraph 4.5 per applicable moisture sensitivity level (MSL) per J-STD-020	Conditions are dependent on MSL level, see Moisture Resistance Testing. ▪ MSL 1: 85°C, 85% RH 168 hours ▪ MSL 2: 85°C, 60% RH 168 hours ▪ MSL 3: 30°C, 60% RH 192 hours
SMT Device Reflow Simulation	JESD22-A113, paragraph 4.6 through 4.9	Peak solder reflow temperature +235°C
Post-Preconditioning Electrical Test	Per device specification	25°C and max. operating temperature

5.1.3 Biased HAST Tests

As a part of package-related tests, biased HAST tests are performed after the Preconditioning Procedure, as shown in Figure 11.

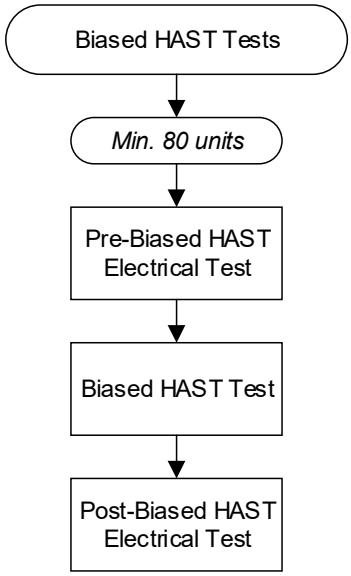

Figure 11. Biased HAST Tests Flow Chart

Table 11. Biased HAST Test Methods

Test	Test Method	Notes
Pre-Biased HAST Electrical Test	Per device specification	25°C and max. operating temperature
Biased HAST Test	JESD22-A110, with continuous bias	96 hours, +130°C, 85% RH
Post-Biased HAST Electrical Test	Per device specification	25°C and max. operating temperature

5.1.4 Unbiased HAST Tests

As a part of package-related tests, unbiased HAST test are performed after the Preconditioning Procedure, as shown in Figure 12.

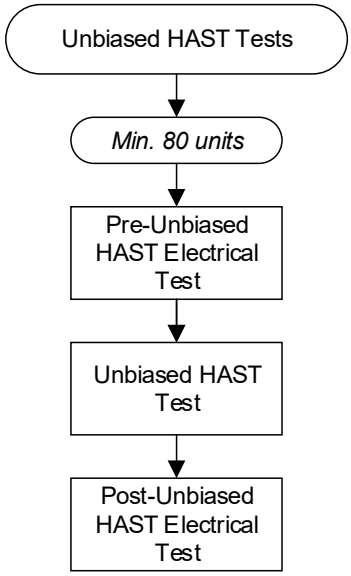

Figure 12. Unbiased HAST Tests Flow Chart

Table 12. Unbiased HAST Test Methods

Test	Test Method	Notes
Pre-Unbiased HAST Electrical Test	Per device specification	25°C and max. operating temperature
Unbiased HAST Test	JESD22-A118	130°C / 85% RH, 96hrs
Post-Unbiased HAST Electrical Test	Per device specification	25°C and max. operating temperature

5.1.5 High-Temperature Storage Tests

As a part of package-related tests, high temperature storage tests are performed after the Preconditioning Procedure, as shown in Figure 13.

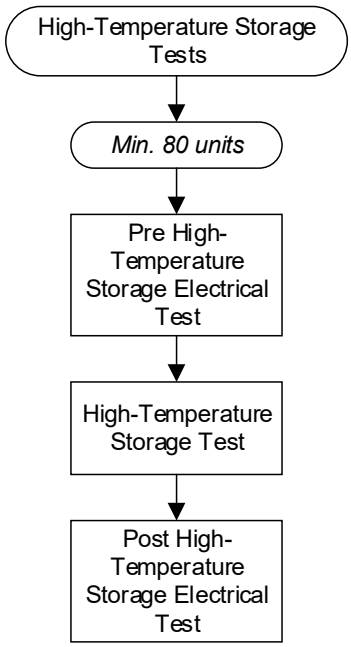

Figure 13. High-Temperature Storage Tests Flow Chart

Table 13. High-Temperature Storage Test Methods

Test	Test Method	Notes
Pre High-Temperature Storage Electrical Test	Per device specification	25°C and max. operating temperature
High-Temperature Storage Test	JESD22-A103 and A113	150°C, 1000hrs
Post High-Temperature Storage Electrical Test	Per device specification	25°C and max. operating temperature

5.1.6 Temperature Cycle Tests

As a part of package-related tests, temperature cycle tests are performed after the Preconditioning Procedure, as shown in Figure 14.

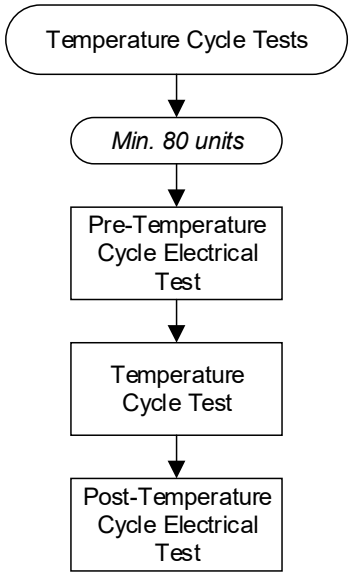

Figure 14. Temperature Cycle Tests Flow Chart

Table 14. Temperature Cycle Test Methods

Test	Test Method	Notes
Pre-Temperature Cycle Electrical Test	Per device specification	25°C and max. operating temperature
Temperature Cycle Test	MIL-STD-883 TM1010	Condition B, 65°C to 150 °C, 500 Cycles minimum
Post-Temperature Cycle Electrical Test	Per device specification	25°C and max. operating temperature

5.2 Device Related Tests

As a part of a one-time, up-front characterization, certain device-related tests are performed, as shown in Figure 15.

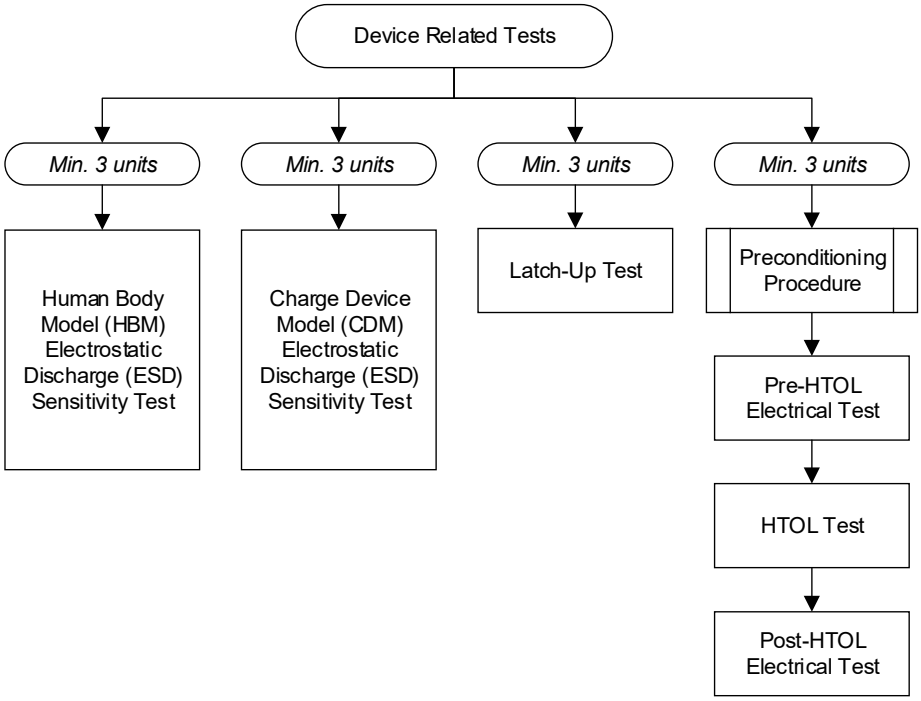

Figure 15. Up-Front Characterization Device Related Tests Flowchart

Table 15. Up-Front Characterization Device Related Test Descriptions

Test	Test Method	Notes
Human Body Model (HBM) Electrostatic Discharge (ESD) Sensitivity Test	MIL-STD-883 TM3015 or JEDEC Test Standard JS-001	Assembly and test areas use JESD625 specification controls
Charge Device Model (CDM) Electrostatic Discharge (ESD) Sensitivity Test	MIL-STD-883 TM3015 or JEDEC Test Standard JS-002	
Latch-Up Test	JESD-78	
Preconditioning Procedure	-	See Preconditioning Procedure
Pre-HTOL Electrical Test	Per Device Specification	25°C, min., and max. operating temperature
HTOL Test	MIL-STD-883 TM1005	Condition D, T_A = 125°C, 1000 hours min. or T_A = 135°C, 800 hours min.
Post-HTOL Electrical Test	Per Device Specification	25°C, min., and max. operating temperature

5.3 Radiation Related Tests

As a part of one-time, up-front characterization, certain radiation-related tests are performed, as shown in Figure 16. Refer to *MIL-PRF-38535 Table C-1* for further information.

The radiation levels that a given device is qualified to can be found on its respective datasheet and radiation test reports.

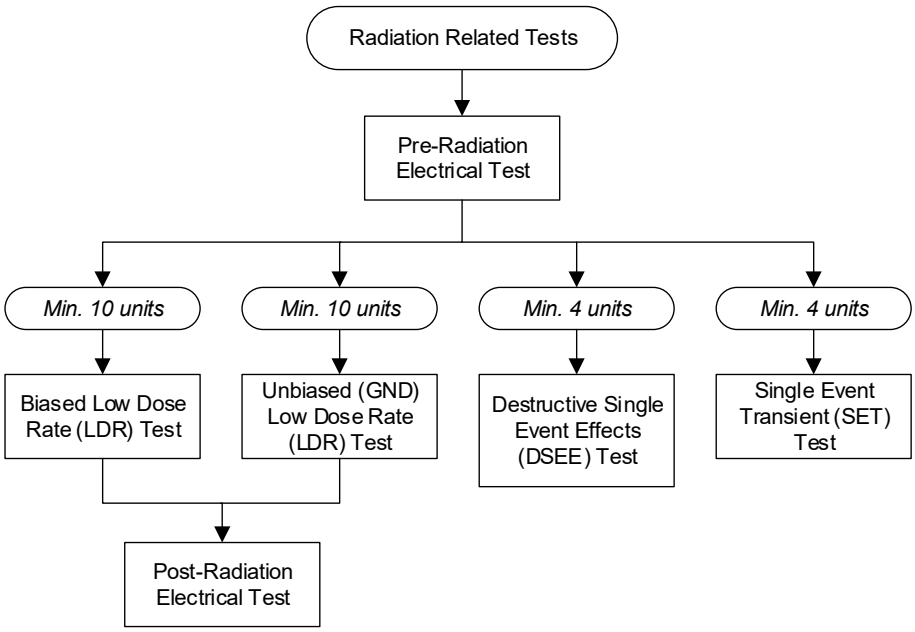

Figure 16. Up-Front Characterization Radiation Related Tests Flowchart

Table 16. Up-Front Characterization Radiation Related Tests

Test	Test Method	Notes
Pre-Radiation Electrical Test	Per device specification, read and record	25°C
Biased Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Unbiased (GND) Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Post-Radiation Electrical Test	Per device specification, read and record	25°C
Destructive Single Event Effects (DSEE) Test	JEDEC Test Standard JESD57A, per device specification	Radiation level as per device specification to assess burnout and latch-up in a heavy ion environment
Single Event Effects (SEE) Test	JEDEC Test Standard JESD57A, per device specification	Radiation level as per device specification

6. Revision History

Revision	Date	Description
1.00	Jun 15, 2023	Initial release.

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