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ENVIRONMENTAL SPECIFICATION FOR ELECTRICAL / ELECTRONIC (E/E) COMPONENTS

TABLE OF CONTENTS

1 GENERAL

1.1 Purpose

This specification defines minimum environmental stress driven qualification and validation requirements for the qualification of all E/E components (devices) used on FCA programs. The scope of the specification is to determine that the E/E Component shall meet environmental and other quality, reliability and functional requirements for the specified vehicle design life.

This document supersedes specifications 9.90111/02 and CS-11982.

1.2 Coverage of this Standard

The scope of the specification is to determine that the E/E Component shall meet environmental and other quality, reliability and functional requirements for the specified vehicle design life. This specification shall be used with SD-12009 "Test Selection Matrix" and Component Specific Engineering Standard (CTS/PF) document (if available) to identify applicable tests for any electrical and/or electronic modules used in the FCA programs.

Direct any questions concerning contents or application of this standard to the Authors listed in front page and/or to the Supervisor of this Standard.

1.3 Limitations on Usage

This standard applies to E2 & E3 classification only. Do not use this specification for electro-mechanical components which are classified as E1 per Table 2. If the component is from class E1, use the applicable device specific tests called out in the device engineering specification or CTS/PF document.

This specification shall not supersede any applicable laws or regulations unless a specific exemption has been obtained.

This is a general specification that covers most of the electrical devices on the vehicles. Please note that special cases should be addressed with dedicated cycles and/or test endurances to be agreed with Quality and Reliability Engineer based on actual usage in the application.

1.4 Device Classification

This section shall define the service life for a component/ device based on customer usage under all the environmental conditions. The following section describes the service life parameters applicable to an E/E component during its entire useful life based on function & packaging location on the vehicle.

Classification codes must be assigned by the Release Engineer / Component Engineer and written in Component Documentation, with concurrence with Quality Reliability Engineering (QRE).

1.4.1 Design Life

The typical design/ service life target for the E/E Component refers to 95th percentile customer usage over the period of 10 years / 150 000 miles or 15 years / 150 000 miles depending on device application defined in section 0. Some commercial applications may have higher targets, such as, 10 years / 200 000 miles or 15 years / 200 000 miles for heavy duty diesel, big gas engines or similar powertrain applications. Design life for any programs shall be defined in the Component Specific Engineering Standard (CTS/PF).

The vehicle design life requirements need to be translated into component specific requirements. For example:

- The 95% customer accumulates about 9 000 hours of vehicle operation with the engine operating for 10 years / 150 000 miles or 12 000 hours for 15 years / 200 000 miles. (150 000 miles equates to 9 000 hours of vehicle operation).
- The 95% customer usage is 10 trips / day. This translates to 41 000 Engine on/off cycles in 10 years / 150 000 miles or 54 750 Engine on/off cycles in 15 years / 200 000 miles.
- Thermal cycles are based on 2 long trips per day or 8 200 cycles in 10 years/150 000 miles or 10 950 cycles in 15 years/200 000 miles.

Refer to Table 1 for the Service Life Requirement based on a typical vehicle design life.

Table 1 - Classification of Service Life Requirements

Service Life in Field	Operating Time (95th percentile)	Non-Operating Time(NOTE 1) (5th percentile)	Engine On/Off Cycles	Thermal Cycles
10 years / 150 000 miles	9 000 h	96 750 h	41 000	8 200
15 years / 150 000 miles	12 000 h	129 000 h	54 750	10 950
10 years / 200 000 miles	12 000 h	129 000 h	54 750	10 950
15 years / 200 000 miles	12 000 h	129 000 h	54 750	10 950

NOTE 1: Based on CUDA studies at FCA US, 150 000 miles are equivalent to 11.25 years and 200 000 miles are equivalent to 15 years of vehicle life for 95th percentile customer usage. Operating time is 160 hours / year for 5th percentile driver (3 000 miles / year). Non-operating time for 10 y / 200 000 mi, 15 y / 200 000 mi and 15 y / 150 000 mi design life will be (15*365*24) (15*160) = 129 000 hours. Similarly, non-operating time for 10 y / 150 000 mi design life will be (11.25*365*24) – (11.25*160) = 96 750 hours.

1.4.2 Device Type Classification

Device is classified as a function of its hardware components based on its type, impact of its function on vehicle, behavior of each function during tests and its work environment, each, as shown in Table 2 shown below:

Table 2 - Component Type Classification Table

Class	Definition
E1	Device without electronic components (e.g. incandescent lamp, etc.) Electric motors with no integrated electronic controllers, relays, switches belong to this category, provided that they do not contain discrete components intended for electronic circuitry, like diodes, varistors, capacitors, resistors, inductors, potentiometers, etc.
E2	Device with passive electronic components with no control function (e.g., LEDs, varistors, resistor filters, capacitors, inductances) Electric motors with no integrated electronic controllers, relays, switches, when containing diodes, varistors, capacitors, resistors, inductors or potentiometers.
E3	Device with control/monitoring functions (e.g.: electronic modules, active sensors, display systems, motors & actuators with active electronics and, more generally, devices equipped with microcontrollers, integrated circuits, transistors, etc.) In addition to electronic control modules, also simple analog electronic circuits with transistors or other solid state devices may be in this category, when they perform any kind of signal processing or control function. The presence of thermistors or other non-electronic devices used for thermal protection of E1 devices does not involve the E3 classification.

1.4.3 Installation Classification

The packaging location, installation instructions and details shall be part of the Device documentation.

Based on the Installation class, the need to either conformal coat or resin paint the device shall be documented in the Component Specific Performance Standard or CATIA / NX drawing for the component.

The Classes based on the Installation of the device are as shown in Table 3:

Table 3 - Classification Based on Installation

Class	Definition (includes any brackets, clamps, fasteners, etc. used for installation)
CI1	Installation in the Engine compartment, but not on Engine
CI2	Installation on Engine
CI2A	Installation on Gearbox/Transmission
CI3	Installation in Passenger compartment or Trunk
CI4	Installation on Vehicle Exterior, Chassis, Underbody
CI5	Installation in the Door compartment (includes liftgate, hood, all doors)

1.4.4 Temperature Classification

Tenv.min (minimum environment temperature in a non-operational state) -40 °C is the default unless otherwise noted. Other values have to be agreed upon between all parties involved.

The value of Tenv.max (maximum environment temperature under worst-case environmental and vehicle operational conditions), which depends mainly on the mounting location of a component and the proximity of heat source(s) during its operational state. Tenv.max is minimum 85 °C.

Components mounted at any location can also have a unique Temperature Class (Actual) TCA, based on technological constraints or actual measurement on vehicle. TCA1 or TCA2 requires providing actual temperature measurement for maximum operating and environmental temperature conditions for the device packaging location. Similarly, for TN1L, operating and environmental minimum temperature for the device packaging location shall be required.

Refer to Table 4 and Table 5 for component classification based on low and high temperatures respectively. (Temperature data at the packaging location is mandatory for using any classification).

Table 4 - Classification Based on Low Temperature

Temperature Class	Minimum Operating Temperature (°C)	Minimum Non-Operating Temperature (°C)	Typical Vehicle Location
TN1	-40	-40	Default minimum ambient condition for all locations on the Vehicle
TN1L	(-10 °C > TN1 > -40 °C)	(-10 °C > TN1 > -40 °C)	Minimum operating temperature limited by Technology (CD / DVD Player, TFT Display, etc.)

Table 5 - Classification Based on High Temperature			
Temperature Class	**Maximum Operating Temperature (°C)**	**Maximum Non-Operating Temperature (°C)**	**Typical Vehicle Location**
TC1	+ 85	+ 85	All locations in cabin except top of IP, steering wheel or roof; Trunk; Insulated/ shielded areas away from heat sources in the Underhood / Chassis
TC2	+ 105	+ 105	Cabin - top of IP, steering wheel or roof, Under hood, Chassis locations away from any heat source - greater than 300 mm
TC3	+ 125	+ 125	Near Engine, Transmission, Brake / Wheel or Exhaust - about 150 to 300 mm, Vehicle Exterior exposed to direct Sunlight
TC4	+ 140	+ 140	Very close to Engine, Transmission, Brake / Wheel or Exhaust - less than150 mm
TC5	+ 155	+ 155	On the Engine, inside Transmission Chamber, on the brake / wheel hub, or adjacent to the Exhaust Manifold
TCA1(NOTE1)	65 °C ≤ TCA1 < 95 °C	65 °C ≤ TCA1 < 95 °C	Temperature limited by either technology or based on actual measurements at the packaging location (CD / DVD Player, Radio, Cluster, etc.)
TCA2(NOTE1)	85 °C ≤ TCA2 < 155 °C	85 °C ≤ TCA2 < 155 °C	Temperature limited by either technology or based on actual measurements at the packaging location (BSM / ESP Module, some PT Sensors / Modules, etc.)
NOTE 1: TCA1 or TCA2 requires providing actual temperature measurement for maximum operating and environmental temperature conditions for the device packaging location.			

1.4.5 Thermal Profile based on Temperature Range

Based on temperature classification (Packaging location) a typical “Thermal Profile” is used to calculate the test duration for High Temperature Operating Endurance test based on Arrhenius Model (Annex A-1) using activation energy, Ea = 0.7. The temperature class TC1, has two different distributions identified - one in Cabin/Trunk location & other outside Cabin/Trunk location as shown in Table 6.

The default is to use the temperature class TC1 to TC5 as defined in Table 6. However, if specific temperature data from test/ field measurements is available or component is limited by technology then the Release Engineer / Component Engineer shall specify the Actual temperature class TCA and its corresponding temperature distribution as shown in Table 7.

Information from the thermal profile and vehicle operational time for specified vehicle design life (Table 1) shall be used to determine test duration for High Temperature Operating Endurance. Refer to Annex A (Section A-1 “Arrhenius Model”) for additional details.

Table 6 - Thermal Profile Distribution Based on Default T_{max} Values									
Distribution for Cabin/Trunk locations (TC1 - TC2)	Temp. Class TC1	Temp. Class TC2	Distribution for other locations (TC1 – TC5)	Temp. Class TC1	Temp. Class TC2	Temp. Class TC3	Temp. Class TC4	Temp. Class TC5	Temp. Class TCA
6%	-40 °C	-40 °C	6%	-40 °C	-40 °C	-40 °C	-40 °C	-40 °C	Thermal Profile distribution empirically specified for actual Tmax values as shown in Table 7
65%	23 °C	23 °C	20%	23 °C	23 °C	23 °C	23 °C	23 °C	
20%	60 °C	60°C	65%	45 °C	58 °C	76 °C	90 °C	100 °C	
8%	80 °C	100 °C	8%	80 °C	100 °C	120 °C	135 °C	150 °C	
1%	85 °C	105 °C	1%	85 °C	105 °C	125 °C	140 °C	155 °C	

Table 7 - Thermal Profile Distribution Based on Actual Tmax Values				
Temp (°C)	Inside Cabin or Trunk(NOTE1)	Component Located Outside Cabin or Trunk(NOTE2)		
	T_{max} <= 85 ^{0}C	85 < T_{max} <= 105 ^{0}C	105 < T_{max} <= 125 ^{0}C	125 < T_{max} <= 155 ^{0}C
-40	6%	6%	6%	6%
23	65%	20%	20%	20%
T	20% T = (T_{max}*60)/85	65% T = (T_{max}*58)/105	65% T = (T_{max}*76)/125	65% T = (T_{max}*100)/155
(T_{max} – 5)	8%	8%	8%	8%
T_{max}	1%	1%	1%	1%

NOTE 1: If T_{max} > 85 ^{0}C for inside cabin /Trunk location, the temperature T shall be constant at 60 ^{0}C.
NOTE 2: If T_{max} <= 85 ^{0}C for outside cabin / Trunk location, the temperature T shall be (T_{max}* 45)/85.

1.4.6 Temperature and Humidity Classification

Depending upon component mounting location, (Inside cabin / Trunk or Outside locations), the values for the default Average Temperature and Average Relative Humidity during component's non-operating time (such as vehicle parked, ignition-off state) are defined in Table 8. This information shall be used to determine test duration for High Temperature Humidity Endurance. Refer to Annex A (Section A-3 "Lawson Model") for further information

Table 8 - Typical Classification of Average Temperature and Relative Humidity		
Mounting Location	Average Temperature during Non-Operating Time	Average Relative Humidity during Non-Operating Time
Inside passenger cabin or trunk	23 °C	64% RH
Outside passenger cabin or trunk	23 °C	65% RH

1.4.7 Average Temperature Delta (Change) Classification

In principle, every temperature change experienced by the component during its Service Life in Field contributes to the cumulative damage due to thermo-mechanical stress. Despite this fact, two large thermal cycles per day are usually sufficient to describe cumulative effect of thermo-mechanical stresses experienced by an E/E component. Based on this principle, the total Number of Thermal Cycles during vehicle's design life can be calculated by using the formula:

Number of Thermal Cycles (Refer to Table 1 for values) = 2*365*Design Life

Typical Average Temperature Delta based on field studies and engineering experience for the different temperature classes is defined in Table 9.

Table 9 - Average Temp. Delta Based on Temperature Class					
Temp. Class TC1 or Tmax = 85 °C	**Temp. Class TC2 or Tmax = 105 °C**	**Temp. Class TC3 or Tmax = 125 °C**	**Temp. Class TC4 or Tmax = 140 °C**	**Temp. Class TC5 or Tmax = 155 °C**	**Temp. Class TCA**
34 °C	40 °C	46 °C	50 °C	55 °C	Empirical formula(NOTE1)
NOTE 1: Temperature Delta = {Actual (Tmax) + 40} * 0.275					

The number of Thermal Cycles acting on a component during its design life and the Average Temperature Delta may deviate significantly from the typical values given above depending on the proximity of heat sources, internal heat generated and/or dissipated by component during operation. In such cases, a suitable Number of Thermal Cycles shall be based on actual temperature delta measured.

Information from the thermal profile and vehicle operational time for specified vehicle design life (Table 1) shall be used to determine test duration for Powered Thermal Cycle Endurance (PTCE). Refer to Annex A (Section A-2 "Coffin-Manson Model") for further information.

1.4.8 Weight Classification and Component Soak Time

During Powered Thermal Cycle Endurance and Thermal Shock validations, the components shall soak sufficiently long at extreme temperatures (usually Tenv.min and Tenv.max) to ensure that all parts of the component have reached that extreme temperature. The necessary soak time depends on the mass of the component. Typical soak times based on component weight are defined in Table 10.

It is a recommended engineering practice to experimentally measure the soak time for every component in representative chambers and with test samples, racks, wiring, etc. For components heavier than 4.53 kg, soak time studies are mandatory to determine the actual component soak time.

Contact Quality Reliability Group - EE Core & PTEE at FCA for any help with this activity

Table 10 - Typical Classification of Component Weight and Soak Time		
Component Weight		**Default Soak Time**
(Wt. Class)	**[kg]**	
W1	< 0.34	20 min
W2	0.34 – 0.68	30 min
W3	0.68 – 0.91	40 min
W4	0.91 – 1.36	50 min
W5	1.36 – 4.53	60 min
W6	> 4.53	Value based on actual measurements

1.4.9 Vibration Classification

During normal operation the system/component undergoes Vibration stresses that depend on the point where it is installed on the vehicle.

As shown in Table 11 below there are five vibration classes for each component based on its packaging location.

Table 11 - Vibration Classification Based on Component Mounting Location

Component Mounting Location	Vibration Class
Components / Devices mounted on the Engine	V1
Component / Devices mounted on the Gear Box	V1A
Component / Devices mounted on Chassis / Body (on Sprung Mass)	V2
Component / Device mounted on moving Body Parts (Doors, Liftgates etc.)	V3
Component / Device mounted on Wheel Knuckle (on Unsprung Mass)	V4

1.4.10 Dust & Water Intrusion (using IP Classification)

The Dust intrusion tests apply to electronic components when dust can degrade the component or the component function. The purpose of water intrusion test is to determine if the component housing provides sufficient protection against water intrusion.

The level/degree of protection against both depends on the component design and the vehicle mounting location Devices shall be classified for required protection against dust and water according to the following IP Codes in ISO 20653.

Unless otherwise required in Component Specific Performance Standard, the minimum required protections based on its Installation classification is as shown in Table 12 and Table 13 below.

Table 12 - International Protection Codes for Solid and Liquid Intrusion (NOTE 1)

Protection Against Dust and Access	IP Code	Protection Against Water Intrusion	IP Code
No protection	0	No protection	0
Dust protection (Presence of dust without any functional degradation)	5K	Vertical water drips	1
Dust proof (No dust allowed and no functional degradation)	6K	Water drips (15 ° inclination)	2
		Water spray	3
		Water splash with pressure	4K
		High-velocity water jet	5
		High-velocity water jet with increased pressure	6K
		Temporary immersion in water (NOTE 2)	7
		Continuous submersion in water (NOTE 2)	8
		High-pressure steam-jet cleaning	9K

NOTE 1: Refer to ISO 20653 for exact descriptions related to automotive applications.
NOTE 2: For immersion and submersion tests an inert UV dye shall be added to the liquid.

Table 13 - Protection For Dust & Water Based on Mounting Location (NOTE 3)		
Class	**Mounting Location**	**Typical IP Category**
CI1 (Normal Mount)	Installation in the Engine compartment but not on the engine	IP6K9K
CI2 (Normal Mount)	Installation on engine	
CI2A (Normal Mount)	Installation on gearbox	
CI1 (Low Mount) (NOTE 1)	Installation in the Engine compartment but not on the engine	IP6K9K and IP6K7
CI2 (Low Mount) (NOTE 1)	Installation on engine	
CI2A (Low Mount) (NOTE 1)	Installation on gearbox	
CI3	Installation in passenger compartment or trunk	IP5KX or IP6KX or IPX0, IPX1, IPX2, or IPXY (NOTE 2) – as specified in the component specification
CI4 (Normal Mount)	Installation on vehicle exterior	IP6K9K and IP6K7 - as specified in the component specification
CI4 (Low Mount) (NOTE1)	Installation on vehicle exterior	IP6K9K and IP6K7
CI5 (dry side)	Installation in door	IP 5K2 or IP 5K1 or more severe, as specified in the component specification
CI5 (wet or humid side)	Installation in door	IP5K3 or IP5K2 or more severe, as specified in the component specification

NOTE 1: Devices mounted partially or totally under the water fording level shall be considered low mount, unless adequate protection against water coverage is provided. Water fording level is 300 mm (for sedans), 500 mm (off – road), and 760 mm (for extreme off-road applications such as Jeeps).

NOTE 2: The IP degree for this installation site is strongly application dependent (e.g. IP 6K2 for convertible vehicles, IP 6K0 for rain sensors. Dust and Water Protection categories shall be defined by Release Engineer / Component Engineer in their component PF when IP XY is selected). In case of IPX0 classification an adequate protection against water shall be installed in the vehicle. Protection classes of minimum IPX2 are preferred.

NOTE 3: Powertrain, transmission, exhaust, fuel system, driveline, electrified vehicles modules, sensors and actuators are all to be considered low mount to validate no capillary action exists during normal vehicle thermal cycling.

1.4.11 Mechanical Shock Endurance Cycle Requirements

The components which are packaged in some specific mounting locations such as doors, lift gates & hoods shall have the ability to resist repeated mechanical loads encountered over the life time of the vehicle.

The number of shocks that a component mounted in such locations shall be determined from the Field Service Life in years, and the shocks/year multiplier for the component mounting location as defined in Table 14 as shown below.

Table 14 - Mechanical Shock Endurance Cycles	
Mounting Location on or Adjacent to	**Shocks per Year of Field Service Life**
Driver Door	7 200
Passenger Door	3 600
Trunk or Lift Gate	1 800
Hood	200

1.4.12 Classification Based on Device Application

Component test duration for some of the durability types tests depend on the device application due to higher design life (reliability) requirement as shown in Table 15 :

Table 15 - Device Application, Design Life and Reliability Requirement	
Device Application	**Design Life (Reliability)**
Passive Safety - examples, ORC, Seatbelt, etc.	15 year / 150 000 miles (R95/C90) OR 15 year / 200 000 miles (R95/C90)
Powertrain with Emission compliance - examples, ECM, TCM, etc.	15 year / 150 000 miles (R95/C90) OR 15 year / 200 000 miles (R95/C90)
All other applications - example, Radio, Door Modules, Instrument Cluster, ABS/ESP, TPM, CBC, etc. (Examples given in this table are for reference only and may switch to different device application as per vehicle specific requirements)	10 year / 150 000 miles (R90/C90 or R95/C90) OR 15 year / 200 000 miles (R90/C90 or R95C90)

1.4.13 Duty Cycle Requirements

Duty cycle classification for the component shall determine if the Mechanical Operating Durability requirement apply as shown in Table 16.

Table 16 - Duty Cycle Classification	
Duty Cycles Requirement	**Mechanical Operating Durability**
Involves customer / driver usage related Duty Cycles for the component (examples: window lift switches, key fob, shifter, radio control knobs, etc.)	Requirement is applicable
Involves duty cycle that is independent of customer usage (ex: ignition on / off cycles, CAN or LIN messages during vehicle operation, etc.)	Mandatory for any modules, sensors that sends CAN or LIN messages as well as ignition on/off related operations. The requirement will be verified during module operational stage of applicable tests (ex: HTOE, PTCE, THC, HTHE, etc.)
Does not involve customer / driver usage related Duty Cycles	Requirement does not apply

1.4.14 Exposure to Direct Sunlight

Component exposure to direct or indirect sunlight anywhere inside or outside the vehicle shall require this test. Duration of Solar Radiation Soak test shall be as shown in Table 17:

Table 17 - Solar Exposure Classification

Solar Exposure Condition	Solar Radiation Requirement
Exposed to direct sunlight - Top of I/P, Steering Wheel, Deck lid, Rear View Mirror, Tire Pressure Monitor (TPM), Park Assist Sensor, etc.	If using SAE-J-2412: 25 days (for components with Direct exposure to sunlight); If using, DIN 75220: 25 days with 100% energy 830 W/m^2 (for Direct exposure to sunlight)
Indirectly exposed to sunlight - other cabin locations, Radio, Door Switches, Instrument Cluster, etc.	If using SAE-J-2412: 7 days (for components with Indirect exposure to sunlight), and If using, DIN 75220: 25 days with 50% energy 415 W/m^2 (for Indirect exposure to sunlight)
Not exposed to sunlight	Solar Radiation Soak test is not required

1.4.15 Exposure to Gravel and/or Mud

For the components outside cabin, trunk or door locations, if there is a likelihood of gravel, grit and/or mud exposure, then additional validation shall be required to withstand special environmental conditions from such stresses. Table 18 below shows how these requirements are derived

Table 18 - Gravel and/or Mud Exposure

Gravel / Mud Exposure	Applicable Test (Requirement)
Component can be exposed to Gravel & Mud	Gravel Bombardment (section 5.4.8) and Mud Resistance test (section 5.5.2) are required
Component can be exposed to Gravel only	Only Gravel Bombardment test (section 5.4.8) is required
Component can be exposed to Mud only	Only Mud Resistance test (section 5.5.2) is required
Unlikely to be exposed to Gravel or Mud	Gravel Bombardment or Mud Resistance tests are not required

1.4.16 Operating Mode Requirements

The Table 19 describes the electrical power supply and I/O states for each Operating Mode during tests according to ISO 16750-1. Provide any additional clarification for DUT specific Electrical State as necessary.

Table 19 - Operating Modes for the Component

Operating Mode		Electrical State
OM1	No voltage is applied to the DUT	
	A	DUT is not connected to wiring harness (component transportation mode)
	B	DUT is connected to wiring harness, but no voltage is applied
OM2	The DUT is electrically connected with supply voltage U_B engine not running (example: any component connected to battery power in the vehicle OR internal component battery - example: Tire Pressure Monitor, Key Fob, etc.) as in a vehicle with all applicable electrical connections made	
	A	DUT functions are not activated (e.g., sleep mode, OFF mode, long time parking, etc.)
	B	DUT is electrically operated and controlled in typical operating mode for any CAN or LIN bus messages communicated during vehicle operation (includes mechanical cycling involving switches, relays, actuators and sensors).
OM3	The DUT is electrically supplied with voltage U_A (engine/alternator active) with all applicable electrical connections made (example: Any component connected to battery power in the vehicle, OR using internal component battery voltage as in case of Tire Pressure Monitor, Key Fob, etc.).	
	A	DUT functions are not activated (e.g. sleep mode, OFF mode) except default functions (e.g. CAN, LIN, etc.).
	B	DUT is electrically and/or mechanically operated and controlled in typical operating mode (includes mechanical cycling involving switches, relays, actuators and sensors).

The Table 20 describes the supply voltage operating modes when device is powered by Alternator (U_A) or Battery (U_B) (12V nominal voltage).

Table 20 - Operating Modes – Supply Voltage

Supply Voltage		Operating Mode
U_A	14.0 ± 0.2 V	OM3A / OM3B (engine/alternator active)
U_B	12.0 ± 0.2 V	OM2A / OM2B (battery voltage, alternator not active)

1.5 Electronic Components Qualification Requirement

All components in an ECU shall be qualified according to the applicable AEC standard (Q100, Q101, Q200, and related documents) or other equivalent standard.

2 REFERENCES

Table 21 - References(NOTE 1)

Document Number	Document Title
7.G2051	COMPLETE VEHICLE Assessment of For-Life (CORROSION RESISTANCE) test results
9.01107	USE PROVISIONS FOR THE I.M.D.S. (International Material Data System) SYSTEM
9.01108	QUALITY OF SUPPLIES Forbidden / limited substances or substances to be monitored (Annex CK)
9.91192	LOW-VOLTAGE CABLE ASSEMBLY
CEP-042	WIRING, DEVICE CONNECTOR SELECTION REQUIREMENTS
CS.00081(NOTE 2)	CORROSION REQUIREMENTS - VEHICLE SYSTEMS AND COMPONENTS
CS.00050	WIRING DESIGN AND PACKAGE REQUIREMENTS
CS-9003	SUPPLIER REQUIREMENTS FOR VEHICLE AND SERVICE PARTS: MATERIAL CONTENT REPORTING, MARKING, AND RECYCLABILITY
DIN 53150	Paints and varnishes - Determination of the drying stage of coatings (modified Bandow-Wolff method)
DIN 75220 Ed. 1992-11-01	Ageing of automotive components in solar simulation units
DS-158	ERGONOMICS PROCESS DRIVEN DESIGN STANDARD
DS-11332	TEST-TO-FAILURE METHODS - EE COMPONENTS & SYSTEMS
IEC 60068-2-2 ed 5 2007-07-16	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-6 ed 7.0 2007-12-13	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)
IEC 60068-2-11:1981 with CORRIGENDUM 1:1999	Basic environmental testing procedures - Part 2-11: Tests - Test Ka: Salt mist
IEC 60068-2-14 ed 6.0 2009-01-12	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-27 ed 4.0 2008-02-27	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock
IEC 60068-2-38 ed 2.0 2009-01-12	Environmental testing - Part 2-38: Tests - Test Z / AD: Composite temperature / humidity cyclic test
IEC 60068-2-60 ed 3.0 2015-06-18	Environmental testing - Part 2-60: Tests - Test Ke: Flowing mixed gas corrosion test
IEC 60068-2-64 ed 2.0 2008-04-29	Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance
IEC 60068-2-68 ed 1.0 1994-08-17	Environmental testing - Part 2-68: Tests - Test L: Dust and sand
IEC 60068-2-70 ed 1.0 1995-12-22	Environmental testing - Part 2-70: Tests - Test Xb: Abrasion of markings and letterings caused by rubbing of fingers and hands
IEC 60068-2-78 ed 2.0 2012-10-30	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state
ISO 2409:2013	Paints and varnishes -- Cross-cut test
ISO 12103-1:1997	Road vehicles -- Test dust for filter evaluation -- Part 1: Arizona test dust
ISO 16750-1:2006	Road vehicles -- Environmental conditions and testing for electrical and electronic equipment -- Part 1: General

Table 21 - References (NOTE 1)	
Document Number	**Document Title**
ISO 16750-3:2012	Road vehicles -- Environmental conditions and testing for electrical and electronic equipment -- Part 3: Mechanical loads
ISO 16750-4:2010	Road vehicles -- Environmental conditions and testing for electrical and electronic equipment -- Part 4: Climatic loads
ISO 16750-5:2010	Road vehicles -- Environmental conditions and testing for electrical and electronic equipment -- Part 5: Chemical loads
ISO 20653:2013	Road vehicles -- Degrees of protection (IP code) -- Protection of electrical equipment against foreign objects, water and access
PF-10099	WIRING HARNESS - ASSEMBLY PERFORMANCE
PF.90012	PERFORMANCE SPECIFICATION FOR AUTOMOTIVE ELECTRICAL CONNECTOR SYSTEMS
QR-10008(NOTE 2)	PRODUCT ASSURANCE TESTING (PAT)
SAE/USCAR-2	Performance Standard for Automotive Electrical Connection Systems
SAE/USCAR-21	Performance Specification for Cable-to-Terminal Electrical Crimps
SAE/USCAR-25	Electrical Connector Assembly Ergonomic Design Criteria
SAE-J-400 2012-10-23	Test for Chip Resistance of Surface Coatings
SAE J1211 2012-11-19	Handbook for Robustness Validation of Automotive Electrical/Electronic Modules
SAE-J-2412 2015-08-11	Accelerated Exposure of Automotive Interior Trim Components Using a Controlled Irradiance Xenon-Arc Apparatus
SD-12009(NOTE 2)	TEST SELECTION MATRIX
SD-12501	PARAMETRIC EVALUATION TECHNIQUE (PET) SPREADSHEET
SD-12659	SUPPLIER PROCESS & COMPONENT CHANGE – VALIDATION REQUIREMENTS (SPCCVR)

NOTE 1: Please refer to beSTandard for FCA standards and for public standard refer to:
- **http://www.iso.org/iso/home/store.htm for ISO standards;**
- **http://webstore.iec.ch/ for IEC standards;**
- **http://store.sae.org/ for SAE standards;**
- **www.din.de/en for DIN standards.**

NOTE 2: CONFIDENTIAL only for FCA internal use.

3 DEFINITIONS/ABBREVIATIONS/ACRONYMS/SYMBOLS

Ambient Temperature: is the local temperature surrounding the component when tested in a test chamber or installed in the vehicle.

BEV: an acronym for Battery Electric Vehicle.

BSR: Buzz, Squeak and Rattle.

CAN: Controller area network

Component Specific Performance Standard: is the Component Specific Function Driven PF or CTS.

Component: is any electrical or electronic assembly used in the vehicle, such as engine control module, instrument cluster, junction block, sensor, switch, etc. Also used interchangeably with terms such as:
- ABS: Antilock Braking System;

- BSM: Brake system module;
- CBC: Central body controller;
- ECU :Electronic Control Unit ;
- ECM : Engine control unit;
- ESP: Electronic Stability Program;
- ORC :Occupant restraints controller;
- TCM: traction control module;
- TPM : tire pressure monitor.

CTE: is an acronym for coefficients of thermal expansion.

CTS: Component Technical Specification.

DUT: Device under test.

DV: design validation.

E/E: is an acronym for Electrical and/or Electronic.

Effect: A detectable change in DUT performance due to an applied stimulus.

EPA: Environmental Protection Agency (in the United States)

FCA: Fiat Chrysler Automobiles

Five Point Check: A test process where parametric measurements of a component's functional parameters are tested at the 5 possible combinations of 3 different temperatures (Tmin, RT, and Tmax) and 3 different supply voltages (UTmin, UTtyp, and UTmax) - Specific combinations include (Tmin, UTmin), (Tmin, UTmax), (RT, UTtyp), (Tmax, UTmin) and (Tmax, UTmax).

HTHE: an acronym for High Temperature & High Humidity Endurance

HTOE: an acronym for High Temperature Operating Endurance test

IAM: Intelligent alternator

Informative: Additional (not normative) information intended to assist the understanding or use of the standard.

Intermittent Operation: When a component goes through pre-defined time cycles of "Operational" and "Non-operation" conditions during the test, the component operational status shall be considered as "Intermittent Operation". The intermittent operation frequencies specified for some of the tests in this standard are only guidelines. The Release Engineer / Component Engineer shall specify the most appropriate operational intermittency for the component in the Component Specific Performance Standard.

IP Class: International Protection Classification for solid and / or water intrusion for automotive applications as described in ISO 20653

Key Functional Parameters: Parameters such as, standby current, operating current, output voltages, signal rise times, etc. which can be used for PET analysis.

LED: Light Emitting Diode

LIN: Local Interconnect Network

LTOE: an acronym for Low Temperature Operating Endurance test

mi: abbreviation for mile as used in NIST Handbook 44 (2007)

Nine Point Check: A test process where parametric measurements of a component's functional parameters are tested at the 9 possible combinations of 3 different temperatures (Tmin, RT, and Tmax) and 3 different supply voltages (UTmin, UTtyp, and UTmax). Other test parameter combinations may be specified in the Component Specific Performance Standard.

Non-Operating Time: is the time [hours] for which an E/E-component is unpowered in field use. Generally this time represents the duration during which the vehicle is parked.

Non-operational: A test condition where a component is powered and waiting for a signal to perform a normal function. The use of mating connectors during the test is required.

Normative: Provisions that are necessary to meet requirements.

NTC: is an acronym for Negative Temperature Co-efficient (Device with NTC feature shuts off power supply or reduces certain component applications (e. g. CD-playing for a car radio) when device temperature goes below certain minimum operating temperature specified).

OEM: original equipment manufacturer

OM: Operating mode.

Operating Time: is the time [hours] for which an E/E-component is powered in field use. Generally this time represents the duration during which the vehicle is driven.

Operational: A test condition where a component is powered and performing normal operating functions.

OSHA: Occupational Safety and Health Administration (in the United States).

PCB: Printed Circuit Board.

PET: Parametric Evaluation Technique, a method used to demonstrate reliability and confidence with parametric data. This method compares the tolerance limits to the calculated statistical population limits. The technique is repeated at specified intervals during testing to detect population drift and changes in variation.

PHEV: Plug-in Hybrid Electric Vehicle

Pmax: Maximum cooling circuit pressure plus 50%.

Power-off: "Power-off" condition exists when it is not electrically connected to a power source or the power source is not supplying any operating voltage. The use of mating connectors during "Power-off" condition are specified for different tests, but may be superseded in the Component Specific Performance Standard.

PS: pre-series.

PSD: An acronym for Power Spectral Density, the power of random vibration intensity measured in g2/Hz or (m/s2)2/Hz where 1 g = 9.80665 m/s2. Over a frequency bandwidth, random vibration is expressed in units of root mean squared acceleration, GRMS.

PT: powertrain.

PTC: is an acronym for Positive Temperature Co-efficient (Device with PTC feature shuts off power supply or reduces certain component applications (e. g. CD-playing for a car radio) when device temperature goes above certain maximum operating temperature specified).

PTCE: An acronym for Powered Thermal Cycle Endurance test.

PV: product validation.

RT: Acronym for Room Temperature, for definition see Table 22 .

Seven Point Check: A test process where parametric measurements of a component's functional parameters are tested at the 7 possible combinations of 3 different temperatures (Tmin, RT, and Tmax) and 3 different supply voltages (UTmin, UTtyp, and UTmax) - Specific combinations include (Tmin, UTmin), (Tmin, UTmax), (RT, UTmin), (RT, UTtyp), (RT, UTmax), (Tmax, UTmin) and (Tmax, UTmax).

Shall: Denotes a requirement.

Should: Denotes a recommendation.

Soak Time (tsoak): The dwell time required for the component to reach the same temperature as chamber ambient during thermal cycling (PTCE or TS).

Sprung Mass: Components with the mounting locations above vehicle springs or suspension.

SSTE: an acronym for Shipping/ Storage Temperature Exposure

Temperature Class: Classification of maximum temperature a component will experience based on its mounting location and specific packaging variations in the vehicle as defined in Temperature Classes for Vehicle Mounting Locations.

Tcoolant: Coolant temperature in liquid cooled modules

Tenv.max: is an acronym for the highest environmental temperature experienced by any component.

Tenv.min: is an acronym for the lowest environmental temperature experienced by any component.
Unless otherwise defined Tenv.min = - 40 ºC

THC: an acronym for Thermal Humidity Cycle

Three Point Check: A test process where parametric measurements of a component's functional parameters are tested at the 3 different supply voltages (UTmin, UTtyp, and UTmax) under room temperature condition - Specific combinations include (RT, UTmin), (RT, UTtyp), (RT, UTmax).

Tmax: maximum temperature.

Tmin: minimum temperature.

Top.max: is an acronym for the maximum operating temperature for the component.

Top.min: is an acronym for the minimum operating temperature for the component.

TS: an acronym for Thermal Shock.

TS: Thermal Shock

TTF: an acronym for Test-to-Failure.

Un-sprung Mass: Components with mounting locations below vehicle springs or suspension.

UTmax: An acronym for the maximum continuous operating voltage as defined in the component specific release document.

UTmin: An acronym for the minimum continuous operating voltage as defined in the component specific release document.

UTtyp: An acronym for the typical operating voltage defined in the component specific release document.

4 REGULATED SUBSTANCES & RECYCLABILITY

Not Applicable. For requirements please refer to the Component Requirements (PF., CTS-, etc.) and to Standards 9.01107, 9.01108 and CS-9003.

5 REQUIREMENTS/CONDITIONS

Due to the continuously increasing demand of higher quality level for automotive devices and the shortening of vehicles' development time, the compliance to validation tests has become a minimum condition, and additional effort is required during engineering development (ED) by the supplier to anticipate failure modes, determine the margins of the device, asses the suitability of use in the installation environment. For more information on these methods and techniques refer to SAE J1211 standard.

5.1 Component / Device validation requirements

The Device shall undergo tests and checks as specified in this standard and in the Device Specification. Supplier and FCA Engineering shall confirm that test results are within the specified target limits. The supplier shall provide test reports after every phase of testing for review by FCA Product Engineering staff. Changes to any environmental requirements from this specification (test, duration, cycles, test parameters, sample size, etc.) shall require written approval from Quality Reliability Engineers at FCA for the Component under consideration.

5.1.1 Joint Analysis of Test Samples

Supplier shall provide detailed test plan and shall always keep it updated. A complete and updated list of laboratories where supplier carries out each test shall be attached to the test plan.

FCA shall reserve the possibility to attend one or more tests and jointly carry out analysis on the Device Under Test (DUT).

5.1.2 Test Conditions

5.1.2.1 Power Supply Measurement

Unless otherwise specified, power supply voltages shall be measured at device terminals.

5.1.2.2 Device Powered Condition

When a test calls out for powered condition, unless otherwise specified in the Component Specific Performance Standard, the supply voltage shall be varied between UTmin, UTtyp and UTmax in such a way that the component is operated 80% of the test duration at UTtyp and 10% each at UTmin and UTmax. This shall be done with a repeating voltage profile such as, 8 min at UTtyp, 1 min at UTmin and 1 min at UTmax. This voltage profile shall be performed at all temperatures specified. UTtyp is based on Alternator voltage specified in Table 19.

Device powered condition shall also simulate operating conditions including ignition On/Off cycles during operational or intermittent-operation sequence of environmental tests. During longer duration tests (examples: High Temperature Operating Endurance, Powered Thermal Cycle Endurance and Mechanical Operational Durability tests, etc.), supplier shall try to complete engine On/Off duty cycles to simulate ignition conditions through different temperature and voltage conditions. Any deviations from completing engine On/Off duty cycles shall be reviewed and approved by Release Engineers / Component Engineers at FCA Engineering.

5.1.2.3 Power Cycling Validation

Every Module, Sensor, or Component shall successfully complete all relevant power cycles validation during post-test functional and parametric tests. The purpose of this validation is to determine the DUT will be able recover and meet all functional requirements under the dwell at, and the transitions between the power states listed below:

1. Sleep
2. Wake - Up
3. Power - Down
4. Power - Up
5. Other relevant power states (consider both warm start and cold start, first battery connection, etc.)

The Power Cycling Validation is applicable at the end of legs 1, 2, 3 and 4 as part of the post-test functional and parametric tests.
The Power Cycling Validation requirements will be developed by FCA Engineering for each individual component and detailed in the Component Specification (e.g. PF) for the device in question.

5.1.2.4 Burn-In (or Device Conditioning) Requirement

A Burn-In (or device conditioning) of minimum 15 minutes is required for all components / devices before the initial Performance and Parametric checks. As part of the Burn-In (or device conditioning) the DUT shall have all the relevant operating conditions using supply voltage range specified in the requirements of the device or the nominal voltage conditions specified in Table 19 of this standard.

5.1.2.5 Ramp Rate for Temperature

Ramp rate shall be between 4 °C/min to 10 °C/min Max. If a supplier does not have a climatic chamber capable of a ramp rate of 4 °C/ min between Tmin and Tmax, then lower ramp rate may be allowed with concurrence from FCA Engineering and Quality Reliability. However, this will increase cycle time and overall test duration.

5.1.3 Test Fixtures, Measurements, and Analysis

5.1.3.1 Fixtures and Connections

Test fixtures shall monitor and exercise the device to validate conformance to selected functional requirements, as specified in the Component Specific Performance Standard. The fixture or test set-up shall be as specified in the Component Specific Performance Standard or CATIA/NX models to simulate the mounting orientation as experienced in the vehicle.

5.1.3.2 Connectors & Harness

Test fixtures shall use mating connectors and harnesses manufactured with wires of correct gauge size and crimping from production intent designs and processes. If the wire harness or connectors used for system or component test are not production intent, the test set-up must be approved by FCA Engineering and Wiring Harness Group with justification for not using representative parts.

Unless stated otherwise, all components shall be tested in the vehicle packaging orientation using production intent mounting / covers, wire harness and connectors, etc. The set-up is extremely important for some of the tests, such as, water & dust intrusion, vibration, mechanical shock and some other tests involving mechanical stresses.

5.1.3.3 Simulations & Loads

For each test the supplier shall provide a functional block diagram showing the configuration of simulators and loads to inputs and outputs that will simulate the vehicle environment and place the DUT in the desired test mode(s).

If actual vehicle loads are connected to the system, the supplier shall describe them by the OEM specific part number and design level. In case simulated loads are used, the supplier shall provide a detailed definition for the same, for example, ABS Motor - OEM Part Number 55521213A, Simulated Speaker Load - 4 Ω, 5% tolerance, 5 W, Simulator for CAN - CANOE, etc.

5.1.3.4 Default Tolerances

Unless otherwise specified in the Component Specific Performance Standard, the following default tolerances shall apply. If the default tolerances are not specified, the requirements will be treated as absolute minimum or maximum value as applicable for the given specification.

Table 22 - Default Tolerances During Validation	
Parameter	**Tolerance**
Chamber Temperature	Spec. ± 2 °C
Room Ambient Relative Humidity	25 – 75%
Chamber Humidity	Spec. ± 3%
Test Voltages	UTmin, UTtyp, UTmax: ± 2%
Voltage	Spec. ± 0.1 V
Current	Spec. ± 1%
Random Acceleration (G_{RMS})	Spec. ± 20% (PSD deviations from applicable tables are not permitted)
Acceleration (Mechanical Shock, G)	Spec. ± 10%
Frequency	Spec. ± 1%across the component range
Room temperature RT	23 °C ± 5 °C or 73 °F ± 9 °F
Vibration	± 3dB for PSD profile over the test range and ± 5% for specified GRMS level. The vibration set-up shall be configured to provide "Crest Factor" of 3.0 (Sigma Value or Sigma Clipping); ± 3dB alarm limits on the control channel and ± 6dB abort limits on the control channel shall be used.

5.1.3.5 Measurements

To obtain reliable data, test equipment and procedures shall meet resolution, and repeatability and reproducibility requirements.

- Resolution: Test measurement equipment shall be capable of a resolution at least one order of magnitude finer than the specification limits for the parameter being measured.
- Repeatability and Reproducibility: Test equipment GR&R shall be a maximum of 10% of the specification limits defined in the Component Specific Release documents. Procedures for calculating GR&R are found in AIAG's "Measurement Systems Analysis Manual".

5.1.3.6 Continuous/ Intermittent Operation including Function Cycling

Continuous/ Intermittent Operation

Tests that require components to be "operational" or "intermittently operated" shall monitor and/or actuate the functions continuously or as per the intermittent operating sequence. If the intermittent operation sequence is required, Component Specific Performance Standard shall specify intermittent operation cycle.

Functional Cycling
The supplier shall provide details for the Functional Cycling when the device requires continuous or intermittent operational sequence to simulate customer usage during and after exposure to the test environment. Supplier shall list the inputs/outputs (including on-vehicle data bus communications, as well as any mechanical actuations) that will be automatically cycled and monitored for proper functional operation.

Functional cycling during operational phase of some of the tests shall account for 95th percentile customer usage, duty cycle loads and operating voltage range experienced during vehicle operations.

5.1.3.7 Functional Checks - Before and After Test

Module functions defined in the Component Specific Performance Standard shall be measured at the start of the test and on completion of the test. The supplier shall ensure that the functional performance is within the specified range for success of the completed test.

5.1.3.8 Parametric Evaluation Technique

Parametric Evaluation Technique (PET) compares the statistical distribution of the sample population based on desired reliability/ confidence (such as, R95/C90 or R90/C90) to demonstrate conformance to acceptance limits during design validation process. PET analysis shall be done on the identified key functional parameters only.

PET analysis is defined in “Product Assurance Testing” manual, QR-10008.

For PET analysis during DV and PV tests (refer to red pentagon in the test flow sequences in Annex B), samples shall be measured for key functional parameters before start of any testing (pre-test measurement) and after completion of all tests (post-test measurements) under selected temperature/ voltage conditions (9, 7, 5 or 3 point checks).
Suppliers shall use PET spreadsheet SD-12501 to demonstrate reliability/confidence targets specified in the component specific performance standard.

5.1.3.9 Functional or Parametric Checks using 3, 5, 7 or 9 Points

Functional or Parametric Checks using 3, 5, 7 or 9 Points as shown in Table 23 based on the device application (Safety, Powertrain or Convenience/ Others).

Three point checks shall be used only for the functional checks (blue diamond in the test flows in Annex B). Nine or seven point checks shall be used for “Safety or Powertrain” applications and at the minimum five point checks shall be used for convenience applications as part of full parametric checks at the start and end of the tests (red pentagon in the test flows in Annex B).

Table 23 - Functional and Parametric Checks Using 9, 7, 5 or 3 Point Check(NOTE1)

	Tenv.min	RT	Tenv.max
UTmin	(9) (7) (5)	(9) (7) (3)	(9) (7) (5)
UTtyp	(9) (3a) (NOTE 2)	(9) (7) (5) (3) (3a) (NOTE 2)	(9) (3a) (NOTE 2)
UTmax	(9) (7) (5)	(9) (7) (3)	(9) (7) (5)

NOTE 1: Nine Point Check: (9); Seven Point Check: (7); Five Point Check: (5); Three Point Check: (3).
NOTE 2: (3a) Three Point Check for temperature dependent devices (e.g. temperature sensors, etc.).

5.1.3.10 Test-to-Failure (TTF)

Where feasible, suppliers shall use Test-to-Failure (TTF) approach to identify & improve design weaknesses on a key failure mode as well as to demonstrate component reliability if the component is identified as a “Key Components” (new technology, new application, new supplier, perennial warranty issues, safety or powertrain, etc. shall determine if the part is key or non-key). Refer to DS-11332 for conducting component TTF. Minimum sample size for TTF shall be 5 samples.

5.1.4 Solder Evaluation

As a minimum requirement the ECU shall comply with IPC-A-610E, class 3 before and after the tests.

Supplier and FCA Product Release Engineers / Component Engineers shall identify the high thermal stress areas on the PC Boards for evaluation after subjecting the ECUs to different environmental stresses as shown in Annex B. As part of Solder Evaluation (cross section / X-ray and/or other approved methodologies), selected boards will be compared using X-Ray images of solder joints at high stress areas or cross-sectioned at high stress areas to compare with the master samples. A map of cross sections shall be agreed between the supplier and FCA. For cross section IPC TM 650 2.1.1.E method is suggested.

Identified PC Boards shall be visually inspected prior to dissection for microscopic evaluation or X-ray of the area. The overall purpose shall be to identify any structural issues, material degradation, signs of debris, residues, burn marks or similar other conditions which can make the ECUs non-functional or impair its reliability, minimum as detailed in the list below:

A. Mechanical and Structural Integrity: Signs of degradation, cracks, melting, wear fastener failures.
B. Solder/Part Lead Fatigue Cracks or Creep or Pad-Lift: Emphasis on large integrated circuits, large massive parts or connector terminations (especially at the end or corner lead pins). Also, parts in high flexure areas of the circuit board.
C. Damaged Surface Mount Parts: Emphasis on surface mounted parts near circuit board edges, supports or carrier tabs. Also, surface mounted parts located in high flexure areas of the circuit board and near connector terminations.
D. Large Part Integrity and Attachment: Leaky electrolytic capacitors, contaminated relays, heat sink/rail attachments, etc.
E. Material Degradation, Growth, or Residues of Corrosion: Melted plastic parts; degraded conformal coatings, solder masks or seals; circuit board de-lamination, lifted circuit board traces, corrosion such as black silver sulfide spots, organic growths, or environmental residues due to dust, salt, moisture, etc. All foreign residues shall be analyzed for material composition and conductivity.
F. Other Abnormal or Unexpected Conditions: Changes in appearance or smell, Indications of poor manufacturing processes, Objectionable squeak and rattles, especially after vibration fatigue.
G. The Formation of Whiskers when Tin, Zinc, or Silver is used: The Lead-Free Solder Validation Test Plan provided in this document will effectively precipitate the formation of whiskers. A close examination of the circuit boards with a magnifying device shall occur on all ECUs, particularly on the ECUs that experienced PTC. The appearance of whiskers during environmental testing will indicate the probability of similar whisker formations occurring in the field. The formation of whiskers poses a risk to close-pitched parts, and may result in a short-circuit situation of parts or ECUs that are stored for service.
H. Dendrite Growth: The circuit board and all parts must be free of any signs of dendrite growth.

5.1.5 Conformal Coating Evaluation

If a board has a conformal coating protection the curing shall be tested according to DIN 53150, drying stage 1, before starting the validation tests.

5.1.6 Test report

A test report including test procedures, testing condition, monitored parameters, operating modes, loads, power profiles, performance data analysis, specification limits, pass-fail summary, and setup pictures shall be submitted in addition to the DVP&R.

Each sample shall have a permanent identification number easily visible and all tested samples shall be stored according to FCA guidelines. If this number is not visible in the picture of the setup, the picture shall be edited to clearly indicate the position of each sample.

Parameters measured before and after testing will be evaluated according to Parametric Evaluation Technique SD-12501 and added to the test report.

Any anomaly during test shall be reported in written form to FCA within 24 hours. Containment actions, root causes, mitigation actions and corrective actions shall be investigated.

5.2 General Environmental Requirements

This standard classifies environmental stresses into four categories typically experienced by E/E components in a vehicle, described as, Climatic, Mechanical, Solids/ Fluids, and Chemicals.

The Component Specific Performance Standard shall specify the requirements and tests for these stress categories required for the Component / Device.

Annex B provides two different (generic) test flow charts. Release Engineers / Component Engineers shall use SD-12009 to document component specific information and identify applicable environmental tests. They shall choose any one of these two flow-charts for the component specific application and paste it in the component specification (Engineers may choose to include both test flows in the component PFs and choose one that meets the testing resources at the time of DV or PV tests).

For any changes resulting from test failures as well as design and/ or process modifications, Supplier and Release Engineers / Component Engineers shall select applicable EE component tests including functional and parametric measurement from the test selection guideline given in Annex D for different supply chain/ product development scenario.

5.3 Climatic Stresses

This category includes tests to demonstrate compatibility with climatic stresses such as temperature, humidity and solar radiation

5.3.1 Shipping/ Storage Temperature Exposure (SSTE)

This requirement simulates shipping & storage temperature conditions experienced by the component similar to:

- When shipping in an unheated air cargo compartment at high altitude (-40 °C) for extended duration
- Enclosed shipping containers in hot climates with radiant heat from solar exposure (+95 °C), and
- Exposure to localized high temperature during BIW paint blemishes repairs in the assembly plant.

These temperatures represent extreme storage exposures in an unpowered state and the purpose of this test is to check if the ECUs are not damaged under such conditions.

Scope:
The shipping and storage temperature test is mandatory for all EE components subjected to following conditions:

If $T_{env.max}$ for the component exceeds 95 °C then Method Cold-Only shall apply to the components. For all other cases, the component shall comply with the Method Hot-and-Cold.

The component shall be unpowered during the test, simulating the shipping / storage condition.

NOTE: Cold soaks during Thermal Shock or Powered Thermal Cycle Endurance do not compensate for this test due to extended cold soak requirements experienced during long duration flight travels.

Test Parameters and Requirements

Table 24 - Shipping & Storage Temperature Requirements	
Applicable Standard	N/A
Test Duration (Hours)	54 hours for Method Hot-and-Cold; 27 hours for Method Cold-Only
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM1A (during hot or cold soak, OM1B may be agreed upon) and OM2B/ OM3B (during 1 hour of operational phase shown in Figure **1**) – Refer to Table 19 & Section 5.1.2.2 for definitions of these operational states.
Monitoring Status	As specified in Component Specification with Continuous Monitoring during operational state only (Section 5.1.3.6)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Temperature	-40 °C to + 95 °C (as shown in Figure 1)
b) Number of cycles	One
Acceptance Criteria	Meets all functional requirements before & after the test. Component shall not exhibit any physical deformation, such as, cracks, warping, discoloration, or other unacceptable appearance issues

Test Procedure:
Method Hot-and-Cold

A. Check the component functions and measure critical parameters at RT (23 °C).
B. Place the components in a thermal chamber
C. Decrease the chamber temperature from RT (23 °C) to the Tenv.min = -40 °C in 1 hour.
D. Maintain the chamber temperature at Tenv.min = -40 °C for 24 hours.
E. Increase the chamber temperature to RT = 23°C in next 1 hour.
F. Operate component for 1 hour intermittently as specified in Component Specification with continuous monitoring.
G. Increase the chamber temperature to the maximum temperature Tenv.max = 95 °C in 1 hour.
H. Maintain the chamber temperature at the Tenv.max = 95 °C for 24 hours.
I. Decrease the chamber temperature from the Tenv.max = 95 °C to RT (23 °C) in 1 hour.
J. Operate component for 1 hour intermittently as specified in Component Specification with continuous monitoring.

Method Cold-Only

A. Check the component functions and measure critical parameters at RT (23 °C).
B. Place the components in a thermal chamber
C. Decrease the chamber temperature from RT (23 °C) to the Tenv.min = -40 °C in 1 hour.
D. Maintain the chamber temperature at Tenv.min = -40 °C for 24 hours.
E. Increase the chamber temperature to RT = 23 °C in next 1 hour.

F. Operate component for 1 hour intermittently as specified in Component Specification with continuous monitoring.

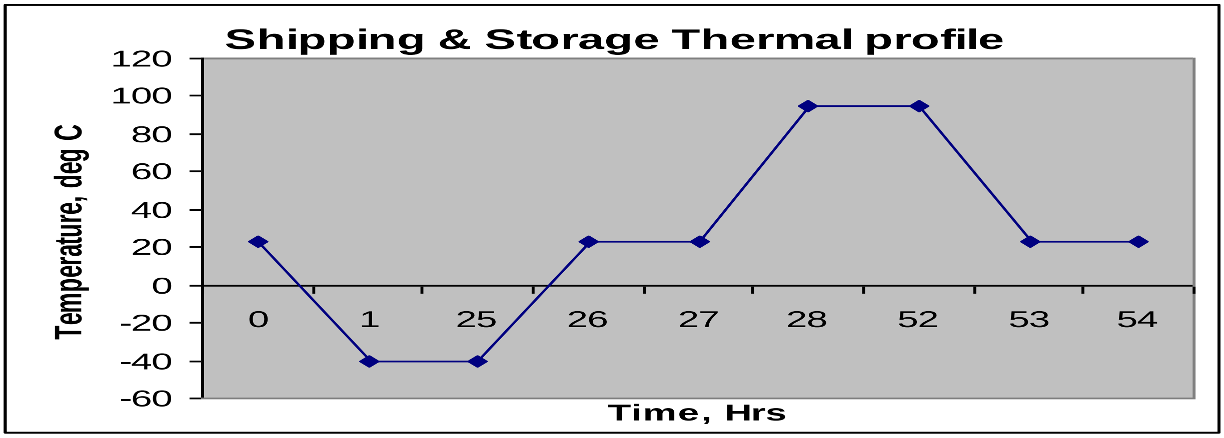


Figure 1 - Test Profile for Shipping & Storage test

5.3.2 Low Temperature Operating Endurance (LTOE)

This test simulates the stresses on a component during low temperature operation experienced during the initial few minutes following a vehicle start in cold weather and before internal or external heating raises the component temperature.

The low temperature failures in the component could include cracking of PCB, ceramic substrates, packaging material or covers; freezing of capacitors with liquid electrolyte; material property changes that affect subcomponent performance; and others.

Scope:
The LTOE test is mandatory for electronic components.

Test Parameters and Requirement

Table 25 - Low Temperature Operating Endurance (LTOE) Requirements	
Applicable Standard	N/A
Test Duration (Hours)	48 hours
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM3B (Intermittent operation - Table 19) & Section 5.1.2.2
Monitoring Status	Continuous Monitoring (Section 5.1.3.6)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Temperature	Higher of Tenv.min or Top.min temperature
b) Number of cycles	24 cycles (of 2 hours each)
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. Part shall not have any signs of physical deformation, burn marks, etc.

Test Procedure:

A. Place component in a climatic chamber.
B. Decrease the chamber temperature to higher of Tenv.min or Top.min temperature.
C. Soak the component at higher of Tenv.min or Top.min temperature in a powered off state for 1 hour.
D. Power on with operational loads using device powered conditions stated in section 5.1.2.2 for 1 hour while maintaining chamber temperature at higher of (Tenv.min / Top.min) temperature.
E. Repeat steps C and D, for a total of 24 times and 48 hours.

5.3.3 High Temperature Operating Endurance (HTOE)

Electronic components are subject to variable temperature conditions caused by internally generated heat, packaging location and local environmental temperatures. The HTOE test simulates failure modes and the cumulative damage that results from bias operation at different temperatures such as solder plastic creep, crack propagation in many materials, drying of electrolytic capacitors, and others.

The total test time will be too excessive if we tested the component based on the actual temperature profiles and bias voltage experienced during vehicle’s service / design life. Therefore, accelerated tests at higher constant temperature with voltage are used to create an equivalent damage. The Arrhenius model is used to describe the kinetics of many chemical and molecular phenomena. The model & an example of computing HTOE Test time is given in Annex A-1 at the end of this document.

Scope:
The HTOE test is mandatory for all electronic components /devices subjected to the following conditions
If certain features of the same module operate at two different temperatures, one at Top.max (lower of the two features) and Tenv.max (higher of the two features) for example: CD mechanism in a typical radio may not operate above +70 0C, whereas, the Radio AM/FM/SAT may be operational at +85 0C, in such a case, during HTOE test, CD mechanism shall be tested at the Top.max of +70 0C, whereas, the Radio (AM/FM/SAT) shall be tested at Tenv.max or +85 0C in operational state. Test duration for both features would be split with agreed percentage ratio (ex: 50% Tuner and 50% CD/DVD functions) and reported in the component specification as shown in
Figure **2**.
For all other cases, where all features operate at the same maximum temperature (Tenv.max is same as Top.max), HTOE test shall be run with one common high chamber temperature at Tenv.max or Top.max as shown in
Figure **3**.

Test Parameters and Requirements

Table 26 - High Temperature Operating Endurance Requirements	
Applicable Standard	ISO 16750-4, High-temperature tests, Operation, IEC 60068-2-2.
Test Duration (Hours)	1 300 Hours (PT-Emission/ Passive Safety applications / 15 years or 200K design life) / 950 Hours (all other applications, typically 10 years or 150K design life) For Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV), modules or sensors, which operate during battery charging, determine actual lifetime operating hours (driving + charging) and calculate HTOE test duration using the Arrhenius Model in Annex A, Section A-1. Lifetime operating hours and HTOE test duration to be agreed by FCA Engineering and Quality & Reliability Engineering.
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2
Operating Mode	OM3B (see - Table 19 & Section 5.1.2.2), maximum permissible loads
Monitoring Status	Continuous Monitoring (Section 5.1.3.6)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
Temperature	Tenv.max or Top.max temperature for the chamber (based on the packaging location or technological limitations) – operational time may be split in two separate operational temperature states for some modules, ex: Radio (AM/FM/Sat) at 85 °C and CD mechanism at 70 °C
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. Part shall not have any signs of electro-migration, dendrite growth, physical deformation, burn marks, etc.

Test Procedure - Constant Temperature Method:

A. Place the component in a thermal chamber and increase the chamber at Tenv.max or Top.max temperature as specified in the Component Specific Performance Standard.
B. Operate the component as per operating mode, test duration and other requirements specified in Table 26. Verify acceptance criteria at the end of the testing.

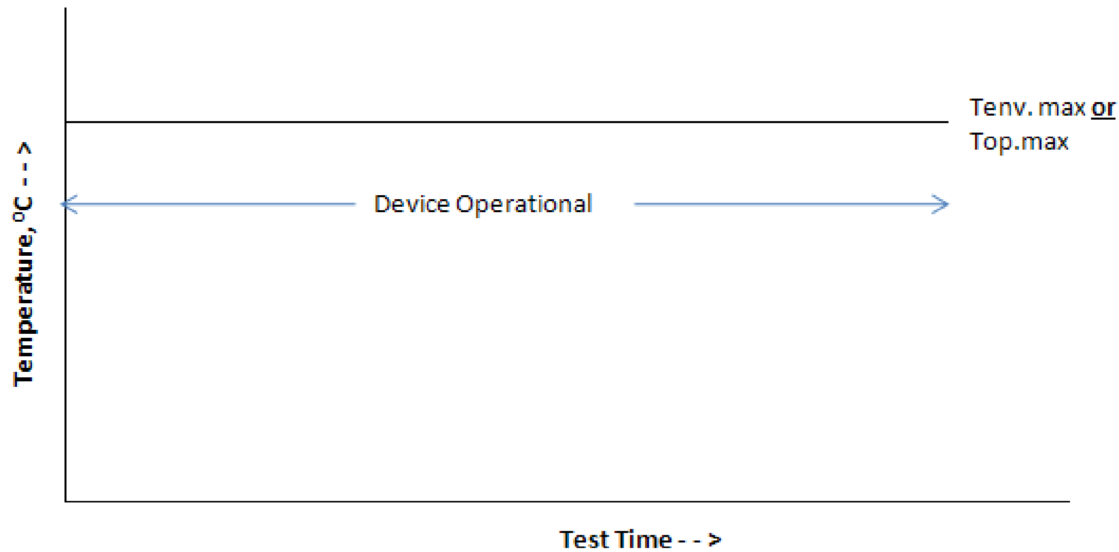


Figure 2 - Profile for HTOE Test (with Only One Common High Op. Temp)

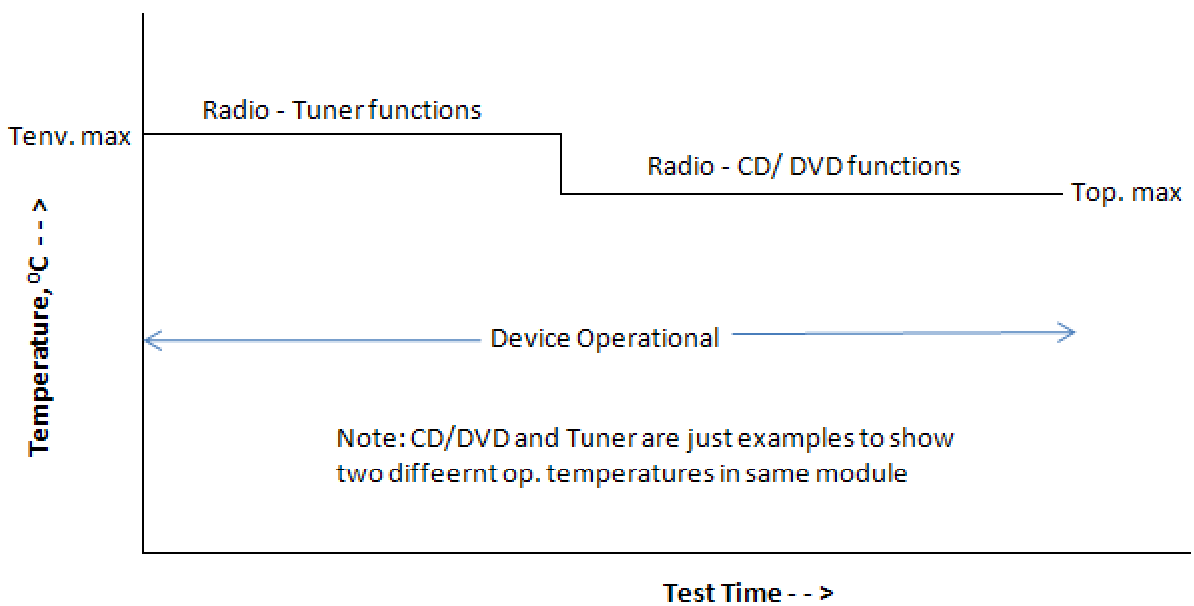


Figure 3 - Profile for HTOE Test (with Different High Op. Temperatures)

5.3.4 Power Thermal Cycle Endurance (PTCE)

The Electrical or Electronic (E/E) PC Board components are constructed from materials with different coefficients of thermal expansion (CTE) and operate in environments where the temperatures are not uniform. During normal vehicle operation, temperatures are dynamically changing causing mechanical stresses on adjoining materials. This may cause mechanical failure, for example, cracked solder joints, printed circuit boards, seals, and traces. The PTCE test simulates solder joint failures which have been common in the electrical or electronic components.

The Coffin-Manson Model describes the fatigue life of materials under shear strain from thermal expansion & contraction. The model & an example of computing PTCE thermal cycles, cycle duration, and total test time is given in Annex A (Section A-2 “Coffin-Manson Model”).

Scope:
The PTCE test is mandatory for E/E components with solder joints. The component shall be thermal cycled between temperature extremes as specified in the Component Specific Performance Standard.

Test Parameters and Requirements

Table 27 - Powered Thermal Cycle Endurance Requirements	
Applicable Standard	ISO 16750-4, Temperature cycling IEC60068-2-14,Test Nb, Change of temperature
Test Duration (Hours)	Shall be based on the Soak Time for the component & ramp rate of the test chamber
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM3B (intermittent operation, maximum permissible loads – Table 19 and Section 5.1.2.2)
Monitoring Status	Continuous Monitoring (Section 5.1.3.6)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Temperature	Between “Tenv.max or Top.max temperature” and “Tenv.min or Top.min temperature” (based technological limitations) –operational time may be split in two separate operational temperature states for some modules, ex: Radio (AM/FM/Sat) at 85 °C / - 40 °C and CD mechanism at 70 °C / -30 °C (See Figure 4 & Figure 5)
b) Number of cycles	500 Cycles (PT-Emission / Passive Safety applications / 15 years or 200K design life) / 300 cycles (all other applications, typically 10 years or 150K design life). For Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV), modules or sensors, which operate during battery charging, determine actual lifetime number of thermal cycles (driving + charging) and calculate PTCE + TS test cycles using the Coffin - Manson Model in Annex A, Section A-2. Lifetime number of thermal cycles and PTCE + TS test cycles to be agreed by FCA Engineering and Quality & Reliability Engineering.
c) Soak Time	Per Section 1.4.8 (Table 10)
d) Ramp Rate	Between 4 °C/Min – 10°C/Min (max). Lower ramp rates are allowed but the cycle time will increase
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. Part shall not have any signs of electro-migration, dendrite growth, physical deformation, burn marks, etc

Test Procedure:
The time durations at the minimum and maximum chamber temperatures and the number of transitions between the temperatures shall be defined in the Component Specific Performance Standard.

A. Place component in a thermal chamber at RT.
B. Ramp down the chamber temperature to Tenv.min or Top.min temperature in a non-operating or low power mode per the Component Specific Performance Standard.+

C. Maintain the chamber temperature for time duration Tsoak. After the Tsoak time, start to operate the component before ramping the temperature. The time required should be specific to the component as specified in the Component Specific Performance Standard.
D. Ramp up the chamber temperature to Tenv.max or Top.max temperature
E. Maintain the chamber temperature for time duration tsoak.
F. Ramp down the chamber to RT. Follow the operating mode, monitoring status and other test parameters specified in Table 27 for PTCE requirements.
G. Repeat steps B through F for the required number of cycles,
H. Perform the functional checks at start and end of the test cycles.

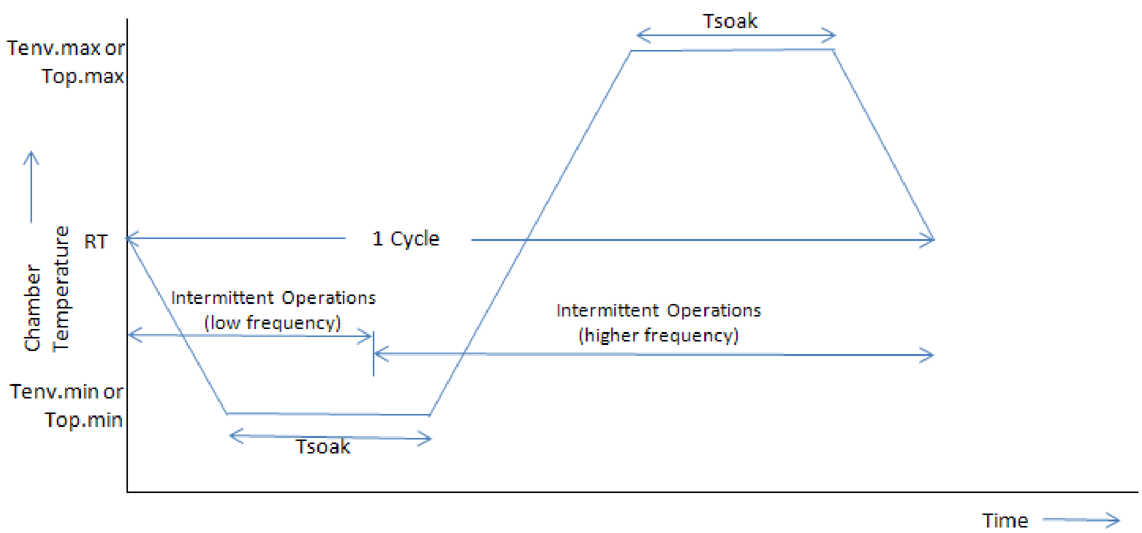


Figure 4 - Profile for PTCE Cycle (with Only One Extreme Op. Temperature)

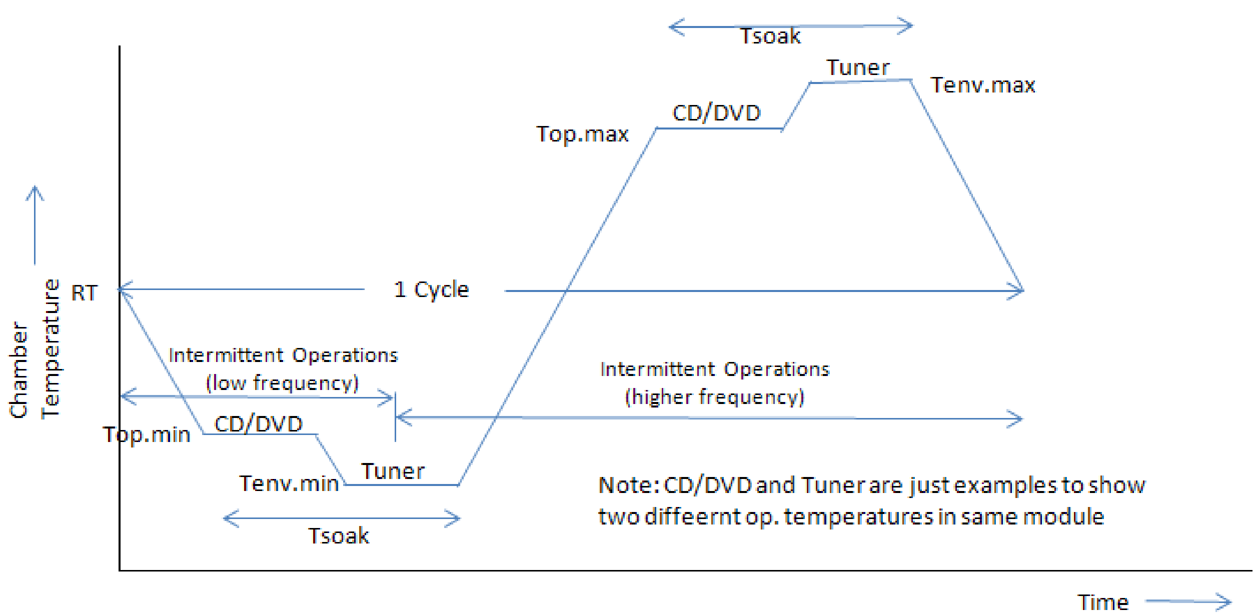


Figure 5 - Profile for PTCE Test (with Different Extreme Op. Temperatures)

5.3.5 Thermal Shock (TS)

It is an accelerated test which simulates a very high number of slower temperature cycles experienced by a component mounted in the vehicle. These changes depend upon the component mounting location, prior vehicle operation, and the outside ambient temperature. The outside ambient temperature change occurs during the temperature difference experienced with day and night cycles, with seasonal variation, and with local weather conditions. A thermal cycle could create solder joint failures, potting or seal failures, and failures of circuit components due to mechanical stresses caused by thermal expansion and contraction. Thermal shock may cause PC board warping, de-lamination, and other effects.

The Coffin-Manson Model describes the fatigue life of materials under shear strain from thermal expansion & contraction. The model & an example of computing thermal shock cycles, cycle duration, and total test time is given in Annex A (Section A-2 "Coffin-Manson Model").

Between, PTCE and TS tests, TS is usually considered as more severe test and could be used to optimize test durations when faced with timing bottleneck. Since, PTCE is an operational test, it offers some distinct advantages not available through TS tests and as a result, FCA practices require balance between PTCE and TS test cycles.

Scope:
The TS test is mandatory for electronic components and may involve Air-Air or Liquid-Liquid TS depending on module packaging environment (example of liquid-liquid include ECUs or Sensor packaged in Transmission Chambers, parts could be transferred between two liquid containers maintained at different extreme temperatures).

Test Parameters and Requirements
Each thermal shock cycle shall transition between Tenv.max and Tmin within 30 seconds. The soak times at Tenv.max and Tmin shall conform to Table 10, Classification of Component Weight and Soak Time, unless there is test data that shows a different soak time is required

The component shall comply with the following:

Table 28 - Thermal Shock Requirements

Applicable Standard	ISO 16750-4, Climatic Loads IEC 60068-2-14, Test Na, Change of temperature
Test Duration (Hours)	Based on the soak time for the component
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM1A (Table 19)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Temperature	Tenv.max (based on the packaging location) or Tmax(Actual measured) and Tmin = - 40°C
b) Number of cycles	500 Cycles (PT-Emission/ Passive Safety applications / 15 years or 200K design life) / 300 cycles (all other applications, typically 10 years or 150K design life). For Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV), modules or sensors, which operate during battery charging, determine actual lifetime number of thermal cycles (driving + charging) and calculate PTCE + TS test cycles using the Coffin - Manson Model in Annex A, Section A-2. Lifetime number of thermal cycles and PTCE + TS test cycles to be agreed by FCA Engineering and Quality & Reliability Engineering.
c) Soak Time	Per Section 1.4.8 (Table 10)
e) Transfer time	< 30 seconds
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. Part shall not have any signs of physical deformation, burn marks, etc.

Test Procedure:
The time durations at the minimum and maximum chamber temperatures (Tsoak) and the number of transitions between the temperatures shall be defined in the Component Specific Performance Standard (Refer to
Figure **6**).

A. Place component in a chamber with dual temperature zone capability and adjust the temperature zones to Tmin and Tenv.max, respectively. If a chamber with dual temperature zone capability is not available, use two chambers in close proximity and maintain one chamber at Tmin and another at Tenv.max.
B. Maintain component at Tenv.max for specified component soak time.
C. Transfer component from Tenv.max zone to Tmin zone within 30 seconds.
D. Keep component at Tmin for the specified component specific soak time.
E. Transfer component from Tmin zone to Tenv.max zone within 30 seconds.
F. Repeat the thermal cycles (steps B through E) for the specified number of test cycles.

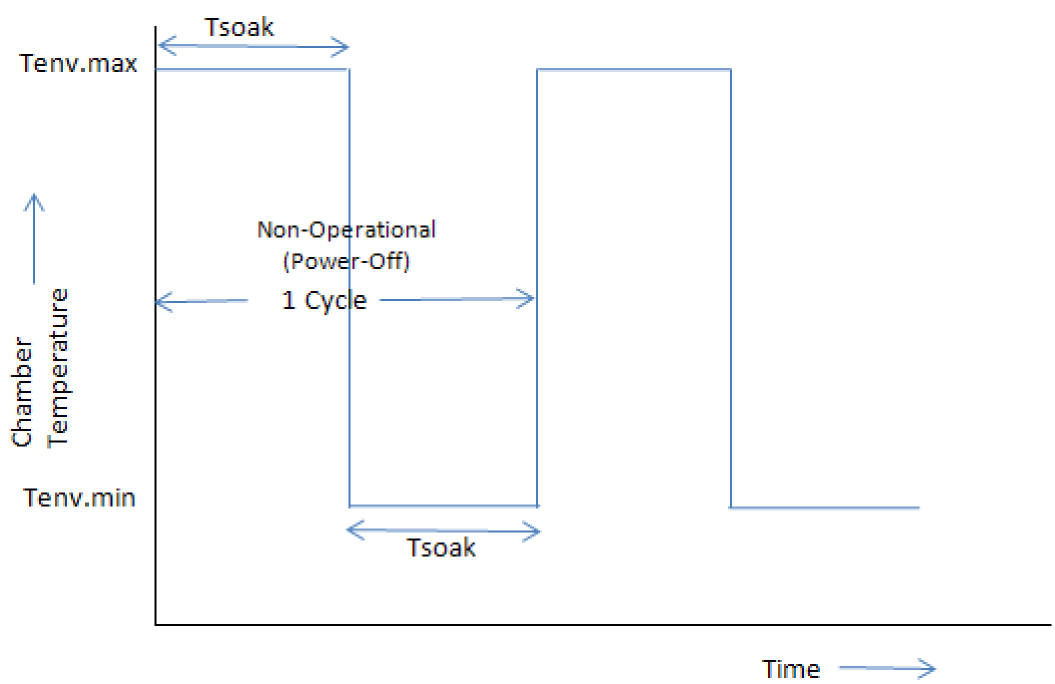


Figure 6 - Thermal Shock Cycle

5.3.6 Thermal Humidity Cycle (THC)

Humidity condensation (every day driving conditions) or frost conditions (during cold climates) can cause failure modes in components & devices over the life. This test ensures that no failures occur when components "breath" in water. If the water is "trapped" within small spaces inside the component, the ice may cause mechanical damage.

Scope:
The THC test is mandatory for all electronic components.

Test Parameters and Requirements

Table 29 - Thermal Humidity Cycle Requirements	
Applicable Standard	IEC 60068-2-38 Test Z/AD, Variable Humidity – "Composite temperature / humidity cyclic test"
Test Duration (Hours)	240 hours (10 days)
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM3B (Table 19 and Section 5.1.2.2). Intermittent Operation: Cycle between Operating Mode OM3B (Power ON and operated in such a manner to minimize power dissipation) and Operating Mode OM3A (Power OFF/Sleep) at a duty cycle appropriate to the thermal mass of the DUT. Typical operating mode time is 30 min ON and 30 min OFF (alternate ON/OFF cycle duration may be used to minimize overheating and to facilitate heat dissipation from the device, example could be 10 min ON & followed by 10 min OFF sequence)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Monitoring Status	Continuous Monitoring is required during the ON state, During the Sleep/OFF state; continuous parasitic current is monitored and recorded over the test period to detect malfunctions during the test (Section 5.1.3.6)
Test Parameters	
a) Temperature	-10 °C to +65 °C
b) Number of cycles	10 cycles (Use Figure **7** for assisted drying, Figure **8** for cycle # 1 – 5 and Figure **9** for cycle # 6 – 10. Test according to IEC 60068-2-38 requirements)
c) Relative humidity	93% (uncontrolled during the intervals defined in IEC 60068-2-38)
Temperature and humidity profile	The first five temperature cycles shall be performed with cold phase; the next five cycles shall be performed without cold phase.
Acceptance Criteria	No increase greater than 50% in parasitic current. Performs as designed during and after the test. Meets all functional requirements before & after the test. Part shall not have any signs of electro-migration, dendrite growth, physical deformation, burn marks, etc.

Test Procedure:

A. Place component in a climatic chamber and operate the chamber in accordance with IEC 60068-2-38 with assisted pre-drying cycle (
B. Figure **8** and
C. Figure **9** provide temperature and humidity for 10 cycles - each cycle is of 24 hour duration. Test according to IEC 60068-2-38 requirements)
D. Intermittently operate and monitor the component functionality throughout the test duration (may involve few minutes to 30 min maximum operational time for every one hour) or as specified in the Component Specific Performance Standard.

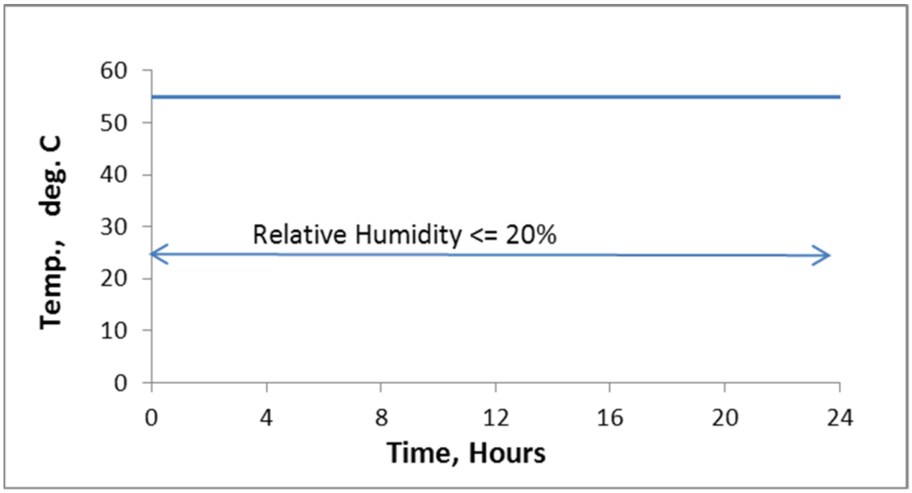


Figure 7 - Thermal Humidity Cycle Assisted Drying (Pre-Conditioning)

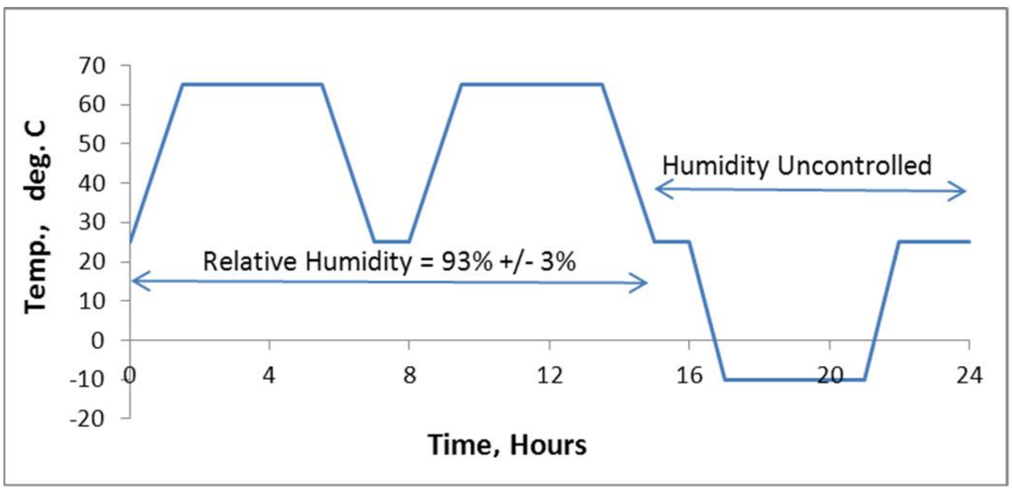


Figure 8 - Thermal Humidity Cycle (with Cold Phase)

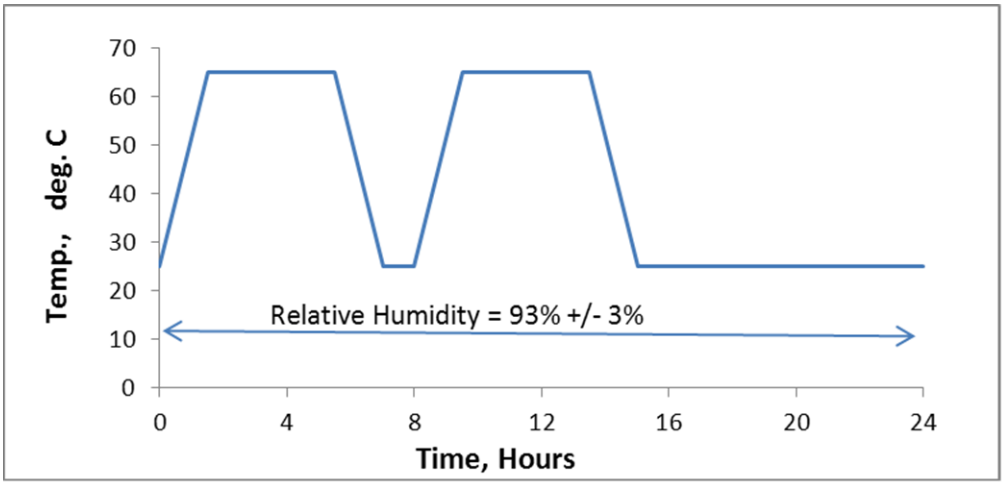


Figure 9 - Thermal Humidity Cycle (without Cold Phase)

5.3.7 High Temperature & High Humidity Endurance (HTHE)

This is to simulate conditions and failure modes when an electronic components / devices are exposed to High temperature and humidity over the vehicle's service life.

These failures include electrical shorts due to oxidation and/or galvanic corrosion of metals, and absorption of water by materials. Water absorption in turn can also cause materials to swell and lose strength causing adhesive, potting, seal, and conformal coating compound failures.

The Lawson Model shall be used to describe the effects of temperature and humidity on the failure life of electronic components. The model & an example of computing HTHE cycles, cycle duration, and total test time is given in Annex A (Section A-3 "Lawson Model).

NOTE: The worst case situation is the 5% usage customer for operating time in service. This maximizes the non-operating time.

Scope:
The HTHE test is mandatory for all electronic components.
Test Parameters and Requirements

Table 30 - High Temperature and Humidity Endurance Requirements

Applicable Standard	IEC 60068-2-78 Constant Humidity – "Damp Heat, Steady State"
Test Duration (Hours)	1 000 Hours (PT-Emission/ Passive Safety applications or exterior packaging locations) / 700 Hours (all other applications for interior cabin or trunk locations) (NOTE1) Please note that special cases should be addressed with dedicated cycles and/or test endurances to be agreed with Quality and Reliability Engineer based on actual usage in the application (e.g. electric and hybrid vehicles).
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2
Operating Mode	OM3B (Table 19 and Section 5.1.2.2 – Operational) for one hour after 47 hours in Operating Mode OM2A (Power OFF/Sleep). The cycle of 48 hours is repeated for the total duration of the test.
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Monitoring Status	Continuous Monitoring is required during the ON state, During the Sleep/OFF state; continuous parasitic current is monitored and recorded over the test period to detect malfunctions during the test (Section 5.1.3.6)

Table 30 - High Temperature and Humidity Endurance Requirements	
Test Parameters	
a) Temperature	85 °C + 4 °C (No negative tolerance)
b) Relative humidity	85% + 4% (No negative tolerance)
Acceptance Criteria	No increase greater than 50% in parasitic current. Performs as designed during and after the test. Meets all functional requirements before & after the test. Part shall not have any signs of electro-migration, dendrite growth, physical deformation, burn marks, etc.
NOTE 1: Alternate HTHE test duration under different lower temperature and higher humidity conditions are specified in Table A-3. Modules which cannot withstand higher temperatures (85 °C), shorter test durations are preferred using alternate higher humidity levels.	

Test Procedure:

A. Place component in a test chamber maintained at 85 °C.
B. Introduce humidity to the chamber and maintain the relative humidity inside the chamber at 85% RH.
C. Accumulate test time when both temperature and humidity are at 85 °C and 85% RH.
D. Functionally test the component every 47 hours or as specified in the Component Specific Performance Standard (may involve few minutes to 1 hour maximum operational time). If the component needs to be removed from the chamber for functional testing, then steps A and B must be repeated when resuming testing prior to accumulating additional test time.
E. Any parametric or functions checks at different thermal conditions (-40 °C, RT, +85 °C) can be performed with humidity uncontrolled.

5.3.8 Solar Radiation Soak

This test shall simulate the aging effects of solar radiation on component surfaces exposed to direct sunlight.

Scope:
The Solar Radiation Soak test is mandatory for electronic components that are normally exposed to direct sunlight and have a visible first surface appearance in the passenger cabin. This test must be conducted for production approved material (usually for VP or PS build vehicles). Solar Radiation Soak test is not required to be repeated, if the prior phase test was completed successfully with no changes to design or materials thereafter.

Test Parameters and Requirements

Table 31 - Solar Radiation Soak Requirements	
Applicable Standard	SAE-J2412 for components inside the passenger compartment or DIN 75220 (Z-OUT), Section “Cycle test (Z). Use tables “Outdoor – daytime” and “Outdoor, indoor 1 and 2, daytime”
Test Duration	If using SAE-J-2412: 7 days (for components with Indirect exposure to sunlight), and 25 days (for components with Direct exposure to sunlight). If using, DIN 75220: 25 days with 50% energy W/m2(for Indirect exposure to sunlight), and 25 days with 100% energy W/m2 (for Direct exposure to sunlight)
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2
Operating Mode	OM1A (Table 19)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Number of cycles	As per SAE-J2412 – 3.8 hours of light cycle & 1.0 hour dark cycle in every cycle for the total test duration specified (7 or 25 days). If the component interior or surface temperature exceeds 95 °C at any time during the test, the design will be reviewed & modified to improve excess heat dissipation or alternate test method shall be used per DIN 75220.

Table 31 - Solar Radiation Soak Requirements	
Acceptance Criteria	Visual inspection of first surfaces for damage or degradation such as overheating, hardening/brittleness in plastics, fissure formation, discoloration, cracking, peeling, etc. Compare first surface condition with acceptance criteria defined in the Component Specific Performance Standard. Maximum 5% removal in crosshatch test according to ISO 2409 (Tape 3M -898 or Tesa 4657). Verify that it meets all electrical & mechanical functional/ performance requirements before & after the test.

5.4 Mechanical Stresses

This category includes tests to demonstrate compatibility with Mechanical stresses such as Vibration, Mechanical shock, Handling drop, Gravel bombardment etc.

5.4.1 Requirements on Connectors & Wiring Harness

Component connectors and wiring pigtails shall meet applicable wiring requirements per CS.00050, PF-10099, 9.91192, PF.90012, CEP-042, SAE/USCAR-2, SAE/USCAR-21, SAE/USCAR-25 and DS-158.

During environmental validation (tests), the production intent approved connectors and wiring harness/ pigtails shall be used. Component, system (device) or vehicle validation tests shall use mating connectors and harnesses manufactured with wires of correct gauge size and crimping from production intent designs and processes. If the wire harness or connectors used for system or component test are not production intent, the test set-up must be pre-approved by FCA Engineering and Wiring Harness Group.

It is supplier's responsibility to obtain test reports from connector supplier to show compliance to connector specific Environmental, Electrical and Mechanical requirements from PF.90012 or other equivalent connector standards. Component or Module supplier shall verify applicable mechanical and Electrical requirements from PF.90012 including (but not limited to): Terminal to Terminal Engage/ Disengage Force, Terminal - Connector Insertion/ Extraction Force, Connector – Connector: Mating/ Un-mating Force, Audible Click, etc. along with Connector orientation to prevent water/liquid ingress, etc.

5.4.2 Device Restraint Performance

E/E Component shall meet Device Restraint Performance requirement specified in this section when tested on a vehicle or a simulated vehicle environment using production mounting set-up (nuts, screws, supporting brackets, etc.) and locking or securing them using predefined torque. E/E Component shall not show any signs of permanent separation or deformation at restraint points when the component is subjected to a load equal to 8 times its weight or 20 N (whichever is greater) at the location that would exert the maximum moment in 3 main axes (X, Y & Z directions as well as + and – directions for a total of 6 directions). For components sensitive to temperatures at the given packaging locations, this test shall also be conducted under tri-temp condition (Tmin, RT, Tmax) based on engineering input.

5.4.3 Mechanical Vibration

These are highly accelerated test that simulate the cumulative vibration damage caused by random and/or sinusoidal vibration stresses on the component due to road and engine while driving. The vibration tests are based on ISO 16750-3.

The vibrations seen by the component are based on its packaging location. The vibration class for the component based on its packaging location is specified in Table 11. Test duration is based on mileage driven criteria (150 000 or 200 000 miles as per the vehicle design life defined in Table 1).

Test durations shall be according to Table 32.

Table 32 - Vibration Test Duration(NOTE1)

Vibration Class	Design Life	Test Duration per axis (h)		
		Random	Sine-on-Random	NOTE
V1, V1A	150 k mi	- - -	33	- - -
	200 k mi	- - -	44	- - -
V2, V3	150 k mi	12	- - -	- - -
	200 k mi	16	- - -	- - -
V4	150 k mi	33	- - -	- - -
	200 k mi	44	- - -	- - -

NOTE1: Both random and swept sinusoidal vibration profiles shall be run simultaneously (Sine-on-Random). Alternatively, run the random vibration profile followed by swept sinusoidal vibration profile (each one for the full test duration).

For vibration classes V1, V1A and V4 the thermal profile of
Figure **10** shall apply.
For vibration classes V2 and V3 the thermal profile of Figure 11 shall apply.

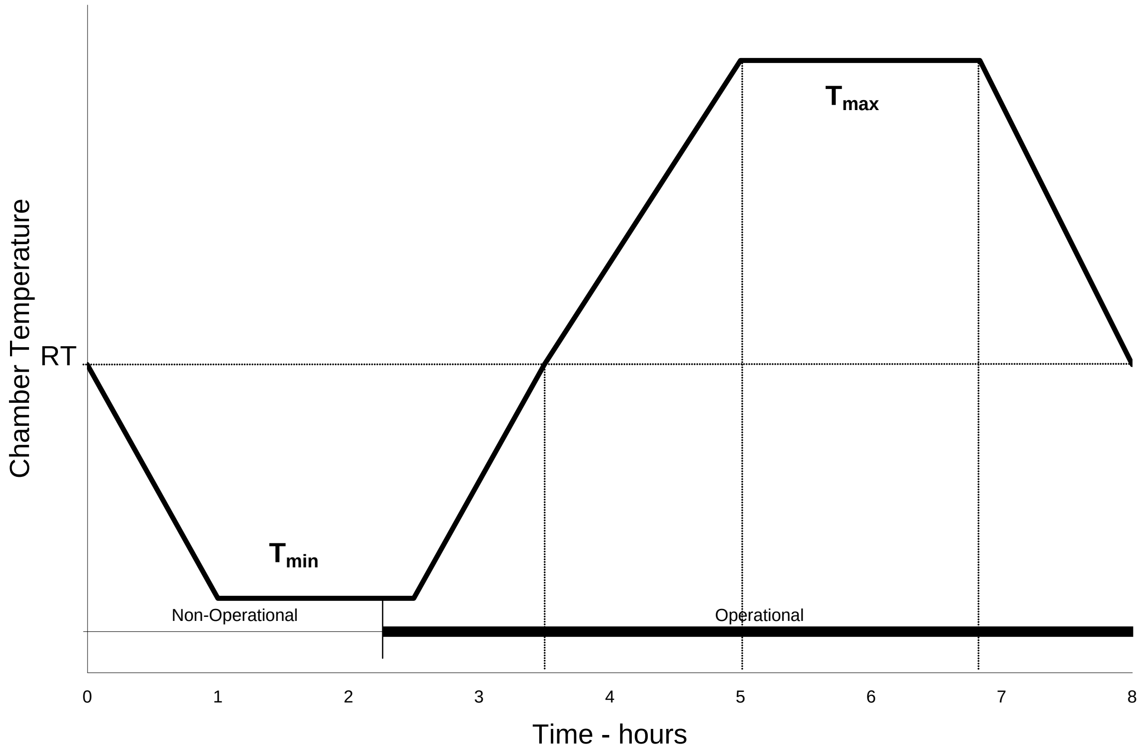


Figure 10 - Temperature Cycle for Vibration Class V1, V1A and V4

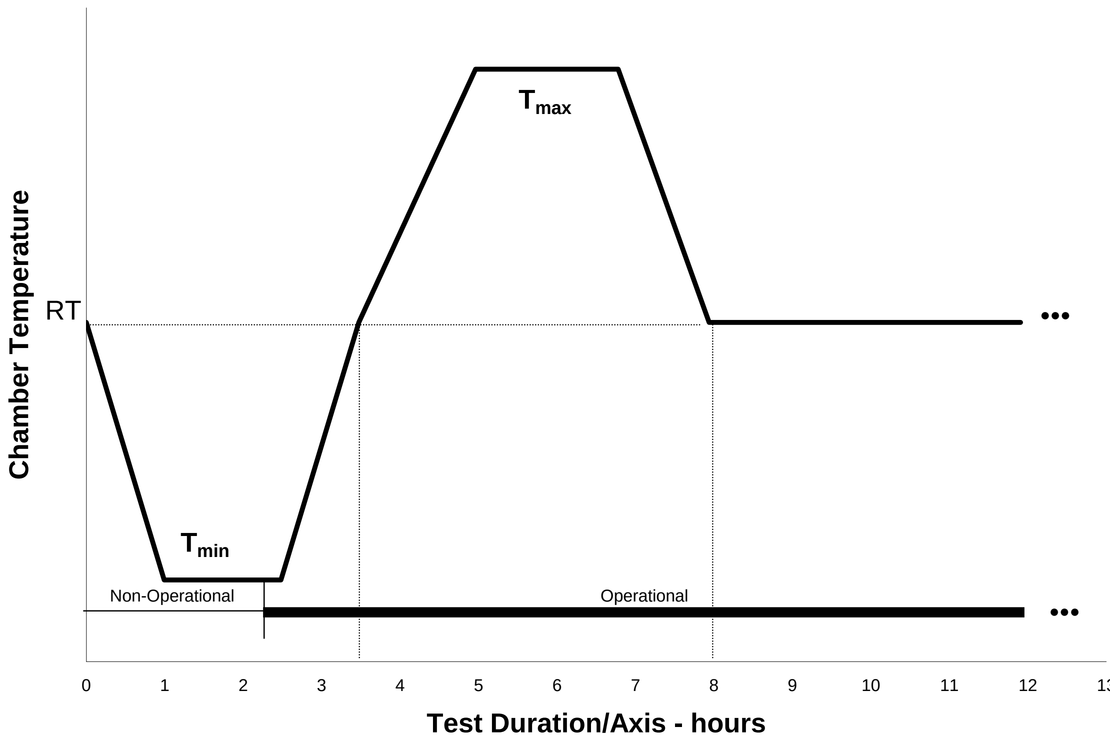


Figure 11 - Temperature Profile for Vibration Classes V2 and V3

Scope:
The vibration tests are mandatory for all electronic components.

Test Procedure:
Tests shall be carried out according to ISO 16750-3:2003 and IEC 60068-2-14:1984 test Nb with deviations specified in this section.

A. Place component on the vibration shaker inside the temperature chamber. Mount the component in one of the axes using a released bracket or mounting hardware, connector and wiring harness. Unless otherwise specified in the Component Specific Performance Standard, the first wiring harness tie down shall be at 97±3 mm and secured to the vibrating fixture for each unit tested.
B. Program the vibration shaker for the random vibration profile, temperatures, ramp rates and duration as given in applicable Tables of each vibration class.
C. Start vibration and temperature sequence. Operate the modules using load boxes as per the specified intermittent operation sequence for the module vibration class.
D. At the end of the test cycle for one axis, repeat sequence A through C for the remaining axes.
E. Acceptance Criteria (All Vibration Classes).
F. Functional performance shall be verified before start and after completion of the test to validate to the requirements.

5.4.3.1 Vibration Class V1 (Components / Devices mounted on the Engine)

Test Parameters and Requirements

Table 33 - Mechanical Vibration Class V1 Requirements

Vibration class	V1 (mounted on the Engine. 2, 3, 4, 5, 6, 8 Cylinder) Vibration with Thermal Cycling.			
Applicable Standard	ISO 16750-3, Test I – Passenger car, engine IEC 60068-2-6,Test Fc: Vibration (sinusoidal) IEC 60068-2-64, Test Fh, Vibration, broad-band random (digital control) and guidance			
Test Duration (Hours / axis)	33 or 44 hours for 150 000 or 200 000 design life respectively			
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.			
Operating Mode	OM3B (Table 19 & Section 5.1.2.2), Intermittent Operation			
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.			
Monitoring status	Continuous Monitoring required			
Test Parameters for Temperature				
Both vibration (Random & Sinusoidal) profiles have a superimposed thermal cycle profile shown in Figure 10 (8 hour profile cycle is repeated until end of the test)	**Breakpoint**	**Time (minutes)**	**Temperature (°C)**	**Operation**
	1	0	23	Not operating
	2	60	-40	Not operating
	3	135	-40	Operating
	4	150	-40	Operating
	5	210	23	Operating
	6	300	Tmax	Operating
	7	410	Tmax	Operating
	8	480	23	Operating
	9	Repeat from breakpoint 1 until the end of the test		
Ramp rate of temperature profile	1 – 1.5 °C/min			
Temperature profile	Lower of the Tenv.max or Top.max for the component temperature class			
Test Parameters for the Sinusoidal Component of the Vibration				
Sinusoidal Vibration Profile for Class V1	**Frequency [Hz]**	**Amplitude of acceleration [m/s^2]**	**Amplitude of acceleration [G]**	
	100	100	10.2	
	150	160	16.3	
	200	250	25.5	
	240	250	25.5	
	300	150	15.3	
	500	150	15.3	
Sweep Rate (Sinusoidal Vibration)	1 octave / minute			
Test Parameters for the Random Component of the Vibration				
Random Vibration profile for Class V1	**Frequency [Hz]**	**Power spectral density (PSD) [(m/s^2)^2/Hz]**	**Power spectral density (PSD) [G^2/Hz]**	
	10	10.0	0.104	
	100	10.0	0.104	
	300	0.51	0.005	
	500	20.0	0.208	
	2 000	20.0	0.208	
	RMS acceleration	181 m/s^2	18.41 G	
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. No damage/BSR, no functional or performance degradation, no undesired or intermittent operations shall be allowed. Part shall not have any signs of physical deformation, burn marks, etc.			

NOTE: Both random and swept sinusoidal vibration profiles shall be run simultaneously (Sine-on-Random). Alternatively, run the random vibration profile followed by swept sinusoidal vibration profile (each one for the full test duration).

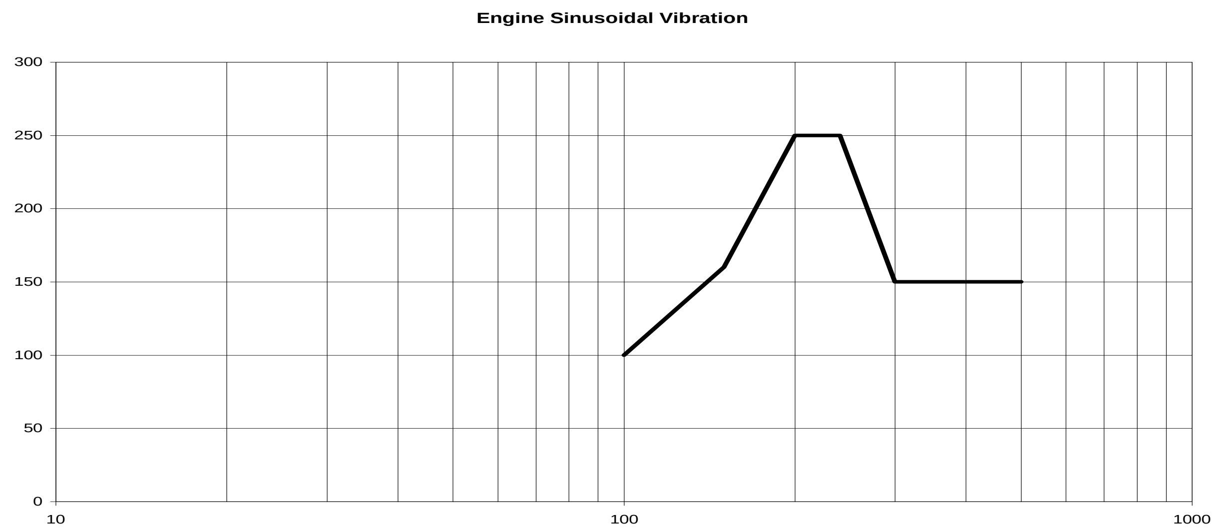


Figure 12 - Engine – Sinusoidal Vibration

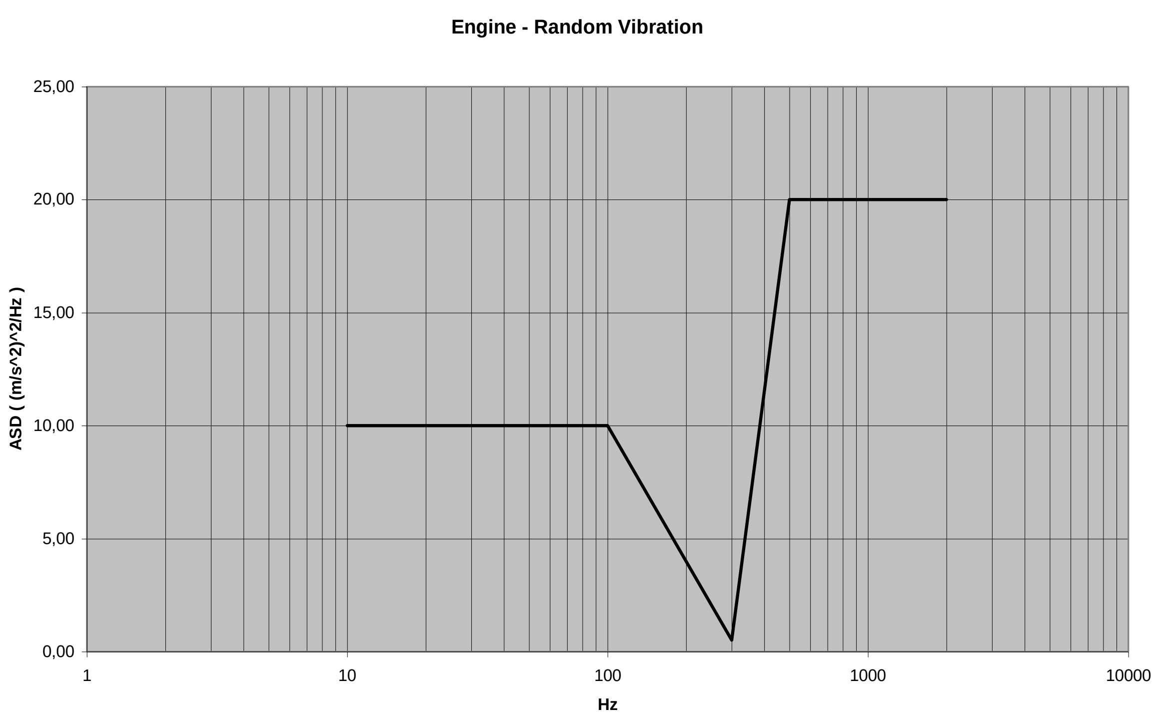


Figure 13 - Engine – Random Vibration

5.4.3.2 Vibration Class V1A (Component / Devices mounted on the Gear Box)

Test Parameters and Requirements

Table 34 - Mechanical Vibration Class V1A Requirements

Vibration class	V1A – (Component / Devices mounted on the Gear Box) Vibration with Thermal Cycling.			
Applicable Standard	ISO 16750-3, Test II – Passenger car, gearbox IEC 60068-2-6,Test Fc: Vibration (sinusoidal) IEC 60068-2-64, Test Fh, Vibration, broad-band random (digital control) and guidance			
Test Duration (Hours) / axis	33 or 44 hours for 150 000 or 200 000 design life respectively			
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.			
Operating Mode	OM3B (Table 19 & Section 5.1.2.2), Intermittent Operation			
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.			
Monitoring status	Continuous Monitoring required			
Test Parameters for Temperature				
Both vibration (Random & Sinusoidal) profiles have a superimposed thermal cycle profile shown in Figure **10** (8 hour profile cycle is repeated until end of the test)	**Breakpoint**	**Time (minutes)**	**Temperature (°C)**	**Operation**
	1	0	23	Not operating
	2	60	-40	Not operating
	3	135	-40	Operating
	4	150	-40	Operating
	5	210	23	Operating
	6	300	Tmax	Operating
	7	410	Tmax	Operating
	8	480	23	Operating
	9	Repeat from breakpoint 1 until the end of the test		
Ramp rate of temperature profile	1 - 1.5 °C/min			
Temperature profile	Lower of the Tenv.max or Top.max for the component temperature class			
Test Parameters for the Sinusoidal Component of the Vibration				
Sinusoidal Vibration Profile for Class V1A	**Frequency [Hz]**	**Amplitude of acceleration [m/s^2]**	**Amplitude of acceleration [G]**	
	100	30.0	3.06	
	200	60.0	6.12	
	440	60.0	6.12	
Sweep Rate (Sinusoidal Vibration)	1 octave / minute			
Test Parameters for the Random Component of the Vibration				
Random Vibration profile for Class V1A	**Frequency [Hz]**	**Power spectral density (PSD) [(m/s^2)^2/Hz]**	**Power spectral density (PSD) [G^2/Hz]**	
	10	10.0	0.104	
	100	10.0	0.104	
	300	0.51	0.0053	
	500	5.0	0.052	
	2 000	5.0	0.052	
	RMS acceleration	96.6 m/s^2	9.85 G	
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. No damage/BSR, no functional or performance degradation, no undesired or intermittent operations shall be allowed. Part shall not have any signs of physical deformation, burn marks, etc.			

NOTE: Both random and swept sinusoidal vibration profiles shall be run simultaneously (Sine-on-Random). Alternatively, run the random vibration profile followed by swept sinusoidal vibration profile (each one for the full test duration).

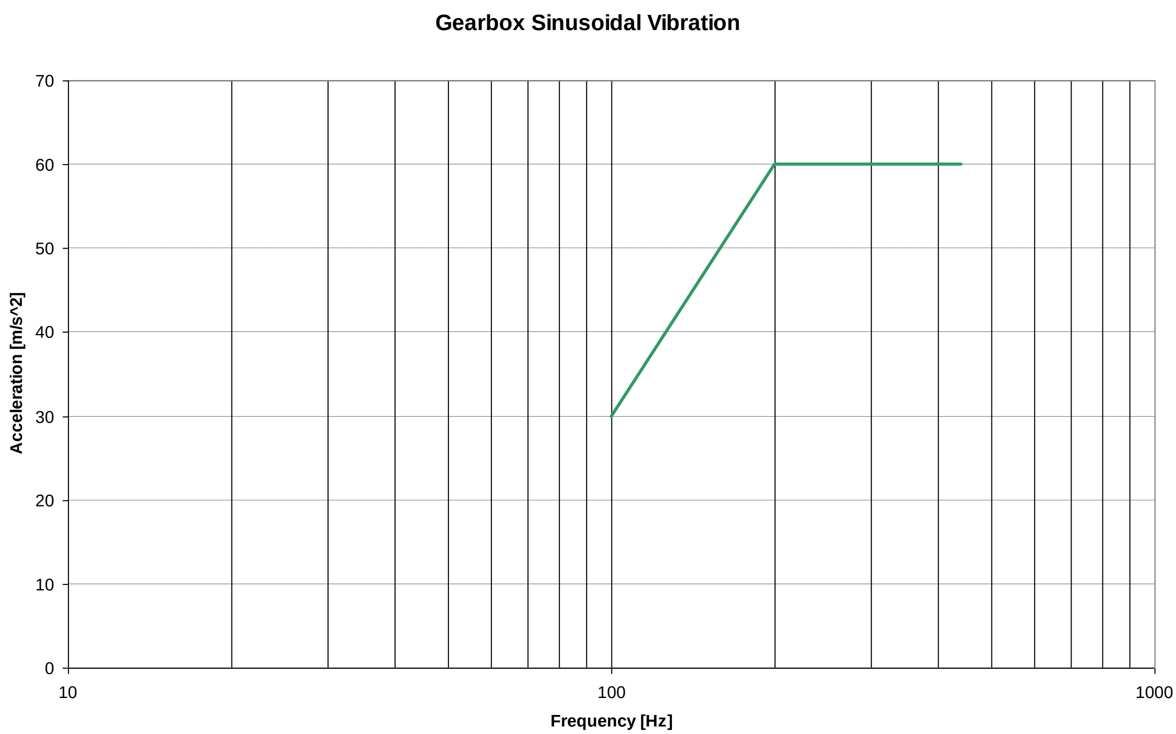


Figure 14 - Gearbox – Sinusoidal Vibration

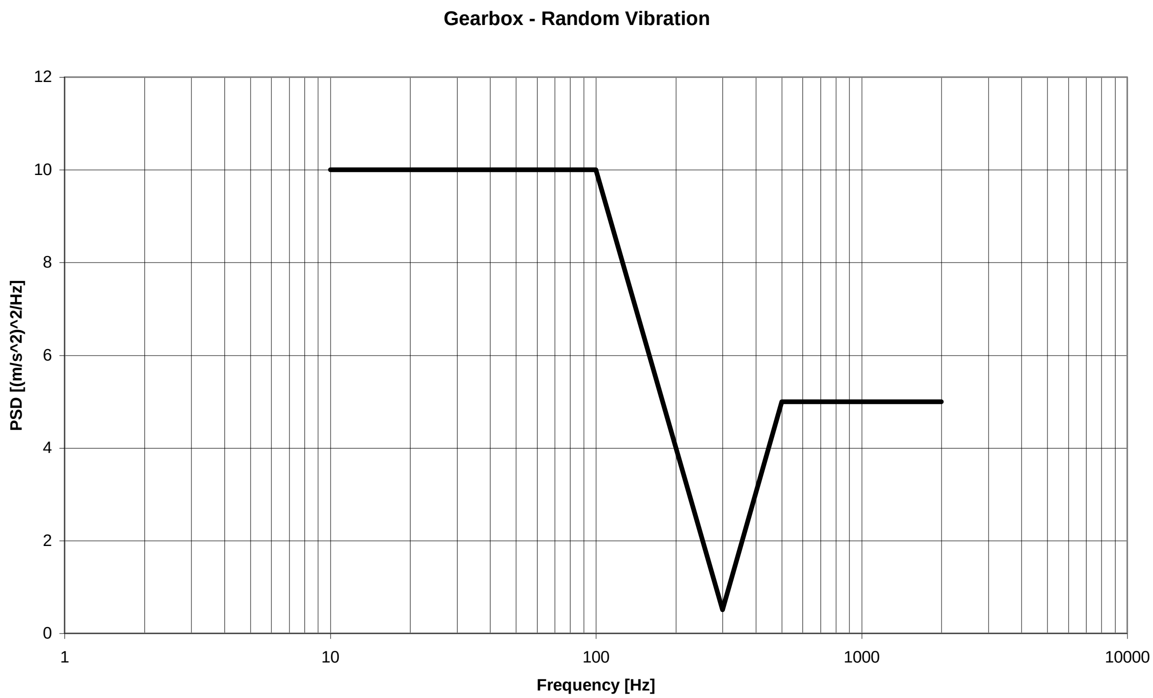


Figure 15 - Gearbox – Random Vibration

5.4.3.3 Vibration Class V2 (mounted on Chassis / Body - on Sprung Mass) and V3 (mounted on moving Body Parts such as, Doors)

Test Parameters and Requirements

Table 35 - Mechanical Vibration Class V2 & V3 Requirements

Vibration class	V2 – (Component / Devices mounted on Chassis / Body - on Sprung Mass; Instrument Panel, Body sheet metal, Overhead console, etc.); V3 – (Component / Device mounted on moving Body Parts - Doors, Liftgates, Tailgate, Trunk etc.) All vibration with Thermal Cycling.
Applicable Standard	ISO 16750-3, Test IV – Passenger car, sprung masses (vehicle body) IEC 60068-2-64, Test Fh, Vibration, broadband / random (digital control) and guidance
Test Duration (Hours) / axis	12 or 16 hours for 150 000 or 200 000 design life respectively
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM3B (Table 19 & Section 5.1.2.2), Intermittent Operation
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Monitoring status	Continuous Monitoring required

Test Parameters for Temperature

During the first 8 hours of each test per axis, the samples are subjected to a low and high temperature cycle according to the Temperature Profile shown in Figure 11

Breakpoint	Time (minutes)	Temperature (°C)	Operation
1	0	23	Not operating
2	60	-40	Not operating
3	135	-40	Operating
4	150	-40	Operating
5	210	23	Operating
6	300	Tmax	Operating
7	410	Tmax	Operating
8	480	23	Operating
9	720	23	Operating

Ramp rate of temperature profile	1 - 1.5 °C/min
Temperature profile	Lower of the Tenv.max or Top.max for the component temperature class

Test Parameters for Random Vibration

Random Vibration profile for Class V2, V3

Frequency [Hz]	Power spectral density (PSD) $[(m/s^2)^2/Hz]$	Power spectral density (PSD) $[G^2/Hz]$
10	20.00	0.2080
55	6.50	0.0676
180	0.25	0.0026
300	0.25	0.0026
360	0.14	0.0015
1 000	0.14	0.0015
RMS acceleration	27.78 m/s^2	2.84 G

Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. No damage/BSR, no functional or performance degradation, no undesired or intermittent operations shall be allowed. Part shall not have any signs of physical deformation, burn marks, etc.

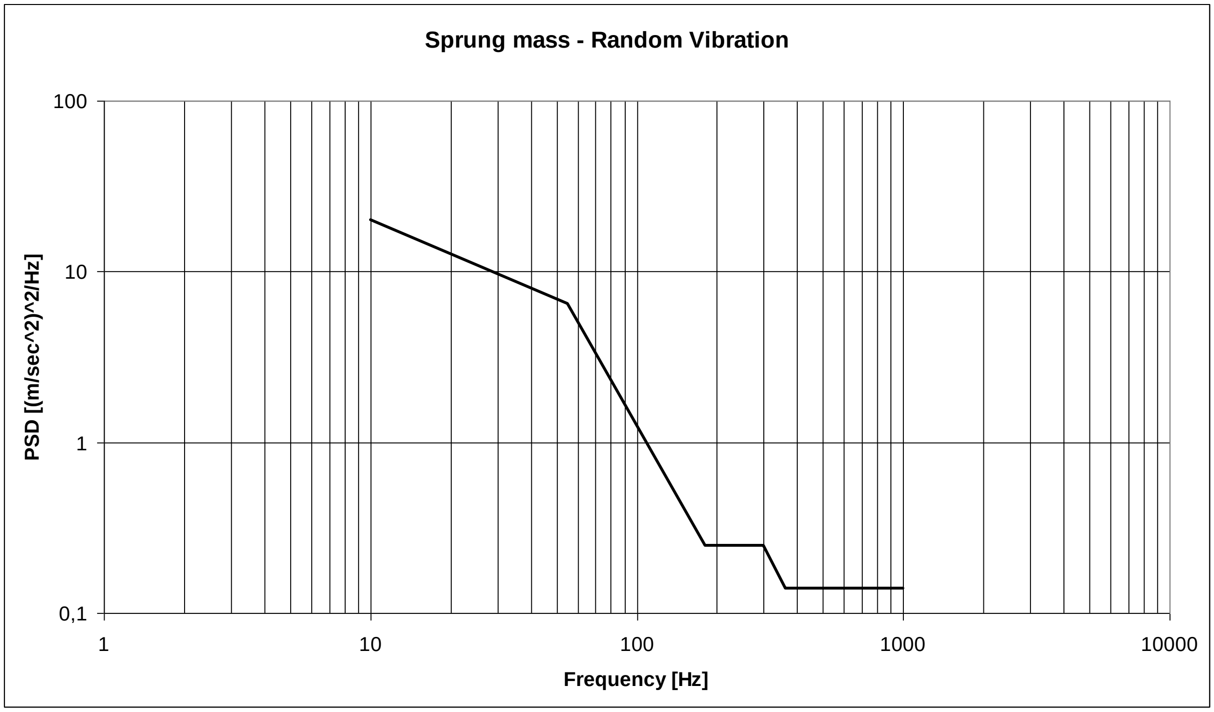


Figure 16 - Sprung Mass – Random Vibration

5.4.3.4 Vibration Class V4 (Component / Device mounted on Wheel, Wheel suspension, Wheel Knuckle etc. - on Unsprung Mass)

Vibration of suspension/ wheel mounted components is random and induced by rough-road-driving. Loads with frequencies lower than 20 Hz are not covered by the test profile specified here. In practice high amplitude can occur below 20 Hz; therefore, loads acting on the component under test in this frequency range shall be considered separately in the component Released Document.

Test Parameters and Requirements

Table 36 - Mechanical Vibration Class V4 Requirements

Vibration class	V4 – (Component / Device mounted on Wheel, Wheel suspension, Wheel Knuckle etc - on Unsprung Mass) Vibration with Thermal Cycling.			
Applicable Standard	ISO 16750-3, Test V – Passenger car, Unsprung masses IEC 60068-2-64, Test Fh, Vibration, broad-band random (digital control) and guidance			
Test Duration (Hours) / axis	33 or 44 hours for 150 000 or 200 000 design life respectively			
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.			
Operating Mode	OM3B (Table 19 & Section 5.1.2.2), Intermittent Operation			
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.			
Monitoring status	Continuous Monitoring required			
Test Parameters for Temperature				
Vibration (Random) profile shown in Figure **17** shall be used with Temperature Profile shown in Figure **10** (8 hour temperature profile cycle is repeated until end of the test)	**Breakpoint**	**Time (minutes)**	**Temperature (°C)**	**Operation**
	1	0	23	Not operating
	2	60	-40	Not operating
	3	135	-40	Operating
	4	150	-40	Operating
	5	210	23	Operating
	6	300	Tmax	Operating
	7	410	Tmax	Operating
	8	480	23	Operating
	9	720	23	Operating
Ramp rate of temperature profile	1 - 1.5 °C/min			
Temperature profile	Lower of the Tenv.max or Top.max for the component temperature class			
Test Parameters for Random Vibration				
Random Vibration profile for Class V4	**Frequency [Hz]**	**Power spectral density (PSD) [$(m/s^2)^2$/Hz]**	**Power spectral density (PSD) [G^2/Hz]**	
	20	200.00	2.08	
	40	200.00	2.08	
	300	0.50	0.005	
	800	0.50	0.005	
	1 000	3.00	0.031	
	2 000	3.00	0.031	
	RMS acceleration	107 m/s^2	10.94 G	
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. No damage/BSR, no functional or performance degradation, no undesired or intermittent operations shall be allowed. Part shall not have any signs of physical deformation, burn marks, etc.			

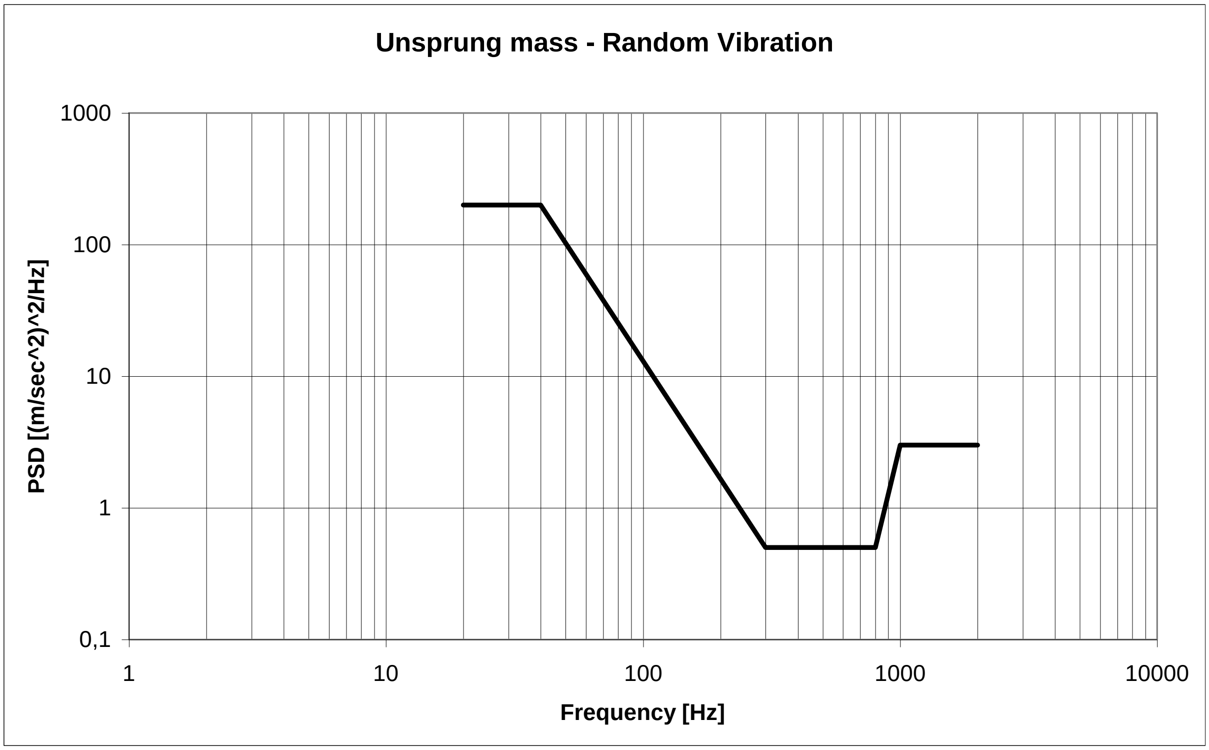


Figure 17 - Unsprung Mass – Random Vibration

5.4.4 Mechanical Shock

The Mechanical Shock test verifies the component's ability to withstand extreme mechanical stresses encountered when a moving vehicle encounters a curb or pot hole.

Scope:
The Mechanical shock test is mandatory for all EE components in all vehicle locations.

Test Parameters and Requirements

Table 37 - Mechanical Shock Requirements

Applicable Standard	IEC 60068-2-27:2008	
Test Duration (Hours)	24 hours (1 day) – Depends on cycles & set-up time	
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.	
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.	
	Test No. 1	**Test No. 2**
Operating Mode	OM1B (Table 19)	OM3B (Table 19)
Monitoring status	-	Continuous Monitoring required
	Test shall be required for all components.	Test shall be required only for components that are required to be operational during collisions (ex: ORC, Engine Controller, ABS/ESP)
Test Parameters		
a) Acceleration [m/s^2]	500	981
b) Duration of rated mechanical stress	6ms or 11ms (as agreed with FCA Engineering)	11ms
c) Shape of rated mechanical stress	Half sine	Half sine
d) Number of shocks per each direction (± X, ± Y, and ± Z)	10 (total 60)	3 (total 18)
e) Test temperature	RT	
Acceptance Criteria	Performs as designed functionally & performance wise during and after the test. No damage, no functional or performance degradation, undesired operation, intermittent operation observed. Part shall not have any signs of physical deformation, burn marks, etc.	

Test Procedure:

A. Define component in-vehicle mounting coordinates relative to the vehicle coordinates X (longitudinal), Y (transverse), and Z (vertical). Mount the component on the shock test equipment to simulate in-vehicle coordinates.
B. Apply half-sine pulse per each direction of ± X, ± Y, and ± Z at room temperature

5.4.5 Mechanical Shock Endurance

The Mechanical shock endurance test verifies the component's ability to withstand repetitive mechanical loads encountered in specific vehicle mounting locations such as doors, lift gates, and hoods. The number of shocks shall be determined from the Field Service Life in years, and the shocks/year multiplier for the component mounting location is as defined in the Section 1.4 Device classification.

Scope:
This test shall apply to electrical components mounted directly on doors, trunk lid, tailgates, or hood (installation class V3) and may also be applied to other components mounted adjacent to these areas that are likely to receive shock stresses (see Component Specific Performance Standard Specification).

Test Parameters and Requirements

Table 38 - Mechanical Shock Endurance Requirements	
Applicable Standard	IEC 60068-2-27:2008
Test Duration (Hours)	N/A
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM3B (Table 19 & Section 5.1.2.2), with Full Loads
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Monitoring status	Continuous Monitoring required
Test Parameters	
a) Acceleration [m/s^2]	400 m/s^2
b) Duration of Shock	6ms
c) Shape of Shock waveform	Half sine
d) Number of shocks	Per Section 1.4.11 (Table 14)
e) Test temperature	RT
Acceptance Criteria	Performs as designed during and after the test. Meets all functional requirements before & after the test. No damage/BSR, no functional or performance degradation, no undesired or intermittent operations shall be allowed. Part shall not have any signs of physical deformation, burn marks, etc.

Test Procedure:

A. Define component in-vehicle mounting coordinates relative to the vehicle coordinates X (longitudinal), Y (transverse), and Z (vertical). Mount the component on the shock test equipment to simulate in-vehicle coordinates.
B. Apply half-sine shocks to the amount as specified in the Table 38.

5.4.6 Handling Drop

This test duplicates a drop from table height to a hard concrete floor. This situation may occur during vehicle assembly or vehicle service operations. This test shall determine if an electrical component gets damaged visibly during handling or not. If it does not show any noticeable damage after the drop test then it shall conform to requirements provided it meets functional requirements.

Scope:
This test is mandatory for all electrical components/devices.

Test Parameters and Requirements

Table 39 - Handling Drop Requirements	
Applicable Standard	ISO 16750-3 Free Fall
Test Duration (Hours)	24 hours (1 Day)
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM1A (Table 19 & Section 5.1.2.2)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Number of drops per component	2 for each of the three samples, a different direction (±) to fall on (±X, ±Y, ±Z) shall be chosen
b) Drop height	1 m on to the concrete surface
c) Test temperature	RT
Acceptance Criteria	After each drop the sample shall be inspected. If it shows no obvious damage it is required that the sample is fully functional according the functional operational checks.

Test Procedure:
Drop the component from 1-m height to a concrete surface (some fragile components, such as, Instrument Cluster, Video Screen, etc. may be dropped from a lower height specified by product/design engineering group). The component shall be oriented prior to the release so that each component is released only twice - once in the positive and negative direction of its primary ± X, ± Y, and ± Z axes.

5.4.7 Mechanical Operation Durability Requirement

Mechanical/ electromechanical component/devices may fail open, closed, or with degraded operations by wear & tear, corrosion, and debris build up. e.g. In case of a switch this can cause the resistance of the contacts to increase, voltage drop between contacts to increase or cause intermittent / erratic operation. Usage over life of vehicle can also cause the lettering/labels to wear off.

This test is to ensure functional/parametric checks are within limits after the wear & tear testing of a mechanical component including switches over the vehicle service life. This test shall also verify the abrasion resistance of labels and inscription on switch surfaces to human interface along with mechanical component functionality through the useful life. The test setup and the number of life cycles for the component/device should replicate the 95th percentile customer usage over the vehicle service life. The number of life cycles depends on the component functions and will generally be different for different functions.

Scope:
This test shall be mandatory for all switches/integrated switches and mechanical components having human interaction during vehicle use.

Test Parameters and Requirements

<table>
<tr><th colspan="4">Table 40 - Mechanical Operation Durability Requirements</th></tr>
<tr><td>Applicable Standard</td><td colspan="3">IEC 60068-2-70 “Abrasion of markings and letterings caused by rubbing of fingers and hands”. For components with mechanical duty cycles, a mechanical operating durability cycles and test procedures shall be defined in the component specific document</td></tr>
<tr><td>Test Duration (Hours)</td><td colspan="3">Based on number of life cycles.(Duty cycles for 95% customer)</td></tr>
<tr><td>Sample size</td><td colspan="3">As per Test Flow in Annex B, Figure B-1 or Figure B-2.</td></tr>
<tr><td>Operating Mode</td><td colspan="3">OM3B (Table 19 & Section 5.1.2.2), with Full Loads</td></tr>
<tr><td>DUT Power and Orientation / Loads</td><td colspan="3">DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.</td></tr>
<tr><td>Monitoring status</td><td colspan="3">Continuous Monitoring required</td></tr>
<tr><td colspan="4">Test Parameters</td></tr>
<tr><td>Number of life cycles</td><td colspan="3">As defined in the Component Specific Performance Standard</td></tr>
<tr><td>Types of activation</td><td colspan="3">As defined in the Component Specific Performance Standard</td></tr>
<tr><td>Actuation force</td><td colspan="3">As defined in the Component Specific Performance Standard</td></tr>
<tr><td>Actuation force direction</td><td colspan="3">As defined in the Component Specific Performance Standard</td></tr>
<tr><td>Cycle rate/cycle frequency</td><td colspan="3">As defined in the Component Specific Performance Standard</td></tr>
<tr><td>Test liquid</td><td colspan="3">Test liquids requirements shall be as specified in the Component Specific Performance Standard.</td></tr>
<tr><td rowspan="11">Test chamber temperatures
(NOTE: Humidity shall be uncontrolled throughout the test)</td><td colspan="3">Thermal cycle according to
Figure 18 (Top.min, RT and Top.max) and the following temperature breakpoints.</td></tr>
<tr><td>Breakpoint</td><td>Time
(hours)</td><td>Temperature
(°C)</td></tr>
<tr><td>1</td><td>0</td><td>RT</td></tr>
<tr><td>2</td><td>2</td><td>RT</td></tr>
<tr><td>3</td><td>2.5</td><td>Top.min</td></tr>
<tr><td>4</td><td>3.5</td><td>Top.min</td></tr>
<tr><td>5</td><td>4</td><td>RT</td></tr>
<tr><td>6</td><td>6</td><td>RT</td></tr>
<tr><td>7</td><td>6.5</td><td>Top.max</td></tr>
<tr><td>8</td><td>7.5</td><td>Top.max</td></tr>
<tr><td>9</td><td>8</td><td>RT</td></tr>
<tr><td>Acceptance Criteria</td><td colspan="3">Performs as designed during and after the test. This shall include measurements of displacement (travel) versus force (load) and of the contact resistance. No mechanical damage, no functional or performance degradation, undesired operation, intermittent operation. Part shall not have any signs of physical deformation, burn marks, etc.</td></tr>
</table>

Test Procedure:

A. Place component/switch in the temperature chamber. Cycle the chamber through the temperature profile shown in
B. Figure **18**.
C. Operate component functions with continuous monitoring for the specified number of cycles defined for Life test. If the component is a switch operate the switch for specified number of switching cycles using mechanical test finger (size 2 according to IEC 60068-2-70) while applying test liquid if specified in the Component Specific Performance Standard. Comply with IEC 60068-2-70 "Environmental testing- Abrasion of marking and lettering due to rubbing of fingers/ hands" for additional information and test procedure details.
D. During the test, 50% of the life cycles shall be performed at RT, 25% of the life cycles shall be performed at higher of Tmin or Top.min (including transition time) and 25% of the life cycles shall be performed at lower of Tenv.max or Top.max (including transition time).

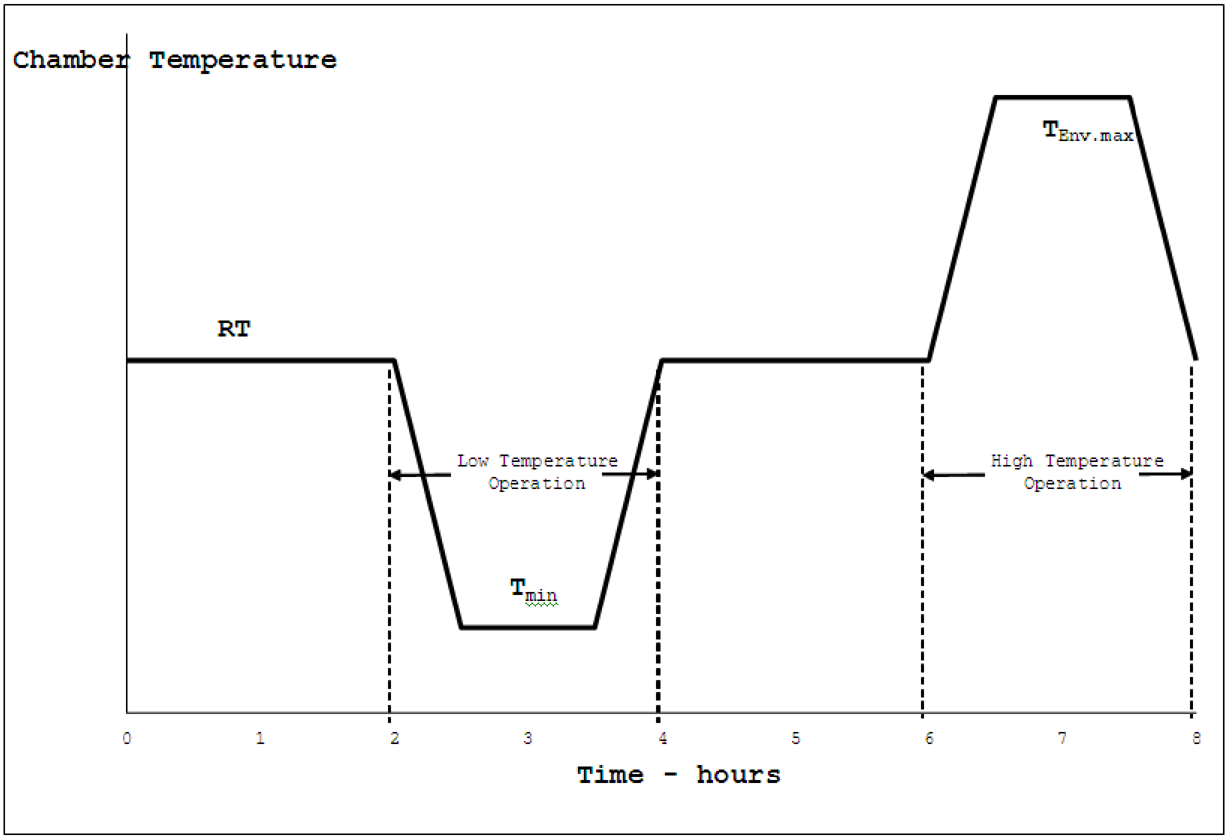


Figure 18 - Mechanical Operation / Abrasion Durability Cycle Profile

5.4.8 Gravel Bombardment

The Gravel Bombardment test is mandatory for exterior, underbody, and underhood electronic components which may be exposed to stone and gravel impacts during vehicle operation.

Scope:
This test applies to underhood, underbody, and exterior electrical components that are exposed to impact from gravel.

Test Procedure and Requirements

Table 41 - Gravel Bombardment Requirements	
Applicable Standard	SAE-J-400 – Resistance of surface coats to chipping caused by gravel impact, Method C. The test will be conducted at RT unless temperature has a significant impact on test results.
Test Duration (Hours)	As required by SAE-J-400 Method C.
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM1A (Table 19 & Section 5.1.2.2), non-operational
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
e) Test Temperature	RT
Acceptance Criteria	Performs as designed during and after the test. The component housing, fasteners, and electrical connections that display minor cosmetic surface damage are acceptable. No functional or performance degradation, undesired operation, intermittent operation or significant physical damage.

Test Procedure:
Test in accordance with SAE-J-400 Method C.

5.5 Solid / Fluid Intrusion

This category includes tests to demonstrate component compatibility to solids and fluids that the component may encounter in the vehicle environment such as water, dust, mud etc.

As part of vehicle level corrosion validation, FCA program vehicles will be subjected to CS.00081 and 7.G2051 tests. All electronic and electrical components (ECUs, Modules, Sensors, Electro-Mechanical devices, Switches, Connectors, Wiring, etc.) shall be verified for acceptable appearance with no functionality or fault-code issues after completion of CS.00081 and 7.G2051.

5.5.1 Dust Intrusion

The Dust Intrusion shall apply to electronic components when the dust intrusion during vehicle operation can degrade the component or its function. The level of protection depends on the component design and the vehicle mounting location. The solid protection class range include: no protection (0), dust protection (5K), and dust proof (6K).

IP (International Protection) codes identify the degree of protection provided by housings against solid and liquid intrusion. The solid and liquid protection categories are defined in Section 1.4.10 (Table 12 and Table 13).

Scope:

This test applies to all electrical components/devices and categorized in IP protection classes IP0X, IP5KX or IP6KX.

Test Parameters and Requirements

Table 42 - Dust Intrusion Requirements	
Applicable Standard	ISO 20653 for IP Classifications and test procedures.
Test Duration (Hours)	24 (1 day)
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM1B (Table 19), non-operational for 10 dust cycles and OM3B (Table 19), operational for 10 dust cycles (Total 20 dust cycles)
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Test Temperature	RT
b) IP Class for Dust	As per Section 1.4.10 (Table 12)
Acceptance Criteria	Performs as designed before & after the test. No functional or performance degradation, undesired operation, intermittent operation. Part shall not have any signs of dendrite growth, physical deformation, burn marks, etc.

Test Procedure:

A. Test in accordance with ISO 20653 (section 8.3.3.2.a) - 6 sec air blowing followed by 15 min of dust settling.
B. Repeat the air blowing and settling cycle for total 20 times using air pressure as specified in IEC 60068-2-68.
C. Clean the component (DUT) by dusting off with dry cloth (not wiping) and check module functionality at RT under tri-voltage conditions (3-point check per Table 23).

Further validation using different particle size may be needed depending on components and applications. This will be detailed in individual component specification.

5.5.2 Mud Resistance

This test is to verify that the component ability to dissipate heat is not affected so much that it impairs the functionality when covered by mud. This test will verify that the component can still function & dissipate heat while covered by mud.

Scope:
This test applies to all electrical under hood, underbody, and exterior components that may get covered with mud in off road applications.

Test Parameters and Requirements

Table 43 - Mud Resistance Requirements	
Applicable Standard	N/A
Test Duration (Hours)	66 hours (2 cycles of 33 hours each approximately)
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM3B (Table 19 & Section 5.1.2.2), Maximum loads
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Test Temperature	RT and Tenv.max
b) Mud mixture	Mix Arizona dust (as per ISO 12103-1) and water in a “2.7:1" ratio by volume
Acceptance Criteria	Performs as designed before & after the test. No functional or performance degradation, undesired operation, intermittent operation. Part shall not have any signs of dendrite growth, physical deformation, burn marks, etc.

Test Procedure:

A. Parametrically test the Component prior to the Mud test and record temperature via thermocouples.
B. Mix the necessary amount of Arizona dust and tap water in a “2.7:1" ratio by volume until the mixture is uniform and visibly free of clumps.
C. Submerge the component with the appropriate connector and wire harness in the mud bath until covered just below (10 mm) the connector/module interface for 5 seconds. If the mud bath has been undisturbed for more than 1 hour, it should be probed to ensure that there are no clumps in the mixture. Additional stirring may be required to break up clumps before submerging the DUT.
D. Remove the component from the mud bath. Position it according to its in-vehicle orientation and place it in an environmental chamber at room temperature. Ramp up to Tenv.max in 30 minutes and operate the component intermittently (cycle of 10 min operational followed by 10 min of non-operational sequence) and record temperatures via thermocouples for a period of 8 hours soak at Tenv. max. Return to room temperature within 30 minutes and stay for at least 16 hours in the in-vehicle position. Operate the component intermittently (cycle of 10 min operational followed by 10 min of non-operational sequence) and record temperatures via thermocouples when chamber is at room temperature.
E. Ramp up to Tenv.max in 30 minutes; operate the component continuously for next 3.5 hours with chamber at Tenv.max and record temperatures via thermocouples.
F. Ramp down chamber to room temperature in next 30 minutes, operate the component continuously for next 3.5 hours with chamber at RT and record temperatures via thermocouples. Clean the component with tap water, air dry the DUT, and parametrically test the component.
G. Repeat steps C through F one more time.

5.5.3 Water or Steam Intrusion

The purpose is to determine if the component housing provides sufficient protection against water intrusion. The degree of protection necessary varies by the vehicle location.
An inert UV dye shall be added to the water for assessing water ingress.

Scope:
This test applies to electrical components categorized in IP protection classes IPX1 thru IPX9K as defined in Table 12. The degrees of protection ranges from no protection (code IPX0) to high pressure steam jet cleaning (IPX9K). The engineer must specify the degree of protection required for the component in the vehicle mounting location as defined in Section 1.4.10 (Table 12).

Test Parameters and Requirements

Table 44 - Water or Steam Intrusion Requirements

Applicable Standard	ISO 20653 for IP Classifications and test procedures.
Test Duration (Hours)	1 day
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM1B (Table 19), non-operational and OM3B (Table 19) operational for 50% test duration each.
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Test Parameters	
a) Test Temperature	RT
b) IP Class for Water Intrusion	Section 1.4.10 (Table 12 and Table 13)
Acceptance Criteria	Performs as designed before & after the test. No functional or performance degradation, undesired operation, intermittent operation. Part shall not have any signs of dendrite growth, physical deformation, burn marks, etc.

Test Procedure:
Test procedure as per ISO 20653 for the applicable protection class.

5.5.4 Salt Water Immersion

This test simulates the immersion of components when a vehicle passes through or stops in water puddles. Leaks can occur across seals or through connector pins.

The test is accelerated by soaking the component in air at Tmax prior to immersion into 0 °C salt water with an inert UV dye. The temperature change may create partial vacuum conditions within the component allowing water to be drawn in through gaps. Using salt water shorts electrical components, allowing a leak to be detected.

Please note that environmental friendly biodegradable UV dyes are currently available.

Scope:
The test is mandatory for electronic components that are mounted below the vehicle specific water fording limit and may be temporarily immersed in water during the life of the vehicle. For passenger car (sedans), the water fording level is 300mm, 500mm (off - road), and 760mm (for extreme off-road applications, such as, Jeeps).

Test Parameters and Requirements

Table 45 - Salt Water Immersion Requirements	
Applicable Standard	N/A
Test Duration (Hours)	3 Days Approx.
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM1B (DUT is connected to wiring harness, but no voltage is applied; ex: Passive Entry Module) or OM3B (Intermittent Operation with maximum loads; ex: Powertrain sensors) - (Table 19 & Section 5.1.2.2) – Device specification to specify operating mode.
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Monitoring status	Continuous Monitoring required during operational mode.
Test Parameters	
Number of cycles	20 cycles
Test Temperature	Tenv.max, if Tenv.max is less than 110°C, otherwise 110°C
Soak Time	Per Table 10
Salt water solution	5% ± 1% by weight
Salt water solution temperature	0°C
Immersion time	5 minutes (Immersion depth, at least 1 inch (25.4 mm) below water surface and includes module connector if the connector is located in the same packaging area as the module)
Acceptance Criteria	Performs as designed before and after the test. No sign of water entry in the module or seal damage, no functional or performance degradation, undesired operation, intermittent operation. Part shall not have any signs of corrosion, physical deformation, burn marks, etc.

Test Procedure:

A. Place component with connector and wiring harness in a temperature chamber and pre-heat components to applicable maximum test temperature.
B. Keep the component at maximum test temperature for the specified component soak time.
C. Remove the component from the chamber, and immerse the component within 30 seconds in salt water with an inert UV dye. The component shall be at least 1 inch (25.4 mm) below the surface of the water.
D. Operate the component at 0 °C while submerged in salt water for 5 minutes with continuous monitoring (for operating mode OM3B); for operating mode OM1B, component is left in submerged water for 5 minutes in non-operational state.
E. Dry the part using air blower and check for functionality at RT.
F. Repeat steps A through E for total of 20 cycles.

5.5.5 Salt Fog

This test simulates costal conditions where fine droplets of salt water are suspended in air. Unsealed electronic components and connectors may be corroded by the suspended salt water droplets. The salt fog test for components located in the cabin or trunk is 24 hours. For under hood or engine compartment, component shall go through 96 hours of Salt Fog test and for exterior, for the wheel or underbody location, the salt fog test duration will be 168 hours.

For devices mounted inside the cabin or trunk the test may be performed considering actual vehicle configuration. FCA Engineering and QRE approval is required to use appropriate trim, covers or shielding during the salt fog test to avoid salt water solution from dripping into a normally covered module.

Scope:
This test applies to all E/E Components.

Test Parameters and Requirements

Table 46 - Salt Fog Requirements	
Applicable Standard	IEC 60068-2-11
Test Duration (Hours)	24 hours for passenger cabin, trunk or door; 96 hours for underhood, or engine compartment; 168 hours for underbody, exterior, wheel locations
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.
Operating Mode	OM2B / OM3B (Table 19 & Section 5.1.2.2), Intermittent Operation as defined in component specification and Section 5.1.3.6 – Typical module operating mode sequence can be 5 to 15 min Operational and 55 to 45 min non-operation during one hour of the test repeated until end of the test.
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Monitoring status	Continuous Monitoring required during operational mode
Test Parameters	
Test Temperature	35°C
Salt water solution	5% ± 1% by weight
Acceptance Criteria	Functional performance as per design intent – before, during & after the test. No function or performance degradation, or undesired or intermittent operation shall be considered as failure. Part shall not have any signs of corrosion, physical deformation, burn marks, etc.

Test Procedure:

A. Place component with mating connectors in the test chamber.
B. Subject component to salt fog atmosphere according to IEC 60068-2-11 while operating the component with continuous monitoring for the test duration as defined in component specification and Section 5.1.3.6.

5.6 Chemical Resistance

This category includes tests to demonstrate component resistance to corrosive effects of gaseous pollutants and accidental fluid spills.

5.6.1 Mixed Flowing Gas

This is an accelerated test to simulate the effects of atmospheric pollutants, corrosive gases on electronics. To accelerate the test, the gases are much more concentrated than seen in field conditions.

Scope:
This test shall apply to all components which are exposed to air (e. g: Power-train sensors or ECUs packaged / operated in the transmission chambers). The test shall not apply to components packaged in the passenger cabin, doors or trunk location.

Test Parameters and Requirements.

Table 47 - Mixed Flowing Gas Requirements		
Applicable Standard	IEC 60068-2-60	
Test Duration (Hours)	14 days	
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2.	
Operating Mode	OM1A (Table 19 & Section 5.1.2.2), non-operational	
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.	
Test Parameters		
Test Temperature	RT	
Relative humidity	75%	
Composition of test gases (NOTE1)	Hydrogen sulfide (H_2S)	10 ppb
	Sulfur dioxide (SO_2)	200 ppb
	Chlorine (Cl_2)	10 ppb
	Nitrogen dioxide (NO_2)	200 ppb
Acceptance Criteria	Performs as designed before & after the test. No functional or performance degradation, undesired operation, intermittent operation. Part shall not have any signs of corrosion, physical deformation, burn marks, etc.	
NOTE 1: ppb = parts per billion (1 in 10^9) volume of contaminants per volume (vol/vol) of air.		

Test Procedure:

A. Follow all the necessary safety procedures (OSHA/ EPA guidelines in USA or equivalent safety agency guidelines in other countries).
B. Place component with mating connector in a test chamber and subject it to mixed flowing gas environment according to IEC 60068-2-60 & parameters per Method 4 and Test procedure 2.

5.6.2 Chemical Exposure

The fluids selected for the test shall be fluids that the component may encounter during the vehicle service life. Supplier and FCA Release Engineering team shall select applicable fluids from the list of fluid given in Annex C. For any reasons, if any particular chemical/ fluid is not listed, this team shall identify these additional liquids before start of testing in the component DVP. These fluids should be distributed among the samples to be tested based on fluid compatibility as shown in Table 49.

Scope:
This Chemical Exposure test is mandatory for all E/E Components.

Test Parameters and Requirements

Complete list of chemicals and application methods is given in the Annex C.

Table 48 - Chemical Exposure Requirements	
Applicable Standard	ISO 16750-5 with FCA Thermal Cycle.
Test Duration (Hours)	24 hours per Fluid application
Sample size	As per Test Flow in Annex B, Figure B-1 or Figure B-2. Maximum fluid application per sample shall not exceed 5 based on fluid compatibility.
Operating Mode	OM2A/ OM3A (Table 19 & Section 5.1.2.2), Non-operational with mating connectors with power to simulate parking situation
DUT Power and Orientation / Loads	DUT powered conditions and burn-in per section 5.1.2.2 and 5.1.2.4. Device & connector orientation and electrical loads shall be per section 5.1.3.1, 5.1.3.2 and 5.1.3.3.
Monitoring status	Continuous Monitoring required during operational mode
Test Parameters	
Test Temperature	As per Figure **19**.
Dwell time at storage temperature	4 hours + 12 hours = 16 hours per cycle (refer to Figure **19**)
Amount of test fluid/chemical	100 ml - Cleaning fluids shall be applied by spraying or using a brush, while bulk liquids shall be applied by pouring/ spilling
Acceptance Criteria	Performs as designed before & after the test. No functional or performance degradation, undesired operation, intermittent operation Part shall not have any signs of corrosion, physical deformation, burn marks, etc.

Test Procedure (Refer to
Figure **19**):
Follow all the necessary safety procedures (OSHA/ EPA guidelines in USA or equivalent safety agency guidelines in other countries).

1. Place component in a temperature chamber maintained at 40 °C on a test fixture representative of in-vehicle position with any protective surrounding structures.
2. Keep the component at 40°C for one hour (a to b). Remove component from the chamber and apply 100 ml of test fluid/chemical by either spraying or pouring to cover all faces of component. Store component at RT for 1 hour (b to c). (NOTE 1)
3. Replace the component in the chamber and keep it at 40 °C for one hour (c to d). Then ramp up the chamber temperature to 70 °C (60 °C if battery acid is used) within 30 min (d to e) and keep the component at that temperature for 4 hours (dwell time - e to f). Ramp down the chamber temperature to 40 °C within 30 min (f to g).
4. Repeat steps 2 and 3 for the same fluid, but prolong dwell time from 4 hours to 12 hours at 70 °C (60 °C if battery acid is used, k to l).
5. Repeat step 2, 3 and 4 for the next fluid in the set. Continue the process for each fluid as specified in the Component Specific Performance Standard

NOTE 1:

A. Spraying of Chemicals (see Annex C). Distance – 6” to 8” pointing nozzle directly at DUT Amount – 10 sprays from a commercial Spray Bottle. Timing – 10 seconds between sprays.

B. Brushing of Chemicals. Amount – 10 brushes (dipped & saturated with liquid). Timing – 10 seconds between brushings. Loading means dipping the brush into the chemical before and between brushes.

C. Splashing of Chemicals (see items listed as "Pour" in Annex C of this document - Simulating an accident with a drinking cup). Amount – 100ml. Distance – 6” to 10”. There should be no liquid left in the cup.

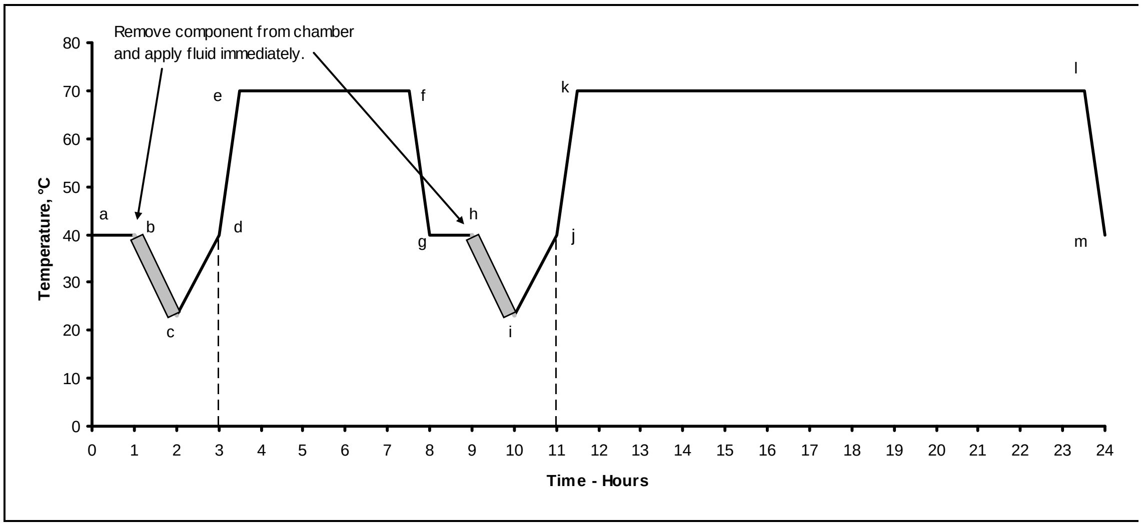


Figure 19 - Temperature Profile (Chemical Exposure Test)

Table 49 - Chemical Exposure – Fluid Distribution					
Fluid/ Chemical Name (Select Applicable Chemical from Annex **C)**	**Test Samples(NOTE 1)**				
	# 1	# 2	# 3	# 4	# 5
Fluid/ Chemical 1	X		X		
Fluid/ Chemical 2		X			X
Fluid/ Chemical 3	X			X	
Fluid/ Chemical 4			X		
Fluid/ Chemical 5	X				X
Fluid/ Chemical 6		X			
Fluid/ Chemical 7				X	
Fluid/ Chemical 8			X		X
Fluid/ Chemical 9			X		
Fluid/ Chemical 10	X			X	
Fluid/ Chemical 11		X			X
Fluid/ Chemical 12		X		X	
Fluid/ Chemical 13	X		X		
Fluid/ Chemical 14					X
Fluid/ Chemical 15		X		X	
NOTE 1: Application of fluids/ chemicals can be in any random order but not exceeding five chemicals per sample.					

6 APPROVED SOURCE LIST

Not Applicable.

Annex A
(Informative)
Accelerated Testing Models and Examples

This annex provides accelerated test models that are applied to determine the appropriate test duration of the following three tests:

- High Temperature Operating Endurance (HTOE) test
- High Temperature and humidity Endurance (HTHE) test
- Powered Thermal Cycle Endurance (PTCE) test

The Arrhenius Model is used to model HTOE test for temperature activated failure mechanisms, the Lawson Model is used to model HTHE test for humidity enhanced corrosion failure mechanisms and the Coffin-Manson Model is used to model PTCE test for thermo mechanical fatigue related failure mechanisms. For further information on the three models, please refer to the technical references provided with model description.

NOTE: Test durations specified in the examples of these acceleration models is for reference only and cannot be used to modify test cycles or durations without written approval from FCA Quality Reliability Engineering.

A-1 Arrhenius Model

The Arrhenius model is used to describe the kinetics of many chemical and molecular phenomena. Many failure modes are caused by mechanisms that operate at the molecular level. These failure mechanisms include electro-migration, diffusion, oxidation, ionic contamination, dielectric breakdown, and surface charge accumulation in silicon oxides, electrolytic corrosion, chemical and galvanic corrosion, aluminum penetration in silicon, and others. Other failure mechanism operates at a macro level and includes solder plastic creep, crack propagation in many materials, drying of electrolytic capacitors, and others.

The model shall be used to accelerate the High Temperature Operating Endurance Test and Example using the Model is as shown below:

The mathematical relationship is:

$$R = C * e^{-E_a / k*T}$$

Where:

- R = the reaction rate
- C = empherical constant
- Ea = empherical activation energy = 0.7 eV/K (Assumed)
- k = Boltzmann constant = 8.617 x 10-5 eV/K)
- T = the (absolute) temperature in °K (degrees Kelvin)

Each failure mechanism has unique activation energy, Ea. Activation energy values for different failure mechanisms are defined in Table A-1:

Table A-1 - Failure Mechanism and Activation Energy Constant (eV)	
Failure Mechanism	E_a [eV]
Dielectric breakdown	0.3 to 0.6
Diffusion failures	0.5
Corrosion - electrolysis	0.3 to 0.6
Corrosion - chemical and galvanic	0.6 to 0.7
Electro-migration	0.5 to 1.2
Charge loss (MOS/EPROM)	0.8
Ionic contamination	1.0
Surface charge accumulation in silicon oxide	1.0 to 1.05
Aluminum penetration into silicon	1.4 to 1.6

The activation energy value is assumed to be, EA = 0.7 eV to calculate the test duration for HTOE test of E/E components. The higher the activation energy, the shorter the test time required. Consequently, all failure mechanisms with activation energies greater than or equal to 0.7 eV is covered by HTOE test. For special and/or new technologies it may be necessary to adopt the activation energy to ensure coverage of the complete Service Life in Field.

The Arrhenius model also describes the life of electronic components at constant temperatures when failures are caused by these molecular mechanisms. A test acceleration factor describes the ratio of field usage time to test time with equivalent damage. When combined with the Arrhenius equation, the following equation results:

$$AF_T = e^{-\frac{E_a}{k}\left[\frac{1}{T_a}-\frac{1}{T_s}\right]}$$

Where:

- AFT = Test Acceleration Factor = Usage Time / Test Time
- Ta = Accelerated test temperature in °K
- Ts = Field service temperature in °K

The temperature during component operating time is not constant during the Field Service Life. The temperature profiles, for different component mounting locations, are defined in Table 6 - Thermal Profile Distribution Based on Default Tmax Values. Each profile is a series of temperatures and corresponding percentage distributions. This information allows the acceleration factor and test time to be calculated for every temperature using the Arrhenius model. The total test duration for HTOE test is calculated using:

$$t_{HTOE} = t_{op.time} \sum_i \frac{p_i}{A_{T,i}}$$

Where:

- t_{HTOE} is the time required for the HTOE test.
- top.time is the component operating time during the vehicle service life in the field.
- pi is the per cent of the time that a component is operating at Ti.
- AT,i is the acceleration factor for the test temperature and the field temperature.

The HTOE test is accelerated by using the maximum possible operating temperature. The default test temperature is the maximum environmental temperature, Tenv.max. For some components, the maximum operating temperature Tmax is less than Tenv.max. Testing at Tmax < Tenv.max, increases the test time since there is less test acceleration. For other components where Tmax > Tenv.max, there is an opportunity to decrease test time by accelerated testing at Tmax.

The $t_{op.time}$ needs to be evaluated for each component. Some electronic components are operated only when the engine is operating. In this case, use the operating time defined in Table 1. In other cases, a component is operating, in a low power wait mode. Some examples would include WIN modules, RKE modules and anti-theft modules. Other devices are not provided any voltage until their use is required. Some examples include rear window defrosters, lights, and motors. Care must be takes in determining the top.time for each component. Each behavior mode or usage condition should be considered.

A calculation example of HTOE test time is shown below

Calculate the HTOE test duration for an Occupant Restraint Controller - ORC Module (Passive Safety application) with a Service Life of 15 years / 150 000 miles. For the given service life criteria, the 95% customer operates the vehicle for 12 000 hours as given in Table 1. Assuming the HTOE test is conducted at Tmax = 85 °C, how much time is required?

Start with a temperature profile as given in the Temperature Profile and Distribution for class TC1 passenger cabin for ORC module..

1. The temperatures are converted from Celsius to the Kelvin absolute temperature scale.
2. Using the distribution, the operating time at different temperatures is calculated.
3. For each temperature, an acceleration factor, AFT, is calculated using the Arrhenius equation.
4. The equivalent test time at Tmax is calculated by dividing the time at each temperature by the acceleration factor for each temperature.
5. The total test time required is the sum of the individual test times.

The result is captured in a table.

Table A-2 : Thermal Profile and % Distribution

Temperatures for Class TC1		Distribution	Operating Time in 12 000 Hours	AFT	Equivalent Test Time @ 85°C
-40°C	233.15°K	6%	720	193 577	0.004 hr
23°C	296.15°K	65%	7 800	115.9	67 hr
60°C	333.15°K	20%	2 400	5.49	437 hr
80°C	353.15°K	8%	960	1.38	696 hr
85°C	358.15°K	1%	120	1	120 hr
				Total	1 320 hr

For simplicity sake, the HTOE test duration shall be 1 300 hours for Powertrain/ Safety applications and 950 hours for other applications as shown in the test flow sequence in Figure B-1.

A-2 Coffin-Manson Model

The Coffin-Mason Model is used to describe fatigue life of materials under shear strain. The model shall be used to accelerate the Powered Thermal Cycle Test and an example using the Model is as shown below

The corresponding acceleration factor (taken from the reference, Failure Modes and Mechanisms in Electronic Packages, P. Viswanadham and P. Singh, Chapman & Hall, New York, 1998) is:

The original equation was:

$$N_f = A * \left[\frac{1}{(Shear\_Strain)^2} \right]$$

Where:

- Nf is the number of shear cycles to failure.
- A is an empherical constant.

Here, the exponent value of 2 indicates the damage that occurs with strain is non-linear. This implies that the many low level shear events may be ignored and emphasis should be placed on understanding the few high shear events. When materials with different CTE's experience temperature changes, the shear strain is proportional to the temperature change, ∆T. Again, larger ∆T events are more significant than the smaller ∆T events for electronic components and can be generalized as shown below:

$$N_f = \frac{A}{(\Delta T)^C}$$

Where the constant C is approximately 2 for solder materials (lead-free as well as lead solders).

This equation can be used to design accelerated thermal cycling tests with produce equivalent shear fatigue damage to solder joints. The relationship is:

$$AF = \frac{N_a}{N_f} = \left(\frac{\Delta T_f}{\Delta T_a} \right)^C$$

Where:

- AF is the test acceleration factor
- Na is the number of cycles required for an accelerated test temperature range ∆Ta=TH-TL.
- Nf is the number of cycles experienced during the service life with usage temperature range ∆Tf.

Typical ∆Tf values for different vehicle locations are defined in Table 7. Since the actual value may be different depending on the vehicle design and internal component heating, it is recommended that the engineer validate the actual amount of thermal delta.

The number of thermal cycles, Nf, is based on 2 major trips/day or 10 950 cycles for 15 years / 150 000 miles. Refer to Table 1 for Thermal Cycles for a given design/ service life.

The PTCE test is an accelerated thermal cycling test designed for the maximum acceleration. To determine the total test time, the number of thermal cycles, Na , multiplied by the duration of each cycle. The cycle is determined by using

- the test chamber ramp rate = 4°C/ minute
- soak times at TL and TH per Table 10
- TL = -40°C.
- TH = maximum (Tenv.max, Tmax)

Calculation of PTCE and TS test cycles

For an ECU categorized in temperature class TC1 and having a Service Life in Field of 10 years, the number of temperature cycles for PTCE and TS tests are calculated as shown below:

1. The Number of Temperature Cycles during the Service Life is Nf = 8200 cycles (see Table 1).
2. Since the component belongs to temperature class TC1, the (typical) Average Temperature Delta in field is ΔTfield = 34°C (see Table 9).
3. From TH = 85°C and TL = -40°C, the Temperature Delta during a test cycles is ΔTf = 125°C.
4. The total number of test cycles for PTCE and TS test cycles are:

$$N_a = 8\,200 \quad cycles * \left(\frac{34}{125}\right)^2 = 607 \quad cycles$$

For simplicity sake, the PTCE and TS cycles shall be 1 000 for Powertrain/ Passive Safety applications and 600 cycles for other applications (half of these cycles would be PTCE and other half TS) as shown in the test flow sequence in Figure B-1 and Figure B2.

A-3 Lawson Model

The Lawson Model describes the effects of temperature and humidity on the failure life of electronic components. The model shall be used to accelerate the High Temperature & High Humidity Cycle Test and Example using the Model is as shown below:

The equation which defines the acceleration factor due to the combined effects of high temperature and relative humidity through the following equation (taken from the reference, Microelectronic Reliability, Volume II: Integrity Assessment and Assurance, edited by E. Pollino, Artech House Publishers, ISBN 0-890-06350-8, 1989) is:

$$AF_T = e^{\left[-\frac{E_a}{k}\left(\frac{1}{T_a} - \frac{1}{T_f}\right)\right]}$$

Where:
- AFT = The temperature acceleration factor.
- EA = Activation energy (EA = 0.47 eV)
- k = Boltzmann constant (k = 8.617 x 10^{-5} eV/°K)
- Ta = The temperature of the accelerated test.
- Tf =The field temperature condition.
- T = Absolute Kelvin temperature (°K)

$$AF_{RH} = e^{b\left[RH_a^2 - RH_f^2\right]}$$

Where:

- AFH = The humidity acceleration factor.
- b = Constant (b = 5.57 x 10^{-4})
- RH = Relative Humidity measured as %
- RHa = The humidity during the accelerated test.
- RHf =The field humidity condition.

$$AF_{T,RH} = AF_T * AF_{RH}$$

Where,

- A_T,R_H = The combined acceleration factor of the Lawson Model which is the product of the temperature and humidity acceleration factors.

This yields the Lawson model equation:

$$AF_{T,RH} = e^{\left[-\left(\frac{E_A}{k}\right)\cdot\left(\frac{1}{T_a}-\frac{1}{T_f}\right)\right]+b\cdot\left[(RH_a)^2-(RH_f)^2\right]}$$

Activation Energy values used for Lawson and Arrhenius models are different, since, each of these models describes completely different failure mechanisms.

The total test duration for HTHE test is calculated by

$$t_{HTHE} = \frac{t_{non-op.time}}{A_{T,RH}}$$

Where:

- t_{HTHE} = Test duration required for HTHE test
- $t_{non\text{-}op.time}$ = Non-Operating Time during Service Life in Field
- $A_{T,RH}$ = Combined acceleration factor of the Lawson Model

Different temperatures, relative humidity level, and test duration may be used if non-electronic failure modes which do not occur in the field are seen at 85°C and 85% RH. Contact the EE Core or Powertrain EE reliability engineer for assistance.

NOTE: The worst case situation is the 5% usage customer for operating time in service. This maximizes the non-operating time.

Calculation of HTHE test duration
For an ECU located in the under-hood compartment and having a Service Life in Field of 15 years / 150 000 miles, the test duration of HTHE test is calculated as shown below:

Since the component is mounted "outside passenger cabin or trunk", the Average Temperature during Non-Operating Time is T_f = 23°C / 296°K and the Average Relative Humidity is R_{Hf} = 65% (see Table 8).

The test conditions for HTHE-test are T_a = 85°C / 358°K and R_{Ha} = 85%. The combined acceleration factor of the Lawson model of $AF_{T,RH}$ = 129.3 is calculated as,

$$AF_T = e^{\left[-\frac{E_a}{k}\left(\frac{1}{T_a}-\frac{1}{T_f}\right)\right]} = 23.32$$

$$AF_{RH} = e^{b\left[RH_a^2 - RH_f^2\right]} = 5.32$$

$$AF_{T,RH} = A_T * A_{RH} = 129.3$$

The non-operating (5th percentile) time during 15 years/ 150 000 miles Service Life in Field is 129 000 hours, from Table 1. The total test duration for HTHE test is calculated by dividing this non-operating Time by the combined acceleration factor of the Lawson model $AF_{T,RH}$ = 123.9:

$$t_{HTHE} = \frac{129\,000\ \text{hour}}{129.3} = 998\ \text{hours}$$

For simplicity sake, the HTHE duration (hours) shall be 1 000 for Powertrain/ Safety applications and 700 hours for other applications as shown in the test flow sequence in Figure B-1 and B-2.
The HTHE test shall be carried out at 85°C/85%RH. In case of known technological limitation of the device, upon written agreement, the test may be carried out under different temperature and humidity conditions as specified in Table A-3.

Table A-3 - HTHE Durations Under Different Temperature & Humidity

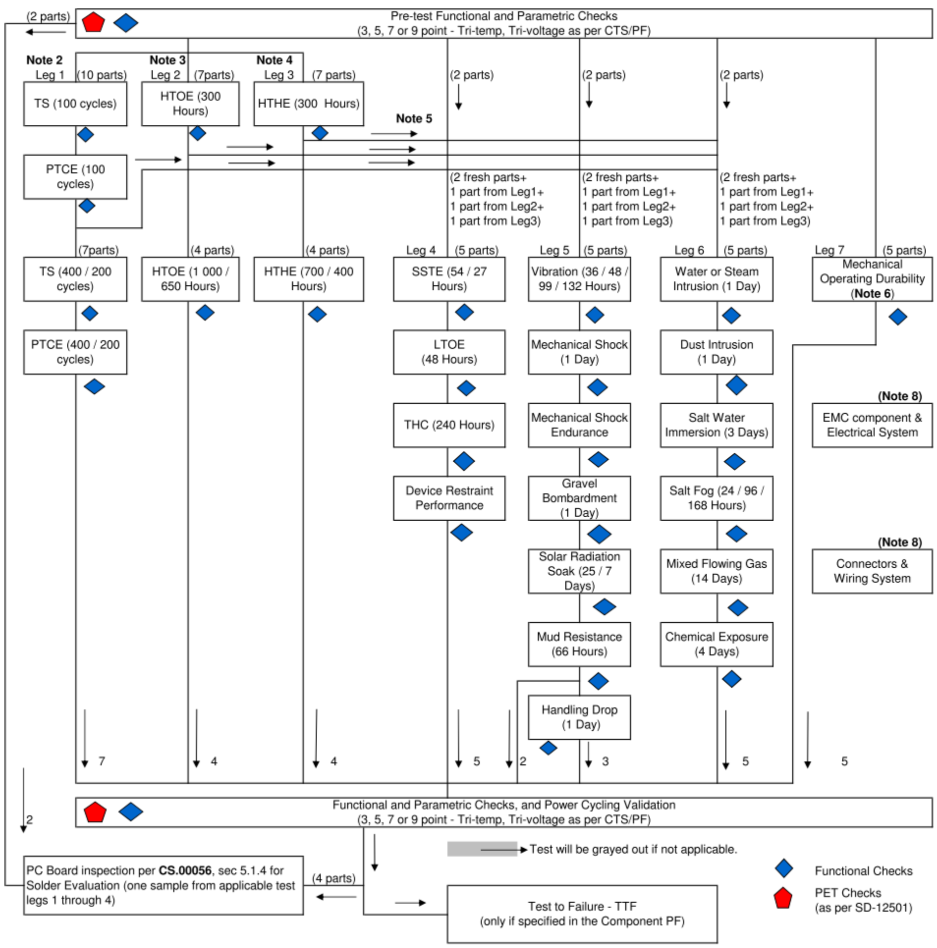
Temperature & Relative Humidity(NOTE1)	**PT-Emission / Passive Safety (either Outside or Inside Cabin) or Other Applications (only Outside Cabin)**	**All Other Applications (Inside Cabin)**
85 C & 85% RH	1 000 Hours	700 Hours
80 C & 90% RH	760 Hours	530 Hours
75 C & 95% RH	570 Hours	395 Hours
70 C & 95% RH	715 Hours	500 Hours
65 C & 95% RH	905 Hours	630 Hours

NOTE 1: Temperature and Relative Humidity values are absolute minimum and no negative tolerance shall be allowed.

End of Annex A

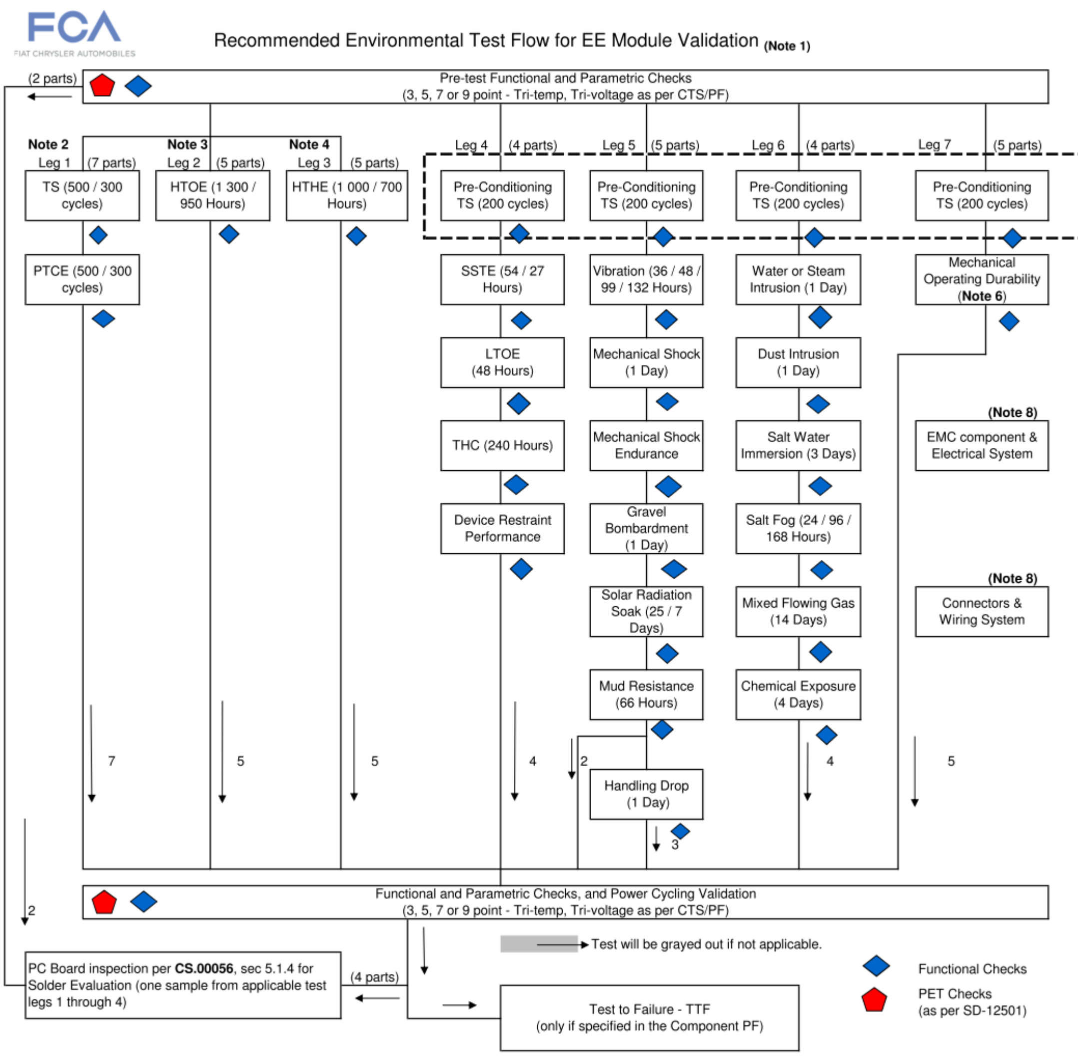
Annex B
(Normative)
Generic Test Flows for EE Component Validation

Recommended Environmental Test Flow for EE Module Validation (Note 1)



NOTE 1: Test flow shall include only applicable requirements from the Environmental Specification **CS.00056**. Test sequence can be altered within a test leg depending on availability of resources.
NOTE 2: For test leg 1 - Components with Powertrain (emission) or Passive Safety applications or 200K design life, shall require 500 TS & 500 PTCE cycles. All other applications shall require only 300 TS & 300 PTCE cycles. Cycle time depends on soak time (and weight classification).
NOTE 3: Components with Powertrain (emission) or Passive Safety applications or 200K design life, shall require 1,300 hours of HTOE, all other applications shall require only 950 hours of HTOE test.
NOTE 4: Components with Powertrain (emission) or Passive Safety applications or components packaged outside cabin locations or with 200K design life, shall require 1000 hours of HTHE, for all other applications - 700 hours of HTHE test at 85C/ 85%RH.
NOTE 5: Pre-conditioned samples from Legs 1, 2, and 3 shall be used for test legs 4, 5, and 6 (one sample each from legs 1, 2, 3). 6 fresh parts will be added as shown when leg 2 is required, otherwise 9 parts shall be added.
NOTE 6: Duty cycles for Mechanical Operating Endurance shall be based on the vehicle design life (10/150K, 15/150K or 15/200K). This test could be separated as special test leg in case of timing bottleneck. If a separate test leg is used to optimize test time, use 1 additional pre-conditioned samples from test legs 1, 2 & 3 for Mechanical Operating Endurance with 2 fresh samples. Test flow shall be customized separately for this purpose (this is not automatic).
NOTE 7: If there are any failures, detailed root cause analysis (RCA) will be conducted to prevent the failure. Pre-conditioning will not be required for revalidation if the design does not include any PCB layout or component changes. Verification requirement will be determined by FCA Quality & Engineering based on the RCA.
NOTE 8: EMC component & Electrical System, Connectors & Wiring System are not part of the Environmental Test Flow. However these requirements are required to pass to meet full component validation.

Figure B-1 - Generic Test Flow Sequence for EE Component Validation



NOTE 1: Test flow shall include only applicable requirements from the Environmental Specification **CS.00056**. Test sequence can be altered within a test leg depending on availability of resources, except for Pre-Conditioning TS tests of Leg 4, Leg 5, Leg 6.
NOTE 2: For test leg 1 - Components with Powertrain (emission) or Passive Safety applications or 200K design life, shall require 500 TS & 500 PTCE cycles. All other applications shall require only 300 TS & 300 PTCE cycles. Cycle time depends on soak time (and weight classification).
NOTE 3: Components with Powertrain (emission) or Passive Safety applications or 200K design life, shall require 1,300 hours of HTOE (Ea = 0.7, 15 years/ 150,000 miles or 15 years/ 200,000 miles), all other applications shall require only 950 hours of HTOE test.
NOTE 4: Components with Powertrain (emission) or Passive Safety applications or components packaged outside cabin locations or with 200K design life, shall require 1000 hours of HTHE (Ea = 0.47), for all other applications - 700 hours of HTHE test at 85C/ 85%RH. Alternate test durations are available in Appendix A-3 of **CS.00056**.
NOTE 5: Not Present
NOTE 6: Duty cycles for Mech Operating Endurance shall be based on the vehicle design life (10/150K, 15/150K or 15/200K). This test could be separated as special test leg in case of timing bottleneck. If a separate test leg is used to optimize test time, use 1 additional pre-conditioned samples from test legs 1, 2 & 3 for Mech Operating Endurance with 2 fresh samples. Test flow shall be customized separately for this purpose (this is not automatic).
NOTE 7: If there are any failures, detailed root cause analysis (RCA) will be conducted to prevent the failure. Pre-conditioning will not be required for revalidation if the design does not include any PCB layout or component changes. Verification requirement will be determined by FCA Quality & Engineering based on the RCA.
NOTE 8: EMC component & Electrical System, Connectors & Wiring System are not part of the Environmental Test Flow. However these requirements are required to pass to meet full component validation.

Figure B-2 - Alternate Test Flow Sequence for EE Component Validation

End of Annex B

Annex C
(Normative)
List of Chemicals and Application Methods

Table C-1 - List of Chemicals and Application Methods (NOTE 2) (NOTE 3)

Chemical Agent	Description	Chemical Class (NOTE1)	Application
Diesel fuel	According to ISO 3170 (EN 590)	A	Pour
"Bio" Diesel	EN 14214	A	Pour
Petrol/Gasoline unleaded	(According to ISO 3170 (EN 228)	A	Pour
Ethanol (E-85) Fuel	Ethanol (E-85)	A	Pour
Gasoline with 15% Ethanol	Gasoline with 15% Ethanol	A	Pour
Methanol	CAS 67-56-1	A	Pour
Transmission fluid	ATF Dexron III	B	Pour
Engine oil (Multigrade Oil)	SAE 0W40, API SL/CF See SAE 10 W 50	B	Pour
Hydraulic fluid / Power steering fluid /	(HVLP ISO VG 46)	B	Pour
Differential Oil	(Hypoid gear oil SAE 75W140, API GL-5)	B	Pour
Greases	KP2K-30	B	Brush
Coolant additive (undiluted antifreeze fluid)	Ethylene glycol ($C_2H_6O_2$) – Water Mixture 1:1	C	Pour
Brake fluid	- ISO 4926 - DOT 4 - DOT 5	C	Pour
Battery fluid	37% H_2SO_4 or KOH	C	Pour
Urea NOx (reduction agent)	ISO 22241-1	C	Pour
Coolant (OAT)	Coolant (OAT)	C	Pour
Protective lacquer	W550 (Co. Pfinder)	C	Cloth, Spray
Protective lacquer remover	Friapol 750 (Co. Pfinder)	C	Cloth
Interior cleaner	Armorall Protectant or equivalent	D	Cloth, Spray
Soapy water	Soapy water (5% soap concentration by weight))	D	Cloth
Windscreen washer fluid	5% anionic tenside, Deionized water	D	Spray
Car wash chemicals	CAS 25155-30-0; CAS 9004-82-4	D	Cloth, Spray
Glass cleaner	CAS 111-76-2	D	Pour, Spray
Wheel cleaner	Xtreme (Sonax)	D	Cloth
Cold cleaning agent	P3-Solvclean AK (Co. Henkel)	D	Cloth, Spray
Ammonium containing cleaner	Ajax (Co. Henkel)	D	Cloth, Spray
Denatured Alcohol	CAS 64-17-5 (Ethanol)	D	Cloth, Spray
Hot beverages containing Caffeine, sugar and milk	Coffee with cream (6 ml.)and sugar (6 ml))	E	Pour
Cold beverages containing caffeine and sugar	Coke	E	Pour
Saline solution	10% salt (NaCl) by weight	E	Pour
Cosmetic products	such as creams e. g. Nivea, Kenzo	E	Cloth
Hand Sanitizer lotion	Hand Sanitizer lotion	E	Cloth, Spray
Suntan lotion	Suntan lotion	E	Cloth, Spray
Perspiration (solution of 5g/l of NaCl + 5g/l of Na_2HPO_4 X 12 H_2O)	Perspiration (solution of 5g/l of NaCl + 5g/l of Na_2HPO_4 X 12 H_2O)	E	Cloth, Spray
Runway deicer	SAE AMS 1435A	E	Pour, Spray
Anti-fungus agent	Sodium hypochlorite (Chlorine	E	Pour, Spray

Table C-1 - List of Chemicals and Application Methods (NOTE 2) (NOTE 3)			
Chemical Agent	**Description**	**Chemical Class (NOTE1)**	**Application**
	bleach) 5%, Biocides 5% (CL-49, Gengard 8142, Spectrus NX1102).		
Additional agents	Additional agents	YY	- - -

NOTE 1: Chemical Class according to ISO 16750-5 :
A - Fuels
B - Oils and lubricants
C - Other operating agents
D - Cleaning agents
E - Other agents

NOTE 2:

- **The fluids to be used for individual components shall be as specified in the Component Specific Performance Standard.**
- **The selection of fluids should be supported by Material Engineering department.**
- **Additional fluids may be used if necessary.**
- **Commercially available fluids may be used when the specified fluids are unavailable or the material specifications have become obsolete.**

NOTE 3: CAUTION: HEALTH AND SAFETY HAZARD!!! OBSERVE ALL HEALTH AND SAFETY REGULATIONS AND PRECAUTIONS WHILE APPLYING THESE FLUIDS.

End of Annex C

Annex D
(Normative)
Test Selection Guideline for Electrical Components Undergoing Design, Process or Supply-Chain Related Changes

Supplier Process & Component Change - Validation Requirments (SPCCVR)

#	Reasons for the Changes	Is this affected?	Thermal Shock (**Note 1**)	Powered Thermal Cycle Endurance	High Temperature Operating Endurance	High Temperature Humidity Endurance	Shipping Storage Temp. Exposure	Low Temperature Operating Endurance	Thermal Humidity Cycle	Mechanical Operating Durability	Vibration	Mechanical Shock	Mech. Shock Endurance (only if applicable)	Gravel Bombardment (if applicable)	Solar Radiation Soak (if applicable)	Mud Resistance (if applicable)	Handling Drop	Water or Steam Intrusion	Dust Intrusion	Salt Water Immersion (if applicable)	Salt Fog	Mixed Flowing Gas (if applicable)	Chemical Exposure	Other applicable tests (Ozone, Vehicle Drive Cycle..etc - **Note 2**)	Solder Evaluation	Applicable EMC Component / Vehicle Tests - **CS-11979, CS-**	Electrical System Tests **CS-11979**	Connector Tests **(SAE/USCAR-2**, if reqd.	Wiring Requirement Tests (**CS-11510**)	Test Flow **(SD-12659)** **(Note 3)**
1	PCB Layout / PC Board material Changes		X			X					X	X													X					1
2	Passive component change (ex: resistors, inductors, capacitors, etc.)		X			X					X	X													X					1
3	Solder material, terminal lead material or process change (Ex: Lead to lead-free or vice versa)		X			X					X	X													X					1
4	Plant/ Location move (Geographical location change)	Yes	X			X					X	X													X					1
5	In-Plant Location move (without new equipments - same equipments)		X			X					X	X													X					1
6	In-Plant Location move (with new or additional equipments)		X			X					X	X													X					1
7	New Manufacturing Line Added		X			X					X	X													X					1
8	Component (electronic) Change (new part with different pad / lead geometry) - ex: IC, Diode, etc.		X		X	X		X			X	X													X	X	X	X	X	2
9	Component (electronic) Change only (totally new part) - no change to layout or pad geometry - ex: IC, Diode, etc.		X		X			X			X	X													X	X	X	X	X	3
10	Conformal Coating changes Adding, removing, changes to the material / chemical properties, process change, or adding new conformal coating equipment.		X			X																								4
11	Changes in bezel/ case (example, change in the rubber or plastic material for sealing, case)		X								X	X		X	X	X		X	X	X	X	X	X	X						5
12	Sealing material changed (ex: change in the rubber or plastic material for sealing, case)		X								X	X				X		X	X	X	X	X	X	X						5
13	Mounting or packaging location change without change in the temp class		X								X	X		X	X	X		X	X	X	X	X	X	X						5
14	Connector Changes		X								X	X				X		X	X	X	X	X	X		X			X	X	5
15	Mounting or packaging location Changed with change in the temp class		X		X	X					X	X		X	X	X		X	X	X	X	X	X			X		X	X	5
16	Mounting Bracket Changed		X								X	X									X									6
17	Electro - Mechanical (Switches Relays)		X							X	X	X																		7

Note 1 - Thermal Shock Cycles will be used to reduce overall test time for combined Thermal Shock and Powered Thermal Cycles as shown in the applicable Test Flows (**SD-12659**).

Note 2 - For some situations, other applicable (Component, System or Vehicle Drive Cycle) tests shall be selected by Engineering, QRE and Supplier team.

Note 3 - Refer to the applicable test flow in (**SD-12659**) for validation requirements.

Note 4 - Final approval for validation plan will require QRE concurance.

Note 5 - Test durations for HTOE and HTHE tests may be higher or lower depending on operational test parameters used. Refer to "Special Test Situation" tab for test paratemeters.

Figure D-1 - Test Selection Guideline for Supply-Chain Changes (SD-12659)

Environmental Test Durations for lower operating temperatures[1] and BEV Applications

Tmax, °C	Temp. Parameters ===>		Top.max	Top.max	(Top.max - Top.min)	(Top.max - Top.min)	(Tmax C to -40 C)	(Tmax C to -40 C)	(Top.max & 85% RH)	(Top.max & 85% RH)
	Top.max, °C	Top.min, °C	HTOE, hours Other applications	HTOE, hours Passive Safety/ Emission	PTCE, cycles Other applications	PTCE, cycles Passive Safety/ Emission	TS, cycles[3] Other applications	TS, cycles[3] Passive Safety/ Emission	HTHE - Cabin with non-safety, hours	HTHE - Outside & Safety or emission, hours
85 C 105 C > 105 C[2]	85/80 105 / 100	-40 -30	950	1300	300	500	300	500	700	1000
	75/70 95 / 90	-30 -20	1100	1500	400	600	300	500	850	1200
	65/60 90 / 85	-20 -30	1300	2000	500	700	300	500	1000	1500
	BEV Applications (for any Top.max & Top.min)		2000 hours		500 cycles		500 cycle		1000 hours	

Note 1: Lower operating temperatures are allowed only for technological limitations. These parameters cannot be used in other situations.

Note 2: For Tmax greater than 105 C, follow the same pattern based on Top. Max shown for 105C situation.

Note 3: Thermal Shock cycles shall remain unchanged, however, test parameters will be between Tmax and -40 C, since, TS is non-operational test.

Figure D-2 - Special Test Situation (SD-12659)

For updated documents please refer to SD-12659.

End of Annex D

Annex E
(Normative)
Additional Validation Requirements for Liquid Cooled Modules

E-1 Introduction

This section defines additional validation test requirements for liquid cooled components, modules, sensors and actuators relative to environmental testing. These validation test requirements are to be used during Engineering Development, DV Testing and PV Testing phases of the product development process.

Product design change validation and process change validation will also follow these test requirements for applicable tests.

E-2 Background

Liquid cooled components, modules, sensors and actuators continue to be introduced into new vehicle programs. The liquid cooled components are typically high power dissipation components used in Battery Electric Vehicle (BEV), Plug in Hybrid Electric Vehicle (PHEV), and motor generator unit (MGU) vehicle applications.

E-3 Methodology

1. Use the standard test definitions provided in this Environmental Test Specification document.
2. Supplement the standard tests with requirements in this section for liquid cooled components.

E-4 Coolant Type and Concentration

1. For all tests use FCA automotive coolant used on actual vehicle application and agreed by FCA Engineering.
2. As default condition, use standard FCA automotive coolant concentration = 50% full strength coolant & 50% water.
3. If standard FCA 50%/50% coolant concentration is not feasible, due to test temperatures with potential to freeze or boil coolant, adjust coolant concentration as agreed by FCA Engineering. As an example, use up to 68% full strength coolant & 32% water, to achieve lower temperature protection and higher boiling point.
4. Use increased coolant concentration only for tests where 50%/50% coolant concentration is not feasible due to test temperatures with potential to freeze or boil coolant.

E-5 Coolant Flow Rate and Pressure

1. Coolant flow rate and pressure based on actual vehicle application and agreed by FCA Engineering.
2. Coolant flow rate to be consistent with flow rate defined for the actual vehicle application.
3. Coolant pressure to be consistent with pressure defined for the actual vehicle application.

E-6 Coolant Set Up Conditions for Standard CS.00056 environmental tests defined in this document.

1. TS Thermal Shock
   a. No coolant required.
   b. Perform test as defined in TS thermal shock section of this document.
2. PTCE Powered Thermal Cycle Endurance
   a. Coolant temperature tracks thermal cycle chamber temperature.
   b. Suggested method is to use coolant radiators inside thermal cycle chamber with coolant reservoir and plumbing. Pumps and pressure regulators outside chamber.
   c. Alternate method is to use external coolant heater / chiller as agreed by FCA Engineering.

   d. Coolant flow is always on and tracking thermal cycle chamber temperature during the test, to contribute to efficient thermal cycle and minimum soak times.
   e. Coolant flow regulators and coolant temperature monitors required, in addition to normal thermal chamber monitors and product under test cyclers and monitors.
   f. Perform test as defined in PTCE powered thermal cycle endurance section of this document.
   g. No coolant leaks internal or external to module.
3. HTOE High Temperature Operating Endurance
   a. Coolant temperature is Tcoolant max as defined for the vehicle application and agreed by FCA Engineering.
   b. Coolant flow is always on.
   c. Coolant flow regulators and coolant temperature monitors required, in addition to normal thermal chamber monitors and product under test cyclers and monitors.
   d. Perform test as defined in HTOE high temperature operating endurance section of this document.
   e. No coolant leaks internal or external to module.
4. HTHE High Temperature Humidity Endurance
   a. Coolant temperature is Tcoolant max as defined for the vehicle application and agreed by FCA Engineering. If Tcoolant max >85 °C, use 85 °C as coolant temp since this is a 85 °C / 85%RH test.
   b. Coolant flow is on when module is operating. Coolant flow is off when module is not operating. This is important so module does not fill with condensation during not operating state.
   c. Coolant flow regulators and coolant temperature monitors required, in addition to normal thermal chamber monitors and product under test cyclers and monitors.
   d. Perform test as defined in HTHE high temperature operating endurance section of this document.
   e. No coolant leaks internal or external to module.
5. SSTE Shipping / Storage Temperature Exposure
   a. Default coolant temperature is room temperature.
   b. Alternate coolant temperature is any coolant temperature that does not exceed maximum coolant temperature defined for the actual vehicle application and agreed by FCA Engineering.
   c. Coolant flow is on only when module is powered at room temperature for this test.
   d. Alternate approach is no coolant flow needed, if not required for module operation during this test. Coolant circuit is full of coolant.
   e. Perform test as defined in SSTE shipping / storage temperature exposure section of this document.
   f. No coolant leaks internal or external to module.
6. LTOE Low Temperature Operating Endurance
   a. Coolant temperature is -40C.
   b. Coolant flow is off when module is not operating. Coolant flow is on, if required at -40C, when module is operating.
   c. Coolant flow regulators and coolant temperature monitors required, in addition to normal thermal chamber monitors and product under test cyclers and monitors.
   d. Alternate approach is no coolant flow needed, if not required for module operation during this test. Coolant circuit is full of coolant.
   e. Perform test as defined in LTOE low temperature operating endurance section of this document.
   f. No coolant leaks internal or external to module.
7. THC Thermal Humidity Cycle
   a. Coolant temperature tracks thermal cycle chamber temperature.

   b. Suggested method is to use coolant radiators inside thermal cycle chamber with coolant reservoir and plumbing. Pumps and pressure regulators outside chamber.
   c. Alternate method is to use external coolant heater / chiller as agreed by FCA Engineering.
   d. Coolant flow is always on and tracking thermal cycle chamber temperature during the test, to contribute to efficient thermal cycle and minimum soak times.
   e. Coolant flow regulators and coolant temperature monitors required, in addition to normal thermal chamber monitors and product under test cyclers and monitors.
   f. Perform test as defined in THC Thermal Humidity Cycle section of this document.
   g. No coolant leaks internal or external to module.

8. Device Restraint Performance
   a. Attach coolant lines.
   b. Coolant circuit is filled with coolant.
   c. Coolant temperature is uncontrolled.
   d. Coolant flow is off.
   e. Coolant circuit is pressurized to Pmax = vehicle application + 50%.
   f. Perform test as defined in device restraint performance section of this document.
   g. No loss of pressure. No coolant leaks internal or external to module.
9. Mechanical Vibration
   a. Coolant circuit is filled with coolant.
   b. Coolant temperature is uncontrolled.
   c. Coolant flow is off, unless cooling is required.
   d. Coolant circuit is pressurized to Pmax = vehicle application + 50%.
   e. External vehicle wire harnesses and vehicle coolant lines are attached to the module and restrained as in vehicle application.
   f. Perform test as defined in mechanical vibration section of this document.
   g. No loss of pressure. No coolant leaks internal or external to module.
10. Mechanical Shock for Test No. 1
    a. Coolant circuit is filled with coolant.
    b. Coolant temperature is uncontrolled.
    c. Coolant flow is off.
    d. Coolant circuit is pressurized to Pmax = vehicle application + 50%.
    e. External vehicle wire harnesses and vehicle coolant lines are attached to the module and restrained as in vehicle application.
    f. Perform Test No. 1 as defined in Mechanical Shock section of this document.
    g. No loss of pressure. No coolant leaks internal or external to module.
11. Mechanical Shock for Test No. 2
    a. Coolant circuit is filled with coolant.
    b. Coolant temperature is uncontrolled.
    c. Coolant flow is off, unless cooling is required.
    d. Coolant circuit is pressurized to Pmax = vehicle application + 50%.
    e. External vehicle wire harnesses and vehicle coolant lines are attached to the module and restrained as in vehicle application.
    f. Perform Test No. 2 as defined in Mechanical Shock section of this document.
    g. No loss of pressure. No coolant leaks internal or external to module.
12. Gravel Bombardment
    a. No coolant required.
    b. Attach coolant lines.
    c. Perform test as defined in Gravel Bombardment section of this document.
13. Mud Resistance
    a. Coolant temperature is Tcoolant max as defined for the vehicle application and agreed by FCA Engineering.

   b. Coolant flow is on during module operation. Coolant flow is off when module is not operating.
   c. Coolant flow regulators and coolant temperature monitors required, in addition to normal thermal chamber monitors and product under test cyclers and monitors.
   d. Perform test as defined in Mud Resistance section of this document.
   e. No coolant leaks internal or external to module.

14. Handling Drop
   a. No coolant required.
   b. No coolant lines attached.
   c. Perform test as defined in Handling Drop section of this document.
15. Water or Steam Intrusion
   a. Default coolant temperature is room temperature.
   b. Alternate coolant temperature is any coolant temperature that does not exceed maximum coolant temperature defined for the actual vehicle application and agreed by FCA Engineering.
   c. Coolant flow is on only when module is powered at room temperature for this test.
   d. Alternative is coolant flow always on during this test.
   e. Alternate approach is no coolant needed, if not required for module operation during this test. Attach coolant lines. Coolant circuit is full of coolant.
   f. Perform test as defined in Water or Steam Intrusion section of this document.
   g. No coolant leaks internal or external to module.
16. Dust Intrusion
   a. Default coolant temperature is room temperature.
   b. Alternate coolant temperature is any coolant temperature that does not exceed maximum coolant temperature defined for the actual vehicle application and agreed by FCA Engineering.
   c. Coolant flow is on only when module is powered at room temperature for this test.
   d. Alternative is coolant flow always on during this test.
   e. Alternate approach is no coolant needed, if not required for module operation during this test. Attach coolant lines. Coolant circuit is full of coolant.
   f. Perform test as defined in Dust Intrusion section of this document.
   g. No coolant leaks internal or external to module.
17. Salt Water Immersion
   a. Coolant temperature is 0C.
   b. Coolant flow is on only when module is powered at 0°C for this test.
   c. Alternate approach is no coolant needed, if not required for module operation during this test. Attach coolant lines. Coolant circuit is full of coolant.
   d. Perform test as defined in Salt Water Immersion section of this document.
   e. No coolant leaks internal or external to module.
18. Salt Fog
   a. Coolant temperature is 35C.
   b. Coolant flow is on only when module is powered at 35C for this test.
   c. Alternative is coolant flow always on during this test.
   d. Alternate approach is no coolant needed, if not required for module operation during this test. Attach coolant lines. Coolant circuit is full of coolant.
   e. Perform test as defined in Salt Fog section of this document.
   f. No coolant leaks internal or external to module.
19. Mixed Flowing Gas
   a. No coolant required.
   b. Attach coolant lines.
   c. Perform test as defined in Mixed Flowing Gas section of this document.
20. Chemical Exposure
   a. No coolant required.

b. Attach coolant lines.
c. Perform test as defined in Chemical Exposure section of this document.

21. EMC
    a. Default coolant temperature is room temperature.
    b. Alternate coolant temperature is any coolant temperature that does not exceed maximum coolant temperature defined for the actual vehicle application and agreed by FCA Engineering.
    c. Coolant flow is on only when module is powered at room temperature for this test.
    d. Alternate approach is no coolant needed, if not required for module operation during this test.
    e. Perform test as defined in FCA approved EMC test plan.
22. Electrical System
    a. No coolant required.
    b. Perform test as defined in Electrical System Test.
23. Connector & Wiring System
    a. No coolant required.
    b. Perform test as defined in FCA & SAE USCAR Connector and Wiring Systems Specifications.
24. Mechanical Operating Durability
    a. Perform coolant circuit thermal cycle / pressure cycle durability.
    b. While performing thermal cycle Tmin to Tmax with appropriate soak time, perform pressure cycle Pmin to Pmax based on defined pressure in the vehicle application +50%.
    c. Number of thermal cycles to be sufficient to complete the required number of pressure cycles.
    d. Pressure cycle frequency to be defined to complete the required number of pressure cycles in a feasible time. Full pressure range must be accomplished on each pressure cycle.
    e. Default coolant temperature is coolant temperature uncontrolled.
    f. Determine actual number of lifetime pressure cycles.
    g. Acceptance criteria: Module functional, no loss of pressure over 30 minutes, no coolant leakage inside or outside the module.
    h. Number of lifetime pressure cycles, pressures and temperatures to be agreed by FCA Engineering and Quality & Reliability Engineering.
25. Parametric Evaluation For All DV / PV Modules Before and After Testing – Coolant circuit
    a. Perform coolant circuit evaluation at Tmin, RT, and Tmax.
    b. Pressurize the coolant circuit for 30 minutes to Pmax = defined pressure in the vehicle application +50%.
    c. Acceptance criteria: Module functional, no loss of pressure over 30 minutes, no coolant leakage inside or outside the module.

End of Annex E

Annex F
(Informative)
Development Team

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End of Annex F