

/NA EVO - Heavy Haul - Hybrid/07. Reference Documents/GETS Standards

84A214732 Tier II Environmental Spec

Tier II Freight

Version: 3.3 (84A214732 Rev. F)

Printed by: 207004581

Printed on: Tuesday, October 20, 2015

Contents

1	SCOPE	2
1.1	Environmental Factors	2
1.2	Acronyms	3
1.3	Definitions	3
1.4	Change Instructions and Authorization	4
2	Applicable Documents	5
3	Guide on How to Use the Document	6
4	Environmental Requirements	7
4.1	Types of Environments	7
4.2	Equipment Locations	7
4.3	Vibration Profiles	12
4.3.1	How Vibration Profiles were Created	12
4.3.2	Locating Vibration Data	13
5	ENVIRONMENTAL CONDITIONS	21
5.1	Salt Fog	21
5.2	Rain	21
5.3	Icing/Freezing Rain	21
5.4	Water Spray	21
5.5	Sand	21
5.6	Dust	21
5.7	Contaminants	21
5.8	Sunlight	22
6	ELECTRICAL ENVIRONMENT	23
6.1	The 74V Battery Bus	23
6.1.1	Operating Characteristics	23
6.1.2	Survivability Requirements	24
6.2	EMI/EME Conducted	25
6.2.1	Conducted Susceptibility	25
6.2.1.1	Level 2 Susceptibility Test	25
6.2.1.2	Level 3 Susceptibility Test	25
6.2.2	Conducted EME	25
6.2.2.1	Conducted Transients Test	25

6.2.2.2	Power Line Radio Frequency Conducted Emissions	25
6.2.2.3	Power Line Audio Frequency Conducted Emissions	25
6.2.2.4	Signal Line Radio Frequency Conducted Emissions	25
6.2.2.5	Signal Line Audio Frequency Conducted Emissions	26
6.3	EMI/EME Radiated	26
6.3.1	Radiated Susceptibility	26
6.3.1.1	Environmental Levels	26
6.3.1.2	Intentional Radiator Levels	26
6.3.2	Radiated Emissions	26
6.4	Electrostatic Discharge (ESD)	27
6.5	HIGH POTENTIAL AC	27
7	Table 6-4 Main Locomotive Circuit Tests	29
7	LOCOMOTIVE HANDLING	
7.1	Acceleration And Deceleration	29
7.2	Mechanical Shock During Shipping	29
7.3	Mechanical Shock When Operating	29
8	Appendix A Locomotive Schematic	31
	Appendix B Locomotive Ambient Operating Environment Profile	
	Distribution FOR CONTINENTAL UNITED STATES	
9	Appendix B Locomotive Ambient Operating Environment Profile	32
	Distribution FOR CONTINENTAL UNITED STATES	

Tier II Freight**Evolution Series Locomotive
Environmental Specification****Revision History**

Rev. Level	Date	Description Of Change	Author
F	10/20/2015	Table 4-1 Corrected CA2 Thermal Cycling time	MJ Fachetti
E	03/04/2015	4.3.2 - updated obsolete Jammu link	DS Krepps
D	12/15/2011	Section 7.3 Updated to define assumption for hard coupling frequency of occurrence	R Evans
C	05/18/2011	Section 1.3 Updated for maximum tunnel duration	R Mischler
B	11/26/2008	Released from DOORS	LD Blakeslee
A	03/10/2006	Table 7.2 Updated for engine /alternator	LD Blakeslee
0	11/14/2003	Initial Release	LD Blakeslee

Tier II Freight

1 SCOPE

1.1 Environmental Factors

This document sets forth the specifications for the various environments the Evolution Series Locomotive (AC and DC) components may encounter during operation and storage. Equipment provided under this specification must meet all performance requirements in the environment for which it is intended; including the most severe requirements if the equipment is used on more than one platform. Such requirements can be determined by combining requirements from individual profiles to arrive at the most severe case.

The parameters listed herein incorporate requirements common to the Association of American Railroads (AAR) standards, Military specifications, International Electrotechnical Commission, Federal Communication Commission (FCC) regulations and various other industry accepted practices. This specification is jointly based on the Advanced Train Control System (ATCS) Environmental Specification 110 and General Electric Transportation Systems Design Guide.

Component Suppliers should note that this specification encourages them to produce high-performance, low-maintenance, high-reliability equipment. They are free to accomplish these objectives and satisfy the requirements of this specification by means of design, techniques and technology, which they consider to be cost effective and appropriate.

Table 1-1 provides examples of how environmental factors have a significant impact on equipment reliability.

Environmental Factors	Impact	Environmental Effects (Examples)
Vibration	Mechanical Stress	<ul style="list-style-type: none"> Loosening of fastening Seal deformation Component fatigue Cracking and rupturing
Mechanical Shock	Excite equipment to respond at both forced and natural frequencies	<ul style="list-style-type: none"> Failures due to increased or decreased friction, or interference between parts Changes in dielectric strength Loss of insulation strength Permanent deformation Low cycle fatigue
High Temperature	Changing physical properties or geometrical dimensions	<ul style="list-style-type: none"> Parts binding from differential expansion of dissimilar materials Less viscosity of lubricants, outward flow of lubricant from joints Distorting and binding of packing, gaskets; seals, bearings, and shafts Closure and sealing strips deteriorating Shorted insulation life
Low Temperature	Changing physical properties or geometrical dimensions	<ul style="list-style-type: none"> Hardening and embrittlement of materials Parts binding from differential contraction of dissimilar materials Loss of lubricant flow caused by increased viscosity Stiffening of shock mounts Condensation and freezing of fluid coolant Change of combustion rate
Thermal Cycling	Thermal stress	<ul style="list-style-type: none"> Binding or slacking of moving parts Differential contraction or expansion of dissimilar materials Deformation or fracture of components Leaking of sealed components Cracking of surface coating
Humidity	Physical and chemical deterioration of material	<ul style="list-style-type: none"> Changes in mechanical properties Swelling of materials due to moisture absorption Degradation of insulation strength Corrosion or fouling of lubricant Loss of plasticity Low humidity may impact commutation

Table 1-1 Examples Of Environmental Impact

Tier II Freight

Environmental Factors	Impact	Environmental Effects (Examples)
Rain	Physical deterioration	<ul style="list-style-type: none"> Promote corrosion of metals Deteriorate surface coating Swelling or cracking of parts
Altitude	Low pressure	<ul style="list-style-type: none"> Leakage of gases or fluids from gasket-sealed inclusion Erratic operation or malfunction of equipment resulting from arching or corona Overheating caused by reduced heat transfer Evaporation of lubricants Erratic starting and combustion of engines Failure of hermetic seals
Salt fog	Corrosion	<ul style="list-style-type: none"> Accelerated stress corrosion Production of conductive coating Corrosion of insulating materials and metals
Sand and Dust	Penetrate into cracks, crevices, bearings and joints	<ul style="list-style-type: none"> Abrasion of surface Penetration of seals Erosion of surface Degradation or clogging of openings and filters Physical interference with mating parts Fouling of moving parts
EMI	Electromagnetic radiation	<ul style="list-style-type: none"> Exciting force in rotating equipment Data corruption in microprocessor-controlled systems Inadvertent alarms Out of tolerance perturbations
Particulars (e.g. Conductive Dust)	Embedded in insulation by vibration	<ul style="list-style-type: none"> Cause insulation failure Create commutation problems

Table 1-1 Examples Of Environmental Impact (Continued)

1.2 Acronyms

The following is a list of acronyms used in this specification:

- AAR Association of American Railroads
- ATCS Advanced Train Control System
- EME Electromagnetic Emission
- EMI Electromagnetic Interference
- ESD Electrostatic Discharge
- FCC Federal Communication Commission
- FFT Fast Fourier Transform
- GETS General Electric Transportation Systems
- IEC International Electrotechnical Commission
- LMS Leuven Measurement System
- PSD Power Spectral Density
- RF Radio Frequency
- RU Replaceable Unit

1.3 Definitions

Definitions used in this specification include:

- **Locomotive Design Life**

Design life is 20 years for all components except those with scheduled preventive maintenance requirements, in which case the component design life is equal to the maintenance interval.

- **Locomotive Year**

8766 hours

Tier II Freight

- **Power Spectral Density**

Describes the power of random vibration intensity as a measurement of g^2/Hz - also known as ESD or Energy Spectral Density.

- **Random Vibration**

Wide band vibration spectra. One whose instantaneous magnitude is random.

- **T_{max}**

Maximum temperature component can expect to be exposed to during locomotive normal operating mode.

- **T_{min}**

Minimum temperature component can expect to be exposed to during locomotive normal operating mode, including locomotive start up.

- **Tunnel Temperature**

During passage through tunnels, equipment in ventilated enclosures and direct-ventilated equipment may be exposed to higher temperatures, as specified in Tables 4-1 through 4-5, for 5 minute average durations with a maximum individual event duration of 13 minutes (approximately 315 such episodes per year).

- **Zone**

A region on the system structure that includes those points where the measured or predicted shock and/ or vibration responses have broadly a similar spectra.

1.4 Change Instructions and Authorization

This specification contains environmental requirements only. The cost and delivery schedule related to the contract shall be administered by GETS Sourcing. This specification is controlled by a CN (GETS internal change notice). Revision letters (A, B, C, etc.) and a date are used to identify the latest revision of this specification. The Sourcing agent shall direct the Supplier regarding all changes. Suppliers are cautioned to proceed with changes only by direction of the Sourcing agent.

Tier II Freight

2 Applicable Documents

Purchase Specification: This Environmental Specification defines the general environments for different locomotive areas (e.g., Radiator Cab, Engine Mounted Areas, etc.). The special environments for particular components (e.g., Traction Motor Blower, Engine Fuel Injector, etc.) may also be defined in the Purchase Specification. Both the general requirements set forth in this Environmental Specification and the special requirements set forth in the Purchase Specification must be satisfied.

Reliability Specification: The following documents specify the reliability requirements for electronic equipment and mechanical equipment:

Reliability and Qualification Specification for Electronic Equipment (GE Drawing # 41A296300AD);

Reliability and Qualification Specification for Mechanical Equipment (GE Drawing # 84A204552).

When applied to environmental qualification, this Environmental Specification shall take precedence in the event of conflict.

When applied to reliability growth and life testing process, the Reliability Specification shall take precedence in the event of conflict.

Other Applicable Documents: The following documents are a part of this specification to the extent that they are referenced herein. In the event of conflict between the documents referenced herein and the requirements of this specification, the contents of this specification shall take precedence. The revision in effect when a purchase order is issued to the supplier shall apply.

TCS Specifications

TCS Specification 110, Environmental Requirements Revision 3

TCS Test Procedures for the Measurement of Locomotive Electromagnetic Interference Characteristics.

Government Specifications - Federal

FCC Regulations, Part 15 (CFR 47)

GETS Specifications

GETS Design Guide 1.1.2, Environmental Specification

Other Industry or Military Specifications

IEC 61000-4-2 Testing and Measurement Techniques - ESD Immunity Test

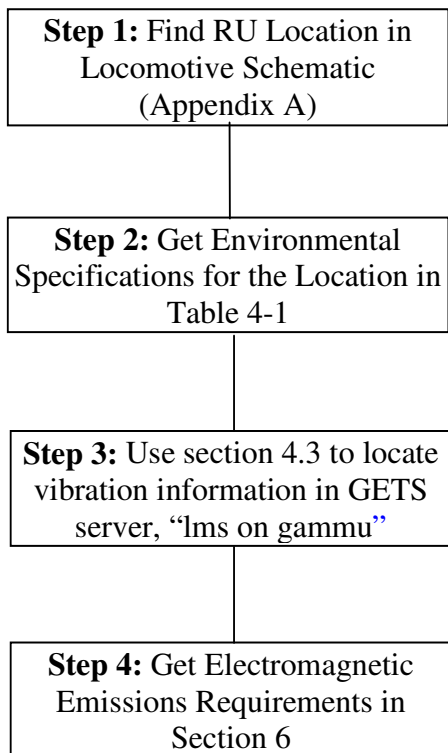
IEC 61000-4-3 Testing and Measurement Techniques - Radiated, Radio Frequency, Electromagnetic Field Immunity Tests

IEC 61000-4-4 Testing and Measurement Techniques - Electrical Fast Transient/Burst Immunity Tests

MIL-STD-461 Electromagnetic Interference Characteristics Requirements for Equipment

Tier II Freight**3 Guide on How to Use the Document**

To get the appropriate environmental specifications, follow these four steps:



Tier II Freight

4 Environmental Requirements

4.1 Types of Environments

The Evolution Series AC Locomotive will operate in a wide range of environments. In order to adequately specify the appropriate operating range for hardware used in various locations on the Locomotive, the following environmental factors are to be considered:

1. Vibration (Section 4.3)
2. Mechanical Shock (Sections 7.2 and 7.3)
3. Temperature (Section 1.3)
4. Thermal Cycling
5. Humidity
6. Rainfall (Section 5.2)
7. Icing/Freezing Rain (Section 5.3)
8. Water Spray (Section 5.4)
9. Altitude
10. Salt Fog (Section 5.1)
11. Sand (Section 5.5)
12. Dust (Section 5.6)
13. Sunlight (Section 5.8)
14. Contamination (Section 5.7)

4.2 Equipment Locations

The locomotive has been divided into specific locations for environmental concern. A summary of the required environments for each compartment is defined in Table 4-1.

Refer to Table 4-1 for the following locations:

- **Air Brake Rack** - All RUs mounted in the air brake compartment
- **Alternator Compartment** - All RUs mounted in the alternator area
- **Axle Mounted** - All RUs mounted on the axle
- **Battery Compartment** - All RUs mounted in the battery compartment
- **Blower Compartment** - All RUs mounted in the blower compartment
- **Control Area 1** - All RUs mounted in the control area 1 (CA1) compartment and engine control panel (ECP) area
- **Control Area 2** - All RUs mounted in the control area 2 (CA2) compartment
- **Control Area 3** - All RUs mounted in the control area 3 (CA3) compartment
- **Control Area 4** - All RUs mounted in the control area 4 (CA4) compartment
- **Control Area 5** - All RUs mounted in the control area 5 (CA5) compartment
- **Control Area 6** - All RUs mounted in the control area 6 (CA6) compartment
- **Control Area 7** - All RUs mounted in the control area 7 (CA7) compartment
- **Control Area 8** - All RUs mounted in the control area 8 (CA8) compartment
- **Control Area 9** - All RUs mounted in the control area 9 (CA9) compartment
- **Dynamic Braking Box** - All RUs mounted in the dynamic braking box
- **Engine Compartment** - All RUs mounted in the engine auxiliary area
- **Engine/Alternator Mounted** - All RUs mounted on the engine or alternator
- **Operator's Cab** - All RUs mounted in the operators cab
- **Operator/Helper's Console** - All RUs mounted on the operator's or helper's console
- **Overhead Console** - All RUs mounted above the operator's or helper's console
- **Platform Mounted** - All RUs mounted on the platform
- **Radiator Cab** - All RUs mounted in the radiator cab (except CA9)
- **Radio Equipment Compartment** - All RUs mounted in the radio equipment compartment
- **Roof of Operator's Cab** - All RUs mounted on the roof of the operator's cab
- **Truck Mounted** - All RUs mounted on the truck

Tier II Freight

	Air Brake Rack	Alternator Compartment	Axle Mounted	Battery Compartment	Blower Compartment
Vibration	See Figure 4-3b for index	See Figure 4-3d for index	See Figure 4-3f for index	See Figure 4-3c for index	See Figure 4-3d for index
Mechanical Shock During Shipping	See Section 7.2				
Mechanical Shock When Operating	See Section 7.3		100 g peak	See Section 7.3	
High Temp, T _{max}	140 F (60 C)	149 F (65 C)	140 F (60 C)	140 F (60 C)	140 F (60 C)
Low Temp T _{min}	-40 F (-40 C)				
Thermal Cycling	T _{min} to T _{max} in 2 hours	T _{min} to T _{max} in 1 hour	T _{min} to T _{max} in 2 hours	T _{min} to T _{max} in 2 hours	T _{min} to T _{max} in 1 hour
Humidity	Relative humidity between 0% to 100%				
Rainfall	N/A	See Section 5.2	See Section 5.2	N/A	See Section 5.2
Icing/Freezing Rain	N/A	See Section 5.3	See Section 5.3	N/A	See Section 5.3
Water Spray	N/A	See Section 5.4	See Section 5.4	N/A	See Section 5.4
Altitude	-200 to 12,000 feet				
Salt Fog	N/A	See Section 5.1	See Section 5.1	N/A	See Section 5.1
Contaminants	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7
Sunlight	N/A	N/A	See Section 5.8	N/A	N/A
Tunnel Temperature	284 F (140 C)	284 F (140 C)	284 F (140 C)	284 F (140 C)	284 F (140 C)
Electrical Environment	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3

Table 4-1 General Environmental Requirements (1 of 5)

Tier II Freight

	Control Area 1	Control Area 2	Control Area 3	Control Area 4	Control Area 5
Vibration	See Figure 4-3b for index	See Figure 4-3c for index	See Figure 4-3c for index	See Figure 4-3c for index	See Figure 4-3c for index
Mechanical Shock during shipping	See Section 7.2				
Mechanical Shock when operating	See Section 7.3				
High Temp, T_{\max}	158 F (70 C)	158 F (70 C)	158 F (70 C)	158 F (70 C)	158 F (70 C)
Low Temp T_{\min}	-40 F (-40 C)				
Thermal Cycling	T_{\min} to T_{\max} in 12 hours	T_{\min} to T_{\max} in 2 hours	T_{\min} to T_{\max} in 2 hours	T_{\min} to T_{\max} in 2 hours	T_{\min} to T_{\max} in 2 hours
Humidity	Relative humidity between 0% to 100%				
Rainfall	N/A	N/A	N/A	N/A	N/A
Icing/Freezing Rain	N/A	N/A	N/A	N/A	N/A
Water Spray	N/A	N/A	N/A	N/A	N/A
Altitude	-200 to 12,000 feet				
Salt Fog	N/A	N/A	N/A	N/A	N/A
Contaminants	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7
Sunlight	N/A	N/A	N/A	N/A	N/A
Tunnel Temperature	N/A	212 F (100 C)	212 F (100 C)	212 F (100 C)	212 F (100 C)
Electrical Environment	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 2	See Section 6 Radiated Susceptibility Level 2	See Section 6 Radiated Susceptibility Level 2	See Section 6 Radiated Susceptibility Level 2

Table 4-1 General Environmental Requirements (2 of 5)

Tier II Freight

	Control Area 6	Control Area 7	Control Area 8	Control Area 9	Dynamic Braking Box
Vibration	See Figure 4-3b for index	See Figure 4-3c for index	See Figure 4-3c for index	See Figure 4-3e for index	See Figure 4-3c for index
Mechanical Shock during Shipping	See Section 7.2				
Mechanical Shock when Operating	See Section 7.3				
High Temp, T_{\max}	122 F (50 C)	122 F (50 C)	122 F (50 C)	140 F (60 C)	257 F (125 C)
Low Temp T_{\min}	-40 F (-40 C)				
Thermal Cycling	T_{\min} to T_{\max} in 2 hours	T_{\min} to T_{\max} in 2 hours	T_{\min} to T_{\max} in 2 hours	T_{\min} to T_{\max} in 1 hours	T_{\min} to T_{\max} in 2 hour
Humidity	Relative humidity between 0% to 100%				
Rainfall	N/A	N/A	N/A	N/A	See Section 5.2
Icing/Freezing Rain	N/A	N/A	N/A	N/A	See Section 5.3
Water Spray	N/A	N/A	N/A	N/A	See Section 5.4
Altitude	-200 to 12,000 feet				
Salt Fog	N/A	N/A	N/A	N/A	See Section 5.1
Contaminants	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7
Sunlight	N/A	N/A	N/A	N/A	N/A
Tunnel Temperature	212 F (100 C)	212 F (100 C)	N/A	N/A	284 F (140 C)
Electrical Environment	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3

Table 4-1 General Environmental Requirements (3 of 5)

Tier II Freight

	Engine Compartment	Engine / Alternator Mounted	Operator's Cab	Operator / Helper's Console	Overhead Console
Vibration	See Figure 4-3d for index	See Figure 4-3d for index	See Figure 4-3b for index	See Figure 4-3b for index	See Figure 4-3b for index
Mechanical Shock during Shipping	See Section 7.2				
Mechanical Shock when Operating	See Section 7.3				
High Temp, T _{max}	212 F (100 C)	302 F (150 C)	158 F (70 C)**	158 F (70 C)**	158 F (70 C)**
Low Temp T _{min}	-40 F (-40 C)				
Thermal Cycling	T _{min} to T _{max} in 0.5 hour	T _{min} to T _{max} in 15 minutes	T _{min} to T _{max} in 12 hours	T _{min} to T _{max} in 12 hours	T _{min} to T _{max} in 12 hours
Humidity	Relative humidity between 0% to 100%				
Rainfall	N/A	N/A	N/A	N/A	N/A
Icing/Freezing Rain	N/A	N/A	N/A	N/A	N/A
Water Spray	See Section 5.4	See Section 5.4	N/A	N/A	N/A
Altitude	-200 to 12,000 feet				
Salt Fog	See Section 5.1	See Section 5.1	N/A	N/A	N/A
Contaminants	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7
Sunlight	N/A	N/A	See Section 5.8	See Section 5.8	N/A
Tunnel Temperature	284 F (140 C)	302 F (150 C)	N/A	N/A	N/A
Electrical Environment	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3

Table 4-1 General Environmental Requirements (4 of 5)

****** This temperature is based on the thermal management system being operative. If system is not operative (e.g., air conditioner not operating), temperature in compartment may rise by as much as 5 C

Tier II Freight

	Platform Mounted	Radiator Cab	Radio Equipment Area	Roof Of Operator's Cab	Truck Mounted
Vibration	See Figure 4-3f for index	See Figure 4-3e for index	See Figure 4-3b for index	See Figure 4-3b for index	See Figure 4-3f for index
Mechanical Shock during Shipping	See Section 7.2				
Mechanical Shock when Operating	See Section 7.3				20 g peak
High Temp, T _{max}	122 F (50 C)	158 F (70 C)	158 F (70 C)**	122 F (50 C)	122 F (50 C)
Low Temp T _{min}	-40 F (-40 C)				
Thermal Cycling	T _{min} to T _{max} in 2 hours	T _{min} to T _{max} in 1 hour	T _{min} to T _{max} in 12 hours	T _{min} to T _{max} in 1 hour	T _{min} to T _{max} in 12 hours
Humidity	Relative humidity between 0% to 100%				
Rainfall	See Section 5.2	See Section 5.2	N/A	See Section 5.2	See Section 5.2
Icing/Freezing Rain	See Section 5.3	See Section 5.3	N/A	See Section 5.3	See Section 5.3
Water Spray	See Section 5.4	See Section 5.4	N/A	See Section 5.4	See Section 5.4
Altitude	-200 to 12,000 feet				
Salt Fog	See Section 5.1	See Section 5.1	N/A	See Section 5.1	See Section 5.1
Contaminants	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7	See Section 5.7
Sunlight	See Section 5.8	N/A	N/A	See Section 5.8	See Section 5.8
Tunnel Temperature	284 F (140 C)	284 F (140 C)	N/A	284 F (140 C)	284 F (140 C)
Electrical Environment	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3	See Section 6 Radiated Susceptibility Level 3

Table 4-1 General Environmental Requirements (5 of 5)

** This temperature is based on the thermal management system being operative. If system is not operative (e.g., air conditioner not operating), temperature in compartment may rise by as much as 5 C

4.3 Vibration Profiles

Random vibration is induced at the point of a component's attachment to the locomotive by a variety of excitations and machinery induced random disturbances. Sinusoidal vibration is induced by periodic excitations from rotating equipment and the engine's combustion process. Because the combined sinusoidal and random vibration that occurs during the unit's service life is assumed to be more severe than sinusoidal and random vibration considered separately, the combined environment is provided in the LMS Tech Manager Reporting Seat and is hereafter referred to as random vibration.

4.3.1 How Vibration Profiles were Created

Tier II Freight

A random vibration environment is expressed as an acceleration spectral density in g^2/Hz (commonly termed power spectral density or simply PSD) over a defined frequency range. To create a time-varying environment, the PSD used for test purposes is the envelope of the spectra for each of a series of time segments (in this case 6-second) overlapped by at least 50 percent. For test purposes, the frequency range provided in this publication is 5 to 1200 Hz with a bandwidth of 0.610352 Hz. The only exceptions are the truck and axle mounted components, where because of the need to provide levels down to 0.6 Hz, the maximum frequency is limited to 500 Hz with a bandwidth of 0.190735 Hz. If more detailed evaluations are required, contact GETS Engineering for levels up to 2000 Hz (except truck and axle).

All levels are based on actual measurements, statistically adjusted for expected spectral levels. For qualification testing an 80/60 confidence level has been selected (i.e., the level of the extreme expected environment is that level not exceeded on at least 80 percent of the fleet conditions, estimated at a 60 percent confidence level). The statistical estimates are made assuming a lognormal unit-to-unit variability having a standard deviation of 15 percent. As a result the estimated levels are greater than the estimated means (namely, the average of the logarithmic values of the spectral levels of data from all available samples) depending upon the number of samples. Each final profile is a smoothed spectra, enveloped by connecting the major peaks.

Vibration levels are dependent on engine speed. Table 4-1 shows the notch duty cycle for a typical locomotive. For test purposes, some engine notch conditions can be combined into one vibration profile. This table shows the conditions that can be combined.

4.3.2 Locating Vibration Data

All applicable vibration data is located on the server, "lms on jammu". [\\Eritrnjamg01.rail.ad.trans.ge.com/lms/VACEVS_Locomotive](http://Eritrnjamg01.rail.ad.trans.ge.com/lms/VACEVS_Locomotive) Available data for individual locomotives includes FFTs, statistical data, time data and photographs of accelerometers for each location surveyed. The combination data from multiple locomotives that is available includes PSD data, PSD spreadsheets and the vibration profile. Figure 4-1 outlines the structure of the data that is located on the server.

Some files such as FFTs, statistical data and PSD data must be accessed from the Navigator in the LMS Tec. Manager Reporting Seat tool. The reporting seat setup file and installation manual can be found on the "lms on jammu" server in the folder "software/lms_Reporting_seat". After installing the reporting seat and opening the navigator tool, follow the path shown in Figure 4-2 to get to the Evolution Series Locomotive data.

Figure 4-3 provides an initial list of the locomotive locations for which vibration data has been collected. The tabulation includes location descriptions, location designation as referenced in the locomotive schematic in Appendix A and the vibration tracking number for finding the applicable data on the "lms on jammu" server. The figures also include the top and side view of each cab with the vibration tracking number used to denote the approximate vibration survey locations.

Engine Notch	Ave. % of time	Ave. % of time
Idle/Skip Fire	57	57
N1	7	12
N2	5	
N3	4	7
N4	3	
N5	3	7
N6	2	
N7	2	
N8	9	9
DB/Skip Fire	8	8
Total	100	100

Table 4-1 Typical Locomotive Duty Cycle Profile

Tier II Freight

- lms on jammu
 - ACEVS_Locomotive
 - AC
 - Loc_01
 - Combined_Sep03
 - Vibration_Profile_N8 (Excel file)
 - Vibration_Profile_N5-7 (Excel file)
 - Vibration_Profile_N3-4 (Excel file)
 - Vibration_Profile_N3-8 (Excel file)
 - Vibration_Profile_Idle_SkipFire (Excel File)
 - Vibration_Profile_DB_SkipFire (Excel File)
 - PSD_Spreadsheets (Excel file)
 - ASCII_Files (not for use)
 - UP5698_Apr03
 - FFT (access via LMS reporting seat xxxx_fd)
 - Time Data (access via LMS reporting seat xxxx_td)
 - Engine Sweep (access via LMS reporting seat xxx_swp)
 - FFT-PSD Mode (access via LMS reporting seat xxx_psd)
 - Photos (JPG)
 - Statistical_Data (Excel file)
 - UP5699_Mar03
 - GE2005_Sep03
 - Historical_Combinations
 - Combined_Dec02
 - Combined_May03
 - Loc_02
 - Loc_03
 - EC
 - MC
 - RC
 - PL
 - DCEVS_Locomotive
 - AC4400_Locomotive
 - AC6000_Locomotive
 - Dash_9_Locomotive
 - Truck
 - AC_Hi_Ad
 - Loc_01
 - DC_Hi_Ad
 - Gen_1_Steerable

Figure 4-1 Vibration data file structure in “lms on jammu” server

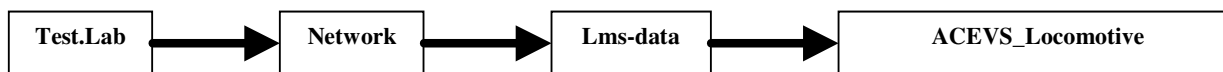


Figure 4-2 Path to vibration data from LMS Tec. Manager Reporting Seat Navigator

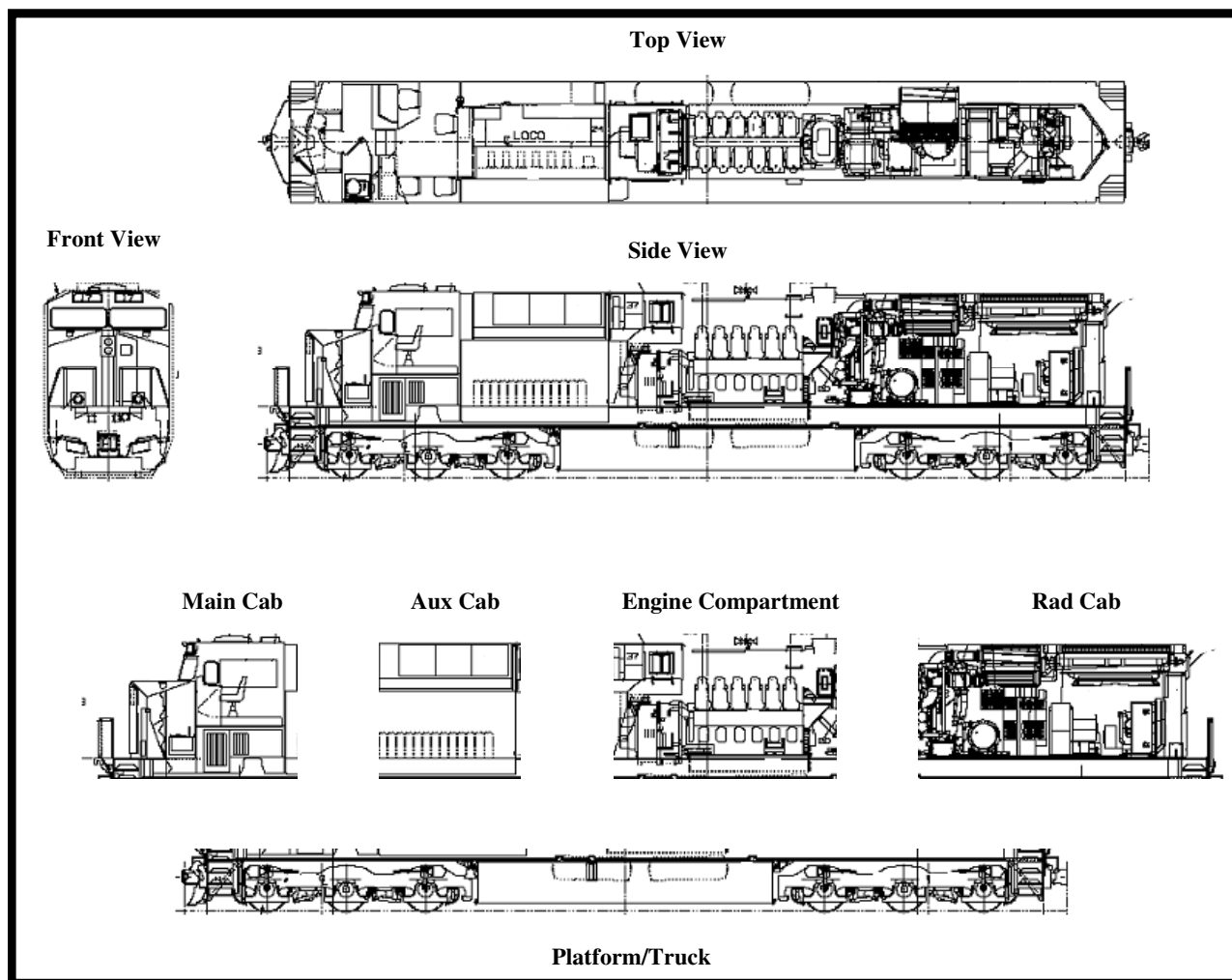
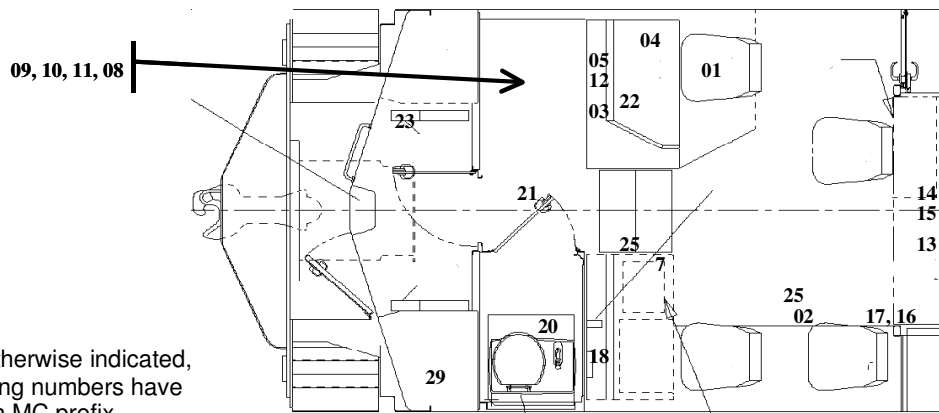
Tier II Freight

Figure 4-3a Locomotive Diagram with five sections identified

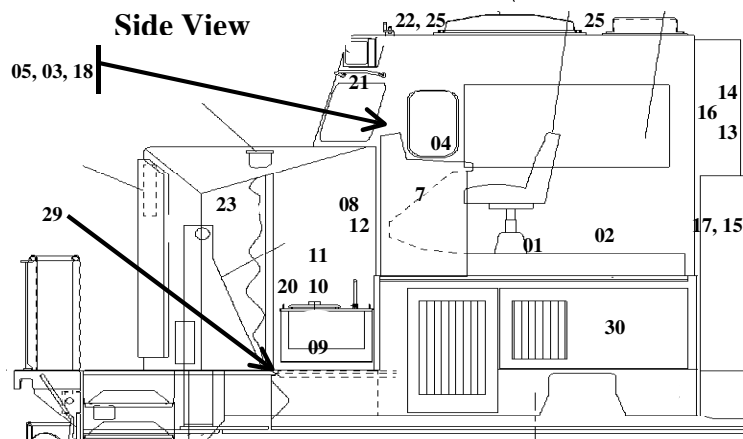
Tier II Freight

Top View



Unless otherwise indicated,
all tracking numbers have
an MC prefix

Side View

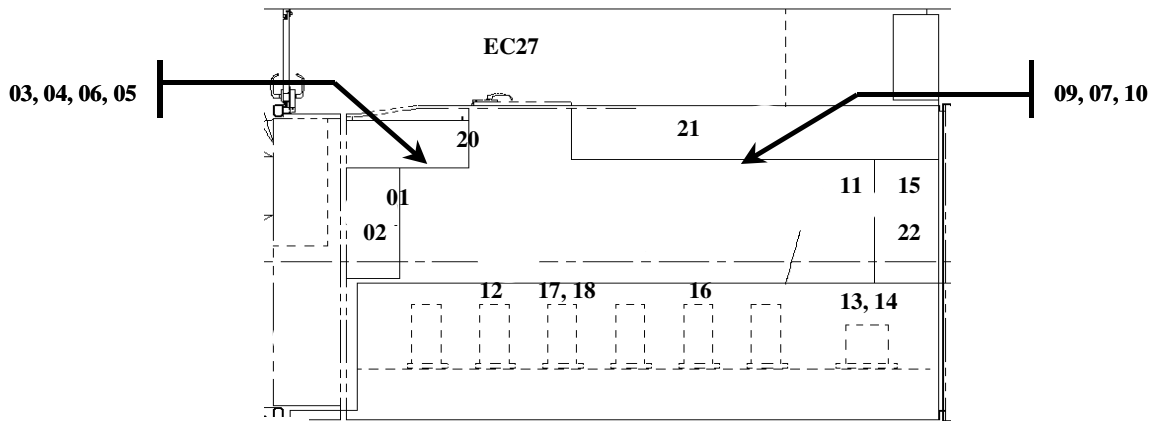


Description	Vibration Tracking #	Description	Vibration Tracking #
Operator's Seat Base	MC01	FIRS	MC16
Ice Box / Fridge	MC02	CMU Top Right Corner	MC17
Op Left display – top left corner – in plane	MC03	Conductor's Display	MC18
Right Rear Corner of Throttle Base	MC04	Rear Engine Foot B Side	MC19
Op Right display – top left corner	MC05	Toilet compartment	MC20
Rear Right Corner of Radio	MC06	RM&D Camera	MC21
Load Control Rack	MC07	Roof #1 End A-Side	MC22
LSI Rack Top Shelf	MC08	Compressed Air Valve	MC23
LSI Rack Fifth Shelf	MC09	Alternator Foot	MC24
LSI Rack Fourth Shelf	MC10	Roof #2 End B-Side	MC25
LSI Rack Third Shelf	MC11	Air Rack center of gravity	MC26
Back of Engineer's Console	MC12	Air Rack foot -- #2 End	MC27
CIO Bottom Right	MC13		
CIO Top Left	MC14	Transtronic Inverter Box	MC29
CPF Top Right Corner	MC15	HVAC Foot	MC30

Figure 4-3b Main cab vibration survey locations

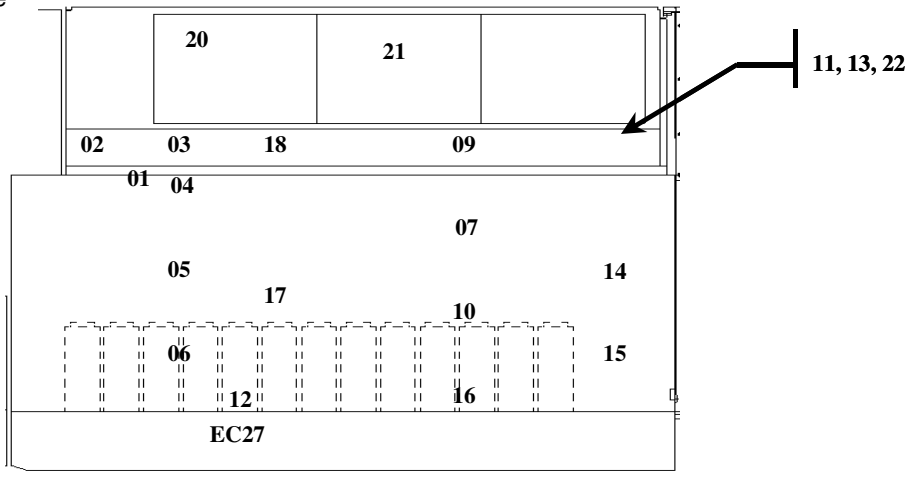
Tier II Freight

Top View



Unless otherwise indicated,
all tracking numbers have
an AC prefix

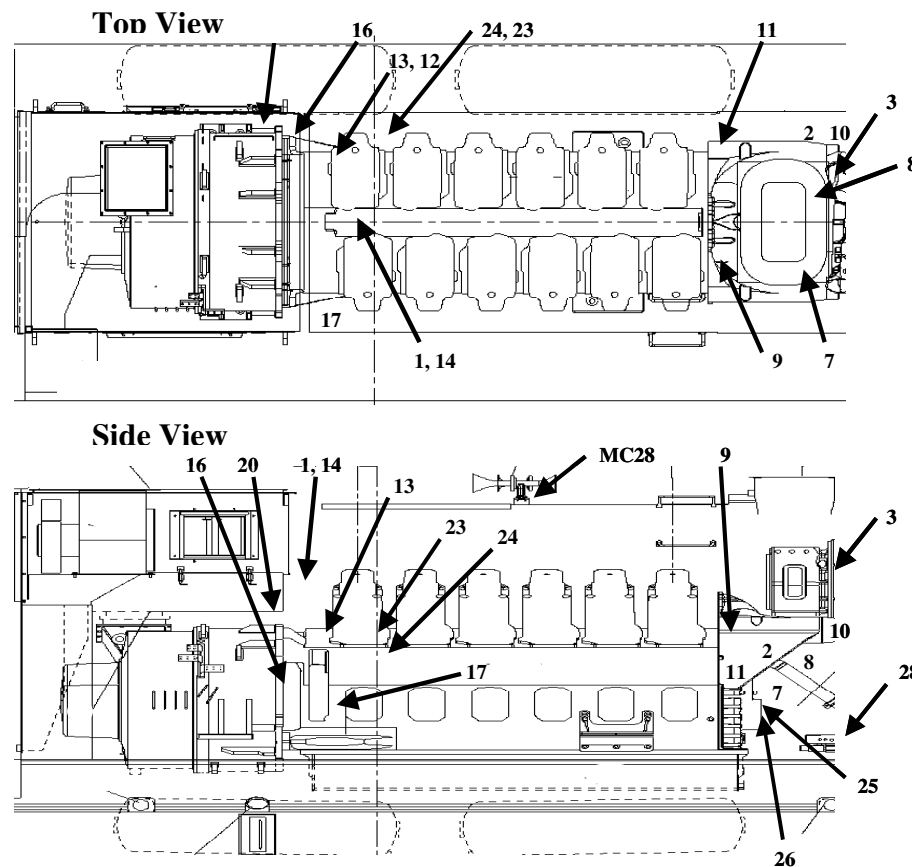
Side View



Description	Vibration Tracking #	Description	Vibration Tracking #
TMC Top Left Corner	AC01	RCM Middle	AC14
Contacto Top Left Corner	AC02	ACT	AC15
CDS Bottom Left Corner	AC03	C5C2 GE capacitor	AC16
LPS Top Left Corner	AC04	IGBT bank 3 middle	AC17
LPS Bottom Right Corner	AC05	IGBT bank 4 top	AC18
GP3 Top Left Corner	AC06	Rear Engine Foot B Side	AC19
AAC Bottom Left Corner	AC07	Dynamic Brake Box A-side #1 end mounting	AC20
TA3 Bottom Left Corner	AC08	Dynamic Brake Box middle mounting foot	AC21
AAC Top Right Corner	AC09	Top near FFR and R2	AC22
RFCl Top Right Corner	AC10	Engine Sensor EFT	AC23
ECU Top Left Corner	AC11	Alternator Foot	AC24
GE Capacitor C21/C22	AC12	Control Area 7	None
RCM Top	AC13	Battery Box Floor	EC27

Figure 4-3c Aux cab vibration survey locations

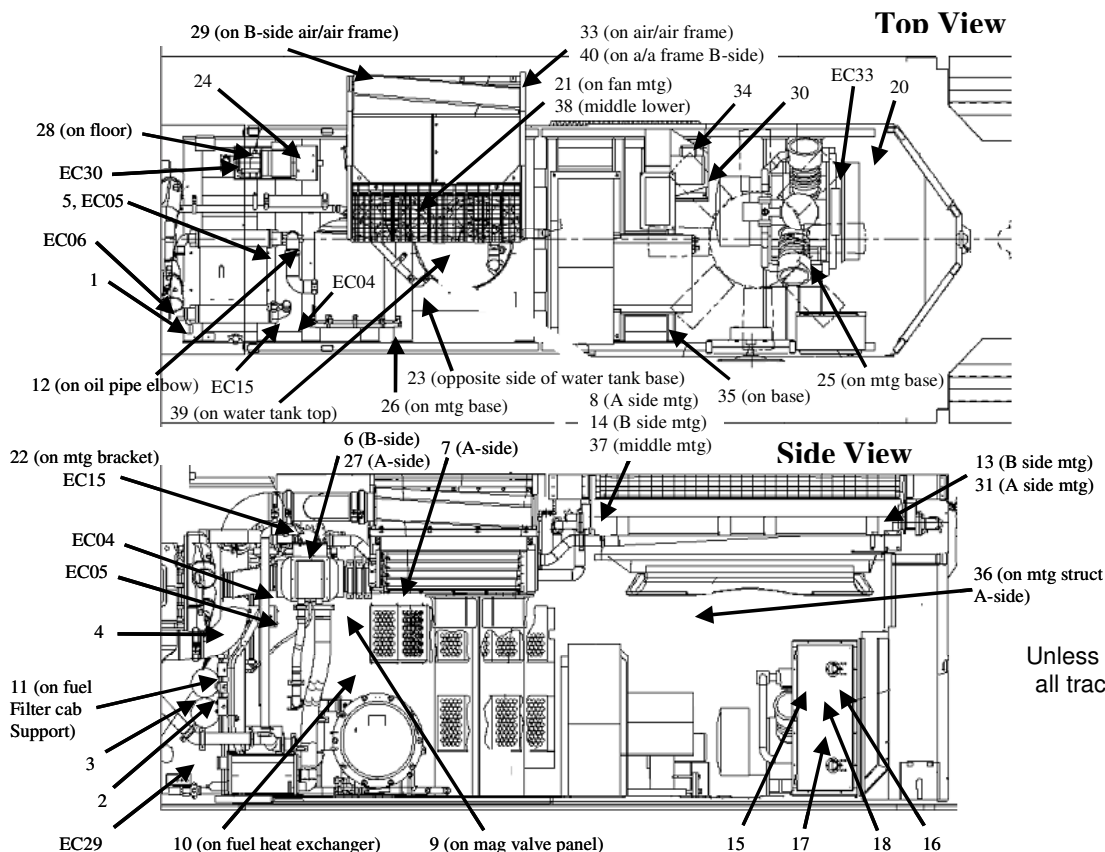
Tier II Freight



Description	Vibration Tracking #	Description	Vibration Tracking #
Engine Sensor MAP	EC01	Engine Sensor EWOT	EC15
Engine Sensor TCMP	EC02	Engine Sensor ECS (Crank speed sensor)	EC16
Engine Sensor TRS	EC03	Engine Sensor BOS	EC17
Engine Sensor EAFP	EC04	Compressor mounting base	EC18
Engine Sensor ATT	EC05	Rear Engine Foot B Side	EC19
Braze oil cooler #1 End B Side inlet pipe	EC06	Engine Sensor connection pannel	EC20
Engine Sensor ELPP/ELPT	EC07		
Engine Sensor EWIT	EC08	Fuel monitor	EC22
Engine Sensor ELIT	EC09	EFI harness at pump	EC23
Engine Sensor IFE	EC10	EFI harness on engine	EC24
Engine Sensor EFT	EC11	EngineFuel Pressure Sensor	EC31
Engine Sensor ECAM	EC12	Alternator Foot	EC32
Engine Sensors ELIP & COP	EC13		
Engine Sensors Air Manifold MAT	EC14	Horn	MC29

Figure 4-3d Engine compartment vibration survey locations

Tier II Freight



Description	Vibration Tracking #	Description	Vibration Tracking #	Description	Vibration Tracking #
Brazed oil cooler #1 End B Side	RC01	Rear Engine Foot B Side	RC19	Radiator – middle #1 End	RC37
Cab support for the fuel filters B Side	RC02	Compressor Valve Panel	RC20	Air to Air Frame middle lower	RC38
Cab sprt for fuel filters middle lower filter	RC03	Air to air fan/motor set #1	RC21	Water Tank top	RC39
Charge air return ducts	RC04	univalve	RC22	Air to Air Frame B Side	RC40
Brazed oil cooler #2 End A Side	RC05	Water tank -- Base	RC23	Engine Sensor EAFF	EC04
Water based intercooler -- B Side	RC06	Fuel Pump	RC24	Engine Sensor ATT	EC05
Air to air frame – A Side	RC07	Compressor mounting base	RC25	Braze oil cooler #1 end B side inlet pipe	EC06
Radiator A Side #1 End	RC08	lube oil filter	RC26	Engine Sensor EWOT	EC15
mag valve a2a fan shutters	RC09	Water based intercooler – A Side	RC27	Air Dryer	EC21
Fuel Manifold -- in plane of object	RC10	Pre-Lube Motor Pump	RC28	Engine oil pipe out	EC25
Cab support for the fuel filters A Side	RC11	Shutters "B" side-shutter plane	RC29	Engine oil pipe out fitting	EC26
Brazed oil cooler #2 End A Side elbow	RC12	Compressed Air Valve Panel	RC30	Water dump valve	EC28
Radiator B Side #2 End	RC13	Radiator A Side #2 End	RC31	Acc on oil pipe - pre-lube check valve	EC29
Radiator B Side #1 End	RC14	Alternator Foot	RC32	Water fill control panel	EC30
contactor middle #1 End	RC15	Shutters "A" side-shutter plane	RC33	Compressor rapid unloader valve	EC33
contactor middle #2 End	RC16	Exhauster Blower Motor Foot	RC34		
contactor lower middle	RC17	Traction motor blower base	RC35		
contactor center	RC18	Rad Fan Support Structure	RC36		

Figure 4-3e Rad cab vibration survey locations

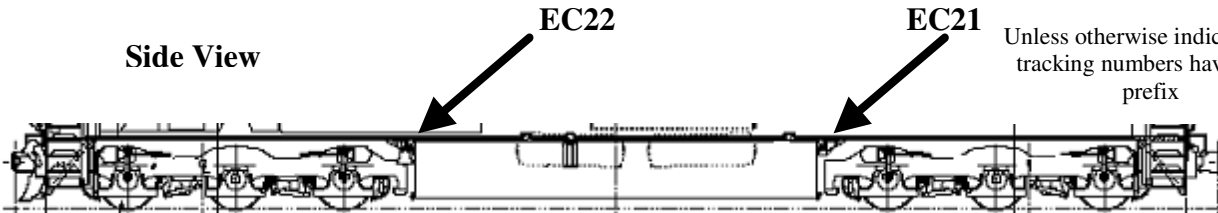
Figure 4-3f Platform/Truck vibration survey locations

Tier II Freight

Ton View



Side View



Unless otherwise indicated
tracking numbers have a l
prefix

Description	Vibration Tracking #	Description	Vibration Tracking #
Fuel Monitor	EC22		
Air Dryer	EC21		

Figure 4-3f Platform/Truck vibration survey locations

Tier II Freight

5 ENVIRONMENTAL CONDITIONS

5.1 Salt Fog

The component shall be able to withstand, without damage or malfunction, heavy salt spray consisting of 5 + 1 % salt concentration (by weight) with fallout rate between 0.00625 and 0.0375 ml/cm²/hr (0.00134 and 0.00923 gal/ft²/hr).

5.2 Rain

The component shall be capable of operating in rain and preventing the penetration of rainfall using a minimum rate of 13 cm/hour (0.4265 ft/hr) and an accompanying wind rate of 18 m/sec (59.055 ft/sec). The water droplets shall be between 0.5 to 4.5 mm (0.0197 to 0.177 in.) in diameter.

5.3 Icing/Freezing Rain

The component shall withstand being subjected to condensed frozen or liquid water during 20% of it's life.

5.4 Water Spray

The component shall be able to withstand, without damage or malfunction, pressurized water having a minimum nozzle pressure of 377kPa (54.68 psia) producing water droplets traveling at approximately 64 km/h (39.77 mph), with water droplet size between 2 and 4.5 mm (0.079 and 0.177 in.) in diameter.

The component shall be able to withstand, without damage or malfunction, pressurized water producing a direct spray at 276kPa (40 psia) flowing from a 6.35 mm (0.25 inch) diameter orifice at a distance of 1.22 m (4 feet) for 10 minutes.

5.5 Sand

Any component mounted on the exterior of the locomotive, or otherwise exposed to outside air, shall be able to withstand, without damage or malfunction, sand composed of 95% by weight of SiO₂ with particle size that varies from 1 to 650 microns (0.0000394 to 0.02559 in.) in diameter. The sand concentration shall be 1.1 + 0.25 g/m³ (0.0000687 + 0.0000156 lbm/ft³). The air velocity shall be 29 m/sec (95.144 ft/sec) oriented perpendicular to each of the component faces.

5.6 Dust

Any component mounted on the exterior of the locomotive, or otherwise exposed to outside air, shall be able to withstand, without damage or malfunction, dust comprised of red china clay (10 + 5% of Fe₂O₃, 20 + 10% of Al₂O₃, 5% solubility's and 65 + 15% SiO₂ and other impurities) or silicon flour (97 to 99% of SiO₂) of particle size that varies from 1 to 650 microns (0.0000394 to 0.02559 in.) in diameter. The dust concentration shall be 10.6 + 7 g/m³ (0.00066 + 0.000437 lbm/ft³). The air velocity shall be 8.9 m/sec (29.2 ft/sec) oriented perpendicular to each of the component faces.

5.7 Contaminants

The component shall be capable of resisting the effects of contaminants which may penetrate the component. The component shall function in the presence of the following list of contaminants and any other corrosives, where appropriate, without experiencing degradation in performance and reliability.

Tier II Freight

Silica (SiO ₂).	Carbon dust - including coal
Iron (FeO ₃).	Copper dust.
Iron dust (Fe ₂ O ₃ -rust).	Brake Shoe Dust.
Acid Base Water (Car -Wash).	Carbon Monoxide
Water vapor.	Sulfur Dioxide
Salt air	Hydrogen Sulfide
Oxides of Nitrogen	Oil vapor (Diesel engine exhaust fumes fuel and Lube Oil).
Ozone	Common cleaning solutions (detergents).

Table 5-1 Contaminants

5.8 Sunlight

The component shall be able to withstand, without damage or malfunction, sunlight for 60% of the life of the component. The sunlight shall be defined with a peak air temperature of 43°C (109.4 °F) and a solar radiation intensity of 1120 W/m² (355.127 BTU/hr/ft²).

Tier II Freight

6 ELECTRICAL ENVIRONMENT

The component shall be self-compatible and compatible with all other components. Externally generated electromagnetic emission (EME) from power cabling, switching functions, inductive transients, radio frequency (RF) transmissions, etc. as stated herein; shall not cause abnormal operation due to electromagnetic interference (EMI), including inadvertent alarms, data transfer errors, or out-of-tolerance perturbations. RF transmission interference includes radiation from a cab-mounted transmitter, transmitters mounted on other sources and portable/ground-based transmitters. The component shall also not generate EMI to cause abnormal operation on any other electronic component.

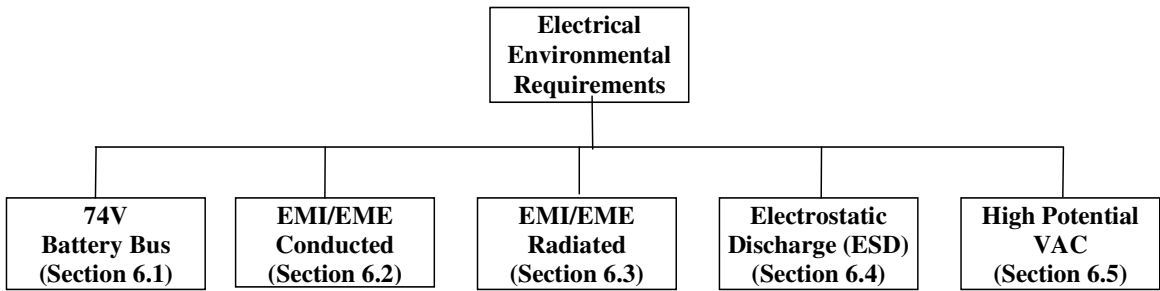


Figure 6-1. Electromagnetic Environmental Requirements

6.1 The 74V Battery Bus

6.1.1 Operating Characteristics

Normal Operation: Unless otherwise specified, all devices must operate normally (within specification) from 45 to 87 volts continuously.

Cranking Operation: If the device is required to operate through cranking (see Figure 6-2) it must operate normally (within specification) under the following conditions (unless otherwise specified):

- Battery voltage down to 25 volts continuously
- Battery supply voltage drop to zero volts due to less than 1 milliohm load impedance for 25 milliseconds, returning to 25 volts until the cranking cycle ends. Assume a source impedance of 9-50 milliohms

Tier II Freight

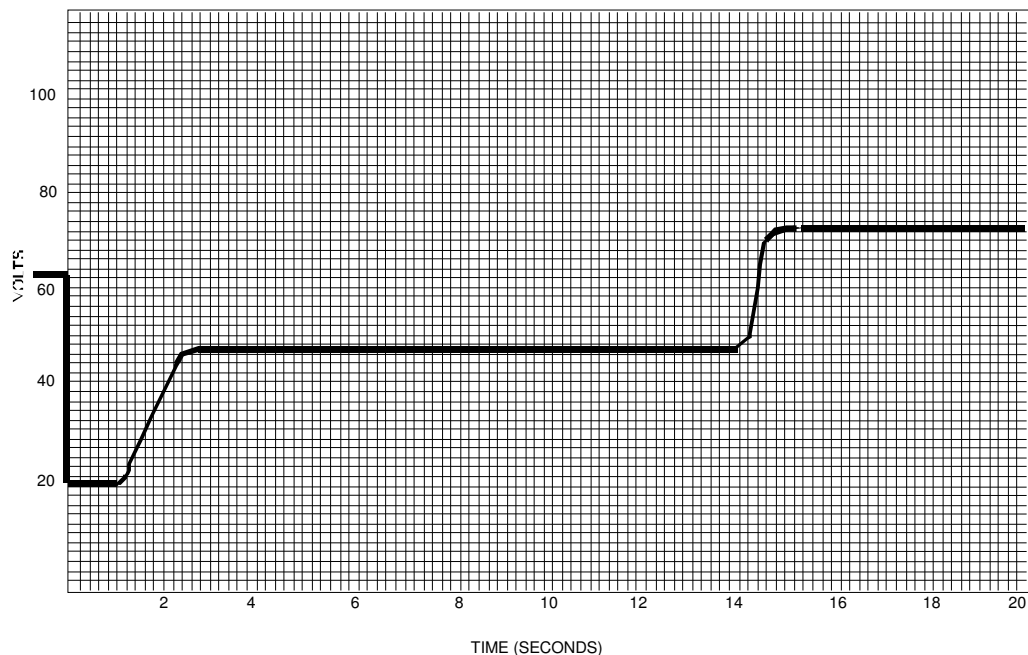


Figure 6-2. Typical Locomotive 74-Volt Bus Voltage Range During Cranking
(Per AAR Locomotive Electronics Architecture Specification)

6.1.2 Survivability Requirements

Reverse Polarity: When directly attached to the battery system, no device shall suffer permanent damage when the power line polarity is reversed

Continuous Voltage: When directly attached to the battery system, no device shall suffer permanent damage when the voltage is between 0 and 85 volts continuous

Transient Associated with Failed Crank: When directly attached to the battery system, no device shall suffer permanent damage from a $\pm 600\text{ V}$ FWHM, 5 millisecond, 26 Joule transient between the battery positive (+) and negative (-). These pulses are usually associated with failed cranking, so assume there will be at least fifteen pulses, 20 seconds apart (per specification 84A207887AA Rev. B, section 8.4 calls for 15 cranks in succession for battery loading requirements and system design purposes). A typical test circuit is shown in Figure 6-3 where R1 is 2 ohms $\pm 10\%$ and RL is 50 ohms.

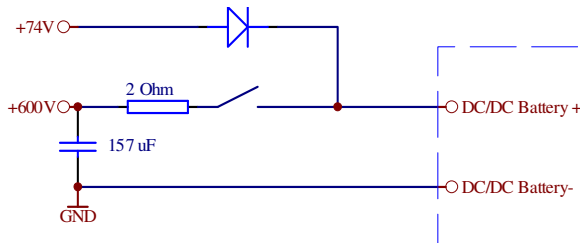


Figure 6-3. A typical test circuit for transients associated with failed crank

Tier II Freight

Transients Associated with a Ground Fault During Crank: Transients can be induced by cranking the local locomotive or by a MU-ed locomotive with a ground fault. (This is a **common mode transient**, as such both battery lines will see the transient at the same time.) Therefore, all devices must survive the following conditions without damage:

- Battery positive to ground 2000 volt DC of both polarities, applied for one minute continuous between the 74V battery bus and any point on the equipment that ties to locomotive chassis
- Battery negative to ground 2000 volt DC of both polarities, applied for one minute continuous between the battery and any point on the equipment that ties to the locomotive chassis.

6.2 EMI/EME Conducted

6.2.1 Conducted Susceptibility

6.2.1.1 Level 2 Susceptibility Test

All components shall operate without any failure or any degradation in performance when exposed to the following **Level 2** multiple burst transients based upon IEC 61000-4-4 specifications. Each outburst, lasting 15 ms and repeated every 300 ms, is composed of multiple pulses each with a 5 ns rise time and a 50 ns Full Width at Half Maximum (FWHM). Direct injection of 1 kV peak pulses with a 5 kHz rep rate will be used to test power lines and the returns, while a Capacitive Coupling Clamp or Direct Injection can be used to inject the 500 V peak pulses with a 5 kHz rep rate for signal/control lines. Both positive and negative polarities will be tested. Devices equipped with shielded signal/control lines can be tested with the shields installed.

6.2.1.2 Level 3 Susceptibility Test

All components shall operate without permanent failure or permanent degradation in performance when exposed to the following **Level 3** multiple burst transients based upon the IEC 61000-4-4 specification. Each outburst, lasting 15 ms and repeated every 300 ms, is composed of multiple pulses each with a 5 ns rise time and a 50 ns Full Width at Half Maximum (FWHM). Momentary upset, and automatic resets are allowed, but Operator intervention must be approved by GETS. Direct Injection of 2 kV peak pulses with a 5 kHz rep rate will be used to test power lines and the returns, while a Capacitive Coupling Clamp or Direct Injection can be used to inject the 1 kV peak pulses with a 5 kHz rep rate for signal/control lines. Both positive and negative polarities will be tested. Devices equipped with shielded signal/control lines can be tested with the shields installed.

6.2.2 Conducted EME

6.2.2.1 Conducted Transients Test

No equipment shall produce ripple, spikes, sags, or transients greater than +5% peak and 10% peak-peak of the input voltage on the power and power return lines.

This shall be verified by acquiring time domain voltage measurements while operating the device in all different operational modes, including startup and shut down. Startup and shut down transients may be waived if system operation is manually controlled. The detection system shall be able to detect 50 nsec FWHM pulses at 80% of the failure threshold.

6.2.2.2 Power Line Radio Frequency Conducted Emissions

The component shall not emit non-intentional conducted radio frequency noise above a level of 10 millivolts peak-to-peak from 50 kHz to 400 MHz on the battery line and its return.

6.2.2.3 Power Line Audio Frequency Conducted Emissions

The component shall not emit non-intentional conducted audio frequency noise above a level of 0.3 volts peak-to-peak from 30 Hz to 50 kHz on the battery line and its return.

6.2.2.4 Signal Line Radio Frequency Conducted Emissions

Tier II Freight

The component shall not emit non-intentional conducted radio frequency noise above a level of 16 millivolts peak-to-peak from 50 kHz to 100 MHz on a signal line and its return.

6.2.2.5 Signal Line Audio Frequency Conducted Emissions

The component shall not emit the non-intentional conducted audio frequency as defined in Table 6-1 on a signal line and its return:

Signal Frequency Range	Noise Level	Noise Frequency Range
900 Hz or Less	2 millivolts peak-peak	50 Hz to 50 kHz
Greater Than 900 Hz	16 millivolts peak-peak	50 Hz to 50 kHz

Table 6-1 Signal Line Conducted Audio Frequency Emissions

6.3 EMI/EME Radiated

The component shall be capable of operating in the presence of an electric field as defined in section 6.3.1. The component shall not contribute to the electromagnetic environment as defined in section 6.3.2.

6.3.1 Radiated Susceptibility

6.3.1.1 Environmental Levels

No component shall exhibit any deviation from operational specifications and tolerances when exposed to the Level 1 radiated fields of 1V/m, 80% 1 kHz AM, from 27 - 1000 MHz at a distance of 1 meter. No component shall exhibit any permanent damage when exposed to the Level 2 radiated fields of 10V/m, 80% 1 kHz AM, from 27 - 1000 MHz at a distance of 1 meter. IEC 61000-4-3, MIL-STD-461E, or equivalent test procedure will be followed. Appropriately scaled testing at 3 meters or 10 meters is permissible in lieu of testing at 1 meter.

6.3.1.2 Intentional Radiator Levels

This paragraph is applicable to equipment that will be operational in an area near where a walkie-talkie could be keyed. When called out in the product specification, all components shall operate as specified when exposed to the Level 3 radiated fields of 100 V/m, 80% 1 kHz AM in the frequency range 30 - 36 MHz, 140 - 165 MHz, and 415 - 465 MHz. If no radiators are present in one or more of the above bands, then no testing in that band is required.

6.3.2 Radiated Emissions

No component shall emit non-intentional radiation above the levels defined in Table 6-2 when measured with a certified receiver antenna system at 10kHz bandwidth and a distance of 1 meter. Appropriately scaled testing at 3 meters or 10 meters is permissible in lieu of testing at 1 meter. A larger bandwidth can be used but no correction will be allowed. The procedures in MIL-STD- 461E Method RE102, or equivalent will be followed.

Tier II Freight

Frequency	Electric Field Maximum Level (dB μ V/m)	Electric Field Maximum Level (μ V/m)
200 kHz	90	30,000
200 kHz - 30 MHz	90 to 39 except as noted below	Log-log straight decrease
27.21 - 27.30 MHz	30	30
30 - 88 MHz	39	90
88 - 160 MHz	44	150
160 - 165 MHz	30	30
165 - 216 MHz	44	150
216 - 450 MHz	46	210
450 - 460 MHz	37	70
460 - 1000 MHz	46	210

Table 6-2 Radiated Emission Levels

6.4 Electrostatic Discharge (ESD)

All cards or components shall operate without failure or degradation in performance after exposure to the unpowered condition levels in Table 6-3 with a certified ESD generator according to IEC 61000-4-2 or equivalent procedure. Any component unable to meet this specification must be labeled static sensitive and obtain GETS approval for use. Any device containing static sensitive components must be labeled "Contains Static Sensitive Devices."

All Cards and Panels shall not require operator intervention when tested to the powered condition levels in Table 6-3 with a certified ESD generator according to 61000-4-2 or equivalent procedure. Any device unable to meet this specification must be labeled static sensitive and obtain GETS approval for use.

Both Direct Contact and Air Discharge tests will be performed with positive and negative pulses.

Type	Condition	Direct Contact Discharge		Air Discharge
		Voltage (kV)	Current (amps)	Voltage (kV)
Cards	Unpowered	4	15.0	15
	Powered	2	7.5	15
Panels	Powered	6	22.5	20

Table 6-3 Electrostatic Discharge

6.5 HIGH POTENTIAL AC

During initial production testing and sometimes during field service, high potential testing is conducted on the locomotive to check wiring. Most equipment is usually disconnected during this locomotive test. If the equipment is not disconnected it must be able to survive without damage exposure to high potential voltages (60 Hz AC) as defined in Table 6-4 for one minute continuous. Leakage current greater than 5mA is not allowable without understanding the implication to the locomotive high potential test. Leakage increases by more than 50% during the one-minute test are not allowed. No charring, flushing or burning is allowed.

Tier II Freight

Locomotive Circuit	Test Voltage (VAC rms)
Propulsion	3000
Auxiliary	1300
Excitation	1000
Control	1000

Table 6-4 Main Locomotive Circuit Tests

Tier II Freight

7 Table 6-4 Main Locomotive Circuit Tests

7 LOCOMOTIVE HANDLING

7.1 Acceleration And Deceleration

During normal operation the equipment will be subjected to repeated sustained accelerations and decelerations of 5 mph/sec (maximum) in a horizontal direction; with an application rate of 4 mph/sec/sec (Jerk rate).

7.2 Mechanical Shock During Shipping

A component, when stored in its shipping and transportation configuration, shall be capable of withstanding the handling shocks of the type defined in Table 7.1. Damage to the shipping container is allowable provided the component is not damaged. When it is determined that testing is necessary to verify the ability to withstand these conditions, a test as defined in Table 7-1 is to be conducted.

These conditions apply for both shipping from the supplier to GETS as well as for spare parts provisioning to the customer.

Weight of Item and Case	See Note	Height of Drop	Number of Drops
Under 50 lb.	A	36 inches	Drop on each face, edge and corner for a total of 26 drops.
50 - 100 lbs	A	24 inches	Drop on each face and corner for a total of 14 drops.
100 - 500 lbs	A	18 inches	Drop on each corner for a total of 8 drops.
Over 500 lbs	B	12 inches	Drop on each bottom edge and bottom face for a total of 5 drops.

Table 7.1 Shipping and Handling

NOTES:

A. Drops shall be made from a quick release hook, or drop tester. The test item shall be oriented such that upon impact a line from the struck corner or edge to the center of gravity of the item and case is perpendicular to the impact surface. Repairs to the shipping container are not allowed between drops. The order of drops shall be randomly determined.

B. One edge of the base shall be supported on a sill five to six inches in height. The opposite edge shall be raised to the defined height and allowed to fall freely. The test shall be repeated for each of the bottom edges. Repairs to the shipping container are not allowed between drops. The order of drops shall be randomly determined.

7.3 Mechanical Shock When Operating

Shock (impact) is considered to be vibration caused by a short-time impulsive non-repetitive force. During hard coupling of the locomotives, RUs will typically see a shock pulse consisting of an initial short-period (3.1 milliseconds) impulse, and followed by a longer period (0.18 seconds) pulse. Note that these time bases are for the full-period sinusoidal excitations. Typical levels are shown in Table 7.2. The restoring peak acceleration is less than 25% of the peak applied. Assume hard coupling of locomotives will occur one per week

Tier II Freight

Axis	Short-Period Peak Amplitude	Long-Period Peak Amplitude
Lateral	1.5 g	1.0 g
Longitudinal	3.0 g	2.5 g 3.5 g's (engine/alternator)
Vertical	1.8 g	1.3 g

Table 7.2 Typical Mechanical Shock Levels for Hard Coupling

Tier II Freight

8 Appendix A

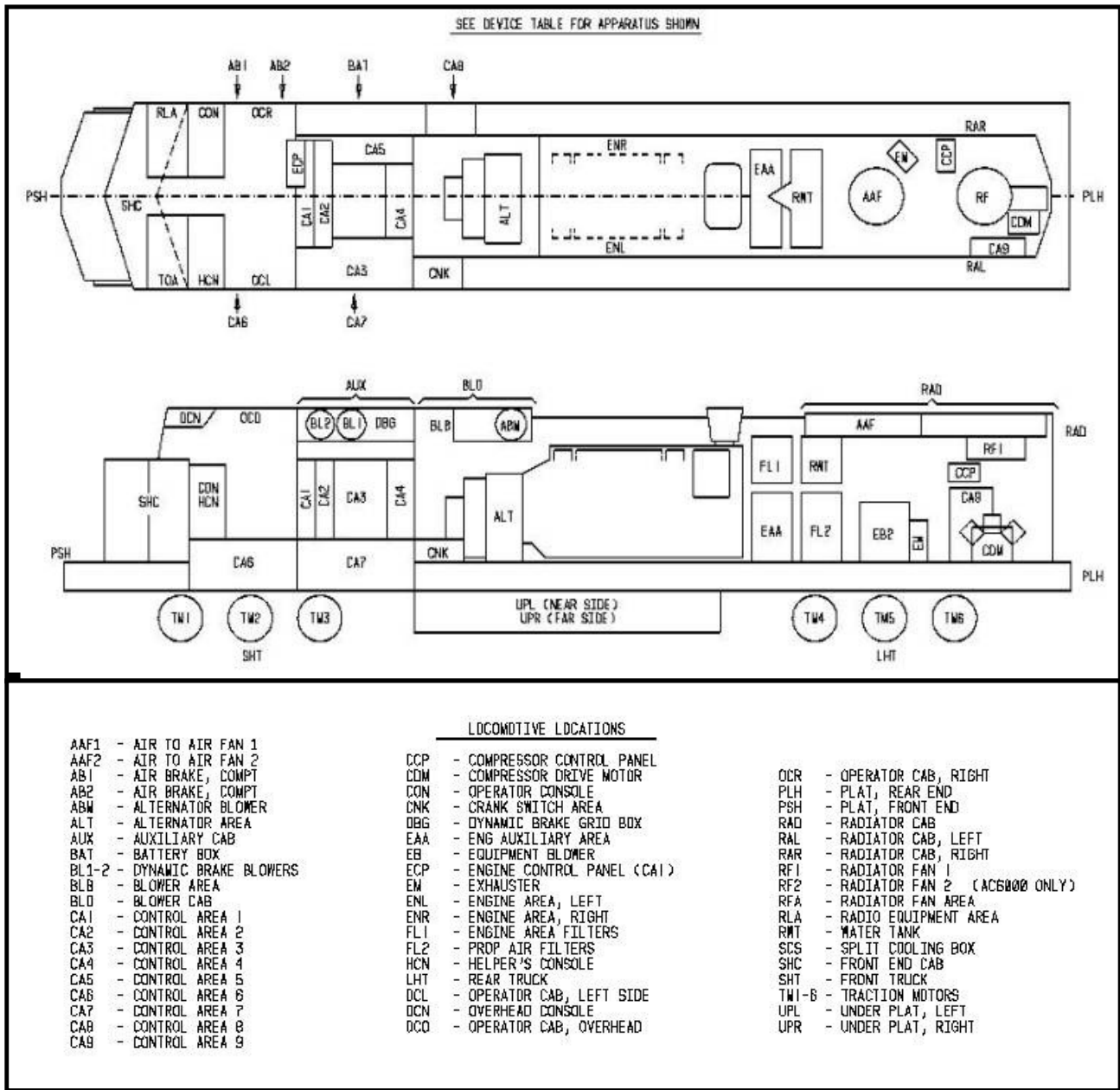
Appendix B

Locomotive Schematic

Locomotive Ambient Operating Environment Profile

Distribution FOR CONTINENTAL UNITED STATES

The following table provides a range of ambient temperatures normally found in the continental United States over a 12-month period, and the percentage of time different areas based on altitude will experience specific levels. When the locomotive is operated as a trailing unit, the ambient temperature will normally rise by as much as 10 C.



Tier II Freight

9 Appendix B Locomotive Ambient Operating Environment Profile Distribution FOR CONTINENTAL UNITED STATES

The following table provides a range of ambient temperatures normally found in the continental United States over a 12-month period, and the percentage of time different areas based on altitude will experience specific levels. When the locomotive is operated as a trailing unit, the ambient temperature will normally rise by as much as 10 C.

Baro Pres.	in HG	29.9 - 28.9	28.9 - 27.8	27.8 - 26.8	26.8 - 25.8	25.8 - 24.9	24.9 - 24.0	24.0 - 23.1	23.1 - 22.2	22.2 - 21.4	21.4 - 20.6
Alt	ft	0 - 1000	1000 - 2000	2000 - 3000	3000 - 4000	4000 - 5000	5000 - 6000	6000 - 7000	7000 - 8000	8000 - 9000	9000 - 10000
T°F [T°C]	Total %	63.50	12.50	9.10	5.70	3.40	2.30	1.10	1.05	1.00	0.30
-40 to -30 [-40 to -34]	0.10	0.064	0.013	0.009	0.006	0.003	0.002	0.001	0.001	0.001	0.000
-30 to -20 [-34 to -29]	0.20	0.127	0.025	0.018	0.011	0.007	0.005	0.002	0.002	0.002	0.001
-20 to -10 [-29 to -23]	0.30	0.191	0.038	0.027	0.017	0.010	0.007	0.003	0.003	0.003	0.001
-10 to 0 [-23 to -18]	0.70	0.445	0.088	0.064	0.040	0.024	0.016	0.008	0.007	0.007	0.002
0 to 10 [-18 to -12]	2.10	1.334	0.263	0.191	0.120	0.071	0.048	0.023	0.022	0.021	0.006
10 to 20 [-12 to -7]	3.80	2.413	0.475	0.346	0.217	0.129	0.087	0.042	0.040	0.038	0.011
0 to 30 [-7 to -1]	7.20	4.572	0.900	0.655	0.410	0.245	0.166	0.079	0.076	0.072	0.022
0 to 40 [-1 to 4]	12.00	7.620	1.500	1.092	0.684	0.408	0.276	0.132	0.126	0.120	0.036
0 to 50 [4 to 10]	15.70	9.970	1.963	1.429	0.895	0.534	0.361	0.173	0.165	0.157	0.047
50 to 60 [10 to 16]	17.70	11.240	2.213	1.611	1.009	0.602	0.407	0.195	0.186	0.177	0.053
60 to 70 [16 to 21]	15.90	10.097	1.988	1.447	0.906	0.541	0.366	0.175	0.167	0.159	0.048
70 to 80 [21 to 27]	12.80	8.128	1.600	1.165	0.730	0.435	0.294	0.141	0.134	0.128	0.038
80 to 90 [27 to 32]	7.60	4.826	0.950	0.692	0.433	0.258	0.175	0.084	0.080	0.076	0.023
90 to 100 [32 to 38]	2.30	1.461	0.288	0.209	0.131	0.078	0.053	0.025	0.024	0.000	0.000
100 to 110 [38 to 43]	0.80	0.508	0.100	0.073	0.046	0.027	0.018	0.005	0.000	0.000	0.000
110 to 122 [43 to 50]	0.40	0.254	0.050	0.036	0.010	0.000	0.000	0.000	0.000	0.000	0.000