EA12-004

GM

11-26-2012

ATTACHMENT Q7

12180 bulletin

Bulletin No.: 12180
Date:
Draft: #1

Recall Bulletin

PRODUCT SAFETY RECALL

SUBJECT: **Driver Door Switch Short Circuit**

MODELS: **2006-2007 Buick Rainier**
2006 Chevrolet TrailBlazer EXT
2006-2007 Chevrolet TrailBlazer
2006 GMC Envoy XL
2006-2007 GMC Envoy
200~~6~~5-2007 Saab 9-7X
Originally Sold or Currently Registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, Wisconsin,

Originally Sold or Currently Registered in New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Quebec.

DRAFT
A FINAL VERSION OF THIS DRAFT WILL BE USED IF THERE IS A DECISION TO RECALL

10/26/12 – 2005MY Saab 9-7X discovered – added to both door module bulletin but revise if necessary once their location is determined – corrosion vs. non.

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CONDITION

General Motors has decided that a defect, which relates to motor vehicle safety, exists in **certain** 2005-2007 model year Saab 9-7X; 2006 model year Chevrolet TrailBlazer EXT and GMC Envoy XL; and 2006-2007 model year Buick Rainier, Chevrolet TrailBlazer, and GMC Envoy~~, and Saab 9-7X~~ vehicles originally sold or currently registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, Wisconsin, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, and Quebec. If fluid enters the driver's door module, it may cause corrosion that could result in a short in the circuit board. A short may cause the power door lock and power window switches to function intermittently or become inoperative.

In rare cases, a short may cause overheating, which could melt components of the door module, producing odor, smoke, or a fire.

CORRECTION

Dealers are to test the driver's window and door lock switches for proper operation. If the switches function properly, dealers are to install a protective coating to the door module. If the switches do not function properly, dealers are to install a new door module.

VEHICLES INVOLVED

All involved vehicles are identified by Vehicle Identification Number on the Investigate Vehicle History screen in GM Global Warranty Management system. Dealership service personnel should always check this site to confirm vehicle involvement prior to beginning any required inspections and/or repairs. It is important to routinely use this tool to verify eligibility because not all similar vehicles may be involved regardless of description or option content.

For dealers with involved vehicles, a listing with involved vehicles containing the complete vehicle identification number, customer name, and address information has been prepared and will be provided to US and Canadian dealers through the GM GlobalConnect Recall Reports, or sent directly to export dealers. Dealers will not have a report available if they have no involved vehicles currently assigned.

The listing may contain customer names and addresses obtained from Motor Vehicle Registration Records. The use of such motor vehicle registration data for any purpose other than follow-up necessary to complete this recall is a violation of law in several states/provinces/countries. Accordingly, you are urged to limit the use of this report to the follow-up necessary to complete this recall.

PART INFORMATION

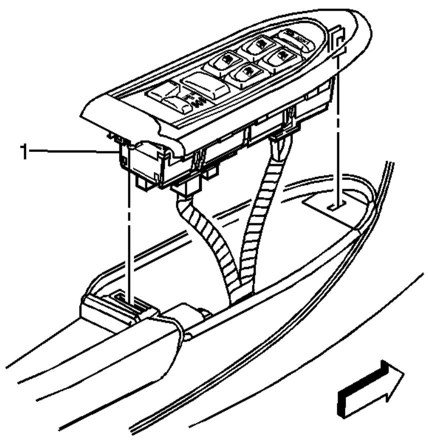
Parts required to complete this recall are to be obtained from General Motors Customer Care and Aftersales (GMCC&A). Please refer to your “involved vehicles listing” before ordering parts. Normal orders should be placed on a DRO = Daily Replenishment Order. In an emergency situation, parts should be ordered on a CSO = Customer Special Order.

Part Number	**Description**	**Quantity/ Vehicle**
19119236	SWITCH KIT,SI WDO	1

SERVICE PROCEDURE

1. Perform a functional test on the driver side door lock and side window switch. Test all switch functions to ensure the driver side door lock and side window switch functions as designed.
    - If the driver side door lock and side window switch passes the functional test, proceed to Step 2.

- If the driver side door lock and side window switch does NOT pass the functional test, replace the driver side door lock and side window switch. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.



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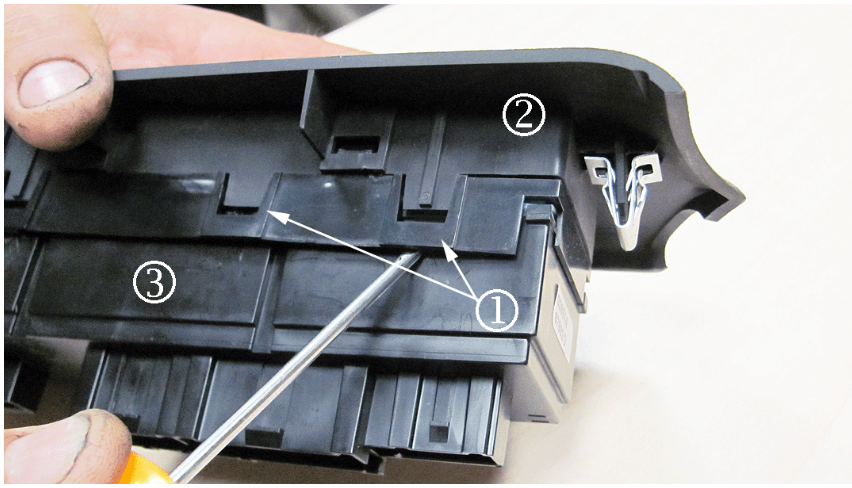
2. Remove the driver side door lock and side window switch. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.

Caution: *To avoid part damage, ensure your hands and work bench are clean BEFORE performing the door lock and side window switch and door module modifications in this bulletin.*

3. Place the driver side door lock and side window switch assembly on a clean work bench.
4. Separate the door module from the door lock and side window switch assembly.

2917368

4.1 Using a razor blade or equivalent, cut the door module label along the seam of the door module as shown in the illustration.



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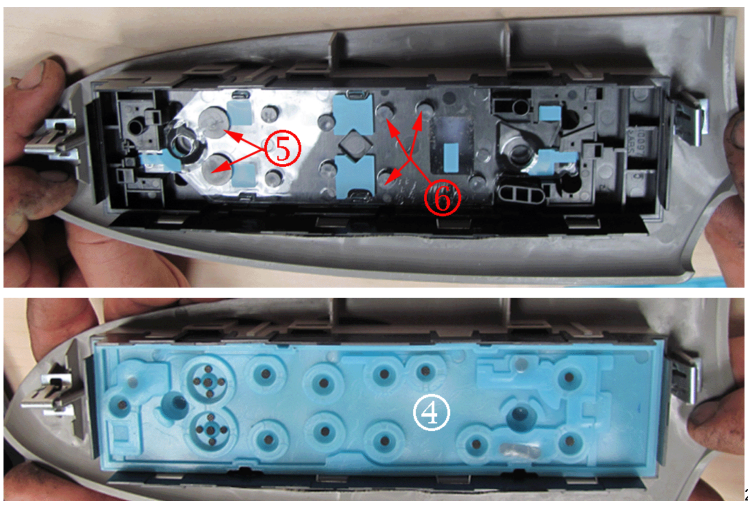
4.2 Using a small flat-blade screw driver, carefully disengage the door module tabs (1).



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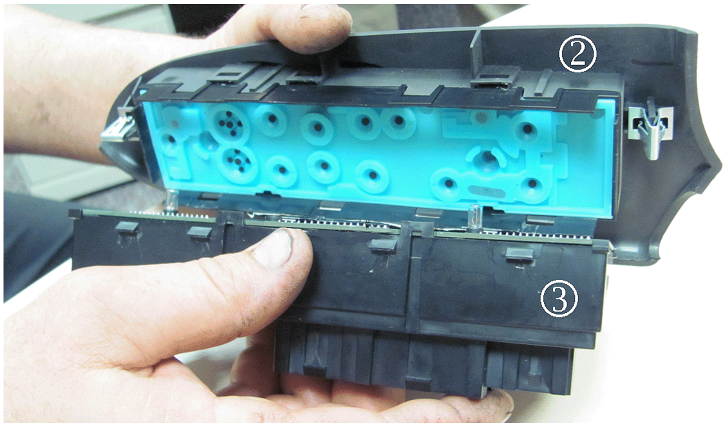
Note: If the door lock and side window switch assembly membrane sticks (4) to the door module contact board and falls out of the door module assembly during the disassembly of the door module and door lock and side window switch assembly, re-install the large actuator pins (5) and small actuator pins (6) and membrane (4). Refer to illustration.



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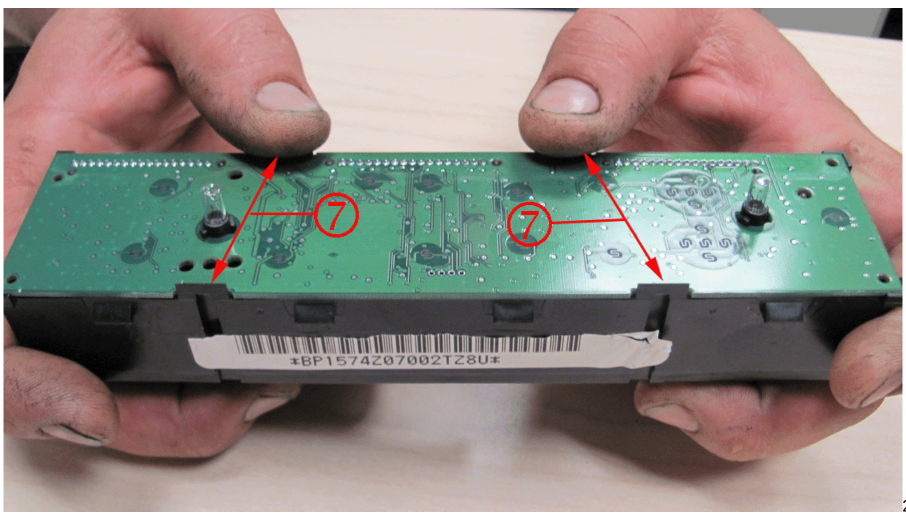
4.3 Separate the door module (3) from the door lock and side window switch assembly (2).

5. Place the door lock and side window switch assembly in a safe location while modifying the door module.



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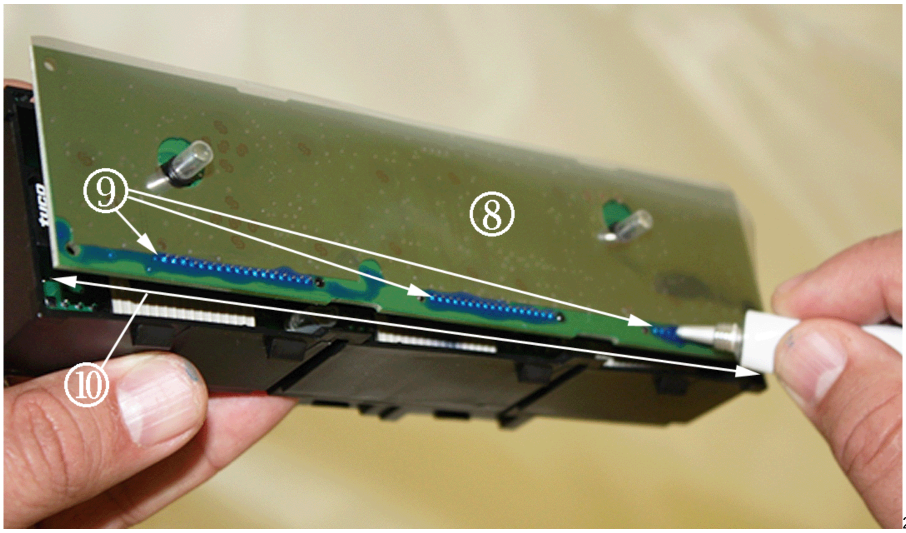
6. Separate the contact board from the door module housing by depressing the contact board tabs (7). Do NOT remove the contact board from the door housing module.



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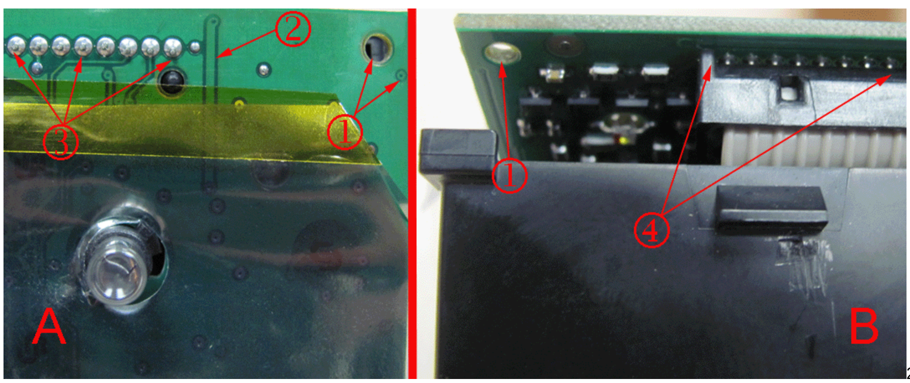
Note: Do NOT attach the ESD protective barrier (8) over the connector pins (9) or contact pads.

7. Remove the backing paper from the ESD protective barrier (8) and attach it to the contact board. Attach the ESD protective barrier (8) along the edge of the connector pins (9). Refer to illustration.
8. Apply the protective coating to the top side of the contact board. Apply the protective coating over the entire length (10) of the contact board from the ESD protective barrier tape edge (8) to the contact board edge.



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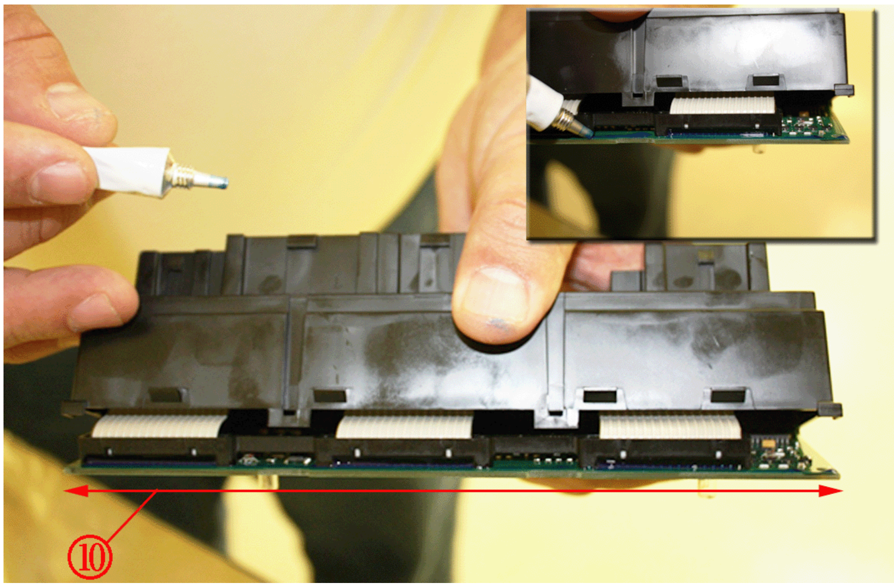
Top "A" and bottom "B" views of the contact board include examples of connector (4), connector pins (3), traces (2), and vias (1).

9. Ensure the protective coating covers the connector pins, traces and vias (holes) in the application area of the contact board.



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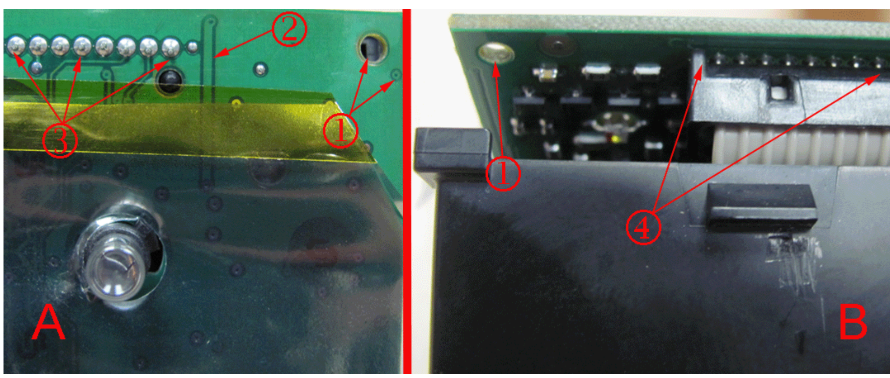
10. Apply the protective coating to the bottom side of the contact board. Apply the protective coating over the entire length (10) of the contact board.



2917380

Top "A" and bottom "B" views of the contact board include examples of connector (4), connector pins (3), traces (2), and vias (1).

11. Ensure the protective coating covers the connector pins, traces and vias (holes) in the application area of the contact board.

Caution: *The cure time for the material is 1 hour. To avoid part damage, do NOT proceed to Step 17 until the material has cured for 1 hour.*

12. Wait 60 minutes to allow the liquid material to cure to a "tacky" state.
13. Remove ESD protective barrier from the contact board of the door module.

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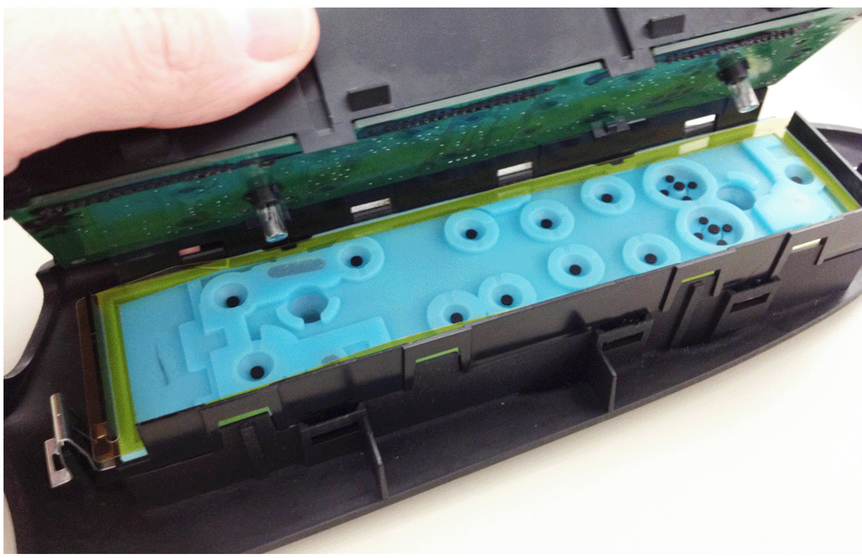
14. Insert the Mylar Kapton® gasket (10) to the inside surface covering the open cutouts of the door lock and side window switch membrane.



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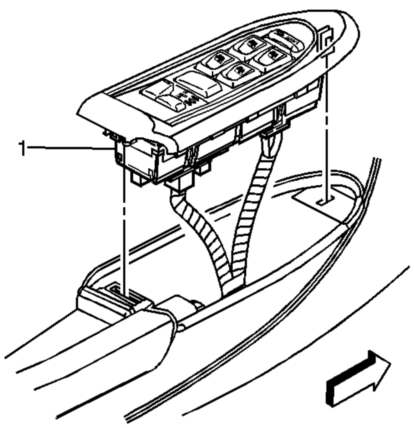
15. Assemble the door module and door lock and side window switch.



Note: Do not program the door module after installing the driver side door lock and side window switch into the door.

16. Install the driver side door lock and side window switch into the door. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.
17. Perform a functional test on the driver side door lock and side window switch. Test all switch functions to ensure the driver side door lock and side window switch functions as designed. Replace the driver side door lock and side window switch if it fails the functional test. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.

CUSTOMER REIMBURSEMENT – For GM US

Customer requests for reimbursement of previously paid repairs for the recall condition are to be submitted to the dealer by <insert 1 year, 2013>, unless otherwise specified by state law. If this is not convenient for the customer, they may mail the completed Customer Reimbursement Request Form and all required documents to the GM Customer Assistance Center.

All reasonable and customary costs to correct the condition described in this bulletin should be considered for reimbursement. Any questions or concerns should be reviewed with your District Service Manager – Aftersales prior to processing the request.

When a customer requests reimbursement, they must provide the following:

- A completed Customer Reimbursement Request Form. This form is mailed to the customer or can be obtained through GM GlobalConnect.
- The name and address of the person who paid for the repair.
- Paid receipt confirming the amount of the repair expense, a description of the repair, and the person or entity performing the repair.

IMPORTANT: GM requires dealers to approve or deny a reimbursement request within 30 days of receipt. If a reimbursement request is approved, the dealer should immediately issue a check to the customer and submit an appropriate warranty transaction for the incurred expense. If a reimbursement request is denied, the dealer MUST provide the customer with a clear and concise explanation, in writing, as to why the request was denied. The bottom portion of the Customer Reimbursement Request Form may be used for this purpose. If the denial was due to missing documents, the customer can resubmit the request when the missing documents are obtained, as long as it is still within the allowed reimbursement period.

Warranty transactions for customer reimbursement of previously paid repairs are to be submitted as required by GM Global Warranty Management. Additional information can also be found in Warranty Administration Bulletin 11-00-89-004.

CUSTOMER REIMBURSEMENT – Saab US

All customer requests for previous repairs for this condition will be handled by the Customer Assistance Center, not by dealers.

A Reimbursement Claim Form is included with the customer letter.

CUSTOMER REIMBURSEMENT - For Canada and Export

Customer requests for reimbursement of previously paid repairs to correct the condition described in this bulletin are to be submitted to the dealer prior to or by <insert 1 year, 2013>.

When a customer requests reimbursement, they must provide the following:

- Proof of ownership at time of repair.
- Original paid receipt confirming the amount of unreimbursed repair expense(s) (including Service Contract deductibles), a description of the repair, and the person or entity performing the repair.

All reasonable and customary costs to correct the condition described in this bulletin should be considered for reimbursement. Any questions or concerns should be reviewed with your GM representative prior to processing the request.

WARRANTY TRANSACTION INFORMATION

Submit a transaction using the table below. Saab dealers not affiliated with General Motors must process transactions through their affiliated GM dealer per regular warranty procedures.

Labor Code	Description	Labor Time	Net Item
V----	Install Protective Coating to Driver Side Door Lock Window Switch	0.7	N/A
V----	Door Lock & Side Window Switch Replacement (inc. programming)	0.5	N/A
V----*	Customer Reimbursement Approved – Not for Saab Use	0.2	**
V---	Customer Reimbursement Denied - For US dealers only	0.1	N/A

* Customer reimbursement will close this recall.

** The amount identified in “Net Item” should represent the dollar amount reimbursed to the customer.

CUSTOMER NOTIFICATION – For US and Canada

General Motors will notify customers of this recall on their vehicle (see copy of customer letter included with this bulletin

CUSTOMER NOTIFICATION – For Export

Letters will be sent to known owners of record located within areas covered by the US National Traffic and Motor Vehicle Safety Act. For owners outside these areas, dealers should notify customers using the attached sample letter.

DEALER RECALL RESPONSIBILITY – For US and Export (US States, Territories, and Possessions)

It is a violation of Federal law for a dealer to deliver a new motor vehicle or any new or used item of motor vehicle equipment (including a tire) covered by this notification under a sale or lease until the defect or noncompliance is remedied.

The US National Traffic and Motor Vehicle Safety Act provides that each vehicle that is subject to a recall of this type must be adequately repaired within a reasonable time after the customer has tendered it for repair. A failure to repair within sixty days after tender of a vehicle is prima facie evidence of failure to repair within a reasonable time. If the condition is not adequately repaired within a reasonable time, the customer may be entitled to an identical or reasonably equivalent vehicle at no charge or to a refund of the purchase price less a reasonable allowance for depreciation. To avoid having to provide these burdensome remedies, every effort must be made to promptly schedule an appointment with each customer and to repair their vehicle as soon as possible. In the recall notification letters, customers are told how to contact the US National Highway Traffic Safety Administration if the recall is not completed within a reasonable time.

DEALER RECALL RESPONSIBILITY – All

All unsold new vehicles in dealers' possession and subject to this recall must be held and inspected/repaired per the service procedure of this recall bulletin before customers take possession of these vehicles.

Dealers are to service all vehicles subject to this recall at no charge to customers, regardless of mileage, age of vehicle, or ownership, from this time forward.

Customers who have recently purchased vehicles sold from your vehicle inventory, and for which there is no customer information indicated on the dealer listing, are to be contacted by the dealer. Arrangements are to be made to make the required correction according to the instructions contained in this bulletin. A copy of the customer letter is provided in this bulletin for your use in contacting customers. Recall follow-up cards should not be used for this purpose, since the customer may not as yet have received the notification letter.

In summary, whenever a vehicle subject to this recall enters your vehicle inventory, or is in your dealership for service in the future, you must take the steps necessary to be sure the recall correction has been made before selling or releasing the vehicle.

Month 2012

Dear General Motors/Saab Customer:

This notice is sent to you in accordance with the requirements of the National Traffic and Motor Vehicle Safety Act.

General Motors has decided that a defect, which relates to motor vehicle safety, exists in certain 2005-2007 model year Saab 9-7X; 2006 model year Chevrolet TrailBlazer EXT and GMC Envoy XL; and 2006-2007 model year Buick Rainier, Chevrolet TrailBlazer, and GMC Envoy~~, and Saab 9-7X~~ vehicles originally sold or currently registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, Wisconsin, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, and Quebec. As a result, GM is conducting a safety recall. We apologize for this inconvenience. However, we are concerned about your safety and continued satisfaction with our products.

I M P O R T A N T

- Your vehicle is involved in safety recall 12180.
- Schedule an appointment with your GM dealer/Authorized Saab Service Center.
- This service will be performed for you at **no charge**.

Why is your vehicle being recalled?

If fluid enters the driver's door module, it may cause corrosion that could result in a short in the circuit board. A short may cause the power door lock and power window switches to function intermittently or become inoperative. In extremely rare cases, a short may cause overheating, which could melt components of the door module, producing odor, smoke, or a fire.

What will we do?

Your GM dealer/Authorized Saab Service Center will test the driver's window and door lock switches for proper operation. If the switches function properly, a protective coating will be applied to the door module. If the switches do not function properly, a new door module will be installed. This service will be performed for you at **no charge**. Because of service scheduling requirements, it is likely that your dealer/Authorized Saab Service Center will need your vehicle longer than the actual service correction time of approximately 30 minutes.

If your vehicle is within the New Vehicle Limited Warranty, your dealer/Authorized Saab Service Center may provide you with shuttle service or some other form of courtesy transportation while your vehicle is at the dealership for this repair. Please refer to your Owner Manual and your dealer/Authorized Saab Service Center for details on courtesy transportation.

What should

You should contact your GM dealer/Authorized Saab Service

you do? Center to arrange a service appointment as soon as possible.

Did you already pay for this repair? If you have paid for repairs for the recall condition, please complete the enclosed form and present it to your dealer/Authorized Saab Service Center with all required documents. Working with your dealer/Authorized Saab Service Center will expedite your request, however, if this is not convenient, you may mail the completed form and all required documents to Reimbursement Department, PO Box 33170, Detroit, MI 48232-5170. The completed form and required documents must be presented to your dealer/Authorized Saab Service Center or received by the Reimbursement Department by [1 year, 2013], unless state law specifies a longer reimbursement period. Because you have already had this condition repaired, you do not need to take your vehicle to your dealer/Authorized Saab Service Center for this recall.

Do you have questions? If you have questions or concerns that your dealer/Authorized Saab Service Center is unable to resolve, please contact the appropriate Customer Assistance Center at the number listed below.

Division	Number	Text Telephones (TTY)
Buick	1-800-521-7300	1-800-832-8425
Chevrolet	1-800-222-1020	1-800-833-2438
GMC	1-800-462-8782	1-888-889-2438
Saab	1-855-880-0808	
Guam	65-6267-1752	
Puerto Rico – English	1-800-496-9992	
Puerto Rico – Español	1-800-496-9993	
Virgin Islands	1-800-496-9994	

If after contacting your dealer/Authorized Saab Service Center and the Customer Assistance Center, you are still not satisfied we have done our best to remedy this condition without charge and within a reasonable time, you may wish to write the Administrator, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590, or call the toll-free Vehicle Safety Hotline at 1.888.327.4236 (TTY 1.800.424.9153), or go to http://www.safercar.gov. The National Highway Traffic Safety Administration Campaign ID Number for this recall is 12VXXX.

Federal regulation requires that any vehicle lessor receiving this recall notice must forward a copy of this notice to the lessee within ten days.

Jim Moloney
General Director,
Customer and Relationship Services

Enclosure
GM Recall #12XXX

EA12-004

GM

11-26-2012

ATTACHMENT Q7

12180-1 letter

GM

SAFETY RECALL NOTICE

October 2012

<CustomerName>
<CustomerAddress>

Dear <CustomerName>:

This notice is sent to you in accordance with the requirements of the National Traffic and Motor Vehicle Safety Act.

General Motors has decided that a defect, which relates to motor vehicle safety, exists in certain <Year> model year <VINDivisionName> <Vehicle_Name> vehicles originally sold or currently registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin. As a result, GM is conducting a safety recall. We apologize for this inconvenience. However, we are concerned about your safety and continued satisfaction with our products.

I M P O R T A N T

Your <Year> model year <VINDivisionName> <Vehicle_Name>, VIN <VIN>, is involved in safety recall <Recall>.

Why is your vehicle being recalled?

If fluid, such as melted snow containing road salt, enters the driver's door module, it may cause corrosion that could result in a short in the circuit board. A short may cause the power door lock and power window switches to function intermittently or may stop working. A short may also cause overheating, which could melt components of the door module, producing odor, smoke, or a fire. Additionally, the windows may raise or lower themselves, without user input. These conditions may occur even with the vehicle parked and the key removed. It is advised that you park the vehicle outdoors until it has been remedied.

What will we do?

PARTS ARE NOT CURRENTLY AVAILABLE, but when parts are available, your <DIV_DLR> dealer will repair the driver door module. This service will be performed for you at **no charge**.

We are working as quickly as possible to correct this condition. When parts are available, we will send you another letter asking you to take your vehicle to your <DIV_DLR> dealer to have your vehicle serviced. If you have already paid for repairs for this condition, a reimbursement request form will be included with the letter.

Do you have questions?

If you have questions or concerns that your dealer is unable to resolve, please contact the <VINDivisionName> Customer Assistance Center at <DivCACPhone>.

Federal regulations require that any vehicle lessor receiving this recall notice must forward a copy of this notice to the lessee within ten days.

<Closing>

GM Recall #12180-1

EA12-004

GM

11-26-2012

ATTACHMENT Q7

12180-1 Saab letter

SAFETY RECALL NOTICE

<CustomerName>
<CustomerAddress>

Dear <CustomerName>:

This notice is sent to you in accordance with the requirements of the National Traffic and Motor Vehicle Safety Act.

General Motors has decided that a defect, which relates to motor vehicle safety, exists in certain 2006 and 2007 model year Saab 9-7X vehicles originally sold or currently registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin. As a result, GM is conducting a safety recall. We apologize for this inconvenience. However, we are concerned about your safety and continued satisfaction with our products.

I M P O R T A N T
Your Saab 9-7X vehicle is involved in safety recall 12180.

Why is your vehicle being recalled?

If fluid, such as melted snow containing road salt, enters the driver's door module, it may cause corrosion that could result in a short in the circuit board. A short may cause the power door lock and power window switches to function intermittently or may stop working. A short may also cause overheating, which could melt components of the door module, producing odor, smoke, or a fire. Additionally, the windows may raise or lower themselves, without user input. These conditions may occur even with the vehicle parked and the key removed. It is advised that you park the vehicle outdoors until it has been remedied.

What will we do?

PARTS ARE NOT CURRENTLY AVAILABLE, but when parts are available, your Authorized Saab Service Center will repair the driver door module. This service will be performed for you at **no charge**.

We are working as quickly as possible to correct this condition. When parts are available, we will send you another letter asking you to take your vehicle to your Authorized Saab Service Center to have your vehicle serviced. If you have already paid for repairs for this condition, a reimbursement request form will be included with the letter.

Do you have questions?

If you have questions or concerns that your Authorized Saab Service Center is unable to resolve, please contact the Saab Customer Assistance Center at 1-855-880-0808.

Federal regulations require that any vehicle lessor receiving this recall notice must forward a copy of this notice to the lessee within ten days.

GM Recall #12180

EA12-004

GM

11-26-2012

ATTACHMENT Q7

20121024124116065

Date: 08/16/2012 Ref. number: Service / Field Action / G_0000143768

Subject: **Upcoming Safety Recall 12180**

GM CUSTOMER CARE AND AFTERSALES
DCS2799
URGENT - DISTRIBUTE IMMEDIATELY

Date: August 16, 2012

Subject: Upcoming Safety Recall 12180

Models: Certain 2006 Chevrolet Trailblazer EXT and GMC Envoy XL; 2006-2007 Chevrolet Trailblazer, GMC Envoy, Buick Rainer and SAAB 9-7x Vehicles Originally Sold or Currently Registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia and Wisconsin

To: All Buick, Chevrolet and GMC Dealers

Attention: General Manager, Service Advisor, Service Manager, Parts Manager, Used Vehicle Sales Manager and Warranty Administrator

Based on information from the National Highway Traffic Safety Administration (NHTSA) website, the media may report that General Motors will be announcing a safety recall that involves certain 2006 Chevrolet Trailblazer EXT and GMC Envoy XL; 2006-2007 Chevrolet Trailblazer, GMC Envoy, Buick Rainer and SAAB 9-7x vehicles originally sold or currently registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia and Wisconsin.

If fluid enters the driver's door module, it may cause corrosion that could result in a short in the circuit board. A short may cause the power door lock and power window switches to function intermittently or become inoperative. In extremely rare cases, a short may cause overheating, which could melt components of the door module, producing odor, smoke, or a fire.

GM engineering is in the process of validating the dealer service procedure to correct this condition. Dealers will be advised when the recall bulletin is being released and the date customer notification letters will be mailed.

The Investigate Vehicle History screen in the Global Warranty Management system will not be updated until the recall bulletin is released. Please do not call GM Technical Assistance.

END OF MESSAGE
GM CUSTOMER CARE AND AFTERSALES

Contact name: Loren Rusk E-Mail: loren.rusk@gm.com
Department: Service - Product Problem Resolution Phone:

Intended roles: General Manager, Parts Manager, Service Advisor, Service Manager, Used Vehicle Sales Manager, Warranty Administrator

Date: 10/09/2012 Ref. number: Service / Field Action / G_0000148089

Subject: **12180 – Upcoming Safety Recall - Driver's Door Module Corrosion**

GM CUSTOMER CARE AND AFTERSALES
DCS2827
URGENT - DISTRIBUTE IMMEDIATELY

Date:	October 9, 2012
Subject:	Upcoming Safety Recall 12180
Models:	Certain 2006 Chevrolet Trailblazer EXT and GMC Envoy XL; 2006-2007 Chevrolet Trailblazer, GMC Envoy, Buick Rainer and Saab 9-7x Vehicles Originally Sold or Currently Registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia and Wisconsin
To:	All GM Dealers and Saab Authorized Service Centers
Attention:	General Manager, Parts and Service Director, Parts Manager, Service Manager, Service Advisor, Used Vehicle Sales Manager, and Warranty Administrator

On August 16, 2012 all Buick, Chevrolet and GMC dealers were advised via GM GlobalConnect message #G_0000143768 of pending safety recall 12180. This product field action involves certain 2006 Chevrolet Trailblazer EXT and GMC Envoy XL; 2006-2007 Chevrolet Trailblazer, GMC Envoy, Buick Rainer and Saab 9-7x vehicles originally sold or currently registered in Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia and Wisconsin.

If fluid, such as melted snow containing road salt, enters the driver's door module, it may cause corrosion that could result in a short in the circuit board. A short may cause the power door lock and power window switches to function intermittently or may stop working. A short may also cause overheating, which could melt components of the door module, producing odor, smoke, or a fire. Additionally, the windows may raise or lower themselves, without user input. These conditions may occur even with the vehicle parked and the key removed.

There are approximately 249,000 U. S. vehicles involved and we are working closely with the supplier to quickly obtain the parts needed to correct this condition. You will be advised when sufficient parts are available to launch this recall.
However, as required by federal regulation, the attached notification letter is being sent today to all involved customers. This is a generic version of the actual letter which will be personalized for each customer. The letter informs customers of the safety defect and that we will correct it at no charge. It also advises customers that they will receive another letter asking them to visit their GM dealer or Saab Authorized Service Center to have this condition corrected when parts are available. In addition, the letter recommends that customers park their vehicles outdoors until the required correction has been performed.

The Investigate Vehicle History screen in the Global Warranty Management system will not be updated until the recall bulletin is released. Please do not call GM Technical Assistance.

END OF MESSAGE
GM CUSTOMER CARE AND AFTERSALES

EA12-004

GM

11-26-2012

ATTACHMENT Q7

door switch6

PARTS INFORMATION

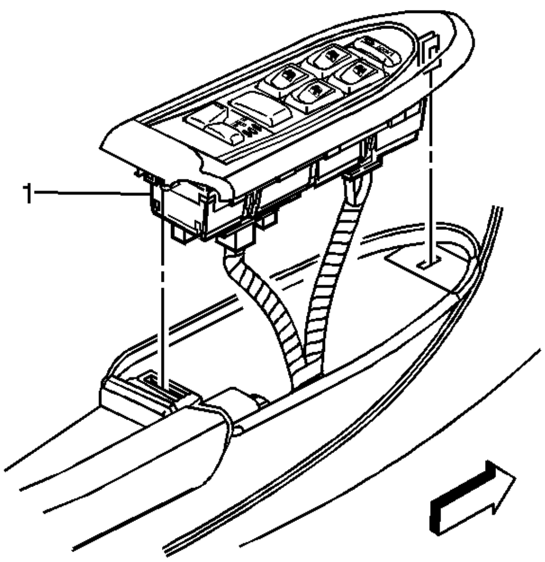
Door Lock and Side Window Switch, P/N XXXXXXX, if required

Door Lock and Side Window Switch Kit, P/N 19119236

Kit includes an ESD protective barrier, Mylar Kapton® gasket and a tube of protective coating.

SERVICE PROCEDURE

1. Perform a functional test on the driver side door lock and side window switch. Test all switch functions to ensure the driver side door lock and side window switch functions as designed.
   - If the driver side door lock and side window switch passes the functional test, proceed to step 2.
   - If the driver side door lock and side window switch does NOT pass the functional test, replace the driver side door lock and side window switch. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.



690976

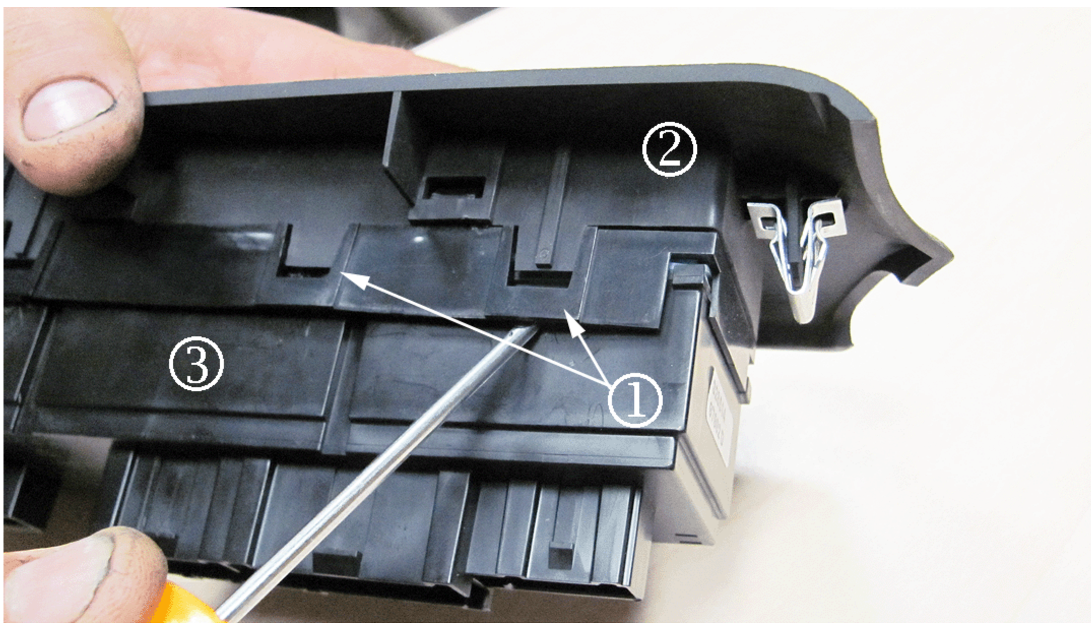
2. Remove the driver side door lock and side window switch. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.

Caution: To avoid part damage, ensure your hands and work bench are clean BEFORE performing the door lock and side window switch and door module modifications in this bulletin.

3. Place the driver side door lock and side window switch assembly on a clean work bench.
4. Separate the door module from the door lock and side window switch assembly.

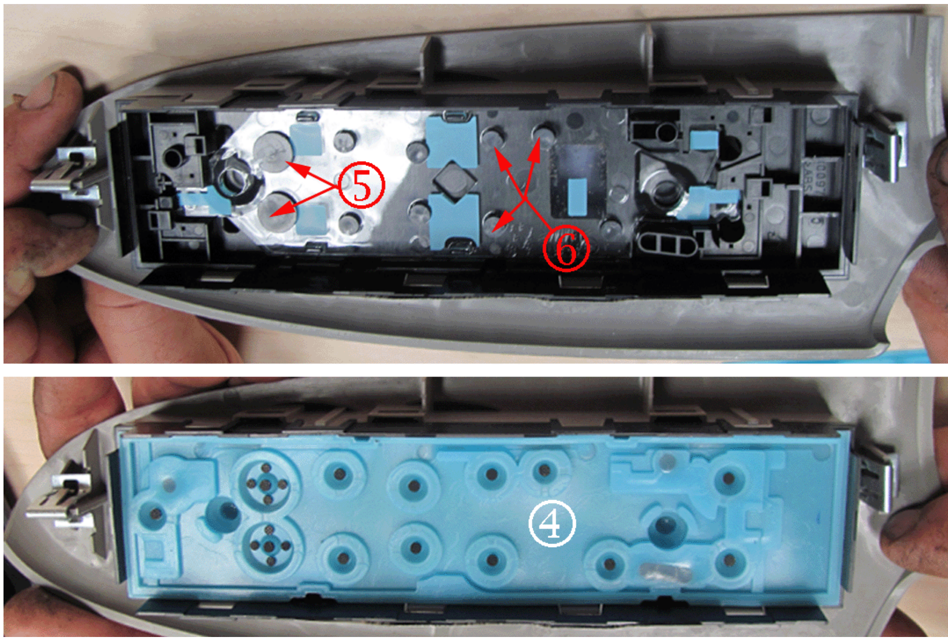
2917368

4.1 Using a razor blade or equivalent, cut the door module label along the seam of the door module as shown in the illustration.



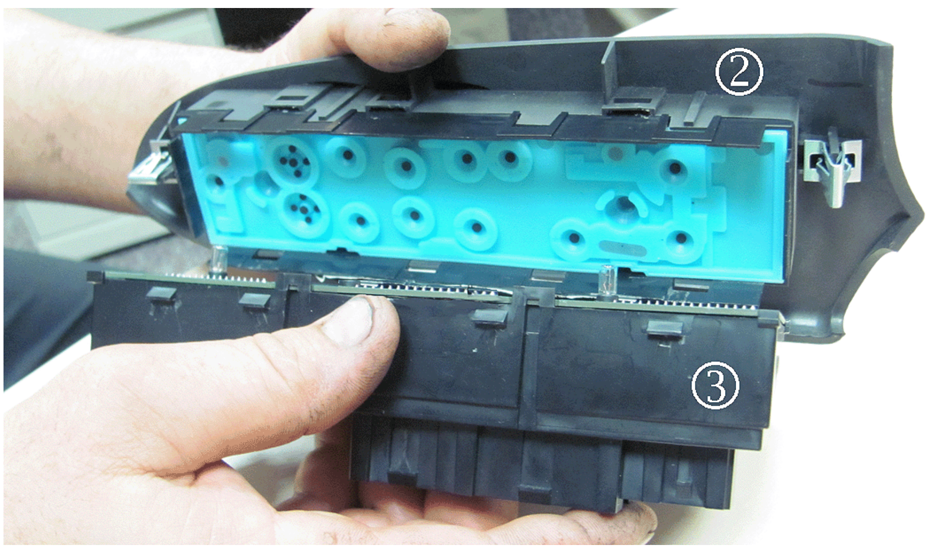
2917370

4.2 Using a small flat-blade screw driver, carefully disengage the door module tabs (1).



2917371

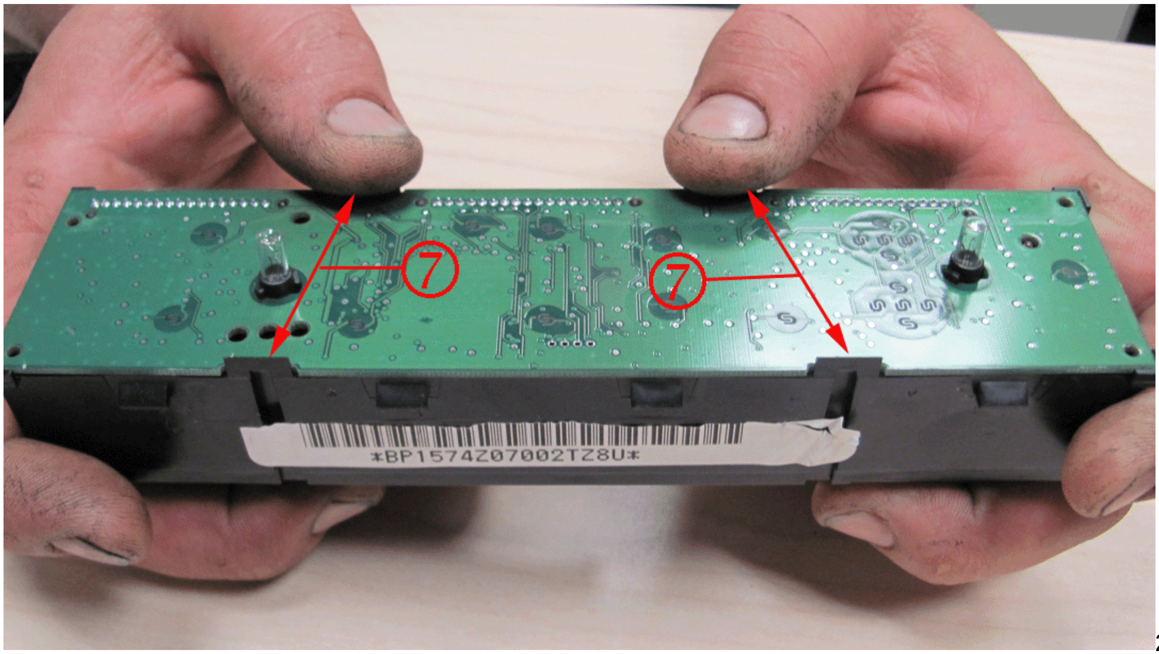
Note: If the door lock and side window switch assembly membrane sticks (4) to the door module contact board and falls out of the door module assembly during the disassembly of the door module and door lock and side window switch assembly, re-install the large actuator pins (5) and small actuator pins (6) and membrane (4). Refer to illustration.



2917377

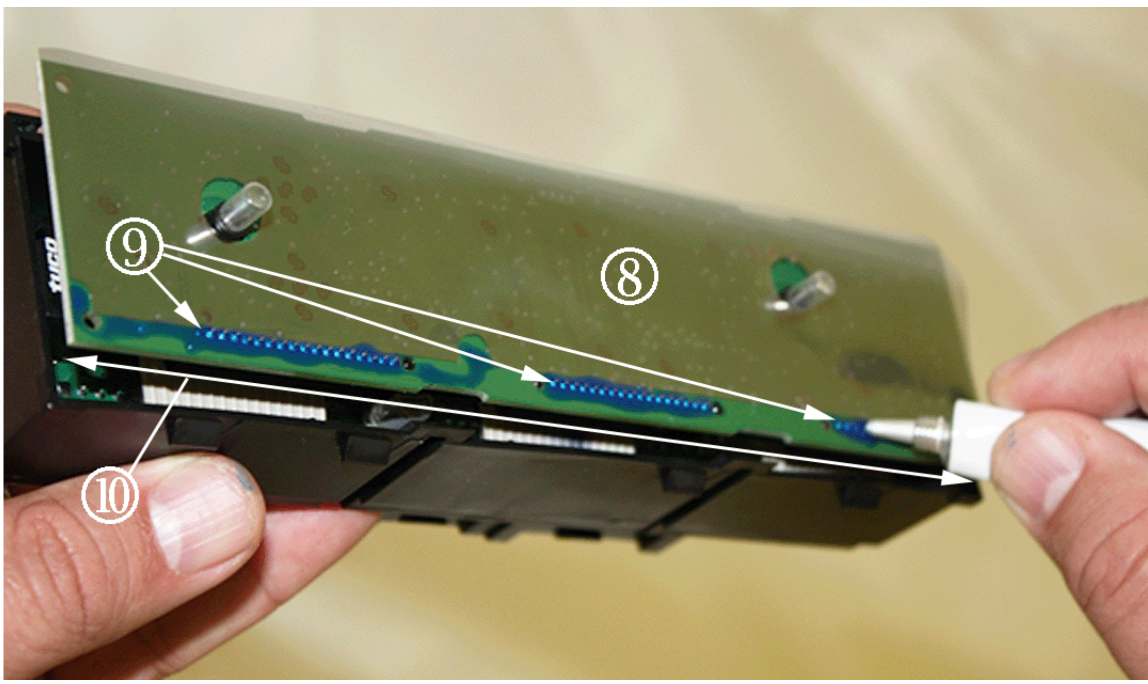
4.3 Separate the door module (3) from the door lock and side window switch assembly (2).

5. Place the door lock and side window switch assembly in a safe location while modifying the door module.



2917376

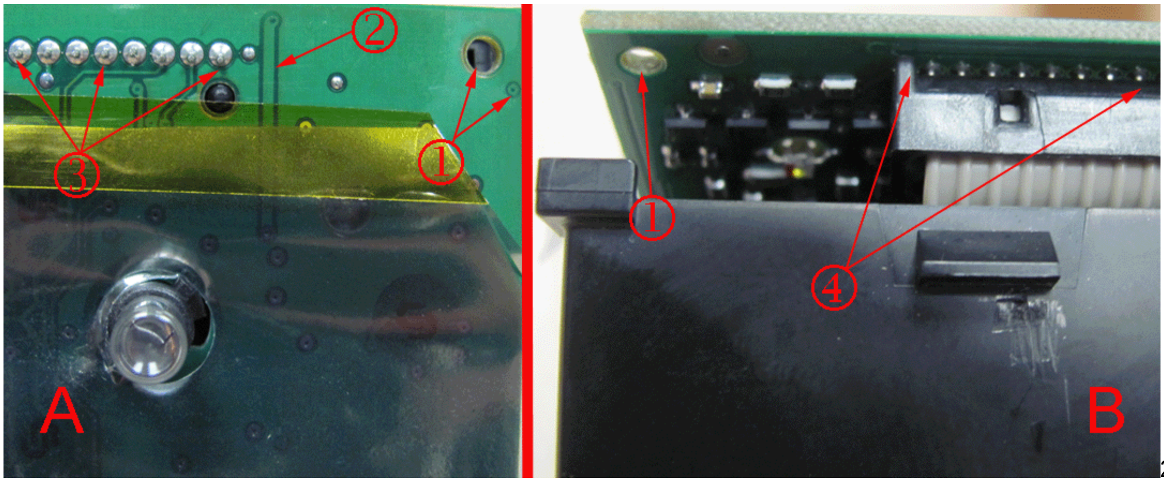
6. Separate the contact board from the door module housing by depressing the contact board tabs (7). Do NOT remove the contact board from the door housing module.



2917379

Note: Do NOT attach the ESD protective barrier (8) over the connector pins (9) or contact pads.

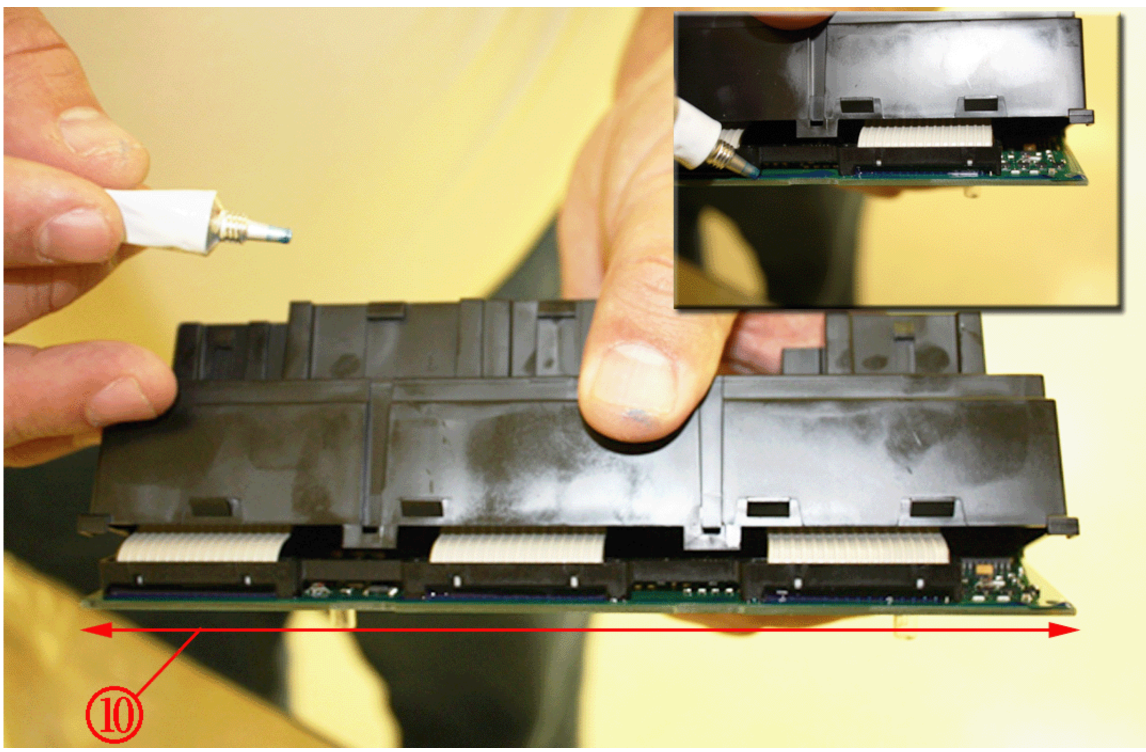
7. Remove the backing paper from the ESD protective barrier (8) and attach it to the contact board. Attach the ESD protective barrier (8) along the edge of the connector pins (9). Refer to illustration.
8. Apply the protective coating to the top side of the contact board. Apply the protective coating over the entire length (10) of the contact board from the ESD protective barrier tape edge (8) to the contact board edge.



2917380

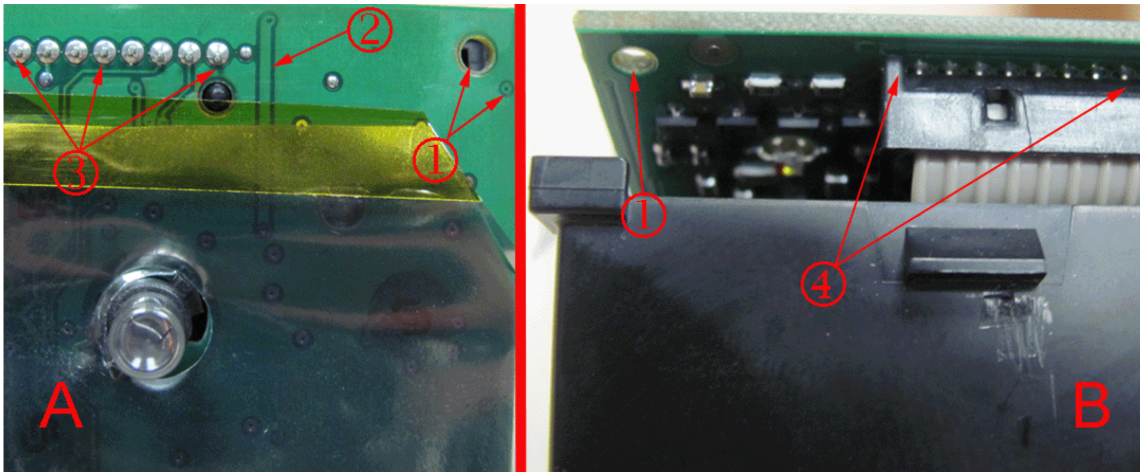
Top “A” and bottom “B” views of the contact board include examples of connector (4), connector pins (3), traces (2), and vias (1).

9. Ensure the protective coating covers the connector pins, traces and vias (holes) in the application area of the contact board.



2917382

10. Apply the protective coating to the bottom side of the contact board. Apply the protective coating over the entire length (10) of the contact board.



2917380

Top “A” and bottom “B” views of the contact board include examples of connector (4), connector pins (3), traces (2), and vias (1).

11. Ensure the protective coating covers the connector pins, traces and vias (holes) in the application area of the contact board.

Caution: The cure time for the material is 1 hour. To avoid part damage, do NOT proceed to step 17 until the material has cured for 1 hour.

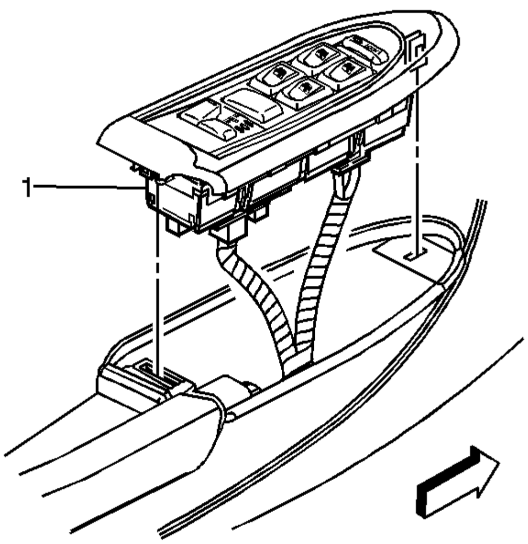
12. Wait 60 minutes to allow the liquid material to cure to a “tacky” state.
13. Remove ESD protective barrier from the contact board of the door module.

2917385

14. Insert the Mylar Kapton® gasket (10) to the inside surface covering the open cutouts of the door lock and side window switch membrane.

2917388

15. Assemble the door module and door lock and side window switch.



690976

Note: Do not program the door module after installing the driver side door lock and side window switch into the door.

16. Install the driver side door lock and side window switch into the door. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.
17. Perform a functional test on the driver side door lock and side window switch. Test all switch functions to ensure the driver side door lock and side window switch functions as designed. Replace the driver side door lock and side window switch if it fails the functional test. Refer to *Door Lock and Side Window Switch Replacement - Driver Side* in SI.

LABOR TIME

Modify Driver Side Door Lock Window Switch 0.7

EA12-004

GM

11-26-2012

ATTACHMENT Q_15_b_

Kit Information

Q_15_b. Repair Kit Information

The repair kit part number is 19119236.

It will be supplied by Kem Krest Corporation, 2040 Toledo Road, Elkhart, IN 465515.

Company contact: Brian LeClair, Account Manager, phone: 574-320-1171.

EA12-004

GM

11-26-2012

ATTACHMENT

GMW3172_14FE07

General Specification for Electrical/Electronic Component Analytical/Development/Validation (A/D/V) Procedures for Conformance to Vehicle Environmental, Reliability, and Performance Requirements

Publication Department: GME Specification Center

1 Scope

This standard applies to Electrical/Electronic systems/components for passenger vehicles and light duty trucks. The standard describes the potential electrical, environmental, durability and capability tests, based on mounting location, for Electrical/Electronic devices.

Nothing in this specification supersedes applicable laws and regulations unless a specific exemption has been obtained. In the event of a conflict between the English and the domestic language, the English language shall take precedence.

A detailed description of concerns and changes in procedures when using lead-free solder is described in Appendix A of this document. The changes in material characteristics of lead-free should be considered throughout the Analysis, Development and Validation activities.

Note: Nothing in the specification supersedes applicable laws and regulations.

Note: In the event of a conflict between the English and the domestic language, the English language shall take precedence.

1.1 Mission/Theme. This standard is intended to document all generic ADV procedures for automotive E/E devices. Specifc tasks, unique to the device technology (i.e. relays, solenoids, motors, etc.) are not addressed in this document. Additional tests with corresponding test flows are to be included to address these additional failure mechanisms. These additional tasks must be noted in the ADVP&R form or the Test Template.

The included process-flow and test-flow charts must be used to insure the effectiveness of this specification.

The **Analysis** procedures are used to aid in designing reliability into the product during the time when physical product is not yet available. Analysis should be the earliest activity in the ADV process and provides the earliest product learning and improvement opportunity.

The **Development/Evaluation** tasks are to be performed on first samples to provide the earliest opportunity to qualitatively evaluate and improve physical product. These activities may use only a single sample to differentiate between the relative weaknesses within the product. HALT is a typical example of this type of test.

Design validation tests that are expected to be of high risk as a result of the DRBFM and AFD should also be run early during the development phase to maximize the number of learning opportunities in areas where the expected need is greatest.

The **Design Validation** (DV) section of this standard describes environmental, durability and capability tests for electrical and electronic equipment. The design validation tasks are to be executed on prototype parts. This section describes common test procedures, based on mounting location in the vehicle. The location-coding requirement is an essential element in the use of this document and must be specified in the CTS or SSTS.

The **Product Validation** (PV) section of this standard requires that only a sub-set of the (DV) tests be rerun. The minimum requirement includes the vibration test with superimposed thermal cycling, the DV specified humidity tests, the frost test, and the shipping vibration test. Additionally, any Design Validation tests that exhibited less than desired performance for DV should be rerun for PV. The process validation tasks are to be run on pilot or production parts. The possible use of Audit Screening during production is to be determined by the end of the PV phase.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

DIN 40050-9
IEC 60068-2-1
IEC 60068-2-13
IEC 60068-2-14
IEC 60068-2-27
IEC 60068-2-38
IEC 60068-2-78
IEC 60529
ISO 16750-2
ISO 16750-3
ISO 16750-4
ISO 8820
ISO 20653
ISO 12103-1

2.2 GM Group Standards/Specifications.

GME3191
GMW3091
GMW3097
GMW3103
GMW3172
GMW3431
GMW8287
GMW8288
GMW14082
GM9123P

3 Requirements

3.1 Terms and Definitions.

3.1.1 Parameter Tolerance. Unless stated otherwise, the following shall define the test environment parameters and tolerances to be used for all validation testing:

Parameter	Tolerance
Ambient Temperature	Spec. ± 3 °C
Room Ambient Temperature	(+23 ± 5) °C
Test Time	(Spec. /+2) %
Room Ambient Relative Humidity	(50 ± 20) %
Chamber Humidity	Spec. ± 5 %
Voltage	Spec. ± 0.1 V
Current	Spec. ± 5 %
Resistance	Spec. ± 10 %
Vibration	Spec. ± (0.2 X g_n) or spec. ± 20 % (whichever is greater)
Shock	Spec. ± 20 %
Frequency	Spec. ± 1 %
Force	Spec. ± 10 %
Pressure	Spec. ± 10 %
Distance	Spec. ± 10 % Spec. ± 10 %

3.1.2 Temperature and Voltage Definition.

Phrase	Symbol	Definition
Minimum Temperature	T_{min}	Minimum limit value of the ambient temperature at which the system and/or E/E device are required to operate.
Maximum Temperature	T_{max}	Maximum limit value of the ambient temperature at which the system and/or E/E device are required to operate.
Post Heating Temperature (soak back)	T_{maxPH}	Maximum limit value of the ambient temperature which may temporarily occur after vehicle cut-off and at which the system and/or E/E device may be operated for a brief period, e.g. on the engine and in its environment.
Repaint Temperature	T_{maxRP}	Maximum temperature which can occur during repainting, but at which the system is not operated.
Room Ambient Temperature	T_{RT}	Room temperature.
Minimum Voltage	U_{min}	Minimum limit value of the supply voltage at which the system and/or E/E device are required to operate.
Nominal Voltage	U_{nom}	Nominal supply voltage at which the system and/or E/E device is operated during the test.
Maximum Voltage	U_{max}	Maximum limit value of the supply voltage at which the system and/or E/E device are required to operate.

3.1.3 Operating Types.

Operating Type		Electrical State
1	No voltage is applied to the DUT.	
	1.1	Not connected to wiring harness.
	1.2	Connected to wiring harness simulating vehicle installation, but no voltage applied.
2	The DUT is electrically connected with supply voltage U_B (battery voltage, generator not active) as in a vehicle with all electrical connections made.	
	2.1	System/component functions are not activated (e.g. sleep mode).
	2.2	Systems/components with electric operation and control in typical operating mode.
3	The DUT is electrically operated with supply voltage U_A (engine/alternator operative) with all electrical connections made.	
	3.1	System/component functions are not activated.
	3.2	Systems/components with electric operation and control in typical operating mode.

3.1.4 Functional Status Classification. The purpose and scope of the FSC classification is to provide a general method for defining the functional performance status classification (FSC) for the functions of automotive E/E devices upon exposure to test conditions or real world operation conditions. An unwanted operation of the DUT is not allowed in any of the following classes. The device must not create a hazard when operated with voltages outside of the design intent. This is applicable to all classes of FSC described above.

Class	**Definition of FSC Class**
A	All functions of the device/system perform as designed during and after the test.
B	All functions of the device/system perform as designed during the test. However, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after the test. Memory functions shall remain class A.
C	One or more functions of a device/system do not perform as designed during the test but return automatically to normal operation after the test.
D	One or more functions of a device/system do not perform as designed during the test and do not return to normal operation after the test until the device/system is reset by simple “operator/use” action.
E	One or more functions of a device/system do not perform as designed during and after the test and cannot be returned to proper operation without repairing or replacing the device/system.

3.2 Code Designation by Location in the Vehicle.

3.2.1 Recommended Coding Designation by Location in the Vehicle. This document distinguishes between the following mounting locations and defines the minimum Electrical, Mechanical, Thermal, Climatic, Chemical, Water and Dust Protection requirements. Other mounting locations are possible and can be addressed using a custom combination of code letters as described in the section entitled “Quoting Requirements”.

Table 1: Code Letters Based on Location in the Vehicle

Mounting Location	Electrical Loads	Mechanical Loads	Operating Temperature Range	Climatic Loads	Chemical Loads	Dust and Water Protection
	Code letter per **Table 2**	Code letter per **Table 3**	Code letter per **Table 4**	Code letter per **Table 5**	Code letter per **Table 6**	Code letter per **Table 7**
Engine Compartment						
Hi location, remote from engine and heat sources	A – F Typically C	C	F	A	E	IP6K9K
Hi location, close to engine or heat sources	A – F Typically C	C	H	A	E	IP6K9K
At/in engine, normal temperature load	A – F Typically C	A or B	H	B	E	IP6K9K
At/in engine, high temperature load	A – F Typically C	A or B	I	B	E	IP6K9K
At/in transmission	A – F Typically C	A or B	I	B	E	IP6K9K
Low mount	A – F Typically C	C	H	B	E	IP6K9K
Passenger Compartment						
Low temperature load (Under dashboard) low temperature load	A – F Typically C	C	A – C	D	A/B	IP5K2
Normal temperature load (Dashboard display or switch) normal temperature load	A – F Typically C	C	D	E	A	IP5K2
High temperature load (Top of dashboard with sun load) high	A – F Typically C	C	E	E	A	IP5K2
Low mount/under seat	A – F Typically C	D	A	D or F	B	IP5K2 IP5K8

Table 1: Code Letters Based on Location in the Vehicle

Mounting Location	Electrical Loads	Mechanical Loads	Operating Temperature Range	Climatic Loads	Chemical Loads	Dust and Water Protection
	Code letter per **Table 2**	Code letter per **Table 3**	Code letter per **Table 4**	Code letter per **Table 5**	Code letter per **Table 6**	Code letter per **Table 7**
Other Locations						
Trunk low mount	A – F Typically C	C or D	A – C	F	D	IP5K8
Trunk high mount	A – F Typically C	C or D	A – C	D	D	IP5K2
Doors and hatches (wet area)	A – F Typically C	E	B – C	H	B	IP5K3
Doors and hatches (dry area)	A – F Typically C	E	B – C	E – D	A	IP5K2
Exterior splash area	A – F Typically C	C	A – C	J	F	IP6K9K
Chassis and underbody	A – F Typically C	C	A – C	I or J or N	F	IP6K8 or IP6K9K
Unsprung mass	A – F Typically C	F	A – C	J or N	F	IP5K4K or IP6K9k
Sealed body cavities	A – F Typically C	C	A – C	D	B	IP5K2
Unsealed body cavities	A – F Typically C	C	A – C	H – I	F	IP5K4K
Exterior at the base of the windshield inside the Plenum or inside the engine compartment	A – F Typically C	C	D – G	I	E	IP6K6K Also run Seal Evaluation if in Plenum
Roof mounted inside the vehicle cabin	A – F Typically C	C	D	D	B	IP6K2 or IP5K2
Z	location (to be completed by GM)					

3.2.2 Code Letter for Electrical Loads. The following table defines the steady state minimum and maximum test voltages to be used as measured at the connector of E/E device.

The table should also be used in specifying the E/E device criteria requirements unless otherwise specified in the CTS.

Table 2: Code Letter for Electrical Loads

Code	Test Voltage (in V)	
Code Letter	**U_{min}**	**U_{max}**
A	4.5	16
B	6	16
C (most common)	**9**	**16**
D	9	18
E	10	16
F	12	16
Z	As Agreed Upon	

- In the voltage range of -13 V to U_{min} and U_{max} to +26 V the Functional Status Classification shall be at minimum class C.
- In the range of the given code letter the Functional Status Classification shall be class A.
- **Nominal Voltage (U_{nom}):** The nominal voltage depends on the operating mode.

Test voltage	U_{nom} (in V)	Generator Status
U_A	14	operating
U_B	12	not operating

3.2.3 Code Letter for Mechanical Loads.

Table 3: Code Letter for Mechanical Loads

Code Letter	Requirements				
	Crush Test	**Random Vibration**	**Mechanical Shock**	**Closure Slam**	**Free Fall**
A	Method A	Engine Envelope 1	Yes	No	Yes
B	Method A	Engine Envelope 2	Yes	No	Yes
C	Method A	Car Duration Sprung-mass	Yes	No	Yes
D	Method A & B	Car Duration Sprung-mass	Yes	No	Yes
E	Method A	Car Duration Sprung-mass	Yes	Yes	Yes
F	Method A	Car Duration Unsprung-mass	Yes	No	Yes
G	Method A	Truck Duration Sprung-mass	Yes	No	Yes
H	Method A & B	Truck Duration Sprung-mass	Yes	No	Yes
I	Method A	Truck Duration Sprung-mass	Yes	No	Yes
J	Method A	Truck Duration Unsprung-mass	Yes	No	Yes
Z	as agreed upon				

3.2.4 Code Letter for Temperature.

Table 4: Code Letter for Temperature

Code Letter	T_{min} in °C	T_{max} in °C	$T_{max\ PH}$ in °C (Underhood Soak Back: 30 min)	$T_{max\ RP}$ in °C
A	-40	+70		+95
B	-40	+80		+95
C	-40	+85		+95
D	-40	+90		+95
E	-40	+105		+95
F	-40	+105	+120	+95
G	-40	+120		+95
H	-40	+125	+140	+95
I	-40	+140		+95
Z	as agreed upon			

3.2.5 Code Letter for Climate.

Table 5: Code Letter for Climate

Code Letter	High Temp Durability (in h)	Minimum Number Of Thermal Shock Cycles	Water Splash	Seal	Salt (hours)	Cyclic Humidity	Constant Humidity	Xenon Arc
A	2000	500	NO	NO	240	YES	YES	NO
B	2000	500	NO	YES	480	YES	YES	NO
C	2000	500	YES	NO	240	YES	YES	NO
D	500	300	NO	NO	144	YES	YES	NO
E	500	300	NO	NO	144	YES	YES	YES
F	500	300	NO	YES	144	YES	YES	NO
G	500	300	NO	NO	240	YES	YES	NO
H	500	300	NO	NO	240	YES	YES+DEW	NO
I	500	300	NO	YES	240	YES	YES	NO
J	500	300	YES	YES	480	YES	YES	NO
K	2000	500	YES	NO	960	YES	YES	NO
L	2000	500	NO	YES	960	YES	YES	NO
M	500	300	YES	NO	960	YES	YES	NO
N	500	300	NO	YES	960	YES	YES	NO
Z	as agreed upon							

High Altitude Testing or Analysis (optional) may be required in all code letter categories per agreement in ADV Task Checklist. For the appropriate number of Thermal Shock Cycle see Table 10.

3.2.6 Code Letter for Chemical Loads. The Coding defines the requirements related to the position of the E/E Device in the vehicle and the appropriate tests for chemical loads.

The table identifies chemical origins that are to be covered by the appropriate material specification. No additional test is required by this specification.

Table 6: Code Letter for Chemical Loads

Code Letter	Mounting Location for Chemical Loads
A	Cabin Exposed
B	Cabin Unexposed
C	Interior Door Mounted (Unexposed)
D	Trunk
E	Under Hood
F	Exterior Area

3.2.7 Code Letter for International Protection by Enclosures. General Motors uses a subset of the International Protection Codes. These IP Codes are to be used unless the CTS specifies differently. The product should be powered immediately following the completion of the water test.

The coding behind IP defines similar to IEC 60529 the requirements regarding dust and water intrusion. The following examples are to explain the use of letters in the IP-Code (Informative). For details see DIN 40050-9 and IEC 60529.

Example:

Code Letter (International Protection)	IP	5K	2
First Element For Dust			
Second Element For Water			

Table 7: Code Letter for International Protection by Enclosure

First code element	**Degree of protection for Dust**	
	Brief description	**Requirements**
X	Not required	None
0	Not protected	None
5K	Dust-protected	Dust shall only penetrate in quantities which do not impair performance and safety
6K	Dust-tight	Dust shall not penetrate
Second code element	**Degree of protection for Water**	
	Brief description	**Requirements**
X	Not required	None
0	Not protected	None
2	Water drips with enclosure inclined by 15°	Vertical drips shall not have any harmful effects, when the enclosure is tilted at any angle up to 15° on either side of the vertical
3	Water spray	Water spray which sprays against the enclosure from any direction at a 60° angle shall not have any harmful effects
4K	Splash water with increased pressure	Water which splashes against the enclosure from any direction with increased pressure shall not have any harmful effects
6K	Strong high-velocity water with increased pressure	Water which is directed against the enclosure from any direction as a strong jet with increased pressure shall not have any harmful effects
8	Continuous immersion in water	Water shall not penetrate in a quantity causing harmful effects if the enclosure is continuously immersed in water under conditions which shall be agreed between supplier and car manufacturer
9K	Water during high-pressure/steam-jet cleaning	Water which is directed against the enclosure from any direction shall not have any detrimental effect

Table 8: Summary of FSC and Operating Types

Test Title	FSC	Operating Type
Parasitic Current Measurement	A	2.1
Jump Start Test	C	3.1/3.2
Reverse Polarity Test	C	2.1/2.2
Over-Voltage Test	C	3.2
Voltage Drop Test	C	3.2
Battery Voltage Dropout Test	C	3.2
Superimposed Alternating Voltage Test	A	3.2
Single Line Interruption	C	3.2
Multiple Line Interruption	C	3.2
Ground Offset Test	A	3.2
Power Offset Test	A	3.2
Short to Battery/Ground Test for Signal Lines	C	3.2
Test for Intermittent Short Circuit	C	3.2
Test for Continuous Short Circuit	C	3.2
Load Circuit Over-Current Test	C	3.2
Isolation Evaluation Test	A	1.1
Puncture Strength Test	A	1.1
Connector Installation Abuse Test Method A	C	1.1
Connector Installation Abuse Test Method B	C	1.2
Fretting Corrosion Degradation Test	A	3.2
Vibration Tests	A	3.2
Mechanical Shock	A	1.2 or 3.2
Door/Trunk/Hood Slam Test	A	3.1/3.2
Crush Test for Device House Method A	C	1.1
Crush Test for Device House Method B	C	1.2
Free Fall (Drop Test)	C	1.1
Low Temperature Wakeup Test	A	2.1/3.2
High Temperature Durability Test	A	3.2
High Altitude Shipping – Low Pressure Test	A	1.1
High Altitude Operating – Low Pressure Test	A	3.2
Thermal Shock in Air Test	A	1.1 or 1.2
Power-Temperature Cycle Test	A	3.2
Thermal Shock/Water Splash	A	3.2
Humid Heat, Cyclic	A	2.1/3.2

Table 8: Summary of FSC and Operating Types

Test Title	FSC	Operating Type
Humid Heat, Constant	A	2.1/3.2
Frost Test For Moisture Susceptibility	A	1.1/3.2
Dew Test	A	1.1/3.2
The Corrosion Salt Mist/Fog Test and Salt Spray Test	A	1.2/3.2
Dust Test	A	1.2
Water Test	A	1.2
Seal Evaluation	A	3.2
Sugar Water Function Impairment Test	A	3.2

3.3 Validation Requirements.

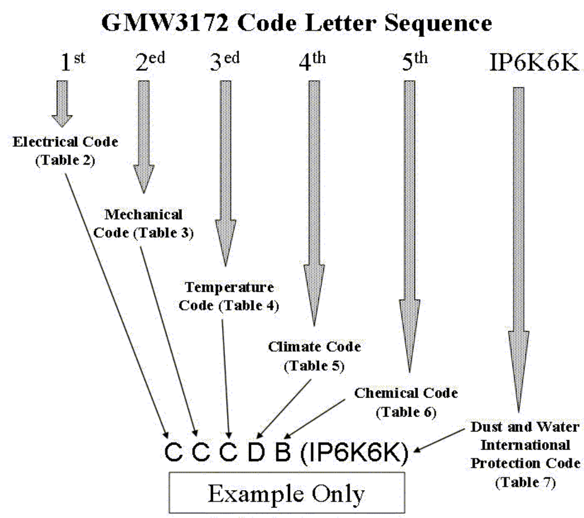
3.3.1 Quoting Requirements.

Example CTS Reliability Paragraph:

"The analytical, developmental and validation mandatory tasks identified in GMW3172 must be performed to ensure adequate product maturity by the end of the product development life cycle. The component shall pass the Design Validation and Product Validation environmental and durability requirements of GMW3172. These requirements shall be clearly identified through use of the GMW3172 Coding System resulting from the location of the product in the vehicle. The code for this product is: __________________. A product reliability of at least 97 %, with a statistical confidence of 50 %, shall be demonstrated on test as described within GMW3172. The supplier must attain world-class reliability for this product. The test requirements contained in this document are necessary but may not be sufficient in all cases to meet this world-class field reliability requirement. The supplier is responsible for assuring that other actions are taken such that world class field reliability requirements are met."

The requirement code for this product must be clearly assigned in the CTS or SSTS. Supplemental testing for failure mechanisms not covered by GMW3172 must be specified in addition to GMW3172. These additional failure mechanisms may include wear or mechanical fatigue.

Figure 1: Code Letter Sequence Requirement



3.3.2 Target Life. The standard target life used in this document is 10-15 years and 100 000 miles. The following adjustments should apply when the Vehicle Technical Specification for the intended use vehicles defines a different target life:

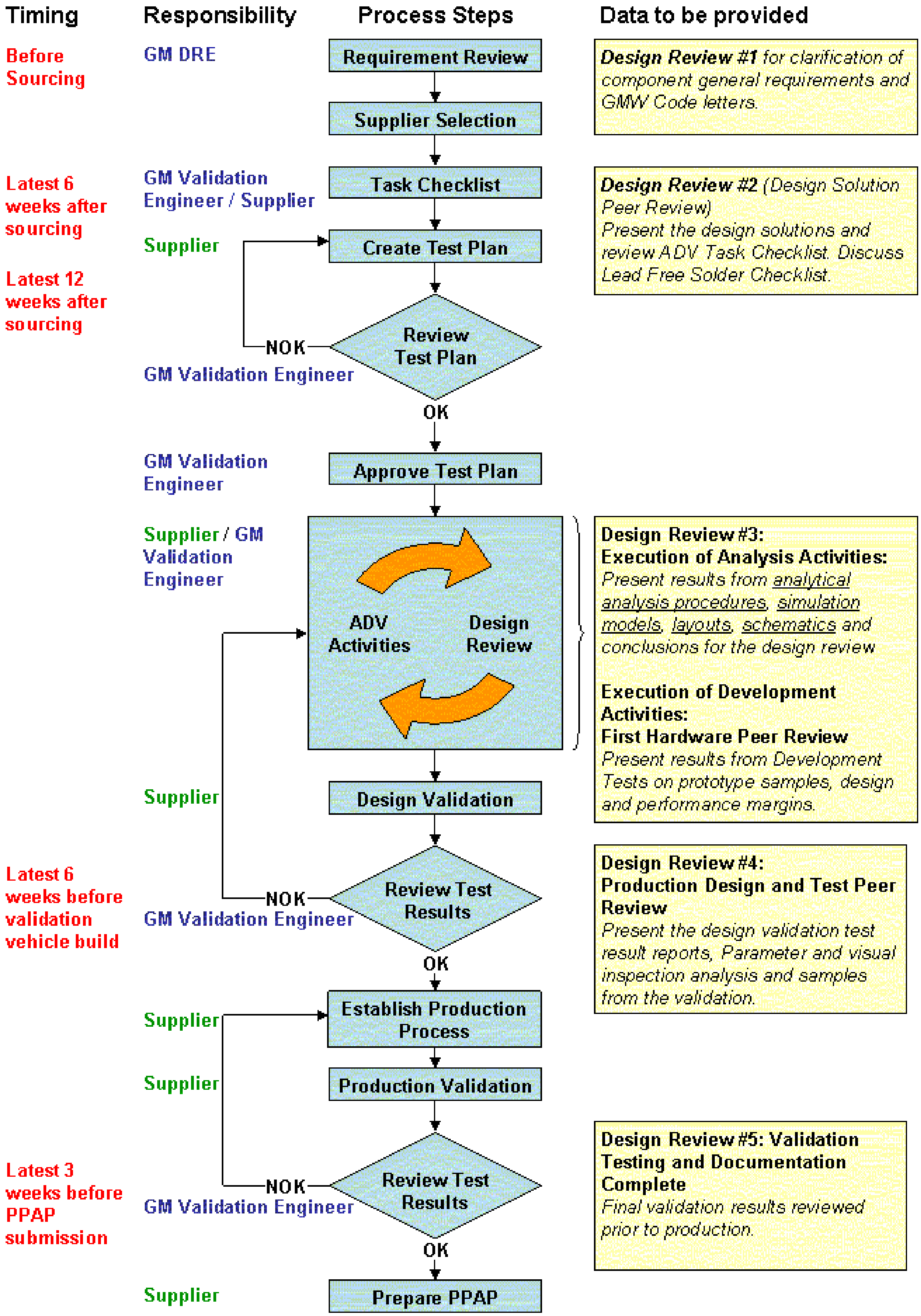
- No adjustments should be made for the demonstration of reliability for thermal fatigue.
- No adjustment should be made for mechanical shock tests.
- No adjustment should be made for moisture and corrosion tests.
- Adjustments should be made for vibration testing. For example, a 150 000-mile requirement should dictate 1.5 times the number of hours of vibration testing defined in this document.

3.3.3 Reliability. A product reliability of at least 97 %, with a statistical confidence of 50 %, shall be demonstrated for the failure mechanisms of vibration and thermally induced fatigue relative to the target life. The test plan for reliability demonstration must encompass the important interactions between fatigue and other failure mechanisms described in this document. The "Universal Durability Test-Flow" provided in this document effectively evaluates these interactions and shall be used for product validation. The demonstration of 97 % reliability on-test for a 99.8 % severe user corresponds to a total population field reliability of (99.5 %). This statement is based on the assumption of a Customer Variability Ratio of three and a Weibull Slope of two. The 99.5 % field reliability has been benchmarked as world class.

3.3.4 Reliability Design Reviews. Reliability design reviews are to be conducted as part of the Peer Review Process.

3.3.5 Materials. The most current material specifications shall be met as defined in the SOR Appendix F10. No additional testing is required by this specification.

3.3.6 ADV Process Flow for Electrical Components.



3.3.7 GMW3172 A/D/V Task Checklists.

Definition of Recommendations:

M Mandatory for electronic modules

M/C Mandatory when condition or design feature exists

R Recommended - shall be conducted but may be waived only by GM under special circumstances.

C Conditional task based on presence of feature, technology, risk, or vehicle location

GMW3172 A/D/V Task Checklist – ANALYTICAL Procedures

Procedure	**Recommended**	**This Program**
Nominal Performance Simulation	M	
Short/Open Circuit Analysis	C	
Circuit Board Resonant Frequency and Displacement Analysis	R	
Thermal Fatigue Analysis	C	
Snap Lock Fastener Analysis (Appendix B)	M/C	
Crush Test Analysis	R	
Heat Dissipation Analysis	M/C	
Lead-Free Solder Checklist (Appendix A)	M	

GMW3172 A/D/V Task Checklist – DEVELOPMENT Procedures

Procedure	**Recommended**	**This Program**
Normal Performance Evaluation	R	
Jump Start Evaluation	R	
Reverse Polarity Evaluation	R	
Over Voltage Evaluation	R	
Short Circuit Evaluation	M	
Groundpath Inductance Sensitivity Evaluation	M/C	
Processor Supervisor Performance Evaluation	M	
Fault Injection Testing	M/C	
Crush Test For Device Housing Development	R	
Free Fall (Drop Test) Development	R	
Mechanical Shock Test Development	R	
HALT – Highly Accelerated Life Test For Design Margin Evaluation	R	
HAST – Highly Accelerated Stress (Humidity) Test	C	
Thermal Performance Development	R	

GMW3172 A/D/V Task Checklist – DESIGN VALIDATION Procedures

Procedure	Recommended	This Program
Vehicle Electrical Transient Tests		
Parasitic Current Measurement	M	
Jump Start Test	M	
Reverse Polarity Test	M	
Over-Voltage	M	
Voltage Drop Test	M	
Battery Voltage Dropout Test	M	
Superimposed Alternating Voltage Test	M	
Open Circuit Test	M	
Ground Offset Tests	M	
Power Offset Test	M	
Short to Battery Test	M	
Short to Ground Test	M	
Short Circuit Endurance Tests	M/C	
Load Circuit Over-Current Test	M/C	
Isolation Resistance	C	
Puncture Strength	C	
Electromagnetic Compatibility	M	
Connector Tests		
GME3191 Connector Tests	M/C	
Connector Installation Abuse Test	M/C	
Mechanical Tests		
Vibration Test	M	
Mechanical Shock	M	
Door/Trunk/Hood Slam Test	M/C	
Crush Test For Device Housing	R	
Free Fall (Drop Test)	M	
Temperature Tests		
Low Temperature Wakeup Test	M	
High Temperature Durability Test	M	
High Altitude Shipping – Low Pressure	M/C	
Thermal Shock Air-to-Air (TS)	M	
Power Temperature Cycle Test (PTC)	M	
Thermal Shock/ Water Splash	C	

GMW3172 A/D/V Task Checklist – DESIGN VALIDATION Procedures

Procedure	Recommended	This Program
Humidity Tests		
Humid Heat Cyclic (HHC)	M	
Humid Heat Constant (HHCO)	M	
Frost Test For Moisture Susceptibility	M	
Dew Test	M/C	
Corrosion Salt Mist/Fog and Salt Spray Test	M	
Tests for Enclosures		
Dust Tests	M	
Water Tests	M	
Seal Evaluation	M/C	
Sugar Water Function Impairment Test	C	

In addition the following tests can be mandatory or conditional task for Product validation.

GMW3172 A/D/V Task Checklist – Product Validation Procedures

Procedure	Recommended	This Program
Vibration Shipping Test	M	
Audit Screening Activity – ESS or HASA per GMW8287		
High Frequency Audit During Production Startup	C	
Continuous Audit During Production	C	

Note: Fill out a Design Validation Checklist for tests that must be repeated in PV in addition to those listed above.

3.4 Test Plan Development. The test-flow shown in this document represents the cumulative global experience and knowledge gained from many products over many years. The strategy underlying this series-parallel test-flow is based on the concepts of "physics of failure" with correlation to field usage. The correlation to field usage is established from many years of data collected by The General Motors Product Usage and Measurement Analysis Group (PUMA).

3.4.1 Supplier Responsibilities. The supplier shall create a test sequence and submit it to GM for approval. The sequence is to simulate one life of electrical input-output usage through a combination of thermal cycling, functional cycling, and environmental and mechanical exposures. The intent is to exercise all of the failure mechanisms. The plan shall demonstrate the reliability requirement, which is specified in the technical specification.

Sample Size: A minimum of three samples shall be used for each test except where noted. The DUT can be used for more than one test. Sample size is critical for reliability demonstration of resistance to vibration fatigue and thermal fatigue.

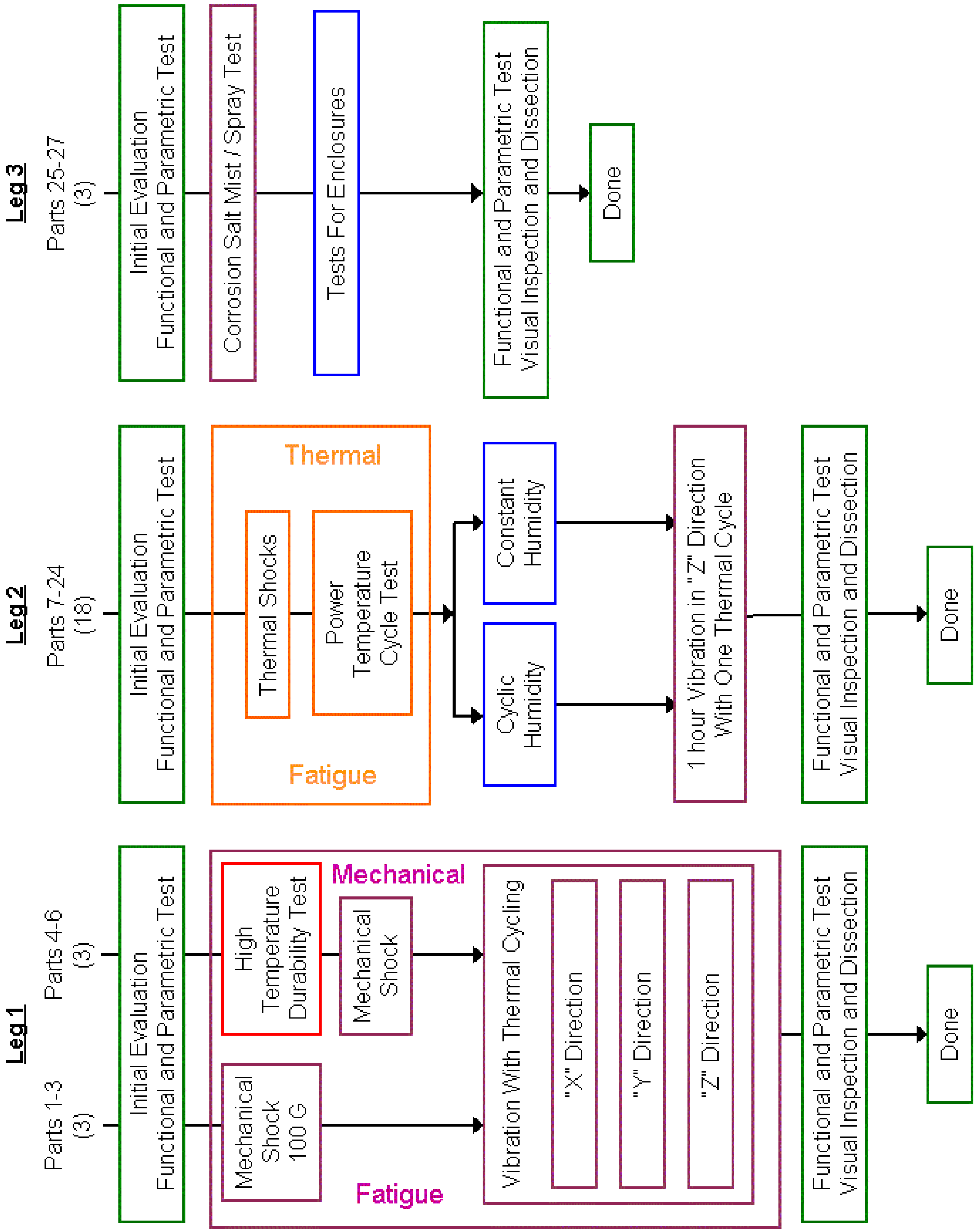
Reliability Demonstration: The reliability requirement of the CTS must be demonstrated for the wear out failure mechanisms as well as the electrical input-output usage cycles. For an electronic module, wear out will be due to thermal- and vibration-induced fatigue. The DUT typically is exercised for the required number of 1-life electrical operational cycles during the Power–Temperature-Cycling (PTC) test. When there is inadequate time during PTC to exercise all of the usage cycles, the usage cycles may also be accumulated during the High Temperature Durability, Vibration, and Humidity Test. Additional testing for wear or fatigue of mechanical portions of the product is not covered by this specification and should be addressed elsewhere in the CTS.

Success-Run Plan: This document uses a success-run test plan for thermal fatigue, combined with a follow-up degradation analysis process to detect the "buds" of potential problems.

Test to Failure Plan: This document uses test-to-failure to quantify reliability for vibration.

3.4.2 Universal Durability Test Flow. The following figure provides a test flow that is to be used to validate product using the specific tests described in this document. The test legs should be run in parallel to minimize total test time. Deviations from this test flow require GM Validation Engineering approval.

Figure 2: Universal Durability Test-Flow



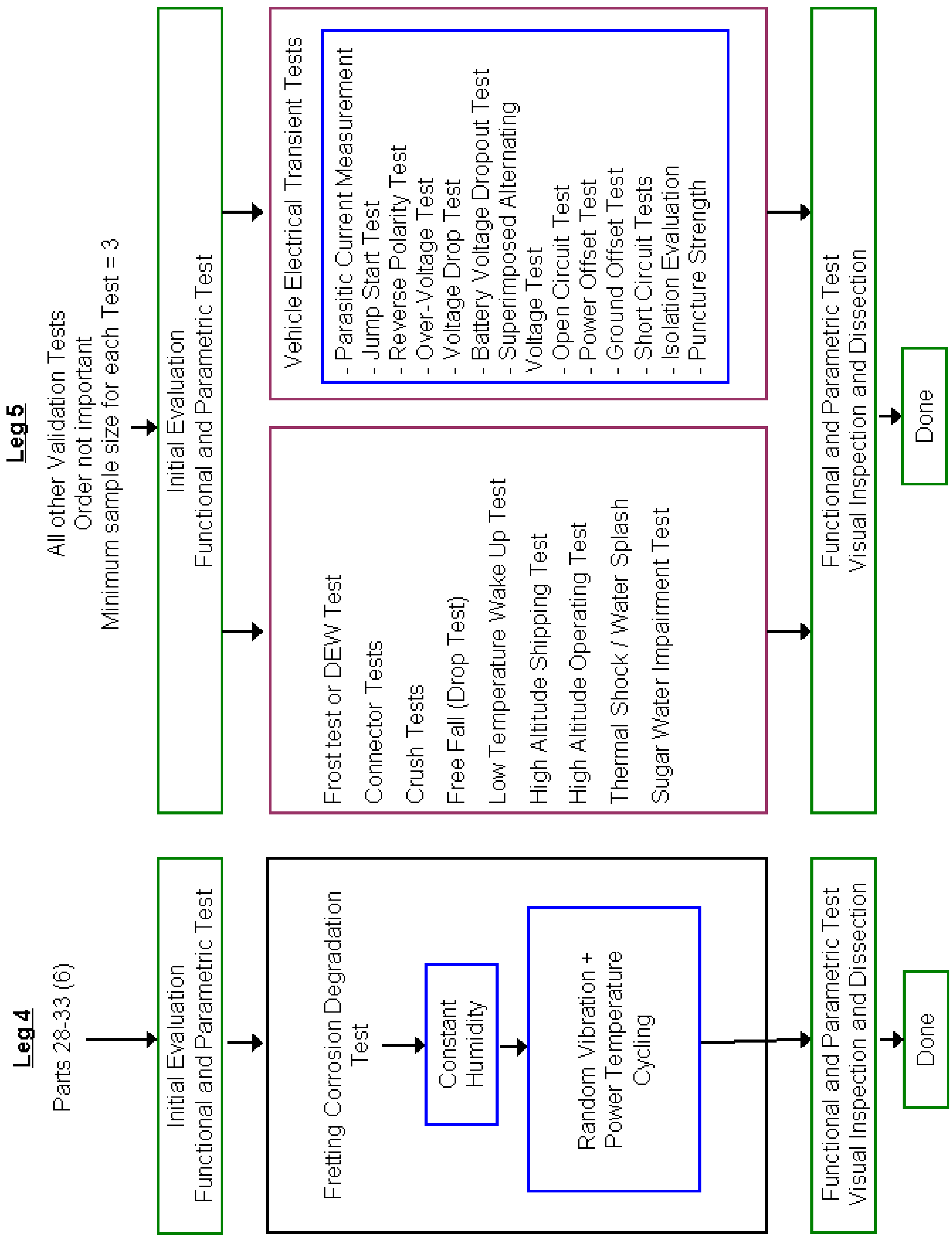

Leg 5
All other Validation Tests
Order not important
Minimum sample size for each Test = 3
Initial Evaluation
Functional and Parametric Test
Frost test or DEW Test
Connector Tests
Crush Tests
Free Fall (Drop Test)
Low Temperature Wake Up Test
High Altitude Shipping Test
High Altitude Operating Test
Thermal Shock / Water Splash
Sugar Water Impairment Test
Vehicle Electrical Transient Tests
- Parasitic Current Measurement
- Jump Start Test
- Reverse Polarity Test
- Over-Voltage Test
- Voltage Drop Test
- Battery Voltage Dropout Test
- Superimposed Alternating Voltage Test
- Open Circuit Test
- Power Offset Test
- Ground Offset Test
- Short Circuit Tests
- Isolation Evaluation
- Puncture Strength
Functional and Parametric Test
Visual Inspection and Dissection
Done
Leg 4
Parts 28-33 (6)
Initial Evaluation
Functional and Parametric Test
Fretting Corrosion Degradation Test
Constant Humidity
Random Vibration + Power Temperature Cycling
Functional and Parametric Test
Visual Inspection and Dissection
Done

Figure 3:

Test Duration for Vibration Tests on Universal Durability Test Flow. Due to accelerated vibration with reduced sample size the duration of test needs to be determined according Table 9. In the following table the duration for vibration in each axis is given for different mounting location and a life of 100 000 miles of customer usage with six samples.

Table 9: Duration for Vibration Tests in Test Flow

Location	Body Style	Duration (h)			
		X-Axis	Y-Axis	Z-Axis (6 Samples)	Z-Axis (23 Samples)
Engine	Car	22	22	66	22
	Truck	22	22	66	22
Body	Car	8	8	24	8
	Truck	18	18	54	18
Unsprung-Mass	Car	8	8	24	8
	Truck	18	18	54	18

Thermal Fatique Test Parameter for the Universal Durability Test Flow.

The number of temperature cycles for the Power Temperature Cycle Test (PTC)+ Temperature Shock Test (TS) depends on the vehicle position where the device for test is normaly located. Therefore the gives the sum of temperature cycles which need to be tested with the samples during validation. The number of cycles also depends on the amount of samples used during the test. The exact number can be derived from Table 10.

Note: No acceleration factor for increased ramp rate exists. Both Temperature Shock and Power Temperature Cycle are coequal. However, thermal shock continues to provide the time advantage of “more cycles per unit of time”.

Table 10: Thermal Fatigue Test Requirements

Code Letter for Temperature	Test Temp Range ΔT in ^{o}C	Total number of cycles PTC + TS	
		Sample Size 23	Sample Size 18
A	110	750	843
B	120		
C	**125**		
D	130		
E	145	1100	1236
F	**145**		
G	160	2000	2248
H	**165**		
I	180		

4 ADV Process Activities

4.1 Analytical Phase of ADV Procedures.

4.1.1 Analysis Activity Mission. After source selection, a joint Supplier/GM Analysis Development Validation (A/D/V) planning team shall select the analytical tasks to be performed and balance or augment them with physical development and validation tasks as needed. The Task Checklist provided is to be used for selecting the A/D/V tasks. These tasks shall be documented and tracked in the ADVP&R form. The team shall select value added tasks appropriate to the requirements, technology and features of the device and balance resource availability with program timing.

Analysis tasks are to be completed prior to the design freeze for building pre-prototype level hardware.

The supplier shall document in formal reports the assumptions, models, tools, results, conclusions and recommendations of each analysis. Analysis reports shall be prepared and maintained in a manner similar to the supplier's validation test reports; copies shall be provided and reviewed with the PDTGM Validation Engineering. When an analysis identifies design deficiencies that cannot be promptly resolved by the supplier, the issue(s) shall be documented in an Incident Report (IR) and presented to the product development team for joint resolution. The resulting corrective action(s) shall be documented in the IR, copies shall be provided to GM.

After source selection, a joint Supplier/GM Analysis Development Validation (A/D/V) planning team shall select the analytical tasks to be performed and balance or augment them with physical development and validation tasks as needed. The checklist provided is to be used for selecting the A/D/V tasks. These tasks shall be documented and tracked in the ADVP&R form. The team shall select value added tasks appropriate to the requirements, technology and features of the device and balance resource availability with program timing. Emphasis is to be placed on reducing risk for new or challenging design features, achieving program timing and reducing costs. If CAE Simulations are used, the Saber (U.S.) or Spice (Europe) modeling tool set is preferred to facilitate use of the GM's modeling system and existing models. Use of other circuit modeling programs requires GM's review.

4.1.2 Nominal Performance Analysis.

Purpose: This analysis is performed to verify that the design of the circuit is capable of producing the required output response.

Procedure: Use a circuit analysis program to analyze nominal circuit conditions.

Criteria: Verify that the design of the circuit is capable of producing the required output response at nominal circuit conditions. Must meet the requirements according to SSTS or CTS or GMW14082.

4.1.3 Short/Open Circuit Analysis.

Purpose: Performed to analyze how a circuit or systems response to potentially disruptive shorts to battery/supply voltages, short to ground and open circuit conditions. This analysis is also performed to verify the ability of components and conductors to survive short/open conditions.

Procedure: Use a circuit analysis program to perform the Short/Open Circuit Analysis.

Criteria: Verify ability of components and conductors to survive short/open conditions. No component limit value should be exceeded that may result in damage during the analysis. Must meet FSC = C under short/open conditions.

4.1.4 Circuit Board Resonant Frequency And Displacement Analysis.

Purpose: This analysis is to be performed for devices with internal printed circuit boards. Structural dynamic modal analysis is performed to determine the fundamental frequency of the circuit board and the resulting maximum board displacement. Low resonant frequencies and the resulting high displacement will cause excessive fatigue damage to interconnect wires and junctions on the circuit board.

Procedure: Quantify the resonant frequency of the circuit board either by formal modal analysis or through the more simple models provided in reference 1 (Steinberg).

Criteria: The resonant frequency of the circuit board must exceed 150 Hz. Low resonant frequencies represent increasing risk of fatigue failure from increased board displacement. The supplier must provide evidence of appropriate corrective action when the resonant frequency is below 150 Hz. The corrective action is to be reviewed with the GM Validation Engineer.

4.1.5 Thermal-Fatigue Analysis.

Purpose: The differential expansion and contraction rates of circuit board elements result in fatigue stress to the junctions involved (solder and lead wires). The differential expansion rates of different materials may also result in the unacceptable deformation of structure resulting in electrical or mechanical problems.

Procedure: Identify the "most at risk" elements of the product as follows:

- Identify the largest surface mounted component on the circuit board.
- Identify components whose Coefficient of Thermal Expansion (CTE) differs the most from each other.

Perform the analysis to quantify fatigue life and expansion/contraction differences that will result in problems. This cyclical stress (fatigue) can be modeled with the empirical models detailed in reference (1) (Steinberg), or through Finite Element Analysis.

Criteria: The design life is to be equal to or greater than the life multiple of three.

4.1.6 Snap Lock Fastener Analysis.

Purpose: The analysis of plastic snap lock features is performed to ensure the following:

- Adequate retention force.
- Acceptable ergonomic forces for assembly.
- Designed in compliance mechanisms to prevent rattles.
- Adequate design margin to ensure that flexing during installation does not exceed the elastic limit of the plastic.

Procedure: Complete the Snapfit Design Worksheet in Appendix B. Additional resources to assist in completing this worksheet are: Design of Integral Attachments and Snapfit Features in Plastic[13].

Criteria: Use the criteria as noted on the Snapfit Design Worksheet in Appendix B to insure that the elastic limits of the plastic material are not exceeded.

4.1.7 Crush Test Analysis.

Purpose: The crush test analysis of the case to ensure that elbow or foot loads on the case will not cause damage to components on the circuit board.

Procedure: Use finite element analysis to insure that the requirements for crush test, as defined as a physical test, is met. The intended load must be identified as being stemming from a person's elbow or foot as described in the test portion for this concern.

Criteria: The deflection of the device cover must not generate forces on components or the circuit board. Additionally, the deflection forces must not cause the cover to detach or "open up".

4.2 Development/Evaluation Phase Of ADV Procedures.

4.2.1 Development Activity Mission. The design validation tests should be reviewed to determine if any of these tests should be run during the development phase.

The development tasks have proven to be beneficial to the development of automotive E/E products. This list is not all-inclusive; the supplier or product team may propose alternative or additional tasks. The procedures can be used to support or confirm the accuracy of the analytical and simulation tasks, or to further new design capability or reliability growth, program risk reduction and/or validate requirements. These tasks may include comparison procedures to select the best materials or components for the design, or to confirm the accuracy of the analysis, or involve obtaining data to refine analysis assumption such as confirming key properties of materials. Development procedures may also be required to fill in gaps where analytical procedures or resources were not available.

The selection of the initial physical development tasks to be performed on devices shall be determined by a joint supplier/GM A/D/V planning team after source selection. The team shall work to create an efficient/lean physical development plan using tasks appropriate to the module's technology and components. Design creation and analysis tasks may reveal issues that will require experimentation for design growth to continue. Therefore, during the program the results of analysis, FMEA and design reviews, etc. shall be used to update the physical development tasks list in the A/D/V plan.

The majority of physical development tasks are to be performed on pre-prototype hardware. The selected tasks and their timing shall be documented and tracked in the program's A/D/V plan.

4.2.2 Electromagnetic Compatibility (EMC) Development. Pre-prototype hardware shall be used to evaluate the capability of the device to meet the requirements of GMW3097, GMW3091 and GMW3103.

4.2.3 Ground Path Inductance Sensitivity Test.

Purpose: Identify potential problems that result from the natural inductance developed in the length and routing of the ground wire system. Inductance can prevent proper programming of flash memory in the vehicle. This phenomenon may not be observed in a bench test unless the inductance consideration is intentionally included.

Procedure: Place a 5 micro-Henry inductor in the ground path of a bench test setup to evaluate the proper function of flash memory programming.

Criteria: Programming should occur properly with the inductance in place.

4.2.4 Waveform Analysis During Startup. A capture of output waveforms during wakeup may be required on a sample of the parts tested. The intent of the waveform analysis is to detect inadvertent actuation of outputs. See the CTS for details of capture duration and criteria for acceptability.

4.2.5 Hardware-Software Functional Robustness Evaluation. Robustness evaluations are in addition to system-level functionality testing that confirms that devices perform their intended function as specified. Robustness evaluations are intended to confirm that the device also “Does Not Do, What It Is Not Supposed To Do” such as: shut down or lock up when confronted with a minor abnormality or behave in an unsafe or unstable manner. These procedures are to be performed as development and validation activities.

4.2.5.1 Processor Supervisor Performance Evaluation.

Purpose: This procedure is intended to verify that that the systems supervisor circuit was correctly implemented and is effective at recognizing faults and initiating corrective action attempts.

Procedure: See Appendix C.

Criteria: Ensure that disruptions and faults can be rapidly detected and corrected.

4.2.5.2 Fault Injection Testing.

Purpose: Fault injection testing consists of a systematic series of evaluations where hardware and/or software elements are purposefully disrupted, disabled or damaged in order to test and grow the robustness of the whole system to deal with abnormalities.

Procedure: See Appendix C.

Criteria: Verify that an E/E device is tolerant of potential system abnormalities.

4.2.6 HALT – Highly Accelerated Life Test For Design Margin Evaluation.

Purpose: The HALT[2] test is not a pass or fail test but rather a qualitative “quick learning method” to identify product weaknesses or operating limits from vibration and temperature.

Procedure: The complete HALT process procedure is explained in detail in GMW8287.

Criteria: The HALT test is not a pass or fail test but rather a qualitative “quick learning method” to identify product weaknesses or operating limits from vibration and temperature. The extreme levels of stressed applied in this test will evaluate design margin for hardware and will bring forth errors in software-hardware interaction as component values change with temperature and stress. Software-hardware interaction problems at temperature extremes are expected to be resolved. Resolution of product improvement will be arrived at jointly through a design review with General Motors. The data required for determining this resolution is:

- Identification of all operating limits and design margins.
- Complete understanding of all hardware and software failures.
- Identification of how the design margins could be improved.
- Identification of the barriers to increasing the design margins.
- Assessing the “Return on Investment” justification for limiting the increase in design margins when improvements are not made.

4.2.7 HAST - Highly Accelerated Stress (Humidity) Test.

Purpose: HAST[5,6] (Highly Accelerated Stress Testing) employs increased temperature and pressure to elevate the vapor pressure of a non-condensing high humidity environment.

Procedure: Conduct HAST per EIA/JEDEC Standard JESD22-A110-B under the conditions described in Appendix D.

Criteria: The DUT shall not exhibit unacceptable levels of current rise during the test and should function properly following cool-down after the HAST test. Test results must be reviewed with General Motors.

4.2.8 High Altitude Operating Evaluation.

Purpose: This analysis is used to determine if the DUT will suffer from overheating when operating the vehicle at a high altitude up to 4572 m (15 000 feet above sea level). High altitude results in a reduction in convective heat transfer from reduced air density.

High altitude analysis is to be performed on all E/E devices that contain significant heat generating elements on their circuit board.

Procedure (Operating Type 3.2): The effect of convective cooling is reduced as the air density decreases. Air density is reduced as altitude is increased. The appropriate multiplier[8] as shown in the following table can account for this phenomenon. The assumptions used to produce the multipliers are as follows:

- The heat transfer coefficient in a naturally cooled system can be expressed as a function of the Gashoff and Prandtl numbers. The temperature and density dependence of the Grashoff number dictates the increase in case-to-ambient-resistance and thus the increase in operating temperatures.
- Energy balance is used in a forced air system and the air temperature rise is inversely proportional to the density of air.
- Power dissipation dominates the temperature rise in a high power fan cooling system. The effect of air density variation on the Reynolds number accounts for the increase in case to ambient resistance, which thus accounts for an increase in operating temperatures.

Altitude	Multiplier		
Meter (Feet)	Fan Cooled (General)	Fan Cooled (High Power)	Naturally Cooled
0	1	1	1
4572 (15 000)	1.77	1.58	1.33

The multipliers as noted are used to adjust the temperature rise for high altitude effects with the use of the following equation:

$T_{altitude} - T_{ambient} = (T_{sea\ level} - T_{sea\ level,\ ambient})\ x\ Multiplier_{altitude}$

Where:

"$T_{altitude} - T_{ambient}$" is the surface or air temperature minus the ambient temperature at altitude and…

"$T_{sea\ level} - T_{sea\ level,\ ambient}$" is the surface or air temperature minus ambient temperature at sea level.

The multiplier to calculate temperature rise requires that one knows the temperature while operating at full power at sea level. Once the surface temperatures are scaled for high altitude, the other critical temperatures, such as junction temperatures can be calculated using a traditional thermal resistance network.

Example: Assuming that a device reaches a stabilized temperature of 50°C on sea level at an ambient temperature of 23°C. This results in a 9 degrees higher temperature on a hight of 4572 meter when calculated according the equation.

$T_{altitude}$=[(50–23)x1.33]+23= 59°C

Criteria: The DUT shall pass the Functional/Parametric Test at each functional check period and at the end of the test. if actual physical testing is performed.

Criteria for passing the analytical process requires documented evidence of adequate The design margin based on the operating specifications for the components of concern must be met.

4.2.9 Thermal Performance Development.

4.2.9.1 Thermocouple Method.

Purpose: Devices that produce heat locally or in many areas should receive special attention to ensure that the components and materials embody adequate design margin relative to the "time at elevated temperature" produced by the device. Temperature measurements with thermocoupling are used to locate and visualize the DUT hot spots. A radio or amplifier is an example of such a device where the components, plastic materials, or media may be adversely affected by the continual production of contained heat.

Procedure: Temperature measurements with thermocoupling are used to locate and visualize the DUT hot spots.

Apply thermocouple near suspected "hot spots" and operate the device at maximum heat generating conditions (but within bounds of the specification per GMW3172). Quantify temperatures and evaluate design margin.

Criteria: The temperatures reached under the conditions identified in the procedure must be less than the maximum permissible for the components involved with an additional level of design margin to insure reliable function over time. The level of design margin necessary must be agreed upon with General Motors.

4.2.9.2 Infrared Imaging Method.

Purpose: These methods may be used to enhance or replace the thermocouple methods. Infrared .

Thermography is used to locate and visualize the DUT hot spots during function and short circuit conditions.

This method may also be used to locate and visualize hot spots during short circuit conditions.

Infrared Thermography is used to locate and visualize the DUT hot spots.

Procedure: Perform the evaluation per the procedure in GMW8288.

Criteria: Modify the design, if necessary, per the guidelines in GMW8288.

5 Validation

5.1 Requirement Verification. The supplier is responsible for developing Functional/Parametric, Continuous Monitoring, and Functional Check Tests for the E/E device. These procedures need to be clearly defined and be approved by GM Validation Engineer prior to testing.

5.1.1 Functional And Parametric Tests. The Functional/Parametric Tests are procedures, which verify the functional, and parametric requirements defined in the CTS.

The Functional/Parametric Test shall be performed at different ambient temperatures (low, room and high) and at multiple power supply operational voltages. The number of different supply voltages and temperatures should be selected to verify each function at its required voltage and temperature limit.

As a minimum, this test shall be performed at the beginning of each test leg and at the end of all test legs. The temperature shall be stabilized for at least 0.5 h min. prior to the Functional/Parametric Test.

All Functional/Parametric Tests must be conducted with actual vehicle loads or simulated loads.

The power supply shall be capable of supplying sufficient current to avoid current limiting under high in-rush conditions. All Functional/Parametric Tests must be conducted with actual vehicle loads or simulated loads. All loads require the approval of GM Validation Engineer and have to be listed in the Test Plan and in the test report.

The Functional/Parametric Tests Shall:

1 Validate functionality by monitoring and recording that all outputs (both hardware and on vehicle communications) are in the correct state for a given set of inputs and timing conditions.

2 Validate parametric values by monitoring and recording the specific voltage, current, and timing levels for all inputs and outputs and ensuring that these levels meet specification requirements.

3 Selected parameters shall be statistically analyzed to evaluate whether build variations result in an acceptable degree of performance variation across the sample set. The distribution of the measured values shall not result in a skewed distribution stacked up against a tolerance limit.

4 Selected comparisons shall be made between parametric measurements made on the E/E devices when new, prior to testing, and when the DUTs complete the test sequences. Comparisons to the original measurements, individually and as a group statistically, shall be made to identify and quantify any performance degradation. If degradation limits are not specified in the CTS, the supplier and the GM Release engineer shall collaborate to define the degradation acceptance/failure Criteria.

5 Functional/Parametric Tests shall be made also in combination of different ambient temperatures and supply voltages. Choose upper and lower limits in temperature and voltage or other suitable parameters.

A suggested combination results in a Five Point Functional/Parametric Test with the following sequence:

Sequence	Temperature	Voltage
1	Room Temperature	Nominal
2	Minimum Temperature	Minimum
		Maximum
3	Repaint (If required)	No Voltage Applied
	Maximum Temperature	Maximum
		Minimum

5.1.2 The Continuous Monitoring Tests verify that the functional requirements are met while the DUTs are being exposed to the test environment.

1 Validate functionality, while the parts are exposed to the test environment, by continuously monitoring and recording exceptions to all outputs (both hardware and on vehicle communications) not being in the correct state for a given set of inputs and timing conditions. Sampling on a frequent basis is an acceptable form of continuous monitoring. The sampling rate shall be reviewed with and approved by GM Validation Engineering.

If available, also Data from internal diagnostic systems shall be used and recorded.

The Functional Check Shall: (Example with Operating Type 3.1)

1 Check functionality, while the DUTs are exposed to the test environment.

2 The DUT shall be powered up from a shut down power mode to a normal operation power mode. All DUT inputs/outputs (including on vehicle communications) shall be cycled and monitored for proper functional operation. The functional check shall be time limited to prevent self-heating of the device while being exposed to specific test environments.

3 The input/output cycling and monitoring shall be automatic and shall not require human intervention or observation at any time during the test to detect and record a nonconformance to specification requirement issue.

Test Criteria: The supplier is responsible for developing a detailed test criteria list, which will define the following:

How and which functional operations will be verified and/or continuously monitored.

The list of key parameters to be measured and recorded.

The list of build variation related parameters to be statistically analyzed.

The list of degradation related parameters to be statistically analyzed.

The nominal and range limit values for the measured parameters to ensure performance in accordance with the CTS.

The procedures must be submitted for approval to the GM Validation Engineer. After approval, the document shall be under change control and any future changes must be submitted for approval to the GM Validation Engineer.

5.1.3 Dimensional Test. The Dimensional Test shall be performed at room ambient temperature. All dimensional and physical requirements, including labels, on the GM released part drawing shall be validated and documented unless indicated otherwise by GM Engineering. Any Dimensional Test results that do not meet the part drawing requirements shall be considered a validation nonconformance issue.

5.1.4 Visual Device Inspection and Dissection. The E/E device Internal & External Inspection is a visual microscopic review of the device's case and internal parts at the completion of reliability testing as specified in the Validation Test Flow section. The purpose of this inspection is to identify any structural faults, material/component degradation or residues, and near to failure conditions caused by the reliability testing. The inspection shall use visual aids (i.e., magnifiers, microscopes, dyes, etc.) as necessary. The following are examples of items the inspection shall examine for:

1 **DUT Mechanical and Structural Integrity:** Signs of degradation, cracks, melting, wear, fastener failures, etc.

2 **Solder/Component Lead Fatigue Cracks or Creep of Lift:** Emphasis on large integrated circuits, large massive components or connector terminations (especially at the end or corner lead pins). Also, components in high flexure areas of the circuit board.

3 **Damaged Surface Mount Components:** Emphasis on surface mount components near circuit board edges, supports or carrier tabs. Also, surface mount components located in high flexure areas of the circuit board and near connector terminations.

4 **Large Component Integrity and Attachment:** Leaky electrolytic capacitors, contaminated relays, heat sink/rail attachments, etc.

5 **Material Degradation, Growth, or Residues of Corrosion:** Melted plastic parts; degraded conformal coatings, solder masks or seals; circuit board delaminations, lifted circuit board traces, signs of dendritic growth across circuit board traces, corrosion such as black silver sulfide spots on chip components, organic growths, or environmental residues due to dust, salt, moisture, etc.

6 **Other Abnormal or Unexpected Conditions:** Changes In Appearance Or Smell.

7 **The Formation Of Tin-Whiskers When Lead-Free Solder Is Used -** The test plan provided in this document will effectively precipitate the formation of tin-whiskers in lead-free solder if that possibility exists during normal life cycle manufacturing. A close examination of the circuit boards with a magnifying device should occur following PTC testing prior the vibration. The appearance of tin-whiskers during the test-flow process will indicate the probability of similar tin-whisker formations occurring in the field. The formation of tin-whiskers poses a risk to close pitched components, and may result in short-circuiting of products that are being used, or stored in a Service Parts Operation.

8 The Circuit Board And All Components Must Be Free Of Dendritic Growth.

A summary of each DUT's condition shall be documented and reported to GM engineering. The supplier may be required to perform further investigation to determine the degree or type of degradation. GM engineering will decide as to the necessity of corrective action.

5.2 Vehicle Electrical Transient Tests.

5.2.1 Parasitic Current Measurement.

Purpose: All of the functions that consume energy from the battery while the vehicle is in an ignition off state must be known and approved. Parasitic current is defined as the current drawn by electrical devices when the vehicle ignition switch is in the OFF position and all electrical accessories are turned OFF. This test defines the measuring method and the maximum acceptable level for the average parasitic current of an electronic component. The ramp down of the voltage should verify that the DUT does not wake up unintentionally.

Procedure (Operating Type 2.1): Monitor the current in all of the DUT supply lines and choose an appropriate current measuring device. The current measuring device must have a sampling frequency that is ten times higher than the smallest current peak the module creates, and the highest value of the peak generated by the DUT must be within the capability of the measuring device. The DUT should be equipped as installed in the vehicle. All inputs, outputs, and sensors are to be electrically connected and in their normal inactive state.

1 Connect the DUT to a variable power supply and adjust the input voltage to (12.6 ± 0.1) V. The system should be at a temperature of +25 °C.

2 Place the system into OFF mode.

3 Measure the current in the system over a time frame for a period that is ten times longer than the longest expected periodic repeated event of the module. Certain modules may experience periodic or occasional wakeups when OFF (OFF-Awake). The current, when in OFF-Asleep and under all OFF-Awake conditions, should be recorded.

4 While measuring the current, decrease the supply voltage by 1 V/min until zero volts are reached. The criteria must be met throughout the decreasing voltage process.

5 The test should be repeated for the various methods in which the DUT can enter the OFF-Asleep state.

6 This data will be used to calculate the average parasitic current experienced over a 40-day period.

Note: The test duration will equal the sum of the 10X measurement durations for each wakeup, and will not require 40 days of testing.

Criteria: The average parasitic current should be calculated as the average current flow over a 40-day period. The maximum allowable average parasitic current shall be 0.250 mA if not provided in the CTS.

The test report must include the following information: a) Parasitic current draw when in OFF-Asleep, b) Parasitic current draw under all OFF-Awake conditions and their time period, c) Calculated average parasitic current draw over 40 days, and d) Parasitic current over the voltage range from 12.6 V down to 0 V.

Example: Average Parasitic Current Calculation:

An ECU is turned OFF and follows the schedule shown below. Assume for this example that the ECU is not part of any Virtual Network that remains active after the key is switched to the OFF position. If the device is part of a Virtual Network then the following calculations should be performed disregarding the wakeup events from other devices.

- 1 h after the OFF power mode the ECU is powered for 1 minute.
- 24 h after the OFF power mode the ECU is powered for 1 minute.
- 5 days after the OFF power mode the ECU is powered for 1 minute.
- 2 weeks after the OFF power mode the ECU is powered for 1 minute.
- 4 weeks after the OFF power mode the ECU is powered for 1 minute.
- 6 weeks after the OFF power mode the ECU is powered for 1 minute.

During the time the module is on it draws 350 mA. When off, the module draws 0.200 mA. Both current ratings apply at +25 °C and 12.6 V. The answer sought in this example is: “What is the average parasitic current draw over the 40-day period?”

$$Answer: \ Parasitic\,current \ = [Current\ when\ on\ \ x \ \ (duty\ cycle)] \\ + [Current\ when\ off\ \ x \ \ (1 - duty\ cycle)]$$

First, 6 weeks is equal to 42 days, so this current level is not used in estimating the average parasitic current. There are five, 1-minute intervals (1-5 above) when the ECU is powered in the 40 day interval and therefore (57 600 /-5) min when it isn’t. (40 days = 57 600 min) Thus, the average parasitic current is:

$$Parasitic\,current \ = \left[350\,mA\ x\ \left(\frac{5}{57\,600}\right)\right] + \\ \left[0.200\,mA\ x\ \left(\frac{57\,600\ -\ 5}{57\,600}\right)\right] \ = \ 0.230\,mA$$

5.2.2 Jump Start Test.

Purpose: This test specifies the procedure for testing the immunity of E/E devices to positive over-voltage.

Procedure (Operating type 3.1 and 3.2): Use the test method according to ISO 16750-2, Over voltage, with the following exceptions:

Table 11: Jump Start Requirement

Test Voltage (V)	Test Time (min)
+26.0	1

Criteria: Functional status should be at minimum class C. All functions needed to start the engine must be available at the test voltage, if not stated differently in the CTS.

5.2.3 Reverse Polarity Test.

Purpose: This test specifies the procedure for testing the immunity of E/E devices to reverse polarity voltage on the power inputs of the device.

Procedure (Operating type 2.1 and 2.2): Use the test method according ISO 16750-2, Reverse Voltage with the following exemption:

Table 12: Reverse Polarity Requirement

Test Voltage (V)	Test Time (min)
-13.5	2

Criteria: Functional status should be at minimum class C.

Note: This test is not applicable to generator or devices that have an exemption stated in the CTS.

5.2.4 Over-Voltage.

Purpose: The over-voltage test addresses two conditions: The condition where the generator regulator fails so that the output voltage of the generator rises above normal value. The second condition is in case of use of battery chargers with high voltage pulses.

Procedure (Operating Type 3.2.):

- Perform a Functional/Parametric Test prior to application of each over-voltage event.
- Connect the power supply to the battery inputs of the DUT and all loads that have battery inputs.
- Turn on the power supply and subject the DUT to the required test voltage for the required test time as noted in Table 13.

Table 13: Over-Voltage Test Requirements

Test Voltage (V)	Test Time (min)
Sweep between +16 to 18 ± 0.2 at 1 V/min for devices that are over voltage protected	60 minutes
Provide a constant 18 V when no over voltage protection is provided	60 minutes

- Perform a Functional/Parametric Test at U_{nom}.

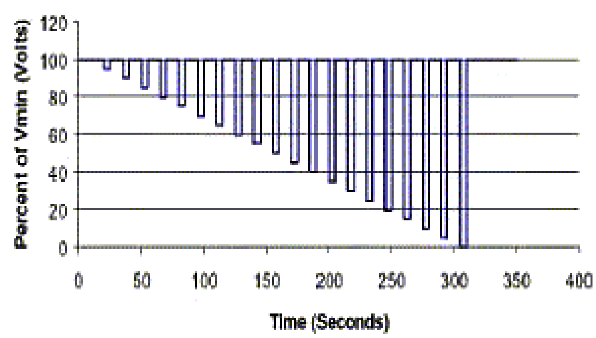
Criteria: Functional status should be at minimum class C.

5.2.5 Voltage Drop Test.

Purpose: This test verifies the proper reset behavior of the device. It is intended primarily for E/E devices with a regulated power supply or a voltage regulator. This test should also be used for microprocessor-based devices to quantify the robustness of the design to sustain short duration low voltage dwells (50 ms.)

Procedure (Operating Type 3.2): Use the test methods in accordance with ISO 16750-2, Reset Behavior At Voltage Drop.

Figure 4: Voltage Drop Test



Apply the test pulse to all relevant inputs and hold this decreased voltage for at least 5 seconds. Check the reset behavior of the DUT. Repeat the test pulse with a hold time of 50 ms at each decreased voltage and check the reset behavior of the DUT.

Criteria: Functional status should be at minimum class C.

5.2.6 Battery Voltage Dropout Test.

Purpose: To determine if the E/E device is immune to decreases (engine cranking and battery rundown) and increases (battery charging) in the battery voltage.

Procedure:

Operating Type 3.2

1 Perform a Functional/Parametric Test.

2 Soak the DUT un-powered until its temperature has stabilized to T_{min}.

3 Set up the battery voltage dropout waveform.

4 Power up the DUT and inject the battery voltage dropout test waveform with the following parameters from variation A in Table Table 14.

5 Perform a Functional Check at U_{min}, between the t_1 and t_2 time intervals.

6 Perform a Functional/Parametric Test after the t_3 time interval at 10 V.

7 Repeat steps (3) through (6) three additional times for the following times for the variations B, C, and D.

8 Repeat steps (2) through (7) at T_{max}.

Note: The zero volt value can be changed to 1 V to check for power reset functionality. This would be appropriate for micro controller devices and external EE-prom memories.

Figure 5: Battery Voltage Dropout Profile

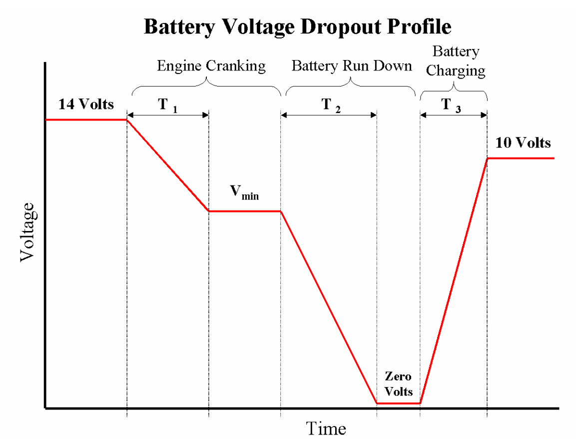


Table 14: Battery Voltage Dropout Test Values

Variations	Time (s)		
	T_1	T_2	T_3
A	0.01	10	1
B	0.1	600	10
C	0.5	3600	120
D	1	28 800	7200

Criteria: Functional status should be at minimum class C.

The DUT shall pass all Functional/Parametric Tests (FSC A).

5.2.7 Superimposed Alternating Voltage Test.

Purpose: To verify the performance of the E/E device when the supply voltage is super-imposed with a sinusoidal alternating voltage. This simulates the output of a poorly damped alternator over a full range of engine RPMS.

Procedure (Operating Type 3.2): Use the test methods in accordance with ISO 16750-2, Superimposed alternating voltage, Severity Level 2.

Criteria: The functional status shall be class A.

5.2.8 Open Circuit Tests.

Purpose: Determine if the device is able to suffer no damage due to incomplete contact conditions and to determine if the part functions properly immediately after the completion of the contacts.

5.2.8.1 Single Line Interruption.

Procedure (Operating Type: 3.2): Use the test methods in accordance with ISO 16750-2, Single Line Interruption.

Criteria: Functional status should be at minimum class C.

5.2.8.2 Multiple Line Interruption.

Procedure (Operating Type: 3.2): Use the test methods in accordance with ISO 16750-2, Multiple Line Interruption.

Criteria: Functional status should be at minimum class C.

5.2.9 Ground Offset Test.

Purpose: This test shall also determine if the device functions properly when subjected to ground offsets between platform modules.

Procedure: (Operating Type 3.2.) The offset shall be applied to each ground line separately and simultaneously. The voltage values shown apply to all interfaces of a module supplied with U_{nom}.

- **Ground offset between platform modules:**

  1 Apply U_{min} to the DUT.

  2 Subject ground line to a +0.8 V offset relative to the DUT ground.

  3 Perform a Functional/Parametric Test under these conditions.

  4 Repeat for next ground line.

5 Repeat for lines simultaneously.

6 Repeat for a -0.8 V offset relative to the DUT ground.

7 Repeat (2) through (6) at U_{max}.

- **Ground offset between platform modules and the powertrain:**

1 Apply Umin to the DUT.

2 Subject ground line to a +1.0 V offset relative to the DUT ground.

3 Perform a Functional/Parametric Test under these conditions.

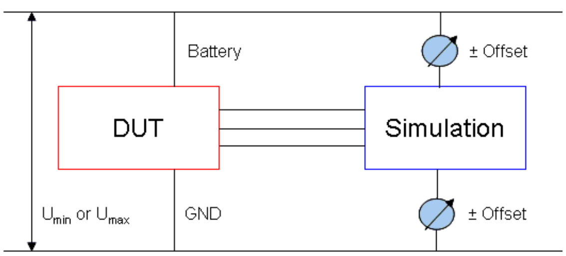
4 Repeat for next ground line.

5 Repeat for lines simultaneously.

6 Repeat for a -1.0 V offset relative to the DUT ground.

7 Repeat (2) through (6) at U_{max}.

Figure 6: Offset Test Setup



Criteria: The functional status shall be class A.

5.2.10 Power Offset Test.

Purpose: This test shall also determine if the device functions properly when subjected to power offsets between platform modules.

Procedure: (Operating Type 3.2.) The Power Offset test applies to all I/O lines that are connected to battery (B+) and switched battery lines (e.g. ignition, switched ignition). The offset shall be applied to B+, each switched battery lines and each I/O line separately. In addition, B+ and switched battery lines shall be tested simultaneously.

1 Apply U_{min} to the DUT.

2 Subject the applicable power line to a +1.0 V offset relative to the DUT power.

3 Perform a Functional/Parametric Test under these conditions.

4 Repeat for next applicable line.

5 Repeat for lines simultaneously.

6 Repeat for a -1.0 V offset relative to the DUT power.

7 Repeat (2) through (6) at U_{max}.

Criteria: The functional status shall be class A.

5.2.11 Short Circuit Tests. Use one of the following short circuit tests for the appropriate type of short circuit protected outputs of the DUT.

5.2.11.1 Short-To-Battery/Ground Test for Signal Lines.

Purpose: Verify immunity of the E/E device to short-to-battery and short-to-ground conditions.

Procedure (Operating Type 3.2): Use the test methods in accordance with ISO 16750-2, Signal Circuits.

Criteria: Functional Status shall be class C. The short to battery fault shall not prevent any other interface from meeting its requirements. The DUT shall pass all Functional/Parametric Tests.

5.2.11.2 Test for Intermittent Short Circuit on load circuits.

Purpose: To determine if the E/E device is able to meet specified requirements when subjected to short circuit conditions. This test is only required for outputs that are specified to be short circuit protected by the means of switching off the output when short circuit is electrically recognized.

Procedure (Operating Type 3.2):

1 Raise and stabilize the chamber temperature to T_{max}.

2 Apply U_{max} to the DUT.

3 At **t** = 0 s, power mode the DUT from Off to On. The outputs under test shall be activated no later than t = 5 s.

4 At **t** = 15 s, apply all of the short circuit conditions described during a 5 minute period and then remove all short circuits for 2 minutes and 45 seconds (the combination of steps 3 and 4 should equal 8 minutes).

5 Power mode the DUT from On to Off.

6 Repeat 3 through 5 until 60 cycles are complete (total short circuit time equals 8 hours).

7 After completing the 60 cycles, perform any required recycle/reset/cool down conditions and confirm the correct operation of the outputs with normal loads.

8 Adjust the battery voltage to U_{min} and repeat steps 3 through 7.

9 Stabilize the chamber temperature to T_{min} and repeat steps 2 through 7.

Note: If multiple shorts are applied simultaneously, then the supplier shall make sure that the test is valid for single shorts as well.

Criteria: Functional Status shall be class C. The short circuit fault shall not prevent any other interface from meeting its requirements. The DUT shall pass all Functional/Parametric Tests.

5.2.11.3 Test for Continuous Short Circuit.

Purpose: This test is required for short circuit protection output types that are specified to be protected by means of electronic current limiting.

Procedure (Operating Type 3.2):

1 Lower and stabilize the chamber temperature to T_{min}.

2 Apply U_{max} to the DUT.

3 Apply an 8 h continuous short circuit condition.

4 Remove the short circuit condition and perform all required recycle, reset and cool down conditions and confirm the correct operation of the outputs with normal loads.

5 Raise and stabilize the chamber temperature to T_{max}.

6 Apply and 8 h continuous short circuit condition to the previously tested outputs.

7 Remove the short circuit condition and perform all required recycle, reset and cool down conditions.

Criteria: Functional Status shall be class C. The external short circuit fault shall not prevent any other interface from meeting requirements. It is also required that the tested outputs be included in parametric measurements. These measurements shall be capable of detecting potential output degradation such as unacceptable current draw and voltage drop changes.

5.2.11.4 Load Circuit Over-Current Test.

Purpose: The purpose of this test is to determine if the DUT is able to meet specified requirements when subjected to maximum current allowable by the protection fuse.

Procedure (Operating Type 3.2):

1 Raise and stabilize the chamber temperature to T_{max}.

2 Apply Unom to the DUT.

3 The load circuit shall be in operation. Apply a short circuit condition to the output so that the load current is 1.35 x the nominal fuse rate current (I_{RP}) of protection.

4 Record fuse blow times and verify that they are within the fuse specification.

5 Repeat with shunts in place of fuses and hold current to upper fuse specification blow time limit.

6 Repeat step (3) to (5) with a short circuit condition to the so that the load current is 2 x I_{RP}. and 3.5 x I_{RP}.

The test duration shall be derived from the corresponding fuse protection characteristic curve (ISO 8820, Operating Time Rating), considering the upper tolerance plus 10 %.

Criteria: Functional Status shall be class C. The external short circuit fault shall not prevent any other interface from meeting requirements. It is also required that the tested outputs be included in parametric measurements. These measurements shall be capable of detecting potential output degradation such as unacceptable current draw and voltage drop changes.

5.2.12 Isolation Evaluation.

Purpose: The loss of insulation quality due to reduced spacing of traces or the degradation of dielectric material from humidity ingress can create performance problems. This test quantifies the resistance between critical elements after the degrading effects of moisture. This test may also be used to evaluate thin film insulator degradation from moisture in electro-mechanical devices such as relays and inductors.

Procedure (Operating Type 1.1): Use the test methods in accordance with ISO 16750-2, Insulation resistance.

- This test shall be performed following a humid heat test.

Criteria: The isolation resistance shall be > $10^6\ \Omega$.

Special Note: The resistance value is the criteria of interest. Less voltage (< 100 V) can be used with electronic devices to prevent damage to susceptible components such as capacitors.

5.2.13 Puncture Strength.

Purpose: Quantify the possibility of breakdown of insulation in applications involving high voltages.

Procedure (Operating Type 1.1):

1 Heat the DUT in a hot air oven to T_{max}.

2 Apply a test voltage of 500 U_{eff} ac with a frequency of 50 Hz for a duration of 2 s to the DUT as follows:

- Between electrically isolated and adjacent terminals,
- Between electrically isolated terminals and electrically isolated metal housing,
- Between electrically isolated terminals and an electrode wrapped around the housing (i.e. metal foil, sphere bath) in the case of plastic material housing.

Criteria: There shall be no puncture or arcing through the insulator.

5.2.14 Electromagnetic Compatibility. The E/E device shall meet the requirements of GMW3091, GMW3097 and GMW3103.

5.3 Connector Tests. All connectors shall meet the requirements defined in GME3191.

5.3.1 GME3191 Connector Tests to Be Run On the DUT. The following tests in GME3191 shall be run on the DUT as an assembly:

- Terminal Retention Force
- Connector Mating Force
- Connector Retention Force
- Connector Disengage Force

5.3.2 Connector Installation Abuse Test.

Purpose: Evaluate bending force weaknesses of the connector, or circuit boards to which the connector is attached. These human applied forces may be the result of side forces during connector attachment, or misplaced forces from hand, elbow or foot during other assembly operations.

Procedure:

Method A – Side forces from hand or elbow

Operating Type 1.1

Functional Status Classification = C

The DUT shall be set up to allow testing on all external surfaces with a 13.0 mm or larger diameter area. Subject the DUT to an evenly distributed 110 N (24.7 lbs) force about any 13.0 mm diameter area for 1.0 s. This represents a simulated hand or elbow load that may possibly occur during vehicle assembly.

Criteria: The DUT shall be able to withstand the above mechanical stress without any shear or yield or loss of function or loss of electrical isolation. The DUT shall pass the Functional/Parametric Test at the end of test.

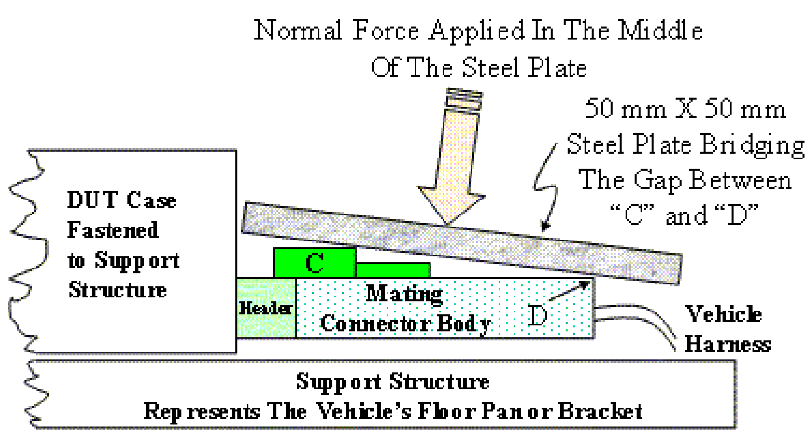
Method B - Foot loads from a misplaced step

Operating Type 1.2

Functional Status Classification = C

This represents a foot load that may possibly occur during vehicle assembly. The DUT connector and header shall withstand, without electrical degradation or permanent physical damage, a simulated foot load of 890 N of a distributed force applied normally through a (50 x 50) mm (or appropriately sized) rigid steel plate for 1 min as shown in the Connector Integrity sketch. This plate represents the sole of a person's shoe. Apply this force to connector and DUT header as shown in the diagram below. The DUT shall be designed to prevent imposing such load when the connector system is unable to sustain such foot loads.

Figure 7: Foot Load Connector Test



Criteria: The DUT shall be able to withstand the above mechanical stress without any shear or yield or loss of function or loss of electrical isolation. The DUT shall pass the Functional/Parametric Test at the end of test.

5.3.3 Fretting Corrosion Degradation Test.

Purpose: This test intends the degradation of contacts used in modules mainly consisting fuses, relays and contacts, by combination of humidity, temperature and vibration profiles.

Procedure:
Operating Type: 3.2
A set of 6 samples has to be used for the following test.

Use the Humid Heat Constant (HHCO) Test with a test duration of 1 day as a pre treatment for the test samples.

Subsequently use the test method according the Random Vibration Test for sprung masses with the following deviations:

Only 24 h vibration in Z-axis.

Thermal Cycle Profile according the Power Temperature Cycle Test (PTC) Profile.

A durability load cycling shall be used during the test. Loads shall be 90 % of generator output.

The most critical circuits (15...30) shall be constantly monitored and shall be predetermined through the use of analysis, thermography, or thermal mapping with thermocouples.

Finally the Load Circuit Over-Current Test shall be done with all samples.

Criteria:
Functional Status shall be class A.
No circuit shall develop an increase in resistance that is more than 3 times that circuit's original resistive value (Weibull analysis to quantify reliability for each circuit)

All contacts shall meet the criteria for "resistance per connection point" defined in GME3191.

No individual circuit shall have more than 20 milliohms of resistance (Weibull analysis to quantify reliability for each circuit)

5.4 Mechanical Tests.

5.4.1 Vibration Tests. The following vibration tests reference different test conditions for cars and for trucks. This document will define a “truck” as a vehicle that will be used in a commercial or semi-commercial environment. A pickup truck would be considered a “truck”, while an SUV or cross-over vehicle would be considered a car.

All Vibration Tests have a superimposed thermal cycling used during test.

A device that is normally attached to the engine through a bracket should be tested without the bracket in place. The DUT shall be directly attached to the shaker table through an adequately rigid fixture.

5.4.1.1 Vibration (Sine + Random) – Mounting Location Engine/Transmission.

Purpose: The vibration of a piston engine can be split up into the sinusoidal vibration, which results from the unbalanced mass forces in the cylinders, and the random noise due to all other vibration sources of an engine. The influence of bad road driving is comprehended in the frequency range from (10...100) Hz. The main failure by this test is breakage due to fatigue.

Procedure (Operating Type 3.2): Use test methods according ISO 16750-3, Test I –Passenger car, engine.

During vibration load testing the DUT shall be simultaneously subjected to vibration and temperature cycles according to the vibration test temperature cycle. The DUT shall be electrically operated and continuously monitored while on test.

Sinusoidal followed by random vibration tests are to be performed on the same DUT. Combined sine on random testing may be performed in one test run if there is a desire to reduce the time on test.

The specified test profiles apply to both gasoline and diesel engines. Test durations apply to both the sinusoidal and random vibration tests.

Cars: Test duration: 22 h for each X,Y and Z coordinate axis (perpendicular to the plane of the circuit board) of the DUT for a base requirement of 100 000 miles.

Trucks: Test duration is the same as for cars for every *100 000 miles of requirement* as noted in the CTS. Example: A 200 000-mile requirement would require 44 h of vibration per axis.

Sinusoidal Vibration

Figure 8: Sinusoidal Vibration For Engine or Transmission

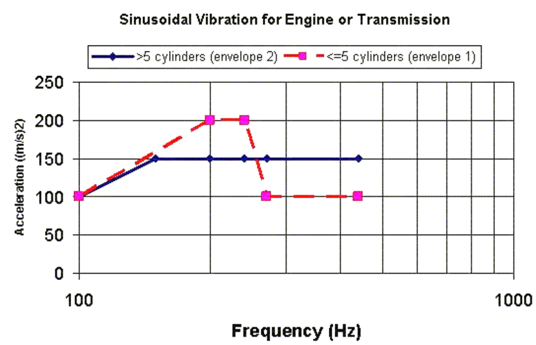


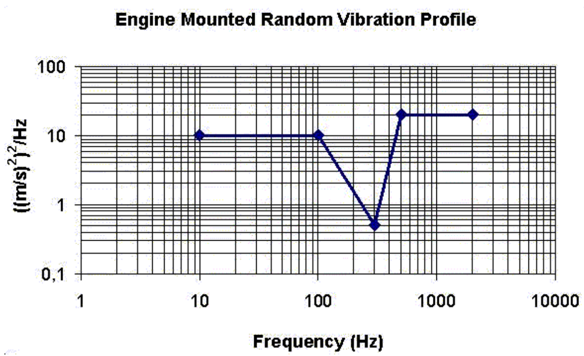
Table 15: Engine/Transmission Sinusoidal Vibration Severity

Envelope 1		Envelope 2	
Freq (Hz)	Maximum Acceleration (m/s^2)	Freq (Hz)	Maximum Acceleration (m/s^2)
100	100	100	100
200	200	150	150
240	200	440	150
270	100		
440	100		

Frequency sweep:	≤ 1 octave/min
Envelope 1:	For ≤ 5 cylinder engines
Envelope 2:	> 5 cylinder engines and 4 cylinder engines with a balance shaft.

Random Vibration:

Figure 9: Random Vibration Profile For Engine Mounted Devices



RMS Acceleration Value = 181 $(m/s)^2$ = 18.4 g

Table 16: Random Vibration Profile Engine Mounted

Frequency in Hz	Acceleration Power Density in $(m/s^2)^2$ /Hz	Power Spectral Density in g^2/Hz
10	10	0.10
100	10	0.10
300	0.51	0.0052
500	20	0.21
2000	20	0.21

Criteria: Functional Status shall be class A.

5.4.1.2 Random Vibration - Mounting Location: Sprung Masses.

Purpose: This test evaluates the DUT for adequate design margin for fatigue resulting from random vibration induced by rough roads.

Procedure (Operating Type 3.2): Use test methods according ISO 16750-3, Test IV – Passenger car, sprung masses (vehicle body).

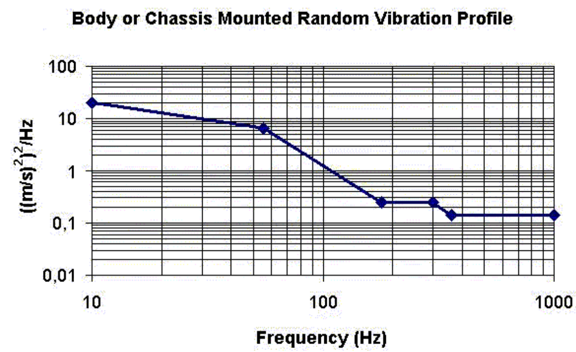
During vibration load testing the DUT shall be simultaneously subjected to temperature cycles according to the vibration test temperature cycle.

The DUT shall be electrically operated and continuously monitored while on test.

Cars: Test duration: 8 h for each X,Y and Z coordinate axis (perpendicular to the plane of the circuit board) of the DUT for a base requirement of each 100 000 miles.

Trucks: Test duration: 18 h for each X,Y and Z coordinate axis (perpendicular to the plane of the circuit board) of the DUT for a base requirement of each 100 000 miles.

Figure 10: Random Vibration Profile For Sprung Masses



RMS Acceleration Value = **27.8 $(m/s)^2$ = 2.84 g**

Table 17: Random Vibration Profile For Sprung Mass

Frequency in Hz	Acceleration Power Density in $(m/s^2)^2$ /Hz	Power Spectral Density in g^2/Hz
10	20	.208
55	6.5	.0677
180	.25	.0026
300	.25	.0026
360	.14	.00146
1000	.14	.00146

Criteria: Functional Status shall be class A.

5.4.1.3 Random Vibration – Mounting Location: Unsprung Masses.

Purpose: This test is applicable for devices which are mounted on unsprung masses (e.g. wheel and wheel suspension). Vibration of unsprung masses is random vibration induced by rough-road-driving.

Procedure (Operating Type 3.2): Use test methods according ISO 16750-3, Test V – Passenger car, unsprung masses (wheel and wheel suspension).

Test Duration:

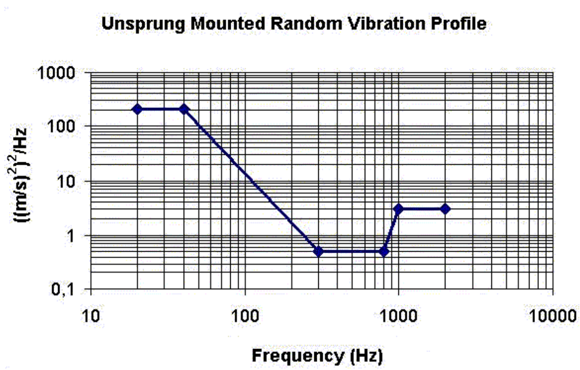
Cars: 8 h for each X,Y and Z coordinate axis (perpendicular to the plane of the circuit board) of the DUT for a base requirement of each 100 000 miles.

Trucks: 18 h for each X,Y and Z coordinate axis (perpendicular to the plane of the circuit board) of the DUT for a base requirement of each 100 000 miles.

Loads below 20 Hz are not covered by the test profile stated here. In practice, high amplitudes can occur below 20 Hz; therefore, loads acting on the component in this frequency range shall be considered separately. The loads between (10...20) Hz shall be covered in the CTS. Frequencies above 1000 Hz can be ignored with the approval of GM Engineering.

Criteria: Functional Status shall be class A.

Figure 11: Random Vibration Profile Unsprung Mass



RMS acceleration Value= 107.3 $(m/s)^2$ = 10.95 g

Table 18: Random Vibration Profile Unsprung Mass

Frequency in Hz	Acceleration Power Density in $(m/s^2)^2$ /Hz	Power Spectral Density in g^2/Hz
20	200	2.08
40	200	2.08
300	0.5	0.005
800	0.5	0.005
1000	3	0.031
2000	3	0.031

5.4.1.4 Thermal Cycle Profile Used During All Vibration Tests. Because in vehicle vibration stress can occur together with extremely low or high temperatures, a simultaneous temperature cycle has to be used during the vibration tests.

The temperature cycle profile definition during the test have to be according ISO 16750-3, General.

The DUT shall be operated and continuously monitored (Operating Type 3.2) throughout the thermal cycle.

In special cases where the start up functionality needs to be tested, the device should be turned off for periods of one minute during the hot, cold and transition periods to evaluate the ability of the product to return to function under the condition of vibration with different temperatures.

In case of self heating components a deviating operating mode can be established with the approval of GM Engineering.

Figure 12: Thermal Cycle Applied During Vibration

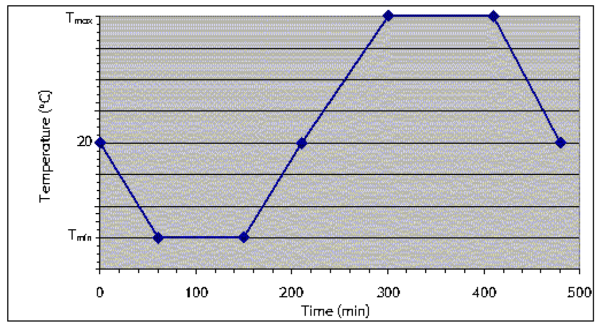


Table 19: Time vs. Temperature for vibration tests

Duration (min)	Temperature (°C)
0	20
60	-40
150	-40
210	20
300	T_{max}
410	T_{max}
480	20

5.4.1.5 Bracket Random Vibration + Thermal Cycle.

Purpose: Evaluate bracket fatigue life over the full range of temperatures. The brackets used in attaching electronic devices are not being evaluated in the vibration tests defined previously. The amplification Q-factor resulting from the attaching bracket has already been factored into the GRMS values specified. The brackets should be evaluated separately using a reduced level of vibration to be defined in the ADVP&R or Test Template.

Procedure: Quantify the resonance frequency of the bracket.

Criteria: The resonant frequency of the bracket without the product attached shall be higher than 150 Hz..

5.4.2 Mechanical Shock.

Purpose: The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to the mechanical stresses like potholes, minor repairable collisions and door closures.

Procedure: Two shock tests have to be performed with different shock parameters. The tests are conducted according to IEC 60068-2-27 Ea.

Operating Type 3.2 or 1.2: However, devices that include relays, such as wiper electronics and window modules, should be evaluated for proper function during the mechanical shock event (operating type 3.2) to ensure unwanted activation does not occur.

Table 20: Mechanical Shock Test

Description	Test # 1	Test # 2
Acceleration	25 g_n	100 g_n
Nominal shock duration	15 ms	11 ms
Nominal shock shape	Half sine	Half sine
Total Number of shocks	132 x 6 = 792	3 x 6 = 18

Criteria: Functional status shall be class A after this test.

5.4.3 Door/Trunk/Hood Slam Test.

Purpose: Special requirements for components mounted in closures (door, trunk lid, hatchback, and hood). The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to the mechanical stresses defined below.

Procedure (Operating Type 3.1/3.2): The tests are conducted according to IEC 60068-2-27 Ea.

Table 21: Slam Based Mechanical Shock Loads

Acceleration	40 x g_n
Nominal shock duration	6 ms
Nominal shock shape	half sine

Table 22: Quantity of Mechanical Shocks For Closures

Closure	**Number of shocks** (in the main direction)
Driver’s Door	100 000
Passenger Door/Hatch Lid	50 000
Trunk Lid	30 000
Rear Doors	20 000
Hood	1500

Criteria: Functional status shall be class A.

5.4.4 Crush Test for Device Housing.

Purpose: At least one pre-prototype unit shall be used to evaluate/verify that the device will meet the crush requirements.

To determine if the E/E device is able to meet specification requirements when subjected to the mechanical stresses imposed during vehicle assembly. Method “A” represents a load imposed by a person’s elbow while leaning forward on the DUT case. Method “B” represents loading imposed by a person standing on the DUT and/or its connector and header. Both conditions are representative of possible assembly plant abuse. The application of these forces should not generate damaging forces on the circuit board or on components mounted on the circuit board.

Procedure: Method A. Operating Type 1.1

Functional Status Classification = C

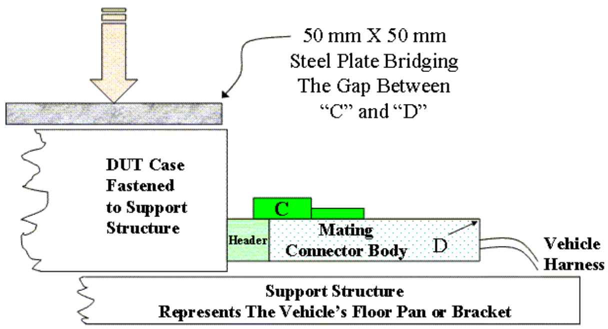
The DUT shall withstand, without electrical degradation or permanent physical damage, a simulated elbow load of 110 N. The DUT shall be set up to allow testing on all external surfaces with a 13.0 mm or larger diameter area. Subject the DUT to an evenly distributed 110 N force about any 13.0 mm diameter area for 1.0 s (this represents the force applied by a person’s elbow). A Functional/Parametric Test shall be performed at the end of test.

Method B. Operating Type 1.2

Functional Status Classification = C

The DUT shall withstand, without electrical degradation or permanent physical damage, a simulated foot load of 890 N of a distributed force applied normally through a (50 x 50) mm (or appropriately sized) rigid steel plate for 1 min as shown in the following figure. Locate the steel plate on top of the DUT and apply the 890 N to the top of the device through the steel plate.

Figure 13: Foot Load Applied To Top of Device Housing



5.4.5 Free Fall (Drop Test).

Purpose: A system/component may drop down to the floor during handling assembly. To determine the level of damage the DUT is subjected to the mechanical stresses.

Procedure (Operating Type 1.1): Use test methods according to ISO 16750-3, Free fall.

Criteria:

- If there is no visible external damage to the DUT, then the DUT shall have no internal damage and shall pass the Functional/Parametric Test at the end of test.
- If there is visible external damage to the DUT and the damage is judged by GM Validation Engineer to be:
  - *Insignificant*, then the DUT shall have no internal damage and shall pass the Functional/Parametric Test at the end of test.
  - *Significant*, then the DUT does not have to meet the performance requirements.

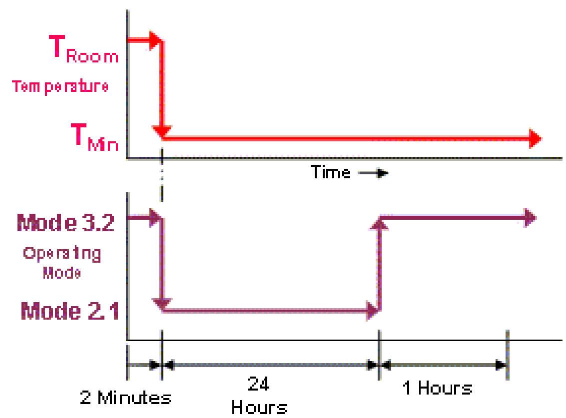
5.5 Temperature Tests.

5.5.1 Low Temperature Wakeup Test.

Purpose: This test verifies DUT functionality after prolonged exposure to low temperature extremes.

Procedure (Operating Type 2.1/3.2.): Testing shall be performed according to IEC 60068-2-1 Test Ab. T_{min} of the operating temperature range is the low temperature that is to be used. At the start of a 24 h cycle, the test parts shall be energized at room temperature for 2 minutes and evaluated for proper function at Unom. The DUT shall then experience a cold soak condition for 24 h at operating mode 2.1. At the end of 24 h, and while still in the cold environment, the product is to be turned on, or awakened from its sleep state, and evaluated for proper function for 1 h at operating mode 3.2.

Figure 14: Low Temperature Wakeup Test Profile



Criteria: Functional status shall be class A. Output waveform analysis during wakeup may also be required to detect inadvertent actuations – see the CTS for specific requirements.

5.5.2 High Temperature Durability Test.

Purpose: To submit the DUT to a sustained high temperature to evaluate material degradation and diffusion based failure mechanisms.

Procedure (Operating Type 3.2): Test according ISO 16750-4, High Temperature Test, Operation, with the following exception:

The test operating voltage shall be nominal for 80 %, low for 10 % and high for 10 % of the functional tests and/or cycles.

Duration of load is 500 h or 2000 h as per table (4), or per the CTS.

In situations where an increase in temperature beyond Tmax is warranted due to post heating (temperature codes "F" and "H") or the repaint temperature $T_{max\ RP}$ is higher than the maximum temperature T_{max} (temperature codes "A" to "F") the following shall apply:

5 % of the required high temperature testing shall occur at the elevated post heating temperature level

(T_{maxPH}). One hour storage shall be done at the repaint temperature $T_{max\ RP}$.

The DUT has to be exercised for the required number of 1-life electrical operational cycles during the High Temperature durability test.

The functional cycling scheme shall exercise the DUT and allow for detection of degradation or failure. T_{max} of the operating temperature range table (4) is the temperature load. Duration of load is 500 h, 2000 h, or per the CTS.

In situations where an increase in temperature beyond T_{max} is warranted due to post heating (temperature codes “F” and “H”) the following shall apply:

5 % of the required high temperature testing shall occur at the elevated post heating temperature level (T_{maxPH})

The test operating voltage shall be nominal for 80 %, low for 10 % and high for 10 % of the functional tests and/or cycles.

Criteria: Functional status shall be class A. All functional requirements shall be met during and after the test. Any inputs/outputs in an incorrect state or any incorrect communication messages shall be considered a nonconformance to specification requirements.

5.5.3 High Altitude Shipping - Low Pressure Test.

Purpose: This test is applicable to devices that are hermetically sealed and may be susceptible to permanent damage when shipped in an unpressurized aircraft up to an altitude of 15240 meters (50 000 feet above sea level).

Procedure (Operating Type 1.1): Test according to IEC 60068-2-13.

Place the DUT in a pressure chamber and lower the absolute pressure to 11 kPa. This test shall be 16 h in duration.

Criteria: The functional status shall be class A after the test.

5.5.4 High Altitude Operating – Low Pressure Test.

Purpose: High altitude testing is to be performed on all E/E devices that contain significant heat generating elements on their circuit board. The reduced air density at high altitude will reduce convective heat transfer and may cause marginal designs to overheat while in operation within the vehicle.

Procedure (Operating Type: 3.2): Place the DUT in a pressure chamber and lower the absolute pressure to 59 kPa. This test shall be 16 h in duration. Perform a Functional Check every 15 min.

Test according to IEC 60068-2-13. The DUT shall be mated to the vehicle interface connector and associated harness at all times.

Criteria: Functional status shall be class A after this test.

5.5.5 Thermal Shock Air-To-Air (TS).

Purpose: This is an accelerated test to evaluate failure mechanisms driven by mismatches in the coefficients of thermal expansion between components and circuit boards.

Procedure (Operating Type 1.1 or 1.2): Use test methods according ISO 16750-4, Rapid change of temperature with specified transition duration. The temperature cycle testing shall be performed according to IEC 60068-2-14 Na.

The appropriate dwell time at each temperature needs to be proven by measurements. The dwell Time at high or low temperature should be 10 min. The “Dwell Timer” shall begin when the inside of the product reaches Tmax (or higher) minus 3 °C or T_{min} (or lower) plus 3 °C.

The minimum number of cycles is given in Table 5. An appropriate number of cycles to reach the required reliability can be derived from Table 10.

Upon agreement with General Motors, this test can be performed without a case, or with a modified case to increase the rate of temperature change.

Criteria: Functional status shall be class A after this test.

5.5.6 Power Temperature Cycle Test (PTC).

Purpose: The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to the power and temperature cycling stresses that cause failures related to mechanical attachments, integrated circuit dies, electromigration, and solder creep.

Procedure (Operating Type 3.2): The Power Temperature Cycle Test shall be performed according IEC 60068-2-14 Nb.

The electrical input/output duty-cycling shall be scheduled such that the required minimum number of 1-life cycles is evenly distributed during the total PTC test.

The control instrumentation must be capable of synchronizing the DUT on/off time with the chamber temperature transitions.

Figure 15: Example of a Power Temperature Cycle

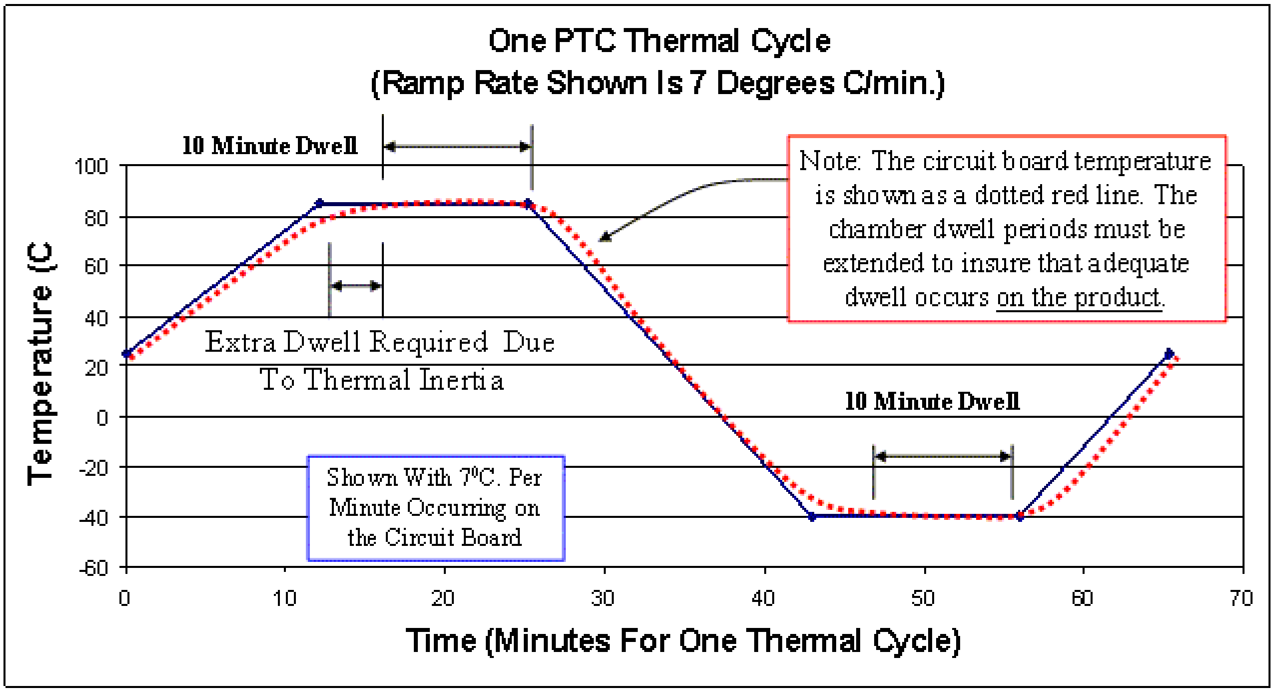


Table 23: Power Temperature Cycling Requirements

Temperature Range	T_{min} to T_{max}
Operating type	3.2
Temperature transition rate	(2...15 ± 1) °C/min with the understanding and approval of GM Engineering.
Dwell time	A 10-minute hot dwell and 10-minute cold dwell is to be used.The “Dwell Timer” shall begin when the product reaches T_{max} minus 3 °C and T_{min} plus 3 °C
Minimum number of thermal cycles	The damage generated with Power Temperature Cycling should represent at minimum 25 % of the total damage by thermal cycling. The minimum number of cycles shall be 100. An appropriate number of cycles to reach the required reliability can be derived from Table 10.
Power moded on 100 s and 20 s off with cycling of loads	During high temperature dwell.
	During the second half of the cold temperature dwell.
	During all transitions.
Power off	Only as dictated by the 20 second off portion of power moding.
Supply Voltage	The test operating voltage shall be nominal for 80 %, low for 10 % and high for 10 % of the functional tests and/or cycles

Criteria: Functional status shall be class A.

5.5.7 Thermal Shock/Water Splash.

Purpose: This test will verify the DUT functionality after exposure to sudden changes in temperature after a water splash. The aim is to simulate driving through water in the wintertime. This applies to E/E devices that lie in the splash area, (i.e. low mounted on the engine.).

Procedure (Operating Type 3.2): Use test method according ISO 16750-4, Ice water shock test.

Criteria: The functional status shall be class A.

5.6 Humidity Tests. For the HHC, HHCO, and DEW humidity tests the DUT shall be powered with a system test voltage of 11.0 V, (to minimize excessive localized heating of DUT components that could cause localized drying). The DUT shall be functionally active but continuously locked in a steady or holding state of inputs and outputs (I/O) and circuit activity (i.e. statically active rather than dynamically I/O exercising active).

Special Concern For Fuses Within The Bused Electrical Center: The zinc material used inside fuses becomes maximally reactive with high humidity and a temperature of +85 °C. The Cyclic Humidity Test, when applied to Bused Electrical Centers can be conducted as described above, however, fuse integrity should receive special attention.

5.6.1 Humid Heat Cyclic (HHC).

Purpose: The cyclic temperature/humidity test is designed to reveal defects in test specimens caused by humid air where electrical malfunctions are caused by moisture. The accelerated breathing and the effect of the freezing of trapped water in cracks and fissures are the essential features of this composite test.

Procedure:
Operating Type 2.1/3.2
Test according to IEC 60068-2-38-Z/AD.

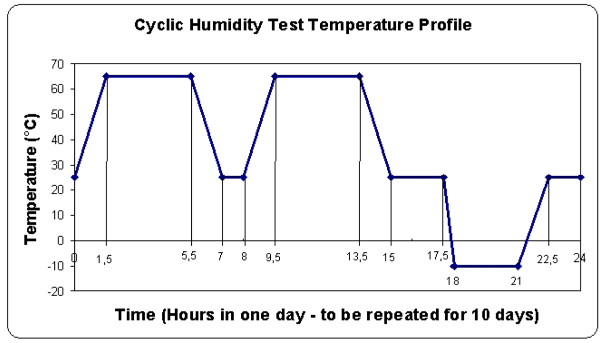
Table 24: Cycling Humidity Test Requirements

High Temperature	+65 °C
Low Temperature	-10 °C
Duration	10 days

The following graph shows the cyclic humidity cycle with the cold cycle included. Five of the first nine 24 hour cycles are to include the cold cycle.

A permanent quiescent current monitoring is needed for every DUT to detect malfunctions.

Figure 16: Cyclic Humidity Test Profile



Criteria: Functional Status shall be class A during and after the test.

5.6.2 Humid Heat Constant (HHCO).

Purpose: Evaluate the functionality of DUTs during exposure to extreme humidity and temperature.

Procedure (Operating Type 2.1/3.2): Test according to IEC 60068-2-78 Cb.

Table 25: Constant Humidity Test Requirements

Temperature	(+65 ± 3) °C
Duration	7 days
Relative Humidity	(95...100) %

<u>Special Note:</u> This test can be accelerated through the use of the Arrhenius-Peck equation with the temperature not to exceed the service temperature of plastic components. This can represent a significant reduction in test time.

<u>Optional:</u> If fungus growth is a concern then this test should be run at +42 °C for 21 days. This cooler and longer test may be applicable when new materials or fluxes are being introduced.

Criteria: Functional Status shall be class A during and after the test.

5.6.3 Frost Test For Moisture Susceptibility.

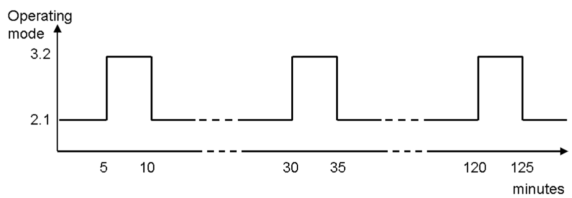
Purpose: The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to condensed moisture. This is a qualitative test for detecting weakness or degradation in a device's moisture resistance capability.

Procedure (Operating Type 1.1/3.2): One cycle of this procedure shall be performed. The test parts shall experience a soak condition in a chamber at (-20 °C) for a minimum of 2 h (operating mode 1.1).

The test parts shall then be transferred to a second chamber maintained at (+45 °C) and (95 %) relative humidity within one minute. The vehicle interface connector and associated harness shall be connected to the parts to allow the Functional/Parametric Test and a monitoring to be performed.

Perform a five minute Functional/Parametric Test after 5 min, 30 min, and 2 h at (+45 °C) while the DUT remains inside the humidity chamber with a relative humidity of (95...100) %. The DUT shall remain in an off state (operating type 2.1) between periods of evaluation. A permanent quiescent current monitoring is needed while the DUT is in the humidity chamber .

Figure 17: Operation During Frost Test



Criteria: The part shall pass the Functional/Parametric Test at all three test intervals.

5.6.4 DEW Test.

Purpose: This test covers requirements for E/E devices that are exposed to extreme humidity levels, due to their installation position in humid locations (e.g. doors, wiper systems in plenums, and sunroof systems).

Procedure: Operating Type 1.1/3.2

Conditioning: Ensure that the surrounding air has free access to internal devices (printed circuit board) by the appropriate method (e.g. opening of the component, removing of covers). This requirement ensures meaningful results within 10 cycles (10 days). If free access to internal devices cannot be guaranteed, the test parameters have to be changed in the relevant specification.

The Dew Test consists of 10 cycles as follows:

Description of one 24 h cycle:

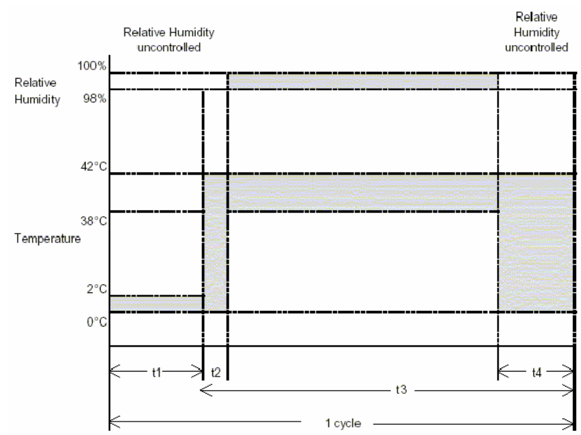
Table 26: Dew Test Requirements

T_1	Time
1	2 h
2	3 min max.
3	22 h
4	1 h

Table 27: Dew Test Operating Types

Operating Type	Time	
1.1	2 h	Exposure (0 /+2) °C relative humidity uncontrolled.
The component is transferred to the high humidity chamber within 3 min.		
3.2	22 h	Exposure to (+40 ± 3) °C and (98 /+2) % relative humidity.

Figure 18: Dew Test Profile



It is recommended to use two separate environmental chambers when performing this test.

Functional Cycling: The component shall be functionally cycled during the +40 °C portion of the test sequence. The functional cycle and the number of cycles shall be individually specified in the relevant component specification or on the component drawing. Requirements of functional status (A) shall be met. If functional cycling while exposure to the high humidity is not possible, it shall be done during the 1 h transfer period at the end of every 24 h cycle. This shall be stated in the relevant specification or on the component drawing.

Criteria: The requirements of functional status A shall be met throughout the test.

5.7 The Corrosion Salt Mist/Fog Test And Salt Spray Test.

Purpose: To verify DUT functionality after exposure to salt spray as experienced in coastal regions and road salt environments.

Due to the availability of different test equipment both test procedures are possible for all vehicle locations. One must choose from two possible tests:

Procedure 1 (Salt Mist) Operating Type 1.2/3.2: Use the test method of ISO 16750-4, Leakage and function Salt Mist.

The number of cycles depends on the mounting location of the DUT. The number of cycles is defined in table Table 28 “Summary of Salt Corrosion Testing” as summarized number of days.

Criteria: Functional status shall be class A.

Procedure 2 (Salt Spray):

Location: Engine Compartment, Door Interior, Vehicle Exterior And Underbody Devices

Electrical devices located in those areas where salt spray rather than just salt mist may be encountered, will be tested according to the following Salt Spray Test.

Mounting and Salt Spray Flow: Mount the DUT centrally between the spray nozzles with appropriate load and voltage applied as described below. The volume and force level of the salt spray should be designed to “wash away any corrosion products that my form on the metal”. Adjust the flow of the salt spray through the spray nozzles so that the streams of fluid are strong enough to hit the opposite wall of the chamber with the sample support walls removed. A typical chamber that is used to perform this test uses 12 nozzles, operating at 15 psi and sprays a total of 30 gallons per minutes. The nozzles typically spray a hollow cone pattern and spray all the way across the chamber (4 feet).

The salt spray solution is to be 5 % salt by weight.

Test Procedure: The following 24 h sequence is repeated as many times as necessary per the requirement for the mounting location:

The following sequence (1,2,3) is repeated three times for a total of 9 h:

1 h at 70 °C with the samples not energized.

Turn off the chamber heat and energize the samples while spraying with a 5 % saline solution for 1 hour. The spray booth should be approximately 35 °C. with the spray solution at room temperature. The pH of the solution should be from (6.5) to (7.2). Operating type 3.2 is to be applied during this one hour operating evaluation period with a Functional Status Classification of “A”.

Turn off the salt spray and de-energize the samples while allowing the parts to cool for 1 hour at 25 °C. Humidity is uncontrolled during this hour and is expected to be high.

A drying period of 15 hours at 25 °C. with the power off. Humidity is uncontrolled but is expected to be high.

This 24-hour test sequence shall be repeated for multiple days as shown in the table:

After the final cycle, perform a Functional/Parametric Test within 1 hour. The DUTs shall also be inspected for signs of corrosion. An external and connector cavity inspection is required at this time; an internal inspection is optional. Internal inspection is required during the “Internal and External Inspection” process at the end of the test sequence. The DUTs shall not be cleaned prior to proceeding onto other tests in the test sequence.

Table 28: Summary of Salt Corrosion Testing

Location	Total Test Hours
Passenger Compartment	144
Door Interior	240
Engine Compartment High Mount or Exterior High Mount – Salt Spray	240/480
Underbody – Salt Spray (duration may be extended to 40 days)	480/960

Criteria: The functional status shall be class A.

The acceptance criteria for corrosion is not limited to conditions as observed at the end of the Salt-Spray Test. Corrosion can start and continue at different times of the test sequence, thus the corrosion acceptance criteria applies to the entire sequence.

Failure of any Functional/Parametric Test item during or at the end of the test is not acceptable.

Structural corrosion damage that reduces any structural physical properties of a material by 25 % or more at the corrosion site is not acceptable. Structural corrosion damage is defined as corrosion related material loss or degradation that weakens the physical properties related to the structural integrity and strength of the device/assembly/packaging. These properties include, but are not limited to, yield strength, hardness, pierce strength, mass, buckling or flex resistance, etc.

Cosmetic appearance external corrosion is not allowed on surfaces exposed to vehicle occupants.

Cosmetic appearance external corrosion on unexposed surfaces that do not penetrate deeper than 5 % of a surface or panel thickness or that do not cover more than 10 % of the unexposed surface area is acceptable.

Corrosion related degradation that results in electrical parameter performance shifts that exceed the allowable drift/variation margins of the parameters analyzed for the start-to-end.

Comparison analysis of the Functional/Parametric Tests is not acceptable.

5.8 Tests for Enclosures.

Dust and water tests are to be performed when the CTS specifies an IP Code (International Protection Code). The IP Code determines the degree of protection and the required test procedures.

5.8.1 Dust Tests.

Purpose: To determine if the enclosure provides sufficient protection from dust intrusion from windblown sand and road dust to allow the DUT to continue to meet the performance requirements specified in the CTS. The accumulation of dust on heat sink devices will adversely affect heat dissipation. Dust may also combine with humidity and salt to produce unintentional conductive paths. Dust accumulation will adversely affect electro-mechanical devices resulting in increased friction or complete blockage of motion.

Procedure (Operating Type 1.2): Test according to ISO 20653 Protection against objects, water and access. This test shall be conducted using ISO 12103-1, A2 Fine Grade Dust and should occur for a period of 8 hours.

Criteria: Functional Status shall be class A.

The DUT shall experience no damage, loss of function, or degradation of performance. The DUT shall pass the Functional/Parametric Test at the end of test prior to cleaning.

5.8.2 Water Tests.

Purpose: To determine if the enclosure meets the International Protection Requirement when specified by the second characteristic IP Code.

Procedure (Operating Type 1.2): Test according to ISO 20653 Protction against objects, water and access.

Test according to ISO 20653 Protction against objects, water and access.
When the second IP Code is 8, use the Seal Evaluation Test explained in the following section, unless stated otherwise in the CTS.

Criteria: Functional Status shall be class A.

The DUT shall experience no damage or degradation of performance. The part shall pass the Functional/Parametric Test at the end of test.

5.8.3 Seal Evaluation.

Purpose: To verify the DUT functionality after exposure to thermal shocks induced by heating in air and cooling in water. The test should be used for sealed electrical devices to evaluate the effectiveness of the seals. This test is the default test when the second IP Code is 8.

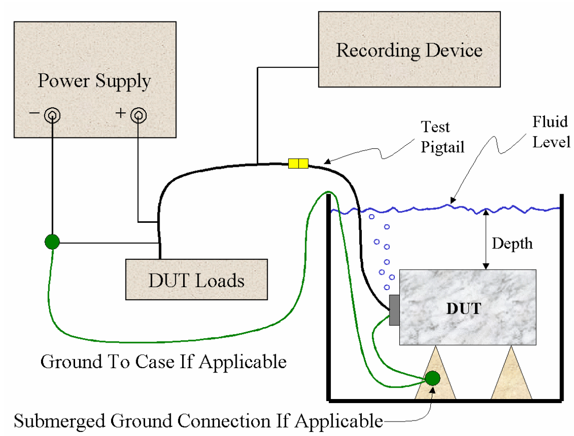
Procedure (Operating Type 3.2): Place the DUT in a temperature chamber at T_{max} for a total of 30 min. Remove the DUT and immediately immerse it in the test solution.

Connect the power and cycling/monitoring equipment during each submergence period. The DUT shall remain submerged for a total of 30 min. Repeat this procedure and function the DUT. Check all functions (and parametric values if necessary) at least once four more times, for a total of five cycles.
Special note: The ground wire is to be placed under water along with the DUT during the test for all sealed controllers when the ground wire will be located low on the vehicle.

Table 29: Seal Evaluation Requirements

DUT Voltage	V_{max}
Fluid Temperature	0 °C
DUT Temperature Above Fluid	T_{max}
Depth	(76 ± 5.0) mm

Figure 19: Seal Evaluation Test Setup



Criteria: Functional Status shall be class A.

The DUT shall be opened and inspected for signs of leakage at the end of the test. No leakage is permitted.

5.8.4 Sugar Water Function Impairment Test.

Purpose: The purpose of this test is to determine if the DUT is able to meet specification requirements when exposed to dried fluids that once contained dissolved sugar.

Procedure (Operating mode is 3.2.): Pour or splash 200 ml of sugar water into the DUT and wipe away any standing or surface liquid. The device shall be mounted in its intended orientation with all bezels and covers in place. The sugar water liquid shall be poured into horizontal devices from the vertical direction, and splashed into vertical devices from a horizontal direction. Sugar water is defined as 200 ml of water with 10 g of sugar fully dissolved. Sugar water is to be applied from a distance of 30 cm. The DUT shall remain un-disturbed and allowed to dry at room temperature for 24 h prior to the evaluation of function.

Criteria: Functional status shall be A. Degradation in operational forces and sound of function (sticking controls) shall be compared to the specification.

6 Product Validation

6.1 General. Changes in location of manufacturing, major process changes, or product design changes should dictate what kind and amount of testing in necessary for product validation. Additionally, weaknesses in the design margins of the product during Design Validation should be considered in developing the product validation plan. The supplier and General Motors shall jointly determine exactly what testing is necessary for process validation.

6.2 Vibration Shipping Test.

Purpose: This test augments all previous vibration testing. The shipping vibration test is intended to evaluate shipping container effectiveness in preventing damage during shipping by all forms of transportation.

Procedure: Perform test per GMW3431.

Criteria: The box of product is to be opened and thoroughly inspected for possible damage following the total 72 h vibration test. Additionally, the product must meet the functional and parametric requirements specified in the CTS. The GM design release engineer may allow a selected evaluation of a statistical sample of parts as opposed to all parts contained in the shipping container. Parts should be randomly chosen from all quadrants of the shipping container if only a sample is taken.

6.3 Evaluation Of Engineering Changes After Production. A new test plan is to be formulated to address the change using the ADV Task Checklist. The management of the test and results are to follow the Development Process Flow as shown in the beginning of this document. Paired comparison testing using accelerated tests can be used to evaluate the new product against the old product.

7 Abbreviations and Symbols

A/D/V Analysis/Development/Validation

AFD Anticipatory Failure Determination™

β Weibull Slope

BEC Bused Electrical Center

C Statistical Confidence

CAN Controller Area Network

CTS Component Technical Specification

DRBFM Design Review By Failure Mode

DRBTR Design Review By Test Results

DUT Device Under Test

DV Design Validation

E/E Electrical/Electronic

EMC Electromagnetic Compatibility

ESD Electrostatic Discharge

FSC Functional Status Classification

GMNA General Motors North America

GME General Motors Europe

G_n Standard acceleration of free fall (Gravitational Constant), 9.80665 m/s^2

HALT Highly Accelerated Life Test

IEC International Electro-technical Commission

IP International Protection

I/O Input/Output

I_{RP} Rated current of protection

L Number of lives to be tested

m Fatigue exponent (slope of the S-N line)

n Number of samples to be tested

PTC Power Temperature Cycles

PV Product Validation

PWA Printed Wiring Assembly (Printed Circuit Board as assembled with all components)

R Reliability

REP Reliability Evaluation Point

SAC Tin-Silver-Copper Solder

SOR Statement of Requirements

TS Thermal Shock in Air Test

8 Deviations

Global consensus achieved.

9 Additional References

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[14] Clech, Jean-Paul, Acceleration Factors And Thermal Cycling Test Efficiency For Lead-Free Sn-Ag-Cu Assemblies, SMTA International Conference, Chicago, Il. September 2005.

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10 Notes

Subparagraphs were not applicable.

11 Additional Paragraphs

Not applicable.

12 Coding System

This standard shall be called up in other documents, drawings, VTS, CTS etc. as follows:

Example: “GMW3172”

Detailed explanation for coding and inclusion into CTS documents appears in the front of the document.

13 Release and Revisions

13.1 Release. This document was first approved and published in December 2000 to replace GM9123P and GMI 12558.

13.2 Revisions.

Rev.	Date	Description (Org.)
B	DEC 2001	Complete Rework (McCullen-GMNA)
C	AUG 2004	Complete Rework (Edson-GMNA)
D	JUL 2004	Rewritten to address lead-free solder and improve prior content (Edson-GMNA)
E	SEP 2005	Complete Rework (Armbrust/Edson/Kurdian/Lange)
F	FEB 2007	Paragraph 3.4.2, Thermal Fatique Test Requirements, Table 10 changed. // Paragraph 5.2.8 Open Circuit Test, Operating Type changed // Paragraph 5.5.2 High Temperature Durability Test, Storage at $T_{max\ RP}$ added. // Paragraph 5.6.3 Frost Test For Moisture Susceptibility, operation changed. // Paragraph 3.2.1, Table 1 changed. // Paragraph 3.4.2, Figure 2 changed. // Paragraph 3.4.2, Table 9 coloum added. // Paragraph 4.2.8 Example added // Paragraph 5.2.2. Tolerance changed, operating type changed // Paragraph 5.2.3. operating type changed // Paragraph 5.2.5. operating type changed // Paragraph 5.2.6. operating type changed // Paragraph 5.2.7. operating type changed // Paragraph 5.2.8. operating type changed // Paragraph 5.2.11. operating type changed // Paragraph 5.4.3. operating type changed // Appendix removed. // Paragraph 5.2.1, Enhanced Purpose for test. // Paragraph 5.6.2, changed referenced IEC-Standard // Paragraph 3.3.3 words added // Paragraph 3.3.4 sentence (reference) deleted. (Andreasson/Edson/Kurdian/Lange)

Appendix A – Lead-free Solder Considerations

The global move to eliminate the use of lead in consumer products through legislative actions has growing applicability for the automotive industry. Circuit boards that reach landfills can create the potential for the lead on the circuit board to leach out of the circuit board and into the ground water. Lead represents the greatest threat to children, who have the greatest retention rate for this poisonous metal. Industry has responded with an alternative solder that is lead-free. The composition of this lead-free solder is usually tin/silver/copper (Sn/Ag/Cu).

Lead-free solder has a reduced fatigue life as compared to leaded solder, even though the tensile strength of lead-free is greater than leaded solder. Lead-free solder also has greater variability in fatigue life as compared to leaded solder. The use of lead-free solder creates additional risks as described below. The following checklist should be reviewed with the supplier to prevent potential problems and provide for adjustments in test plans as noted:

- A comprehensive Failure Modes Effects Analysis (FMEA) or DRBFM must be performed to identify and address lead-free solder-specific failure mechanisms.
- Lead-free solders have higher melting points and poorer wetting capabilities as compared to leaded-solders. The temperature increase can be as much as a 34 °C over lead based solder. The increase in temperature results in electronic components being exposed to higher temperatures during assembly. These higher temperatures can also increase the probability of “popcorning” with plastic encapsulated components. Popcorning is the cracking or exploding of the plastic case of the component resulting from high pressures of superheated steam. The superheated steam is the result of trapped water vapor within the plastic matrix becoming superheated from the higher temperature soldering process. Special efforts may be necessary to control the humidity of the environment of stored components awaiting assembly. *Discussions with the “Supply Chain” of component manufacturers must be conducted early in the program to prevent temperature related problems.*
- Thermal aging (time at elevated temperature) can lead to the formation of Kerkendall Voids at the interfaces of tin and copper. The formation of a string of these voids can produce a perforated tear line that represents a significant weakness relative to mechanical shock. The Universal Durability Test-Fow places the 500-hour thermal aging test prior to the first mechanical shock test specifically to address this concern.
- Lead-free solder quickly shifts from a ductile material to a brittle material at a temperature of -30 °C. This phenomenon does not happen with leaded solder. This can represent a significant risk in high mechanical shock areas like the door, engine, and locations on unsprung-mass. The mechanical shock tests should be run at Tmin when lead-free solder is used in the most severe applications.
- Flux residues from lead-free solder may be more inclined to produce ionic contamination when compared to lead based fluxes, and special attention should be given to the frost and humidity testing of lead-free solder assemblies.

- Lead contamination in lead-free solder processes leads to intermetallic formations, resulting in further reduction of fatigue life of solder joints. Therefore, the mixing of leaded and lead-free technologies on the same circuit board, or within the same manufacturing environment, should be avoided (but is not forbidden). The use of lead-free components soldered onto a circuit board with leaded solder generally does not create a problem. One notable exception occurs when bismuth (Bi) is involved. Bismuth-tin can be used as the tinning material for components and can be used for component attachment to circuit boards. The addition of bismuth in the tin alloy for circuit fabrication has the advantage of a reduced melting point, thus reducing the temperature that the components will experience. However, bismuth combines with lead and tin to form a ternary phase material with a very low melting point of only 96 °C. This low melting point material is formed at attachment points and represents a significant risk for automotive applications. The addition of bismuth is also discouraged because it is a by-product of the lead mining industry.
- A detrimental tin based phenomenon, known as "Tin Whisker Formation", is most noticeable in lead-free solder. Internally developed compressive stresses from the cooling process or the diffusion of copper into tin, can cause tin whiskers to form as compressive stresses are reduced. This phenomenon will occur without any special environmental condition being imposed. Parts "on the shelf" at room temperature will develop tin-whisker formation almost as quickly as parts in service. Components that are soldered lead-free to the circuit board should have a boundary layer (an example would be nickel-plating) between the copper and the tin. The boundary layer will significantly reduce tin whisker formation by reducing the diffusion of copper into tin.
- A second tin based phenomenon, known as "Tin-Pest", is also possible when the tin is not protected. Wart-like formations on the tin will begin to appear in cold temperatures and will degrade the tin into a gray powder. The "tin-pest" phenomenon is cold temperature driven starting at (-13 °C) and reaches a maximum reaction rate at (-30 °C). The phenomenon can be eliminated as long as there are minute traces of lead in the tin. Four nine's tin (extremely pure) should not be pursued as this will be more susceptible to Tin-Pest.
- No acceleration factor for thermal shock is to be applied to Lead-free solder[14]. Thermal shock does continue to be a desirable method for obtaining more thermal cycles per unit of time and will continue to be used per this specification.
- Lead-free solder requires a longer hot and cold dwell than does leaded solder for creep to occur[13]. While this has little bearing on field usage, it has a significant effect when lab based accelerated thermal cycling is used to evaluate fatigue life. Lead-free solder requires three times the dwell duration as does leaded solder to achieve optimum damage per unit of test time. Research[14] has shown that a 10-minute dwell period is optimum for lead-free solder.

Appendix B – Plastic Snapfit Design Worksheet

1. The Primary Objective Of The Design Should Be To Develop An Interlocking Integral Attachment Using Engaging Lugs In The Direction Of Primary Forces

The attachment strategy should utilize the engagement of interlocking lugs functioning in the primary direction of usage force. Plastic snapfit features should operate perpendicular to the primary direction of usage force to minimize stress on snapfit structure. Example: a sphere is made in two halves. The primary direction of force during use results in “pulling” the two halves apart. One could plan to snap the two halves together directly, but that would place primary forces on the snapfit features. The optimum strategy involves engaging the two halves through interlocking lugs with a small twisting motion. Radial snapfits would be designed to keep the lugs engaged. The snapfits must only resist an “unscrewing” motion, the least likely direction of usage force.

- When an interlocking lug approach is not feasible because of motion constraints, a “hook and snapfit” should be considered. The hook is a very strong and robust retention feature that is also easy to mold. The hook acts as a retention feature, a locator, and controls the motion to better align the snapfit. The single snapfit completes the assembly.
- When a hook-and-snapfit is not feasible because of motion constraints or geometry interferences, an over designed, minimum quantity snapfit system should be used. The “all snapfit approach” should be the last resort in the design strategy.

2. Ultimately, Two Different Design Forces Will Surface That Must Be Specifically Addressed In The Design Process. These Two Forces Must Be Defined And Understood Before The Design Process Can Proceed

- The force that works to “disconnect” the attachment.
- The force needed by a human being to assemble the attachment.

a. The snapfit will, most probably, be required to retain a dynamically functioning force. This is certainly true in automotive applications. Vibration, usage forces, and the accidental “drop” must be comprehended by the retention requirement. First calculate the actual weight that the snapfit must hold and then calculate the “effective weight” that must be retained resulting from the dynamic effect of impact operating on that weight.

Example:

- Retention force required under dynamic conditions.
  - Our attachment must retain a 1 lb weight.
  - 10 Gs are expected to operate on the 1 lb weight as a result of extreme pothole encounters.
  - The retention force should be at least 10 times the weight of the part being retained (> 10 lbs retention force is required)
- My retention force requirement is: . . . . lbs.

b. Snapfits are generally designed to utilize a human assembly process. The forces required to repetitively make the assembly must be low enough to prevent human injury. The following forces have been established as upper limits by experts in the world of human factors for the following methods of assembly. The requirements are:

- Allowable installation forces are not to exceed:
  - 27 Newtons (6 pounds) per hand.

- 11 Newtons (2.5 pounds) for a thumb.
- 9 Newtons (2 pounds) for a single finger.
- I expect that my assembly will be made using (one hand, two hands, finger, etc.).

  ____
- My maximum assembly force requirement is: ____________________ lbs.

3. Your Assembly Should Not Be Allowed To Move In Any Unwanted Direction, And This Includes Rotation. You Must Document How You Are Controlling The Motion Of Three Axes Of Translation, And Three Axes Of Rotation

Show how you have constrained three translations and three rotations. Also show that you have not double constrained any rotation or translation. Multiple constraints in any one direction can create interference problems.

4. Establish Whether This Assembly Will Be Designed For Disassembly Without Damage

When disassembly is necessary, the snapfit geometries must allow for disassembly either through an applied force or by providing an access opening for a release tool. When the assembly is expected to come apart by applying force then the ramp angle that is used for retention must not exceed the "critical angle". The critical angle is a value less than 90°, but will act as if it was 90°. If any value greater than the critical angle is used, the assembly will not come apart as desired. When a tool will be used to release the hook attachment, access must be provided and the use of a "limiter" is very important to ensure that the tool does not permanently damage the snapfit cantilever (see section 12 for explanation of "limiter").

- This assembly will be designed to be disassembled (yes or no?). ________________

5. Identify The Engineering Parameters For The Materials Being Used In This Design

a. Identify the "permissible short term strain" for the plastic elements that will be experiencing strain during the flexing that occurs during assembly. The following are reasonable approximations the basic types of plastic:

- 1 % for glass filled plastic.
- 2 % for "ABS"
- 2.5 % for "ABS-Polycarbonate blend"
- 3 % for Polycarbonate
- 4 % for Acetyl and Nylon
- 5 % for "TPO" and polypropylene
- The material that will be flexing in this design is: ____________
- The maximum permissible strain for this material is: ____________ %. (Between (1...5) %.

b. Friction

- Friction will be a critical factor in the forces necessary for assembly and for retention of serviceable designs. The “coefficient of friction” is a unit-less parameter (μ) with a value between .2 and .8, with .5 a good average.
- The expected coefficient of friction for the two materials that will be sliding against each other in this design is . . . .

6. Engagement Of The Snapfit Hook

- Adequate engagement of the snapfit hook is necessary to ensure robustness under conditions of dynamic loading, dirt, flash and dimensional variation.

  A Good Rule of Thumb for automotive applications: no less than two millimeters of engagement. Three to six millimeters is preferred for larger assemblies.

- The larger engagements are necessary when there are strong dynamic forces working to disengage the parts.
  - The engagement that I believe is necessary for this design is: ____________________ mm.

7. Effect Of Engagement Variation On Variation In Force

- Situations that require “extra” control of variation in force to assemble should perform the following analysis:
  - Variation in the degree of engagement will translate into variation in force needed to snap the assembly together. This translation between engagement variation and force variation can be calculated as follows:
    - ◊ Assume “k” is the spring constant that relates force of assembly to displacement of engagement feature as in $force \;=\; k\ x\ displacement$
    - ◊ Assume “4” times sigma $_{\text{displacement}}$" is the range of variation expected 95 % of the time in the engagement feature displacement and “sigma $_{\text{displacement}}$” is the value we will use in our equation.
    - ◊ Assume “4 times sigma $_{\text{force}}$” will be the range of variation expected 95 % of the time in the assembly force
    - ◊ $4\,times\ \ sigma_{force}\ =\ 4\ x\ \sqrt{k^2\ x\ sigma^2_{displacement}}$
    - ◊ This variation (4 times sigma $_{\text{force}}$) will be centered about the nominal value calculated for the force to assemble
  - Smaller values of “k” will result in less variation. Smaller “k” values are often achieved through longer cantilevers. Many times, longer cantilevers are difficult to package due to space limitations and thus a compromise is established.

8. Environmental Conditions

- The service temperature for the stressed plastic must be greater than the worst-case high temperature environmental conditions.
- The high temperature condition is detrimental because it accelerates the creep phenomenon that may occur in continuously strained plastic. An automotive application will experience a maximum temperature either with the car running (underhood application), or parked in the Arizona sun (interior application).
- The design margin for temperature is the service temperature minus the worst-case high temperature environmental temperature. The design margin should be a positive number, if not, either the material should be changed, the location changed to an area of a lower temperature, or the continuous stresses on cantilevers reduced to near zero.
  - The service temperature for the plastic that will be stressed in this design is: ________ °C
  - The worst-case temperature for the snapfit elements of this design is: ________ °C
  - The temperature design margin is : ________ °C

9. A Compliant Mechanism That Absorbs Looseness Should Be Built Into This Design

This will prevent relative motion that creates squeaks and rattles while accommodating variation in parts. The compliant mechanism is usually accomplished in one of two ways. The angle of the locking ramp surface of the snap-fit feature provides the compliance, or a separate “spring like feature” is added to take up any looseness in the assembly. Examples of compliant mechanisms are shown in the reference sections.

- Show and explain the compliant mechanism that you have designed into this assembly to prevent squeaks and rattles. Quantify how much variation your compliant mechanism is capable of handling.

10. Design The Actual Flexing Snapfit Feature

The design strategy for the flexing cantilever should first address strain management and then forces. The following is a good process to follow:

- Review the equations for strain and force when a cantilever is flexed. Note how some dimensions have a greater effect than others because they are squared or cubed in the equation.
- Establish the amount of hook engagement desired for this application (explained in 5.)
- Establish the length of cantilever necessary for the amount engagement planned.
  - *A good Rule of Thumb: the length of the cantilever should be 8 to 10 times the length of the hook engagement for plastics similar to ABS.*
- The thickness of the cantilever is often predetermined from wall thickness. When necessary (walls thicker than two millimeters), modifications to reduce the cantilever thickness should be considered to assist in controlling the strain in the cantilever.
- Calculate the width of the cantilever to develop the forces desired.
  - Altering the width generally does not affect the strain in the cantilever, but does affect the forces. Increasing the width will increase the force proportionally, and vice versa.
- Use thickness tapering and width tapering to make your design more efficient. See the tapering section in the references for the suggested ratio of the taper (usually 2 to 1). Tapering can be helpful when attempting to obtain the greatest degree of flexure from a short cantilever.

- The forces that the flexing cantilever will exert depend on the plastic material being used. The Secant Modulus is a characteristic of the plastic and is used to determine how much force a particular type of plastic will exert in a flexing situation. Secant Modulus values for various plastics can be found in the reference material.
- The equations necessary to perform the following are available from the GM Material and Fastening Center Analysis Guidelines described in “Fundamentals of Snap fit Design” (Version 2.0). Commercial software is also available to improve the accuracy and speed of this analytical process.
  - Show the math that predicts the forces to assemble and disassemble.
  - Show the math that allows for disassembly, if disassembly is a requirement.
  - Show the math that predicts that the strain in the plastic will be less than the maximum permissible strain. This strain generally occurs during the time of maximum deflection during assembly.
  - Show the math that dictates the ramp angles for engagement and disengagement of the snapfit feature. Detail the profile of the ramps on the snapfits.
  - Show the math that dictates the dimensions and all proportions of the flexed snapfit feature.
  - Engineering is always a compromise. Write down what you believe are the two most prominent weaknesses of this snapfit attachment design, even though you have rigorously engineered this assembly. This information will assist the design team in understanding what key dimensions or handling/packaging considerations should receive special attention during manufacturing.

11. “Guides” Should Be Employed To Act As Alignment Tools Outside Of The Snapfit Process

The guide system should provide the effect of “fitting a shaft into a large cone”. Guides should provide full control of motion prior to the engagement of any snapfits. Guides are often used in a cumulative manner as explained in the following “Good Example”.

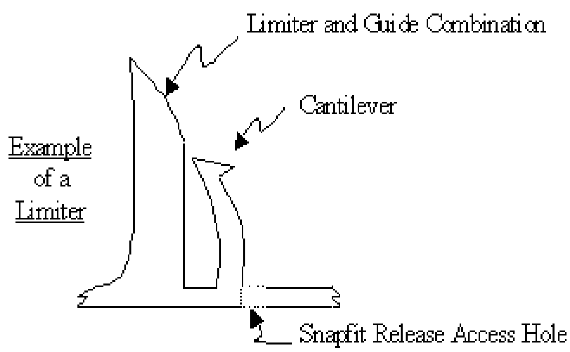
- Good Example: The first guide is easily seen by the operator, and positions the engagement process in one axis. A second guide is engaged following the first, and begins to control rotation. No remaining attention must be given to alignment, and the operator has only to concentrate on insuring complete snapfit engagement through tactile/audible feedback.
- Bad Example: A speaker grille is to be snapfit attached to a door inner panel. No guides are employed, and there are 12 snapfits around the perimeter that must be engaged, all at the same time. Placing the grille against the door obscures all vision of the snapfit engagements and the operator is left wondering if all 12 attachments were completed.
  - Identify the guide system you are employing and explain how it fully aligns the snapfits prior to their engagement.

12. Snapfits Often Lack Structural Robustness As A Result Of The Requirement To Flex During Assembly. An Additional Feature Can Be Added, Known As A "Limiter", Which Protects The Snapfit Feature From Overextension Or Damage

Damage can occur from the use of pry tools, shipping forces, or warpage occurring from the stacking of hot parts right out of the mold. See the figure below for an example of a "limiter". The "limiter" can also become a "guide" (explained in number 10.), thus serving two functions.

Identify and explain your use of limiters. If you will not be using a limiter then you must explain why not!

Figure 20: Limiter Example Used In Snapfit Design



Appendix C – Software Fault Tolerance Robustness Testing

Processor Supervisor Performance Evaluation

Purpose:

This procedure is intended to verify that that the system supervisor circuit was correctly implement and is effective in recognizing faults and initiating corrective action attempts. Digital micro-processing devices use a “Dead-Man-Like-Switch” supervision circuit known as a “Watchdog” or “COP” (Computer Operating Properly) to monitor for the continued presence of a State of Health (SOH) indicator signal. To ensure that disruptions and faults can be rapidly detected and corrected, the supervisor circuit monitors special pulses sent by the microprocessor. Programmed pulses are sent by the microprocessor within specified time intervals as the result of hand shaking typically between timing interrupt routines and the main programming loop. If the “supervisor” is not toggled within the pre-defined time period, it is assumed that the processor is hung up or executing an endless loop. The supervisor then generates a pulse to the processor to warn that a fault has occurred, typically this directly or indirectly triggers a system reset. The reset process also triggers a diagnostics counter that documents the number of COP triggered resets over a specified number of system power up activation cycles.

Preparation: This procedure only applies to devices with digital processors. Prior to performing this procedure a design review of the hardware and software of the supervisor system is to be performed with GM to ensure the basic design is correctly implemented. NOTE: *It is unacceptable for both the SOH (positive going (Low-High) and negative going (High-Low) pulse events to be triggered by the same subroutine called from the same software structure. Achieving comprehensive processor and programming SOH coverage requires that one side of the SOH Signal is called from the main programming or operating system loop, and the reciprocating signal is called from an a interrupt triggered routine.*

Test Set up: The test procedure requires one production intend device, a system simulator, and an oscilloscope monitoring the device’s internal supervisor circuit stimulation input and reset trigger output signals. These are monitored for each processor element (Micro-controller, Microprocessor, Digital Signal Processor (DSP), Display processor . . . etc.) included in the EE Device. For each processing unit in the device, perform the following: prepare and load programming with test code that can be triggered by an operator command to separately disable each software handshaking element of the SOH stimulation signal.

Procedure:

1) With the device operating in a normal condition, disable the SOH stimulation signal from the interrupt triggered event. Monitor the supervisor circuit and the system to verify that the loss of the SOH signal results in an appropriate and timely system correction response signal. The processor must also respond by returning to, or resetting back, to normal operation in a manner that prevents erratic or unstable operation of the device. Verify that appropriate system diagnostic information is correctly logged, updated and resetting functions are performed correctly. Document the recovery time and diagnostic data for the test report, and note any observation of abnormalities exhibited by the device under test. *NOTE: A momentary orderly suspension of tasks or signals during a system reset is acceptable.*

2) With the device returned to normal operating condition, disable the SOH stimulation signal from the main programming loop. Monitor the supervisor circuit and the system to verify that the loss of the SOH signal results in an appropriate and timely system correction response signal. The processor must also respond by returning to, or resetting back, to normal operation in a manner that prevents erratic or unstable operation of the device. Verify that system appropriate diagnostic information is correctly logged, updated and resetting functions are performed correctly. Document the recovery time and diagnostic data for the test report, and note any observation of abnormalities exhibited by the device under test.

Fault Injection Testing

Purpose:

Fault injection testing consists of a systematically series of evaluations where hardware and/or software elements are purposefully disrupted, disabled or damaged in order to test and grow the robustness of the whole system to deal with abnormalities. The ultimate goal is to verify that an E/E device is tolerant of potential system abnormalities. This requires that:

1) The device will not be physically damage by an abnormal input or output.
2) That operation of the device will remain stable and ensure safe vehicle operation.
3) If the abnormality or disruption is removed, the device will resume normal operation.

NOTE: The GMW3172 short circuit endurance tests are the primary procedures for verification that the device is not physically damaged by system abnormalities. The fault injection procedures focus on functional stability during abnormalities. When possible, fault injection evaluations may be performed in combination with the physical short circuit tests, or they may be performed separately after the short circuit tests have confirmed the physical capabilities.

Preparation: Prior to performing this procedure, a mechanization review of the device's internal and external hardware and software is required in order to organize the device into logical functional subsystems of related inputs and outputs. This may include I/O that is internal to the device and does not directly connect to the vehicle.

The supplier shall develop a detailed test script that shall be in the form of a table or matrix that contains a section for each function, with a sectional line item for each disruptive event applied to each I/O relevant to the function. Space shall be reserves on each line to document the system response to each disruption injection, and if the response is acceptable or if stability improvements are needed.

Detailed software test scripts that determines the sequence of which I/O shall be disrupted during which phases of functional operation may also be required for complex or sequence timing critical systems. Special attention shall be given to dynamic sequences with position feedback and/or timing critical signals. The test plan is to be reviewed and approved by the GM Product Development Team.

When function critical parameters come from digital values, delivered over a data link, the denial or disruption of this data shall as so be included as line items in the fault tolerance evaluation plan.

Test Set Up: The procedure requires one production intend device, a system simulator and a breakout box that allows each signal to be shorted to ground, shorted to its supply voltage or battery voltage, and open circuited. A data link simulator, with the data stream controllable by the tester, is also required when control or command information is delivered via a data link.

Procedure:

1) For each test case in the test plan, set up the appropriate functional operating conditions, and for each I/O related to the function sequentially apply: 1) a short to ground condition, 2) a short to supply or battery voltage and 3) an open circuit condition. Apply each fault injected state long enough to identify any functional effects and/or to verify the correct activation of relevant fault identification, recovery and diagnostic algorithms. Document the observation and the acceptability judgment on the test script matrix.

   When inputs are in the form of digital values the fault injection format shall be: 1) Outside of valid data range - low value, 2) Outside of valid data range - high value and 3) Data absent or withheld. Apply each fault injected state long enough to identify any functional effects and/or to verify the correct activation of relevant fault identification, recovery and diagnostic algorithms.

2) Move sequentially, I/O by I/O, date link value by data link value and function by function through the detailed test plan until all test conditions are completed.

Acceptance Criteria:

1) It is acceptable for the injection of a disruptive condition to discrete I/O circuits to falsely trigger or prevent activation of its related function.

2) It is not acceptable for fault injection on analog circuit to disrupt functionality. The valid range of all analog inputs shall be scaled so that hard ground shorts, voltage shorts, and opens circuits are outside a valid operation range so that fault conditions can be recognized by the processor and appropriate diagnostics codes set. Verify that appropriate diagnostics codes are correctly set.

3) It is not acceptable for a fault injection to create a system or software runaway condition, or a lock up condition such as a continuous loop, waiting for an action to occur. Verify that I/O time-out conditions, and any related diagnostics are functioning properly.

4) It is not acceptable for a fault injected on one circuit or function to cause a disruption in a any other circuit or function.

Appendix D – Accelerated Humidity Testing

The effect of Humidity results in a mixture of failure mechanisms that are intrinsic to automotive use. HAST is a highly accelerated humidity diffusion test that can only operate above 106 °C. This test is intended for electronic circuit boards and electronic components. This test is not intended for plastic-electronic assemblies because the temperature in this test exceeds the service temperature for most common plastics.

This high stress environment will accelerate the effects humidity and temperature according to the Arrhenius-Peck relationship as shown below. A HAST test operated at 130 °C and 90+% R.H. provides the following acceleration factors:

- 1 day of HAST is equivalent to 21 days of 85 °C/85 %
- 1 day of HAST is equivalent to 97 days of 65 °C/85 %
- 1 day of HAST is equivalent to 1414 days of 35 °C/85 %

Ten years of the effect of humidity for the ingress of water vapor into components and circuit boards can be accomplish in approximately two days of HAST testing at 130 °C and 90+% R.H.

The use of the Arrhenius-Peck[5] stress-life math model suggests that this is equivalent in damage to 4656 hours of 65 °C at 85 % R.H., or 194 days of constant humidity testing, as defined in this document. Equally damaging tests of "lower-temperature-longer-durations" are permitted through use of the Arrhenius-Peck relationship as noted below:

Equation 14 Arrhenius-Peck Acceleration Factor For Temperature and Humidity

$$Accel\,factor\ =\ Exp\ \left(\frac{E_A}{k}\ x\ \left(\frac{1}{T_1}\ -\ \frac{1}{T_2}\right)\right)\ x\ \left(\frac{Humidity_{low}}{Humidity_{high}}\right)^{-2.66}$$

Where:

k = Boltzmann Constant = (1.380 658 ± 0.000 012) x 10^{-23} J/K or **k = (8.6173 X 10 –5 eV·K)** $^{-1}$

E_a = Average Conservative Activation Energy = 1.28 x 10^{-19} J **E_a= (0.8 eV)**

T_2 = Higher Temperature (on test)

T_1 = Lower Temperature (ambient)

Temperature is in Degrees Kelvin (Celsius plus 273) and humidity is in "% RH"

Appendix E – GME Test Template

Device Under Test (no abbreviations):	Release Date:	Revision:
DUT Part Number(s):	DUT Manufacturer:	
Drawing Number:	Project:	
Prepared by (Supplier):	Mounting Location in Vehicle:	
Approved by (Supplier):	Approved by vehicle manufacturers Responsible Engineer:	

Revision History

Date	Description
This Test Plan is approved with the following corrections and/or added conditions:	

Introduction:

The Global Environmental Component Test Plan (TP) shall be completed by the supplier and submitted to the vehicle manufacturers Environmental Design Review Team member(s)for approval in line with the GM Master Timing Chart, but at least 60 days prior to the start of Component testing. All sections shall be included as stated in the outline, only additions of new sections are allowed. If a section is not applicable, this shall be stated in the document after the relevant section description.

Purpose:

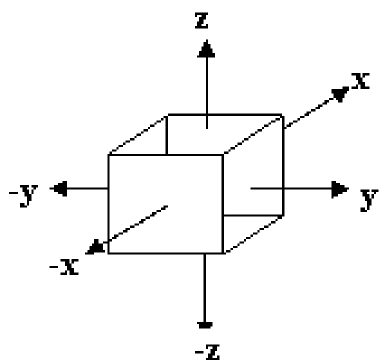
The purpose of the Global Environmental Component Test Plan section documents the DUT operation and test procedures for all tests according GMW3172. It describes all relevant test set-ups and the procedures to verify the environmental robustness of the design and production.

Guideline for Test Descriptions:

Provide specific test set-up information and information to the DUT, including block diagrams, photographs, etc. indicating DUT connections to facility and test equipment. Do not include copies of generic set-up diagram from IEC/ISO/SAE or other standards as long as you refer to the documents.

All boxes should be filled by supplier and can be enlarged as necessary. The information inside every Box should include as much detailed information, as necessary for the completion of the test and its traceability/repeatability.
Chapters as given in the template should stay in the same order.

Consider the following box as an example; what could be the content for the free fall (Drop Test).



Applicable Standard:	GMW3172, Free Fall (Drop Test).
Operating Type:	1.1
Parameters:	Temperature = (+23 ± 5) °C
	Height = 1 m of free fall
	Surface = Concrete
Procedure:	Choose the X-Axis for the first fall. Repeat the fall with the same axis, but in the opposite direction. Repeat step 1 and 2 with the next sample in Y-Axis. Repeat step 1 and 2 with the third sample in Z-Axis. Document all visual damages by picture and add them to the test report. Perform a functional test.
Pass/Fail Criteria:	The DUT must pass the functional test, or the damage is judged by GM Validation Engineer.

Quoting Requirements in Documentation

According to the Subsystem Technical Specification, the drawing of the DUT or the quoting requirements, the following code letters for the tests specified in GMW3172 are defined:

Electrical Loads	Mechanical Loads	Operating Temperature Range	Climatic Loads	Chemical Loads	Dust and Water Protection

This Classification results in following Parameters:

U_{nom}	=	± 0.1 V	T_{room}	=	± 5 °C
U_{max}	=	± 0.1 V	T_{max}	=	± 3 °C
U_{min}	=	± 0.1 V	T_{min}	=	± 3 °C

Deviations from the above mentioned requirements shall be agreed by the responsible GM Validation Engineer and need to be described in this document.

Test Requirements (The following already exists as the ADVP&R Form used in North America)

Paragraph Validation test	Number of Samples for DV	Number of Samples for PV	Design Validation Calendar week	Product Validation Calendar week
Electrical Loads				
Parasitic Current Measurement				
Jump Start				
Reverse Polarity				
Over-Voltage				
Voltage Drop Test				
Battery Voltage Dropout Test				
Superimposed Alternating Voltage				
Open Circuit Tests				
Ground Offset Test				
Power Offset Test				
Short Circuit Tests				
Isolation Evaluation				
Puncture Strength				
Connector Tests				
Connector Installation Abuse Test				
Fretting Corrosion Degradation Test				
Mechanical Loads				
Vibration Test				
Mechanical Shock				
Crush Test For Device Housing				
Free Fall				
Climatic Loads				
Low Temperature Wake Up Test				

Test Requirements (The following already exists as the ADVP&R Form used in North America)

High Temperature Durability Test				
High Altitude Shipping Test				
High Altitude Operating Test				
Thermal Shock in Air				
Power Temperature Cycle Test				
Thermal Shock /Splash Water				
Humid Heat Cyclic				
Humid Heat Constant				
Frost Test For Moisture Susceptibility				
Dew Test				
Corrosion Salt Mist/Spray Test				
Test For Enclosure				
Dust Test				
Water Test				
Seal Evaluation Test				
Sugar Water Function Impairment				

Test Flow for Validation

Design Validation

(to be filled by supplier, enlarge this area as necessary)

Product Validation

(to be filled by supplier, enlarge this area as necessary)

Product Family Description

Provide a brief DUT product family description, including any similarities and differences of planned hardware and software revisions. In some cases, it may make sense to select a specific sample for test that represents the entire DUT family. Please state the justification and rationale for doing this.

(to be filled by supplier, enlarge this area as necessary)

Product Functional Description

Provide a brief overview of the DUT functions, including system interfaces. Use wording that describes the system to those not familiar with the product. Define all abbreviations. Provide a list of all used connector pins and their function.

(to be filled by supplier, enlarge this area as necessary)

Operating Types

The following table reflects the electrical operating type of GMW3172. Describe the input-states or mechanical fixation for each operating type or give a reference to the functional test.

Operating Type		Electrical State
1	No voltage is applied to the DUT.	
	1.1	*(to be filled by supplier, enlarge this area as necessary)*
	1.2	*(to be filled by supplier, enlarge this area as necessary)*
2	The DUT is electrically connected with supply voltage U_B (battery voltage, generator not active) as in a vehicle with all electrical connections made.	
	2.1	*(to be filled by supplier, enlarge this area as necessary)*
	2.2	*(to be filled by supplier, enlarge this area as necessary)*
3	The DUT is electrically operated with supply voltage U_A (engine/alternator operative) with all electrical connections made.	
	3.1	*(to be filled by supplier, enlarge this area as necessary)*
	3.2	*(to be filled by supplier, enlarge this area as necessary)*

Functional Verification

In this section all necessary functions- and states of the DUT for the tests are defined. Indicate methods, criteria and measurements that will be generally used and repeated for the tests in this chapter.

Functional and Parametric Test

Provide a functional and parametric test that is used between environmental tests, to evaluate the correct performance of the device under test. List all hardware inputs, outputs and major functions. Add the resulting active and inactive state together with their tolerance and acceptance criteria.

(to be filled by supplier, enlarge this area as necessary)

Continuous Monitoring

In case of electrical operation of the DUT during the test, a continuous monitoring takes place. The method below should describe the procedure to detect malfunctions during the test. Define a procedure which shows how this is done, how often this takes place and which values will result out of this monitoring.

(to be filled by supplier, enlarge this area as necessary)

Durability Load Cycling

Provide a functional- / load cycle which is for example repeated during the Power Temperature and Durability Tests or on every test with operating type 3.2. The input/output cycling shall be scheduled such that the required minimum number of 1 life cycle of a vehicle for each function is evenly distributed and achieved during the PTC or Durability Test.

One Cycle of the durability load cycling is divided into the following sequence that is repeated for the required test-time.

Loads

In case of electrical operation of the DUT during the test, a continuous monitoring takes place. The method below should describe the procedure to detect malfunctions during the test. Define a procedure which shows how this is done, how often this takes place and which values will result out of this monitoring.

(to be filled by supplier, enlarge this area as necessary)

Device Internal & External Inspection

The E/E device Internal & External Inspection is a visual microscopic review of the device's case and internal parts at the completion of validation testing. Describe the points of interest and to which will be paid special attention.

(to be filled by supplier, enlarge this area as necessary)

Test Description
Electrical Tests

Parasitic Current Measurement

(to be filled by supplier, enlarge this area as necessary)

Jump Start

(to be filled by supplier, enlarge this area as necessary)

Reverse Polarity Test

(to be filled by supplier, enlarge this area as necessary)

Over Voltage Test

(to be filled by supplier, enlarge this area as necessary)

Voltage Drop Test

(to be filled by supplier, enlarge this area as necessary)

Battery Voltage Dropout Test

(to be filled by supplier, enlarge this area as necessary)

Superimposed Alternating Voltage Test

(to be filled by supplier, enlarge this area as necessary)

Open Circuit Tests

(to be filled by supplier, enlarge this area as necessary)

Power/Ground Offset Test

(to be filled by supplier, enlarge this area as necessary)

Short Circuit Tests

(to be filled by supplier, enlarge this area as necessary)

Isolation Resistance

(to be filled by supplier, enlarge this area as necessary)

Puncture Strength

(to be filled by supplier, enlarge this area as necessary)

Connector Tests

Connector Installation Abuse Test

(to be filled by supplier, enlarge this area as necessary)

Fretting Corrosion Degradation Test

(to be filled by supplier, enlarge this area as necessary)

Mechanical Tests

Vibration Test

(to be filled by supplier, enlarge this area as necessary)

Mechanical Shock

(to be filled by supplier, enlarge this area as necessary)

Crush Test For Device Housing

(to be filled by supplier, enlarge this area as necessary)

Free Fall (Drop Test)

(to be filled by supplier, enlarge this area as necessary)

Temperature Tests

Low Temperature Wake Up Test

(to be filled by supplier, enlarge this area as necessary)

High Temperature Durability

(to be filled by supplier, enlarge this area as necessary)

High Altitude Test

(to be filled by supplier, enlarge this area as necessary)

Thermal Shock in Air

(to be filled by supplier, enlarge this area as necessary)

Power Temperature Cycle Test

(to be filled by supplier, enlarge this area as necessary)

Power Temperature Cycle Test

(to be filled by supplier, enlarge this area as necessary)

Thermal Shock/Water Splash

(to be filled by supplier, enlarge this area as necessary)

Corrosion Salt Fog/Mist Test

(to be filled by supplier, enlarge this area as necessary)

Humid Heat Cyclic

(to be filled by supplier, enlarge this area as necessary)

Humid Heat Constant

(to be filled by supplier, enlarge this area as necessary)

Frost Test For Moisture Susceptibility

(to be filled by supplier, enlarge this area as necessary)

Dew Test

(to be filled by supplier, enlarge this area as necessary)

Tests For Enclosures

Dust Test

(to be filled by supplier, enlarge this area as necessary)

Water Test

(to be filled by supplier, enlarge this area as necessary)

Seal Evaluation

(to be filled by supplier, enlarge this area as necessary)

Sugar Water Function Impairment Test

(to be filled by supplier, enlarge this area as necessary)

EA12-004

GM

11-26-2012

ATTACHMENT

GM9110P

PROCEDURE FOR TESTING SWITCHES

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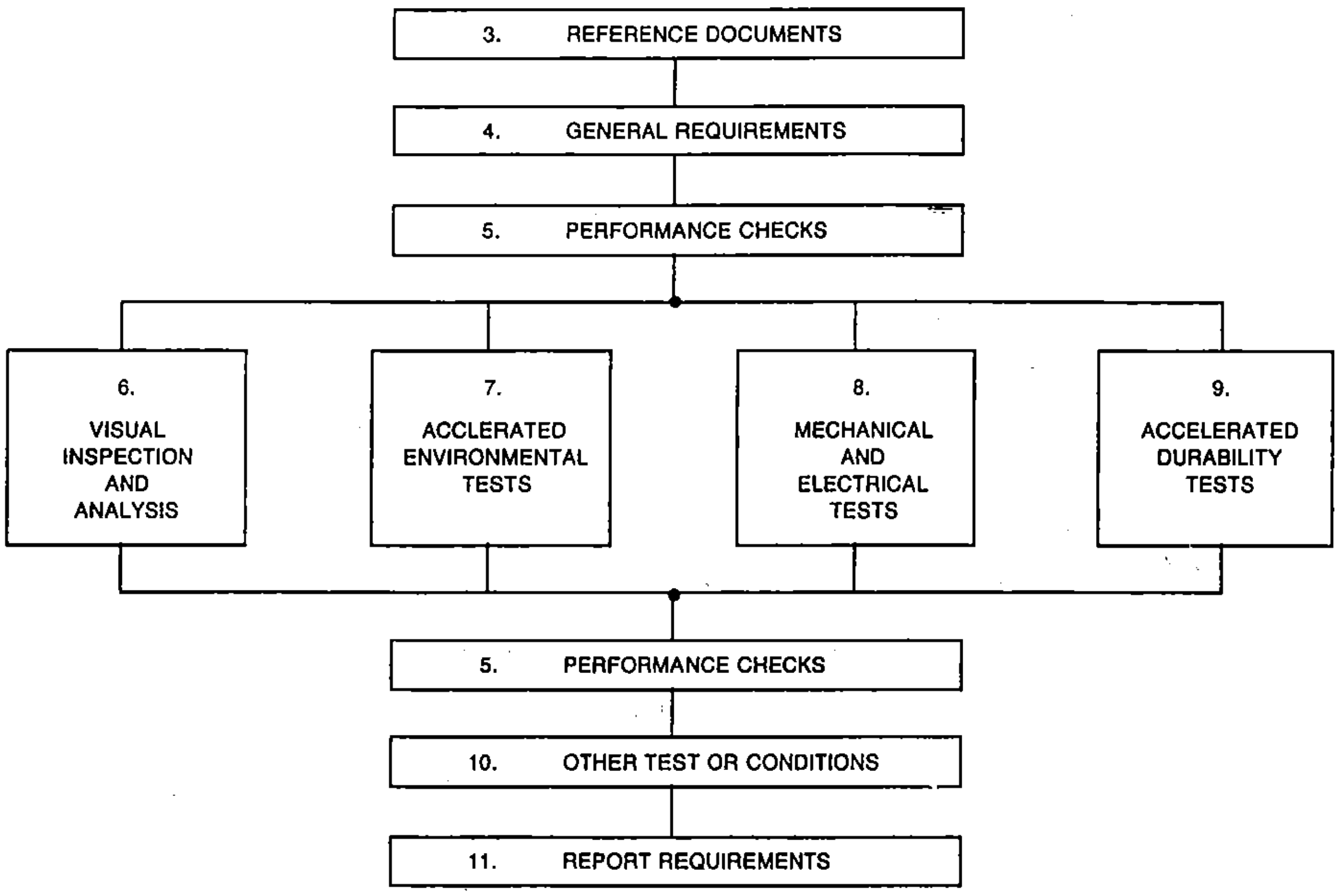
1 SCOPE. This procedure covers the laboratory testing of automotive switches containing sliding or separating electric contacts. The method of actuation includes, but is not limited to, differentials in temperature, pressure, vacuum, fluid level, mounting angle (tilt) or displacement.

2 ORGANIZATION AND OUTLINE.

2.1 Procedure Diagram. Block diagrams are provided where necessary to clarify the detail of this procedure. An outline has been provided and Appendices give a glossary of terms and construction details for selected fixtures used in the procedure.

(Continued)



© Denotes change from previous issue.

SWITCH TASK FORCE				
	8-87	–	Issued	SRSC
CONTROL DIVISION	DATE	SYM	REVISION RECORD	AUTHORITY

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2.2 PROCEDURE OUTLINE.

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(Continued)

3 REFERENCE DOCUMENTS REQUIRED.

3.1 Part Drawing. The part drawing shall be used for dimensional requirements. The part drawing shall also include a circuit schematic, connector body part number, temperature measurement point and a view which indicates vehicle mounting position to be compatible with this test procedure (for example, the circuit schematic identifies the internal circuits for voltage drop, isolation resistance and other circuit checks).

3.2 Product Design Specification. The product design specification shall identify the parameters as detailed in 3.2.1 through 3.2.3. The product design specification may or may not be integral with the part drawing.

Note: The first 3 pages are August 1987 and the remaining pages are November 1989. The was not any content change. The two versions are the same.

Bill Skelton per Al Schwartz

PROCEDURE FOR TESTING SWITCHES
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3.2.1 Applicable tests and the order in which the tests are to be performed if different than outlined by this procedure.

3.2.2 Limits for performance and durability tests and definitions of conditions under which those limits apply if different than outlined by this procedure.

3.2.3 Functional definition for the device to be tested describing the application electrical load(s), specific electrical outputs as a response to specific inputs, and special make/break sequences as required (see Figures 1A and 1B).

3.3 Test Order. The laboratory test order shall provide location and documentation of test samples, identify the type of test to be performed (investigative/validation) and describe special tests when not part of this procedure.

3.3.1 Investigative Tests. Investigative tests are frequently used to evaluate specific areas of the design as a tool in the designing of the product, for trouble checks, or to evaluate proposed quality improvement or cost savings concepts. Special instrumentation or measurements requiring sample disassembly preclude investigative tests for validation or supplier approval samples. Investigative tests may be continued even after a technical part failure has occurred to learn more about the device under test. Three types of investigative tests are recommended for new products.

1.0 FUNCTIONAL DESCRIPTION

Refer to the product drawing.

The Switch Pod Assembly consists of the following buttons:

1.1 HEADLAMP Button

1.1.1 This button controls the illumination of the headlamps, parklamps and the intrument panel/console.

1.1.2 When the switch is ON, a small indicator light on the left side of the HEADLAMP and PARKLAMP buttons will be illuminated.

1.1.3 This button possesses an "alternative action" operation; the ON position of the HEADLAMP button will be canceled by a second depression.

1.2 PARKLAMP Button

1.2.1 This button controls the illumination of parklamps and the instrument panel/console.

1.2.2 When this switch is ON, a small indicator light on the left side of the button will be illuminated.

1.2.3 This button possesses an "alternative action" operation; the ON position of the PARKLAMP button will be canceled by a second depression.

FIGURE 1A - PRODUCT DESIGN SPECIFICATION FUNCTIONAL DEFINITION

Pot	Voltage Level	Value	Slide Control Position
Interior/ Panel	Maximum	4.5 V (90%)	"OFF"
	Minimum	0.5 V (10%)	"HIGH"
Twilight Sentinel	Maximum	4.5 V (90%)	"MAX"
	Minimum	0.5 V (10%)	"OFF"

1.1.6 Potentiometer schematic, reference Figure 1.1.6.

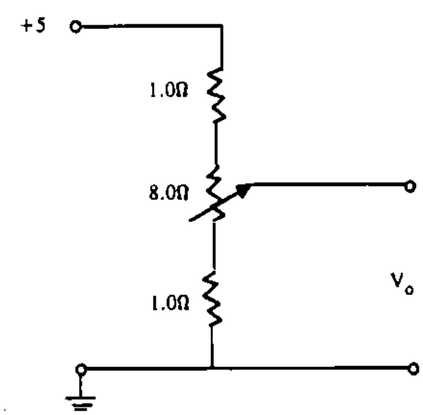

Figure 1.1.6

FIGURE 1B - PRODUCT DESIGN SPECIFICATION FUNCTIONAL DEFINITION

3.3.1.1 Itemized Voltage Drop Test. It is desirable to identify the voltage drop (V7 - V1, V5 - V6, etc) associated with each current carrying member, connector, or electrical interface over time. These tests assess the degradation which occurs at each interface or justify the choice of one material over another. Figure 2A gives an example of an itemized voltage drop test.

3.3.1.2 Physical Attribute Test. It is desirable to identify shifts in contact force or overtravel (for example) as a result of wear or stress relaxation induced by durability tests. Measurement of physical parameters may require disassembly of the test specimen which is not typically done to a validation/supplier approval sample.

3.3.1.3 Contact Resistance for Low Level Circuits. It is desirable to measure contact interface voltages in low level circuits where precautions must be taken not to break thin surface films by excessive force or excessive voltage. Standardization of measurement pick-up points also improves the repeatability of the measure. Figure 2B gives a recommended approach for elastomer dome contacts.

PROCEDURE FOR TESTING SWITCHES
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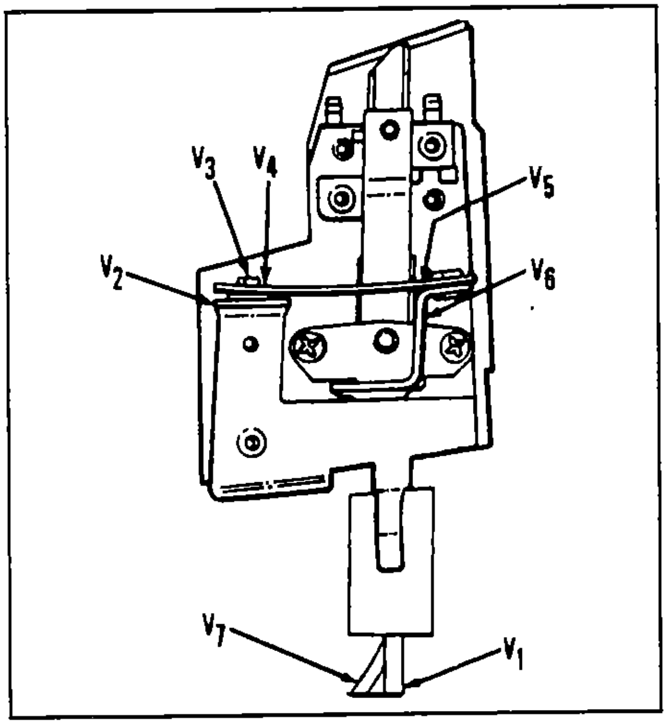

FIGURE 2A - ITEMIZED VOLTAGE DROP TEST

3.3.2 Validation Tests. Validation or sample approval tests are acceptance type tests in which special care is exercised not to disturb the integrity of the sample. Consideration shall be given to the inherent repeatability or subjectivity of certain tests outlined by this procedure before designation as an FMVSS validation or compliance test.

3.4 Materials and Processes Standards. Suppliers are expected to subscribe to General Motors Engineering Materials and Processes Standards as several of these standards are called out by this procedure. Subscription information is contained in the General Motors Quality Standard for Purchased Material.

3.4.1 Standards required:

GM9058P	Leak Check (Paragraph 4.1)
GM4499P	Automotive Weld Quality Tests
GM9105P	Evaluation of Conducted Transient Susceptibility of Automotive Electronic Devices
GM9106P	Specification Guidelines of Device Immunity to Conducted Transients
GM4465P	Humidity
GM4298P	Salt Spray (Mist) Testing
GM2251M	Soapy Water
GM6015M	Alcohol Base Cleanser
GM6048M	Engine Oil
GM6162M	Gasoline (Unleaded)
GM6038M	Ethylene Glycol
GM4653M	Brake Fluid
GM6137M	Automatic Transmission Fluid
GM9071P	Tape Adhesion Tests for Paint
GM4351M	Decorative Second Surface Finishes on Plastic Parts

3.5 FMVSS Requirements. Suppliers are expected to be aware and comply to Federal Motor Vehicle Safety Standards where applicable as outlined in the General Motors Quality Standard for Purchased Material.

4 GENERAL REQUIREMENTS.

4.1 Record Retention. A central file shall exist for the storage of laboratory reports and calibration records and a record retention policy concerning these records shall be established. The file shall be periodically audited by an

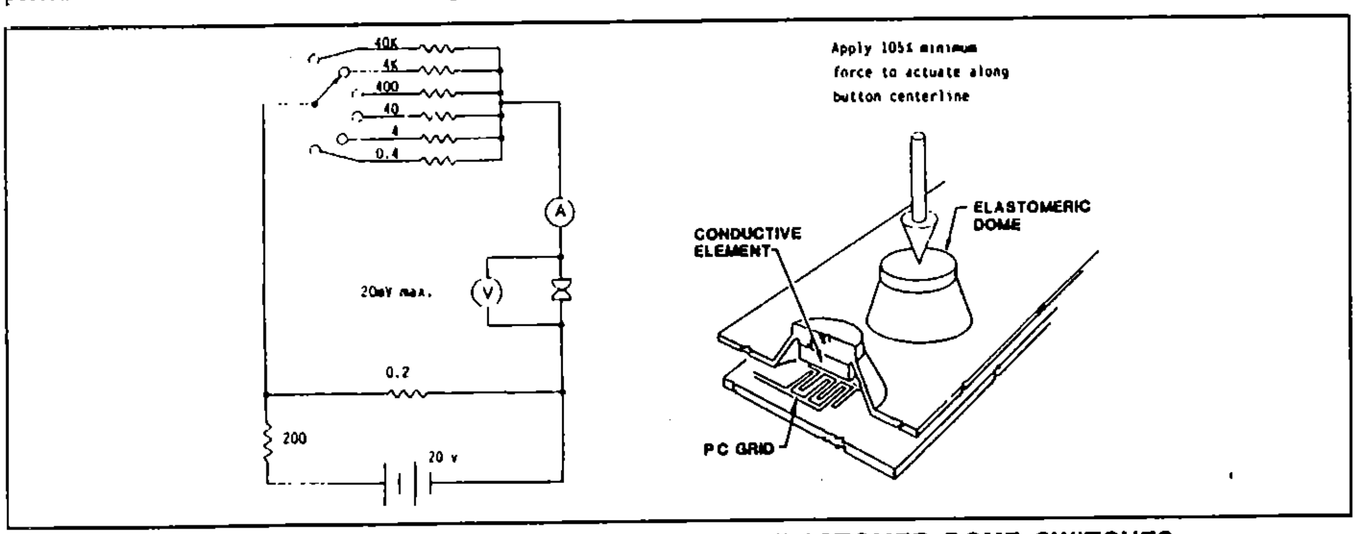

FIGURE 2B - CONTACT RESISTANCE FOR ELASTOMER DOME SWITCHES

PROCEDURE FOR TESTING SWITCHES
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independent source and shall be made available to GM product engineering upon request.

4.2 Sample Documentation.

4.2.1 General Motors engineering test samples shall be identified by part number and serial number unless otherwise noted. Performance test data shall be provided with the sample submission for each serial number. In addition, statistical distributions shall be calculated for the sample lot for each performance parameter and shall be submitted to the release engineer. Parts shall be shipped in containers and with scuff protection which simulates production packing.

4.2.2 Production samples shall be selected at random from pieces which have been subjected to all normal processing including final packing.

4.3 Sample Size. Unless otherwise noted, a minimum of 39 samples will be required to complete the tests outlined herein with the samples divided as listed below. Performance evaluations are to be conducted before test, intermediately, and after test where applicable.

Visual Inspection and Analysis .... 6 pieces
Mechanical and Electrical Test .... 11 pieces
Environmental Tests .... 11 pieces
Operating Durability .... 11 pieces

4.4 Power Sources.

4.4.1 Performance and Static Test.

4.4.1.1 Output Current. The power source shall be capable of supplying a continuous output current as required by the design loads including inrush or stall currents.

4.4.1.2 Regulation. The output voltage shall not deviate more than 1.0 volt from zero to maximum load (including surges) and shall recover 63% of its maximum excursion within 5.0 milliseconds.

4.4.1.3 Ripple Voltage. Ripple voltage shall not exceed 300 mV peak to peak.

4.4.2 Durability Tests. An automotive battery of 450 – 650 cold crank amps shall be connected in parallel with the power supply. Where all test samples are energized simultaneously instead of sequenced or where more than 11 samples are tested, use a battery or batteries capable of at least 100 cold crank amps per sample. Power supplies meeting the requirements in 4.4.1 may be used without a parallel battery provided a correlation has been made by testing 10 switches, 5 with battery and 5 without battery, and comparing contact transfer at 3 times the expected life of the switch. A battery shall be used whenever a consistent visible difference exists between the two sample lots.

4.5 Test Tolerances. Test setups and equipment shall be capable of maintaining test parameters (expressed in nominals) within the limits found in Table 1.

TABLE 1

Test Parameter	Applied Tolerance
Air Pressure (Laboratory)	6540 to 800 mm Hg
Room Temperature	23 + 5 C
Test Chamber Temperature	nominal ± 3 C
Time	nominal ± 5%
Forces	nominal ± 5%
Distances	nominal ± 1%
Voltage	nominal ± 0.1 volt
Current (Performance Test)	nominal ± 0.2 amp
Current (Durability Test)	nominal ± 15%

Not to be used for performance dependent variable (see Paragraph 4.6).

4.6 Measurement Accuracy. Meters and gauges used to assess the performance dependent variable as defined by the basic function of the test sample shall be capable of measuring to one count less than the specified value. For example, even though a 0.1 mm and 0.10 mm shaft might be the same diameter, a technician could use calipers capable of 0.01 mm resolution to measure the first but would need a micrometer to obtain 0.001 mm resolution for the latter value.

4.7 Test Repeatability.

4.7.1 Equipment repeatability studies shall be performed on all laboratory equipment after initial calibration and before use for product evaluation. Individual meters and gauges may be certified by manufacturer specifications. All equipment used for product evaluation shall be repeatable to within 10% of the specification value (ex: 10 consecutive readings on the same switch which actuates at 0.10 mm must be within a 0.01 mm range).

4.7.2 Laboratory masters are calibrated test samples which are saved to evaluate long-term drift in test equipment. Laboratory masters shall be used as a correlation tool whenever test specifications are created or revised.

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4.8 Test Default Conditions. When specific test conditions are not given either by the product design specification or elsewhere in the procedure, the following basic conditions shall apply:

4.8.1 When a mounting view is not provided by the part drawing, samples shall be mounted with terminal centerlines as indicated in Table 2. The mounting environment shall include baffles or enclosures which simulate vehicle air flow restrictions and production, prototype, or simulated bezels and bolts which may pinch or stress mounting lugs or case sidewalls.

TABLE 2

Vehicle Mounting Position	Terminal Centerlines
Instrument Panel	Horizontal
Door/Console	Vertical pointing down
Engine/Chassis	45 degrees from horizontal

4.8.2 Test or measurement shall be performed at room temperature.

4.8.3 Open circuit voltage shall be 14.0 volts at switch terminals for 12-volt system, 5.0 volts at switch terminals for 5-volt system or 28.0 volts at the switch terminals for 24-volt system.

4.8.4 Load current shall be the resistive rated load given by the test specification.

4.8.5 Duty cycle shall be 1.0 seconds on, 9.0 seconds off.

4.8.6 Connections shall be via the production or prototype connector listed on the part drawing with appropriate wire gauge based on test load as indicated by Table 3 unless otherwise noted.

TABLE 3

Test Load (amp)	Acceptable Wire Gage	
	Customary (ga)	Metric (mm)
0.5 - 3.0	20	0.5
3.1 - 15.0	18	0.8
15.1 - 20.0	14	2.0
20.1 - 40.0	10	5.0

4.8.7 The rate of actuation shall be as noted in Table 4.

TABLE 4

Mode of Actuation	Rate of Actuation
Air Temperature	5 ± 1 C per minute
Pressure	2500 ± 500 mm Hg per second
Vacuum	40 ± 10 mm Hg per second
Fluid Level	25.0 ± 5 mm per minute
Angular Displacement	5.0 ± 1 degree per second
Linear Displacement	50.0 ± 5 mm per second/50 N max
Fluid Temperature	10 ± 3 C per second

4.9 Failure Determination. Test failure will be determined should any sample exhibit either of the following conditions:

4.9.1 Performance outside product requirement specification limits regardless of age, cycles, or temperature provided other test limits have not been exceeded.

4.9.2 A missed cycle during durability test if verification is provided as follows:

(a) Check basic setup and instrumentation including mounting, stroke, rate of actuation and actuation force.

(b) Attach oscilliscope, chart recorder or other data acquisition equipment across the circuit in question.

(c) Allow test to continue while frequently monitoring for a failure to make, a failure to break, or a nuisance cycle as indicated by the original test equipment.

(d) Check to assure the miss was also captured by the auxiliary monitoring equipment.

(e) Re-check basic setup and instrumentation.

4.9.3 Disposition of Samples. Should a test failure occur, contact the requesting party to determine if the test is to be continued to gain additional product experience or if testing is to be suspended. When contact cannot be immediately made, the type of test shall determine the disposition of samples. If the test order indicates the test is investigative in nature, continue until the requesting party is available. If the test order is for sample approval or validation testing, stop the test and await further instruction.

5 PERFORMANCE CHECKS. The tests detailed in 5.1 through 5.15 are quantitative or semi-quantitative in nature and are not expected to stress any part or component beyond its anticipated application limit. Performance measurements are performed at room temperature using test heads or new production or prototype connectors unless otherwise noted. Minimum frequencies for performance checks are given by

PROCEDURE FOR TESTING SWITCHES
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Table 5. Use the standard data sheet provided in Figure 22. The performance check sequence or individual performance checks may be performed in addition to the minimum requirements given by Table 5 as necessary. Omit the tests which are not called out by the product design specification or test order.

5.1 Voltage Drop. Voltage drop is a measure of the power and associated temperature rise a circuit is generating as it passes current. Voltage drop measurements conducted across contacts which have remained open for sustained periods will be higher than measurements taken after one or two cycles. For this reason, start the voltage drop test by measuring contact interfaces which require actuation; then return to the contacts which make circuit in the deenergized state.

5.1.1 Apply the nominal test specification operating parameter (temperature, pressure, displacement, etc) which causes an electrical circuit change of state to occur. Maintain the operating parameter at a level at least 110% of the test specification minimum to assure stability.

5.1.2 A Kelvin or 4-wire approach shall be used to assure the connector interface is not part of the recorded measurement. When a Kelvin approach is not practical due to device design, such as in the case of skirted or sealed switches, voltage drop shall be determined by placing the voltmeter probes on the female connectors or at a point on the harness 76.2 mm from the connector interface. Note any non-Kelvin method used on the test data sheet.

5.1.3 Use an analog or digital voltmeter capable of 0.001 volt resolution and apply the rated resistive load as defined by the test specification. Refer to the circuit schematic for terminal identification; then check all contact interfaces for all normally open and normally closed circuits.

5.1.4 Take the voltage drop measurement 0.5 – 3.0 seconds after the load current has stabilized. If reading is out of specification limits, repeat measurement 3 times while switching the rated load and average readings to assure the value will be repeatable when returned to the design source. If the switch function is intermittent, test at a steady state resistive load equal to the steady state application load.

TABLE 5

Test Sequence	Performance Check Frequency	
	New Product	Previously Validated
6. Visual Inspection & Analysis	Before & after individual tests	Before test & after 6.6 sequence
7. Mechanical & Electrical Tests		Before & after test sequence
8. Environmental Tests		Before & after test sequence
9. Durability Tests	Before, at 25, 50, 75, 100, 150, 200, & 300% expected life as noted	

5.2 Open Circuit Resistance. Open circuit resistance is a measure of air gap across contacts and is made by impressing a high voltage across the air gap. Separating contacts with a physical air gap will have a very high open circuit resistance where sliding contacts may breakdown as low as 30 – 80 volts due to wear and debris after durability.

5.2.1 Apply the nominal test specification actuation parameter (see Table 4) which causes the electrical contacts to rest in an open state. Maintain the operating parameter at a level at least 110% of the test specification minimum to assure stable switch position.

5.2.2 Use a megohmmeter or hi-pot type tester capable of placing a 24.0 to 500 volt DC potential across the contact air gap. Read the open circuit resistance directly or calculate it by measuring microampere leakage; then apply ohms law.

5.2.3 Check the open circuit resistance for all contact air gaps in both the energized and unenergized positions (SPDT configuration). Refer to the circuit schematic for identification of circuits. Apply 110% of the nominal actuation parameter if necessary to maintain stable switch position.

5.2.4 Do not exceed 500 volts DC potential when performing pre-endurance performance evaluations to prevent dielectric breakdown, tracking or other forms of sample degradation.

5.2.5 When checking sliding contact switch assemblies, either as an interim durability performance check or at the conclusion of endurance tests, proceed as follows:

(a) In the off or open circuit position apply 24.0 volts DC across the assessable switch terminal as indicated by the circuit schematic. The leakage current shall not exceed 1.2 microampere (equivalent to 20.0 megohm isolation resistance).

(b) Raise the DC potential to 110 volts DC while monitoring for dielectric breakdown or leakage exceeding 5.5 microampere (equivalent to 20.0 megohm isolation resistance).

(c) Raise the DC potential to 250 volts DC while monitoring for dielectric breakdown or leakage exceeding 12.5 microampere (equivalent to 20.0 megohm isolation resistance).

(d) Raise the DC potential to 500 volts DC while monitoring for dielectric breakdown or leakage exceeding 25.0 microamps (equivalent to 20.0 megohm isolation resistance).

(e) Record the last open circuit voltage at which the isolation resistance was greater than 20 megohm. Do

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not continue to raise the open circuit voltage. Test equipment must current-limit to prevent arcing, charging of particulates, or carbonization as a result of breakdown exceeding 1.0 megohm.

5.2.6 The voltage potential may be raised to increase the leakage current as a means of evaluating open circuit resistance at the conclusion of durability testing.

5.2.7 Alternating current breakdown testers are more severe at equivalent voltages and therefore results will be acceptable provided the device passes the test.

5.3 Isolation Resistance. Isolation resistance is a measurement of the dielectric breakdown between the electrically "hot" contact structure and other isolated circuits or the switch case, base, cover, etc.

5.3.1 Use a megohmmeter or hi-pot type tester capable of producing a 500 volts DC potential from all isolated terminals to the switch base, cover and all isolated circuits as externally measurable. Refer to the circuit schematic to determine where isolation occurs.

5.3.2 Do not exceed 500 volt DC potential when performing pre-endurance and interim performance evaluations as a precaution to prevent dielectric breakdown, tracking or other forms of sample degradation.

5.3.3 Alternating current breakdown testers are considered more severe at equivalent voltages and therefore results will be acceptable provided the device passes the test.

5.4 Analog Outputs (Figure 1B). Monitor the device electrical output with an oscilliscope, chart recorder or other suitable data acquisition system capable of acquiring and storing data at a rate of 40 samples per second or more.

5.4.1 Use a well-regulated valve, motor or test chamber to produce a rate of actuation as given in 4.8.7 unless otherwise specified.

5.4.2 Review the stored output waveform for discontinuities and voltage or current levels as specified by the device functional definition (see Figure 1B).

5.5 Temperature Rise.

5.5.1 Mount the test sample, including baffles or enclosures which simulate actual air flow, in a manner consistent with its application and energize all continuous circuits at room temperature. Continuous circuits shall be any circuit which is normally expected to be energized for any period exceeding 10 minutes. Where a switch is intermittent in operation or combines continuous and intermittent circuits, pulse the intermittent circuits per 4.8.5.

5.5.2 Apply the rated load to each switch circuit as defined by the product requirement specification.

5.5.3 Monitor sample temperature at the location given by the part drawing. Where no temperature measurement location is specified by the part drawing or test order, place the thermocouple on the switch housing at a point nearest the switch terminal with the highest current per square unit of cross-sectional area.

5.5.4 Temperature stabilization shall be defined as the temperature level at which 3 consecutive readings taken 5 minutes apart change less than 2 C.

5.6 Function Check. Checks at ambient extremes are used to verify the continuous duty nature of the device and evaluate performance over the application temperature range. The type of test required (calibration or SAE) is dependent on the nature of the device being tested. These tests shall be performed on the operating durability samples before and at 100, 150, 200 and 300% of the operating life requirement. Performance limits for actuation forces, travel, etc, will typically be different than performance limits at room temperature.

5.6.1 Calibration Test. A calibration type test is to be performed on switches which change circuit in response to an actuation parameter (fluid, pressure, or force) which substantially changes properties due to temperature or on switches which have mechanisms or components which are substantially changed by temperature (ex: bi-metal or wax temperature switches, pressure switches, etc). Table 6 lists the operating procedure for calibration tests.

5.6.2 SAE Test. The SAE test assures proper make/break sequencing and evaluates the affects of temperature on fits, clearances, greases, springs or other elements which have recoverable physical property changes as a function of temperature. The name of this test comes from its use by SAE for testing instrument panel switches such as beam change or turn signal. Table 6 lists the operating procedure for SAE tests.

TABLE 6

Calibration Test	Reference	SAE Test
Soak hot Circuit on	5.6.3	Soak hot Circuit on
Check actuation while hot	5.6.4	Not applicable
Not applicable	5.6.5	Circuit on Check switching
Soak cold Circuit off	5.6.6	Soak cold Circuit off
Circuit on Check calibration while cold	5.6.4	Not applicable
Not applicable	5.6.5	Circuit on Check switching

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5.6.3 Heat the samples in circulated air to the maximum rated temperature identified by the product requirement specification. For continuous duty switches, apply a power supply voltage of 14.0 volts and the rated load unless otherwise noted. Allow the samples to soak for a period of 4.0 hours.

5.6.4 Reduce the operating parameter (pressure, temperature, vacuum, etc) until an electrical change of state occurs. Record the level at which the change of state occurred. Raise the operating parameter level until the electrical circuit changes back to its energized state. Record the level as before. Repeat 3 times allowing a 5-minute rest between cycles. Average the 3 readings to determine the calibration point(s).

5.6.5 Remove the samples from the temperature chamber, attach connector body if necessary, and immediately start cycling the parts while monitoring the application electrical circuit for proper sequence, timing and/or force to actuate. Up to 5 switches may be removed from the temperature chamber at one time, provided the total elapsed time for analysis is less than 2 minutes; otherwise, remove samples one at a time.

5.6.6 Stabilize samples at −40 C by soaking for 1 hour without being energized. For calibration tests, raise the operating parameter until an electrical change of state occurs; then proceed as in 5.6.4. For SAE tests, repeat 5.6.5 before preceding. The power supply open circuit voltage shall be 16.0 volts during the cold test. If the sample contains a constant current power supply, repeat the cold test sequence at 10.0 volts to determine the effect of increases in on-time to source the design power.

5.6.7 Monitor all normally open and all normally closed circuits during each evaluation sequence.

5.6.8 Basic displacement type switches may be operated by hand.

5.6.9 Current interruption for beam change switches shall not exceed 100 milliseconds. Sequence of other electrical make/break switches shall be as noted by the test specification functional definition.

5.7 Displacement. Switch travel and specifics regarding points of electrical make and break may be critical to customer satisfaction. Total travel, travel to actuate, overtravel after actuation and travel to reset shall be determined for basic displacement type switches when required by the product design specification.

5.7.1 Equipment. Figures 3A, 3B and Appendix B give details of a fixture capable of plotting, on graph paper, the force to actuate the electrical continuity as a function of displacement. Other means including gauge blocks, dial indicators or "Instron Testers" are also acceptable.

5.7.2 Position and Mounting.

5.7.2.1 Position the switch so that the displacement pick-up and the switch actuator are both approximately in the center of their travel (see Figure 3B). Centering the pick-up at the center of the switch travel is required to maintain accuracy and to minimize the measurement error on switches which have a rotary action.

5.7.2.2 Mount the sample in a manner consistent with its application mounting. Care should be taken to assure the mounting method does not alter the body of the switch in a manner inconsistent with its mounting. Zero the measurement on the graph paper with the switch completely depressed and with a 50 newton actuation force. By forcing the switch actuator against its own stop to zero, the measurement provides a repeatable zero point for switches which are preloaded in their application (ex: beam change switch) and for bi-directional switches in which hysteresis may cause shifts in the neutral position (ex: 3-position rocker switch with center-off position). Forcing the switch actuator against its own stop also insures the switch will not shift mounting position during the test run.

5.7.3 Rate of Actuation. Due to the need for accurate measurement of distances, the rate of actuation may be as little as 1/100 the application rate of actuation. The rate of application shall be as near the intended rate of application as practical. Evaluate the effects of actuation rate by performing the test at various speeds. As the speed of actuation is increased, the detrimental effects of friction will yield to inertial energy allowing acceptable measurements. Operate the device at a speed such that small changes in displacement rate do not yield changes in dimensions at which switching occurs. Note the rate of actuation on the test data sheet or force displacement curve.

5.7.4 Repeatability. Test equipment such as that from Figure 3A have shown that switches are repeatable in nature (see Figure 4A). However, some switch mechanisms may require multiple tests due to their design (ex: push-push switch with two detent [SPDT] positions; see Figure 4B).

5.7.5 Definitions.

5.7.5.1 Travel to actuate (Item 1, Figure 5A) is the distance from the switch preload or free position (or from the point at which the plunger or button exerts a friction force opposing the direction of travel) to the point at which the last normally open contact indicates a voltage at least 98% of the open circuit voltage.

5.7.5.2 Pretravel (Item 2, Figure 5A) is the distance from the switch preload or free position to the point at which the electrical contacts or mechanism first starts to move perceived electrically or by a sharp change in force.

5.7.5.3 Overtravel (Item 3, Figure 5A) is the distance from the last contact make to the zero point at which the plunger or button stops with 50 N actuation force.

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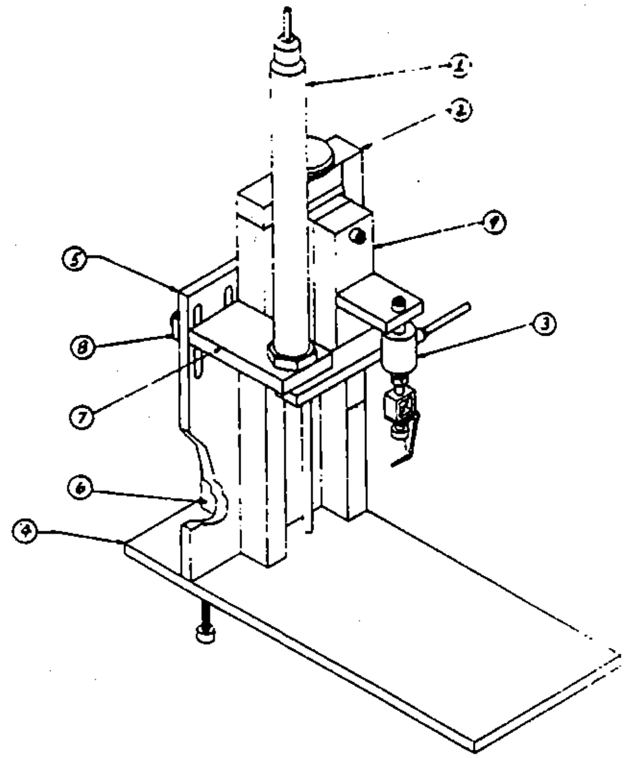

Item:

1. LVDT: Daytronic DS2000 or equivalent
2. Velmex Inc. unislide asm. # A 4012WIE or equivalent
3. Load Cell: Sensotec Model # 34 or equivalent

Not Shown — Signal Conditioners (2) required Daytronic # 3230 and # 3270 or equivalent

FIGURE 3A - FORCE DISPLACEMENT FIXTURE

5.7.5.4 Total travel (Item 4, Figure 5A) is the sum of travel to actuate and overtravel.

5.7.5.5 Reset travel (Item 5, Figure 5A) is the distance from the zero point to the last reset point to which the switch may be again actuated.

5.7.5.6 For switches with no normally open contacts, the procedure is the same except for the point of actuation is where the contact voltage is at least 98% less than the open circuit voltage.

5.8 Force to Actuate. Switch forces and specifics regarding points of electrical make/break may be critical to system function or critical to customer satisfaction. Force to actuate, feel, and return force shall be determined for basic displacement type switches. Refer to the part drawing for location of force pick-up probe. If no location is referenced, pick the center of any obvious or consistent feature and note the location on the test data sheet.

5.8.1 Equipment (see Figure 3A). Other means including spring scales and subjective ratings are also acceptable based on release engineering approval.

5.8.2 Position and Mounting. The switch shall be mounted in a manner consistent with its application mounting perpendicular to the force probe and as shown in Figure 3B. Care should be taken to assure the mounting method does not alter the body of the switch in a manner inconsistent with its mounting.

5.8.3 Rate of Actuation. The importance of overcoming frictional forces and operating as near the intended rate of application as practical is explained in 5.7.3. Operate the device at a rate of actuation such that small changes in displacement rate do not yield changes in force to actuate the device. Note the rate of actuation on the test data sheet or force displacement curve.

5.8.4 Repeatability. Test equipment such as that from Figure 3 has shown that switches are repeatable in nature (see Figure 4A). However, some switch mechanisms may require

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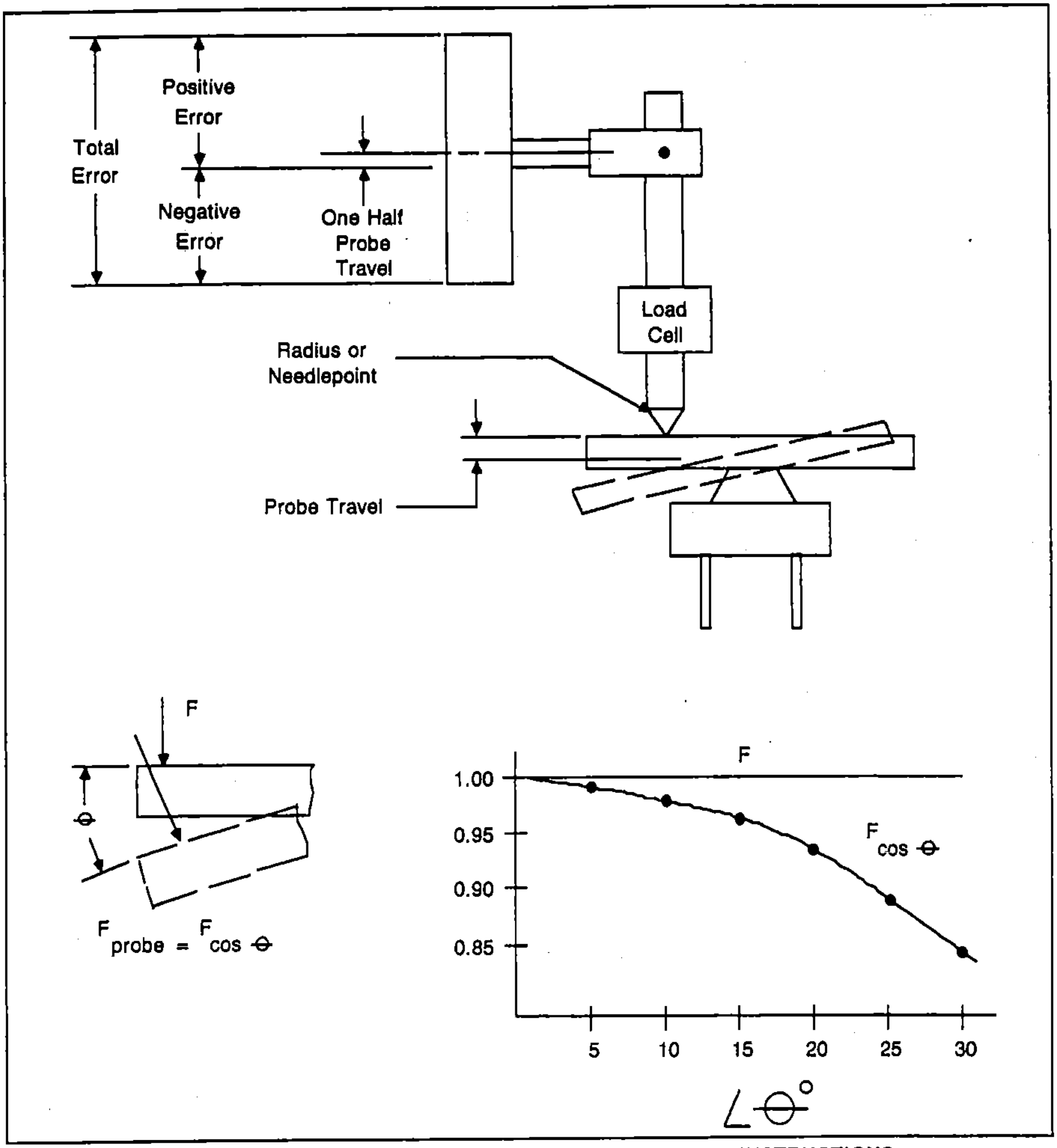

FIGURE 3B - FORCE DISPLACEMENT FIXTURE SETUP INSTRUCTIONS

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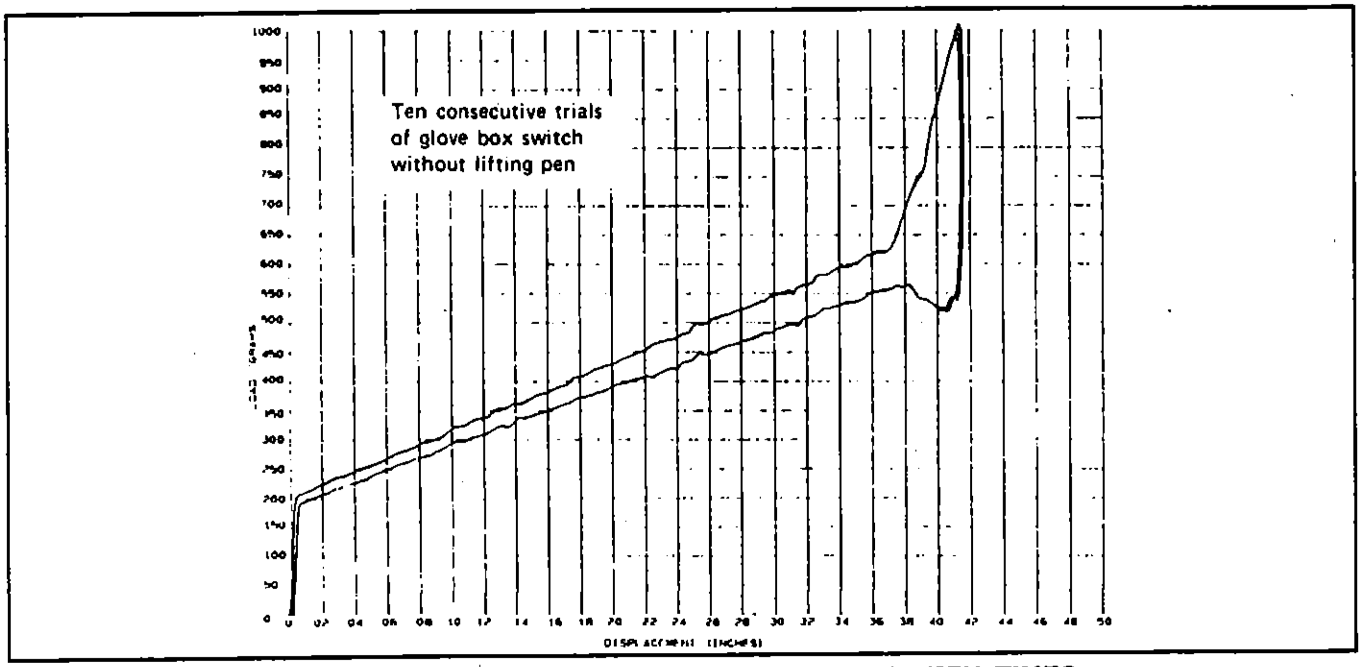

FIGURE 4A - GLOVE BOX SWITCH ACTUATED TEN TIMES

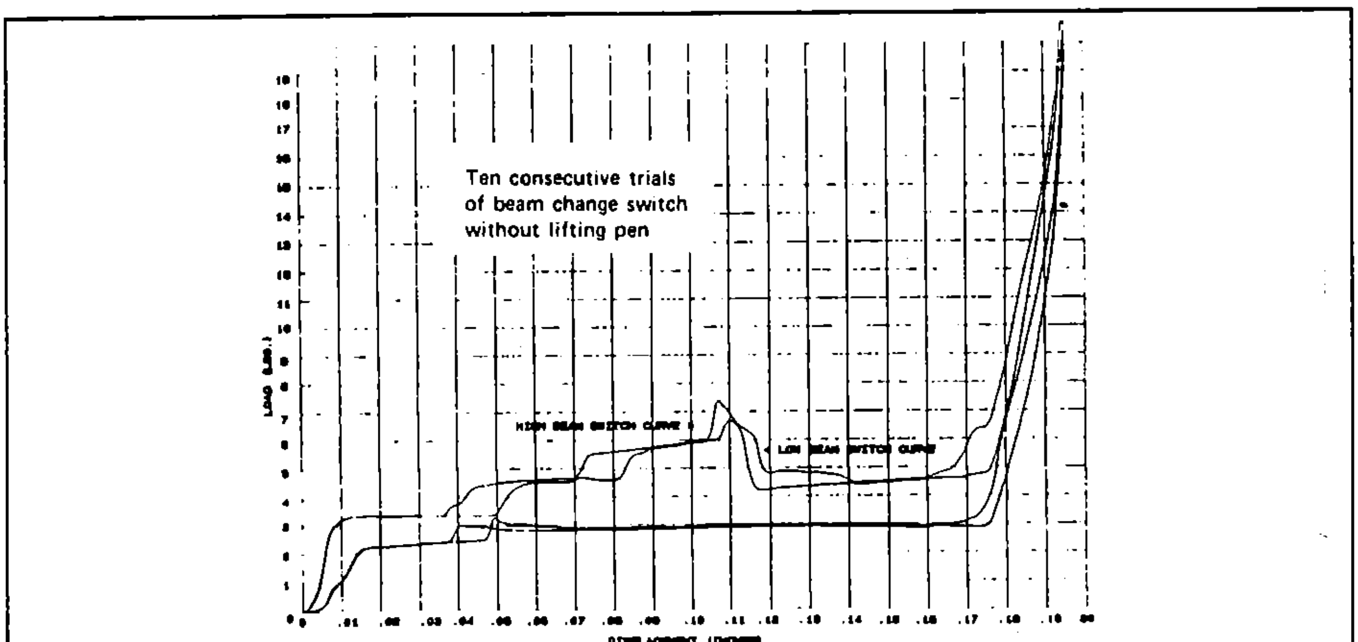

FIGURE 4B - BEAM CHANGE SWITCH ACTUATED TWO TIMES

multiple tests due to design (exs: push-push switch with two detent [SPDT] positions; see Figure 4B).

5.8.5 Definitions.

5.8.5.1 Force to actuate (Item 1, Figure 5B) shall be the maximum force required to complete contact closure and bring the mechanism to rest in its detent position.

5.8.5.2 Return force (Item 2, Figure 5B) is the minimum force exerted by the plunger or button return spring.

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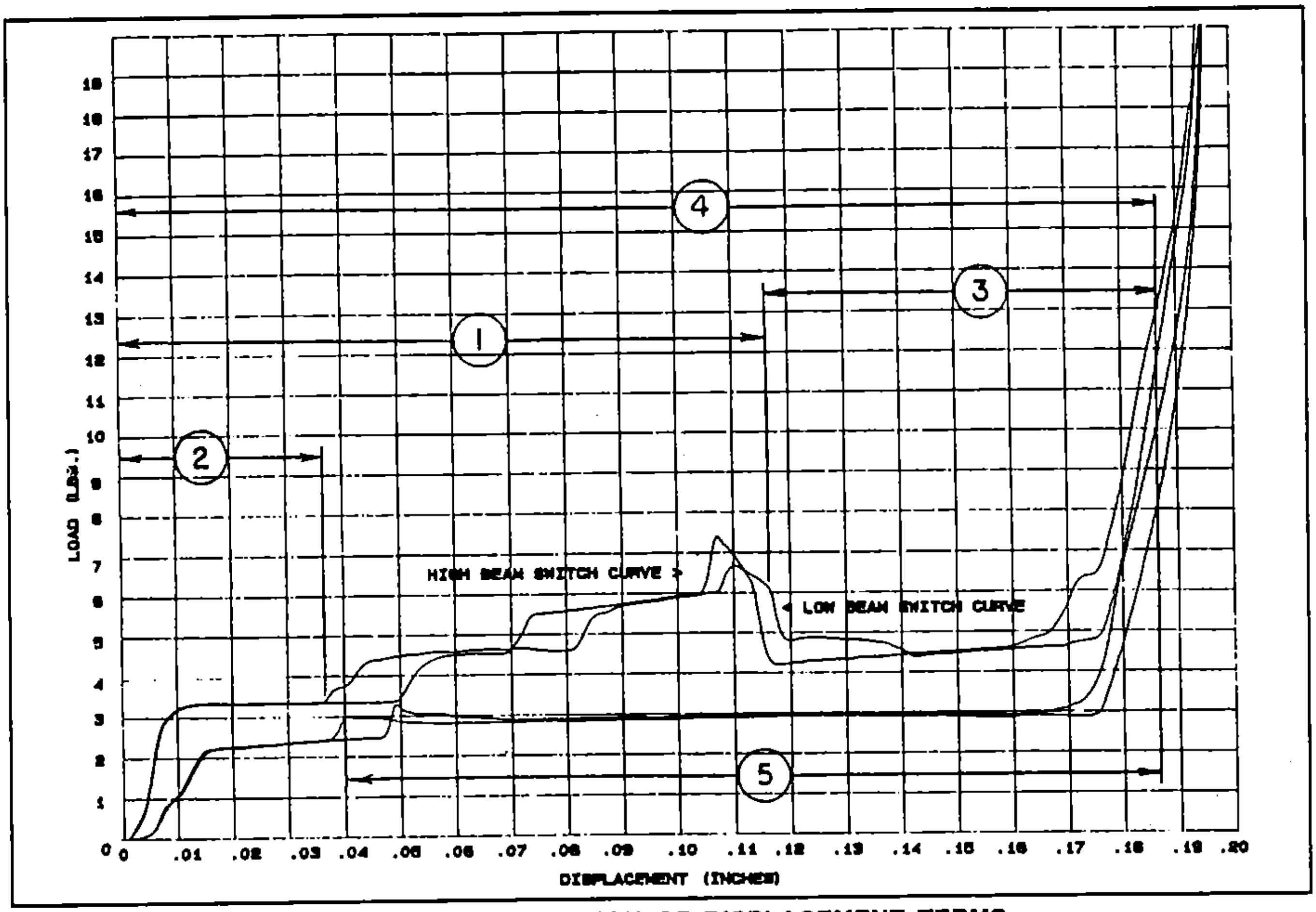

FIGURE 5A - DEFINITION OF DISPLACEMENT TERMS

5.8.5.3 Feel shall be an evaluation of 5 areas of the force to actuate curve (see Figure 5C):

(a) The "hash" (Item A, Figure 5C) or width of the band of force excursions about the nominal force displacement curve prior to actuating. An excessive band width may fool the operator into thinking he has actuated the switch prematurely.

(b) The tactile ratio (Item B, Figure 5C) is the force to actuate divided by the force which exists when the switching mechanism releases all of its stored energy and the slope of the curve once again becomes positive.

(c) The tactile slope (Item C, Figure 5C) is the slope of the force to actuate curve after the switch mechanism releases its stored energy lowering the force to actuate. Where the slope is not great enough, the switch cannot be "tactile" in nature. Where the slope is too great, a "broken stick" feel is perceived.

(d) The end of travel slope (Item D, Figure 5C) is the slope of the force to actuate curve as the switch actuator approaches the stop or zero point. An excessive slope may cause operator discomfort similar to that possible with capacitate switches that have little or no travel.

(e) The hysteresis (Item E, Figure 5C) is between the actuate and return portion of the force displacement curve. If the return spring force near the stop or zero point is too low the operator perceives a "sticky" feel.

5.9 Illumination and Color.

5.9.1 Equipment. A spectroradiometer and associated hardware shall be used in the calibration of laboratory masters or filters for visual evaluation. Guidelines for laboratory accuracy and calibration may be found within SAE J1330, Photometry Laboratory Accuracy Guidelines.

5.9.2 Mount a laboratory master which has been approved by product engineering for uniformity and intensity in a dark

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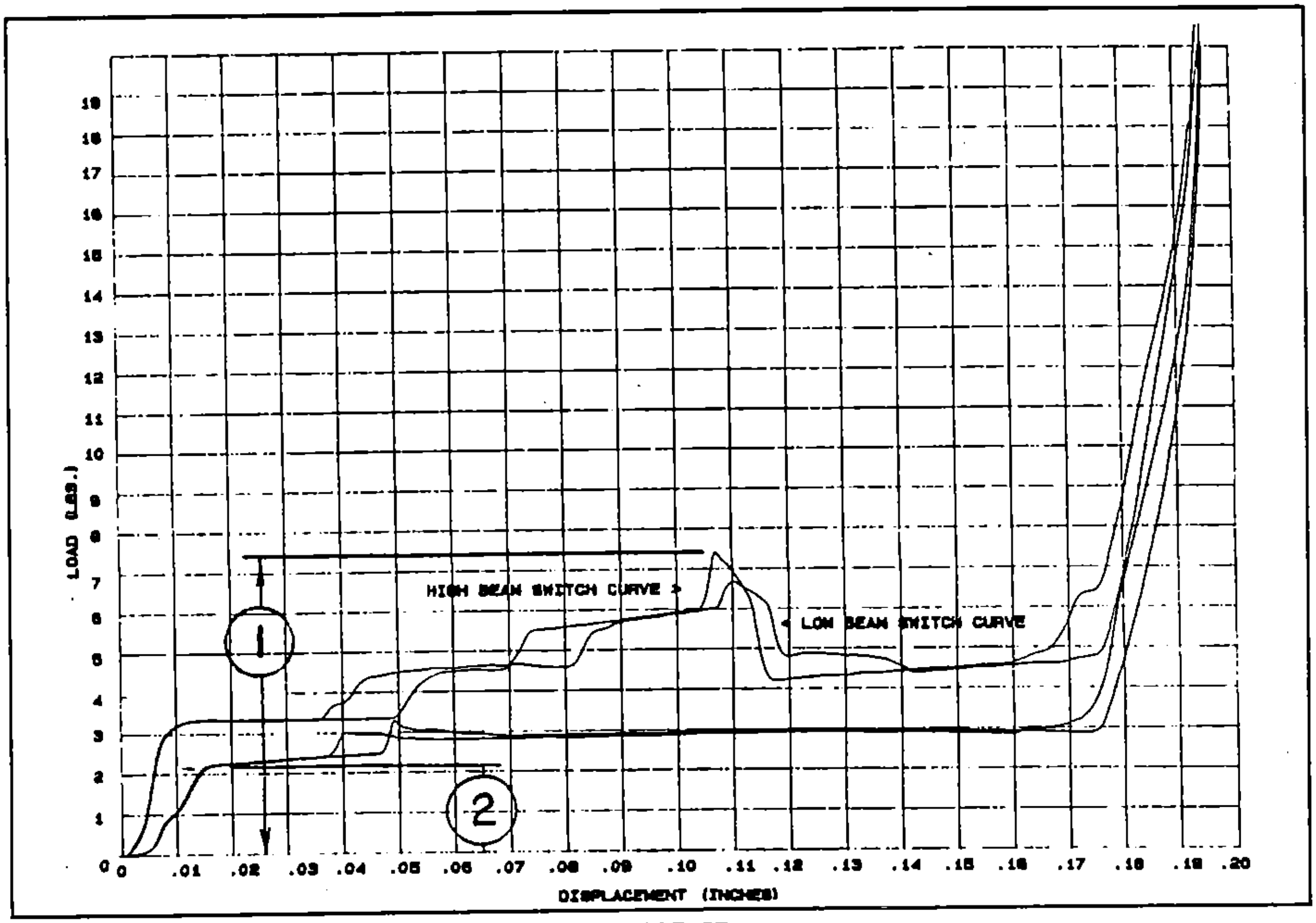

FIGURE 5B

room with less than 0.01 foot lamberts of ambient light, fully loaded, and at the rated voltage and/or frequency. View or take measurements in a position corresponding to the design normal operating position of the device. Allow sufficient time for the light output to stabilize. No emissive light sources except the sample being tested shall be on during the measurement.

5.9.3 Visual Method. The color of the light from the device undergoing inspection may be compared visually with the color of the light from a standard. The standard may consist of a filter, limit glass or masters approved by product engineering. The chromaticity coordinates of the color standards shall be as close as possible to the limits listed by the test specification. The color of the standards shall be determined spectrophotometrically.

5.9.4 Comparitor Method. The light from the device illuminates a portion of the comparator field. The standard illuminates an immediately adjacent field portion of an equal area. It is preferable that the standard field should surround the comparator field or vice versa. The locations of the standard and test sample shall be adjusted so the comparison fields have equal and uniform luminance (brightness).

5.9.5 Tristimulus Method. In this method, photoelectric receivers, with spectral responses that approximate the CIE standard spectral tristimulus values, are used to make color measurements. In making these measurements, a sphere may be used to integrate the light from a colored source. The source shift that results from the spectral selectivity of the sphere paint shall be corrected by the use of a filter, correction factor or appropriate calibration.

5.9.6 The test samples shall be evaluated for the range of color identified by the masters (visual) or tristimulus values specified. Pin holes, light leaks or intensity gradients across individual buttons shall be noted. Samples of unacceptable assemblies shall be saved or photographed and returned to the design source.

5.9.7 Reduce the illumination voltage and note the voltage at which the illumination becomes indiscernible in a dark room with less than 0.01 foot lamberts ambient light.

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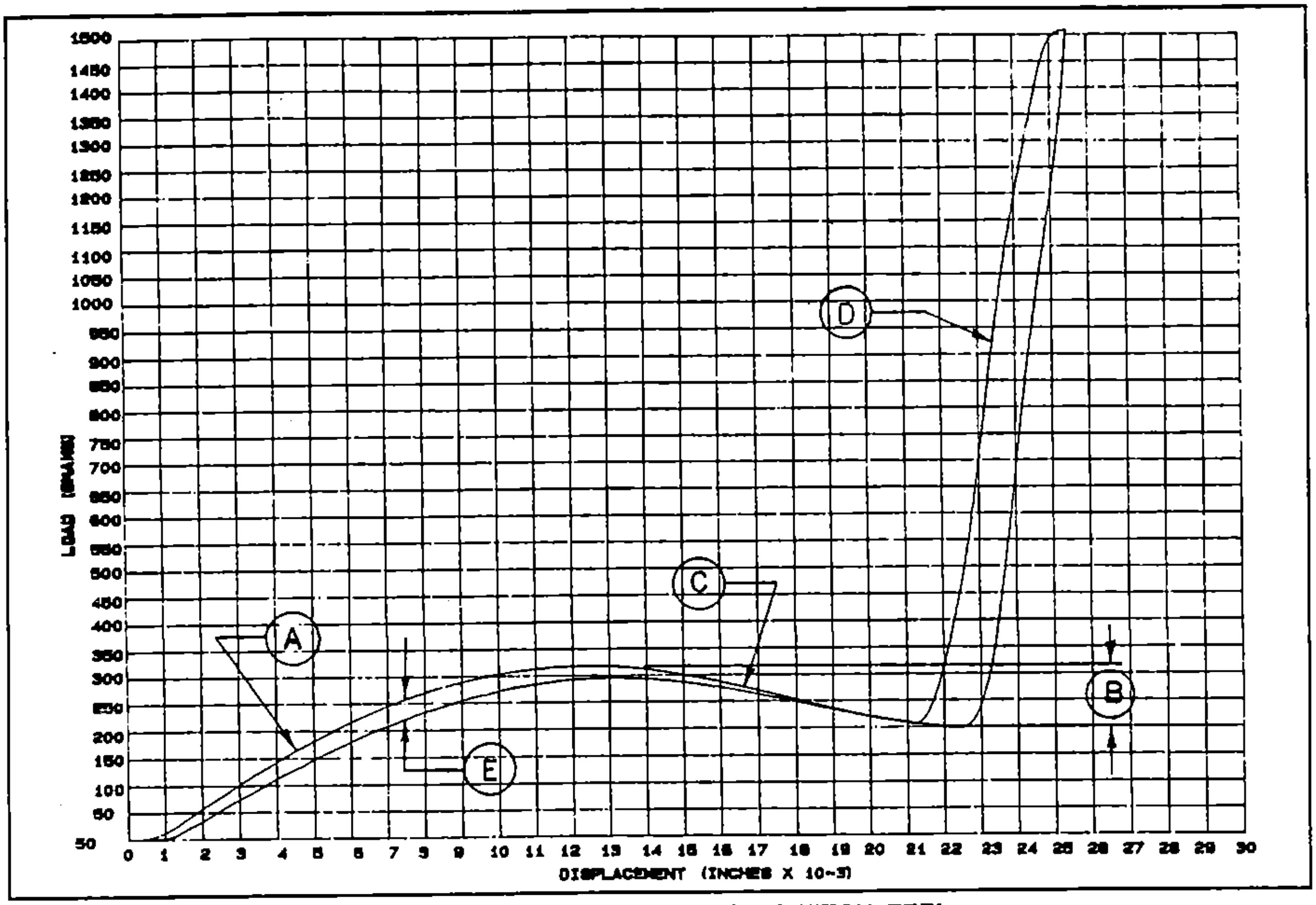

FIGURE 5C - DEFINITIONS OF SWITCH FEEL

5.10 Appearance. Test samples shall be compared under white fluorescent light to the laboratory masters approved by product engineering. Note any sign of scuffs, scratches, sink marks, cracks, nicks or blisters. Samples of unacceptable assemblies shall be saved or photographed and returned to the design source.

5.11 Audible Sound. Sound level checks are to be made using a sound level meter with an oscilliscope output at a point 900 mm from the face of the switch to the face of the microphone. The microphone shall be a 12.7 mm diameter free field or pressure type with a sensitivity of 50 mV/Pa and a frequency range of 6.5 Hz to 8kHz minimum.

5.11.1 Mount the switch by its application mounting structure perpendicular to the axis of the dosimeter microphone in an enclosure with a background noise level not to exceed 45dB on an A-weighted scale.

5.11.2 Record the sound level waveform due to actuation in decibles on the A-weighted scale. If an operator's hand is required to energize the switch, it should be an integral part of the measurements.

5.11.3 Make a sound measurement for both the on-to-off and off-to-on modes of operation.

5.12 Contact Bounce.

5.12.1 Mount the sample in its normal mounting orientation carrying its application load including inrush or stall currents to eliminate the potential of local magnetic fields at the contacts or mounting position influencing contact bounce.

5.12.2 Monitor the contacts using an oscilliscope with a minimum sampling rate of 40 MHz.

5.12.3 Where questions concerning analysis of the captured waveform arise, the method shown in Figure 6 shall be used. Note the number of contact bounces, total duration of the bounce period, and upper and lower voltage limits on the test data sheet.

5.13 Leak Check. There shall be no air leakage at the interface or between part seals and joints when the assembly is subjected to the specified air pressure while under water. Care must be taken to assure an apparent leak is continuous

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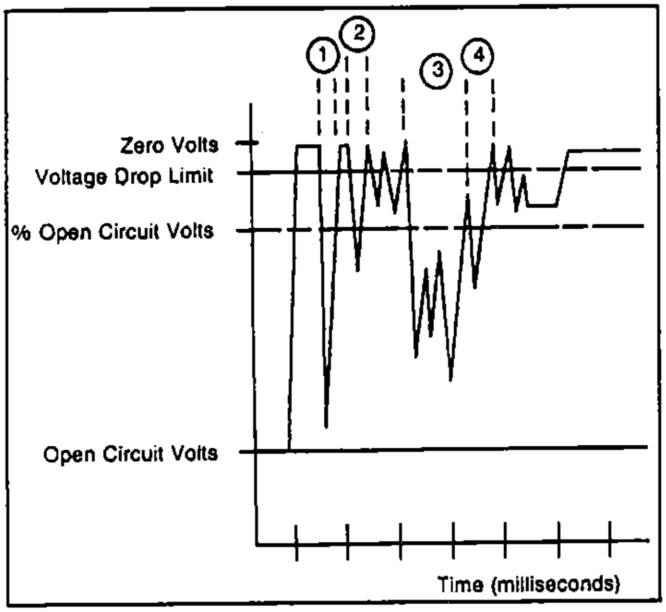


FIGURE 6 - CONTACT BOUNCE EXAMPLE, FOUR BOUNCES

and not the short term escaping of air entrapped in crevices or under the part or fixture. This is accomplished by subjecting the assembly to pressure for 5 minutes in each switch detent position. Use a test head or fixture designed to the upper tolerance limit for female threads and vice versa for male threads. Other acceptable means of leak testing includes the use of inert gases and gas analyzers.

Liquid fuels, manual transmission, transaxle, and window washing systems .... 10 psi gage

Engine oils, transmission fluid, and engine cooling systems .... 80 psi gage

Air conditioning systems .... 500 psi gage

Brake systems .... 2500 psi gage

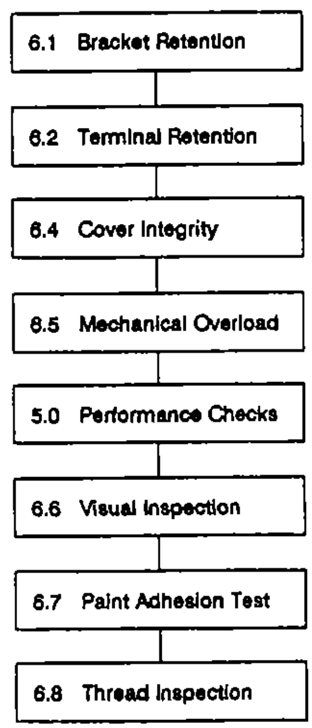
5.14 Chatter Test. The chatter test is used to assure that temporary changes in pressure, as a result of the switch energizing its load, do not cause system oscillations and to evaluate the surety of make for temperature switches.

5.14.1 Pressure Switches. Use a well-regulated valve capable of producing an essentially half-sinesoidal waveform of pressure verses time. The product design specification shall give application parameters for the minimum actuation pressure, expected head drop, etc., as shown in Figure 7. Note the ability of the sample to complete the pressure surge without nuisance contact openings exceeding 1.0 milliseconds duration on the test data sheet.

5.14.2 Temperature Switches. Use a well-regulated temperature chamber capable of increasing or decreasing temperature at a 5.0 degree per minute rate. Stabilize the actuation temperature at 90% of the test specification minimum for 5 minutes unless otherwise noted. Ambient temperature shall be room temperature unless the mounting of the switch dictates a different environment (ex: temperature switch in oil). Raise the actuation temperature at the above rate to 110% of the product design specification minimum while monitoring contact bounce per 5.12.

5.15 Rattle Evaluation. Lightly shake the switch in the direction to cause the actuation buttons to rattle. Where a question to the severity of the subjective shake evaluation occurs, perform a PIND test per Mil-Std-202F, Appendix D. Regardless of test method, note if the actuation buttons or switch mechanism rattles on the test data sheet.

6 VISUAL INSPECTION AND ANALYSIS. A minimum of 6 new samples shall successfully complete each test below in the order specified (6-pass, O-fail) except where specific test plans call for larger sample sizes. Omit tests which are not applicable to the device under test. Performance checks are to be made after the mechanical overload sequence and before visual inspection. Visual inspection is a destructive test.



6.1 Bracket Retention. Apply the force given by the test specification along and perpendicular to the plane defined at the bracket attachment surfaces. Push or pull in the direction to separate the switch from a master bracket based on the

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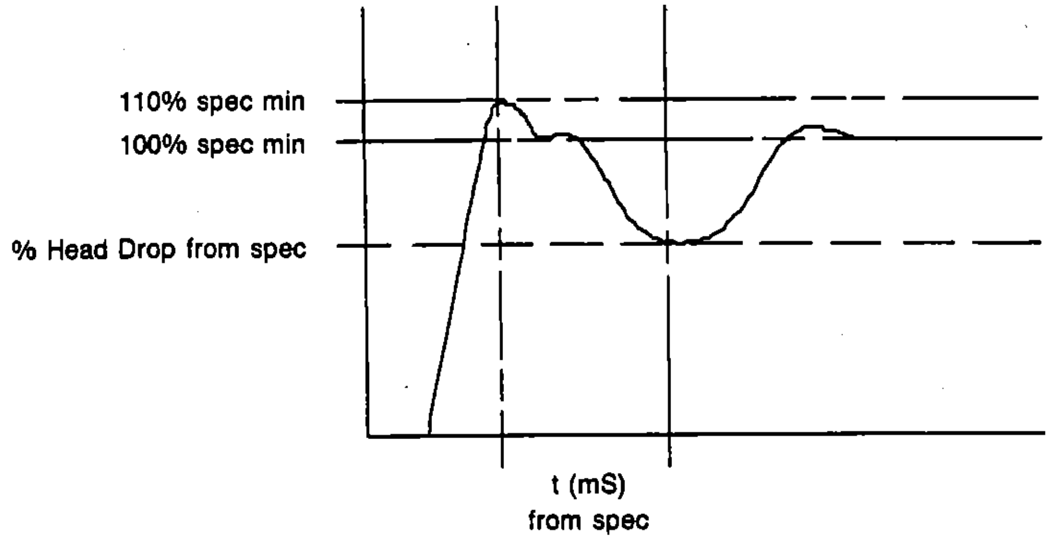

FIGURE 7 - CHATTER TEST WAVEFORM

nominal bracket design (for snap-in brackets). Note the force to insert and the force to remove the bracket on the test data sheet.

6.2 Terminal Retention. Apply the force given by the test specification along the axis defined by the centerline of the switch terminals. The terminals must not yield, thus suffering a permanent deflection when pushed. If no specification value is given, each individual terminal shall withstand a 220 N force without permanent deflection exceeding 0.1 mm.

6.3 Connector Insertion. This test is required to evaluate the forces necessary to mate and unmate connectors to switch assemblies.

6.3.1 Equipment. Use a production or prototype connector body and female terminal(s) which have been crimped to the appropriate wire gage (see Table 3). Assemble female terminals in connector; then crop the wire at the connector surface at which the testor load will be applied. The diameter of the testor actuator shall exceed the diameter of the connector body.

6.3.2 Connector Location. Seat the connector visually up to 0.3 mm from the initial force reading on the fixture.

6.3.3 Procedure. Unless otherwise noted, assemble the connector at a rate of 50 mm per second while recording the actuator force on a chart recorder or equivalent system. Note the maximum force to seat the connector on the test data sheet. Also note if locking features seat and if visual air gaps exist on sealed or "weatherproof" designs.

6.4 Cover Integrity.

6.4.1 Cover to Base Retention. The cover shall not shear or otherwise separate from the terminal base upon the application of a pull in the direction to separate. Apply a 110.0 N force unless otherwise specified.

6.4.2 Cover Strength. The cover shall not yield (causing loss of function or loss of electrical isolation) upon the application of a push in the direction to engage the connector body. Evenly distribute a 110 N force about any 13.0 mm diameter area unless otherwise specified.

6.5 Mechanical Overload.

6.5.1 Mount the test sample consistent with its application mounting position.

6.5.2 Unless otherwise noted, apply an actuation load equal to 200% of the maximum specified load to actuate (temperature, pressure, force, vacuum, etc) at the rate given in 4.8.7.

6.5.3 Apply the load along the plunger centerline or button center in the direction to actuate for displacement type switches.

6.5.4 The switch shall meet all design specification performance requirements after test.

6.6 Visual Inspection.

6.6.1 Workmanship. Magnification up to 10X may be used in performing visual inspection for requirements controlling the following:

(a) Cracks, burrs, chips or filings, extraneous foreign material or oil, weld and solder splatter.

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(b) Clearances between fixed and moving parts.

(c) Irregularities such as scratches or nicks on contact surfaces.

(d) Contact alignment or registration.

(e) Damage due to quality, shipping or handling.

6.6.2 Contact Force. On many switches contact force cannot be measured directly and must be calculated based on the force-deflection characteristics of the spring system. The force-displacement fixture shown in Figure 3A is capable of accurately discerning contact forces (Item 2, Figure 8) due to the change in spring rate inherent to the contact system.

6.6.3 Air Gap. Contact air gap (Item 3, Figure 8) may be calculated from the distance between the inflections in the force displacement curve when using the fixture shown in Figure 3A.

6.6.3.1 To measure air gap when not using the force-displacement fixture or to calibrate the axis of the force-displacement fixture when the mechanical lever arm is not precisely known, insert a feeler gauge between the contacts. The widest blade which does not cause a visual physical movement of the stationary contacts shall determine the contact air gap.

6.6.4 Joined Parts.

6.6.4.1 Strength of brazed or soldered parts shall be tested by applying a force that produces deformation of the joined parts and then examining the joint for evidence of cracking.

6.6.4.2 Strength of welded joints, except contacts, shall be tested by applying a force that causes the parts to be torn apart. Examination shall then be made to determine if the failure occurred at the weld or within the part material. See GM4499P for detailed procedure.

6.6.4.3 Strength of the contact joint shall be measured by applying a shearing force parallel to the longitudinal axis. Observations shall be made for perceptible movement of the contacts at 110 N applied force and symmetry of weld.

6.6.4.4 Stake integrity for riveted contacts shall be tested by scribing a line across the contact joint and applying a 0.4 Nm torque to turn the rivet. No movement shall be observable. (Note: Round shank in round hole only.) Other punch geometries require GM engineering approval.

6.7 Paint Adhesion Test. Paint adhesion tests for decorative finishes are to be performed per GM9071P.

6.8 Thread Inspection. Inspection of male or female threads may be made using a 3-wire system, thread ring or plug gauges, or screw-pitch gauge when specified by the test order.

7 MECHANICAL AND ELECTRICAL TESTS. A minimum of 11 new samples shall successfully complete each test as detailed in 7.1 through 7.7.6 in the order specified (11-pass, 0-fail) except where specific test plans call for larger sample sizes. Omit tests which are not applicable to the device under test. The test plan may also call for the same test samples to complete the environmental test sequence.

7.1 Electrical Transient Tests. Electrical transient tests shall be conducted per GM9105P and GM9106P unless otherwise noted. Transient testing is generally required only on switches which incorporate electronics in the design.

7.1.1 Test Levels. Use the pulse test levels found in GM9106P based on the functional status classification (A, B, C) and performance region (I, II, III) required by the product design specification. If no functional status or performance

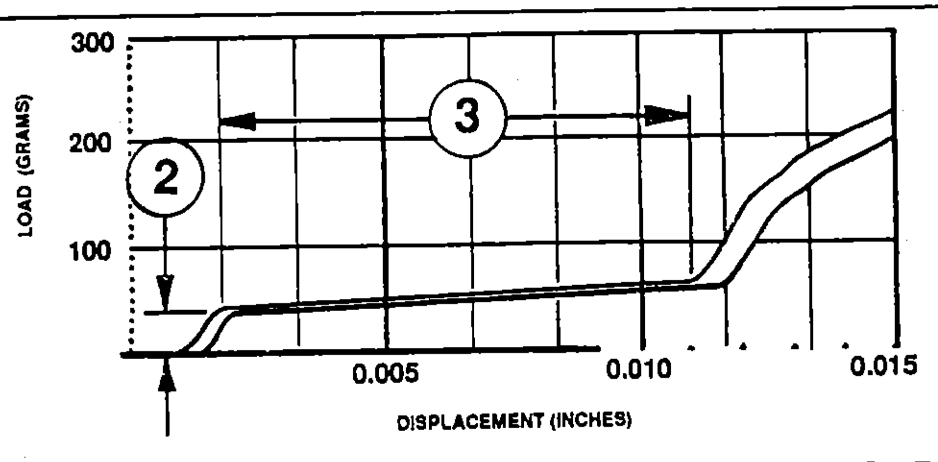

FIGURE 8 - MEASUREMENT OF CONTACT FORCE AND AIR GAP

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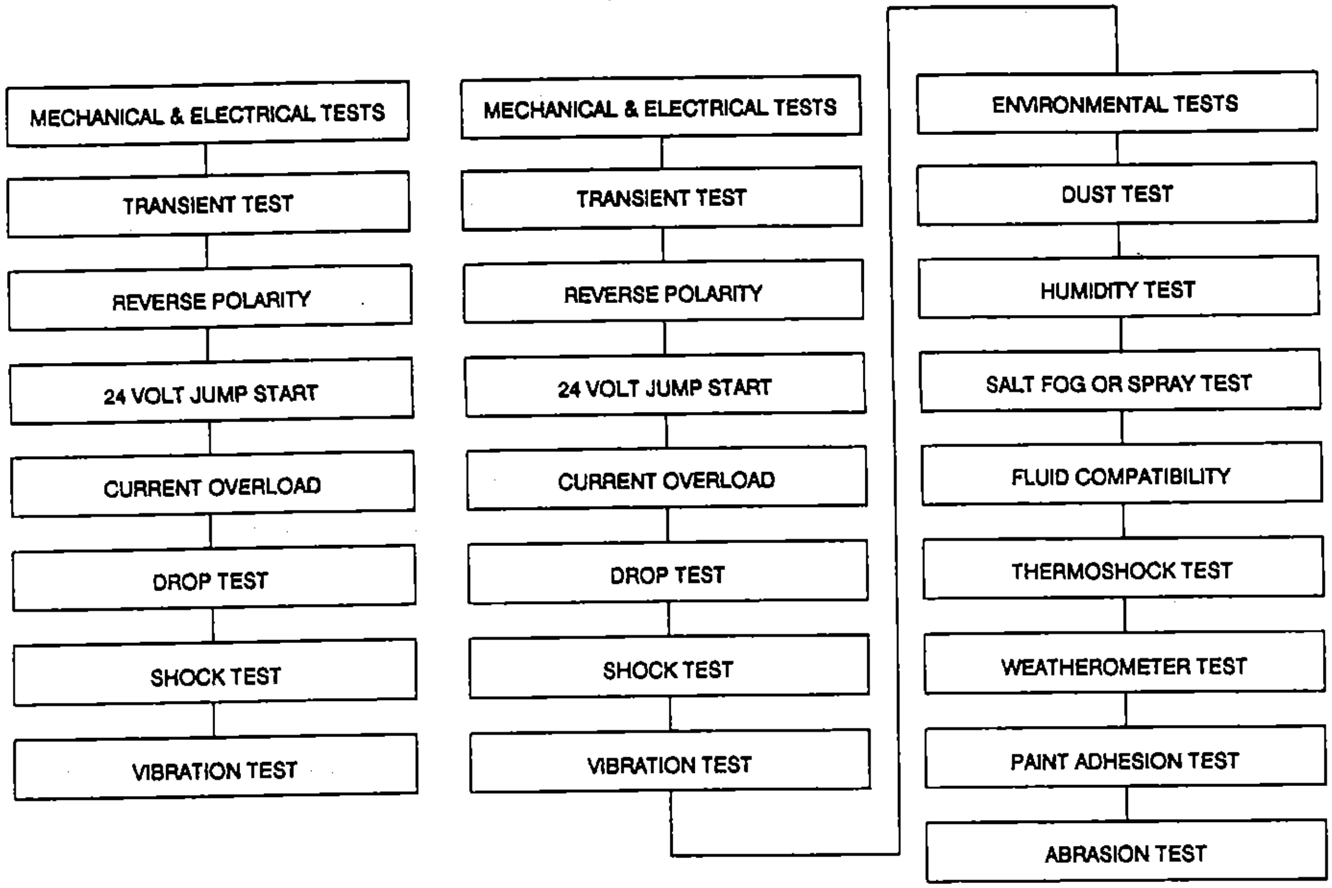
MECHANICAL AND ELECTRICAL TESTS



region is specified, test at least 2 parts at each test level (1 – 4) and note the resulting performance region for each level on the test data sheet.

7.1.2 Sensitivity. Unless otherwise specified, the device shall be capable of meeting all performance requirements upon completion of the transient test series.

7.2 Reverse Polarity Test. Exposure to reverse polarity may be the result of improper jump starts or reversing connector bodies during assembly. Apply a 14.0 volt potential in a polarity opposite that indicated by the circuit schematic using the load and test conditions noted in the Test Default section except the duty cycle is to be one cycle as follows: off/30 seconds on/off. Note whether the device retains all functions during the test, how long before it deviates from normal function if it ceases to function, and if or how long it takes to return to normal operation after removal of the test voltage on the test data sheet.

7.3 Twenty-four Volt Jump Start Test. Apply a 24.0 volt potential across the switch terminals using the load and test conditions of 4.8. Apply one cycle as follows: off/30 seconds on/off. Note whether the device retains all functions during the test, how long before it deviates from normal function if it ceases to function, and if or how long it takes to return to normal operation after removal of the test voltage on the test data sheet.

7.4 Continuous Current Overload. Continuous current overload tests are designed to assure the device will not act as a fuse or exhibit contact welding when exposed to short term electrical overloads or stall inrush currents. Continuous overloads are to be applied based on the current rating, type of device and application circuit protection.

7.4.1 Devices rated less than or equal to 25.0 amps continuous and protected by fuses shall be exposed to 3 cycles of twice the rated load with 10-minute rest periods between each cycle. One cycle consists of making, carrying current for 5 minutes, then breaking. Intermittent duty switches may be cycled per 4.8.5. The contacts must operate freely throughout the test.

7.4.2 Devices rated greater than 25.0 amps continuous or any device which is system protected only by fusible link shall

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be divided into lots and subjected to the overload tests as follows:

(a) 4 pieces: Apply 55.0 amps for 75.0 seconds at 14.5 volts; repeat. Apply 90.0 amps for 20.0 seconds at 14.5 volts; repeat. Allow 10 minute rest periods between each application of current.

(b) 2 pieces: Apply 5 cycles of 200 amps at 14.5 volts. One cycle consists of 0.5 seconds-on, 2.0 seconds-off. The device is to make, carry, and break the load.

(c) The contacts must operate freely throughout the test.

7.4.3 Circuit Breakers.

7.4.3.1 Circuit breakers shall not trip when subjected to 110% rated load for one hour at maximum rated temperature when mounted in an air-circulated air oven.

7.4.3.2 Circuit breakers shall trip or begin to cycle continuously, dependent upon their function, when subjected to 150% rated load at room temperature. Note the time to open, in seconds, on the test data sheet.

7.4.4 Test setup for overload tests is to be as shown in Figure 9. For cycling circuit breakers, bare the test lead 45 mm from the device under test and attach a thermocouple to the wire and record the temperature rise as a function of the effective current the cycling circuit breaker passes.

7.5 Drop Test. Mutilation due to severe shocks during shipping and assembly is not assessable unless physical damage is evident. Therefore, a drop test has been developed to assure lightweight components will function when exposed to severe shocks which typically do not show external damage.

7.5.1 Equipment. Figure 10 and Appendix C give specifications typical of a fixture capable of maintaining axis of drop without influencing the mass of the free falling body. The equipment illustrated is capable of holding samples of up to 60 mm maximum on any side. For larger samples, equivalent designs are acceptable.

7.5.2 Procedure. Raise the carrier tube such that the distance from the anvil to the nearest sample surface is 900 mm unless otherwise specified.

7.5.3 Samples shall be dropped at least one sample in each axis horizontal, vertical and lateral, both positive and negative, as defined by Figure 11. Add a suffix (see Figure 11) to the sample serial number to document axis of drop.

7.5.4 Should a sample exhibit catastrophic mutilation, such as cracked or broken appendages, severed or flattened terminals, etc., replace it with a new sample before proceeding with the remainder of the tests. Such an occurrence does not constitute a failure.

7.6 Shock Test. Complete function is required, even under severe operational shocks which are typical to automotive applications (ex: chuckholes). All devices shall be capable of completing the shock test satisfactorily.

7.6.1 Equipment shall be capable of providing a 20g-11 millisecond half sine shock pulse. Apply shock pulses in the axis identified by the serial number supplement and Figure 11. Monitor the contact voltage at all contact interfaces. Energize the sample per 4.8, except duty cycle.

7.6.2 Mount the test unit by its normal mounting points to the test fixture. Torque all fasteners to their recommended limits.

7.6.3 Impact the sample while monitoring all contact interfaces for nuisance opening or closures. Nuisance shall be any

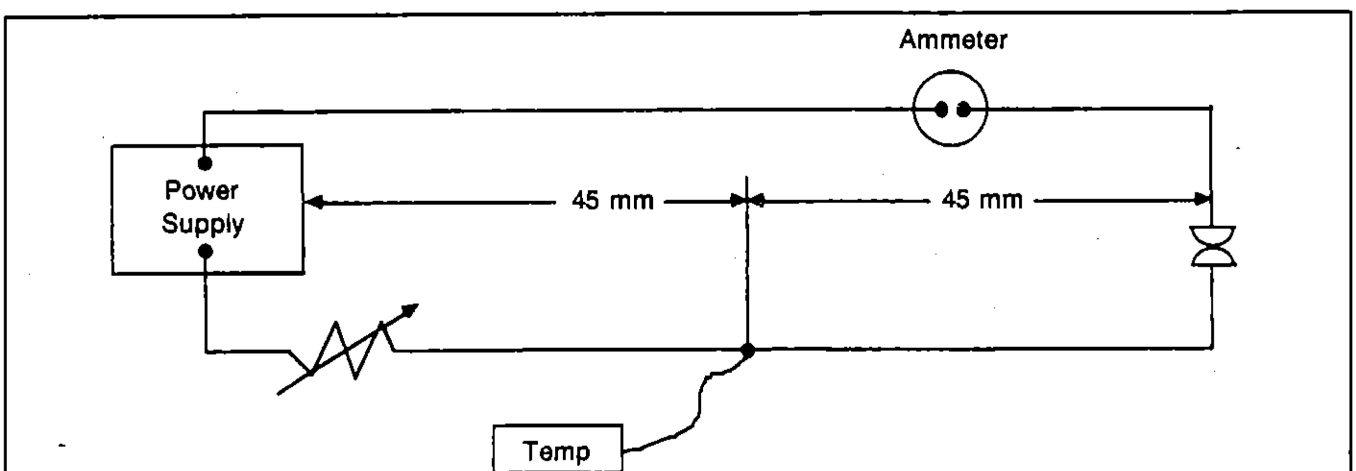

FIGURE 9 - STANDARD TEST CIRCUIT - CIRCUIT BREAKERS

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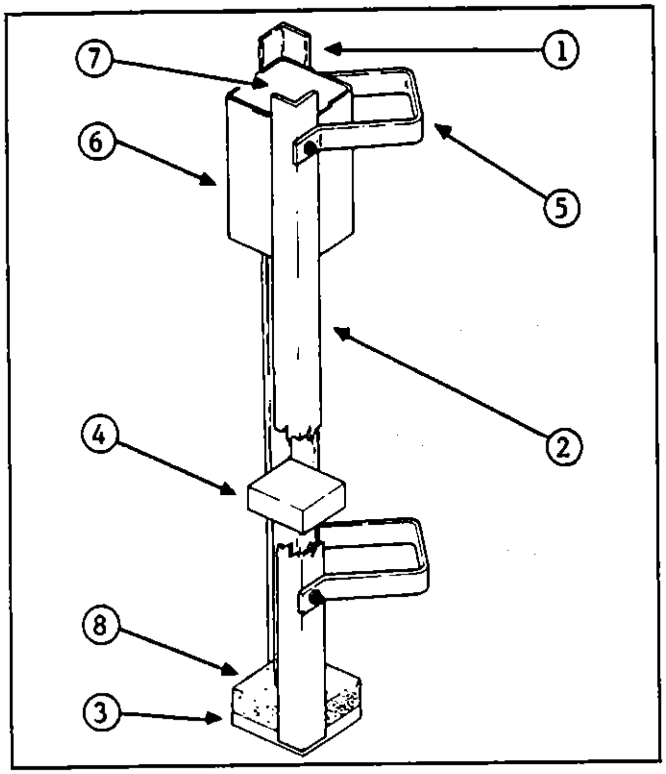

FIGURE 10 - DROP TEST FIXTURE

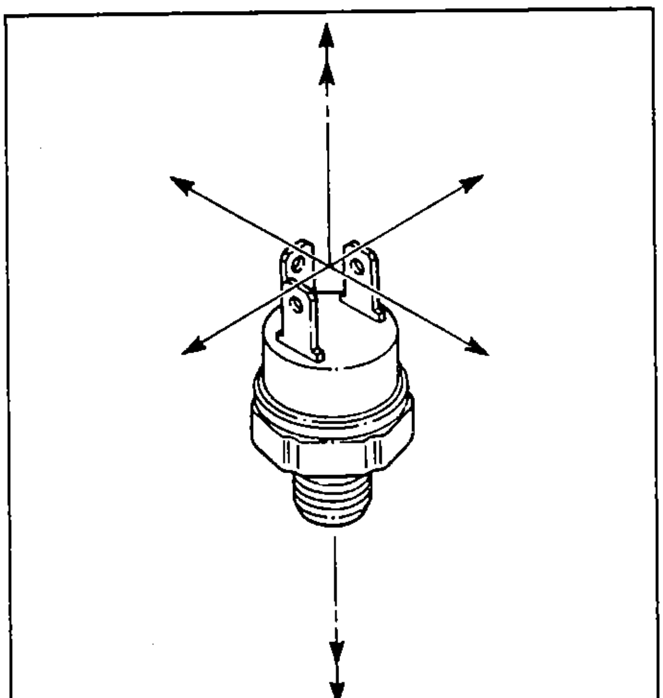

FIGURE 11 - IDENTIFICATION OF AXIS FOR DROP, SHOCK AND VIBRATION TESTS

opening or closure exceeding 1.0 millisecond unless otherwise noted.

7.6.4 For continuous duty or "latching" switches, impact the sample again except with the contacts manipulated or modulated into each switch detent position. Data requirements are the same as in 7.6.3.

7.7 Vibration Durability. A random vibration schedule has been developed based on the range of expected operational oscillations typical to instrument panel or body mountings (Table 7). However, the product design specification shall give specific test schedules for engine mounted components due to wide variations in amplitude, rigidity and damping which preclude a generic schedule. Also, a traditional vibration sweep per SAE J575, Tests for Motor Vehicle Lighting Devices and Components, and procedures for conducting a resonant search sweep are given.

7.7.1 Equipment. Closed loop vibration controllers which are capable of maintaining a tolerance of ± 4.0 dB from the nominal from 10 to 2000 Hz are acceptable.

7.7.2 Mounting. Mount the test sample by its normal mounting position to a test fixture which represents the application mounting. Torque all fasteners to their recommended limits.

7.7.3 Accelerometer Placement. Mount the control accelerometer to the test fixture as near as practical to the mounting points of the product and centrally located on the test fixture. Do not mount the control accelerometer on the test sample. Mount response accelerometers on the test sample as required by the test order.

7.7.4 Vibration Schedule.

TABLE 7

Breakpoint Frequency (Hz)	Magnitude (G SQRD/Hz)	Slope Between Breakpoints (dB/Octave)*
*10	0.070	
		(0.0)
*20	0.070	
		(−5.42)
40	0.020	
		(0.0)
350	0.020	
		(−9.20)
550	0.005	
		(−20.02)
700	0.001	
		(−100.12)
750	0.0001	
		(0.0)
2000	0.0001	

RMS G Level = 3.2 G.
Maximum G level limited to 3 times the RMS level.
Tolerance: ± 4.0 dB from 10 to 2000 Hz * = liner slopes on log-log plots only.

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7.7.4.1 There shall be a random schedule for I.P. and body mountings, including engine compartment fender, grille and bulkhead and other chassis locations only. The frequency range for vibration input is to be from 10 to 2000 Hz with the spectral description as shown in Table 7. This schedule should be replaced by specific application schedule when available.

7.7.4.2 Engine mounted components shall be tested per a vibration schedule that approximates a GM Proving Ground durability schedule for the component under test. SAE Paper No. 840501 describes the background for this test method.

7.7.4.3 SAE Sine Schedule. The frequency range for vibration input is to be from 10 to 55 Hz at a linear sweep period of 2.0 minutes per complete sweep cycle: 10 Hz – 55 Hz – 10 Hz. Excursion: 1.0 (+0.1, –0.0) mm peak to peak over the specified frequency range.

7.7.4.4 Resonant Search. The frequency range for vibration input is to be from 10 to 1000 Hz at a linear sweep rate of 1.0 octaves/min as shown in Figure 12. Place a feedback accelerometer on the part cover if placement location is not given by the test order. Note resonant frequencies on the test data sheet.

7.7.5 Test Duration. Each test specimen shall be subjected to one or more of the previous vibration schedules for 4 hours in each of 3 mutually perpendicular axis (total time 12 hours). See Figure 11 for definitions on axis or orientation.

7.7.6 Circuit Check. Monitor all contact interfaces for nuisance opening or closing exceeding 1.0 millisecond unless otherwise noted. Check both normally open and normally closed contact sets.

7.7.7 Actuation State. The samples shall be tested in each detent position. For continuous duty or "latching" switches,

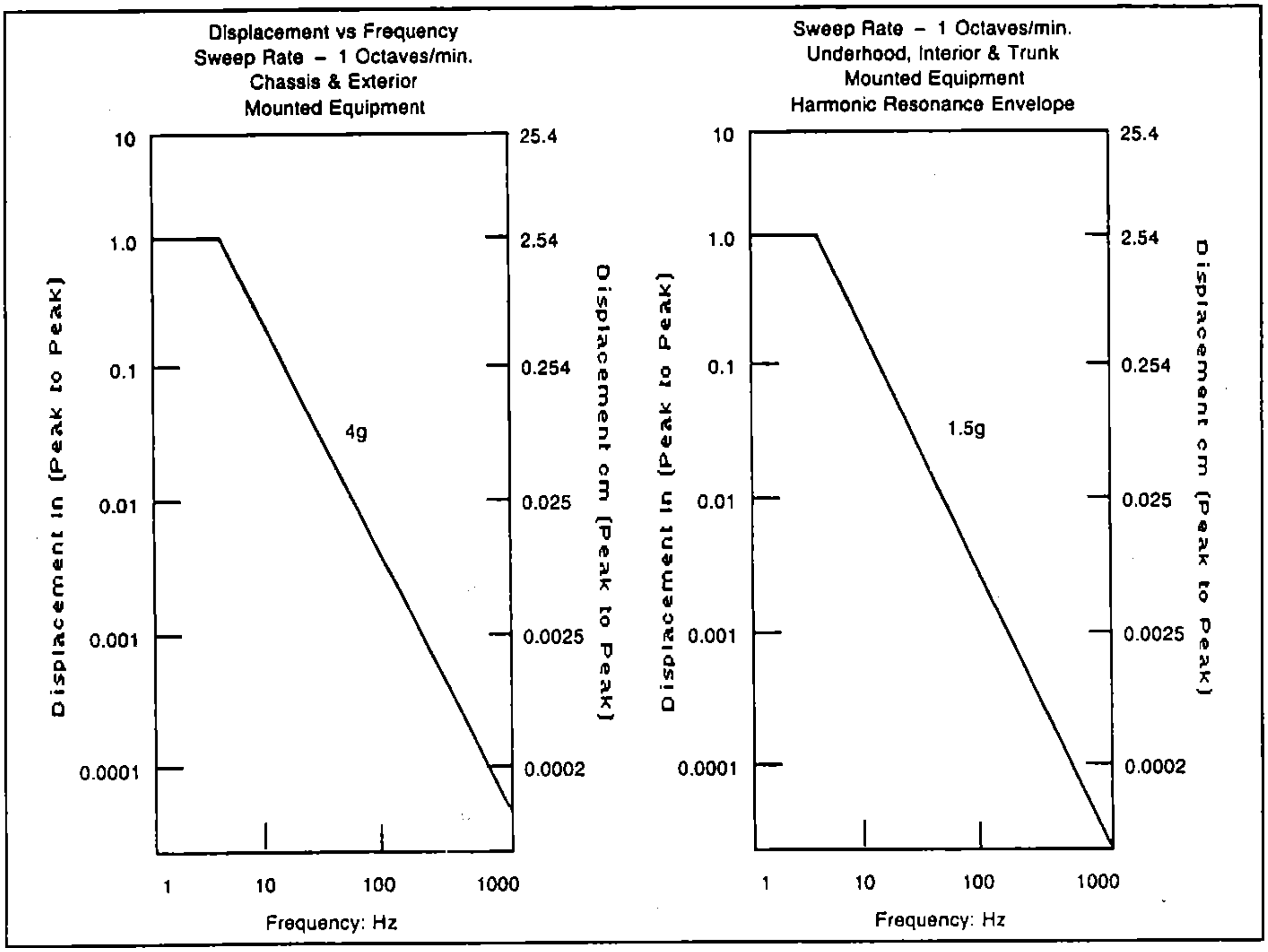

FIGURE 12 – RECOMMENDED RESONANT SEARCH VIBRATION PROFILE

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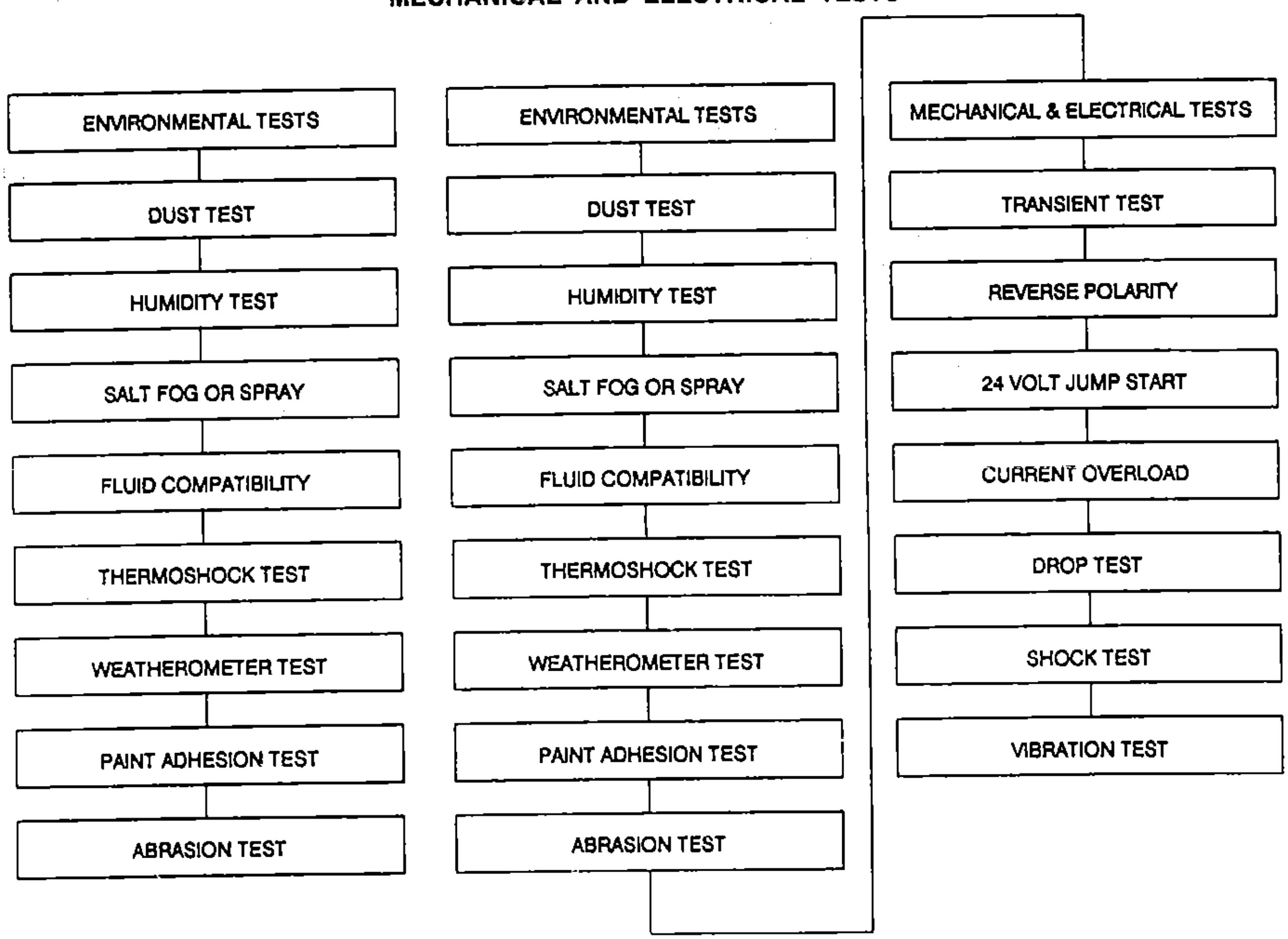
manipulate or modulate the samples through each detent position by interrupting the test as necessary. Each position is to receive vibration exposure equal to the total test time divided by the number of detent positions.

8 ACCELERATED ENVIRONMENTAL TESTS. A minimum of 11 new samples shall successfully complete each test as detailed in 8.1 through 8.8.2.4 in the order specified (11-pass, 0-fail) except where specific test plans call for larger sample sizes. Omit tests which are not applicable to the device under test. Synergistic testing may be performed where the capability exists to combine one or more test sequences to shorten test time. Synergistic testing does not eliminate the test requirements for environments which are not part of the synergistic test (ex: fluid compatibility). Describe the type of synergistic test on the test data sheet (Figure 25). The test plan may also require the same test samples to complete mechanical and electrical test sequence at the conclusion of the environmental test series.

8.1 Dust Test. All devices (such as switches) are susceptible to dust and foreign material contamination which may penetrate into cracks, crevices, bearings and joints causing a variety of damage, such as fouling moving parts, making relays inoperative, or acting as a nucleus for collection of water vapor and hence a source of possible corrosion. Complete function and performance shall be maintained after 8 hours of exposure to the dust test unless otherwise noted.

8.1.1 Equipment. Figures 13A and 13B give specifications for a fixture capable of performing dust tests. Other box geometries and dust distribution methods of equivalent designs are allowable provided a suitable means exists to maintain and verify a dust concentration of 0.003 – 0.014 g/m3. An acceptable means for doing this is by use of a properly calibrated smoke meter and a standard light source or use of a dust concentration sampler (Ref: VWR Scientific Catalog No. 26750-006).

MECHANICAL AND ELECTRICAL TESTS



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8.1.2 Mounting. Place the test item in the chamber positioned as near the center of the chamber as practical. If more than one item is being tested, there shall be a minimum clearance of 100 mm between surfaces of test items or any other material or object capable of furnishing protection. Also, no surface of the test item shall be closer than 100 mm from any wall of the test chamber. Orient the item so as to expose the most critical or vulnerable parts to the dust stream. The test item orientation may be changed during the test if so required by the component specification.

8.1.3 Dust. Fill the test chamber with 6 Kg/m3 course dust conforming to SAE J726 or GM package number 1543637. (Note: GM packaged dust is available from AC Spark Plug Division, General Motors Corp., Flint, Michigan, at a nominal cost. Correspondence should be directed to the Dust Development Laboratory.) Agitate the dust for 5 seconds during each 20-minute period. The cycle is repeated for 8 hours.

8.1.4 Procedure. Cycle the dust test samples in accordance with 4.8 Test Default Conditions. When cycling of the samples is not feasible manipulate or modulate the samples through each detent position by interrupting the test as necessary. Each position is to receive a dust exposure time under power, equal to the total test time divided by the number of detent positions.

8.1.5 Pass Requirements. Turn off all chamber controls and allow the test item to return to standard ambient conditions. Remove accumulated dust from the test item by brushing, wiping or shaking, care being taken to avoid introduction of additional dust into the test item. Under no circumstances shall dust be removed by either air blast or vacuum cleaning. Each sample shall complete a basic functional check per 5.6.5 within 15 minutes after removal from the dust chamber and before preceding with the next test sequence.

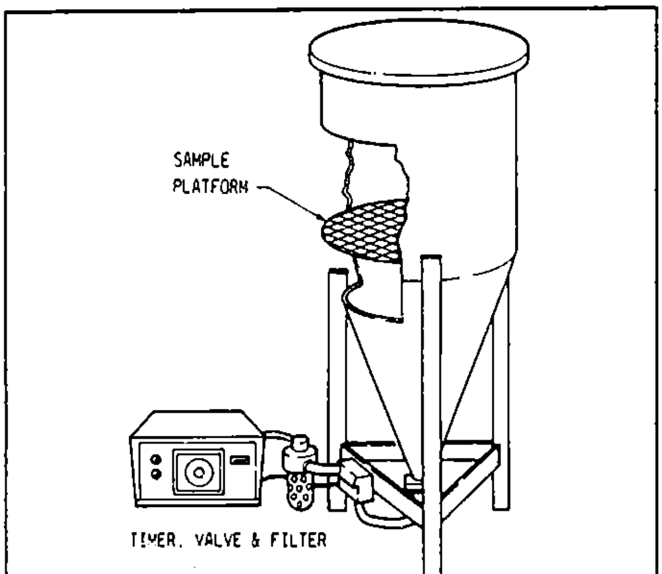

FIGURE 13A - DUST TEST FIXTURE (TYPICAL)

8.2 Humidity Test. All devices may be subject to high humidity conditions regardless of vehicle mounting position. All devices shall be capable of completing 120 hours exposure to humidity test unless otherwise specified. Use equipment and procedures required by GM4465P except as noted below.

8.2.1 Apparatus. The chamber and accessories shall be capable of maintaining a minimum 95% RH while temperature cycling. Provisions shall be made to prevent the dripping of condensation on the test samples.

8.2.2 Conditions in the Humidity Cabinet. Continuously vary the chamber temperature from 24 - 38 C and back once over each 24-hour period maintaining at least 95% RH.

8.2.3 Test Conditions. The samples shall be cycled in accordance with 4.8, except for the duty cycle: 1 hour on/3 hours off. The cycle is repeated to 120 hours. When cycling of the test samples is not feasible, manipulate or modulate the samples through each detent position by interrupting the test as necessary. Each position is to receive an exposure time equal to the total exposure time divided by the number of detent positions.

8.2.4 Examination of Specimens. Turn off all chamber controls and allow the test samples to return to standard ambient conditions. Each sample shall complete a basic functional test per 5.6.5 within 15 minutes after removal from

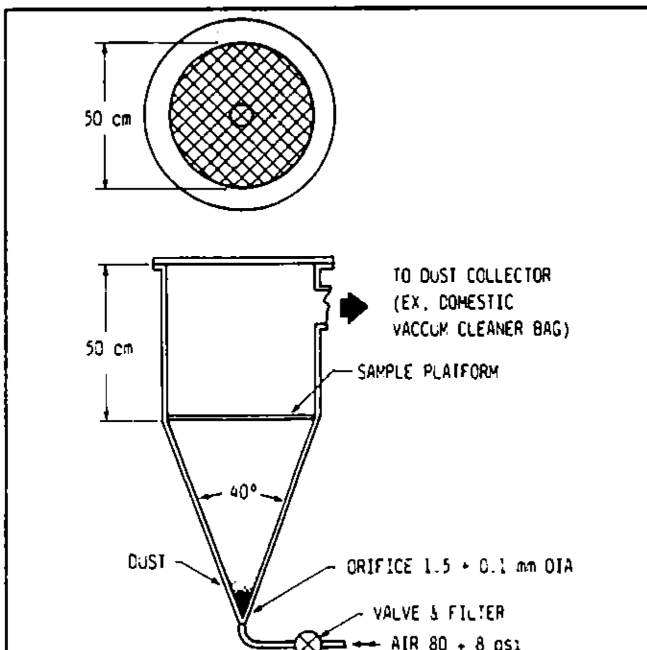

FIGURE 13B - DUST TEST FIXTURE (CONSTRUCTION)

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the humidity chamber and before preceding with the next test sequence.

8.3 Salt Spray Test. The salt spray and salt fog tests as defined by this procedure were adapted from ASTM B117B which is a test to simulate the effects of seacoast environments or road salts on metals with or without protective coatings. When used to test electrical components as outlined in 8.3.1 through 8.3.4, the tests also serve to evaluate the construction of the device and the nobility or neutralness of the internal materials of construction and contact interfaces. Evaluations of protective coatings for appearance and corrosion at the component level (ex: bracket) are to be performed using GM4298P. Immunity to corrosive salts is evaluated based on vehicle mounting position.

TABLE 8

Description	Test	Procedure
Passenger Compartment & Certain Chassis Locations	5% Salt Fog Test	Paragraph 8.3.1
Engine Compartment & Certain Chassis Locations	5% Salt Spray Test	Paragraph 8.3.2
Engine Compartment Brackets & Plated Surfaces	5% Salt Fog Test	GM4298P

8.3.1 Salt Fog Test. The apparatus required for salt spray (fog) testing consists of a fog chamber, a salt solution reservoir, a supply of suitable conditioned compressed air, one or more atomizing nozzles, specimen supports, provisions for heating the chamber and necessary means of control. The size and detailed construction of the apparatus are optional provided the conditions obtained meet the requirements of GM4298P (5% neutral salt spray at 35 C). See Figure 14.

8.3.1.1 Control the box environment as outlined in GM4298P.

8.3.1.2 Mount samples in chamber in the orientations given by Figure 15 with appropriate load and voltage as outlined in 4.8, except duty cycle.

8.3.1.3 The sample shall be manipulated or modulated such that the switch rests in each position a length of time equal to the total exposure time divided by the number of switch detent positions. The total exposure time is to be 96 hours unless otherwise noted.

8.3.1.4 Remove the samples and allow to dry in air at the conclusion of testing.

8.3.2 Salt Spray Test. Figures 16A and 16B give specifications for a fixture capable of performing salt spray tests.

8.3.2.1 Mount samples in the orientations given by Figure 15 centrally located between the 12 spray nozzles with the appropriate load and voltage as outlined in 4.8.

8.3.2.2 Adjust the flow of the salt spray through the spray nozzles so that the streams of fluid are strong enough to just hit the opposite wall of the chamber with the sample support walls removed.

8.3.2.3 Procedure. Ten cycles (240 hrs) are to be completed under the test default conditions of 4.8, except as follows:

(a) Heat the chamber for one hour in moving air at 71 C with samples not energized.

(b) Turn off heat and energize samples while spraying 5% saline solution by weight for one hour; solution to be at room temperature.

(c) Turn off salt spray, de-energize sample and allow parts to cool one hour in moving air at room temperature.

(d) One cycle consists of repeating the previous steps three times, then allowing an additional 15 hours drying time.

8.3.3 Test Solution. The saline solution shall meet the requirements given by GM4298P (Section 6, Test Solution) for both salt fog and salt spray tests.

8.3.4 Salt Fog and Salt Spray Performance. Samples must complete a basic functional test per 5.6.5 after exposure and after drying at least one hour at room ambient. If performance improves with cycling, note the number of cycles required to acquire normal operation on the test data sheet.

8.4 Fluid Compatibility. These tests are intended to assure vehicle operating liquids, chemicals and oils will not degrade the materials of construction, identification or function of electrical/electronic components. Fluids have been selected based on vehicle component location and potential frequency of occurrence. Use GM recommended liquids where available.

8.4.1 Brush Test. Passenger compartment switches which are mounted in the instrument panel with openings predominantly in the vertical plane shall receive a brush-on application of the liquids from Table 9. Apply a brushed on coating (one liquid to a sample) uniformly over the surface of the sample. Follow with a 48-hour soak in a closed container or bell jar approximately 500% of the part(s) volume in capacity. The samples need not be segregated during the soak period.

8.4.1.1 Brush. The brush shall be a toothbrush with a handle made of a nonreactive material. The brush shall have 3 long rows of hard bristles, the free ends of which shall lie in the same horizontal plane. The toothbrush shall be used exclu-

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sively for a single solvent; and when there is any evidence of softening, wear, bending or loss of bristles, it shall be discarded.

8.4.2 Pour Test. Engine compartment, chassis, or passenger compartment switches which mount in armrests or consoles or have openings in the horizontal plane shall receive a poured on application of the liquids (one liquid to a sample) listed in Table 9 (except hand cleaner). Figure 17 gives the apparatus for the pour test. Wipe the excess fluid from the surface of the switch while still in body position and allow to dry for a period of 24 hours.

TABLE 9

Location	Reference	Liquid	Mix
Engine Compartment and Chassis	GM6048M	Engine Oil	50% by volume
	GM6162M	Gasoline (Unleaded)	50% by volume
	GM6038M	Ethylene (Glycol)	50% by volume
	GM4653M	Brake Fluid	50% by volume
	Commercial	Washer Solvent	pre-mix 50% by volume
	GM6137M	Auto Transmission	
Passenger Compartment	Commercial	Cofee	
	Commercial	Cola	
	GM2251M	Soapy Water	
	GM6015M	Alcohol Base Cleanser	10% by volume
	Commercial	Ammonia Base Cleanser	10% by volume
	Commercial	Vinyl Plasticizers	
	Commercial	Hand Cleanser	

8.4.3 Identification and date code must remain legible. Sample shall meet performance requirements after a 20-cycle conditioning procedure. Document the performance test results on the test data form (Figure 22).

8.5 Thermal Shock Test. A thermal shock test has been developed to simulate rapid changes in operating temperature due to cold weather warm-up characteristics, or the effect of rain or road splash on equipment operating at elevated ambient (see Figure 18). Effects of thermal shock include cracking and delamination of finishes, cracking and crazing of encapsulation compounds, opening of case seams, or changes in electrical characteristics due to mechanical displacement or rupture.

8.5.1 Equipment. Use a thermal shock chamber or 2 chambers each set at each operating temperature extreme.

8.5.2 Mount the sample in the test chamber in its normal mounting position with load and voltage as defined in 4.8. The samples are to be energized during the ambient and above ambient portions of the test only.

8.5.3 One cycle shall consist of the following:

(a) Place sample in freezer at −40 C for 1 hour, sample unenergized.

(b) Remove specimen from freezer and allow to warm up in air at room temperature for 4 minutes, sample energized.

(c) Place the sample in oven set at maximum operating temperature for 1 hour, sample energized.

(d) Remove sample from oven and place in freezer stabilized at −40 C after 2 minutes, sample unenergized.

(e) Repeat the cycle 10 times.

8.5.4 Thermal Shock Performance. Samples shall meet a functional cycle test after removal from −40 C ambient and before the frost induced from removal dries.

8.6 Paint Adhesion Test. Paint adhesion tests for decorative finishes are to be performed using the procedures listed in GM9071P at the conclusion of the environmental tests sequence when called out by the test specification or test order. Include the test results as an addendum to the standard data sheet (Figure 25) if necessary.

8.7 Weatherometer Test. A weatherometer test is provided to evaluate the appearance of decorative second surface finishes on plastic parts. These tests shall be conducted on separate samples from those previously identified for environmental tests.

8.7.1 Equipment. Use an Atlas Model XW Weatherometer equipped with a Corex-D Filter and Water Cam 51-9, or equivalent, operated at 75 C as measured and regulated by a back panel thermometer per ASTM E188 (Reference: GM4351M) (Type A).

8.7.2 Procedure. Subject the samples to 200 hours exposure to the weatherometer test.

8.7.3 Appearance Requirements. Note evidence of cracking, peeling, blistering, lifting, loss of adhesion or kindred failure of the coating visible to the naked eye after exposure. The amount of discoloration shall be subjectively evaluated based on acceptable degradation masters approved by GM product engineering. Include the test results as an addendum to the standard data sheet (Figure 25) if necessary.

8.8 Abrasion Test. This test method outlines the procedure to be followed for determining the wear resistance of organic

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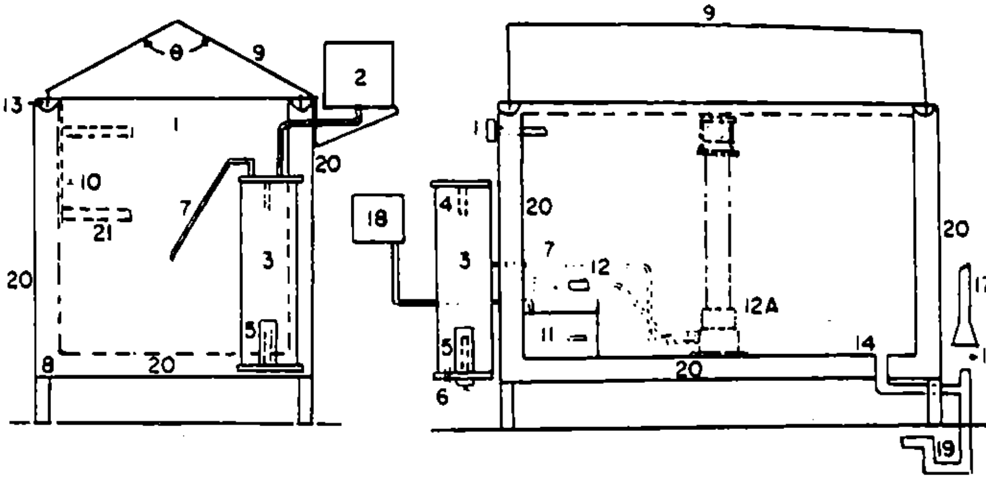
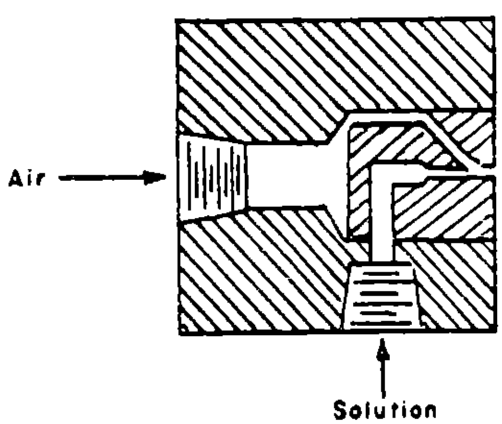


θ – Angle of lid, 90 to 125 deg
1 Thermometer and thermostat for controlling heater (Item No. 8) in base
2 Automatic water levelling device
3 Humidifying tower
4 - Automatic temperature regulator for controlling heater (Item No. 5)
5 Immersion heater, non-rusting
6 Air inlet, multiple openings
7 Air tube to spray nozzle
8 Strip heater in base
9 Hinged top, hydraulically operated, or counterbalanced
10 Brackets for rods supporting specimens, or test table
11 - Internal reservoir
12 - Spray nozzle above reservoir, suitably designed, located, and baffled
12A Spray nozzle housed in dispersion tower located preferably in center of cabinet
13 - Water Seal
14 Combination drain and exhaust. Exhaust at opposite side of test space from spray nozzle (Item 12), but preferably in combination with drain, waste trap, and forced draft waste pipe (Items 16, 17, and 19)
16 - Complete separation between forced draft waste pipe (Item 17) and combination drain and exhuast (Items 14 and 19) to avoid undesirable suction or back pressure
17 Forced draft waste pipe.
18 - Automatic levelling device for reservoir
19 - Waste trap
20 - Air space or water jacket
21 - Test table or rack, well below roof area



Typical Spray Nozzle.

FIGURE 14 – SALT SPRAY (FOG) FIXTURE

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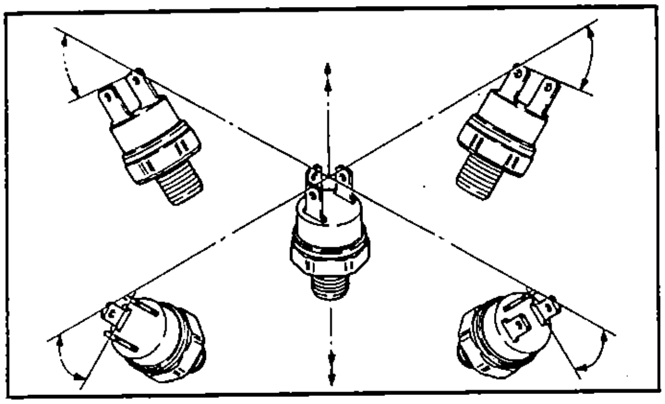

FIGURE 15 - MOUNTING POSITION FOR SALT SPRAY TESTS

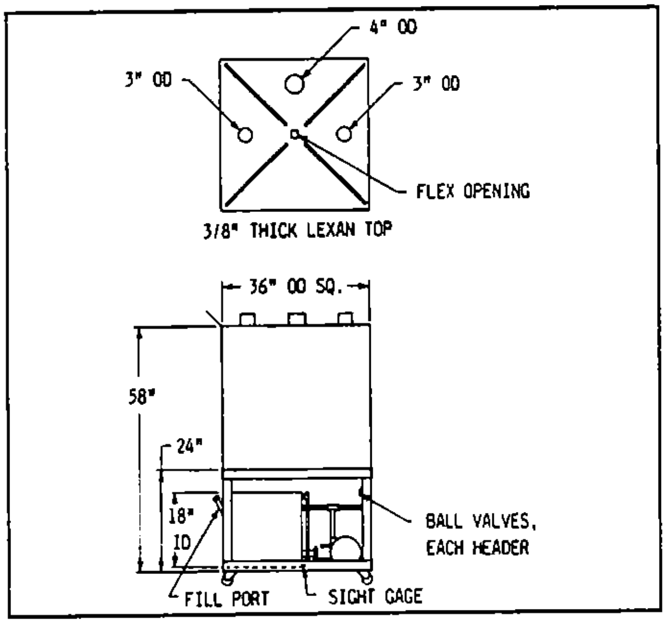

FIGURE 16A - SALT SPRAY FIXTURE

coatings on plastic or metal substrates by means of the RCA wear tester.

8.8.1 Equipment.

8.8.1.1 RCA wear test machine constructed according to RCA print EX-6219264 (see Figure 19). (Available from: Norman Tool Stamping Co., Evansville, IN 47711-9418)

8.8.1.2 Nitrile rubber O-ring (Acushnet H14327, or equivalent). The hardness on a Wallace micro indention tester should measure approximately 65 on the Shore A scale. The O-ring should be replaced if signs of wear-through or flat spots are exhibited.

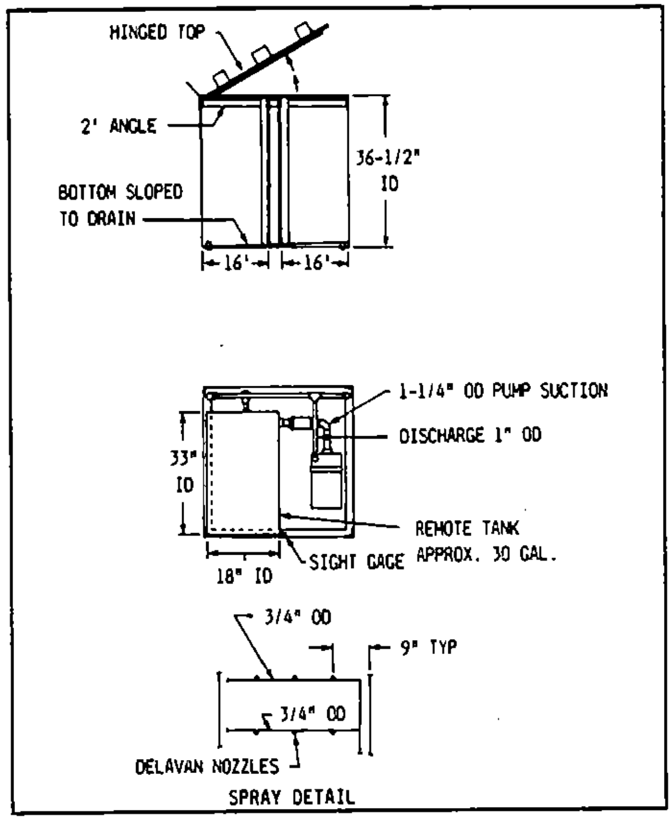

FIGURE 16B - SALT SPRAY FIXTURE DETAIL

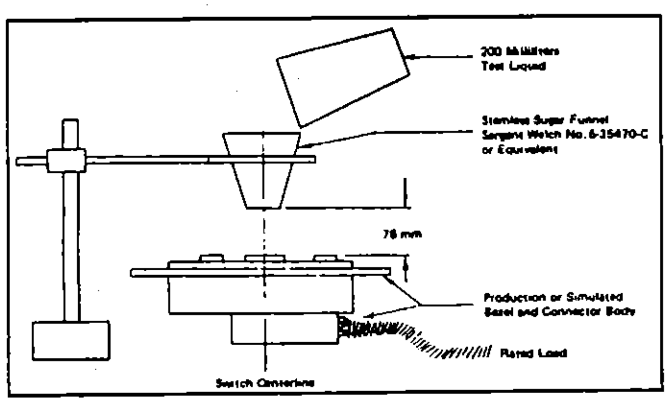

FIGURE 17 - APPARATUS AND METHOD OF POUR TEST

8.8.1.3 Paper tape conforming to Federal specification (tape, teletypewriter, perforator, No. UUT00120E) except without oil. For standardization of this test, paper from the following supplier may be used where available: Nationwide Paper Co., 151 Neal Avenue, Indianapolis, IN, (tape identified as Perfection Paper Co., No. 7976 perforation tape, buff color, unoiled, 11/16 inch wide, on 2 inch cores, 8.5 inches dia). The paper should be replaced at least every 6 months.

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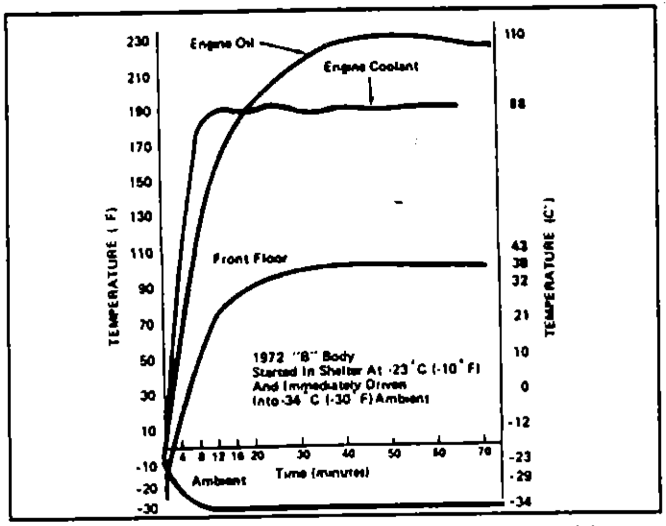


FIGURE 18 – VEHICLE COLD WEATHER WARM-UP CHARACTERISTICS

8.8.1.4 Check the speed of tape travel. It shall be 276.9 cm ± 2.54 cm.

8.8.1.5 Check the length of tape in contact with the test sample during one wear cycle. It should be 5.56 cm ± 0.16 cm of tape per cycle.

8.8.2 Procedure.

8.8.2.1 Place the test sample on a sample holder in a level position. There should be no appreciable deflection of the sample during the entire procedure.

8.8.2.2 Adjust lever assembly to a level position. The tape backed by the roller assembly must be resting on the test area during this adjustment.

8.8.2.3 Adjust the counter to zero and start the wear cycle by activating the electrical drive motor.

8.8.2.4 The machine is operated either for a specified number of cycles or for the number of cycles required for the coatings wear through to the base substrate. The wear test evaluation should be made by averaging 3 readings per test surface or as otherwise specified.

9 ACCELERATED DURABILITY TESTS. Durability tests may be run to a bogey or until failure, dependent upon the requirements of the engineering department responsible for the release of the device specified. A 1000-hour test is also recommended for devices which may be energized continuously for periods typically exceeding 30 minutes (ex: ignition, headlamp, oil pressure, cooling fan switch, etc). Eleven samples minimum (11-pass/0-fail) shall be subjected to each operating durability section required by the product design specification unless specific test plans require larger sample sizes. Where multiple applications for a single part number exist, each application must be tested separately, increasing the sample size, unless otherwise noted.

9.1 Bogey Testing. Testing as a specific load to a defined cycle life or portion thereof shall be used to assess degradation for one of the purposes listed in 9.1.1 through 9.1.3. The actual loads and harnesses shall be used to further simulate the proposed system.

9.1.1 To assure a presently available part number will be satisfactory under new application conditions.

9.1.2 To assess physical parameters and provide correlation data as a function of actuation cycles (ex: contact force, material transfer).

9.1.3 As production audits whereby samples are selected at random and exposed to shortened test sequences to provide feedback to a quality assurance program.

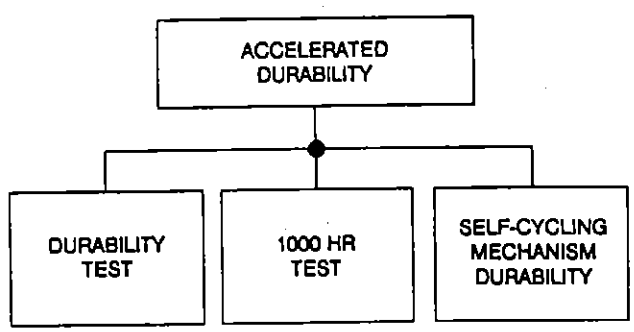
9.2 Life Testing. Testing to failure identifies the capabilities of a new design. If failures are not produced at 3 to 4 times the expected life value (or bogey), the load or duty cycle may be increased and a mapping factor developed. Given a failure distribution, reliability may be calculated based on an estimate of usage cycles for the proposed function.

9.3 Durability Equipment.

9.3.1 Each sample shall be continuously monitored to assure actuations equal attempts for each circuit at the conclusion of testing. Electrical or electromechanical counters, if used, must have a minimum 10K ohm impedance.

9.3.2 The sample (actuations) counters shall not count a cycle should the open circuit voltage across the contacts when designed to be open is less than 10% of the open circuit voltage at the switch input terminal(s) or if the test load remains operating as discernible to the naked eye.

9.3.3 Rate of Actuation. A method shall be provided to control the rate of actuation in a manner consistent with application demands. Consideration shall be made in the design of said durability equipment such that the rate of actuation may be controlled at various rates as specified on the part drawing, test specification or test order.



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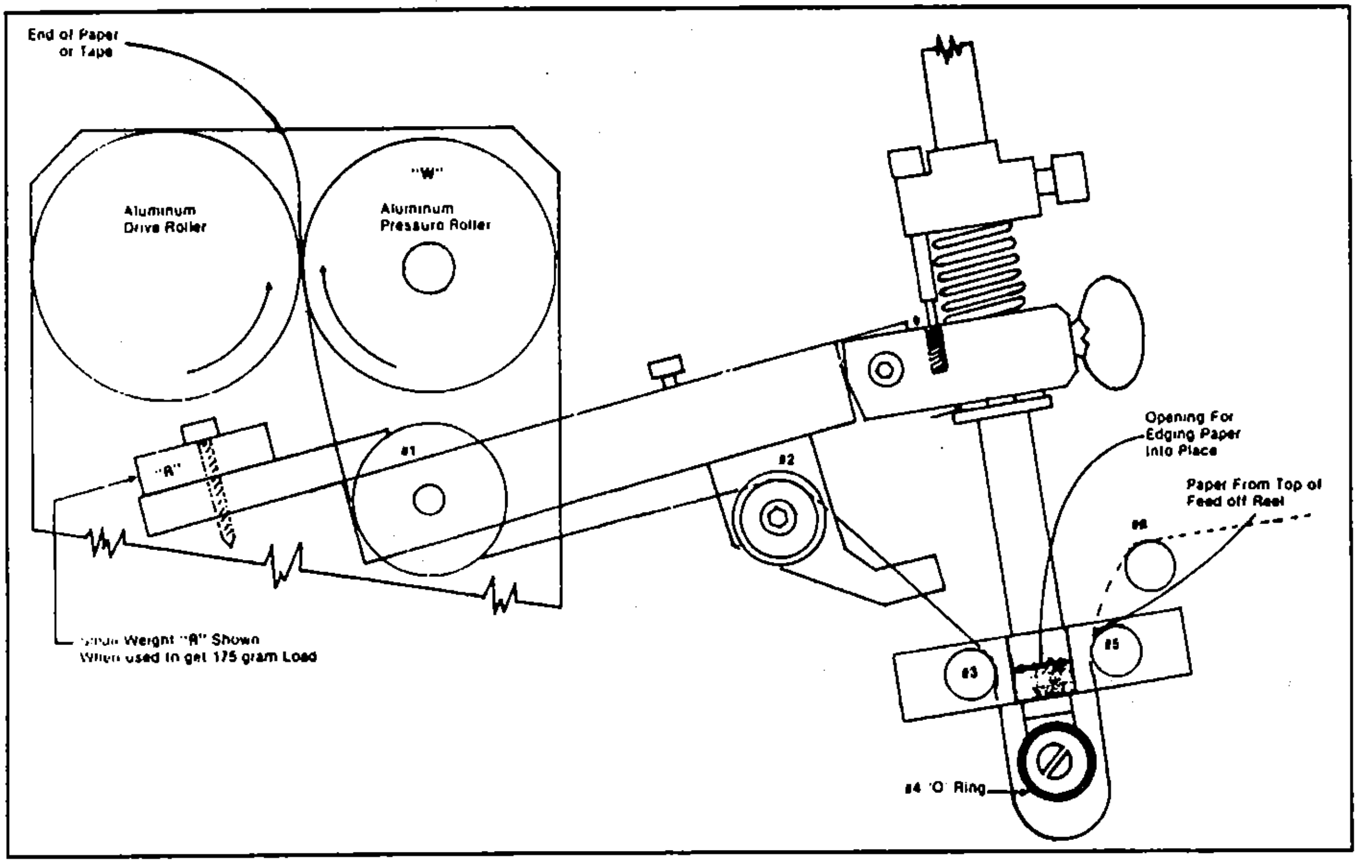

FIGURE 19 - RCA WEAR TESTER (AVAILABLE FROM: NORMAN TOOL STAMPING CO., EVANSVILLE, IN 47711-9418)

9.3.4 Actuation Force, Pressure, etc. A method shall be provided to control the maximum force applied during actuation in a manner consistent with application designs. Consideration shall be made in the design of said durability equipment such that the maximum force to actuate may be controlled at various levels as specified by the part drawing, test specification or test order. (Reference: Test specification maximum force to actuate.)

9.3.5 Multiple Circuits. Switches which are packages of several switches not actuated by a common mechanism may be tested separately or in a combined manner dependent upon equipment availability. Note any changes to duty cycle or total cycles made to facilitate combined testing on data sheet Figure 26.

9.3.6 Connectors. Use new production or prototype terminals and connectors for each switch sample. Change the connectors after every 5 insertions or after any sustained 125 C operation. Test connectors may be changed as frequently as deemed necessary.

9.3.7 Mounting. The mounting fixture shall include production, prototype or simulated bezels, bolts or retainers which simulate the application mounting without improperly pinching or stressing mounting lugs or case sidewalls. Some environmental features may also be combined with the durability fixturing (ex: shock simulating door slam).

9.4 Durability Temperature. Unless otherwise noted, samples shall be continuously thermocycled as shown in Figure 20 or cycled at stabilized ambient temperatures as indicated by Table 10.

9.5 Durability Voltage. Unless otherwise noted, open circuit voltage shall be 14.0 volts at the device terminals regardless of temperature.

9.6 Duty Cycle. Four cycle rates have been determined effective in the testing of electromechanical devices based on minimizing temperature rise while accelerating the nature of the test. When testing switch packages with multiple functions in a combined manner, provide a timing diagram as an addendum to the test data sheet (Figure 26).

9.7 Test Load. Use actual loads modified as necessary to facilitate cooling and/or shortening of cycle time to maintain the proper duty cycle. Simulated loads may be used provided

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a correlation report is available and referenced on the test data sheet (see Figure 26).

9.8 Warm Up. Re-calibrate durability voltage 30 minutes after initial start up to compensate for change in resistance of loads. Check load current draw to assure it is within 15% of nominal. If not, replace load or upgrade test fixture wiring as necessary.

9.9 Durability Performance. Samples are to be subjected to a complete performance assessment before and at 25, 50, 75, 100, 150, 200 and 300% of the operating life requirement when applicable unless the durability test equipment design allows for automatic measurement or control (to max/min limits) of all performance requirements.

9.10 Continuous Test, 1000-Hour. Continuous testing evaluates long-term creep or drift in separating contacts which see few if any opening cycles (ex: circuit breakers or switches with circuit breakers) or in switches which are energized for periods typically exceeding 30 minutes. The length of exposure time has been selected to minimize the duration of the test while obtaining sufficient exposure to extrapolate a life estimate.

9.10.1 Operating Parameters.

9.10.1.1 A resistor load equaling the nominal application load is acceptable and an automotive battery is not required across the power supply.

9.10.1.2 Terminal voltage is to be per 4.8.3 unless otherwise noted.

9.10.1.3 Ambient temperature is to be the maximum operating temperature given by the test specification.

9.10.2 Test Equipment. Provide a means of automatically recording voltage drop at the switch terminals for each circuit on an hourly basis.

9.10.3 Test Procedure. Record voltage drop across switch terminals once every hour throughout the duration of the test. Cycle the switch manually 5 times once every 24–72 hours to prevent voltage drop increases from occurring at switch interfaces which are not designed for sustained closed circuit operation. Temperature rises at these interfaces may influence the life of the circuit under test.

TABLE 10

Typical Application	Max Operating Temperature	Test Ambient (%)			
		-40 C	23 C	85 C	125 C
Passenger Compartment	85 C	10	70	20	--
Engine Compartment	125 C	25	25	--	50

9.11 Self-Cycling Mechanism Durability. Devices which continuously cycle upon the application of an electrical load (or overload) shall be tested to a time bogey or until failure, dependent upon the requirements of the engineering department responsible for release.

9.11.1 Equipment. A suitable method shall be provided to record the on-time and off-time in seconds except circuit breakers which may be tested using the circuit shown in Figure 9.

9.11.2 Procedure. Durability temperature, durability voltage, test load, warm up and durability performance requirements as previously outlined in 9.4, 9.5, 9.7, 9.8 and 9.9 shall be required.

9.11.3 Data. Record the total number of cycles the part failed to meet on-time or off-time specification limits, maximum and minimum on and off times, and the total hours accumulated at which each occurred. Also record the hours at which first on-time or off-time discrepancy occurred. For circuit breakers only, also monitor average temperature as shown in Figure 9 at one hour intervals.

10 OTHER TESTS OR CONDITIONS. Other tests or conditions may be performed when requested. Note the procedure change requested on the test data sheet.

11 REPORT REQUIREMENTS.

11.1 Calibration Sheets. Reference shall be made to measurement standards through calibration sheets and/or lab masters. A calibration sheet is provided as part of this procedure (Figure 21).

11.2 Data Requirements.

11.2.1 Data shall be recorded at the start of, between, and at the conclusion of test as noted by the standard data sheets which are part of this procedure (Figures 22 through 26). All original data is to be filed with the laboratory copy of the report.

TABLE 11

Application	Duty Cycle %	Recommended On/Off Period On / Off
Double Throw Switches	50	3 sec / 3 sec
Test Loads less than 25.0 amp continuous	25	1 sec / 3 sec
Test Loads greater than 25.0 amp continuous	20	1 sec / 4 sec
Fan Assemblies which coast to a stop between cycle and intermittent switches greater than 25.0 amp	10	1 sec / 9 sec

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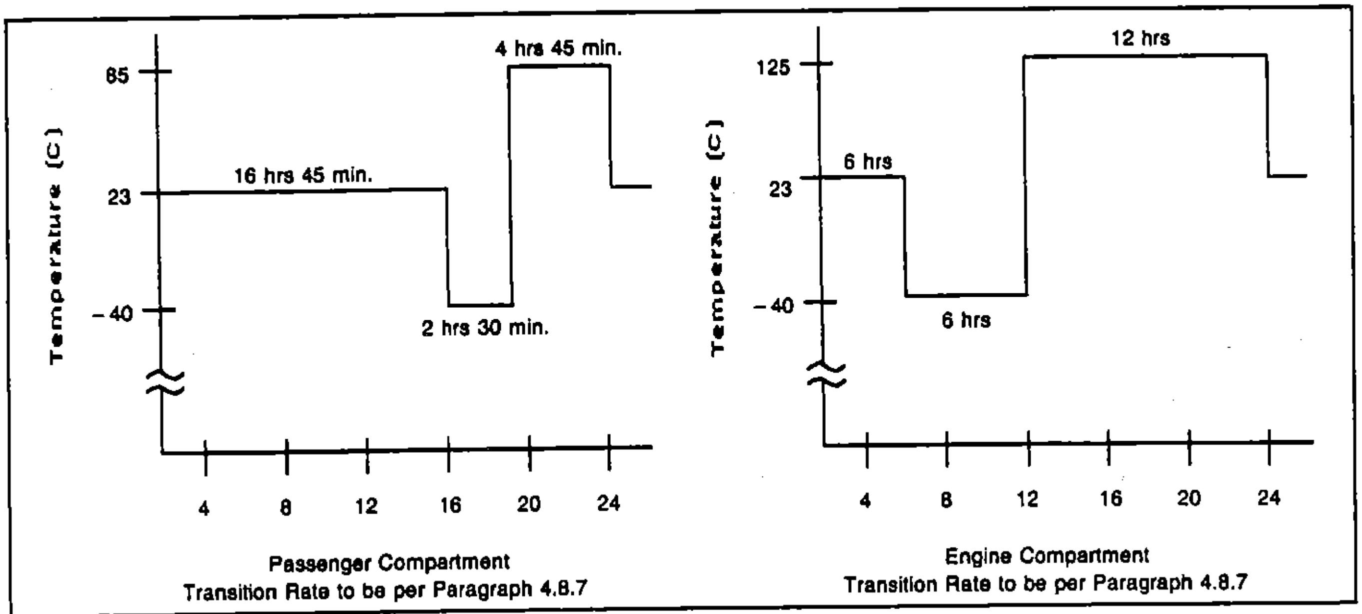

FIGURE 20 - DURABILITY THERMOCYCLE PROFILE

11.2.2 Curves shall be drawn or data analyzed when requested by the test order. Examples of typical curves are shown for the following functions:

(a) Normal probability plot (performance parameters) Figure 27.

(b) Voltage drop vs. cycles or hours (durability test) Figure 28.

(c) Weibull life curve (durability test) Figure 29.

(d) Circuit breaker performance (performance test) Figure 30.

12 GENERAL INFORMATION. This standard was issued in August 1987, approved by the switch committee. The latest revision was editorial change in November 1989.

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Report No. ____________

INSTRUMENT CALIBRATION

(Submit this data sheet with the other data sheets when the information is not otherwise preserved in the testing laboratory records)

Test Date ____________

Instrument Description	Instrument Number	Calibration Date	Next Calibration Due Date
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

Recorded by ________________________________ Date ____________
(Signature)

FIGURE 21 - CALIBRATION SHEET

PROCEDURE FOR TESTING SWITCHES
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Name: ______________________ Part No.: ______________ Source: ______________

Report No.: ______________________ Start Date: ______________ Finish Date: ______________

Comments: ____

____

Indicate Tests Performed:

- ☐ 6 Visual Inspection and Analysis
- ☐ 6.1 Bracket Retention
- ☐ 6.2 Terminal Retention
- ☐ 6.3 Connector Insertion
- ☐ 6.4 Cover Integrity
- ☐ 6.5 Mechanical Overload
- ☐ 6.6 Visual Inspection
- ☐ 6.7 Paint Adhesion Test
- ☐ 6.8 Thread Inspection
- ☐ 7 Mechanical and Electrical Tests
- ☐ 7.1 Electrical Transient Tests
- ☐ 7.2 Reverse Polarity Test
- ☐ 7.3 24-Volt Jump Start Test
- ☐ 7.4 Continuous Current Overload
- ☐ 7.5 Drop Test
- ☐ 7.6 Shock Test
- ☐ 7.7 Vibration Durability
- ☐ 8 Accelerated Environmental Tests
- ☐ 8.1 Dust
- ☐ 8.2 Humidity Test
- ☐ 8.3 Salt Spray Test
- ☐ 8.4 Fluid Compatibility
- ☐ 8.5 Thermal Shock Test
- ☐ 8.6 Paint Adhesion Test
- ☐ 8.7 Weatherometer Test
- ☐ 8.8 Abrasion Test
- ☐ 9 Accelerated Durability Tests
- ☐ 9.1 Bogey Testing
- ☐ 9.2 Life Testing
- ☐ 9.10 1000 Hour Continuous Test
- ☐ 9.11 Salt-Cycling Mechanism Durability

Ref	Description		Limits	Post-Test	Pre-Test
5.1	Voltage Drop	Circuit 1			
		Circuit 2			
		Circuit 3			
5.2	Open Circuit Resistance	Circuit 1			
		Circuit 2			
		Circuit 3			
5.3	Isolation Resistance				
5.4	Analog Outputs				
5.5	Temperature Rise				
5.6	Function Check	-40 C			
		23 C			
		85/125 C			
5.7	Displacement	Total			
		Overtravel			
		Other			
5.8	Level to Actuate	Actuate			
		Return			
		Other			
5.9	Illumination				
	Color				
5.10	Appearance				
5.11	Audible Sound				
5.12	Contact Bounce				
5.13	Leak Check				
5.14	Chatter Test				
5.15	Rattle Evaluation				

Technician: ______________________ Division: ______________________ Date: ______________

FIGURE 22 – PERFORMANCE SUMMARY

PROCEDURE FOR TESTING SWITCHES
GM9110P

Name: ____________________ Part No.: ____________ Source: ____________

Report No.: ____________________ Start Date: ____________ Finish Date: ____________

Comments: ____

____

Ref	Description			Limits	Serial No.					
6.1	Bracket Retention	Along Axis								
		Perpendicular								
6.2	Terminal Retention									
6.3	Connector Insertion									
6.4	Cover Integrity	Retention								
		Strength								
6.5	Mechanical Overload	Actuator								
		Knobs - Pull								
		Pigtail - Pull								
6.6	Visual Inspection	Workmanship								
		Contact Force	N.O.							
			N.C.							
		Cover Integrity	Cir 1							
			Cir 2							
		Weld Peel								
6.7	Paint Adhesion									
6.8	Thread Inspection									

Technician: ____________________ Division: ____________ Date: ____________

FIGURE 23 - VISUAL INSPECTION AND ANALYSIS

PROCEDURE FOR TESTING SWITCHES

GM9110P

Name: ______________________ Part No.: ______________ Source: ______________

Report No.: ______________________ Start Date: ______________ Finish Date: ______________

Comments: ____

____

Ref	Description			Limits	Serial No.					
7.1	Translent Test	GM9105P Pulse No.	1							
			2							
			3							
			4							
			5							
			6							
7.2	Reverse Polarity									
7.3	24-Volt Jump Start									
7.4	Current Overload	Switch	7.4.1							
			7.4.2							
		Circuit Breaker	7.4.3.1							
			7.4.3.2							
7.5	Drop Test									
7.6	Shock Test	Energized								
		De-Energized								
7.7	Vibration Test	Random								
		Sinusoidal								
		Resonant Frequency								

Technician: ______________________ Division: ______________________ Date: ______________

FIGURE 24 - MECHANICAL AND ELECTRICAL TESTS

PROCEDURE FOR TESTING SWITCHES

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Name: ______________________ Part No.: ______________ Source: ______________

Report No.: ______________________ Start Date: ______________ Finish Date: ______________

Comments: ____

	Dust Test	Humidity Test	Salt Spray	Fluid Comp	Thermal Shock
Equipment	☐ Figure 13 ☐ Other	☐ Section 8.2.1 ☐ Other	☐ Figure 14 ☐ Figure 16 ☐ Other	☐ Brush ☐ Pour ☐ Other	☐ Oven/Freezer ☐ Other
Mounting	☐ Figure 15 ☐ Other	☐ Figure 15 ☐ Other	☐ Figure 15 ☐ Other	☐ Application ☐ Other	☐ Application ☐ Other
Operation	☐ Auto-Cycled ☐ Manipulated ☐ Not Cycled ☐ Not Powered	☐ Auto-Cycled ☐ Manipulated ☐ Not Cycled ☐ Not Powered	☐ Auto-Cycled ☐ Manipulated ☐ Not Cycled ☐ Not Powered	☐ Auto-Cycled ☐ Manipulated ☐ Not Cycled ☐ Not Powered	☐ Auto-Cycled ☐ Manipulated ☐ Not Cycled ☐ Not Powered
Pass Requirements	☐ Functional ☐ Calibration	☐ Functional ☐ Calibration	☐ Functional ☐ Calibration	☐ Functional ☐ Calibration ☐ Performance ☐ Paragraph 8.4.3	☐ Functional ☐ Calibration ☐ Performance

			Serial No.					
Ref	Description	Limits						
8.1	Dust Test							
8.2	Humidity Test							
8.3	Salt Spray Test							
8.4	Fluid Compatibility							
8.5	Thermal Shock							
8.6	Paint Adhesion							
Other								

Technician: ______________________ Division: ______________________ Date: ______________

FIGURE 25 - PROCEDURE FOR TESTING SWITCHES

PROCEDURE FOR TESTING SWITCHES
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Name: ______________________ Part No.: ______________ Source: ______________

Report No.: ______________________ Start Date: ______________ Finish Date: ______________

Comments: ____

____

Ref	Description		Limits	Intermediate Durability Performance					
				25%	50%	75%	150%	200%	300%
9.4	Cycles Completed								
9.7	Test Chamber Temperature								
	Test Current								
5.1	Voltage Drop	Circuit 1							
		Circuit 2							
		Circuit 3							
5.2	Open Circuit Resistance	Circuit 1							
		Circuit 2							
		Circuit 3							
5.3	Isolation Resistance								
5.4	Analog Outputs								
5.5	Temperature Rise								
5.6	Function Check	-40 C							
		23 C							
		85/125 C							
5.7	Displacement	Total							
		Overtravel							
		Other							
5.8	Level to Actuate	Actuate							
		Return							
		Other							
5.9	Illumination								
	Color								
5.10	Appearance								
5.11	Audible Sound								
5.12	Contact Bounce								
5.13	Leak Check								
5.14	Chatter Test								
5.15	Rattle Evaluation								

Technician: ______________________ Division: ______________ Date: ______________

FIGURE 26 – INTERMEDIATE DURABILITY PERFORMANCE

PROCEDURE FOR TESTING SWITCHES

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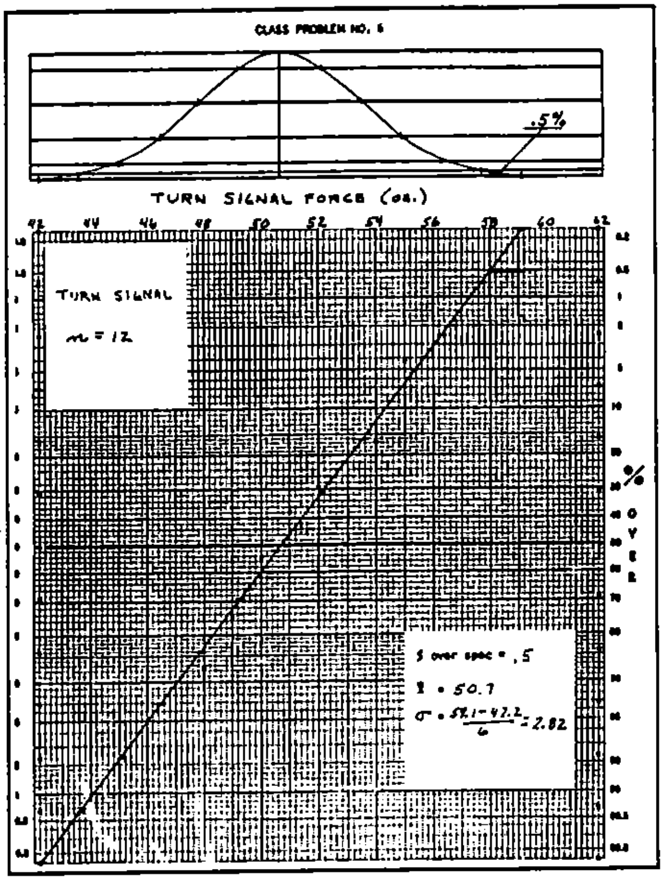

FIGURE 27A - NORMAL PROBABILITY PLOT

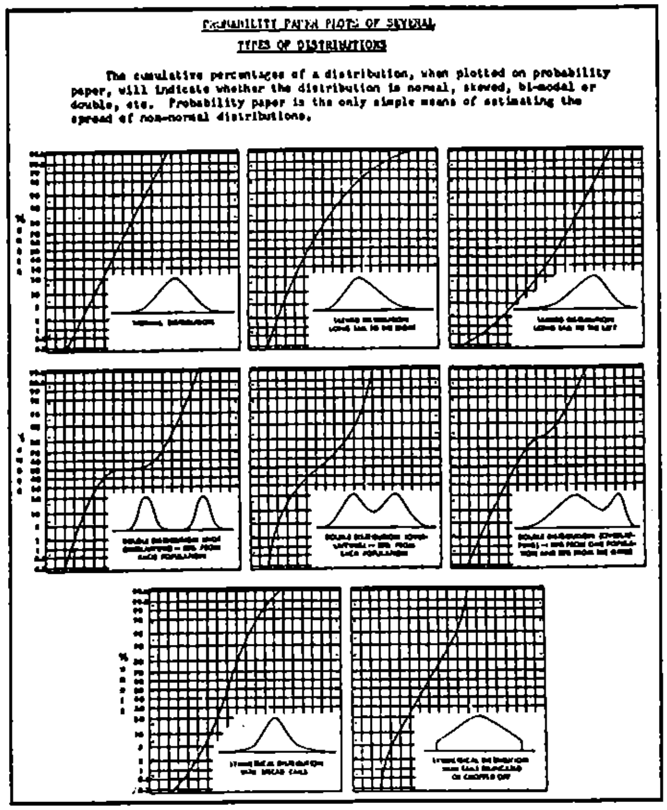

FIGURE 27B - NORMAL PROBABILITY PLOT

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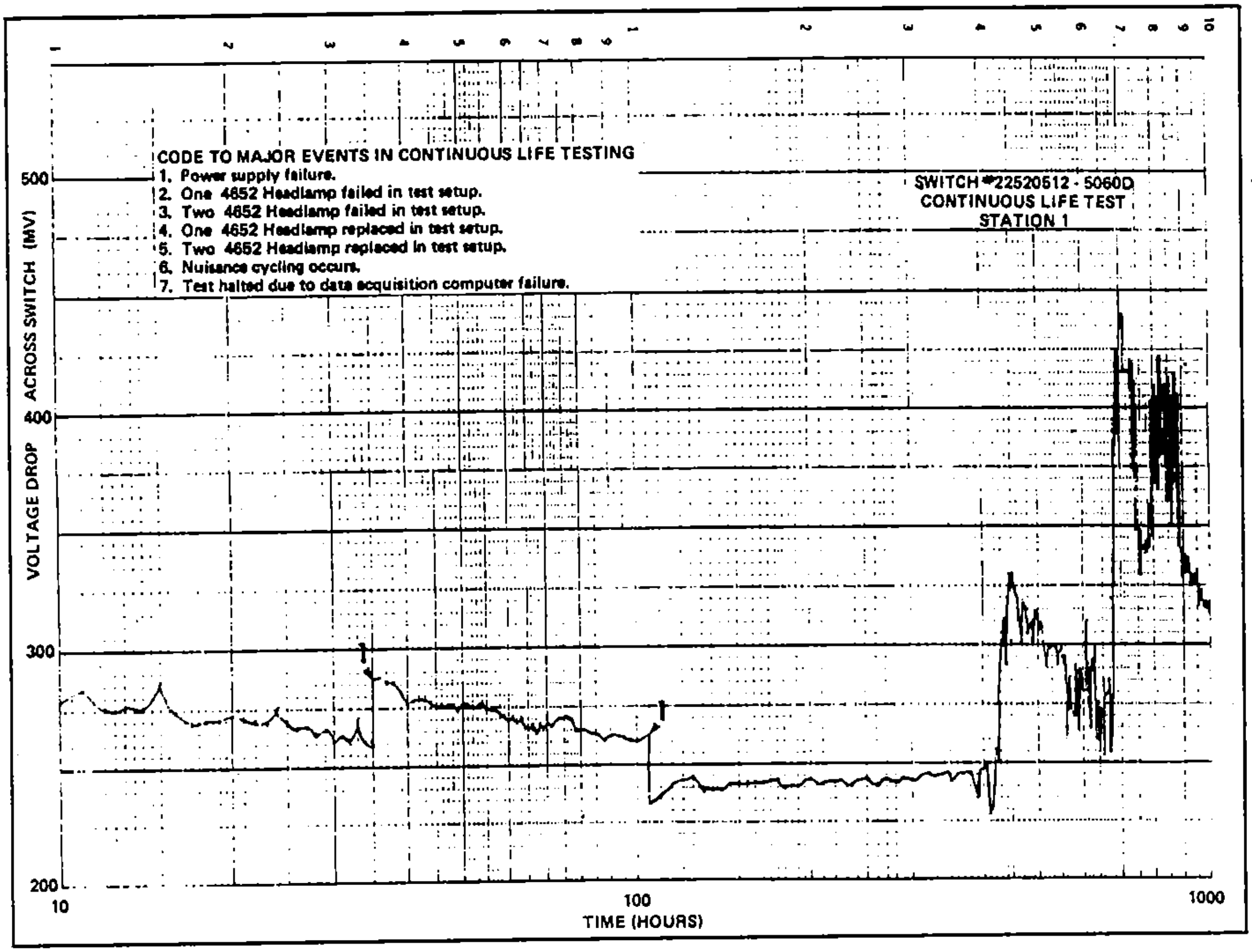

FIGURE 28 - VOLTAGE DROP VS. HOURS OPERATION

PROCEDURE FOR TESTING SWITCHES
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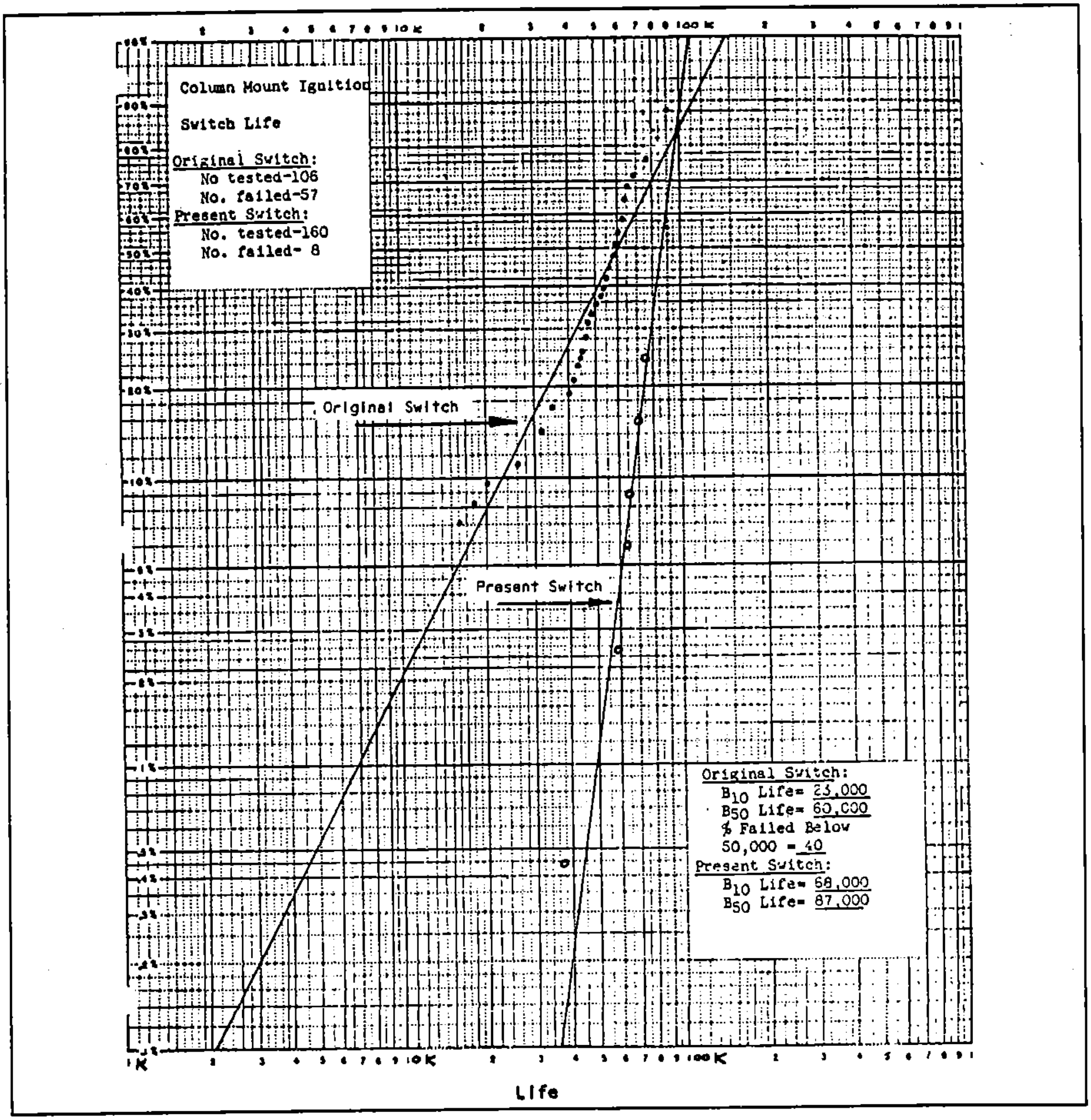

FIGURE 29 - WEIBULL PLOT

PROCEDURE FOR TESTING SWITCHES
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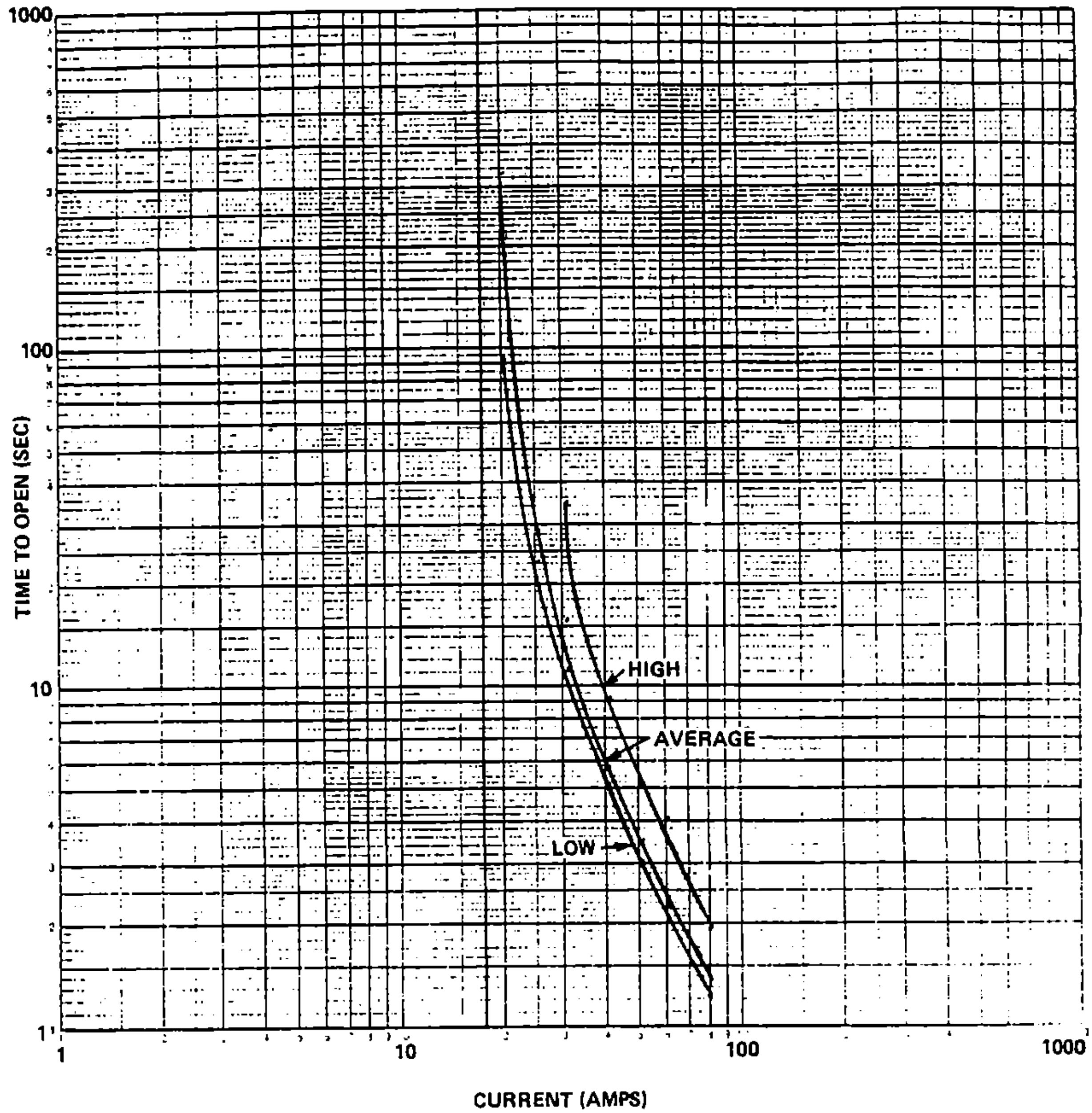

CIRCUIT BREAKER CALIBRATION – NEW SWITCH AT 23° C

FIGURE 30 - CIRCUIT BREAKER PERFORMANCE

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APPENDIX A
GLOSSARY OF TERMS

BASIC FUNCTION - A description in words which identifies specific switch outputs or change of state in response to operator commands or inputs.

DETENT - A physical stop at the ends or along a switch's travel. A change in required force to actuate is generally used to form detents.

DIELECTRIC BREAKDOWN - Voltage fretting is the process by which an applied potential is able to pass through oxide films or tarnish. Once a leakage is established, a tunneling effect may decrease the interface resistance substantially. The applied voltage which causes a sudden decrease in open circuit resistance is referred to as the breakdown voltage.

DPDT - (Double Pole Double Throw) A somewhat more complex device with two moving contact arms (Double Pole) with two electrical circuits on each (Double Throw). May be further defined by the notation C.O. (Center Off).

ELECTROMECHANICAL - Having a mechanical action developed by a current of electricity.

ENERGIZED - When power is connected or disconnected in response to driver, microprocessor, or other command. Other words with the same meaning include: ON, ACTUATE, BIASED. Antonyms: DE-ENERGIZED, OFF, DE-ACTUATE, UNBIASED. For switches which contain intermittent circuits, pulse these circuits at the default or specified duty cycle for environmental durability tests whenever this specification requires energization. Operate continuous loads continuously.

EQUIVALENT RESISTANCE - The control circuit DC resistance which can be determined without specimen disassembly. The externally measurable resistance may include electronic devices such as diodes, resistors, or transistors in series or parallel with the switch contacts.

KELVIN MEASUREMENT - A measurement technique which places the test probes ahead of the high current connections to eliminate the voltage drop associated with the power connections.

LEAKAGE - Current passes between open contacts when voltage potential exists. By increasing the potential to 500 volts DC or more the current flow or leakage becomes measurable even though at a micro or nanoampere scale. Leakage at a known voltage is useful in estimating contact air gap or carbon loading of grease without specimen disassembly.

MEGOHMMETER - A device designed to measure isolation resistance directly by applying ohms law to the microampere leakage produced at a fixed voltage. Ohms law is applied by calibration of the meter scale used to read isolation resistance.

NOMINAL BRACKET DESIGN - Using the nominal of the dimensions which dictate the tightness of the bracket to cover fit and latch mechanism to create a lab master for bracket retention tests.

NORMALLY CLOSED CONTACT - A set of contacts forming an electrical circuit when the switch is in the unenergized or normal state and forming an isolated circuit when the control circuit is energized.

NORMALLY OPEN CONTACT - A set of contacts forming an isolated circuit when the switch is in the unenergized or normal state and forming an electrical circuit when the control circuit is energized.

NUISANCE - An event which contradicts the basic function of the device. An example of a nuisance opening would be the momentary opening of a normally closed contact due to the vehicle passing through a chuckhole.

PERFORMANCE DEPENDENT VARIABLE - The attribute which is changed to cause a change in state of the sample's electrical circuit.

RESISTIVE RATED LOAD - The load in amperes a switch is capable of (1) carrying continuously without internal damage and (2) completing 100,000 switching cycles without failure. These tests are performed using a resistive load to eliminate variations in inductance or bulb filament inrush currents to improve the repeatability of the test. Although manufacturers are encouraged to advertise or rate their device based on its inherent design capability, the rating requirement specified on the part drawing shall be used when performing performance or durability tests.

SHEAR - An action or force that causes two parts of a body to slide on each other in a direction parallel to their plane of contact.

SOAK - Expose the device under test to specific temperature and voltage conditions while the sample is mounted in the test chamber with all necessary attachments. In this manner performance may be immediately assessed after the required time period.

SPDT - (Single Pole Double Throw) A simple switch with one and only one moving contact arm or pole to which two sets of contacts, one normally open, one normally closed, are

PROCEDURE FOR TESTING SWITCHES
GM9110P
APPENDIX A
GLOSSARY OF TERMS

attached (Double Throw). May be further defined by the notation C.O. (Center Off).

SPST - (Single Pole Single Throw) A simple switch with one and only one moving contact arm or pole to which one and only one set of contacts are attached (Throw). May be further defined using notations N.O. (Normal Off) or N.C. (Normally Closed).

STATIC TEST - A test in which the load or air flow does not change with time.

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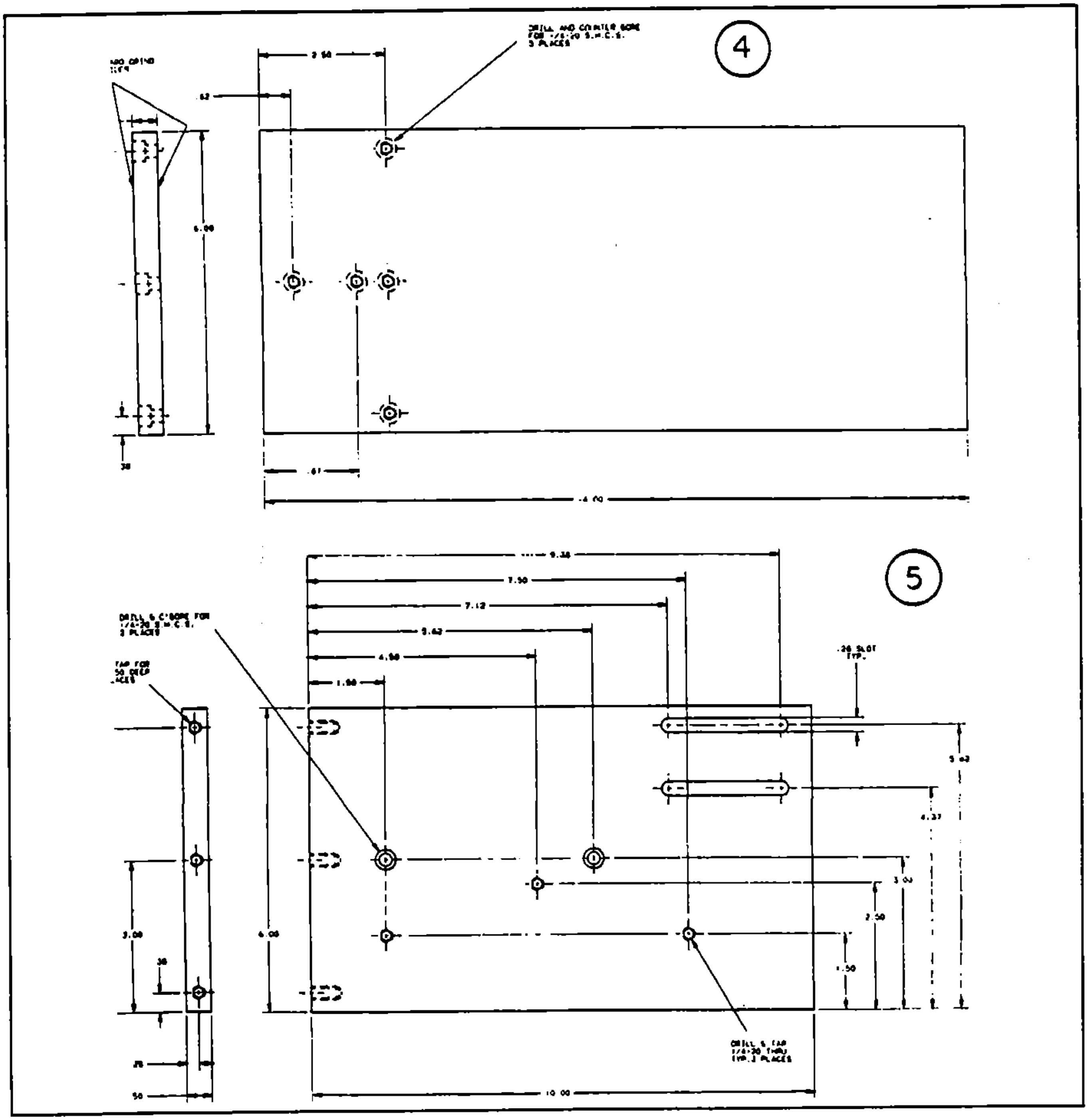
APPENDIX B
DETAILS OF FORCE DISPLACEMENT TEST FIXTURE



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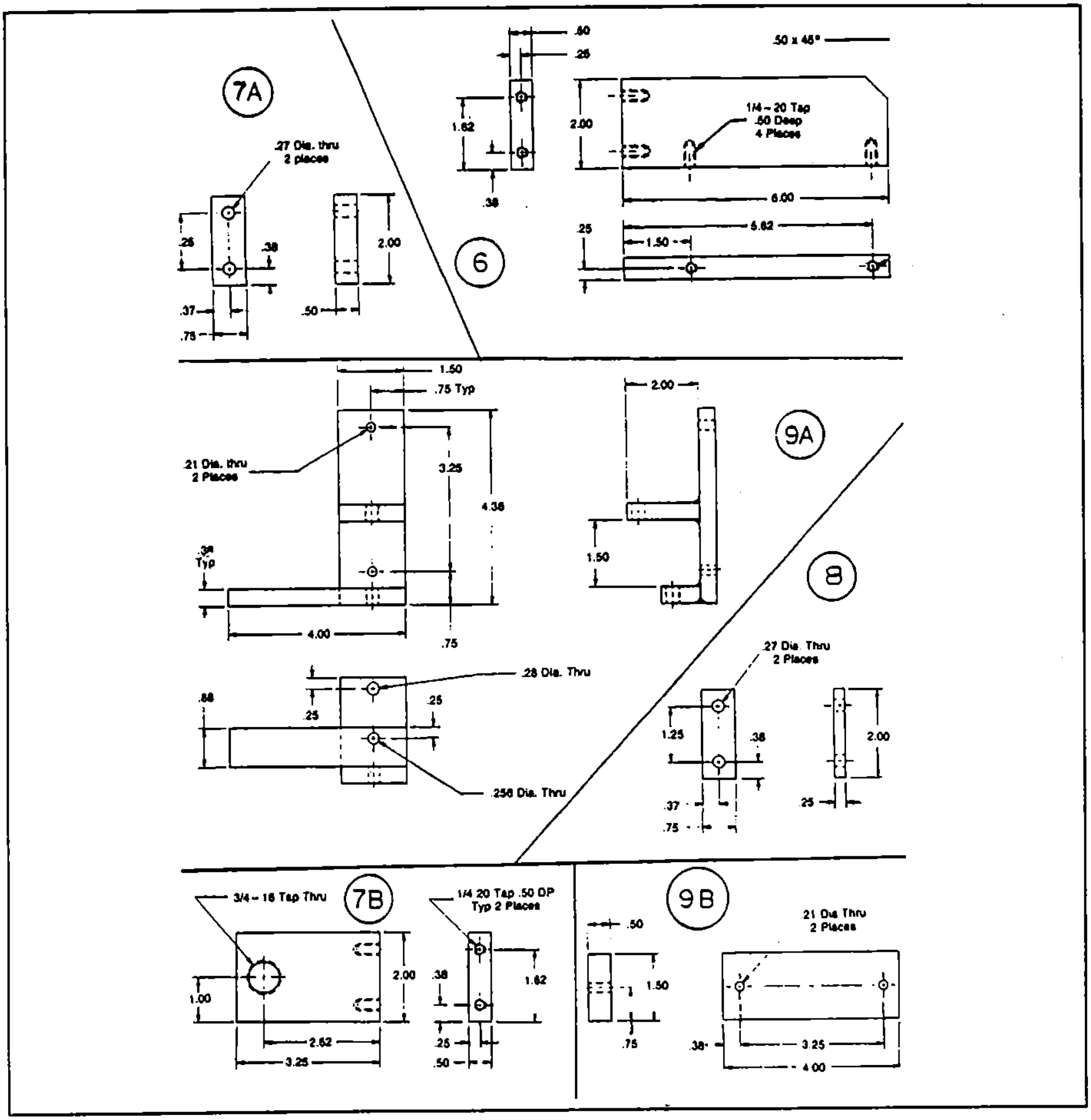
APPENDIX B
DETAILS OF FORCE DISPLACEMENT TEST FIXTURE



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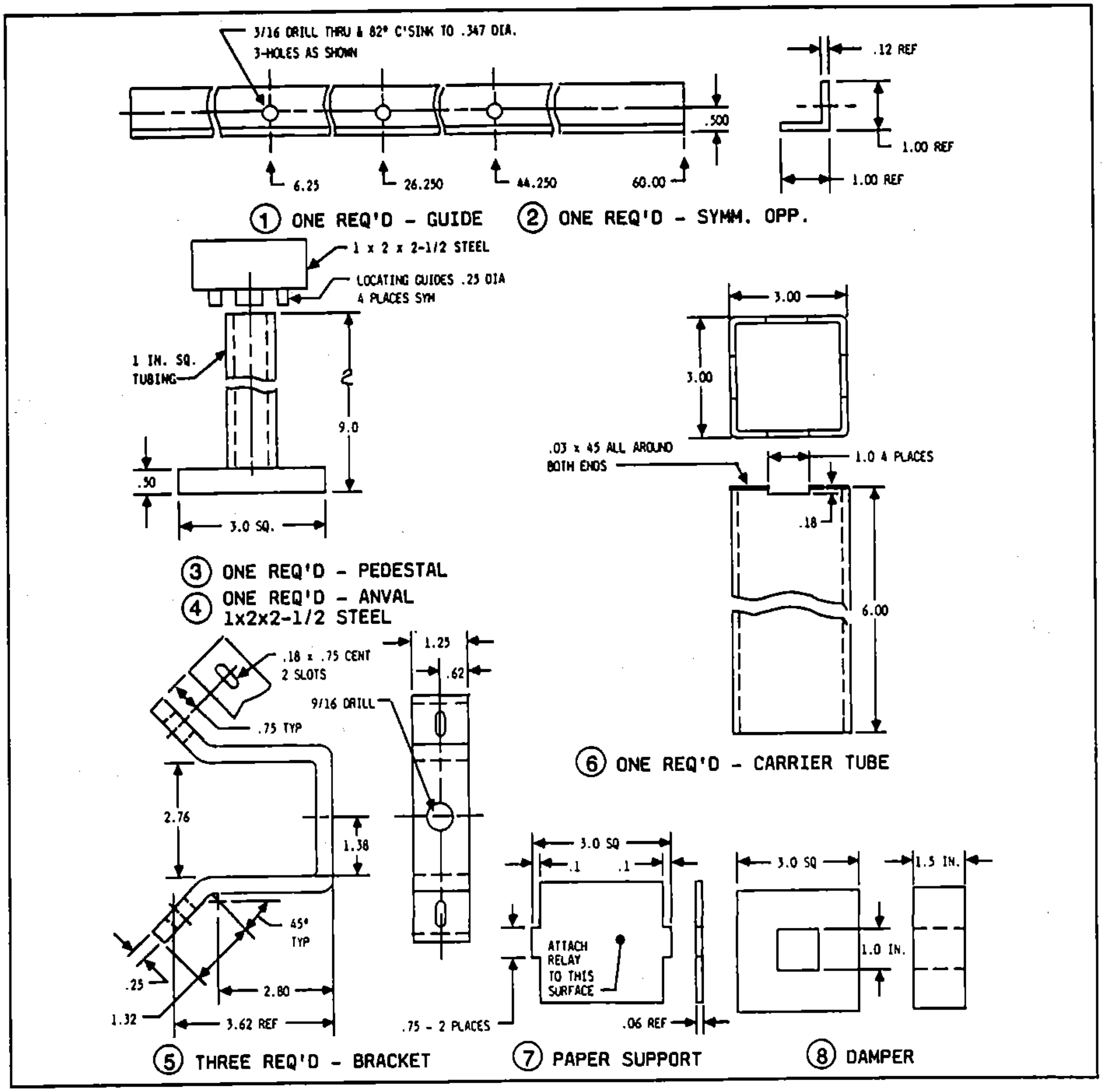
APPENDIX C
DETAILS OF DROP TEST FIXTURE



PROCEDURE FOR TESTING SWITCHES
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APPENDIX D
PIND TEST METHOD

D1 PURPOSE. The purpose of this test is to detect the presence of free-moving particulate contaminants within sealed cavity devices. This test method is specifically directed toward relays and other devices where internal mechanism noise makes rejection exclusively by threshold level impractical. This test method also may be used prior to final sealing in the manufacturing sequence as a means of eliminating loose particles from the interior of the device.

D2 APPARATUS. The basic PIND system is comprised of the components listed below. (Substitutions of individual units or complete system may be made providing the test requirements of D3 are met.)

(a) Vibration power source consisting of electrical driver audio oscillator and low frequency audio amplifier.

(b) Ultrasonic sound detection system consisting of a crystal transducer with frequency response of 36 kHz–44 kHz and associated translator preamplifier capable of converting transducer output to 20 Hz–5kHz.

(c) Small vibration shaker or two shakers coupled together.

(d) Oscilloscope, single beam, with 100 kHz minimum bandwidth capable of external synchronization.

(e) Audio speaker or headset.

(f) Test fixture to adapt transducer to shaker head and isolate it from external noise sources.

(g) Holding fixture designed to hold flat surface of unit under test firmly against the sensing surface of the transducer.

(h) Shock test fixture (see Figure D1).

(i) Calibration unit per D3.1(c).

(j) Random vibration generator.

D3 PROCEDURE. Test equipment shall be assembled as shown in Figure D2. System calibration as defined in D3.1(b) shall be performed at the following intervals:

(a) Each time equipment is turned on.

(b) Each change of operators.

(c) At initiation and completion of test for each group of devices.

(d) Every four hours throughout testing.

Whenever system sensitivity is found to be below specified minimum, all units tested subsequent to previous acceptable calibration shall be retested. Units rejected for particle noise shall not be reworked or retested for the purpose of acceptance. Units rejected for excessive mechanism noise may be retested for the purpose of eliminating the mechanism noise.

D3.1 Calibration.

(a) Each unit of test equipment subject to calibration shall be maintained in accordance with MIL-C-45662.

(b) System calibration shall consist of verifying the proper oscilloscope pattern while calibration unit is being energized by the shaker head at the frequency and acceleration specified in D3.2. Calibration shall also include elimination of extraneous noise which interferes with proper performance of the test.

(c) Test the system with a container (size approximately 12.5 mm x 25 mm x 25 mm, or smaller) which contains a 60/40 solder ball with a diameter of 0.127 mm. Listen to the audible sound and observe the oscilloscope response to the solder ball.

(d) Test the system with a container (size approximately 12.5 x 25 mm x 25 mm, or smaller) which contains no particle and compare the audible sound and the oscilloscope response to the results of D3.1(c) to insure that particles are detectable.

D3.2 Test Setup. The area in which the PIND system is used shall be carefully selected to avoid external interference from electrical and mechanical noise which will decrease the effectiveness of the test.

(a) Set audio oscillator to 27 ± 1 Hz.

(b) Adjust audio amplifier to produce 3–5 g (1.78–3.56 mm) displacement at shaker head.

(c) Check mechanical and electrical systems to minimize background noise. Background noise shall not increase more than 3 dB when shaker is placed in operation (except shaker reversal noise) and total system noise shall not exceed 20 mV. Adjust oscilloscope trace to less than 4 divisions displacement and center shaker reversal noise as shown on trace to less than 4 divisions displacement and center shaker reversal noise as shown on Figure D3A. No other noise spikes shall be detectable.

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(d) Adjust audio output to comfortable level.

(e) With calibration unit mounted on shaker, verify proper oscilloscope and system sensitivity to produce random noise spikes of 40 mV minimum (Figure D3C).

D3.3 Test Procedure.

D3.3.1 Degausing. Devices not incorporating permanent magnets and devices being tested prior to final magnetization shall be degaused prior to PIND testing.

D3.3.2 Lead Protection. When a device incorporates relatively long and flexible leads, the leads shall be suitably restrained from striking the shaker/fixture or striking each other during test. Care shall be taken to prevent damage caused by resonance.

D3.3.3 Testing. Mount unit under test in the center of acoustic transducer with largest flat surface down (unless otherwise noted). Energize shaker and monitor for visual and audible evidence of loose internal material as evidenced by nonperiodic noise spikes (Figure D3C). A single burst of noise is cause for rejection whether or not the indication can be repeated.

Allow test to proceed for approximately 5 seconds. If no failure is detected, apply a random acceleration for 3 seconds maximum or 3 to 5 shock pulses (not to exceed the rating of the device) perpendicular to the axis of vibration (see Figure D1). Monitor for 5 seconds; then repeat random vibration or shocks and monitor for an additional 5 seconds (30 seconds maximum per axis).

NOTE: If excessive mechanism noise occurs (Figure D3D) such that particle noise would be undetectable, the following action may be taken to reduce the noise:

(a) Reorient unit by rotation about the shaker axis.

(b) Change shaker amplitude within the specified limits.

(c) Tilt shaker axis off vertical in any direction (not exceeding 30 degrees) to provide a gravitational side component to the shaker acceleration.

(d) With approval of the procuring agency, a different test frequency may be established for a given device.

(e) Cancel out periodic noise.

If no particle is detected, rotate unit to another flat surface providing vibration in a different axis. Repeat above test for not to exceed 30 seconds. Units shall not be tested with terminals or other non-cavity portions of the assembly in contact with the transducer.

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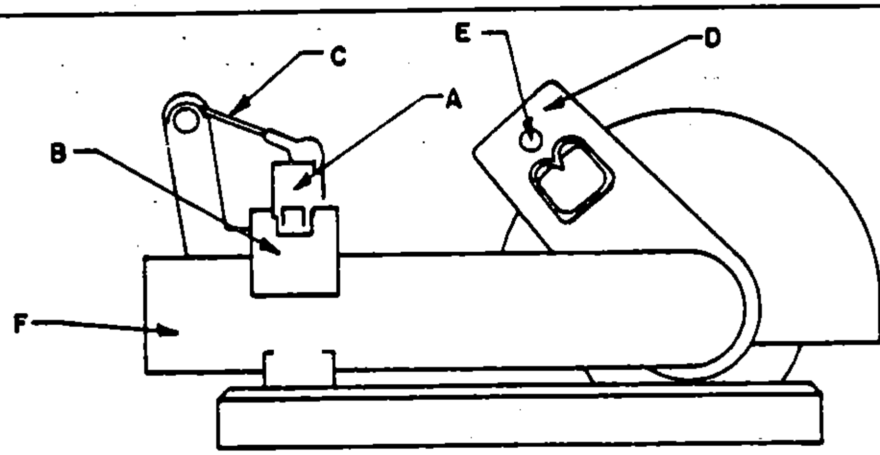

A. Unit under test.
B. Holding fixture.
C. Holding spring.
D. Angle indicator & adjustment.
E. Holding and droping pin.
F. Droping arm.

FIGURE D1 - SHOCK TEST FIXTURE

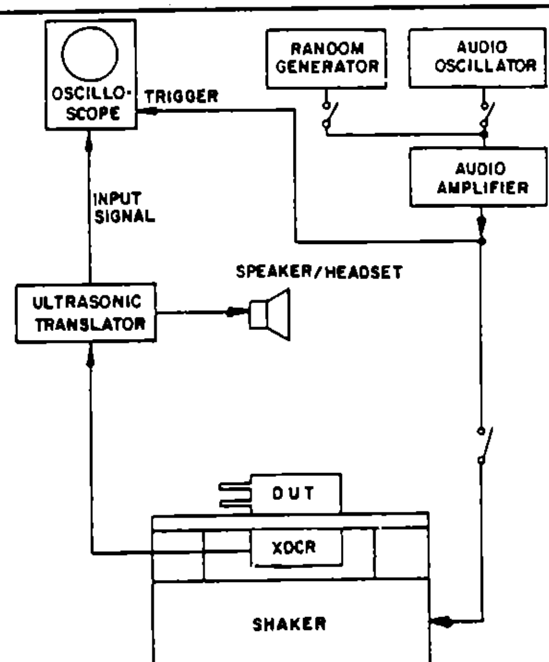

FIGURE D2 - TYPICAL TEST CIRCUIT

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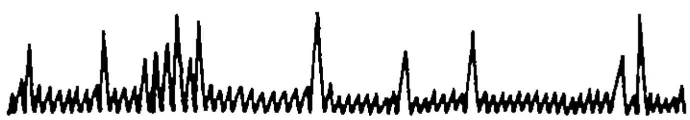
ACCEPTANCE CRITERIA: Each unit tested shall meet the acceptance.

Shaker noise.
Timebase adjusted to locate shaker reversal noise bursts at ends of oscilloscope trace. Test unit not mounted.

a

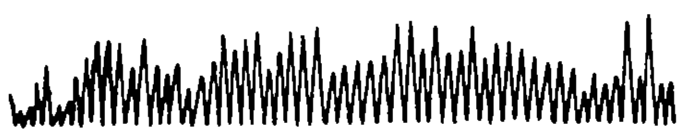
Inherent mechanical noise. Synchronized spike may appear at different locations on time base for each unit under test.

b



Particulate noise. Non-synchronized spikes of any magnitude appear randomly and may disappear as test progresses. Unit is rejectable.

c



Excessive mechanical noise. Synchronized trace masks more than 50% of oscilloscope trace. Unit is rejectable.

d

FIGURE D3 - REPRESENTATIVE OSCILLOSCOPE TRACES