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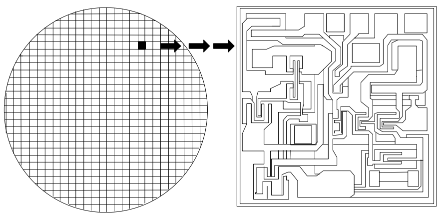
February 14, 2019



FAILURE MECHANISM BASED STRESS TEST QUALIFICATION FOR MEMS MICROPHONE DEVICES

Automotive Electronics Council
Component Technical Committee

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AEC-Q103-003 Failure Mechanism Based Stress Test Qualification for MEMS Microphones Devices

Acknowledgment

Any document involving a complex technology brings together experience and skills from many sources. The Automotive Electronics Council would especially like to recognize the following significant contributors to the development of this document:

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Automotive Electronics Council
Component Technical Committee

FAILURE MECHANISM BASED STRESS TEST QUALIFICATION FOR MICRO ELECTRO-MECHANICAL SYSTEMS (MEMS) MICROPHONE

1. SCOPE

This document contains a set of failure mechanism based stress tests specific to Micro Electro-Mechanical Systems (MEMS) Microphone technologies used in vehicle cabin environments. This document shall be used in conjunction with AEC-Q100. The circuit elements of MEMS devices are susceptible to the same mechanisms as standard IC's, thus must meet the requirements defined in AEC-Q100. The MEMS portion of these devices, including circuit and package interactions, must meet the requirements defined herein.

The objective is to precipitate failures in an accelerated manner compared to use conditions, or to simulate extreme events to draw out design or intrinsic process deficiencies. This set of tests should not be used indiscriminately. Each qualification project should be examined for:

a. Any potential new and unique failure mechanisms
b. Any situation where these tests/conditions may induce failures that would not be seen in the application
c. Any extreme use condition and/or application that could adversely reduce the acceleration

Use of this document does not relieve the MEMS supplier of their responsibility to meet their own company's internal qualification program. In this document, "user" is defined as all customers using a device qualified per this specification. User specific requirements will need to be considered in addition to these recommendations. The user is responsible to confirm and validate all qualification data that substantiates conformance to this document.

1.1 Purpose

The purpose of this specification is to determine that a MEMS Microphone device is capable of passing the specified stress tests and thus can be expected to give a certain level of quality/reliability in the application.

1.2 Reference Documents

Current revision of the referenced documents will be in effect at the date of agreement to the qualification plan. Subsequent qualification plans will automatically use updated revisions of these referenced documents.

1.2.1 Automotive

AEC-Q100	Failure Mechanism Based Stress Test Qualification for Integrated Circuits

1.2.2 Military

MIL-STD-202	Test Method Standard: Electronic and Electrical Component
MIL-STD-883	Test Method Standard: Microcircuits

1.2.3 Industrial

JEDEC JESD-22	Reliability Test Methods for Packaged Devices
DIN 50018	Testing in a saturated atmosphere in the presence of sulfur dioxide
EN 60068-2-60	Environmental testing - Flowing mixed gas corrosion test
ISO 16750-5	Road vehicles - Environmental conditions and testing for electrical and electronic equipment – Part 5: Chemical loads

1.3 Definitions

1.3.1 AEC Q103-003 Qualification

Successful completion and documentation of the test results from requirements outlined in this document and AEC-Q100 document allows the supplier to claim that the part is “AEC-Q103-003 qualified”.

1.3.2 AEC Certification

Note that there are no "certifications" for AEC-Q103-003 qualification and there is no certification board run by AEC to qualify parts. Each supplier performs their qualification to AEC standards, considers customer requirements and submits the data to the customer to verify compliance to AEC-Q103-003.

2. GENERAL REQUIREMENTS

MEMS Microphone device qualification shall be compliant to AEC-Q100 with additional requirements as defined herein.

2.1 Precedence of Requirements

In the event of conflict in the requirements of this standard and those of any other documents, the following order of precedence applies:

a. The purchase order (or master purchase agreement terms and conditions)
b. The (mutually agreed) individual device specification
c. This document
d. AEC-Q100
e. The reference documents in Section 1.2 of this document
f. The supplier's data sheet

For the device to be considered a qualified part per this specification, the purchase order and/or the individual device specification cannot waive or detract from the requirements of this document.

3. QUALIFICATION AND REQUALIFICATION:

3.1 Qualification of a New MEMS Microphone Device:

The stress test requirements for qualification of a new MEMS Microphone device is defined in Table 1. Test Group M provides guidance on testing specific to MEMS Microphone technology and package integrity. Note that this test group also includes module-level testing to be performed per agreement between user and supplier on a case-by-case basis.

3.2 Criteria for Passing Requalification

All requalification failures shall be analyzed for root cause. Once corrective and preventative actions are in place and proven effective, the device may then be considered AEC-Q103-003 requalified.

4. QUALIFICATION TESTS

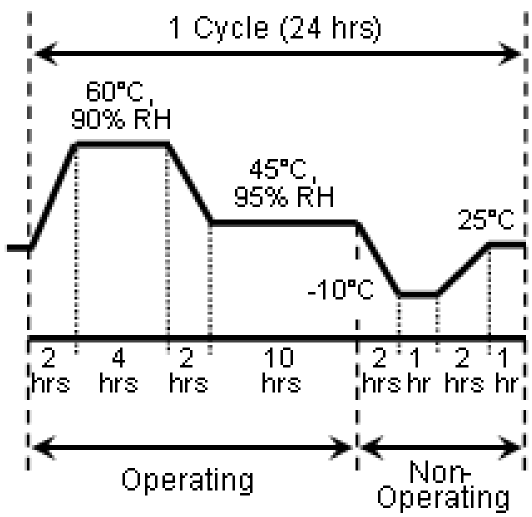
4.1 General Tests

This specification defines the requirements for the qualification of MEMS Microphone devices. It is to be used in conjunction with AEC-Q100, rather in lieu of. AEC-Q100 shall be used to qualify the active circuitry and basic package integrity of the device. In addition to the well-known IC failure mechanisms in AEC-Q100, MEMS Microphone devices require specific qualification tests to verify its performance. These unique qualification tests and/or test sequences are detailed in Table 1A and Figure 1. Table 1B lists the AEC-Q100 tests updated to address MEMS Microphone device failure mechanisms. Not all AEC-Q100 tests apply to MEMS Microphone devices, its specific package structure, or the MEMS application environment; these tests are detailed in Table 2.

<table>
<tr>
<td>

Humidity & Temperature Cycle

+65℃/90%RH │ +45℃/95%RH │ -10℃
5 cycles
Check once per day
Operating, 8VDC bias *



</td>
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Additional Requirements

1) Subject the devices to 5 cycles. Operate the devices continuously at normal load stress conditions during the operating portion of the cycle.

</td>
</tr>
</table>

Figure 1: Humidity & Temperature Cycle Test

* **Note:** The 8VDC operating bias is used as an example only, the actual DC Bias is application dependent per agreement between user and supplier on a case-by-case basis.

Table 1A: MEMS Microphone Specific Qualification Test Methods

Note: AEC-Q100 shall be used to qualify the active circuitry contained within the MEMS Microphone device, as well as package integrity for the active circuitry. The tests are specific to MEMS Microphone technology and package integrity.

TEST GROUP M – MEMS MICROPHONE SPECIFIC STRESS TESTS								
STRESS	**ABV**	**#**	**NOTES**	**SAMPLE SIZE / LOT**	**NUMBER OF LOTS**	**ACCEPT CRITERIA**	**TEST METHOD**	**ADDITIONAL REQUIREMENTS**
Humidity and Temperature Cycle	**HTC**	M1		77	3	0 Fails	JEDEC JESD22-A108 IEC 60068-2-2, Test-BA	For surface mount devices, PC before HTC testing. Test Conditions: temperature, humidity, and durations as defined in Figure 1. HTC Notes: 1) Subject devices to 5 cycles, each cycle 24 hours in duration. 2) Operate devices continuously at normal load stress conditions during the operating portion of the cycle: • 65ºC/90%RH, 2 hours ramp up, 4 hours at temperature/humidity, 2 hours ramp down (8 hours total). • 45ºC/95%RH, 10 hours at temperature/humidity. 3) Non-operating portion of the cycle: • 2 hours ramp down to -10ºC/uncontrolled RH, 1 hour at temperature. • 2 hours ramp up to 25ºC/uncontrolled RH, 1 hour at temperature. 4) Operating DC bias is application dependent per agreement between user and supplier on a case-by-case basis. 5) **TEST before and after HTC at room and hot temperature.**
Low Temp Operating Life	**LTOL**	M2		77	3	0 Fails	JEDEC JESD22-A108 IEC 60068-2-2, Test-AA	-40ºC Ta for 1000 hours. For previously qualified process technologies, this test and its accept criteria can be performed only per agreement between user and supplier on a case-by-case basis. **TEST before and after LTOL at room temperature.**
Low Temperature Storage	**LTS**	M3		77	3	0 Fails	JEDEC JESD22-A119 IEC 60068-2-2, Test-AA	-40ºC Ta for 1000 hours. **TEST before and after LTS at room temperature.**

Table 1A: MEMS Microphone Specific Qualification Test Methods (continued)

TEST GROUP M – MEMS MICROPHONE SPECIFIC STRESS TESTS (CONTINUED)								
STRESS	**ABV**	**#**	**NOTES**	**SAMPLE SIZE / LOT**	**NUMBER OF LOTS**	**ACCEPT CRITERIA**	**TEST METHOD**	**ADDITIONAL REQUIREMENTS**
Maximum Pressure Test	**MPT**	M4		77	3	'---	'---	160dB SPL sinewave for 10 cycles. Any audible frequency can be used as long as 160dB is maintained. This test and its accept criteria can be performed only per agreement between user and supplier on a case-by-case basis. **TEST before and after MPT at room and hot temperature.**
Endurance Life Test	**ELT**	M5		77	3	'---	'---	96 hours at 130dB continuous signal obtained by electrical pulse stimulation of the membrane or applying a 130dB pressure wave to the MEMS Microphone device through use of a speaker. This test and its accept criteria can be performed only per agreement between user and supplier on a case-by-case basis. **TEST before and after ELT at room and hot temperature.**
Damp Heat Cycle with Frost	**DHCF**	M6	'---	'---	'---	'---	'---	This test and its accept criteria can be performed only per agreement between user and supplier on a case-by-case basis.
Salt Mist Test	**SMT**	M7	'---	'---	'---	'---	'---	This test and its accept criteria can be performed only per agreement between user and supplier on a case-by-case basis.
Dust Particle Contamination	**DST**	M8	'---	'---	'---	'---	'---	This test and its accept criteria can be performed only per agreement between user and supplier on a case-by-case basis.

Table 1B: AEC-Q100 Qualification Test Methods Updated for MEMS Microphone Devices

Note: AEC-Q100 Table 2 tests updated to address MEMS Microphone device failure mechanisms.

UPDATED TEST GROUP A – ACCELERATED ENVIRONMENT STRESS TESTS								
STRESS	**ABV**	**#**	**NOTES**	**SAMPLE SIZE / LOT**	**NUMBER OF LOTS**	**ACCEPT CRITERIA**	**TEST METHOD**	**ADDITIONAL REQUIREMENTS**
Temperature-Humidity-Bias	**THB**	A2	P, B, D, G, C, F	77	3	0 Fails	JEDEC JESD22-A101	For surface mount devices, PC before THB (85ºC/85%RH for 1000 hours). **TEST before and after THB at room and hot temperature.** **For MEMS Microphones: THB shall be applied due to nature of application environment (i.e., no pressure present). HAST should not be considered as an alternate test.**
Temperature-Humidity (without Bias)	**TH**	A3	P, B, D, G, F	77	3	0 Fails	JEDEC JESD22-A101	For surface mount devices, PC followed by TH (85ºC/85%RH for 1000 hours). **TEST before and after TH at room temperature.** **For MEMS Microphones: TH shall be applied due to nature of application environment (i.e., no pressure present). AC or UHST should not be considered as an alternate test.**

UPDATED TEST GROUP G – CAVITY PACKAGE INTEGRITY TESTS								
STRESS	**ABV**	**#**	**NOTES**	**SAMPLE SIZE / LOT**	**NUMBER OF LOTS**	**ACCEPT CRITERIA**	**TEST METHOD**	**ADDITIONAL REQUIREMENTS**
Mechanical Shock	**MS**	G1	H, D, G	12	3	0 Fails	JEDEC JESD22-B104	3 pulses, 0.5 msec duration, 10,000 g peak acceleration in X, Y and Z planes. **TEST before and after at room temperature.**
Variable Frequency Vibration	**VFV**	G2	H, D, G	12	3	0 Fails	JEDEC JESD22-B103	20 Hz to 2 KHz to 20 Hz (logarithmic variation) in 12 minutes, 4X in each orientation, 20 g peak acceleration. **TEST before and after at room temperature.**
Package Drop	**DROP**	G5	H, D, G	10	3	0 Fails	---	Drop device 10X on each of 6 axes (60 drops total) from a height of 1.2m onto a concrete surface. **TEST before and after DROP at room temperature.**

Table 2: AEC-Q100 Tests NOT APPLICABLE to MEMS Microphones

TEST GROUP	ABV	#	STRESS	COMMENTS
A - Accelerated Environment Stress	HAST	A2	Biased HAST	THB is performed in lieu of HAST. MEMS Microphones utilize a cavity package with hole, acceleration with humidity penetration is not applicable.
	AC or UHST	A3	Autoclave or Unbiased HAST	MEMS Microphones utilize a cavity package with hole, acceleration with humidity penetration is not applicable.
	PTC	A5	Power Temperature Cycling	MEMS Microphones are low power devices (<<1W) (<1mA @ 3V).
B - Accelerated Lifetime Simulation Tests	EDR	B3	NVM Endurance, Data Retention, Operational Life	Memory related test; MEMS Microphones do not use on-chip memory.
C - Package Assembly Integrity Tests	LI	C6	Lead Integrity	Only required for through hole devices; MEMS Microphones utilize a surface mount cavity package.
E - Electrical Verification Tests	FG	E6	Fault Grading	MEMS Microphones do not use extensive digital blocks.
	SC	E10	Short Circuit Characterization	MEMS Microphones are not smart power devices.
	SER	E11	Soft Error Rate	MEMS Microphone doesn't embed SRAM or DRAM.
G - Cavity Package Integrity Tests	CA	G3	Constant Acceleration	For Ceramic packaged cavity devices only; MEMS Microphones use plastic encapsulated packages. MS and DROP are sufficient to cover all MEMS Microphone related potential failure modes.
	GFL	G4	Gross/Fine Leak	For ceramic packaged cavity devices only; MEMS Microphones use plastic encapsulated packages.
	LT	G6	Lid Torque	For ceramic packaged cavity devices only; MEMS Microphones use plastic encapsulated packages.
	IWV	G8	Internal Water Vapor	For ceramic packaged cavity devices only; MEMS Microphones use plastic encapsulated packages.

Appendix 1: Q103-003 Certification of Design, Construction and Qualification

Supplier Name: **Date:**

The following information is required to identify a device that has met the requirements of AEC-Q103-003. Submission of the required data in the format shown below is optional. **All entries must be completed; if a particular item does not apply, enter "Not Applicable".** This template can be downloaded from the AEC website at http://www.aecouncil.com.

This template is available as a stand-alone document.

Item Name	Supplier Response
1. User's Part Number:	
2. Supplier's Part Number/Data Sheet:	
3. Device Description:	
4.1. Control Wafer/Die Fab Location & Process ID: a. Facility name/plant #: b. Street address: c. Country:	
4.2. MEMS Wafer/Die Fab Location & Process ID: a. Facility name/plant #: b. Street address: c. Country:	
4.3. Cap Wafer/Die Fab Location & Process ID: a. Facility name/plant #: b. Street address: c. Country:	
4.4. Cap Wafer to MEMS Wafer bonding Location & Process ID: a. Facility name/plant #: b. Street address: c. Country:	
5.1. Control Wafer Probe Location: a. Facility name/plant #: b. Street address: c. Country:	
5.2. MEMS Wafer Probe Location: a. Facility name/plant #: b. Street address: c. Country:	
5.3. Bonded Wafer Probe Location: a. Facility name/plant #: b. Street address: c. Country:	
6. Assembly Location & Process ID: a. Facility name/plant #: b. Street address: c. Country:	
7. Final Quality Control A (Test) Location: a. Facility name/plant #: b. Street address: c. Country:	

8.1. Control Wafer/Die: a. Wafer size: b. Die family: c. Die mask set revision & name: d. Die photo:	See attached ☐ Not available ☐		
8.2. MEMS Wafer/Die: a. Wafer size: b. Die family: c. Die mask set revision & name: d. Die photo:	See attached ☐ Not available ☐		
9.1. Control Wafer/Die Technology Description: a. Wafer/Die process technology: b. Die channel length: c. Die gate length: d. Die supplier process ID (Mask #): e. Number of transistors or gates: f. Number of mask steps:			
9.2. MEMS Wafer/Die Technology Description: a. Wafer/Die process technology: b. Sensor length x width x depth: c. Sensor anti-stiction coating d. Die supplier process ID (Mask #): e. Number of sensor detection elements (e.g., comb/fingers cells, pressure-sensing cells, thermal cells): f. Number of mask steps:			
9.3 Cap to MEMS Wafer Bonding Technology Description: a. Bonding process technology: b. MEMS cavity gas atmosphere after bonding: c. MEMS cavity pressure range after bonding:			
10.1 Die Dimensions: a. Die width: b. Die length: c. Die thickness (finished): d. Membrane thickness:	Control Die:	MEMS Die:	Cap Die:
10 2. MEMS Thickness: a. After bonding: b. Bonded wafer thinning process description: c. Finished MEMS die thickness:	MEMS Wafer:		
11. Die Metallization: a. Die metallization material(s): b. Number of layers: c. Thickness (per layer): d. % of alloys (if present):	Control Die:	MEMS Die:	Cap Die:
12. Die Passivation: a. Number of passivation layers: b. Die passivation material(s): c. Thickness(es) & tolerances: d. MEMS Anti-stiction Coating:	Control Die:	MEMS Die:	Cap Die:

13.1. Die Overcoat Material (e.g., Polyimide) or Capped MEMS Die (e.g., Gel):	Control Die:	MEMS Die:	
14. Die Cross-Section Photo/Drawing:	Control Die: See attached ☐ Not available ☐	MEMS Die: See attached ☐ Not available ☐	Cap Die: See attached ☐ Not available ☐
15. Die Prep Backside: a. Die prep method: b. Die metallization: c. Thickness(es) & tolerances:	Control Die:	MEMS Die:	Cap Die:
16. Die Separation Method: a. Kerf width (µm): b. Kerf depth (if not 100% saw): c. Saw method:	Control Die: Single☐ Dual☐	MEMS Die: Single☐ Dual☐	Cap Die: Single☐ Dual☐
17. Die Attach: a. Die attach material ID: b. Die attach method: c. Die placement diagram:	Control Die:	MEMS Die:	
18. Package: a. Type of package (e.g., plastic, ceramic, unpackaged): b. Ball/lead count: c. JEDEC designation (e.g., MS029, MS034, etc.): d. Lead (Pb) free (< 0.1% homogenous material): e. Package outline drawing:	 Yes ☐ No ☐ See attached ☐ Not available ☐		
19.1. Mold Compound: a. Mold compound supplier & ID: b. Mold compound type: c. Flammability rating: d. Fire Retardant type/composition: e. Tg (glass transition temperature)(°C): f. CTE (above & below Tg)(ppm/°C):	 UL 94 V1 ☐ UL 94 V0 ☐ CTE1 (above Tg) = _____ CTE2 (below Tg) = _____		
19.2. Package Material Used Before or After Mold Over MEMS or Capped MEMS Die: a. Material type and ID: b. Minimum material coverage: c. Maximum material coverage:	 Supplier for items b and c shall supply MEMS material coverage drawing with dimensions		
20.1 Die to Leadframe Wire Bond: a. Wire bond material: b. Wire bond diameter (mils): c. Type of wire bond at die: d. Type of wire bond at leadframe: e. Wire bonding diagram:	 See attached ☐ Not available ☐		
20.2 Die to Die Wire Bond: a. Wire bond material: b. Wire bond diameter (mils): c. Type of wire bond at Control die: d. Type of wire bond at MEMS die: e. Wire bonding diagram:	 See attached ☐ Not available ☐		

21. Leadframe (if applicable): a. Paddle/flag material: b. Paddle/flag width (mils): c. Paddle/flag length (mils): d. Paddle/flag plating composition: e. Paddle/flag plating thickness (µinch): f. Leadframe material: g. Leadframe bonding plating composition: h. Leadframe bonding plating thickness (µinch): i. External lead plating composition: j. External lead plating thickness (µinch):	Control Die:	MEMS Die:
22. Substrate (if applicable): a. Substrate material (e.g., FR5, BT, etc.): b. Substrate thickness (mm): c. Number of substrate metal layers: d. Plating composition of ball solderable surface: e. Panel singulation method: f. Solder ball composition: g. Solder ball diameter (mils):		
23. Unpackaged Die (if not packaged): a. Under Bump Metallurgy (UBM) composition: b. Thickness of UBM metal: c. Bump composition: d. Bump size:		
24. Header Material (if applicable):		
25. Thermal Resistance: a. θ_{JA} °C/W (approx): b. θ_{JC} °C/W (approx): c. Special thermal dissipation construction techniques:		
26. Test circuits, bias levels, & operational conditions imposed during the supplier's life and environmental tests:	See attached ☐ Not available ☐	
27. Fault Grade Coverage (%):	_____ % Not digital circuitry ☐	
28. Maximum Process Exposure Conditions: a. MSL @ rated SnPb temperature: b. MSL @ rated Pb-free temperature: c. Maximum dwell time @ maximum process temperature:	** Note: Temperatures are as measured on the center of the plastic package body top surface.* _____ at _____ °C (SnPb) _____ at _____ °C (Pb-free)	

<table>
<tr><td colspan="2">Attachments:
Die Photo ☐
Package Outline Drawing ☐
Die Cross-Section Photo/Drawing ☐
Wire Bonding Diagram ☐
Die Placement Diagram ☐
MEMS material coverage drawing with dimensions ☐
Test Circuits, Bias Levels, & Conditions ☐</td><td colspan="2">Requirements:
1. A separate Certification of Design, Construction & Qualification must be submitted for each P/N, wafer fab, and assembly location.
2. Design, Construction & Qualification shall be signed by the responsible individual at the supplier who can verify the above information is accurate and complete. Type name and sign below.</td></tr>
<tr><td>Completed by: _____</td><td>Date: _____</td><td>Certified by: _____</td><td>Date: _____</td></tr>
<tr><td colspan="2">Typed or Printed:</td><td colspan="2"></td></tr>
<tr><td colspan="2">Signature:</td><td colspan="2"></td></tr>
<tr><td colspan="2">Title:</td><td colspan="2"></td></tr>
</table>

Appendix 2: Minimum Requirements for MEMS Microphone Qualification Plans and Results

The following information is required as a minimum to identify a device that has met the requirements of AEC-Q103-003. Submission of data in this format is optional. However, if these templates are not used, the supplier must ensure that each item on the template is adequately addressed. The templates can be downloaded from the AEC website at http://www.aecouncil.com.

A2.1 Plans

1. Part Identification: Customer P/N and supplier P/N.
2. Site or sites at which life testing will be conducted.
3. List of tests to be performed (e.g., JEDEC method, Q100 and Q103-003 method, MIL-STD method) along with conditions. Include specific temperature(s), humidity, and bias to be used.
4. Sample size and number of lots required.
5. Time intervals for end-points (e.g., after PC, 0 hour, 500 hour, 1000 hour).
6. Targeted start and finish dates for all tests and end-points.
7. Supplier name and contact.
8. Submission date.
9. Material and functional details and test results of devices to be used as generic data for qualification. Include rationale for use of generic data.

A2.2 Results

All of the above plus:

1. Date codes and lot codes of parts tested.
2. Process identification.
3. Fab and assembly locations.
4. Mask number or designation.
5. Number of failures and number of devices tested for each test.
6. Failure analyses for all failures and corrective action reports to be submitted with results.

Revision History

Rev #	Date of change	Brief summary listing affected sections
-	Feb. 14, 2019	Initial Release