

Bendix Commercial Vehicle Systems LLC Elyria, Ohio		
GUIDELINE TITLE: Electronics Test Guideline Climatic Validation Tests Guideline Owner: <u>Thomas Legeza</u>	DEPARTMENT:	<u>Platform 8439</u>
	PLM Team:	<u>EEE1</u>
	Guideline Number:	Y203401
	REVISION:	
	ISSUE DATE:	29-Sept-2021
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Cover Sheet

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Y203401

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Revision Summary Table

Revised By	Approved By	Rev	Section	Description	Reason	Date
EEB	TSL	000		Initial Release		30-Sep-2016
JAM	TSL	001	7.9	Update to test	Update	27-July-2017
JAM	TSL	001	7.10	Clarification of test procedure	Update	27-July-2017
JAM	TSL	001	7.12	IP ratings not implemented	Clarification	27-July-2017
JAM	TSL	002	Various	Guideline owner updated	Update	29-Sept-2021
JAM	TSL	002	Various	Removed number of units tested for each test	Clarification	29-Sept-2021
JAM	TSL	002	Various	Update J1455 specification date to latest. Remove test sample number	Update	29-Sept-2021
JAM	TSL	002	3.1	Added SAE Specification J2721, update revision number	Update	29-Sept-2021
JAM	TSL	002	7.2	Update low storage temperature value	Update	29-Sept-2021
JAM	TSL	002	7.6	Update Humidity Test diagram	Update	29-Sept-2021
JAM	TSL	002	7.8	New Test	New	29-Sept-2021
JAM	TSL	002	7.10	New Test	New	29-Sept-2021
JAM	TSL	002	7.11	Update tumbler test for percentages of material and DUT to be mounted on base plate/ steel substrate	Information missing	29-Sept-2021
JAM	TSL	002	7.12	Clarification of test procedure J2721 Clarification of dunk soak cycle Correct GRMS value	Clarification	29-Sept-2021
JAM	TSL	002	7.13	Remove table reference	Clarification	29-Sept-21
JAM	TSL	002	7.14	Update cycles to 378 Update steam cleaning	Update	29-Sept-2021

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Revised By	Approved By	Rev	Section	Description	Reason	Date
JAM	TSL	002	7.16	Added Portland cement	Update	29-Sept-2021
JAM	TSL	002	7.17	Added number of bombardments	Clarification	29-Sept-2021
JAM	TSL	002	7.18-7.19	Update Altitude values	Update	29-Sept-2021
JAM	TSL	002	7.20	Added Notes about humidity and BDR, corrected figure reference	Update	29-Sept-2021
JAM	TSL	002	8.0	Add new test to test flow	New	29-Sept-2021
JAM	TSL	002	Table	Minor revision to align revisions in table	Correction	27-Dec-2021

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1. Introduction

The purpose of this guideline is to provide a framework for standard product testing during the product development process. This document is to serve as a guide to how each test should be performed; engineers may customize individual tests to meet their product requirements.

This document shall be treated as confidential and for internal use only. Where external reporting is needed, refer to industry specifications such as those by SAE or ISO.

2. Scope

This guideline is applicable to all North American facilities and all functional areas of Bendix Commercial Vehicle Systems.

3. Related Documents

3.1. Industry Standards

Document Number	Publication Date	Title
SAE J1455	<i>MAR 2017</i>	Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
SAE J400	OCT 2012	Test for Chip Resistance of Surface Coatings
<i>SAE 2721</i>	<i>NOV 2011</i>	<i>Recommended Corrosion Test Methods for Commercial Vehicle Components</i>

3.2. Bendix Documents

Document Number	Publication Date	Title
Y082010	10 Dec 2004	Work Instruction - Chemical Dip & Splash Test

4. Definitions

A = Amperes
DC = direct current
DTC = Diagnostic Trouble Code
DUT = Device Under Test
Multivolt = operation across 12V and 24V system voltages
V = Volts

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5. Tolerances

Unless otherwise specified, the tolerances within this document are:

- Pressure: ± 0.25 psi (± 0.02 bar)
- Voltage: ± 0.2 VDC
- Current: ± 10 milliamp
- Time: ± 0.5 milliseconds
- Force: ± 0.1 lbs (± 0.4 N)
- Temperature: $\pm 1^{\circ}\text{C}$

6. Operating Environment

6.1. Operating Temperature

Mounting Location	Minimum Temperature	Maximum Temperature
In Cab	-40 $^{\circ}\text{C}$	85 $^{\circ}\text{C}$
In Cab (Direct Sunlight)	-40 $^{\circ}\text{C}$	115 $^{\circ}\text{C}$
Chassis (Forward/Rear)	-40 $^{\circ}\text{C}$	120 $^{\circ}\text{C}$ /85 $^{\circ}\text{C}$
Chassis (near heat source)	-40 $^{\circ}\text{C}$	150 $^{\circ}\text{C}$
Chassis (Wheel End)	-40 $^{\circ}\text{C}$	165 $^{\circ}\text{C}$
Engine Bay	-40 $^{\circ}\text{C}$	125 $^{\circ}\text{C}$
Engine Bay (near heat source)	-40 $^{\circ}\text{C}$	150 $^{\circ}\text{C}$

Table 6.1

6.2. Operating Voltage

System Voltage	Minimum Voltage	Nominal Voltage	Maximum Voltage
12 Volts	9.0 \pm 0.1 Volts	14.2 \pm 0.1 Volts	18.0 \pm 0.1 Volts
24 Volts	18.0 \pm 0.1 Volts	28.4 \pm 0.1 Volts	36.0 \pm 0.1 Volts

Table 6.2

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7. Design Validation Test Standards - Climatic

Prior to performing any of the prescribed validation tests in this document, the responsible Engineer shall define:

- All test harness lengths, connection points, and measurement points.
- All DUT operating modes to be exercised during the test.
- The pre-test, in-test, post-test functional test, data collecting, and inspection requirements to be used as part of the test acceptance criteria (pass/fail).
 - Include any additional function tests pertaining to harnesses and enclosures (i.e. High Pot Tests, Pressurization Tests, etc.)
 - Follow best practice of performing functional tests “as a system” which includes: any electrical harnesses that would be used (standard or specialty), any air hoses that would be connected (even if testing without air pressure), and anything else that is called out to be connected to the DUT (covers, brackets, connectors, etc.)

All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.

Except where noted otherwise, multivolt DUTs shall be tested with the test parameters listed for both 12V and the 24V system voltages.

Except where noted otherwise, the DUT shall be connected to a voltage supply source capable of providing at least 15A of current more than the DUT's maximum rated current.

Except where noted otherwise, an in-line fuse or circuit breaker shall not be used between the voltage source and the DUT. When using a fuse, the fuse rating shall be according to the product specification communicated to the customer.

Units must adhere to all expected outputs during the Test Acceptance Criteria steps to be considered passing the test.

Record all relevant DUT information which will include but not limited to: part number, serial number, software revision, and configuration of the DUTs.

All DUTs will be labeled per each test request that it is tested. It will be labeled with the minimum of the test request number and index number (example: TR009999-01).

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7.1. Three Temperature Parametric Test

Test Overview

The DUT will be subjected to minimum and maximum operating voltages (Table 6.2) at room temperature, minimum, and maximum temperatures (Table 6.1). Place the DUT in an environmental chamber at ambient temperature and at nominal voltage. Ramp temperature to minimum test temperature and allow DUT to soak at this temperature for one hour. Change test voltage to minimum operating voltage and dwell for one hour then change test voltage to maximum test voltage and dwell for one hour. Change operating voltage to nominal and ramp temperature of chamber maximum test temperature and allow unit to soak at this temperature for 1 hour. Change test voltage to minimum operating voltage and dwell for one hour then change test voltage to maximum test voltage and dwell for one hour. Change test voltage to nominal and ramp test temperature to ambient.

Test Summary

Test Summary	
SAE Specification	N/A
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Temperature	Table 6.1
Test Voltage	Table 6.2
Temperature Change Rate	Max of 5 °C/minute
Dwell Time @ each temperature and voltage	1 Hour

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Test Acceptance Criteria

- All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test (at each temperature and voltage). This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.2. Storage Temperature Test

Test Overview

The DUT will be subjected to storage temperatures test with temperatures as stated in table below.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <i>MAR 2017</i> , section 4.1.1.6
Typical State of Sample	Not Powered
Functional Test	Before/After Test

Test Parameters

Test Parameters	
Parameter	Value
Low Test Temperature	-55°C for 24 hours
High Test Temperature	95°C for 48 hours, 125 for 2 Hours
Temperature Change Rate	Max of 5 °C/minute
Number of Cycles	1

Test Acceptance Criteria

- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.3. Thermal Cycle Test

Test Overview

The DUT will be subjected to test cycle outlined in Figure 7.3.1. One test cycle consists of varying temperature levels for 24 hours. The minimum and maximum temperatures as listed in table 6.1. The cycle consists four hours at minimum temperature, twelve hours at maximum temperature, and eight hours at ambient temperature minus ramp time. The DUT will complete 30 cycles (720 hours).

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.1.3.1, and figure 2A, "24 Hour Thermal Cycle Test"
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Low/High Test Temperatures	Table 6.1
Test Voltages	Table 6.2
Temperature Change Rate	3.0 °C/minute
Number of Cycles	30 (30 Days)

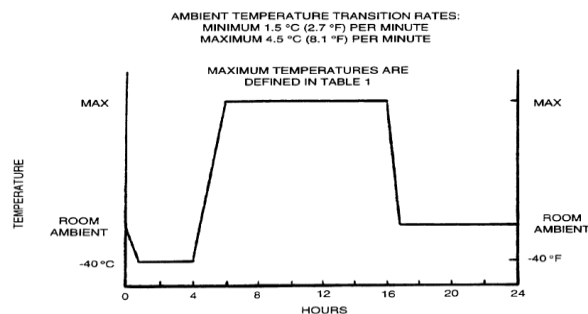


Figure 7.3.1 - Thermal Cycle Profile

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Test Acceptance Criteria

- All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.4. Thermal Shock Test (Short)

Test Overview

The DUT shall be subjected to the test cycle consisting of a one hour soak at the minimum operating temperature followed by a transfer to the hot chamber for a one hour soak at the maximum operating temperature. Each transfer shall occur in 5 seconds or less. The DUT shall be subjected to a total of 84 cycles (168 hours).

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.1.3.2
Typical State of Sample	Not Powered
Functional Test	Before/After Test

Test Parameters

Test Parameters	
Parameter	Value
Low/High Test Temperatures	Table 6.1
Temperature Change Rate	< 5 Seconds
Number of Cycles	84

Test Acceptance Criteria

- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.5. Thermal Shock Test (Long)

Test Overview

The DUT shall be subjected to the test cycle consisting of a one hour soak at the minimum operating temperature followed by a transfer to the hot chamber for a one hour soak at the maximum operating temperature. Each transfer shall occur in 5 seconds or less. The DUT shall be subjected to a total of 500 cycles (1000 hours).

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.1.3.2
Typical State of Sample	Not Powered
Functional Test	Before/After Test

Test Parameters

Test Parameters	
Parameter	Value
Low/High Test Temperatures	Table 6.1
Temperature Change Rate	< 5 Seconds
Number of Cycles	500

Test Acceptance Criteria

- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.6. Humidity Test (Short)

Test Overview

The DUT is subjected to the test cycle consisting of the cycle outlined in figure 7.6.1. A single test cycle is defined as 24 hour period of the varying temperature and humidity levels.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.2
Typical State of Sample	Powered
Functional Test	Before/During/After Test

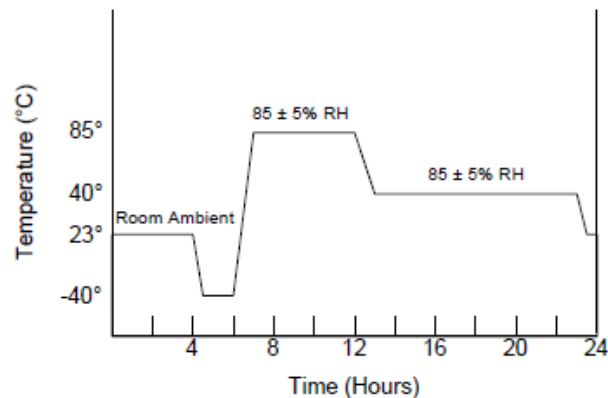


Figure 7.6.1 Humidity Test (Short)

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Low Test Temperature	-40°C
High Test Temperature	85°C
Temperature Change Rate	Max of 5 °C/minute
Number of Cycles	1

Test Acceptance Criteria

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- All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
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7.7. Humidity Test (Long)

Test Overview

The DUT is subjected to a constant 85°C with 85% ± 5% RH. The DUT is subjected to this environment for a total of 1000 hours (about 41.5 days)

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.2
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Test Temperature	85°C
Test Humidity	85% ± 5%
Test Length	1000 Hours

Test Acceptance Criteria

- All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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Platform 8439

PLM Team:

EEE1

Guideline Number:

Y203401

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7.8. Frost Test

Test Overview

The DUT is subjected to a frost test. Environmental room where the test is being performed needs to be at a temperature of at least 22°C and humidity needs to be least 40%.

To create the frost, open the door of the environmental chamber and power off the chamber.

Test Summary

Test Summary	
<u>SAE Specification</u>	<u>SAE J1455 MAR 2017, section 4.2</u>
<u>Typical State of Sample</u>	<u>Powered</u>
<u>Functional Test</u>	<u>Before/During/After Test</u>

Test Parameters

Test Parameters	
Parameter	Value
<u>Test Voltage</u>	<u>Table 6.2</u>
<u>Test Temperature</u>	<u>-40C</u>
<u>Soak Time</u>	<u>60 minutes</u>
<u>Test time with door open</u>	<u>Less than or equal 5 minutes</u>

Test Acceptance Criteria

- All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.9. Salt Spray Fog Test

Test Overview

The DUT is subjected to a salt spray consisting of 5 parts NaCL to 95 parts of water. Test is repeated with 5 parts MgCL₂ to 95 parts of water. The DUT will be mated with sealed connector(s) for this test. This test is not required for unsealed modules with unsealed connectors.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.3.3.1
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Test Temperature	35°C
Length of Test	
Mounting Location	Test Length (Hours)
In Cab	96
Chassis	240
Engine Bay	240

Test Acceptance Criteria

- All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.10. Immersion Test

Test Overview

The DUT is subjected to a water immersion consisting of 5 parts NaCL to 95 parts of water. DUT will soak in salt water at 74 °C for 1 hour, then be transferred to the salt water at 0 °C for 1 hour. Transfer from hot to cold will occur in < 2 minutes. The DUT will be mated with sealed connector(s) for this test. Test is repeated with 5 parts MgCL₂ to 95 parts of water. Rinse DTU with deionized water between the two different salt solution exposures.

Test Summary

<u>Test Summary</u>	
<u>SAE Specification</u>	<u>SAE J1455 MAR 2017, section 4.3.3.2</u>
<u>Typical State of Sample</u>	<u>Powered</u>
<u>Functional Test</u>	<u>Before/During/After Test</u>

Test Parameters

<u>Test Parameters</u>	
<u>Parameter</u>	<u>Value</u>
<u>Test Voltage</u>	<u>Table 6.2</u>
<u>Test Temperature</u>	<u>74 °C and 0 °C</u>
<u>Immersion Depth</u>	<u>1 Meter</u>
<u>Test Length</u>	<u>1 Hour at each temperature</u>

Test Acceptance Criteria

- All critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.11. Tumbler Test

Test Overview

The DUT is subjected to a Tumbler Test that subjects the DUT to a corrosion solution then it is placed in an environmental chamber and temperature cycled. The DUT is typically fastened to a base plate / substrate (ASTM A36 Steel Plate) that would emulate the vehicle mounting application. The combination of the Tumbler with solution and temperature cycle is considered one cycle. This test is not required for unsealed modules with unsealed connectors.

Test Summary

Test Summary	
SAE Specification	<i>SAE J2721 NOV2011, Section 6.1, table 3</i>
Typical State of Sample	Not Powered
Functional Test	Before and After Test

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Test Parameters

Test Parameters	
Parameter	Value
Test Temperature	TBD°C
Length of Test	30 Cycles
Tumbler Solution Change	At Least once every 5 days
<i><u>Salt Solution * Percentage by Mass solution 6 from SAE J2721 Table 3</u></i>	
Sodium Chloride	1%*
Calcium Chloride CaCl ₂	3%*
Potassium Chloride KCl	0.5%*
Magnesium Chloride MgCl ₂	2.5%*
Water H ₂ O	93%*
Corrosion Solution in Tumbler	
Salt Solution	1600 ml
12 Sieve Oil Dry	100 ml
Diatomaceous Earth	50 ml
Rock Salt (.125" Max Dia)	4 Cups
Thermal Cycle	
0.5 hours (ramp up)	85°C @ 0% RH
8.0 hours (soak)	85°C @ 0% RH
0.5 hours (ramp up)	85°C @ 95% RH
8.0 hours (soak)	85°C @ 95% RH
0.5 hours (ramp down)	23°C @ 0% RH

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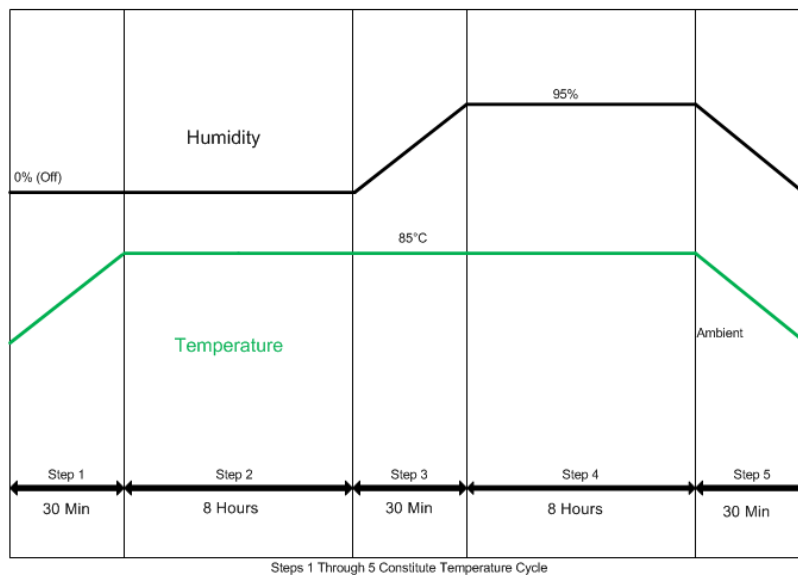
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Test Setup

- Mix salt solution
- Pour 1600 ml of salt solution into tumbler and add the remaining materials listed under corrosion solution

Test Acceptance Criteria

- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- Additional inspection after 6 months to check for corrosion damage since test completion
- The DUT will not have any physical damage at the completion of this test.

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7.12. Immersion Test (Dunk Test)

Test Overview

Immersion testing provides analysis of sealed connector(s) and the sealed enclosure integrity. The DUTs is subjected to water immersion consisting of 5 parts NaCL to 95 parts of water. The DUTs will be immersed in the salt water solution for a period of one hour (one DUT in the hot side and the other on the cold side). The DUTs should be completely covered with the salt water solution. After one hour period of DUTs being exposed to salt water solution, the DUTs should then be transferred to the opposite salt water solution (DUT from hot salt solution to cold salt solution, DUT from cold salt solution to hot salt solution). This transfer should take place within one minute. This defines one dunk soak cycle.

At the completion of the 3 dunk soak cycles per figure 7.11.1, the DUTs will be subjected to a combined environmental profile as described in figure 7.11.2

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.3.3.2
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Hot Test Temperature	74°C
Cold Test Temperature	0°C
Dunk Soak Cycles per one Complete Cycle	<u>3</u>
Complete Cycles (Dunk & AGREE)	15

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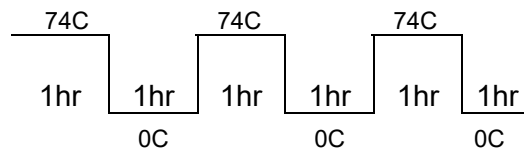
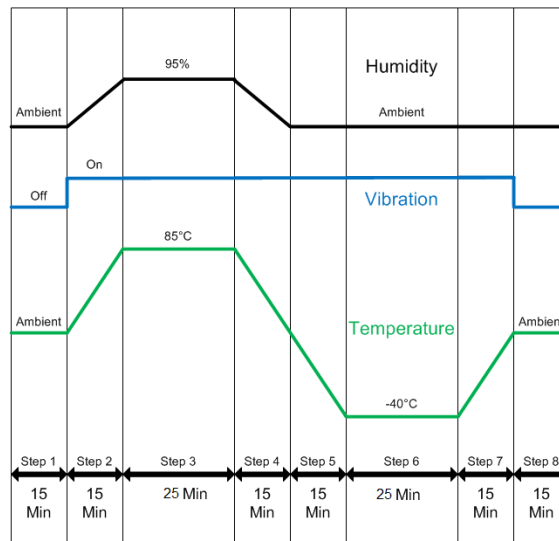


Figure 7.11.1 – Salt Water Immersion Dunk Soak Cycles Profile



Break Point	Frequency	Value (g ² /Hz)
1	10	0.0500
2	50	0.0500
3	100	0.0187
4	200	0.0187
5	500	0.0100
6	1000	.0025
Vibration Level		3.4 grms

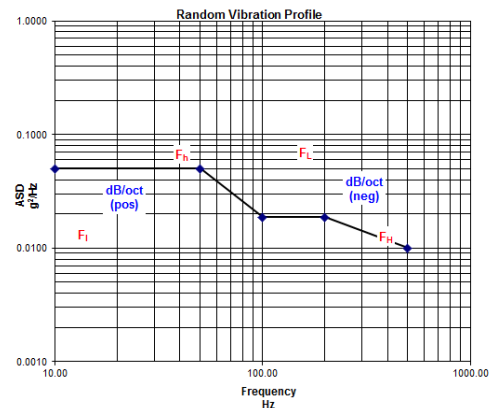


Figure 7.11.2 – Salt Water Immersion AGREE Cycle Profile

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Test Acceptance Criteria

- For all powered tests, all critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.13 Exposure to Chemicals and Oils

Test Overview

The DUT is subjected to a chemical exposure of selected chemicals listed in table below. The engineer will list all applicable chemicals that the DUT is to be subjected to during this test in the TR based upon mounting location. The testing is to follow work instruction Y082010 and is usually performed by the materials lab. The engineer will determine if testing will differ from this work instruction and add the additional tests to the Test Request (i.e. add temperature soak to the test).

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.4)
Bendix Work Instruction	Y082010
Typical State of Sample	Not Powered
Functional Test	Before and After Test

Potential Chemicals and Oils	
Engine Oils and Additives	Battery Acid
Transmission Oil	Waxes
Rear Axle Oil	Kerosene
Power Steering Fluid	Freon
Brake Fluid	Spray Paint
Axle Grease	Paint Strippers
Window Washer Solvent	Ether
Gasoline	Dust Control Agents (MgCl ₂)
Diesel Fuel	Moisture Control Agents (CaCl ₂)
Fuel Additives	Vinyl Plasticizers
Alcohol	Undercoating Material
Anti-Freeze Water Mixture	Muriatic Acid
Degreasers	Ammonia
Soap and Detergents	Diesel Exhaust Fluid (32.5% solution of high-purity urea in de-mineralized water)
Steam	

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Test Parameters

Test Parameters	
Parameter	Value
Chemicals Tested	Engineer Selected

Test Acceptance Criteria

- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.14 Pressure Washing /Steam Clean Test*Test Overview*

The DUT is subjected to pressure wash test and steam clean test. The DUT shall be mounted in its normal operating position with drain holes if used open. If a sealed connector is used, it needs to be installed. This test is not required for unsealed modules with unsealed connectors. Perform the pressure wash test first then proceed to the steam clean test. Each DUT should be exposed to the total amount of cycles in a manner that has each of the sides of the DUT having an equal amount of cycles (63 applications on each surface of a six sided device if testing to 378 total cycles). If a round DUT is being tested, apply 63 applications on each of the top and bottom. The remainder of the allotted cycles would be equally distributed around the circumference of the DUT.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.5
Typical State of Sample	Not Powered
Functional Test	Before and After Test

Test Parameters

Test Parameters	
Parameter	Value
High Pressure Wash	
Water Temperature	Ambient Tap Water
Water Pressure	1020 Psi
Distance from ECU	8 to 12 Inches
Flow Rate	150 Gal/Hr
Cycle Time	3 sec
Number of Cycles	<u>378</u>
Steam Clean Wash	
Water Temperature	93°C ± 5°C
Water Pressure	<u>3500 Psi</u>
Distance from ECU	8 to 12 Inches
Flow Rate	<u>360 Gal/Hr</u>
Cycle Time	30 sec
<u>Spray Cycles</u>	<u>Each exposed surface</u>

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Test Acceptance Criteria

- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.15 Fungus

Test Overview

The DUT is inoculated with a fungal spore mixture and allowed to incubate under cyclic temperature and humidity conditions to permit fungal growth.

It is possible that testing need not be done if the product can comply by design. This can be done by reviewing product material and component datasheets to ensure they are non-nutritive to fungus (SAE J1455 MAR 2017, section 4.6.4).

Test Summary

Test Summary	
SAE Specification	SAE J1455 MAR 2017, section 4.6
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Typical Fungal Spore Mixture	Aspergillus Flavus, A. versicolor, and Penicillium Funiculosum
Incubation Period	30 Days

Test Acceptance Criteria

- For all powered tests, all critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.16 Dust and Sand

Test Overview

The DUT is subjected to a Dust and Sand Test. The dust that is used will conform to ISO 5011 coarse grade, such as Portland cement.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.7
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Temperature	23°C
Concentration	0.88 g/m ³
Length of Test	24 Hours

Test Acceptance Criteria

- For all powered tests, all critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.17 Gravel Bombardment

Test Overview

The DUT is subjected to a gravel bombardment with gravel outlined in SAE J400 REV NOV2002, Section 5. This test is not required for unsealed modules with unsealed connectors.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.8
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Temperature	23°C
Gravel Pass Through	15.86 mm Space Screen
Gravel Retained	9.53 mm Space Screen
<u># of Bombardments</u>	<u>1 or number specified by product engineer</u>

Test Acceptance Criteria

- For all powered tests, all critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.18 Altitude (Operating)

Test Overview

The DUT is subjected to atmospheric conditions listed below along with the same temperature cycle that is performed during the Thermal Cycle Tests.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <i>MAR 2017</i> , section 4.9* <i>with some</i> <i>modifications</i>
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Temperature	Figure 7.3.1
Atmospheric Conditions	<u>4.57</u> Kilometers @ 52.7 kPa Absolute Pressure
Length of Test	24 Hours (1 Temp Cycle)

Test Acceptance Criteria

- For all powered tests, all critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.19 Altitude (Non-Operating)

Test Overview

The DUT is subjected to atmospheric conditions listed below along with the same temperature cycle that is performed during the Thermal Cycle Tests.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <i>MAR 2017</i> , section 4.9 <i>* with some modifications</i>
Typical State of Sample	Not Powered
Functional Test	Before and After Test

Test Parameters

Test Parameters	
Parameter	Value
Temperature	Figure 7.3.1
Atmospheric Conditions	<u>15.24 Kilometers @ 10 kPa</u> Absolute Pressure
Length of Test	24 Hours (1 Temp Cycle)

Test Acceptance Criteria

- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.20 Combined Environmental Testing (AGREE Test)

Test Overview

The damaging effects from combined environmental testing (AGREE) testing can be greater than exposing the DUT to each of the elements that make of the AGREE test in series. The DUT is subjected to the profile described in figure 7.20.1. This profile combines temperature, humidity, and vibration.

Test Summary

Test Summary	
SAE Specification	SAE J1455 <u>MAR 2017</u> , section 4.12
Typical Number Tested	5
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters	
Parameter	Value
Test Voltage	Table 6.2
Temperature	Figures 7.20.1 & 7.20.2
g-Force	Figures 7.20.1 & 7.20.2
Length of Test	102 Cycles (\approx 21 Days)

Notes:

- For in cab ECUs reduce the humidity down to 20%
- For ECUs EC-80 ECUs with BDR enable, run BDR enabled for 4 days then disable BDR. The reason for this is with the legacy cycle boxes the ABS cycle causes BDR hard stop events which will cause DTC of EEPROM writes exceeded.

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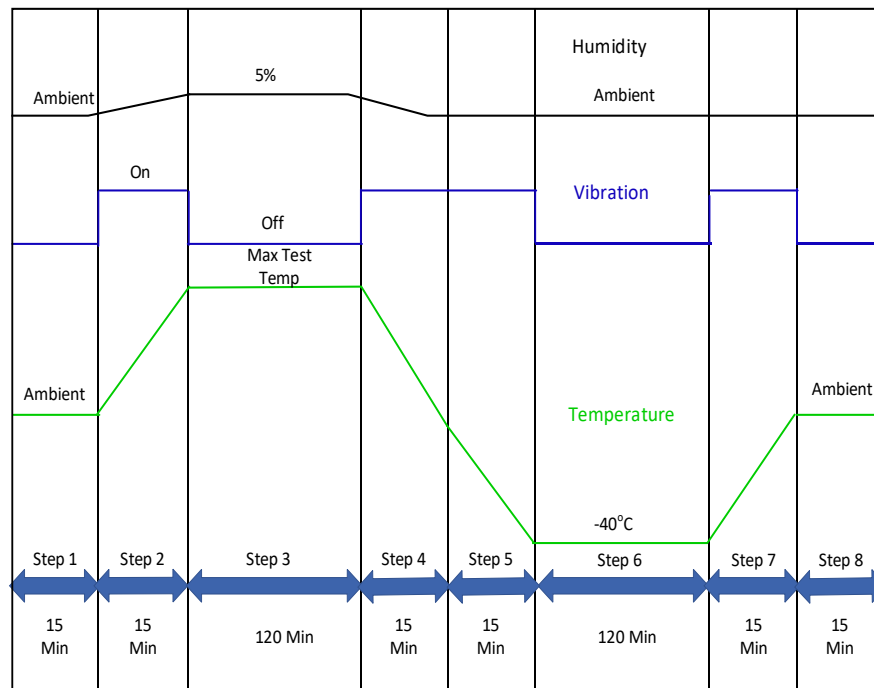
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Steps 2 Through 7 Constitute One Cycle

Break Point	Frequency	Value (g ² /Hz)
1	10	0.009494
2	50	0.009494
3	100	0.003551
4	200	0.003551
5	500	0.001899
6	1000	0.000475
Vibration Level		1.50 grms

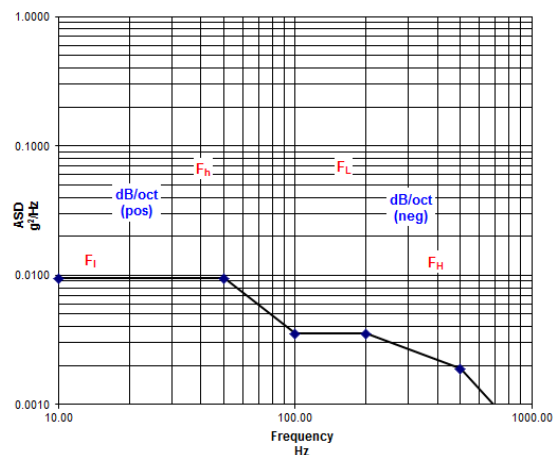


Figure 7.20.1 – AGREE Profile (Cab-Mounted)

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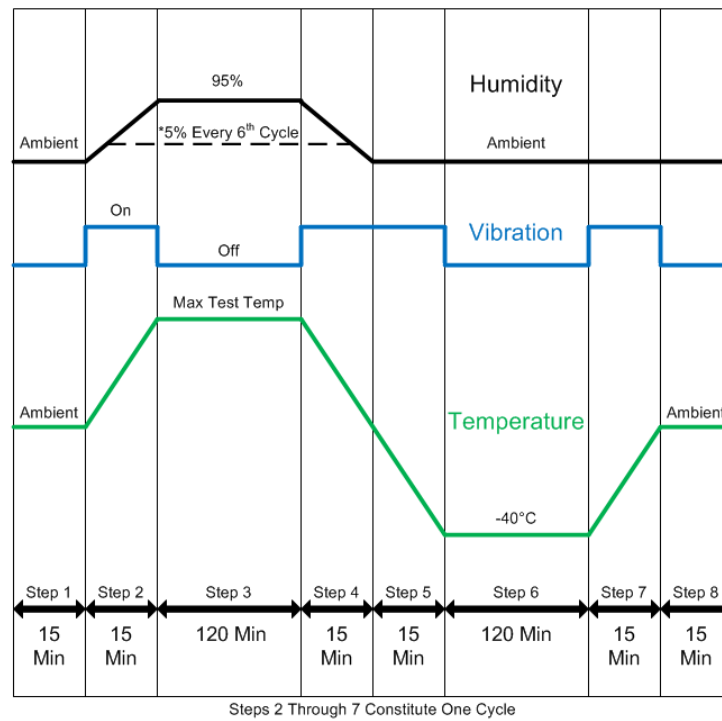
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Break Point	Frequency	Value (g^2/Hz)
1	10	0.05
2	50	0.05
3	100	0.0187
4	200	0.0187
5	500	0.01
6	1000	0.0025
Vibration Level		3.4 grms

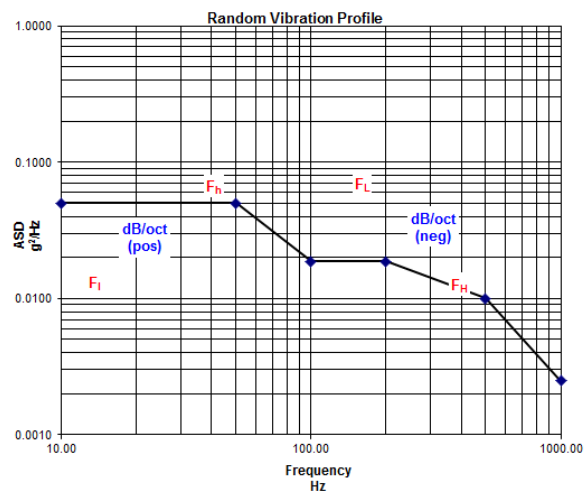


Figure 7.20.2 – AGREE Profile (Chassis-Mounted)

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Test Acceptance Criteria

- For all powered tests, all critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test.

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7.21 Salt Spray Test

Test Overview

The DUT will be subjected to Salt Spray test cycle outlined in the test parameters below. The total test time is 1,023 hours.

Test Summary

Test Summary	
SAE Specification	N/A
Typical State of Sample	Powered
Functional Test	Before/During/After Test

Test Parameters

Test Parameters		
Step	Parameter	Time
1	Ramp to Max Temp (Table 6.1)	30 Min
2	Soak Max Temp (Table 6.1)	2 Hours
3	Ramp to 25 °C	1 Hour
4	Soak at 25 °C with 5% Salt Spray on for 10 Seconds every Hour	70 Hours
5	Ramp to 50 °C with 95% Humidity	1 Hour
6	Soak at 50°C @ 95% Humidity	96 Hours
7	Repeat six times	

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Test Acceptance Criteria

- For all powered tests, all critical test parameters (e.g. DTC's, temperature, pressures, sensor outputs, solenoid activations, etc.) shall be monitored and analyzed for anomalies continuously during the duration of the test.
- The DUTs shall pass a functional test during this test. This functional test may differ from the one performed at the end of the test.
- There should be no degradation of performance or function after the completion of this test. It will meet the requirements at room temperature as defined by the responsible engineer.
- At the completion of the functional tests when testing is complete, the DUTs shall be disassembled then inspected for internal contamination and material degradation as defined by the responsible engineer.
- The DUT will not have any physical damage at the completion of this test. Minor surface corrosion is acceptable (due to galvanic reaction) but no structural damage should occur.

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7.22 List of Various Additional Tests of Interest

Test	Reference	Notes
Aggressive Wheel End Corrosion Test	IEC-68-2-52	

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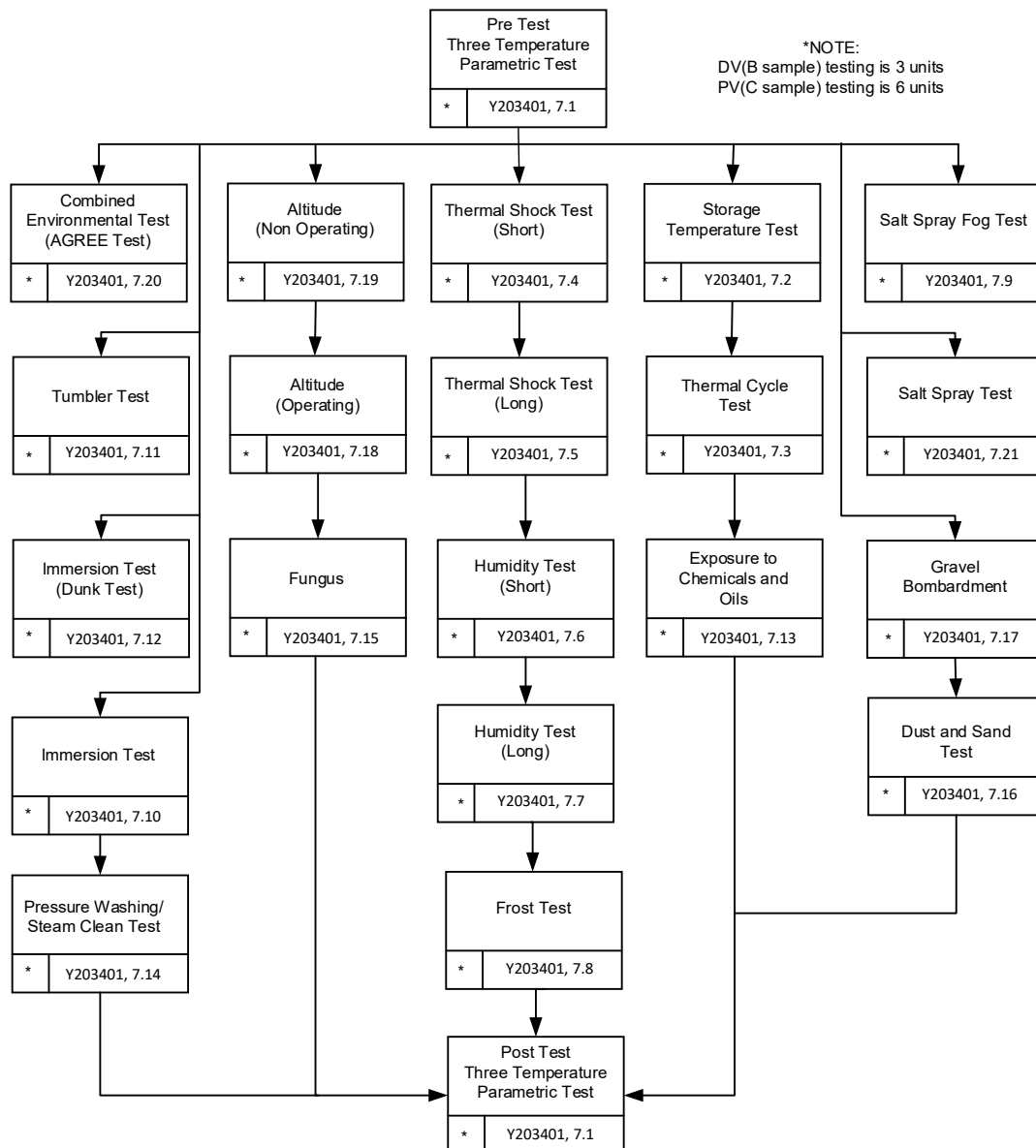
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8 Recommended Test Sequences

Final sequence and test sample quantity to be determined by the product group.



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