



# SURFACE VEHICLE RECOMMENDED PRACTICE

J1455™

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Recommended Environmental Practices for Electronic Equipment  
Design in Heavy-Duty Vehicle Applications

## RATIONALE

Added to 2.1.1 SAE Publications, SAE J2721 Recommended Corrosion Test Methods for Commercial Vehicle Components.

Changed title of section 3 to "Document Application and Organization".

Changed title of 3.1 to "Application".

Added paragraph title under 3.1 of "Environmental Data and Test Method Validity".

Changed title of 3.2 to "Organization".

Clarified 3.2.1 to reflect changes in organization of Section 4.

Added 3.2.2 to reflect changes in organization of Section 4.

Added 3.2.3 – removed original list of factors and replaced with a table that lists the factors discussed in Section 4 and what section number they are.

Added 3.2.4 to replace discussion of Section 5 from 3.2.1.

Added 4.3.3.3 to include SAE J2721 corrosion standard.

Added SAE J2721 to 4.3.4.

## 1. SCOPE

The scope of this Recommended Practice encompasses the range of environments which influence the performance and reliability of the electronic equipment designed for heavy duty on and off road vehicles, as well as any appropriate stationary applications which also use these vehicle derived components. A few examples of such vehicles are on and off highway trucks, trailers, buses, construction equipment, and agricultural equipment including implements.

### 1.1 Purpose

This document is intended to aid the designer of commercial vehicle electronic systems and components by providing guidelines that may be used to develop environmental design goals. Specific test requirements are to be agreed upon by the customer and supplier.

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## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

- |             |                                                                                                                                                                    |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SAE J400    | Test for Chip Resistance of Surface Coatings                                                                                                                       |
| SAE J1113-1 | Electromagnetic Compatibility Measurement Procedures and Limits for Components of Vehicles, Boats (up to 15 m), and Machines (Except Aircraft) (16.6 Hz to 18 GHz) |
| SAE J1211   | Handbook for Robustness Validation of Automotive Electrical/Electronic Modules                                                                                     |
| SAE J1812   | Function Performance Status Classification for EMC Immunity Testing                                                                                                |
| SAE J2721   | Recommended Corrosion Test Methods for Commercial Vehicle Components                                                                                               |

#### 2.1.2 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, [www.iso.org](http://www.iso.org).

- |              |                                                                                                                                                                                                        |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ISO 11452-8  | Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 8: Immunity to magnetic fields                                               |
| ISO 11452-10 | Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 10: Immunity to conducted disturbances in the extended audio frequency range |
| ISO 5011     | Inlet air cleaning equipment for internal combustion engines and compressors -- Performance testing                                                                                                    |

#### 2.1.3 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, [www.iec.ch](http://www.iec.ch).

- |              |                                                                                                                                                                                       |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IEC CISPR 25 | CORR 1 Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers CORRIGENDUM 1 |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

#### 2.1.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, [www.astm.org](http://www.astm.org).

- |            |                                                        |
|------------|--------------------------------------------------------|
| ASTM B117  | Standard Method of Salt Spray (Fog) Testing            |
| ASTM C150  | Specification for Portland Cement                      |
| ASTM D880  | Method for Incline Impact Test for Shipping Containers |
| ASTM D5276 | Method for Drop Test for Loaded Boxes                  |

### 2.1.5 Military Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

MIL-STD-810F Environmental Test Methods and Engineering Guidelines MIL-STD-202G—Test Methods for Electronic and Electrical Component Parts

### 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

TAPPI T801 Impact Resistance of Fiberboard Shipping Container

TAPPI T802 Drop Test for Fiberboard Shipping Containers

## 3. DOCUMENT APPLICATION AND ORGANIZATION

### 3.1 Application

#### Environmental Data and Test Method Validity

The information included in the following sections is based upon test results achieved by major North American truck manufacturers and component equipment suppliers. Operating extremes were measured at test installations normally used by manufacturers to simulate environmental extremes for vehicles and original equipment components. They are offered as a design starting point. Generally, they cannot be used directly as a set of operating specifications because some environmental conditions may change significantly with relatively minor physical location changes. This is particularly true of vibration, engine compartment temperature, and electromagnetic compatibility. Actual measurements should be made as early as practicable to verify these preliminary design baselines.

The proposed test methods are currently being used for laboratory simulation or are considered to be a realistic approach to environmental design validation. They are not intended to replace actual operational tests under adverse conditions. The recommended methods describe standard cycles for each type of test. The designer must specify the number of cycles over which the vehicle electronic components should be tested, as well as the specific pass and fail criterion for the conducted tests prior to testing. The number of cycles will vary depending upon equipment, location, and function. While the standard test cycle is representative of an actual short term environmental cycle, no attempt is made to equate this cycle to an acceleration factor for reliability or durability. These considerations are beyond the scope of this document.

### 3.2 Organization

3.2.1 Section 4 describes the environmental factors that need to be considered when developing electronic equipment and the test methods recommended for evaluating the factor.

3.2.2 Section 4 is organized to cover three facets of each factor:

Definition of the factor.

Description of its effect on control, performance, and long-term reliability.

A review of proposed test methods for simulating environmental stress.

3.2.3 The following lists identifies the factors and the relevant Section 4 paragraph.

| Factor                                          | Section |
|-------------------------------------------------|---------|
| Temperature                                     | 4.1     |
| Humidity                                        | 4.2     |
| Salt Spray Atmosphere                           | 4.3     |
| Exposure to Chemicals and Oils                  | 4.4     |
| Steam Cleaning and Pressure Washing             | 4.5     |
| Fungus                                          | 4.6     |
| Dust and Sand                                   | 4.7     |
| Gravel Bombardment                              | 4.8     |
| Altitude                                        | 4.9     |
| Mechanical Vibration                            | 4.10    |
| Mechanical Shock                                | 4.11    |
| Combined Environmental Testing                  | 4.12    |
| General Heavy-Duty Truck Electrical Environment | 4.13    |

3.2.4 Section 5 lists the various areas in the vehicle and parameters to be considered when designing components for these areas.

a. Under-hood

1. Engine (Lower Portion)
2. Engine (Upper Portion)
3. Bulkhead

b. Interior (Forward)

1. Floor
2. Instrument Panel
3. Headliner
4. Inside Doors

c. Interior (Rear)

1. Bunk Area
2. Storage Compartment

d. Chassis

1. Forward
2. Rear

e. Exterior of Cab

1. Under Floor
2. Rear
3. Top
4. Doors

### 3.3 Combined Environments

The vehicle environment consists of many natural and induced factors. Combinations of these factors are present simultaneously. In some cases, the effect of a combination of these factors is more serious than the effect of exposing samples to each environmental factor in series. For example, the suggested test method for humidity includes high and low-temperature exposure. This combined environmental test is important to vehicle electronic components when proper operation is dependent on seal integrity. Temperature and vibration is a second combined environmental test method that can be significant to components. During design analysis, a careful study should be made to determine the possibility of design susceptibility to a combination of environmental factors that could occur at the planned mounting location. If the possibility of susceptibility exists, a combined environmental test should be considered (see 4.12).

### 3.4 Test Sequence

The optimum test sequence is a compromise between two considerations:

3.4.1 The order in which the environmental exposures will occur in operational use.

3.4.2 A sequence that will create a total stress on the sample that is representative of operation stress.

The first consideration is impossible to implement in vehicle testing since exposures occur in a random order. The second consideration prompts the test designer to place the most severe environments last. Many sequences that have been successful follow this general philosophy, except that the temperature cycle is placed or performed first in order to condition the sample mechanically.

### 3.5 Sample Size

3.5.1 The engineering team should consider factors that could influence the number of samples required to draw reasonable conclusions about system performance. Some factors might include cost, system application, relation to safety, new or modified design, etc. This number should be determined at the beginning of the test process.

## 4. ENVIRONMENTAL FACTORS AND TEST METHODS

### 4.1 Temperature

#### 4.1.1 Definition

Thermal factors are probably the most pervasive environmental hazard to vehicle electronic components. Sources for temperature extremes and variations include:

##### 4.1.1.1 The Vehicle's Climatic Environment, Including the Diurnal and Seasonal Cycles

Variations in climate by geographical location must be considered.

##### 4.1.1.2 Heat Sources and Sinks Generated by the Vehicles Operation

The major sources are the engine and drive-train components, including the brake system. Wide variations are found during operation. For instance, temperatures on the surface of the engine can range from the cooling system 88 °C (190 °F) to the surface at the exhaust system at 816 °C (1500 °F). This category also includes conduction, convection, and radiation of heat because of the various modes of the vehicle's operation.

##### 4.1.1.3 Self-Heating of the Equipment Due to Its Internal Dissipation

A design review of the worst-case combination of peak ambient temperature (see 4.1.1.1 and 4.1.1.2), minimized heat flow away from the equipment, and peak-applied steady-state voltage should be conducted.

#### 4.1.1.4 Vehicle Operational Mode and Actual Mounting Location

Measurements should be made at the actual mounting site during the following vehicular conditions while they are subjected to the maximum heat generated by adjacent equipment, and while they are at the maximum ambient environment:

- a. Engine start
- b. Engine idle
- c. Engine high speed
- d. Engine turn off (prior history important)
- e. Various engine/road conditions

#### 4.1.1.5 Thermal Cycling

- a. Extremes - The ultimate upper and lower temperatures the equipment is expected to experience.
- b. Cycling - The cumulative effects of temperature cycling within the limits of the extremes.
- c. Shock - Rapid change of temperature. Figure 1 illustrates one form of vehicle operation that induces thermal shock and is derived from an actual road test of two vehicles. Thermal shock is also induced when vehicle electronic components at elevated temperature is exposed to sudden rain or road splash, or when it is moved from a heated shelter into a low (-40 °C/-40 °F) ambient temperature environment.

The vehicle electronic component designer is urged to develop a systematic, analytic method for dealing with steady-state and transient thermal analysis. The application of all devices containing semiconductors is temperature limited. For this reason, the potential extreme operating conditions for each application must be scrutinized to avoid failure in the field.

#### 4.1.1.6 Ambient Conditions Before Installation Due to Storage and Transportation Extremes

Shipment in unheated aircraft cargo compartments may lower the minimum storage (non-operating) temperature to -50 °C (-58 °F). Under certain conditions the upper storage temperature may exceed the maximum ambient operating temperature (i.e., paint booth requirements).

#### 4.1.2 Effect on Performance

The damaging effects of thermal stock and thermal cycling include:

- 4.1.2.1 Cracking of printed circuit board or ceramic substrates.
- 4.1.2.2 Fatigue failures of solder joints.
- 4.1.2.3 Delamination of printed circuit boards and other interconnect system substrates.

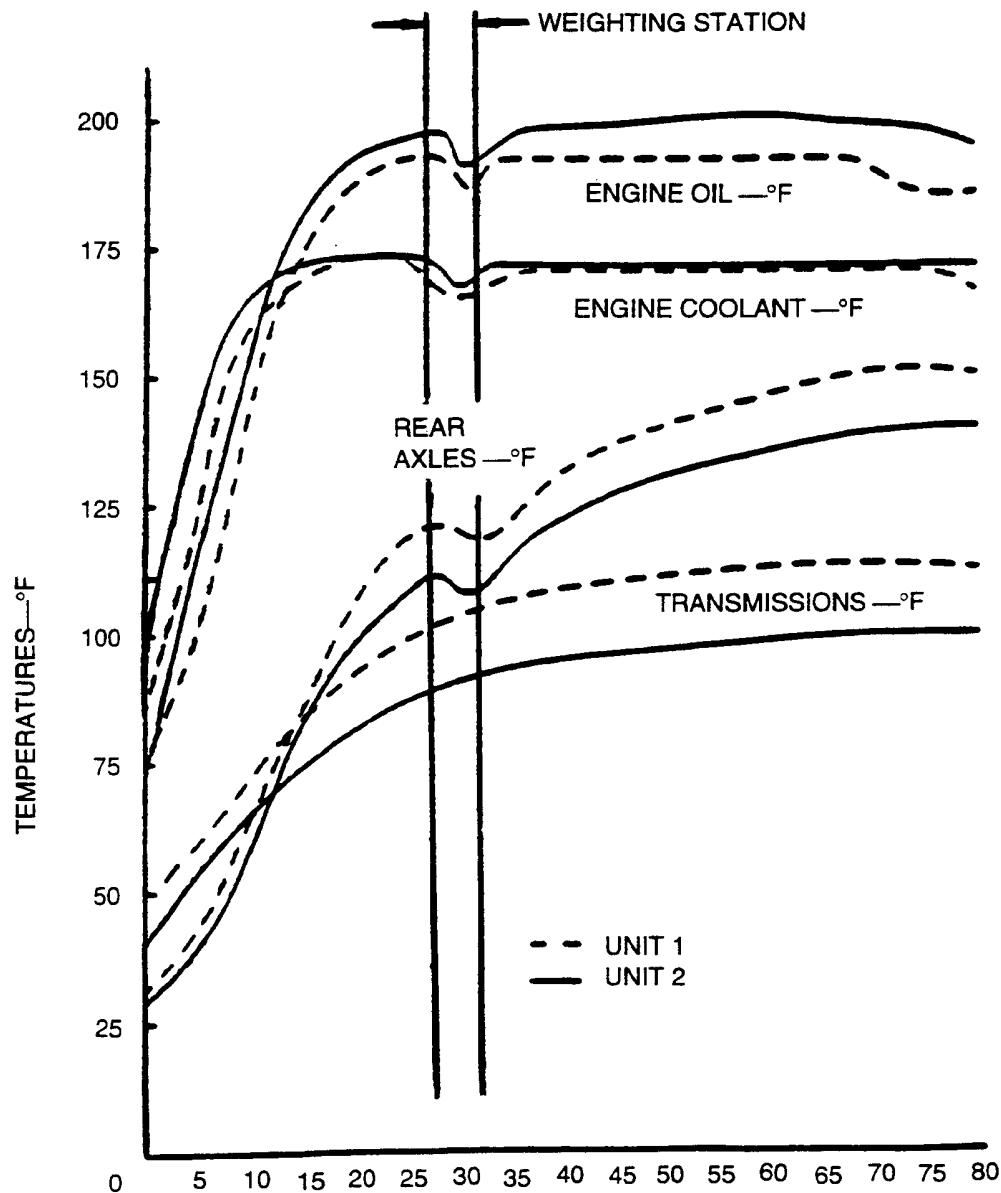


**Figure 1 - Time into run-minutes vehicle warm-up characteristics**

- 4.1.2.4 Seal failures, including the breathing action of some assemblies, due to temperature-induced dimensional variation that permits intrusion of liquid or vapor borne contaminants.
- 4.1.2.5 Failure of circuit components due to direct mechanical stress caused by differential thermal expansion.
- 4.1.2.6 The acceleration of chemical attack on interconnects, due to temperature rise, can result in progressive degradation of circuit components, printed circuit board conductors, and solder joints.
- 4.1.2.7 Exceeding the dissociation temperature of surrounding polymer or other packaging components.

- 4.1.2.8 Carbonizing of the packaging materials resulting in the eventual progressive failure of the associated passive or active components. This is possible in cases of excessively high temperature. In addition, non-catastrophic failure is possible because of electrical leakage in the resultant carbon paths. Catastrophic failures can occur as well, in the form of thermal damage.
  - 4.1.2.9 Changing the active device characteristics with increased heat, including changes in gain, impedance, collector-base leakage, peak blocking voltage, collector-base junction second breakdown voltage, etc.
  - 4.1.2.10 Changing the passive device characteristics, such as permanent or temporary drift in resistor value and capacitor dielectric constants, with increased temperature.
  - 4.1.2.11 Changing the inter-connect and relay coil performance due to the conductivity temperature coefficient of copper.
  - 4.1.2.12 Changing the properties of magnetic materials with increasing temperature, including Curie point effects and loss of permanent magnetism.
  - 4.1.2.13 Changing the dimensions of packages and components leading to the separation of subassemblies.
  - 4.1.2.14 Changing the strength of soldered joints because of changes in the mechanical characteristics of the solder.
  - 4.1.2.15 The severe mechanical stress caused by ice formation in moisture bearing voids or cracks.
  - 4.1.2.16 The very rapid and extreme internal thermal stress caused by applying maximum power to semiconductor or other components after extended cold soak under aberrant operating conditions such as 36 V battery jumper starts.
- 4.1.3 Recommended Test Methods

Recommended temperature cycle profiles are shown in Figures 2A and 2B. Recommended extreme temperatures to be used with the profiles are shown in Table 1. If temperature characterization has been performed according to 4.1.1.4, the measured temperature may be substituted for the values in Table 1 for the purpose of this document. The recommended thermal shock profile is shown in Figure 2C. Separate test chambers may be used to generate the temperature environment described by the thermal shock profile. The number of cycles for each test is a function of the vehicle electronic component application. Temperature extremes for products designed for other applications, may need to be adjusted accordingly.

By means of circulation, the air temperature should be held to within  $\pm 3\text{ }^{\circ}\text{C}$  ( $\pm 5\text{ }^{\circ}\text{F}$ ) at each of the extreme temperatures. The test specimens should be placed in a position, with respect to the air stream, where there is substantially no obstruction to the flow of air across the specimen. Care must be exercised however to assure that the test samples are not subject to temperature transition rates greater than that defined in Figures 2A and 2B. Direct heat conduction from the temperature chamber heating element to the specimen should be minimized.

NOTE: Airflow is a function of actual equipment location. Simulation of actual airflow and thermal transfer operation conditions should be considered in the test design (see Section 3).

Electrical performance should be measured under the expected operational minimum and maximum extremes of excitation, input and output voltage, and load at both the cold and hot temperature extremes. These measurements provide insight into electrical variations with temperature. Functional electrical testing during temperature transitions or immediately after temperature transitions, is a means of detecting poor electrical and mechanical connection integrity.

AMBIENT TEMPERATURE TRANSITION RATES:

MINIMUM 1.5 °C (2.7 °F) PER MINUTE

MAXIMUM 4.5 °C (8.1 °F) PER MINUTE

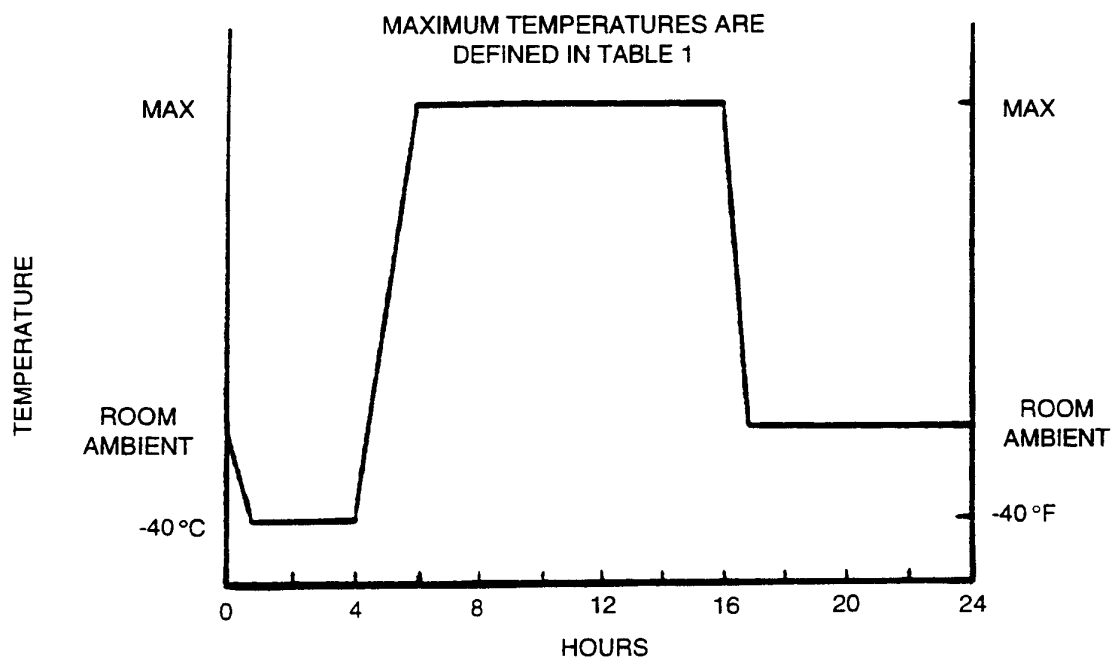


*Figure 2A – 24 hour thermal cycle*

AMBIENT TEMPERATURE TRANSITION RATES:

MINIMUM 1.5 °C (2.7 °F) PER MINUTE

MAXIMUM 4.5 °C (8.1 °F) PER MINUTE

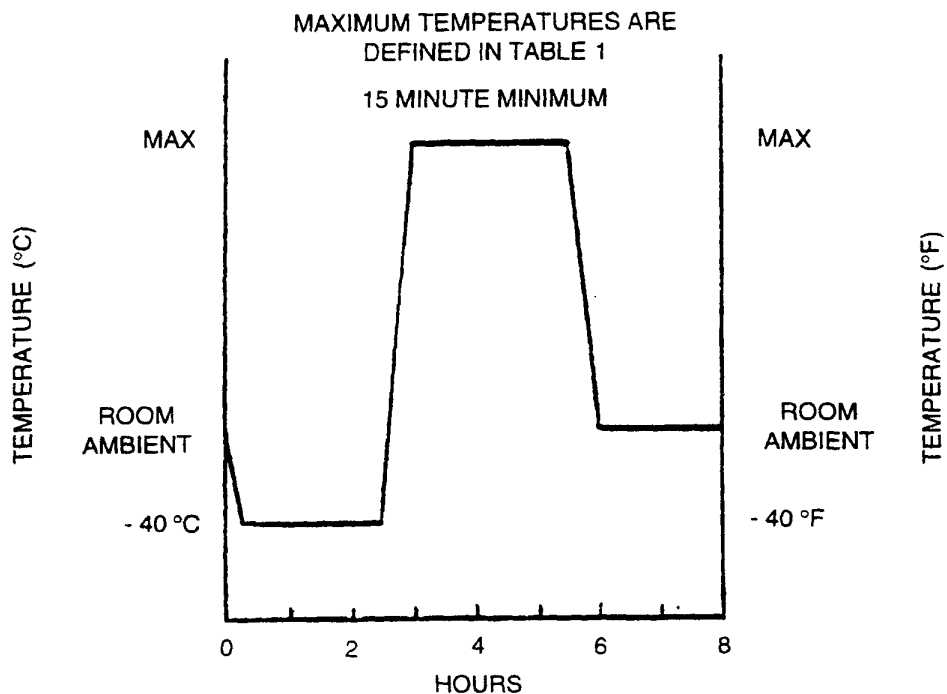


*Figure 2B - Short (8 hour) thermal cycle*

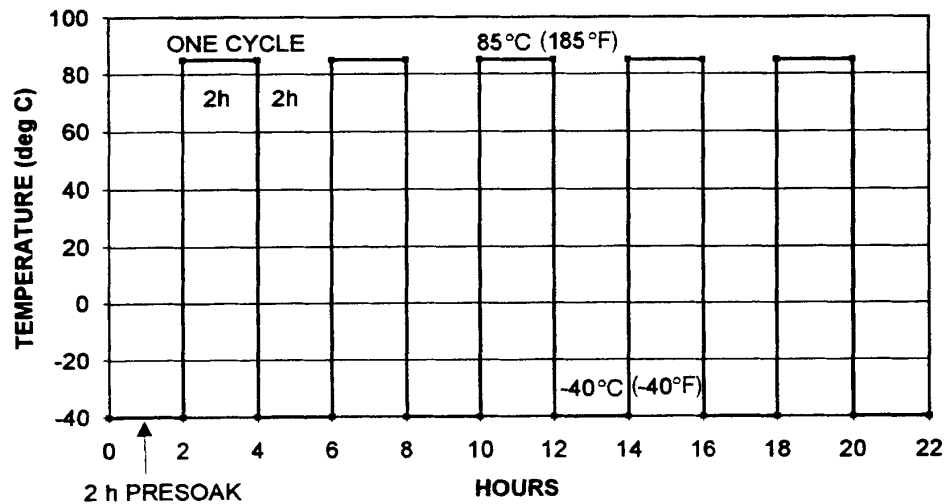


Figure 2C - Thermal shock

Figure 2

Table 1 - Environmental extreme summary heavy-duty cab over engine truck/tractor

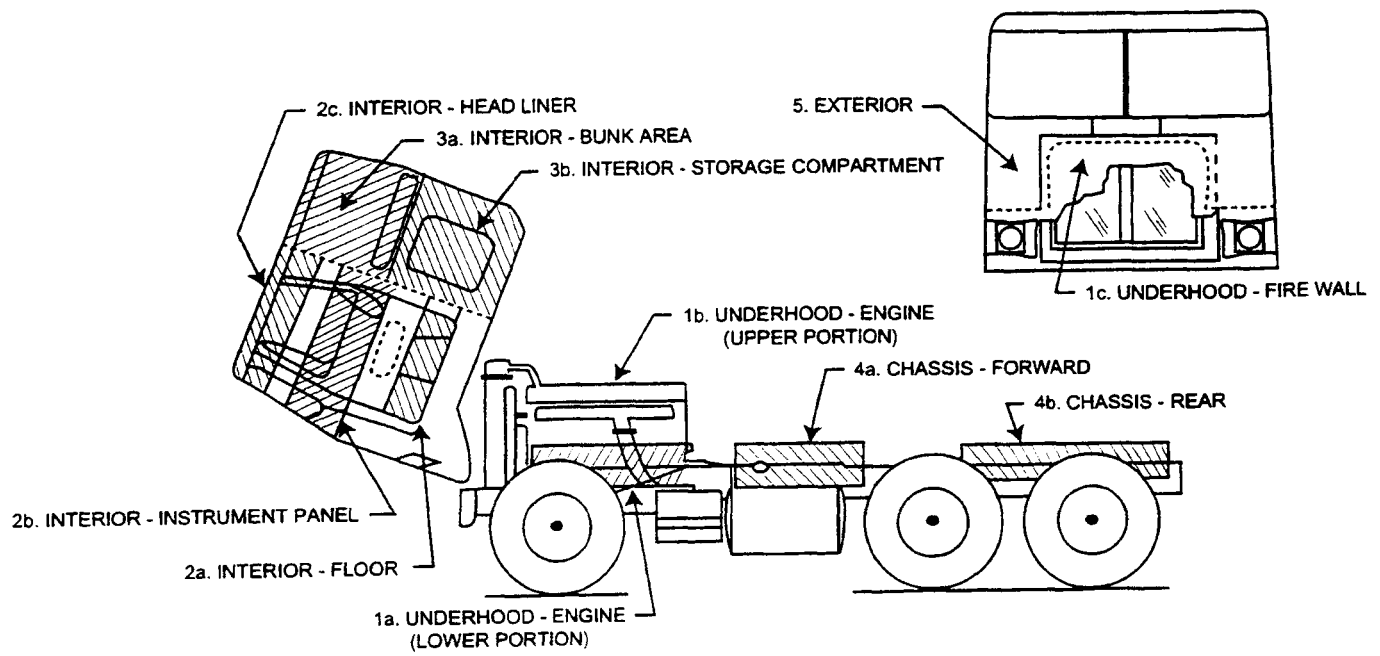
|                         |                                      | Temperatures       |                       |
|-------------------------|--------------------------------------|--------------------|-----------------------|
| Location <sup>(1)</sup> |                                      | Min                | Max <sup>(2)(4)</sup> |
| ENGINE                  | 1a Under-hood - Lower                | -40 °C<br>(-40 °F) | 141 °C<br>(285 °F)    |
|                         | 1b Under-hood – Upper <sup>(3)</sup> | -40 °C<br>(-40 °F) | 307 °C<br>(585 °F)    |
|                         | 1c Under-hood Bulkhead               | -40 °C<br>(-40 °F) | 141 °C<br>(285 °F)    |
|                         |                                      | -40 °C<br>(-40 °F) | 66 °C<br>(150 °F)     |
| INTERIOR                | 2a Floor                             | -40 °C<br>(-40 °F) | 85 °C<br>(185 °F)     |
|                         | 2b Instrument Panel <sup>(4)</sup>   | -40 °C<br>(-40 °F) | 79 °C<br>(175 °F)     |
|                         | 2c Headliner                         | -40 °C<br>(-40 °F) |                       |
|                         | 2d Inside Door                       | -40 °C<br>(-40 °F) | 93 °C<br>(200 °F)     |
|                         | 3a Bunk Area                         | -40 °C<br>(-40 °F) | 74 °C<br>(165 °F)     |
|                         | 3b Storage Compartment               | -40 °C<br>(-40 °F) | 120 °C<br>(250 °F)    |
| CHASSIS                 | 4a Forward                           | -40 °C<br>(-40 °F) | 85 °C<br>(185 °F)     |
|                         | 4b Rear                              | -40 °C<br>(-40 °F) |                       |
|                         |                                      | -40 °C<br>(-40 °F) |                       |
| EXTERIOR                | 5a Under                             | No Data            |                       |
|                         | 5b Back                              | No Data            |                       |
|                         | 5c Door                              | -40 °C<br>(-40 °F) | 85 °C<br>(185 °F)     |
|                         |                                      | -40 °C<br>(-40 °F) |                       |
|                         | 5d Top                               | No Data            |                       |

(1) Figure 3 - Pictorial Description of Locations.

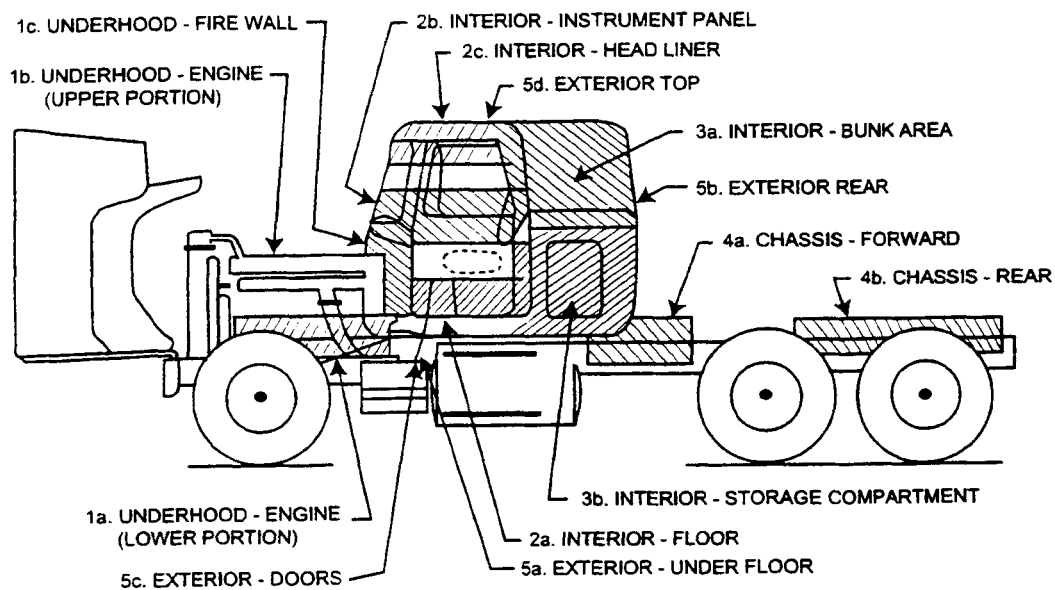
(2) If temperature characterization has been performed according to 4.1.1.4, the measured temperature may be substituted for the values in Tables 1A and 1B for the purpose of this document.

(3) Exhaust Manifold 816 °C (1500 °F).

(4) Windshield (Daylight opening on top of instrument panel) Direct sunlight surface temperature 115 °C maximum (240 °F maximum).



### HEAVY-DUTY CABOVER ENGINE TRUCK



### HEAVY-DUTY CONVENTIONAL TRUCK

*Figure 3 - Vehicle environmental zones*

#### 4.1.3.1 Temperature Cycle Test

The test method of Figure 2A, a 24 hour cycle, offers longer stabilization time and permits a longer room ambient test period. Figure 2B, an 8 hour cycle, provides more temperature cycles for a given test duration. It is applicable to most vehicle electronic components whose temperatures will reach stabilization in a shorter cycle time. Stabilization should be verified by actual measurements with thermocouples or other means. It is important that all parts of the test specimen be held at the specified maximum and minimum temperatures for at least 15 minutes, after reaching stability at that temperature. This is done to maintain thermal or pressure stresses generated in the test specimen for a reasonable period of time.

#### 4.1.3.2 Thermal Shock Test

Thermal shock that can be expected in the vehicle environment is simulated by the rate of change shown on the recommended thermal shock profile portrayed in Figure 2C usually specified as no greater than 5 minutes. The thermal shock test should begin with a 2 hour presoak at  $-40^{\circ}\text{C}/-40^{\circ}\text{F}$ . The test item should be transferred to the hot chamber ( $85^{\circ}\text{C}/185^{\circ}\text{F}$ ) where it should remain for 2 hours, then transferred back to the cold chamber ( $-40^{\circ}\text{C}/-40^{\circ}\text{F}$ ) where it should remain for an additional 2 hours. Each transfer should be accomplished in 1 minute or less. The 2 hour dwell in the hot chamber and 2 hour dwell in the cold chamber constitute one thermal shock cycle.

#### 4.1.3.3 Thermal Stress

Thermal stress fatigue failures are caused by repetitive cycling across the thermal profiles of Figures 2A, 2B, and 2C. The number of cycles to be conducted is a function of the vehicle electronic component application. Functional electrical testing during temperature transitions or immediately after temperature transitions, is a means of detecting poor electrical and mechanical connection integrity, as well as providing information of any potential negative impact on the design due to components varying coefficients of expansion. The effect of thermal stress is similar to thermal shock, but is caused by fatigue.

NOTE: Although uniform oven temperatures are desirable, the only means of heat removal in some vehicle environments may be by special heat sinks or by free convection to surrounding air. It may be necessary to use conductive heat sinks with independent temperature controls in the former case and baffles or slow speed air stirring devices in the latter to simulate such conditions in the laboratory (see Section 3).

#### 4.1.4 Related Specifications

A generally accepted procedure for small part testing is defined in MIL-STD-202G, Method 107G, Thermal Shock, Test Condition A or B, alternately MIL-STD-810F, Method 503.4. The short dwell periods at high temperature are satisfactory where temperature stabilization is verified by actual measurements.

### 4.2 Humidity

#### 4.2.1 Definitions

(Contained in 4.2.2.)

#### 4.2.2 Effects on Performance

Both primary and secondary humidity sources exist in the vehicle. In addition to the primary source externally applied ambient humidity, the cyclic thermal-mechanical stresses caused by operational heat sources introduce a variable vapor pressure on the seals. Temperature gradients set up by these cycles can cause the resulting moisture to be drawn into the enclosure.

The actual relative humidity in the vehicle depends on factors such as operational heat sources, trapped vapors, air-conditioning, and cool-down effects. Recorded data indicates an extreme condition of 98% relative humidity at  $38^{\circ}\text{C}$  ( $100^{\circ}\text{F}$ ).

Primary failure modes include corrosion of metal parts because of galvanic and electrolytic action, as well as corrosion caused by interaction with contaminated water and oxygen. Other failure modes include changes in electrical properties, surface bridging corrosion products and condensation between circuits, decomposition of organic matter because of attacking organisms (for example, mildew), and swelling of elastomers.

#### 4.2.3 Recommended Test Methods

The most common way to determine the effect of humidity on vehicle electronic components is to over test and examine any failure for relevance to the more moderate actual operating conditions. The most common test is an 8 hour active temperature humidity cycling under accelerated conditions (Figure 4A). A second test is an 8 to 24 hour exposure at 103.4 kPa gage pressure (15 lbf/in<sup>2</sup> gage) in a pressure vessel (Figure 4B). This is a quick and effective method for uncovering defects in plastic encapsulated semiconductors.

An optional frost condition may be incorporated during one of these humidity cycles. Electrical performance should be continuously monitored during these frost cycles to note erratic operation. Heat-producing and moving parts may require altering the frost condition portions of the cycle to allow a period of non-operation induced frosting.

#### 4.2.4 Related Specifications

Many related humidity specifications are recommended for review and reference. The first: MIL-STD-810F, Method 507.4, Procedures I through III, Humidity, is a system-oriented test method. The second, a modified version of MIL-STD-202G, Method 103B, Humidity (Steady State), is intended to evaluate materials. The third, MIL-STD-202G, Method 106F, Moisture Resistance, is a procedure for testing small parts.

### 4.3 Salt Spray Atmosphere

#### 4.3.1 Definition

Vehicle electronic components mounted on the chassis, exterior, and under-hood are often exposed to a salt spray environment. In coastal regions, the salt is derived from sea breezes, and in colder climates, from road salt. Historically salt has been a solution comprised of NaCl, but MgCl<sup>2</sup> is now in use as a road salt in some areas. New compounds should be considered for their corrosive potential as they come into use. Although salt spray is generally not found in the interior of the vehicle, it is advisable to evaluate the floor area for potential effects of saline solutions that were transferred from the outside environment by vehicle operators, passengers, and transported equipment. In addition to the effects of salt spray on the electronic components and connectors, mounting hardware and enclosures can also sustain corrosive damage if not properly designed, located, or protected.

#### 4.3.2 Effect on Performance

Failure modes due to salt spray are generally the same as those associated with water and water vapor. However, corrosion effects and alteration of conductivity are accelerated by the presence of saline solutions and adverse changes in pH. Inadequate sealing of connectors and component enclosures can lead to failure of electronic components. Very severe corrosion conditions can lead to mounting failures.

MAXIMUM TEMPERATURES ARE  
DEFINED IN TABLE 1

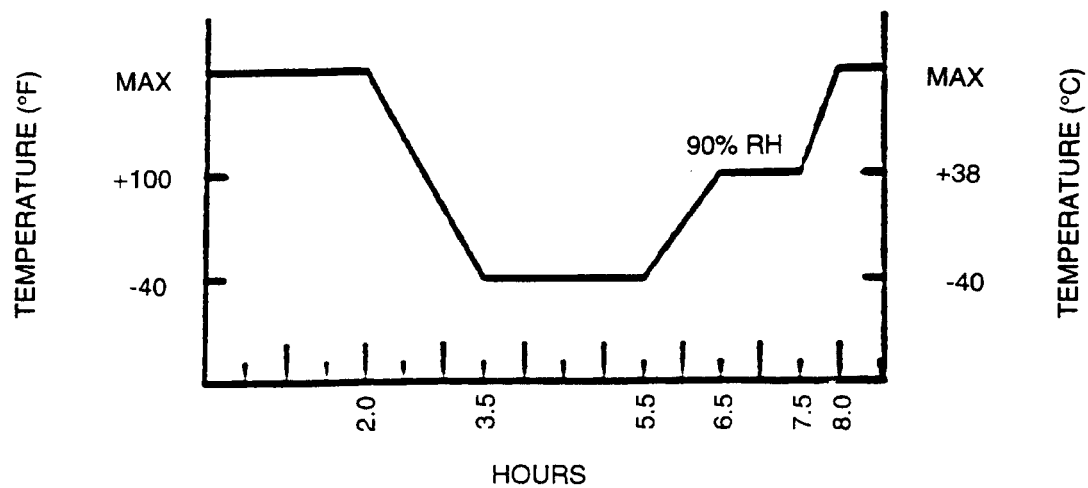


FIGURE 4a—8 h HUMIDITY CYCLE

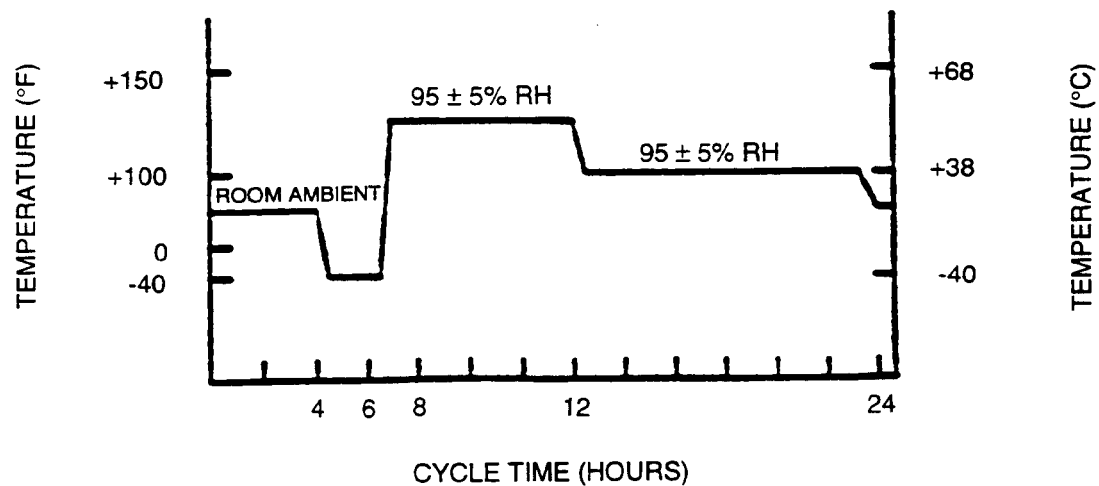


FIGURE 4b—24 h HUMIDITY CYCLE

Figure 4 - Recommended humidity cycles

### 4.3.3 Recommended Test Methods

#### 4.3.3.1 Salt Spray (Fog)

One recommended test method for measuring susceptibility of vehicle electronic component to salt spray is the American Society for Testing and Materials (ASTM) Standard Method of Salt Spray (Fog) Testing Number B117. Similar test methods are found in MIL-STD-202G, Method 101D, and MIL-STD-810F, Method 509.4. This test precipitates the effects of corrosion on exposed hardware and unsealed enclosures. However, salt spray alone may produce only moderate effects on sealed enclosures and connector integrity. Salt spray should be used as a general guide to salt water ingress susceptibility, but should not replace immersion testing for components located in high splash areas.

The test consists of exposing the vehicle electronic component to a solution of five parts salt to 95 parts water, atomized at a temperature of 35 °C (95 °F). Components in low splash areas should be exposed to the salt spray for a period of 24 to 96 hours. Electronic components that are mounted on the chassis or other high splash areas should be exposed to a minimum of 240 hours of salt fog. The actual exposure time must be determined by analysis of the specific mounting location and amount of splash encountered. The vehicle electronic component should be tested under nominal conditions of voltage and load throughout the test. Where possible, mounting hardware should be included in the test.

When the tests are concluded, the test specimens should be evaluated for visual evidence of unwanted salt precipitation or accumulation. The samples should then be gently rinsed in clean running water, about 38 °C (100 °F), to remove salt deposits from the surface, and then immediately dried. Drying should be done with a stream of clean, compressed dry air at about 175.8 to 241.3 kPa gage pressure (35 to 40 lbf/in<sup>2</sup> gage). A performance test on the specimens should be completed within 1 hour of completion of the test to prevent a drying out of the product prior to testing. Care should be taken to keep all interface connections intact at the conclusion of the test. An inspection of the enclosure, connectors, mounting hardware, and surface finish should be performed to determine the resistance of salt spray on the test samples. There should be no degradation of performance or function, and only minimal traces of corrosion should be allowed.

#### 4.3.3.2 Immersion Testing

Immersion testing provides an enhanced analysis of sealed connector and sealed enclosure integrity. During immersion testing, utilizing a 5% by weight salt water solution as the fluid, the component should be operational during the test. All connectors and seals should be intact in a configuration that resembles as close as possible the actual field. In this test, the vehicle electronic component in its normal exterior package is immersed in salt water at about 74 °C (165 °F). The test sample should be completely covered by the salt water. The component should remain immersed for a period of 1 hour. The component shall then be transferred to a salt water solution maintained at about 0 °C within 2 minutes of leaving the hot salt water bath. The unit shall be left to soak in the cold bath for a period of 1 hour. This constitutes one hot-cold 'dunk' soak cycle. A total of three 'dunk' soak cycles should be performed.

At the completion of the dunk soak cycles, the test units should be subject to the combined environmental profile in Figure 14. Vibration and humidity are optional, but recommended to reduce the number of test cycles. Vibration activates a 'percolating' effect and accelerates sealing failures. Humidity decreases the drying effect of the high temperature extremes.

The total number of dunk cycles and combined environmental cycles is determined by the severity of the mounting location. Multiple dunk and combined environmental cycles should be performed on components mounted in frame rail, chassis, and other high splash areas.

NOTE: The Pascal (Pa) is the designated SI (metric) unit for pressure and stress. It is equivalent to 1 N/m<sup>2</sup>.

Where leakage resistance values are critical, appropriate measurements under wet and dry conditions may be necessary.

#### 4.3.3.3 Vehicle Component Location Based Testing

Determine the proper test based on the location of the component using SAE J2721.

#### 4.3.4 Related Specifications

ASTM B117 is a recommended test method.

SAE J2721 is a recommended test method.

## 4.4 Exposure to Chemicals and Oils

### 4.4.1 Definition

Vehicle electronic components mounted on or in the vehicle are exposed to varying amounts of chemicals and oil. A list of potential environmental chemicals and oils includes:

Engine Oils and Additives

Transmission Oil

Rear Axle Oil

Power Steering Fluid

Brake Fluid

Axle Grease

Window Washer Solvent

Gasoline

Diesel Fuel

Fuel Additives

Alcohol

Anti-Freeze Water Mixture

Degreasers

Soap and Detergents

Steam

Battery Acid

Waxes

Kerosene

Freon

Spray Paint

Paint Strippers

Ether

Dust Control Agents (magnesium chloride)

Moisture Control Agents (calcium chloride)

Vinyl Plasticizers

Undercoating Material

Muriatic Acid

Ammonia

Diesel Exhaust Fluid (DEF) is 32.5% solution of high-purity urea in de-mineralized water

The modified chemical characteristics of these materials when degraded or contaminated should also be considered.

### 4.4.2 Effect on Performance

Loss of the integrity of the enclosure can result in corrosion or contamination of vulnerable internal components causing reduced performance or possible loss of function. Connector seals may deform and become ineffective in protecting the connector cavity resulting in corroded connector pins. Over extended periods of time, performance degradation, shorts, or opens can be expected. Non-metallic enclosures may become brittle or lose rigidity. Certain non-metallics may exhibit fractures or cracking when subject to solvents. The aesthetics of the packaging may also be effected and unacceptable by the customer. The chemical compatibility can be determined by laboratory chemical analysis.

### 4.4.3 Recommended Test Methods

The vehicle electronic component designer should first determine what level of exposure the parts must withstand complete immersion or splash, and which fluids are likely to be present in the application. Immersion and splash tests are generally performed following other environmental tests because this sequence tends to aggravate incipient defects in enclosure materials, seals, seams, and bushings that might otherwise escape notice.