American Railway Engineering and Maintenance of Way Association
Letter Ballot 38 20-05

1. Committee and Subcommittee:
   AREMA C&S Committee 38

2. Letter Ballot Number: 38 20-05

3. Assignment:
   MP's revised at Spring ‘20 meeting.

4. Ballot Item:
   Ballot 38 20-05: This ballot contains the MP approved at the Spring ‘20 meeting:
   • 11.05.01 Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment

5. Rationale:
   Revised Manual Parts
A. **Purpose**

This Manual Part recommends environmental requirements for electrical and electronic equipment, including microprocessor-based equipment, utilized in railroad signal systems. It outlines the range of environmental conditions of this equipment for storage and operation.

B. **General**

1. Railroad signal equipment operates in a wide range of environments, ranging from benign to severe. A benign environment is one in which the ambient conditions are closely controlled at a predetermined level. A severe environment is one to which no controls or conditioning is applied. These widely differing levels of environmental stress impose very different requirements on signal devices and control equipment. To adequately specify the environmental operating range for each piece of equipment, five classes for wayside and five classes for vehicle are established with parameter levels for each.

2. The vibration aspect of the environment is further characterized by wideband impact vibrations generated from the train wheel to running rail interface. A stress event, or stress cycle, occurs at a particular wayside location during every wheel passage with location specific frequency content being dependent on track layout and material properties of the track support structure. The number of stress events at a typical wayside location over the course of the typical wayside equipment service life (25 years) is on the order of $10^7$ to $10^8$.

3. The procuring railroad should state the intended operating environment for all signal equipment being procured.

4. The manufacturer should conduct qualification tests per approved procedures, and submit test data to provide proof of compliance with each of the environmental parameters of the most severe class that the equipment is designed to comply with.

C. **Classes of Environment**

1. Wayside Environment
Class A: Roadbed
Equipment is directly attached to track components such as rails, ties, or is mounted between the ties, within striking distance of debris falling from or attached to a train. (Examples: Impedance bonds in electrified territory, wheel detectors, transponders, switch machines, hot bearing detectors, etc.)

Class B: Wayside Outdoors
Typical railroad right-of-way. Equipment is located within 20 feet of the track centerline, but not directly on the track bed. (Examples: Wayside signals, AEI system antennas, junction boxes, etc.)

Class C: Wayside Signal Enclosures
Basic shelter from rain and snow is provided, but without heating, air conditioning or humidity control.

Class D: Wayside Control Room
Basic shelter from rain and snow is provided. Also, heating is provided, but without air conditioning or humidity control.

Class E: Computer Rooms
Ground benign environment, with heating, air conditioning and humidity control.

2. Vehicle Environment

Class F: Vehicle Exterior (Axle Mounted)
Equipment is mounted on "unsprung" components of the locomotive, such as wheels and axles.

Class G: Vehicle Exterior (Truck Mounted or Coupler Mounted)
Equipment is mounted on "sprung" component of the locomotive or other rolling stock. (e.g. End of Train Devices).

Class H: Vehicle Exterior (Platform Mounted)
Equipment is mounted in space outside the enclosed areas of the locomotive that are exclusive of direct contact with the rails. (e.g., antennas, AEI tags, etc.)

Class I: Vehicle Interior (Platform Mounted) Environment in the enclosed interior spaces of the locomotive, such as the short hoods (designed for crash protection), exclusive of the engine compartment and cab spaces.

Class J: Vehicle Interior (Cab)
Environment in spaces of the locomotive that are intended for continuous crew occupancy. Includes interiors of transit cars.

Note: Coupler Knuckle–Mounted Equipment (End of Train Device).

D. Environmental Limits

This section provides the details of the parameters representing the environmental classes listed in Section C. A summary of the parameter limits in each class is given in Section E.

1. The specified storage temperatures are the lowest and highest ambient air temperatures expected to be experienced during storage or in service with power off. Equipment is not expected to be capable of operating at these temperatures, but to survive them without damage or degradation. This shall be proven by an approved test procedure.

2. The specified operating temperatures are the lowest and highest ambient temperatures expected to be experienced by the equipment during normal operation. The equipment is expected to be powered and to operate within these operating temperatures. The equipment shall be functional within 30 sec. after initial application of power. Proper application of power and normal operation at the specified temperature extremes shall be verified by an approved test procedure.

3. The equipment shall be operated or stored without damage or degradation at the specified ambient noncondensing humidity. The specified humidity is for an ambient operating temperature of +86°F (+30°C) and storage temperature of +140°F (+60°C). "Non-condensing" is a condition where equipment is at or above dew point temperature and liquid water is not condensing on the inside or outside surfaces of the equipment.

4. Vibration

Equipment shall be designed and manufactured to withstand the specified vibration environments without damage, degradation, or abnormal operation.

To verify that the equipment can withstand the operating environment without damage, vibration tests shall be performed according to the following procedure:

a. Sinusoidal Vibration Tests
The equipment shall be subjected to sinusoidal cycling along each of the three mutually perpendicular axes. Each cycle shall consist of a sine sweep from 5 Hz to 200 Hz and back to 5 Hz for equipment classes A, B, C, D, E, I, and J, or from 5 Hz to 1,000 Hz and back to 5 Hz for equipment classes F, G, and H. During each sine sweep, the frequency of applied vibration shall be swept over the specified range logarithmically. Sweep times shall be 12 min. for the 5 Hz 200 Hz - 5 Hz range, and 17 min. for the 5 Hz 1,000 Hz - 5 Hz range. These sweep times are equivalent to a logarithmic sweep rate of approximately 0.9 octave/minute. Twenty (20) complete sine sweep cycles shall be applied along each of the three mutually perpendicular axes. Test durations for each axis shall be 4 hr. for the 5 Hz - 200 Hz - 5 Hz sweep case, and 5 hr. 40 min. for the 5 Hz – 1,000 Hz - 5 Hz sweep case. Input vibration levels shall be as specified in Figure 1151-1, which is a graphical representation of the vibration limits specified in Section E. Each sine sweep consists of a constant displacement input over the initial low frequency range, followed by a constant acceleration input over the remainder of the frequency range up to the peak frequency.

b. Exploratory Sine Sweep

It is recommended that an exploratory sine sweep test be conducted during the design phase to identify equipment resonance and potential problem areas. This test should be conducted at a vibration level of 0.05" P-P (5-10Hz) and 0.5g P over the remaining frequency-range for the class of equipment as specified in Section E.

c. Equipment Mounting Technique

The equipment shall be attached directly to the vibration exciter or transition table. For large equipment items that do not conveniently fit the vibration exciter or transition table, a rigid fixture shall be used to connect the equipment item to the exciter or transition table. The rigid fixture shall be capable of transmitting the vibration conditions specified herein. The input control sensing device(s) shall be rigidly attached to the vibration table, or fixture if used, as near as possible to the attachment point(s) of the test item.

Equipment which is normally vibration-isolated in service shall use the service isolators when mounted for the vibration tests.
d. Equipment Operation

The equipment shall function according to the procurement specification without failure after sinusoidal vibration testing.

e. Test Tolerances unless otherwise specified by the procuring activity, the tolerances for the test conditions shall be as follows:

Vibration Frequency: ± 2% or ± 1/2 Hz below 25 Hz

Vibration Amplitude: ± 10%

f. In the sweep test, sufficient number of accelerometers should be used to identify vibration characteristics of those units or subassemblies, which are susceptible to the vibration, representative of other units, and/or critical to performance of the equipment. An example of accelerometer application on Cab Signal Equipment is given as follows:

- one on the enclosure;
- one on a cardfile;
- one on a vital relay;
- one on a power supply board;
- one on a filter board.

5. Mechanical Shock

Equipment shall be designed and manufactured to withstand the specified shock and transient vibration encountered in all shipping, storage, and operating modes without damage, degradation or abnormal operation. The equipment shall be capable of withstanding six shock pulses of terminal-peak sawtooth shape along each of the three mutually perpendicular axes (three shock pulses in each positive direction and three shock pulses in each negative direction). The peak value and duration of each shock shall be as specified for the particular equipment class in Section E, Environmental Parameter Limits. An approved 3-axis shock pulse test shall be used to confirm compliance with these requirements. The equipment shall function according to the procurement specification without failure after being subjected to these shock pulse tests. Shock pulse tolerance limits are as specified in Figure 1151-2.
6. Electromagnetic Interference (EMI)

Electromagnetic Interference guidelines are contained in Manual Part 11.5.2.

7. Dielectric Requirements

Equipment shall be designed and manufactured to have the specified dielectric strength. Dielectric strength measurements shall be made from any external isolated terminal of the equipment to any other external isolated terminal and from any isolated external terminal to chassis or ground. External isolated terminals include all input, output and power terminals of the equipment intended for connections external to the signal and communication housing.

7.1 AC Voltage Test

This test is to be done first. If the device under test (DUT) passes this test no further testing is required. If this test fails, proceed to Section 7.2.

The AC Test voltage levels shall be the rms values specified and shall be derived from a 60 Hz sinusoidal source. The test voltage shall be applied continuously for a period of 60 seconds, with the leakage current not exceeding 1.5 mA per 1000 V rms of applied test voltage.

Test conditions are: Barometric pressure: 29.92 inches, Temperature: +59°F (+15°C), Humidity: 75%

7.2 DC Voltage Test

If the AC voltage dielectric test in Section 7.1 fails, it must be determined if the leakage is from a resistive path or a reactive (capacitive) path. A resistive path would be considered undesirable but leakage due to capacitive reactance inherent in the capacitance between the DUT’s wiring and its grounded enclosure is acceptable as long as the leakage current is kept below the specified value. Keep in mind the use of discrete capacitors in a line-to-ground configuration is not being condoned here for use in vital circuits. We are talking strictly about inherent capacitance of the already controlled wiring within the DUT.
To determine if the leakage is resistive or capacitive, a DC voltage source must be used. The DC voltage value is to be set at the peak value of the specified rms voltage. The peak value is found by multiplying the rms value by 1.414. See the example below:

Example:
The test voltage is specified to be 2000 Vrms. The device under test (DUT) fails the leakage test which has an allowable limit of 1.5 mA per 1000 Vrms. In this example it would have exceeded 3mA. To determine if the leakage is resistive or reactive the DUT is tested using the DC voltage equivalent of the peak value of the rms voltage. The DC test voltage is calculated as follows:

\[ V_{DC} = V_{rms} \times 1.414 \]
\[ V_{DC} = 2000 \times 1.414 \]
\[ V_{DC} = 2828 \text{ Volts DC} \]

The 2828 VDC is then applied to the DUT and should use a leakage allowance based on the same conversion factor. That is, if the specification is 1.5 mA per 1000 Vrms we can equate that to 1.5 mA per 1414 VDC. This would translate to an allowable 3 mA leakage at 2828 VDC.

During any dielectric strength test, there is the possibility of the leakage current slowly increasing during the 1 minute test duration. This is due to creepage or conductive migration. However, as long as the leakage current stays below the specified value as stated above, the test is considered passed.

It should be noted here that there is a distinct difference between leakage and breakdown. Most High Potential (Hi-Pot) Testers have the capability of discerning between the two.

**Cautionary Note:**
There are some instances where certain EMI injection specifications must be met and it is difficult to meet the effects of this testing without the use of Line-to-Ground Capacitors. The amount of capacitance required to meet the EMI requirements may cause the dielectric test to fail. All capacitors have the potential to degrade in a low impedance manner. In vital circuits this can be a problem because as a single mode failure, a low impedance or short-to-ground is not detectable in most applications. However, a second failure of the same nature may present a vitality problem. The designers of "vital" circuits and equipment must be aware of this and where such equipment is used, or attached to "vital" circuits, appropriate safety analysis should be performed. — There are ways to mitigate the effects of EMI and still pass the dielectric testing but often with compromise, but that is beyond the scope of this Manual Part.

8. Corrosive/Abrasive Environment

The signal equipment shall be designed and manufactured to operate without damage and degradation when exposed to potentially corrosive/abrasive elements such as salt spray, rain, hail, sand and dust particles; and contaminants such as iron dust, oil vapor, oxides of nitrogen, ozone, carbon dust, copper dust, and common cleaning solutions. Satisfactory performance shall be verified by approved test procedures or operating experience of similar equipment in similar environment.

E. Environmental Parameter Limits

Parameter limits are specified in the following Table 1151-1 for each of the equipment environment classes:

Table 1151-1
## 11.5.1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Class A (Roadbed)</th>
<th>Class B (Wayside Outdoors)</th>
<th>Class C (Wayside Signal Enclosures)</th>
<th>Class D (Wayside Control Room)</th>
<th>Class E (Computer Room)</th>
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<td>Temperature</td>
<td>Operating</td>
<td>-40 F (-40 °C)</td>
<td>-40 F (-40 °C)</td>
<td>-40 F (-40 °C)</td>
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<td>+158 F (+70 °C)</td>
<td>+158 F (+70 °C)</td>
<td>+158 F (+70 °C)</td>
<td>+156 F (+70 °C)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Minimum</td>
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<td>-67 F (-55 °C)</td>
<td>-67 F (-55 °C)</td>
<td>-67 F (-55 °C)</td>
<td>+5 F (-15 °C)</td>
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<td>Maximum</td>
<td>+185 F (+85 °C)</td>
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<td>+185 F (+85 °C)</td>
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<td>0.1&quot; p-p</td>
<td>0.07&quot; p-p</td>
<td>0.05&quot; p-p</td>
<td>0.05&quot; p-p</td>
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<tr>
<td></td>
<td>20-200 Hz</td>
<td>4.2 g p</td>
<td>2.0 g p</td>
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<td>1.0 g p</td>
<td>1.0 g p</td>
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<td>Mechanical Shock (11ms)</td>
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<td>10 g p</td>
<td>10 g p</td>
<td>10 g p</td>
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<tr>
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<td>600</td>
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<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tbody>
</table>

Note 1: *3,000 Vrms for Electromechanical Equipment, e.g. vital relays and switch machines
**2,000 Vrms for Electronic Equipment

Industry Standards such as MIL-STD-810G may be used as a guideline to develop the qualification test methods.
### Table 1151-1 (Continued)

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Temperature</td>
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<td>-40 F (-40 C) +158 F (+70 C)</td>
<td>-40 F (-40 C) +158 F (+70 C)</td>
<td>-40 F (-40 C) +158 F (+70 C)</td>
<td>-40 F (-40 C) +158 F (+70 C)</td>
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<td>-67 F (-55 C) +185 F (+85 C)</td>
<td>-67 F (-55 C) +185 F (+85 C)</td>
<td>-67 F (-55 C) +185 F (+85 C)</td>
<td>-67 F (-55 C) +185 F (+85 C)</td>
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<td>Maximum</td>
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<td>Vibration</td>
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<td>10-200 Hz</td>
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<td>200 – 1000 Hz</td>
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<td>2.5 g p</td>
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</tr>
<tr>
<td></td>
<td>5-20 Hz</td>
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<td>---</td>
</tr>
<tr>
<td></td>
<td>20-1000 Hz</td>
<td>20 g p</td>
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<td>Mechanical Shock (11ms)</td>
<td>Shipping</td>
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<td>10 g p</td>
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<tr>
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<td>No</td>
</tr>
</tbody>
</table>

Note: *3,000 Vrms for Electromechanical Equipment, e.g. vital relays and switch machines**
**2,000 Vrms for Electronic Equipment
Industry Standards such as MIL-STD-810G may be used as a guideline to develop the qualification test methods.
Figure 1151-1: Sine Sweep Input Acceleration Levels Versus Frequency for Different Classes of Railroad Signal System Equipment.
Figure 1151-2: Terminal-Peak Sawtooth Shock Pulse Configuration and Its Tolerance Limits