

Report No. IT-06-0027-1

GUIDELINE SPECIFICATION FOR URBAN RAIL CARS

BOEING VERTOL COMPANY
Surface Transportation Systems Department
Philadelphia, Pa. 19142



March, 1973

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URBAN MASS TRANSPORTATION ADMINISTRATION
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16. Abstract This document is the guideline specification to be used as the standard form for the preparation of detail procurement specifications for the design, construction and test of self-propelled urban rail cars. This specification provides guidelines for both commuter and rapid transit rail cars. The purpose of this specification is to establish uniform practices for the preparation of detail procurement specifications for these two types of vehicles to aid in the use and comparative analysis of the specification content. This specification encourages the use of modern technology and innovation by establishing measurable performance objectives rather than specifying existing equipment or equivalent. The specification covers all subsystems of the vehicle applicable to this type of equipment as a class and not unique to one design.					
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INDUSTRY ENDORSEMENT

by the

Institute for Rapid Transit Committee
on the Review of the Guideline Specification

with representation from the

American Transit Association
Advisory Committee on Car Equipment

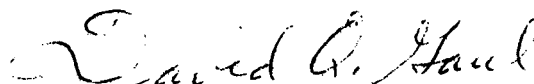
The Institute for Rapid Transit and American Transit Association, working through the Committees listed above, have been pleased to cooperate with the Urban Mass Transportation Administration of the U.S. Department of Transportation and their contractor, the Vertol Division of the Boeing Company, in the development of the Guideline Specification for Urban Rail Cars. We appreciate the consideration given to our suggestions and the incorporation of many of these suggestions in the Guideline Specification.

When refined and completed, this Guideline Specification will provide a standard format which will be helpful not only to operating agencies, prime contractors and subcontractors, but also to local and Federal government agencies who might be involved in a particular procurement. The Guideline Specification will simplify preparation of the detailed specifications, facilitate comparison of specifications, and point out areas requiring further research, as well as areas of possible standardization.

We are pleased with the progress that has been made over the past 9 months in the development of this specification. Much effort is still required to cover all the rapid transit equipment requirements of the industry. The necessary refinements could be accomplished, as we have done to date, by reviewing each new draft. This procedure is time-consuming and tends to perpetuate itself. We feel that the best method to accomplish our objective is the application of the Guideline Specification to a number of procurements. To do this, freedom must be given to revise the Guideline Specification as necessary to fit a particular procurement.

The Urban Mass Transportation Administration has assured us that the purpose of this project is to develop a standard format for the procurement of transit cars rather than to dictate standards for the industry. We have been assured that UMTA has no objections to revisions within the format to make the detailed specification suitable for the procurement in question.

With these assurances, the Joint Committees endorse the use of the Guideline Specification for trial application purposes and urge its members to use the format in developing the detailed specification for their next procurement unless specifications are already developed. The Committees also agree to meet twice a year to recommend further refinements to the Guideline Specification as a result of trial applications by its members.



David Q. Gaul
Chairman, IRT Committee on
the Review of the Guideline
Specification, and
Chairman, ATA Advisory
Committee on Car Equipment

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DEFINITIONS

For the purpose of this specification, commuter rail car and rapid transit rail car are defined as follows:

COMMUTER RAIL CAR - A self-propelled, passenger carrying rail car, equipped with a control cab and designed to operate as multiple units on railways that are part of a general railroad system of transportation, with typical station spacing of 1 to 20 miles. In certain applications, commuter cars may be non-powered, non-control, or both. Commuter cars are subject in part to regulation by the Federal Railroad Administration.

RAPID TRANSIT RAIL CAR - An electric self-propelled, passenger carrying rail car, equipped with a control cab and designed to operate as single or multiple units on subway, surface or elevated urban railways with frequent station stops. Some cars may be non-control, or non-powered/non-control.

INTRODUCTION

This document is the guideline specification to be used as the standard form for the preparation of detail procurement specifications for the design, construction, and test of self-propelled urban rail cars. This specification provides guidelines for both commuter and rapid transit rail cars and supersedes the Guideline Specification for Urban Rail Commuter Cars published in March, 1972.

The purpose of this specification is:

- To establish uniform practices for the preparation of detail procurement specifications for these two types of vehicles to aid in the use and comparative analysis of the specification content.
- To establish measurable performance objectives rather than specifying existing equipment or equivalent.
- To cover all subsystems of the vehicle applicable to this type of equipment as a class, not unique to one design.

Detail specifications shall conform to the following requirements:

1. The detail specification shall agree with this specification guideline in paragraph arrangement, numbering and headings.
2. Where paragraphs of this guideline specification are directly applicable, the detail specification shall incorporate the complete paragraph.
3. Where quantitative values are to be specified, the detail specification shall, under the corresponding paragraph number and heading, repeat the wording from the guideline specification and insert the quantitative values. Additional quantitative values not provided for in this guideline specification shall be added in the appropriate sections of the detail specification.
4. Where specific deviations and/or supplementary requirements are appropriate, the detail specification shall define the specific deviations and/or supplementary requirements under the appropriate paragraph number.

5. Where the specification of alternative systems, subsystems, or design features is required, the additional paragraph(s) shall use the same paragraph number as the basic paragraph with Alternative No. 1, Alternative No. 2, etc., in parentheses immediately after the paragraph number.
6. Where paragraphs of this guideline specification are not applicable or not required, the detail specification shall call out NOT APPLICABLE or NOT REQUIRED after the corresponding paragraph number and heading.

SCOPE

This specification comprises the detailed requirements for the design, construction, and testing of an Urban (Rapid Transit, Commuter) Rail Car System for the (purchaser) including program management, demonstration, product support, and data requirements.

The overall characteristics of the vehicle are as follows:

- Model Designation -
- Number and Types of Cars -
- Number of Seated Passengers -
- Type of Power System -

The purchaser shall provide additional descriptive matter concerning intended use, train consist, basic operating unit, compatibility required with existing equipment, and any other general information considered pertinent to the new equipment order. The following statement may be included:

This specification has been written on the basis of performance required, rather than specific hardware, to allow bidders to employ innovation and advanced technology where appropriate. The design criteria that are known have been specified. If other factors are required, the contractor shall be held responsible for making these requirements known to the purchaser, and shall not be relieved of the responsibility for providing an adequate design.

SYSTEM REQUIREMENTS

2.1 GENERAL

This section defines the criteria for the design and manufacture of the (transit, commuter) car, including the operational parameters, structural strength, performance, material, vibration, acoustical, and environmental requirements.

2.1.1 DIMENSIONS AND DESIGN CONSIDERATIONS

2.1.1.1 Car

Length of car over coupler faces	_____
Length of car over anti-climbers	_____
Distance, Center to Center of trucks	_____
Width of car body, maximum	_____
Width over threshold	_____
Width over side plates	_____
Height of car (Lt. car weight, new wheels):	
a. Top of rail to top of roof	_____
b. Top of rail to pantograph (locking down) if used	_____
c. Top of rail to car floor	_____
d. Top of rail to top of anti-climber	_____
e. Top of rail to centerline of coupler	_____
Interior width at seat line, minimum	_____
Height, minimum, floor to headlining at centerline of car	_____
Width of side door openings	_____
Width of end door openings	_____
Height of side door openings	_____
Height of end door openings	_____
Height from floor to bottom of side window	_____
Height from floor to top of side window	_____
Width of window opening (clear glass)	_____

Maximum vertical distance from top of floor to bottom of all undercar equipment _____
 Truck wheelbase _____
 Wheel diameter, new _____
 Wheel diameter, worn (minimum) _____
 Wheel gauge _____
 Maximum number of cars in train _____
 Minimum number of cars in train _____
 Seating capacity _____

2.1.1.2 Track

Minimum lateral radius at centerline of tracks (yard and operating tracks) _____
 Corresponding super-elevation _____
 Maximum super-elevation _____
 Corresponding curve radius (radii) _____
 Corresponding qualifying factors (Ft. of tangent track) _____
 Radius of minimum convex vertical curve _____
 Radius of minimum concave vertical curve _____
 Track gauge _____
 Running rail - maximum vertical wear _____
 Maximum vertical tie and plate wear _____
 Nominal height of third rail _____
 Nominal height third rail coverboard over running rail _____
 Variance in height of third rail from nominal _____
 Distance between centerline of third rail and gauge of near running rail _____
 Maximum catenary height from top of rail _____
 Minimum catenary height from top of rail _____
 Maximum deviation of catenary from centerline of tracks _____
 Stagger of catenary (inches per foot) _____

2.1.2 WEIGHTS

2.1.2.1 The maximum allowable weight for single unit cars, "A" cars, "B" cars, etc., empty but ready to run, shall be specified by the purchaser. Allowable weight difference between "A" and "B" cars, weight distribution between trucks and lateral center of gravity displacement may also be specified.

2.1.2.2 The contractor shall provide a "weight breakdown statement" of the light car in sufficient detail to enable assessment of structural elements. System and major component weights shall be provided.

2.1.2.3 The contractor shall weigh each complete car at shipment and furnish the weight ticket to the purchaser.

2.1.3 DRAWINGS

The following drawings form a part of these specifications. Purchaser may indicate that drawings are to be used as a guide for reference purposes only. The contractor shall submit drawings as required for clarification of his proposal.

<u>Contractor Dwg. No.</u>	<u>Title</u>
_____	_____
_____	_____

2.2 PERFORMANCE CHARACTERISTICS

2.2.1 DEFINITION OF SYSTEM UNITS FOR PERFORMANCE SPECIFICATION

2.2.1.1 Electric Propulsion

2.2.1.1.1 The required performance shall be obtained using a system voltage of ___ volts (DC or ___ Hz AC). Nominal system voltage will be ___ volts with operating extremes of ___ volts and ___ volts. All on-board equipment and systems shall meet the specified performance within the cited extremes.

2.2.1.1.2 The maximum acceleration and braking shall be obtained utilizing a motor duty cycle based on the operating profile illustrated in Figure 2-1. The thermal design of the motor shall be such that the duty cycle (Figure 2-2) may be repeated over a _____ time period, including a ___ second station dwell time after each cycle. Maximum train speed shall be obtained using not more than the ___ motor rating and within the motor speed (RPM) limitations.

2.2.1.1.3 Power consumption shall not exceed ___ KWH/car mile averaged for a round trip between locations and under conditions to be specified by the purchaser. Conditions to be specified shall include systems to be operating, number of cars or standard train, etc. Bidder shall submit power consumption data for the purchaser's evaluation.

2.2.1.2 Internal Combustion/Gas Turbine Propulsion

2.2.1.2.1 The maximum acceleration shall be obtained using the _____ power rating of the traction engine. The maximum speed shall be obtained using not more than the _____ engine rating.

2.2.1.2.2 The fuel grade to be used in service and for the required performance shall be _____.

2.2.1.3 Definition of Standard Train

2.2.1.3.1 The standard train shall consist of ___ married pairs, ___ single-unit cars and/or ___ (non-control, single-ended, single-unit, etc.) cars. Performance of each car of this standard train is contained in sections 2.2.2, 2.2.3 and 2.2.4.

2.2.1.3.2 For performance purposes, the assigned weight of each car in the standard train shall be defined by symbols. The weight in pounds shall be the weight of the cars as produced. The figure used in the performance evaluation shall be based on the empty car operating weight as determined from the actual weight of the first five cars produced.

The weight of the car shall be defined as follows:

Light Car Weight..... AWO

Normal Load Car Weight..... AW1

Comprises:

AWO

Seated Load..... lbs.

(___ passengers at ___ lbs. ea.)

Standing Load..... lbs.

(___ passengers at ___ lbs. ea.)

Full Load Car Weight..... AW2

Comprises:

AWO

Seated Load..... lbs.

(___ passengers at ___ lbs. ea.)

Standing Load..... lbs.

(___ passengers at ___ lbs. ea.)

Crush Load Car Weight..... AW3

Comprises:

AWO

Seated Load..... lbs.

(___ passengers at ___ lbs. ea.)

Standing Load..... lbs.

(___ passengers at ___ lbs. ea.)

2.2.1.4 Condition of Standard Train

The acceleration, speed, and braking performance shall be met with new wheels of ___ inch diameter. The maximum deviation of wheel speed from average on any (car or truck) due to wheel wear shall be ___ percent. With fully worn wheels of ___ inch diameter, the standard train shall be capable of the sustained speed required in section 2.2.3.

2.2.1.5 Condition of Roadbed

2.2.1.5.1 The performance requirements for acceleration, speed, and deceleration shall be met using dry, standard-quality track.

2.2.1.5.2 Ride quality, vibration and noise criteria shall be met, assuming both standard and minimum-quality track.

2.2.1.5.3 Track quality, standard and minimum, may be defined in this paragraph.

2.2.1.6 Climatic Conditions

The capability to perform within the performance requirements of acceleration, speed and deceleration as defined, shall not be affected by the climatic conditions in the area of operation.

2.2.1.7 Performance Summary for Standard Train

Balancing Speed (level, tangent track)	_____	mph
Nominal Initial Acceleration	_____	mphps
Nominal Deceleration:		
Dynamic Braking (____ to ____ mph)	_____	mphps
Service Friction Braking (____ mph)	_____	mphps
Emergency Friction Braking (____ mph)	_____	mphps
Max. Combined Dynamic/Friction Braking)	_____	mphps
Jerk Rate, Normal Acceleration and Braking	_____	mphpsps
Time to Reach ____ mph (AW____)	_____	seconds
Distance Travelled in ____ seconds from a standing start (AW____)	_____	feet
Distance to Reach ____ mph (AW____)	_____	feet
Maximum Speed on ____ foot long, ____ percent adverse grade (AW____), accelerate to and maintain	_____	mph

2.2.1.8 Performance Data Formats

Purchaser may elect to present detailed performance requirements using the formats shown in Figures 2-2 through 2-7. Bidder shall use these formats for submittal of performance data as required by section 2.2.9.

2.2.2 ACCELERATION REQUIREMENTS

2.2.2.1 The acceleration performance of the car shall be as follows at Car Weight (AW____):

Maximum Initial Acceleration	_____	mphps
Nominal Initial Acceleration	_____	mphps
Minimum Initial Acceleration	_____	mphps

The nominal initial acceleration of _____ mphps shall be maintained up to a train speed of _____ mph. (See Figure 2-4 for Acceleration Diagram if specified by the purchaser.)

2.2.2.2 Deviation from the nominal initial acceleration of _____ mphps shall not exceed ____ percent, and the average acceleration over any time period shall be within ____ percent of nominal initial acceleration. This shall be under control of the load-weighting system, exclusive of the translation error of car weight to load-weighting output signal. (See Figure 2-4 for initial acceleration tolerances and Figure 2-5 for time-speed-distance diagram if specified by the purchaser.)

2.2.3 CONTINUOUS SPEED REQUIREMENTS

2.2.3.1 The following table summarizes the required maximum speed performance at car weight (AW___) with new wheels, and with fully worn wheels:

<u>Track Conditions</u>	<u>Speed</u>
Level, Tangent	____ mph
____ Percent Adverse Grade, ____ ft. in length, maintain	____ mph
____ ft. Radius Curve	____ mph

2.2.4 DECELERATION REQUIREMENTS

2.2.4.1 Service Braking System

2.2.4.1.1 The deceleration performance of the car shall be as follows for all car weights up to AW___ at speeds up to ____ mph:

Maximum Full Service Braking	_____ mphps
Nominal Full Service Braking	_____ mphps
Minimum Full Service Braking	_____ mphps

Braking performance estimates shall include train resistance for zero wind and motor and gear losses. (See Figure 2-4 for Braking Diagram if specified by the purchaser.)

2.2.4.1.2 Deviation from nominal full service braking of ____ mphps shall not exceed ____ percent, and the average braking effort over any _____ time period shall be within ____ percent of nominal full service braking, under control of the load-weighting system, exclusive of the translation error of car weight to load-weighting output signal.

2.2.4.1.3 Both service friction braking and dynamic braking systems shall be capable of developing the performance specified in paragraphs 2.2.4.1.1, 2.2.4.1.2 and Figure 2-4 (if specified). This requirement is deleted for the dynamic brake system below its fade point of ____ mph. (See Figure 2-6 for service brake time-speed-distance diagram if specified by the purchaser.)

2.2.4.1.4 If specified, each service brake system shall be capable of ____ complete maximum-performance stops from ____ mph in a time period of ____ minutes with a brake system cooling period of ____ minutes between brake applications. Track conditions shall be _____, car weight shall be AW___.

VEHICLE OPERATING PROFILE

(SINGLE CAR, STD. TRAIN, ETC.)

Car Weight: AW = _____ lbs.

Station Spacing (Avg.) = _____ miles

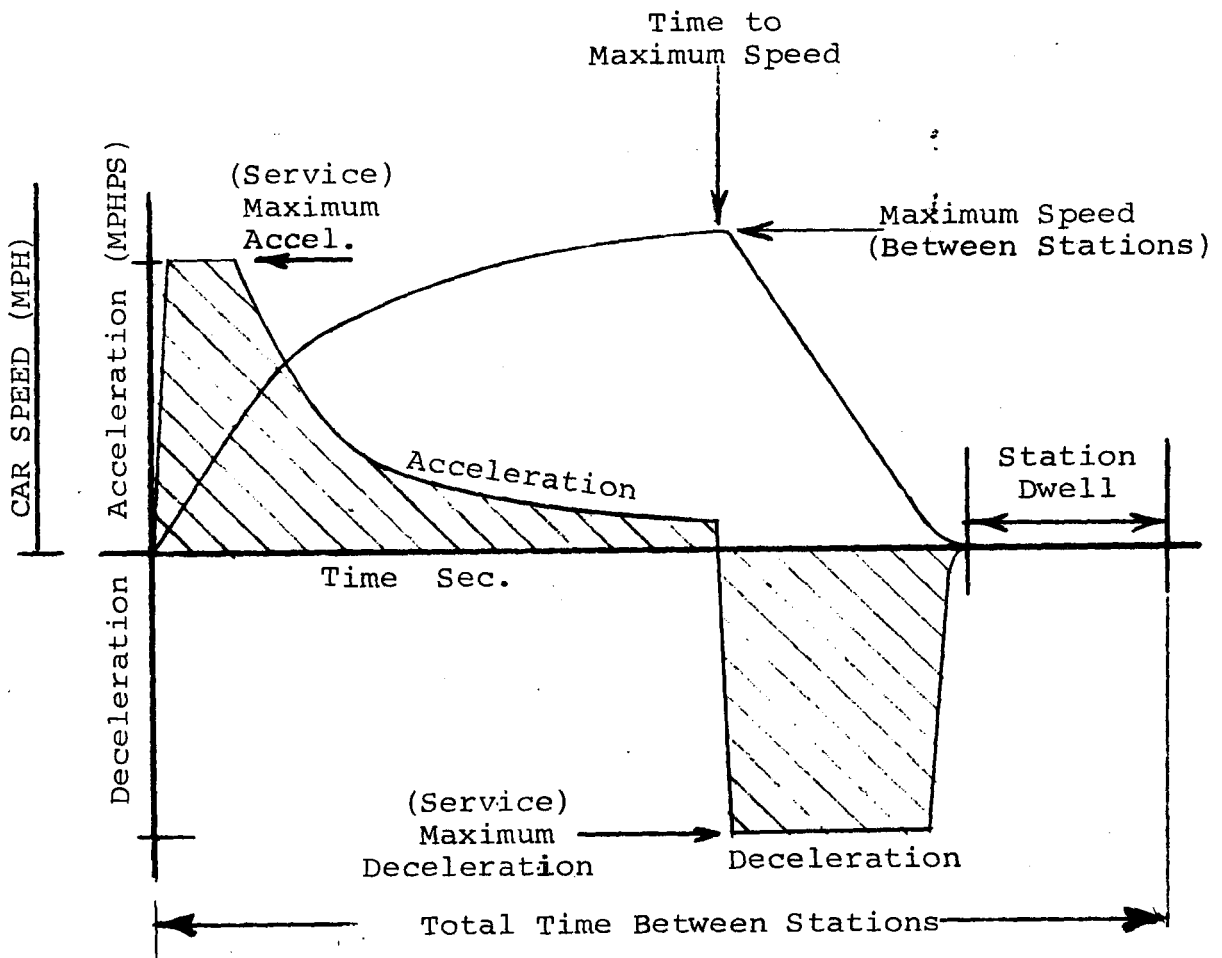


Figure 2-1

MOTOR DUTY CYCLE

CAR WEIGHT: AW = _____

(SINGLE CAR, STD. TRAIN, ETC.)

NOTES:

1. LEVEL TANGENT TRACK
2. ___ MPH HEADWIND
3. GEAR RATIO =
4. WHEEL DIA. =
5. DEAD TIME =
6. JERK RATE =
7. ROTATING INERTIA =
8. GEAR LOSSES INCLUDED

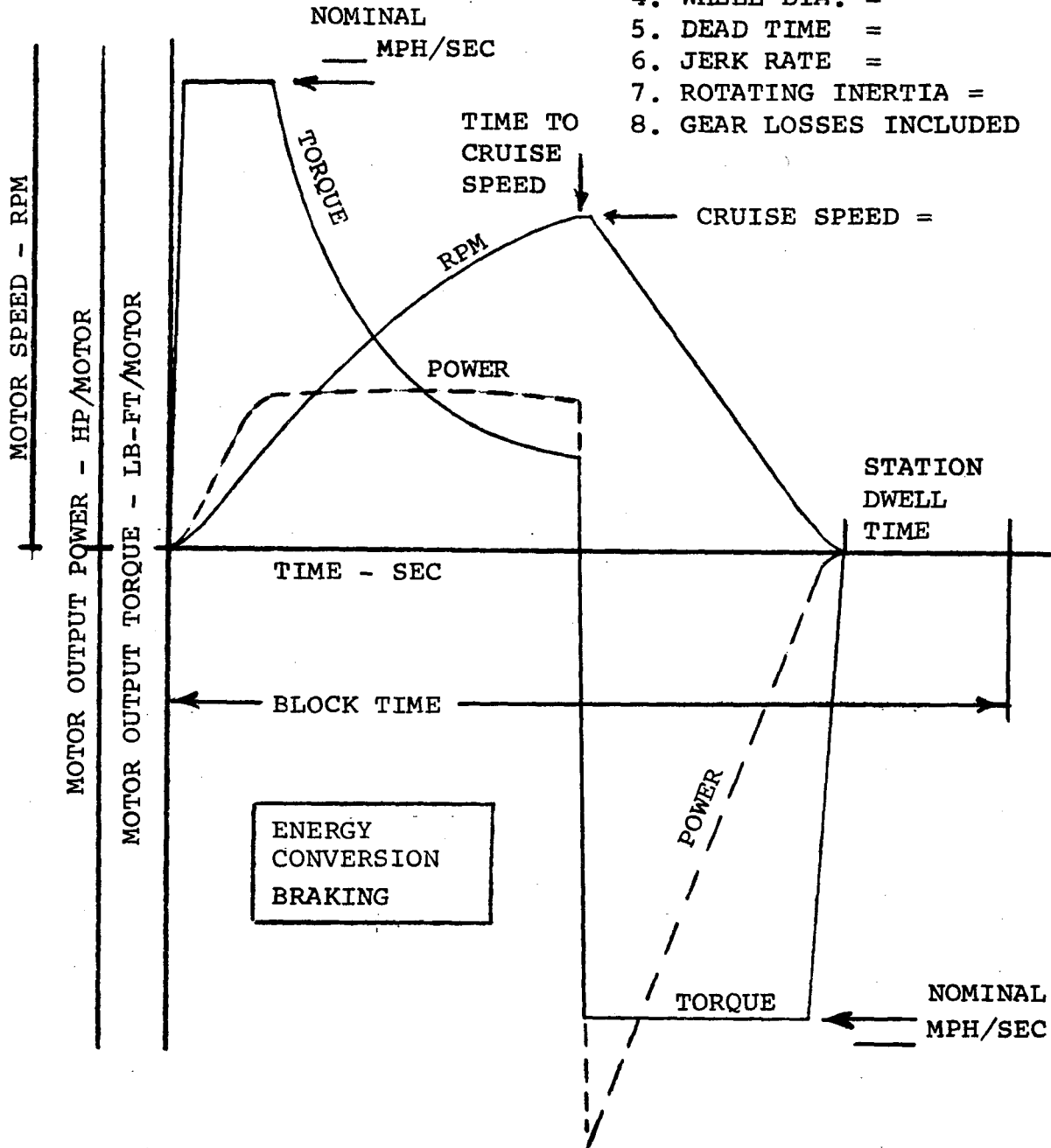


Figure 2-2

TRACTIVE EFFORT - SPEED CHARACTERISTICS
FOR
DESIGN PERFORMANCE LEVELS

Notes

1. Level tangent track
2. ___ mph headwind
3. Gear Ratio =
4. Wheel diameter =
5. ___ motors per car
6. Gear losses included

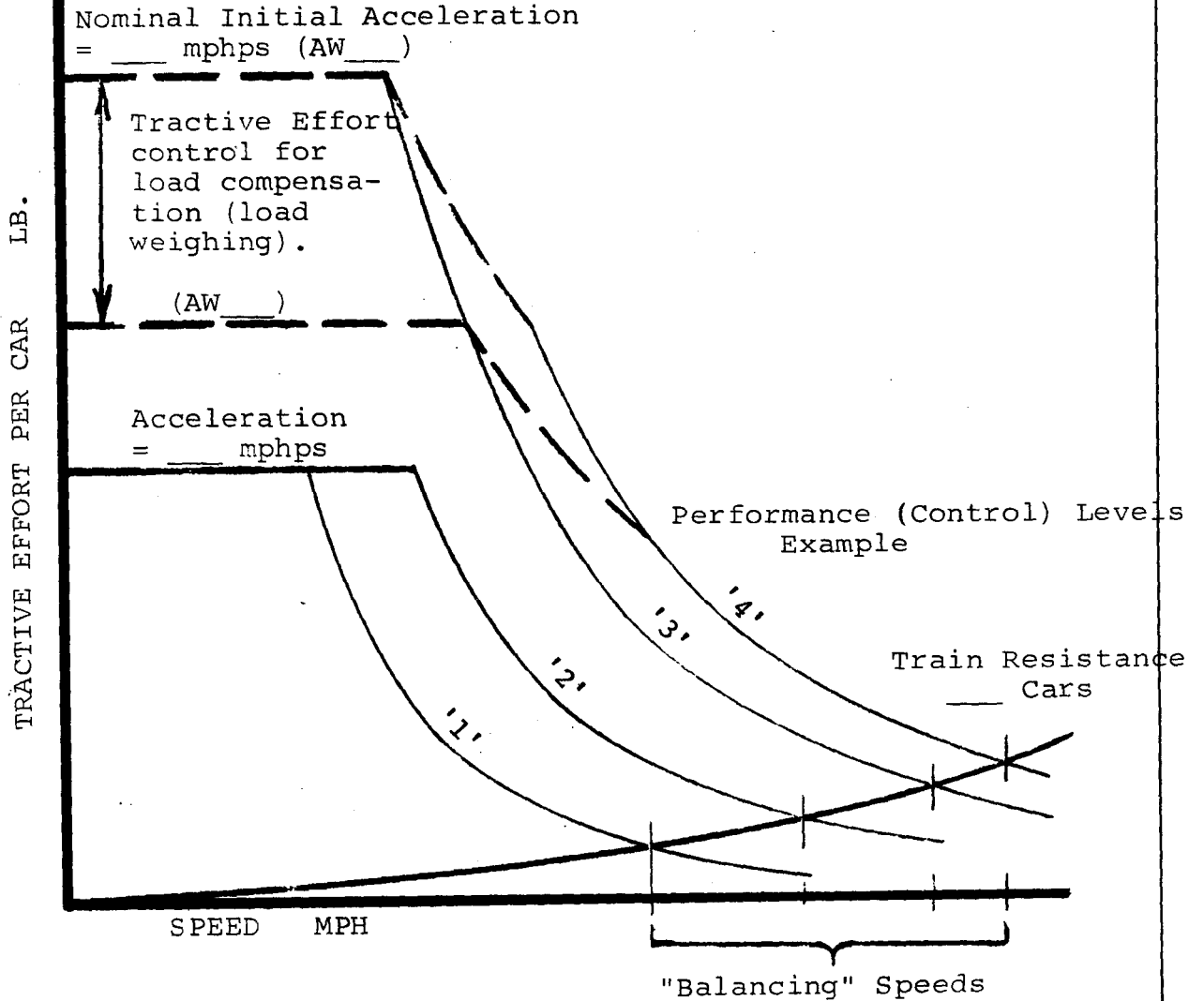


Figure 2-3

ACCELERATION & DECELERATION PERFORMANCE

CAR WEIGHT: AW = _____
 (SINGLE CAR, STD. TRAIN, ETC.)

NOTES:

1. LEVEL TANGENT TRACK
2. _____ MPH HEADWIND
3. GEAR RATIO = _____
4. ROTATING INERTIA = _____
5. NEW WHEEL DIA. _____
6. GEAR LOSSES INCLUDED
7. DUTY CYCLE PER FIGURE 2-2
8. _____ MOTORS PER CAR

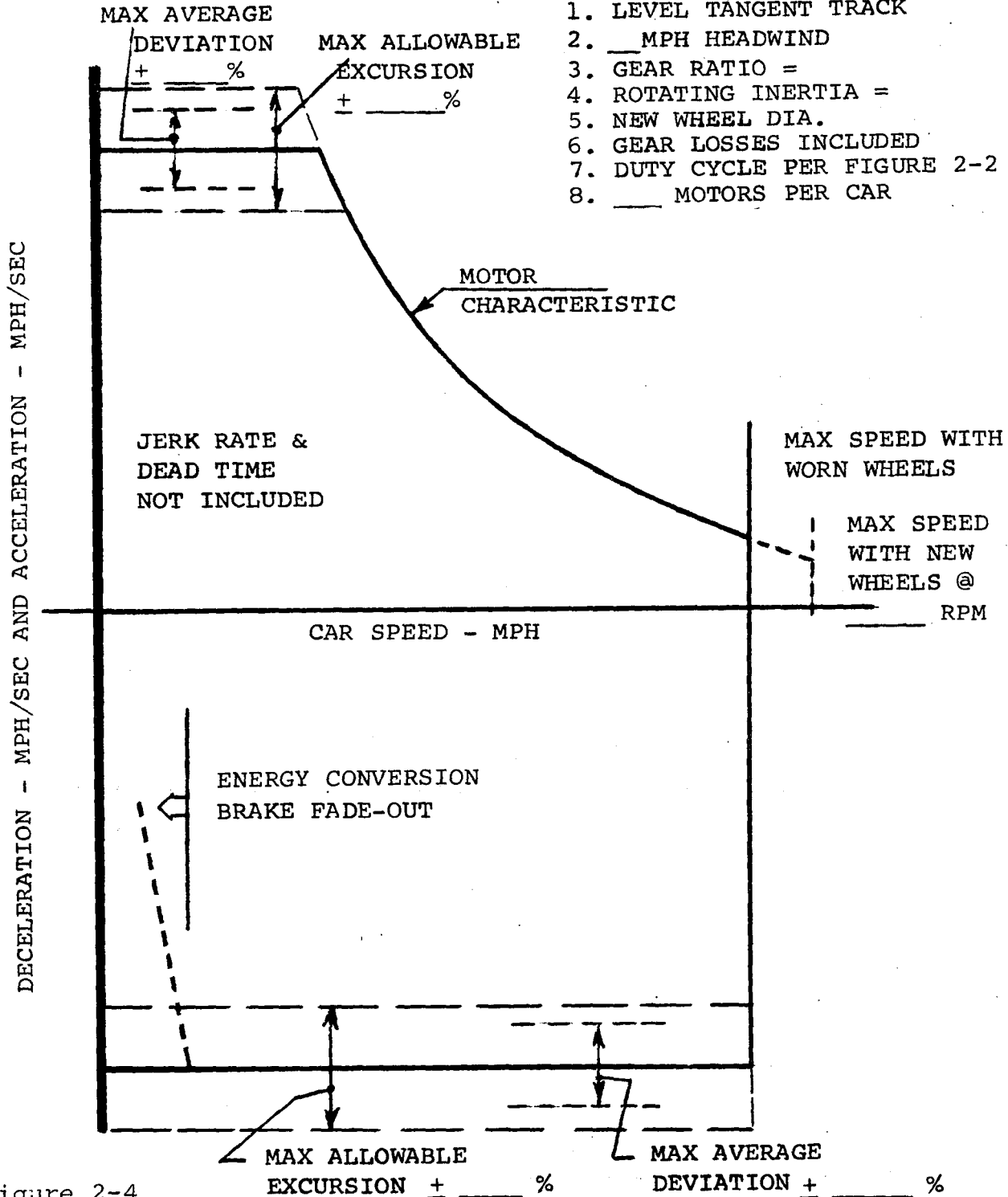


Figure 2-4

TIME & DISTANCE TO SPEED
CAR/TRAIN WEIGHT: AW =

NOTES:

1. LEVEL TANGENT TRACK
2. MPH HEADWIND
3. ACCELERATION PER FIGURE 2-4
4. NEW WHEEL DIA.
5. JERK LIMITS AND DEAD TIME INCLUDED

(SINGLE CAR, STD. TRAIN, ETC.)

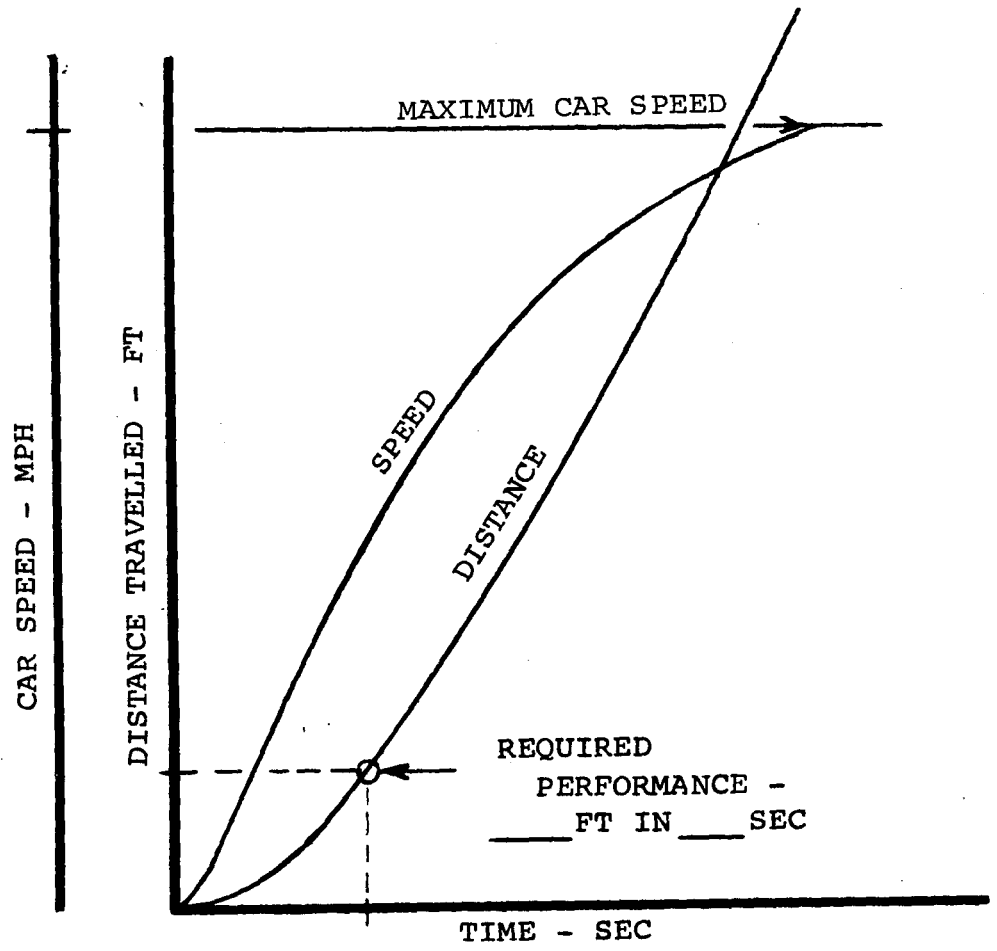


Figure 2-5

TIME AND DISTANCE TO STOP

CAR/TRAIN WEIGHT: AW =

NOTES

1. LEVEL TANGENT TRACK. (SINGLE CAR, STD. TRAIN, ETC.)
2. DECELERATION PER FIGURE 2-4.
3. NEW WHEEL DIAMETER.
4. JERK LIMITS INCLUDED AT END OF STOP.

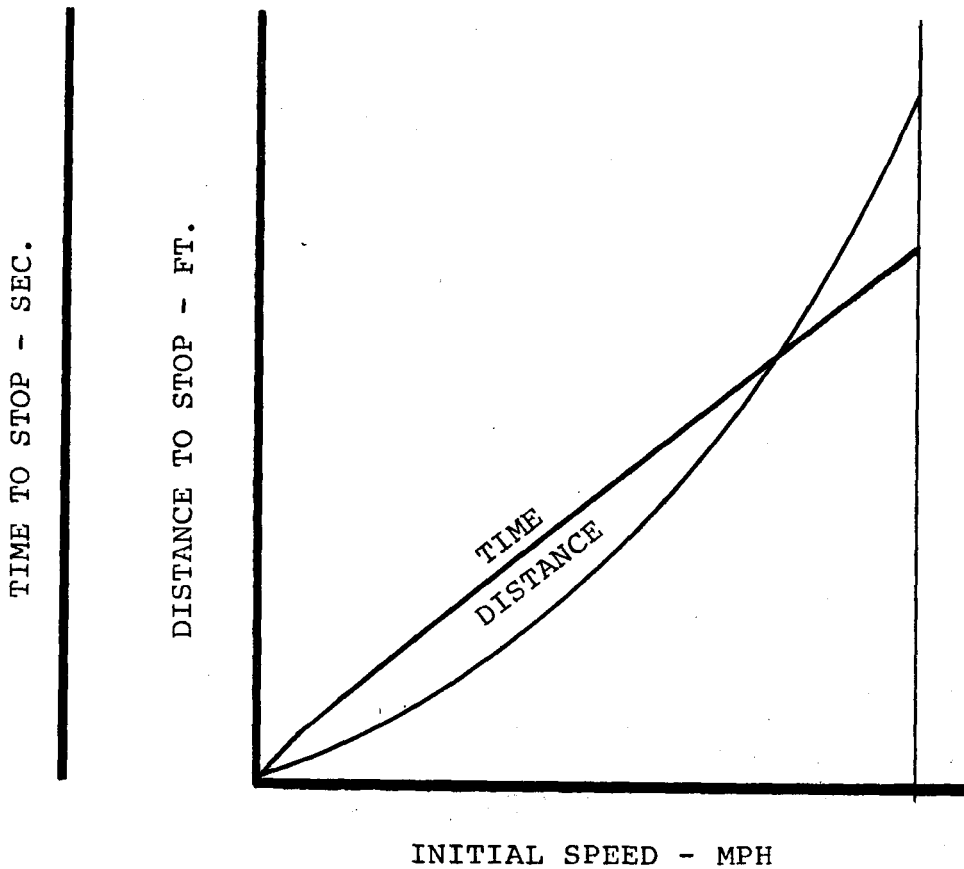


FIGURE 2-6

2.2.4.1.5 The service friction brake system (with/without) dynamic braking, shall be capable of the following performance at car weight AW___:

<u>Initial Speed</u>	<u>Average Deceleration*</u>	<u>Distance to Stop (Optional)</u>
___ mph	___ mphps	___ ft.
___ mph	___ mphps	___ ft.

*Average deceleration = Initial speed divided by time from BRAKE signal to time of stop.

2.2.4.1.6 The dynamic (regenerative)/friction brake blending function, if used, shall be assigned to the friction brake system. The friction brake system shall receive a fail-safe electrical feedback indication of dynamic brake level, compare it with brake level request and supplement with friction braking as required. Brake blending shall operate under the jerk rate limits of section 2.2.6. Combined (blended) braking shall not be less than service friction braking.

2.2.4.2 Emergency Brake System

2.2.4.2.1 The nominal emergency friction braking deceleration rate shall be ___ mphps ± ___ percent at speeds up to ___ mph using friction braking only. This rate shall be achieved up to car weight AW___, under control of the load-weighting system, exclusive of the translation error of car weight to load-weighting output signal.

2.2.4.2.2 The emergency friction braking system (with/without) dynamic braking shall be capable of the following performance at car weight AW___:

<u>Initial Speed</u>	<u>Average Deceleration*</u>	<u>Distance to Stop (Optional)</u>
___ mph	___ mphps	___ ft.
___ mph	___ mphps	___ ft.

*Average deceleration = Initial speed divided by time from BRAKE signal to time of stop.

2.2.4.2.3 Use of the emergency-stop mode of train control (shall/shall not) disable the wheel slip-slide system (and/or) jerk rate limitation system.

2.2.5 WHEEL SLIP-SLIDE PROTECTION (OPTIONAL)

2.2.5.1 General

The slip-slide system shall detect slips and slides whether they are random or synchronous. The wheel slip-slide protection system shall be fail-safe in design and construction. The normal failure mode of the system shall be such as to render the wheel slip-slide system ineffective and allow the brake to be applied. The slip-slide system shall not allow braking to be removed for more than ___ seconds. If this limit is exceeded, the system shall be bypassed and full braking effort restored.

The efficiency of the wheel slip-slide protection system shall be at least ___ percent during slips in acceleration and ___ percent during slides in braking over the entire speed range of the cars. The efficiency, as defined in Figure 2-7, is equal to the actual change in speed expressed as a percentage of the maximum change in speed dictated by the limit of adhesion during any continuous sequence of the wheel slip-slide protection system.

2.2.5.2 Operation

The slip-slide protection system shall function properly with differences of up to ___ inches in diameter among the wheels of a car. The following detection parameters may, as an option, be defined in order to achieve the slip-slide protection system efficiency of ___ percent.

Slips in acceleration and slides in braking on the order of ___ percent of axle speed or ___ rpm, whichever is greater.

Wheel acceleration or deceleration rates in excess of ___ rpmps.

2.2.5.2.1 Upon detection of a slip during acceleration, power shall be reduced on the affected _____ of the car until the slip is corrected. Power shall then be reapplied automatically under the jerk limit control limitations of section 2.2.6. Indication (must be) provided to the motor-man. Release of tractive effort (shall not) be jerk limited.

SLIP-SLIDE PROTECTION SYSTEM
EFFICIENCY

$$\text{Efficiency} = \frac{\text{Area } (A_2)}{\text{Area } (A_1 + A_2)} \times 100\%$$

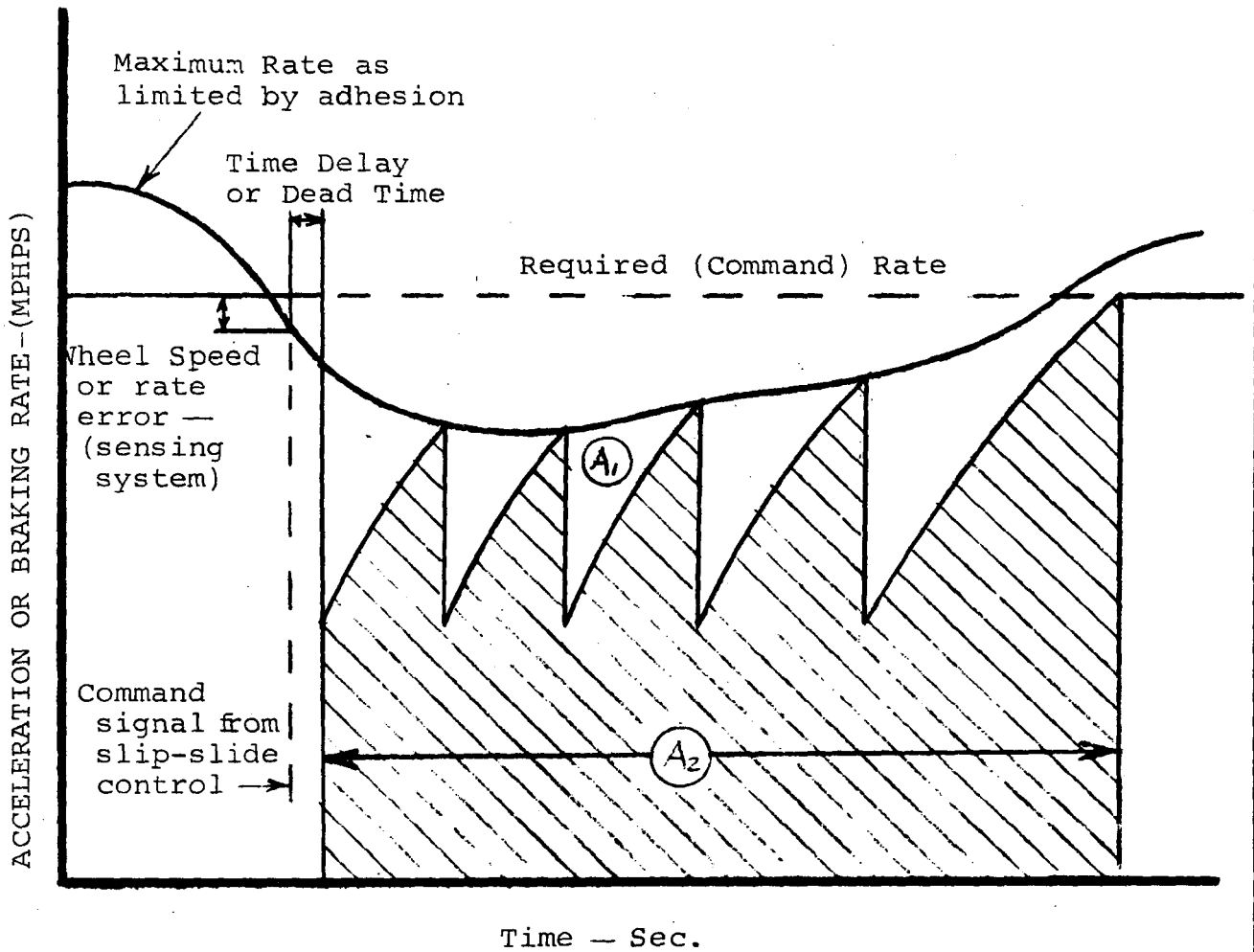


Figure 2-7

2.2.5.2.2 Upon detection of a slide during braking, the dynamic braking shall be reduced on the affected (car or truck) of the car until the slide is corrected. Friction braking shall be removed from the affected (truck or axle) only, until the slide is corrected. After the slide has been corrected, braking shall be reapplied automatically at a rate consistent with obtaining maximum performance without exceeding the specified jerk limit.

2.2.5.2.3 The wheel slide protection system shall be functional under all braking commands (including/except) an emergency brake application. The system shall be so arranged that failure of any component of this system shall not prevent development of a full emergency brake application.

2.2.5 (Alternate No. 1)

The coupled axle effect of a parallel connected AC induction motor system shall be a suitable alternative for slip-slide protection.

2.2.6 JERK RATE

2.2.6.1 The maximum rate of change of acceleration or deceleration of each car in the standard train shall not be more than ___ mphs/second under all normal ATC or MTC control signals. Jerk rate limitation shall be inherent in the propulsion and braking system.

2.2.6.2 The maximum rate of change of acceleration or deceleration during step changes in control signals (ATC or MTC) shall be _____ to _____ mphs/second (adjustable) or as an option, _____ mphs/second (non-adjustable).

2.2.6.3 The jerk rate limits of paragraph 2.2.6.1 shall apply to power and braking applications and re-applications, but not to release of tractive effort, during normal function of the wheel slip-slide system.

2.2.6.4 Jerk rate limiting for braking shall be fail-safe in design such that failure of the system shall not reduce the maximum available braking rate during deceleration.

2.2.7 CONTROL RESPONSE (DEAD) TIME (Exclusive of Motorman)

The maximum allowable response times for all detection and control systems shall be as follows:

Control Signal Change (ATC and/or MTC) _____ sec.
Acceleration and Deceleration Modulation
(Slip-slide system) _____ sec.

2.2.8 CAR LOAD-WEIGHING SYSTEM (Optional)

2.2.8.1 The load-weighing system shall provide signals proportional to the load on the truck to both the traction system and dynamic (regenerative) and friction braking systems. The accuracy of the load-weighing system shall permit compliance with the acceleration and braking requirements of paragraphs 2.2.2.2 and 2.2.4.1.2 respectively, and the emergency braking requirements of paragraph 2.2.4.2.1.

2.2.8.2 Failure of the load-weighing system shall not allow greater (acceleration or) deceleration than would be obtained with an empty car without load weighing, and not less (acceleration or) deceleration than would be obtained with a fully loaded car (AW2) without load weighing.

2.2.8 (Alternate No. 1)

Rate control by frequency rate of change with an AC induction motor system shall be a suitable alternative to load-weighing with tractive effort control.

2.2.9 SUBMITTAL OF PERFORMANCE DATA

Curves containing estimated values of car performance shall be provided by the contractor to substantiate the performance characteristics of the vehicle, if changed in any respect from data submitted at the time of bid. The data shall be presented in formats similar to Figures 2-2 through 2-7. This performance data shall include all pertinent data and criteria used to derive the performance characteristics of section 2.2.

2.3 STRENGTH REQUIREMENTS

2.3.1 GENERAL

The entire car system, which includes car body structure trucks, doors, seats, and interior appointments, shall be capable of resisting, without permanent deformation or failure, unless otherwise specified, the loads inherent in the type of service for which the vehicle is intended.

The trucks, including wheels, axles, and brakes, shall withstand, without failure, the repeated loads induced by normal service and those specified by the fatigue test (See section 17).

The contractor shall be responsible for the allowable stresses used throughout the design. However, these values shall not be greater than those taken from approved government publications, such as MIL-HDBK-5 and MIL-HDBK-17, or various society standards, e.g., ASME, AISI, SAE, Aluminum Association, AAR and AWS, whenever possible, or other sources specified and/or approved by the purchaser.

2.3.2 DEFORMATION

The car structure, including door support structure, shall not deform in a manner that would impair system function under normal static and dynamic loads and operating conditions.

2.3.3 WEIGHT AND MASS DISTRIBUTION

The weights to be used for structural analysis and design are those assigned weights as prescribed in section 2.1.2 of this specification. Distribution of passenger load will be taken as uniform over the car length. Mass items will be assigned to the actual location on the structure.

2.3.4 FATIGUE

Critical parts of the car system shall be designed for the repeated loads, service life, and environment for which the vehicle is intended. The allowable stresses selected for analysis and design are the responsibility of the contractor and shall be taken from the acceptable sources specified in paragraph 2.3.1 duly corrected for stress concentration, fretting, stress ratio, etc. The use of allowable stresses from other sources will require substantiation for approval by the purchaser.

2.3.5 DESIGN CONDITIONS

Design conditions are covered under the specific sections to which they apply, e.g., Car Body, Trucks, etc.

2.3.6 SUBMITTAL OF STRUCTURAL DESIGN DATA

The contractor shall submit, within ___ days after contract, a complete stress analysis of the car structure, trucks, and major equipment supports, to show compliance with the strength level requirements specified herein, with particular reference to the end sill, side sills, top chord members, body and door posts, including their attachment to the roof and underframe structure, coupler mounting, and end frame unit, if used.

In addition, a structural diagram shall be submitted showing materials used, areas, section moduli, weight, etc.

2.4 MATERIALS

2.4.1 GENERAL

2.4.1.1 Composition, mechanical properties, and quality level shall conform to the latest release of the designated AISI, SAE, ASTM, or AAR specification.

2.4.1.2 Commercial materials not covered by a specification shall be clearly identified by the commercial trademark and name and address of the manufacturer. A description of the material composition shall also be made available to the purchaser for approval.

2.4.1.3 Use or substitution of materials other than those designated shall have prior approval by the purchaser.

2.4.1.4 All materials shall be mill-finished unless otherwise specified.

2.4.1.5 All joining surfaces shall be clear and free from dirt, grease, scale, and other contaminants prior to attachment or joining.

2.4.2 STEEL

2.4.2.1 Structural steel sheet, other than Low Alloy High Tensile, shall conform to the requirements of ASTM A-569, A-570 and A-611 as applicable.

2.4.2.2 Structural steel plates and bars shall conform to the requirements of AAR M-116 or ASTM A-113 Grade _____.

2.4.2.3 Structural heat-treated alloy steel suitable for welding shall conform to the requirements of ASTM A-514 Grade _____.

2.4.2.4 Low alloy, high tensile structural steel shall conform to the requirements of specification _____.

2.4.2.5 Steel castings for (journal boxes, truck spring seats, body castings, etc.) shall conform to the requirements of ASTM A-27, Grade _____ or AAR M-201, Grade _____.

2.4.2.6 High-strength steel castings for (center bearings, contact shoe brackets, truck height adjusters, etc.) shall conform to the requirements of ASTM A-148, Grade _____ or AAR M-201, Grade _____.

2.4.2.7 Low alloy steel castings for (truck frames, truck bolsters, etc.) shall conform to the requirements of specification _____ or AAR M-201, Grade _____.

2.4.2.8 Carbon steel forgings shall conform to the requirements of ASTM _____, Grade _____, AISI _____, or AAR M-126 Grade _____.

2.4.2.9 Alloy steel forgings shall conform to the requirements of ASTM _____, Grade _____, AISI _____, or AAR M-127 Grade _____.

2.4.2.10 Hot rolled bar steel for (brake levers, rods, hangers, brake bolts, etc.) shall conform to the requirements of ASTM _____, AISI _____, or AAR M-122 Grade _____.

2.4.2.11 Rivet steel shall conform to the requirements of ASTM A-502, Grade _____, A-31 Grade _____, or A-131 as applicable.

2.4.2.12 Carbon steel bolts for structural joints shall conform to the requirements of ASTM A-325.

2.4.2.13 Alloy steel bolts for high strength joints shall conform to the requirements of ASTM A-354 Grade _____ or A-490.

2.4.2.14 Spring steel for (wear plates, coil springs, etc.) shall conform to the requirements of ASTM _____ Grade _____ or AAR M-114 as applicable.

2.4.2.15 Steel wheel forgings shall conform to the requirements of ASTM A-504 Grade _____ or AAR M-107 Class _____.

2.4.2.16 Steel wheel castings shall conform to the requirements of ASTM A-631 Grade _____ or AAR M-208 Class _____.

2.4.2.17 Carbon steel axle forgings shall conform to the requirements of AAR M-101 Grade _____ or ASTM A-236 Grade _____.

2.4.2.18 Alloy steel axle forgings shall conform to the requirements of ASTM A-238 Grade _____ or AAR M-127 Grade _____.

2.4.2.19 Coupler material, unless otherwise specified, shall conform to the requirements of applicable AAR Coupler specifications.

2.4.3 CORROSION-RESISTANT STEELS

2.4.3.1 Corrosion-resistant steel type _____, condition _____, shall conform to the mechanical properties, composition, and workmanship requirements of specification _____.

2.4.3.2 Corrosion-resistant austenitic steel type _____ with 0.03 maximum carbon or stabilized austenitic steel type _____ shall be used for all fusion-welded or brazed applications.

2.4.3.3 Corrosion-resistant steel fasteners used to attach corrosion-resistant steel parts shall conform to the requirements of specification _____.

2.4.4 ALUMINUM ALLOYS

2.4.4.1 Aluminum alloys shall conform to the composition, strength, quality requirements, and corrosion-resistance requirements of the specifications of the Aluminum Industries Association.

2.4.4.2 Aluminum alloys joined by fusion welding shall be weldable aluminum alloy with high strength, good resistance to corrosion, and not requiring heat treatment after welding.

2.4.4.3 Sheet and plate aluminum alloy shall conform to specification _____.

2.4.4.4 Aluminum alloy castings shall conform to the requirements of specification _____, Grade _____. Castings shall be free from blowholes, cracks, shrinkage, and other injurious defects.

2.4.4.5 Aluminum alloy bar, rod, and extruded shapes shall conform to the requirements of specification _____.

2.4.4.6 Aluminum alloy rivets shall conform to the requirements of specification _____.

2.4.4.7 Aluminum alloy bolts, nuts, and screws, if permitted by the purchaser, may be used in non-structural, lightly loaded aluminum parts and shall conform to specification _____.

2.4.5 MAGNESIUM ALLOYS

Magnesium alloys shall be restricted from use on urban rail cars unless specifically authorized by the purchaser.

2.4.6 SOLDERING, WELDING AND BRAZING

2.4.6.1 Fusion welding shall be accomplished in accordance with appropriate specifications as follows:

<u>Base Metal</u>	<u>Specification</u>
Steel	AWS _____
Aluminum	AWS _____
Corrosion-Resistant Steel	AWS _____

2.4.6.2 Welding electrodes and filler metal shall conform to the applicable specifications as follows:

<u>Base Metal</u>	<u>Specification</u>
Steel	AWS _____
Aluminum	AWS _____
Corrosion-Resistant Steel	AWS _____

2.4.6.3 Resistance welding shall be performed in accordance with the requirements of specification _____ for aluminum and _____ for steel.

2.4.6.4 Brazing shall be accomplished in accordance with specification _____. Brazed joints shall not be in the vicinity of subsequent fusion-welded joints or other operations which involve high temperature.

2.4.6.5 Welding to repair defects, where permitted by the purchaser, shall be accomplished in accordance with a procedure approved by the purchaser.

2.4.7 NON-DESTRUCTIVE INSPECTION

2.4.7.1 Non-destructive inspection techniques and applicable acceptance criteria shall be as defined by the component drawing.

2.4.7.2 Magnetic particle inspection shall be performed as specified or as approved by the purchaser.

2.4.7.3 After magnetic particle inspection, parts shall be sufficiently demagnetized so that the residual field will not interfere with future processing or operation of the part.

2.4.7.4 Penetrant inspection, both fluorescent and dye penetrant, shall be performed in accordance with specification _____.

2.4.7.5 Radiographic inspection, when required, shall be performed in accordance with specification _____.

2.4.8 FASTENERS

2.4.8.1 Bolts and Nuts

Steel bolts shall be in accordance with paragraphs 2.4.2.12 and 2.4.2.13. Nuts shall meet the requirements of ASTM A-194, A-325 or A-563 as applicable. Bolts and nuts shall conform to the latest standards of the American National Standards Institute. Bolts and nuts shall be cut to American National Standards threads with a Class 3 fit. Bolts, unless otherwise specified, shall be furnished with hexagon nuts, and unless shown on the drawings as being peened, shall be drilled for and furnished with a suitable cotter pin and spring-lock washer. Cotter pins may be omitted on bolts 3/8-inch or less in diameter. The number of different sizes of bolts shall be kept to an absolute minimum. Self-tapping screws shall not be used unless specifically approved by the purchaser. All steel screws, bolts and nuts shall have an approved rust-preventive finish.

Aluminum alloy bolts, nuts and screws shall be in accordance with paragraph 2.4.4.7.

2.4.8.2 Lock Washers and Lock Nuts

Lock washers 5/8-inch size and smaller, may be commercial standard, and those 3/4-inch size and larger shall be in accordance with specification _____. For applications having the approval of the purchaser, elastic stop nuts with nylon collars may be used instead of standard nuts and lock washers. Where elastic stop nuts are used, the bolt threads must provide a Class 3 fit, with ends chamfered, must be clean and smooth, without burrs, and at least one and one-half threads must come through the locking collar. Bolts for use with elastic stopnuts must not be sheared or drilled for cotter pins. All lock washers and lock nuts shall have an approved rust preventive finish.

2.4.8.3 Rivets

Steel rivets shall be in accordance with paragraph 2.4.2.11. Blind rivets, if used, shall be approved by the purchaser.

Aluminum alloy rivets shall be in accordance with paragraph 2.4.4.6.

2.4.9 NON-METALLIC MATERIALS

Fabrics and other non-metallic materials used for interior appointments shall not be affected by industrial compounds used for cleaning purposes. Where any commonly used cleaner or lubricant will be detrimental to the application, the contractor shall inform the purchaser prior to approval of the engineering design.

2.4.9.1 Sandwich Panels

Sandwich panels shall include, but not be limited to, metal-faced plywood core, metal-faced balsa wood core, and honey-comb core with metal or other approved facing material.

2.4.9.1.1 Unless otherwise specified, all sandwich panels shall conform to the requirements of specification _____. Flame-retardant materials must retain their properties indefinitely. Flame resistance, smoke and toxicity characteristics must be approved by the purchaser.

2.4.9.1.2 All plywood shall be grade _____. Inner plies shall be grade _____, solid and jointed core. All plywood shall have a minimum of plies as follows:

3/8-inch or less	_____
1/2- to 3/4-inch	_____
Greater than 3/4-inch	_____

2.4.9.1.3 All non-metallic core materials shall be pressure treated with flame-retardant materials prior to application of any surfacing material. Treatment shall conform to specification _____. Treatment materials shall be non-toxic to man and non-corrosive. Any strength reduction associated with this treatment shall be reported to the purchaser in writing.

2.4.9.1.4 All finished panels shall incorporate a continuous edge reinforcement on all edges to facilitate transfer of stresses and to seal the edge against moisture penetration and other damage, unless otherwise specified by the purchaser.

2.4.9.1.5 Treated core material shall be certified to meet the flame-resistant requirements of _____.

2.4.9.1.6 After treatment, all plywood shall be kiln-dried to a moisture content of less than ___ percent and then stored under cover. Treated plywood shall be primed or sealed as soon as possible after fabrication. If, after treatment, any treated surfaces are newly cut, these surfaces shall be treated with the same fire-retardant materials used in the original treatment.

2.4.9.1.7 The following metal facings are acceptable for sandwich panel applications:

<u>Panel Application</u>	<u>Sheet Material</u>	<u>Type</u>	<u>Minimum Thickness</u>
_____	_____	_____	_____
_____	_____	_____	_____

2.4.9.2 Elastomers

Elastomeric parts shall be fabricated from materials compounded to withstand the environment under which the purchaser's system must operate. Elastomeric parts may include door and window seals, glazing strips, truck bumpers and snubbers, structural and compressible gaskets and mounting pads.

2.4.9.2.1 Elastomeric parts shall be capable of withstanding operational temperatures of ___°F to ___°F. Elastomeric parts shall not be painted unless specifically approved by the purchaser.

2.4.9.2.2 Elastomeric materials shall have the following minimum properties when tested in accordance with the applicable specification:

<u>Physical Property</u>	<u>Test Method</u>	<u>Performance Requirement Value</u>
Hardness	_____	_____
Tensile Strength	_____	_____
Elongation	_____	_____
Flame Resistance	_____	_____
Ozone Resistance	_____	_____
Resistance to Heat Aging	_____	_____
Resistance to Oil Aging	_____	_____
Resistance to Permanent Set	_____	_____

2.4.9.3 Safety Glass

2.4.9.3.1 Laminated glass used in side windows and interior partitions shall conform to specification _____. Minimum thickness shall be ___ inches and the glass shall be tinted where required by the detail specification.

2.4.9.3.2 Laminated glass used in cab windows shall conform to the specification called out in paragraph 2.4.9.3.1 except that minimum thickness shall be ___ inches.

2.4.9.3.3 Laminated glass used in the cab windshield shall conform to specification _____. Minimum thickness shall be ___ inches. As an option, the purchaser may specify that one or both layers of laminated safety glass shall be heat-strengthened (tempered).

2.4.9.4 Marking Films

2.4.9.4.1 All marking film decals and adhesives shall conform to the requirements of specification _____. Application techniques shall be in accordance with manufacturer's recommendations.

2.4.9.4.2 Marking films shall have the following physical properties:

Flexibility	_____
Thickness	_____
Opacity	_____
Gloss	_____
Heat Resistance	_____
Chemical Resistance	_____

2.4.9.5 Plastic Sheets and Laminates

Plastic laminates and thermoplastic sheets shall meet the following requirements:

2.4.9.5.1 Fiberglass-Reinforced Plastics - Resins shall be of good commercial grade thermosetting, fire-retardant polyester materials, selected to meet the physical and molding process requirements indicated. Resins shall be pigmented to match the colors indicated.

Fiberglass reinforcement shall be mat, fabric, woven roving, continuous roving, chopped strand preforms, chopped spun roving, or swirl mat, as required to meet the physical and process requirements indicated. Glass content by weight shall be ___ to ___ percent, except as otherwise approved.

Gelcoat shall be resistant to scuffing, fire and weather, perspiration and cleaning agents. Gelcoats shall be pigmented to match the color indicated. The minimum thickness of gelcoat shall be ___ inch, unless otherwise approved. A primer gelcoat shall be used when the surface of the finished panel is to be painted.

Additives, fillers, monomers, catalysts, activators and inhibitors, pigments, and flameproofing materials shall be added to the resin mixes as required to obtain finished products with the characteristics indicated. Mineral filler shall not exceed ___ percent of the finished weight for the preformed matched die molding process.

Fiberglass-reinforced plastic shall be manufactured by one of the following methods, or other methods as approved by the purchaser:

- a. Method I - Open Molding
 - Hand Layup
 - Spray Layup
- b. Method II - Matched Die Molding
 - Preform

Production techniques shall ensure that glass fiber reinforcement is distributed throughout the final product in such a manner to avoid resin-rich sections. Reinforced plastic parts shall have greater thickness at attachment joints and edges as required and approved. No exposed sharp edges on parts shall be permitted.

All open molded parts shall be gelcoated except as approved by the purchaser. Plastic laminates which are to be painted shall be sanded and filled before the prime and finish coats are applied. Plastic laminates which are not to be painted shall be uniformly pigmented to match the color indicated. Surfaces shall be uniform, smooth, and free of porosity and crazing.

Fiberglass-reinforced plastics shall have the following minimum properties when tested in accordance with the applicable specification:

<u>Physical Property</u>	<u>Test Method</u>	<u>Performance Requirement Value</u>
Hardness	_____	_____
Tensile Strength	_____	_____
Compressive Strength	_____	_____
Flexural Strength	_____	_____
Impact Strength	_____	_____
Flame Resistance	_____	_____
Heat Resistance	_____	_____
Thickness	None	_____

2.4.9.5.2 High-Pressure Laminated Melamine Plastic - Shall be two-ply laminated material consisting of a hard plastic film facing permanently bonded to a base sheet. These laminated plastics shall conform to specification _____ and shall be self-extinguishing when tested in accordance with _____.

2.4.9.5.3 Thermoplastic - Material shall be of the _____ type and shall have the following minimum properties when tested in accordance with the applicable specification:

<u>Physical Property</u>	<u>Test Method</u>	<u>Performance Requirement Value</u>
Specific Gravity	_____	_____
Hardness	_____	_____
Tensile Strength	_____	_____
Flexural Strength	_____	_____
Flame Resistance	_____	_____
Heat Shrinkage	_____	_____
Thickness	None	_____

2.4.9.6 Resilient Foams

Foams shall only be used where permitted by the purchaser. All foam material shall be graded and labeled in accordance with the requirements indicated and as standard with the recognized industry associations or societies. Flame resistance, smoke and toxicity characteristics must be approved by the purchaser. Any flame retardant treatment must retain its properties indefinitely.

2.4.9.6.1 Latex and Neoprene Foam - All materials and workmanship shall conform to the requirements of specification _____. Foam shall be a soft, resilient, porous product made from compounded natural or synthetic rubber latex or a mixture of the two, and shall consist of a network of open or interconnecting cells. Unless otherwise specified, latex foam shall be molded to size and shall have a smooth, natural skin surface, formed by contact with the mold or cover plates. Molded material shall have a high resistance to tearing, flexing, wetting and exposure to flame. Cored and slab, or uncored stock shall be selected to best meet requirements of each particular application. Grades of stock shall be subjected to approval by the purchaser.

The foam product shall be made from frothed latex which shall be shaped in a mold, leveled on a belt, or cast against a fabric while in a fluid state. The fluid froth shall then be gelled and vulcanized by combining with sulphur to impart resilience, good aging, and permanence of shape, and the vulcanized product washed before drying. The foam product shall be cored or uncured, and molded to shape and dimensions as required.

Tolerances on dimensions of latex foam rubber products shall meet the requirements set forth in ASTM D-1055, Table II. Latex foams shall have the following minimum properties when tested in accordance with the applicable specification:

<u>Physical Property</u>	<u>Test Method</u>	<u>Performance Requirement Value</u>
Density	_____	_____
Maximum Compression Set	_____	_____
Accelerated Aging - maximum change in compression resistance	_____	_____
Flexural Strength after _____ cycles	_____	_____
Flame Resistance	_____	_____

2.4.9.6.2 Urethane Foam - All materials and workmanship shall conform to specification _____. Foam shall be soft, resilient, porous, expanded cellular product produced by the interaction of polyhydroxy compounds, water and isocyanates. Unless otherwise specified, urethane foam shall be molded and shall have a natural skin on the surface. The molded material shall have a high resistance to tearing, flexing, wetting and exposure to flame. Cored and slab or uncored stock shall be selected to best meet requirements of each particular application. Special components as indicated shall be dimension-molded.

The foam product shall be made from _____ type polyether base urethane or approved equal.

Tolerances on dimensions of urethane foam products shall not exceed those indicated for latex foam.

Urethane foams shall have the following minimum properties when tested in accordance with the applicable specification:

<u>Physical Property</u>	<u>Test Method</u>	<u>Performance Requirement Value</u>
Density	_____	_____
Indentation Load Deflection	_____	_____
Indentation Load Ratio	_____	_____
Maximum Compression Set	_____	_____
Steam Autoclave Test		
1. Change ILD,		
25% Deflection	_____	_____
2. Compression Set	_____	_____
Flame Resistance	_____	_____

2.4.9.6.3 Flat Cushioning Foam - (Carpet pad) shall be a resilient, porous product conforming to specification _____. It shall be molded sheet with flat parallel surfaces having high density skin faces and a woven fibrous burlap fabric facing on one surface sufficient to maintain dimensional stability. Minimum thickness shall be ___ inches. Flame spread shall not exceed ___ when tested in accordance with _____.

2.4.9.7 Fabrics

2.4.9.7.1 Plastic-Coated Fabrics - All materials shall be vinyl coated and shall conform to specification _____. Total fabric weight shall not be less than ___ ounces per square yard. Flame spread shall not exceed _____ when tested in accordance with _____.

2.4.9.7.2 Woven Upholstery Fabrics - All materials and workmanship shall conform to specification _____. Total fabric weight shall not be less than ___ ounces per square yard. Fabrics shall be treated for flame retardance. All upholstery fabrics shall have the following minimum properties when tested in accordance with the applicable specification:

<u>Physical Property</u>	<u>Test Method</u>	<u>Performance Requirement Value</u>	
		<u>Warp</u>	<u>Fill</u>
Thread Count	_____	_____	_____
Tensile Strength	_____	_____	_____
Seam Strength	_____	_____	_____
Tear Strength	_____	_____	_____
Abrasion Resistance	_____	_____	_____
Perspiration Resistance	_____	_____	_____
Dry Crocking	_____	_____	_____
Wet Crocking	_____	_____	_____

2.4.9.7.3 Carpet - All materials and workmanship shall conform to the requirements of specification _____. Pile yarn shall be ___percent _____. Backings (warp) shall be _____ or equivalent material approved by the purchaser. Minimum construction features shall be as follows:

Yarn Plys	_____	
Wires	_____	
Wire Height	_____	
Pitch	_____	
Weights per square yard, minimum:		
Yarn	_____	
Chain	_____	
Stuffer	_____	
Filling	_____	
Back Coating	_____	
Total	_____	
Edge and seam treatment	_____	_____

Carpet fabrics shall be cleanable by standard commercial methods suitable for the specific material, construction and color of the fabric as installed.

Carpet fabric shall have the following minimum properties when tested in accordance with the applicable specification:

<u>Physical Property</u>	<u>Test Method</u>	<u>Performance Requirement Value</u>
Wear Resistance	_____	_____
Tuft Lock	_____	_____
Shrinkage	_____	_____
Flame Resistance	_____	_____

2.4.9.8 Caulking and Sealing

Application of all caulking and sealing compounds shall be in accordance with the manufacturer's recommendations.

2.4.9.8.1 Caulking Compounds - Shall be non-staining, and shall be supplied in colors closely matching those of adjacent materials and surfaces.

Caulking primers shall be quick-drying, colorless, non-staining sealers of the type and consistency as recommended by the manufacturer of the caulking materials, for the particular surfaces involved.

Packing (Backstop) shall be non-staining resilient material, such as glass fiber roving, or neoprene, butyl, polyurethane or other closed-cell foams, or other compressible material, compatible with the caulking compound used.

Butyl tape shall be extruded polyisobutylene sealer compounded of 100-percent solids.

2.4.9.8.2 Application and Workmanship - Joints, spaces and junctures to be packed and caulked or sealed shall be completely cleaned of all dirt, dust, oil, and other foreign materials which would adversely affect the caulking work. Surfaces shall be thoroughly dry before application of caulking compounds. When so stipulated by the manufacturer of the sealants, paint and other protective coatings shall be removed from surfaces to be caulked prior to priming and application of sealants. Preparation of surfaces to have polysulfide liquid polymer or silicone compounds applied directly to them shall conform to manufacturer's recommendations.

When caulking against aluminum frame members with adhesive type compounds, all film type isolation or separation coatings which have been applied to the aluminum surfaces shall be removed immediately before applying the caulking, to the maximum depth of the caulking seam.

Compounds shall be applied with pneumatic guns having proper size nozzles exerting sufficient pressure to fill completely all voids and joints. Unless otherwise indicated, the entire perimeter of each opening shall be caulked. Where the use of the gun is impracticable, suitable hand tools shall be used. The finish of caulking joints on flush surfaces, and in internal corners shall be neatly pointed. All excess material shall be removed. Caulking, where exposed, shall be free of wrinkles and uniformly smooth.

Application of polysulfide compounds shall be in strict accordance with the manufacturer's recommendations. Storage shall be at temperatures below 50°F. Compounds shall not be used when they become too jelled to be discharged in a continuous flow from the gun. Modification of caulking compounds by addition of liquids, solids or powders, shall not be permitted. When using two-part compounds, only the amount of caulking which can be installed within four hours shall be mixed.

All adjoining surfaces, finishes, and fixtures shall be carefully protected throughout the caulking operations, and any stains, marks or damage thereto as a result of caulking and sealing work shall be corrected in a manner satisfactory to the purchaser.

2.5 PROTECTIVE COATINGS AND FINISHES

2.5.1 GENERAL

The contractor's processing procedures and facilities shall be subject to review and approval by the purchaser.

2.5.1.1 Dissimilar Metal Protection

Dissimilar metals shall be protected in accordance with MIL-STD-889 or as specified by the purchaser.

2.5.2 SURFACE TREATMENT

2.5.2.1 Aluminum Alloys

Surface treatment on aluminum alloys shall be selected from the following, unless otherwise specified:

- a. Chemical film treatment in accordance with ASTM B449-67 or ASTM D1730-67
- b. Anodic coating in accordance with ASTM D1730-67
- c. Hard anodic coating (where resistance to wear and abrasion is desired) in accordance with MIL-A-8625, Type III.

2.5.2.2 Carbon and Low Alloy Steels

Contractor shall furnish the purchaser with a list of all pieces intended for plating, including a description of the process and the reasons for plating. Cadmium plating shall meet the requirements of ASTM A165. Chromium plating (for wear) on steel shall meet the requirements of ASTM B177. Zinc plating

on steel shall meet the requirements of ASTM A164. Hot galvanized (zinc) coating requirements are to meet the requirements of ASTM A123.

2.5.2.3 Corrosion-resistant steels need not be plated except in dissimilar metal contact applications.

2.5.2.4 Brass, bronze, copper, and nickel alloys require no surface treatment except as specified in the detail specification.

2.5.3 PAINTS AND COATINGS

2.5.3.1 Color standards shall be in accordance with _____.

2.5.3.2 Areas exposed to corrosive fluids or cleaning solutions shall be protected with coatings resistant to those fluids. Resistance to the following cleaning fluids is specifically required: _____.

2.5.3.3 Exterior surface areas of the car body are to be coated in accordance with the detailed specification.

2.5.3.4 Interior metal surface areas of the car body, including detail parts, shall be coated with _____ primer in accordance with the requirements of the detailed specification.

2.5.3.5 Paints shall be checked for fire retardation to the requirements of ASTM D1360 and ASTM D1361.

2.5.3.6 Preparation of zinc-coated steel surfaces for painting shall be in accordance with ASTM D2092.

2.6 ENVIRONMENTAL REQUIREMENTS

2.6.1 CLIMATIC CONDITIONS

The complete car, including all equipment and components, shall be capable of operating reliably and safely without damage to the equipment, when continuously subjected to any atmospheric temperature between -____°F and +____°F, and when subjected to any combination of solar heat, humidity, wind, rain, lightning, snow, ice, dirt, and dust that may occur in the geographical area in which the car will operate.

2.6.2 EXTERNAL OPERATIONAL ENVIRONMENT

The detail specification will provide a complete description of those operational elements which must be considered during car design and development. This description will include, but is not limited to, the following:

- a. Track geometry and alignment
- b. External environmental characteristics (tunnel, elevated, etc.) which may affect noise levels, vibration, temperatures

2.6.3 EFFECT ON EXTERNAL ENVIRONMENT (If specified)

The detail specification will specify the limits of environmental pollution that will be tolerated when the railcar is placed into operation. Limits, where applicable, will be specified for acceptable levels of air, noise, and thermal pollution and test methods will be defined for determining compliance.

2.7 VIBRATION CRITERIA (If specified)

2.7.1 COMPONENT DESIGN CRITERIA

2.7.1.1 General Provisions

All car body-mounted, truck frame-mounted and truck axle-mounted components shall be designed to have structural integrity and be operationally reliable for infinite life in the vibration environment at the point of attachment of the component. In addition, these components shall be designed to prevent unacceptable vibration inputs to the attachment structure.

2.7.1.2 Vibration Environment

The vibration spectrum at the point of attachment shall be defined to reflect the fundamental forcing frequencies and the forcing levels at these frequencies throughout the operational range of the vehicle. The component structure and mounting shall be designed to prevent amplification, through component resonance, beyond a level twice that of the attachment point.

2.7.1.3 Vibration Output

Where rotating components are installed, the vibratory force output of those components shall be such that the vibration environment specified for component design shall not be exceeded. The contractor shall guard against the creation of harmful and annoying secondary vibrations caused by interaction of the rotating component with the mounting structure.

2.7.2 RIDE QUALITY AND PASSENGER COMFORT

2.7.2.1 General Provisions - Throughout the operational environment, the car shall be designed to be free from objectionable vibration and shock. All equipment mounted in the passenger areas shall be free from resonance to avoid all annoying audio and visual distraction.

2.7.2.2 Vibration Levels - At all passenger and operator locations throughout the car, vibration levels shall not exceed those specified in the following paragraphs. These levels shall apply to floor, wall, seat frame and all areas with which the passengers and operators come in contact.

- a. Steady state conditions at all steady railcar speeds, up to maximum speed, on tangent and curved track, average vibration levels measured during a typical ten-second running period shall not exceed the levels specified in Figure 2-8. No peak acceleration value (half amplitude) when measured to include frequencies below ___ Hz shall exceed ___ G.
- b. Transient conditions for any slow or rapid linear acceleration or deceleration, or during switching or at crossovers, the maximum vibration levels, recorded to include frequencies below ___ Hz, shall not exceed ___ G recorded in any direction.

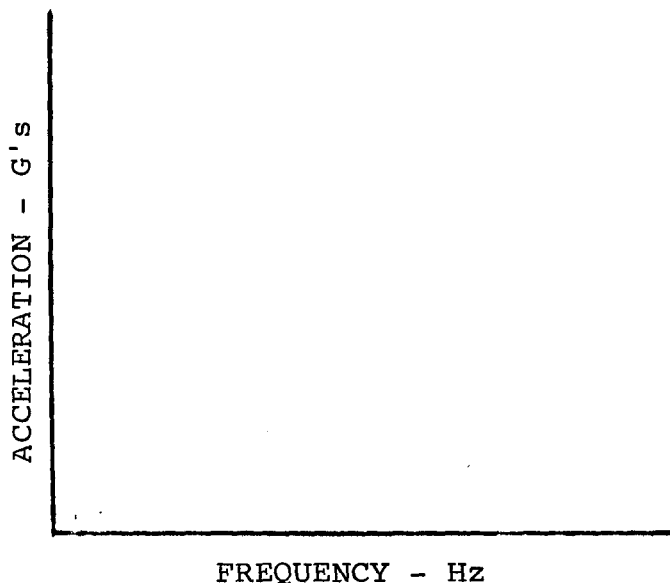


Figure 2-8. RIDE QUALITY REQUIREMENTS

Vibration measurements shall be made in the car at locations and orientations which reflect vibration representative of passenger comfort based on proven experience or as a result of vibration analyses conducted to ensure the car meets the design requirements.

2.7.2.3 Track Condition - Vibration measurements made to ensure compatibility with the above criteria shall be made on standard and minimum quality track as defined in para. 2.2.1.5.3.

2.7.2.4 Vibration Analysis - The frequencies of the sources of excitation such as wheels, motors, gears and rail joint spacing shall be defined throughout the operational environment. Vibration analyses shall be conducted to ensure freedom from resonance or unacceptable dynamic amplification of all major structural components as they influence the passenger comfort. All non-structural panels, trim and equipment installations shall be analyzed or treated for vibration attenuation to ensure no resonances in the operating regime.

Where vibration measurements are to be made on non-operationally representative track, vibration analyses shall be conducted to allow extrapolation of the measured data to the average operational track conditions expected to be encountered.

2.8 NOISE CONTROL (If specified)

2.8.1 GENERAL

This section contains the general requirements for maximum allowable sound pressure levels in crew and passenger spaces and at the wayside.

2.8.1.1 Definitions

a. Sound Pressure Level - The sound pressure level

in decibels is defined as $20 \log \frac{p}{P_0}$ where p is the measured rms sound pressure and P_0 is the reference pressure, 0.0002 dyne/cm².

b. Reported Sound Pressure Level - The sound pressure level to be reported in satisfying this specification shall be the arithmetic average of the measured minimum and maximum levels as measured on the slow meter position, provided the difference between the average and maximum is 3 db or less. If this difference is greater than 3 db, then the level to be reported shall be obtained by subtracting 3 db from the maximum level.

- c. Auxiliary Systems - An auxiliary system is any mechanism or structure other than the car body, traction motor, or propulsion system gearing which performs a function at some time during the operation of the car; e.g., heating and air conditioning system, pumps, car door operation, motor alternator, air compressor or hydraulic power unit, fluorescent lamps and ballasts, and braking system.
- d. Pure Tone or Narrow Band - If the sound pressure level of any one-third octave band exceeds the level in the adjacent one-third octave bands by 5 db or more, that band shall be considered to contain pure tone or narrow-band components.
- e. Requirements - The following figures and tables shall be presented in the detail specification:
 - Fig. 2-9 - Interior Noise Levels and Test Conditions
 - Fig. 2-10 - Wayside Noise Levels and Test Conditions
 - Table 2-1 - Equipment Noise Levels and Test Conditions

2.8.2 APPLICABLE DOCUMENTS

The following documents form a part of this section to the extent specified herein by the purchaser.

American National Standards Institute publications, including:

- S1.1 - Acoustical Terminology (including Mechanical Shock and Vibration)
- S1.2 - Physical Measurement of Sound, Method for
- S1.4 - General Purpose Sound Level Meters, Specification for
- S1.6 - Preferred Frequencies and Band Numbers for Acoustical Measurements
- S1.10 - Calibration of Microphones, Method for the
- S1.11 - Octave, Half-Octave, and Third-Octave Band Filter Sets, Specifications for

2.8.3 REQUIREMENTS FOR NOISE CONTROL

2.8.3.1 Interior Noise - The maximum allowable sound pressure levels in all parts of the car shall not exceed the values of Fig. 2-9 for the specified test condition. Noise levels shall be surveyed at the ear levels of seated and standing passengers with the doors closed and all equipment operating.

2.8.3.2 Wayside Noise - Sound pressure levels audible at the wayside shall not exceed the values of Fig. 2-10 for the specified test conditions for dry level tangent and curved track. The radius of curvature for curved track measurements shall not exceed _____ feet. Measurements shall be made at axle height, 50 feet from the track centerline with the car operating on ballast and tie track.

2.8.3.3 Equipment Noise - Car equipment, including draft gear, should be designed so that associated noise levels are not audible above the sound levels generated by the car in operation. Equipment noise measured prior to installation shall not exceed the levels of Table 2-1. Noise generated by the public address system in the standby condition shall not exceed the levels in the car with the system off.

2.8.3.4 Pure Tone or Narrow-Band Noise - If interior noise environments contain pure tone or narrow-band components as defined by paragraph 2.8.1.1.d, the requirements of Fig. 2-9 shall be lowered by 5 db.

2.8.3.5 Required Reports - Engineering report on noise testing shall be submitted in accordance with Section 17.4.5.

Prior to car construction, the contractor shall submit an engineering report for approval by the purchaser which shall include the following data:

- a. Engineering estimates of the sound pressure level environment inside and outside the railcar and the engineering basis (pertinent structural data, tests, calculations, etc.) for such estimates.
- b. Estimates or measurements of sound pressure levels generated by auxiliary systems.

INTERIOR NOISE

[ALL EQUIPMENT OPERATING]

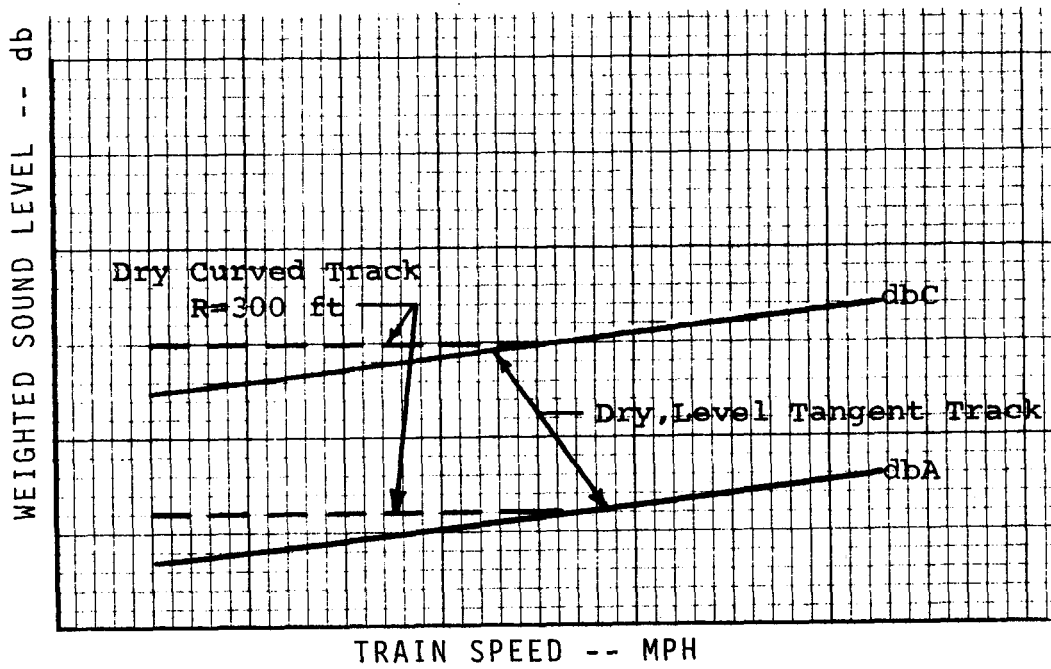


Figure 2-9

WAYSIDE NOISE

[50 FT. FROM TRACK C]

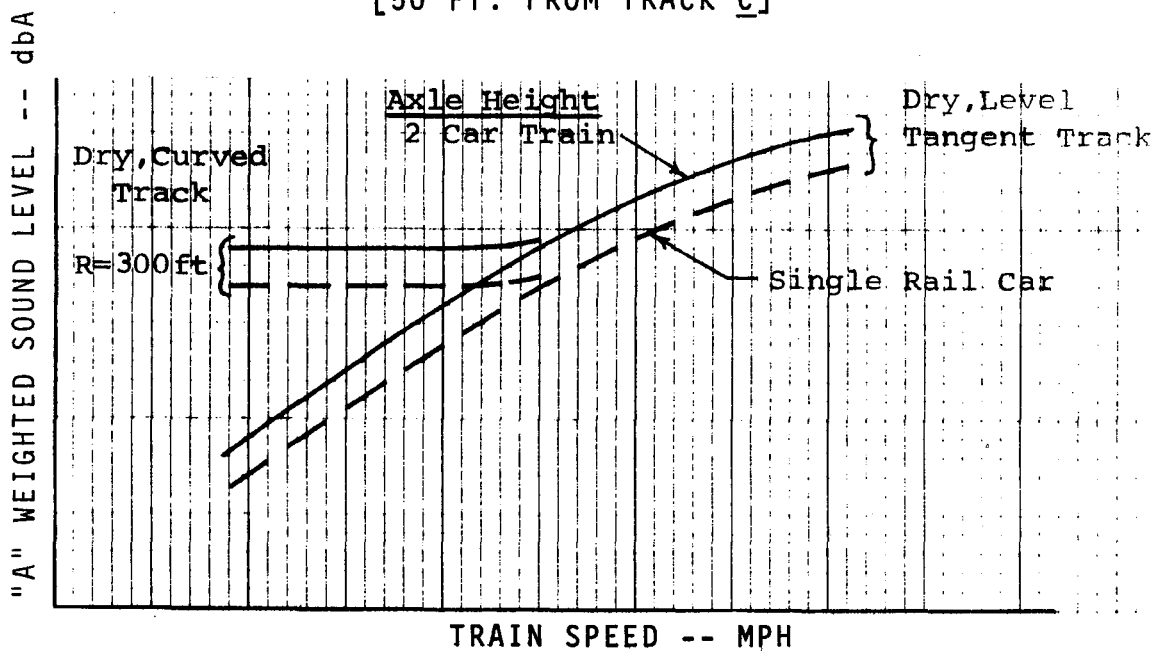


Figure 2-10

TABLE 2-1

EQUIPMENT NOISE LEVELS

PRIOR TO INSTALLATION ON CAR

SYSTEM	TEST CONDITIONS		NOISE LEVEL REQUIREMENTS (dba)
	MEAS. DIST. (FEET)	EQUIP. OPER. CONDITION	
TRACTION MOTOR			
PROPULSION SYSTEM GEARING			
OTHER COMPONENTS			

CAR BODY

3.1 GENERAL

The car body shall include the elements housing the operating crew and passenger sections and all related structure and appurtenances.

The car body shall be designed with structural integrity meeting the specified operational, functional, and safety requirements.

The car body arrangement and dimensions shall be as prescribed in the detail specification.

3.2 MOCKUPS AND MODELS

3.2.1 OPERATING CAB

The contractor shall construct a full-scale mockup of the cab showing the location and arrangement of the controls, switches, seat, front and side windows, doors, partitions, heater and any other apparatus required by this specification. Preliminary drawings of the compartment shall be submitted for approval before the mockup is constructed. The mockup shall be inspected and approved by the purchaser before the design is finalized. This mockup shall remain intact as approved. Approval of the above-mentioned mockup shall be binding as to all other cars to be built, except that such approval does not in any way relieve the contractor of responsibility for the proper function and adequacy of the design.

3.2.2 UNDERFLOOR EQUIPMENT ARRANGEMENT

The contractor shall construct a model in _____ or larger scale, showing the underfloor arrangement of each car type. The model shall show the location and arrangement of the apparatus, raceways, conduit, piping and coupling equipment. The mockup shall be inspected and approved for equipment arrangement by the purchaser before the underfloor equipment arrangement is finalized.

3.2.3 SEATS

The contractor shall construct the necessary seat mockups during the development of the seat design. Mockups intended to convey appearance only shall be at least _____ size. Mockups intended to depict seat cushion contour for comfort assessment shall be full-size.

3.3 CONSTRUCTION

The car body shall be constructed to meet the design and strength requirements specified below. Acceptable materials, processes, manner of fabrication and attachment shall be specified by the purchaser.

- a. The car structure shall be designed for the design loads specified. Consideration shall be given to the use of energy attenuating structures or other means to increase the crashworthiness of the vehicle.
- b. The car structure must be of sufficient stiffness to be commensurate with the requirements of Sections 2.7 (Vibration) and 2.8 (Noise) of this specification.
- c. Commuter car design conditions shall meet or exceed the requirements of DOT/FRA Regulation 49CFR230 - Locomotive Inspection, Subpart D - Multiple Operated Electric Units, Section 230.457 - Body Structure, for train empty weight over 600,000 pounds and Section C of the AAR Manual of Standards and Recommended Practices (if specified).

3.3.1 VERTICAL LOADING

A vertical uniform loading of _____ pounds, representing the maximum passenger load added to the empty car, when applied to the car structure in a manner representing the actual distribution of load, shall not cause the stress level in any structural member to exceed ___% of the allowable stress for the material used.

3.3.2 CAMBER

- a. Maximum camber shall not be greater than _____ inches between bolsters at light car weight.

- b. Minimum camber shall not be less than ___ inches between bolsters at crush load.

3.3.3 COMPRESSION LOADING

The car body shall resist a static compressive end load of _____ pounds applied along the car body longitudinal centerline, on the end underframe or anticlimber, without permanent deformation in any structural member. A vertical load of _____ pounds shall be applied simultaneously.

3.3.4 CRASHWORTHINESS CRITERIA

- a. The vehicle shall withstand a ___ MPH impact with a solid object and sustain zero damage.
- b. The vehicle shall withstand a ___ MPH impact and damage shall be confined to the draft gear.
- c. The vehicle shall withstand a ___ MPH impact and damage shall be confined to the forward two feet of the vehicle and there shall be no hazardous electrical damage.
- d. For vehicle impacts at speeds above ___ MPH, moderate damage to the vehicle structure is expected.

3.3.5 HOISTING AND JACKING

The car structure shall be capable of being raised either by jacking or hoisting such that no yield occurs when the most critical combination of load points is used. Each jack and hoist point shall be designed for vertical load combined with a horizontal component. These values and location of the lifting points will be specified here by the purchaser.

3.4 UNDERFRAME

The underframe shall consist of the structural assembly on which the floor is mounted and to which the sides, ends, trucks, and coupler are attached. The underframe shall be designed to function integrally with the other car body elements in resisting design loads. Material and construction requirements shall be as prescribed in the detail specification.

- a. The underframe shall be designed as an integral part of the body structure and shall be subjected to the conditions of section 3.3.
- b. The underframe shall resist the coupler-draft gear induced loads of section 4.1.2 without permanent deformation.

- c. The underframe shall withstand separately the truck longitudinal shear load of _____ pounds and the vertical reaction from the truck of _____ pounds without permanent deformation.
- d. The underframe structure shall provide supports for equipment of sufficient strength and rigidity to withstand the load conditions of Section 3.9.2 and the vibration requirements of Section 2.7. The supports shall be such that the mounted equipment natural frequencies are well removed from the truck and car body natural frequencies.

3.4.1 END UNDERFRAME

Statement as to what the end underframe consists of: integrity, material and construction requirements.

3.4.2 CENTER SILL

3.4.3 BOLSTERS OR CROSSBEARERS

3.4.4 ANTICLIMBER

The anticlimbing structure shall withstand, without yielding, an applied vertical load of _____ pounds.

3.5 BODY SHELL

The body shell shall include the side, roof, end and skirt elements mounted to the underframe.

3.5.1 SIDES

Material, type of construction, manner of fabrication, attachment, integrity and exterior finish shall be specified. The side structure shall be designed to withstand the following loads:

- a. The loadings induced due to the sides acting as an integral part of the car body structure.
- b. Loads induced from other sources: e.g., seats, door mechanisms, windows, etc.

3.5.2 ROOF

The roof structure shall be designed to withstand the following loads without yielding:

- a. A vertical download of _____ pounds spaced every _____ inches, corresponding to men working on the roof.

- b. A normal pressure of _____ pounds per square foot corresponding to the service environment: e.g., water washing equipment, aerodynamic pressure, snow load, etc.
- c. A vertical load equal to the weight of the roof-mounted equipment, plus _____ maintenance personnel weighing _____ pounds each. This load is to be distributed over an area of structure similar in size to that of the equipment installed: e.g., pantograph, air conditioning unit, etc.
- d. Equipment support structure shall be of sufficient strength and rigidity such that it will conform to the vibration requirements of Section 2.7.

3.5.3 ENDS

The car body end structures shall be designed to the following loads:

- a. Collision Post - Each collision post shall have a section modulus (Z) about the car body transverse axis of at least _____ inches³ for 110,000 psi yield stress material, or a proportionately greater value for material of lesser yield stress.
- b. Collision Post - A horizontal longitudinal compressive load of _____ pounds applied 18 inches from the centroid of the underframe support. This will result in the onset of yield.
- c. Collision Post - A horizontal shear load of _____ pounds applied at a point even with the top of the underframe member to which it is attached. No yield.
- d. Collision Post - Attachments to the supporting members at the roof or underframe shall withstand the loads specified in "b" above without shear reinforcements. The collision post shall be assumed to be a simple beam with free end supports.
- e. Corner Posts - Strength levels of the corner post structure shall be taken as ___% of those specified for the collision posts.

3.5.4 SKIRTS (Optional)

Arrangement and dimensions as per detail specification. Removability and interchangeability requirements.

3.5.5 OTHER

3.6 INSULATION

3.6.1 GENERAL

As approved by the purchaser, insulation materials shall be of the rigid, non-rigid, or spray-on type. Materials shall be non-absorptive of fluids and gases, vermin-proof, and shall meet the performance requirements specified. Flame-retardant materials must retain their properties indefinitely and flame resistance, smoke and toxicity characteristics must be approved by the purchaser.

3.6.2 GRADING AND LABELING

All materials shall be graded and labeled as standard with the recognized industry associations or societies. Labels shall be permanently affixed to, or imprinted on, the materials.

3.6.3 INSTALLATION

All insulation materials shall be installed in accordance with the manufacturer's recommendations. Rigid and non-rigid, preformed insulation shall be secured with mechanical fasteners or fire-resistant adhesives, or both. Spray-on insulation shall be applied over surfaces free from dirt, grease and other contaminants which might affect the adherence of the material. Parts subject to corrosion shall be given the required protection prior to receiving insulation.

3.6.4 MATERIALS

The insulation materials shall be selected by the contractor to meet the performance requirements specified. The following materials are acceptable. Other materials may be used subject to approval by the purchaser.

Rigid Insulation:

Non-Rigid Insulation:

Spray-On Insulation:

3.6.5 PERFORMANCE REQUIREMENTS

3.6.5.1 All insulation materials shall meet the requirements of Section 2.4.9 for the specific type indicated.

3.6.5.2 All acoustic insulation shall meet the requirements of Section 2.8.3.

3.6.5.3 All thermal insulation shall have a thermal conductivity of not greater than ___ BTU per hour per square foot per ___°F per inch of thickness when tested in accordance with _____.

3.7 FLOORS

Floors shall include continuous, horizontal planar elements mounted to the underframe.

3.7.1 PRIMARY FLOOR

Material, type of construction, attachment, drainage and sealing provisions and vibration isolation requirements shall be specified. The floor shall withstand the dead load plus an equivalent passenger load of _____ pounds per square foot. Deflection shall be limited to ___ % of the short span.

3.7.2 SUB FLOOR

Concept, material, type of construction, and attachment.

3.8 OPERATING CAB

Location and arrangement shall be specified by the purchaser. Apparatus and equipment list shall be included.

3.9 UNDERCAR

3.9.1 EQUIPMENT ENCLOSURES

Materials, construction, fasteners and attachments, drainage, cooling, and environmental requirements shall be specified.

3.9.2 UNDERCAR EQUIPMENT

The equipment assigned to the undercar area shall resist, without failure, the following load conditions if specified by the purchaser:

- a. Longitudinal direction _____ g
- b. Lateral direction _____ g
- c. After the loss of one point of support, the remaining supports shall be capable of restraining the equipment in all directions within the specified envelope under _____ g vertical loading.

3.10 INTERIOR

3.10.1 FLOOR COVERING

Material, arrangement, and manner of attachment shall be specified.

3.10.2 SIDE LINING

Material, color and style, surface finish, method of attachment, and access provisions shall be specified. The interior lining shall be designed to the following stiffness requirements if specified by the purchaser:

- a. A centrally applied load of _____ pounds on contact area of not less than _____ square inches shall not deflect the panel more than _____ % of the short beam length.
- b. A uniform pressure of _____ pounds per square foot shall not deflect the panel more than _____ % of the short beam length.
- c. The panel shall be capable of absorbing _____ foot-pounds of energy without permanent deformation or cracking.

NOTE: The values should be adjusted to reflect areas of greater human contact.

3.10.3 CEILING (Same as 3.10.2 - SIDE LINING)

3.10.4 MISCELLANEOUS

To include door pockets, windscreens, partitions, etc.

3.11 WINDOWS

Arrangement and dimensions, glazing materials, light transmission characteristics, manner of installation, replaceability, and interchangeability requirements shall be specified.

3.11.1 SAFETY FACTOR

A factor of _____ shall be used on the following loads to obtain yield load. Deflection is limited to _____ % of the short span under the yield load.

3.11.2 PRESSURE LOADING

The following uniform pressure loadings shall be applied perpendicular to the surface of the window:

Windshield	_____	pounds	per	sq.	ft.
Side Windows	_____	"	"	"	"
End Windows	_____	"	"	"	"

3.11.3 IMPACT LOADING

The motorman's windshield shall withstand, without penetration, the impact of a ___ lb. projectile at a velocity of ___ mph. Area of contact at impact shall be specified.

3.12 SEATS

Arrangement, dimensions, material, type of construction, manner of attachment, etc., shall be specified by the purchaser.

3.12.1 PASSENGER SEATS

The seat structure, including car body support structure and attachments to the car structure, shall be designed to resist the following loads without permanent deformation:

- a. A distributed load of _____ pounds per passenger applied horizontally along the upper edge of the seat back, both directions.
- b. A vertical load of _____ pounds applied downward on the top edge of the seat back at mid-span.
- c. A vertical load of _____ pounds per passenger applied in the center of each seat bottom.
- d. A vertical load of _____ pounds per passenger applied at the center of the front edge of each seat.
- e. A vertical load of _____ pounds applied downward at the free end of each arm rest.
- f. A horizontal load of _____ pounds applied laterally (in relation to seat axis) in either direction at the free end of each arm rest.
- g. A handhold load of _____ pounds applied in any direction.

3.12.2 MOTORMAN'S SEAT

The seat structure, support, and attachments shall withstand, without permanent deformation, a vertical, uniformly distributed load of _____ pounds applied at the forward edge of the seat with the seat in the critical adjusted position.

3.13 STANCHIONS, HAND RAILS, GRAB HANDLES, BARRIERS AND STEPS (Optional)

3.13.1 GENERAL

- a. Stanchions, hand rails and barriers shall be provided as indicated in the contract drawings. Stanchions and hand rails shall have an outside diameter of _____ and shall be of approved stainless steel clad or stainless steel tubing, not less than _____ inches thick with a (satin) finish.
- b. Stanchions and hand rails shall be securely held at each end in fittings unless otherwise specified. Fittings shall be of _____ material and the finish shall match that of the stanchions. All fittings shall provide a permanently tight and rattleproof fastening, and be free of burrs and sharp edges that will create a hazard to passengers or employees working on the cars.
- c. Steps and grab handles shall be provided on the exterior of the car as shown in the contract drawings.

3.13.2 STRENGTH

The following loads shall be resisted without permanent deformation:

- a. Stanchions and vertically-oriented handholds, apply _____ pounds horizontally at mid-height.
- b. Hand rails and horizontally-oriented handholds, apply a uniformly distributed vertical load of _____ pounds per foot.

3.14 DOORS AND OPERATING MECHANISM

3.14.1 SIDE DOORS

Type, arrangement, dimensions, material, type of construction and surface finish shall be specified by the purchaser. The door design shall meet the requirements of section 15.6 with regard to the aged and the handicapped. Doors shall not rattle or vibrate in the closed position.

- a. The side door and supporting structure shall withstand, without door release or permanent deformation, and shall perform in a satisfactory manner after loading with _____ pounds, applied perpendicularly to the door plane, at mid-height of the door leading edge.
- b. The entire door system, including support mechanisms and drive system, shall withstand, without failure, _____ million cycles of operation while being subjected to the loads induced by the operating characteristics of section 3.14.2. A cycle consists of the door moving from the closed position through open and back to closed.
- c. The entire door system, including support mechanisms and drive system, shall withstand, without permanent deformation, an obstruction load of _____ pounds applied to the contact strip on the door edge. This load shall be applied over a small contact area (not a sharp object), in plane and perpendicular.

3.14.2 SIDE DOOR OPERATING MECHANISM

Each side door shall be operated by a powered operator as specified by the purchaser. The door operator shall provide for smooth, continuous opening and closing of the doors under all design and operating conditions with no bouncing at either end of the cycle. The door operator shall prevent the doors from being forced open manually. The door operator shall be designed to operate resisting a force of _____ pounds at mid-travel. Door opening and closing times shall be as required in the detail specification.

3.14.3 END DOORS

Type (hinged or sliding), dimensions, material, type of construction, locking provisions, weathertightness and surface finish shall be specified by the purchaser. The door shall be able to resist, without permanent deformation, a normal pressure of _____ pounds per square foot corresponding to an extreme level of body contact perpendicular to the plane of the door.

3.14.4 CAB DOORS

Type (hinged or sliding), dimensions, material, type of construction, locking provisions and surface finish shall be specified by the purchaser.

3.15 INTERCAR CLOSURE/VESTIBULE (Optional)

The intercar closure shall be designed to provide a weather-tight passageway between cars and to operate safely and satisfactorily under all operating conditions to be encountered.

The intercar closure shall be designed for the following conditions:

- a. In the uncoupled position, the intercar closure shall resist a vertical load of _____ pounds applied at a faceplate. Deflection shall not exceed ____ inches.
- b. The intercar closure shall have a longitudinal stiffness of $K =$ _____ pounds per inch measured at a faceplate.

3.16 TOILET (Optional)

Location and arrangement as specified by the purchaser.

COUPLER AND DRAFT GEAR

4.1 GENERAL

4.1.1 CONFIGURATION

A fully automatic mechanical coupler shall be provided at each end of a single-unit car and at each cab end of a married pair, which represents each end of a two-car unit. Electrical and pneumatic (if required) connections shall be an integral part of the coupler assembly so that connections are automatically made when cars are mechanically coupled.

At the non-cab end (center of a two-car unit), a _____ type coupler (or drawbar) shall be provided. Electrical and pneumatic (if required) connections shall be provided by couplers or plug-in jumper cables and hoses.

4.1.2 STRENGTH REQUIREMENTS

The coupler, coupler carrier, anchorage, and attachment to the car underframe shall be designed to the following loads. Commuter car design conditions shall equal or exceed the strength requirements as specified in the DOT regulations and AAR specifications for train weight over 600,000 pounds.

- a. Energy absorption in buff, minimum, is ____ foot-pounds at ____ pound force.
- b. Energy absorption in draft, minimum, is ____ foot-pounds at ____ pound force.

- c. The draft gear preload shall be _____ pounds in draft and buff.
- d. The draft gear emergency release (optional) load shall be _____ pounds in buff.
- e. The coupler-draft gear shall have an attachment to the car structure that will withstand the following loads without permanent deformation:
 - 1. Buff load = _____ pounds
 - 2. Draft load = _____ pounds
- f. The coupler and its carrier shall withstand, without yielding, a vertical load (both directions) of _____ pounds applied at the coupler, both before and after actuation of the emergency release.
- g. The retractable coupler (optional) shall be designed for end loads of:
 - 1. Buff load = _____ pounds
 - 2. Draft load = _____ pounds

4.1.3 GEOMETRIC REQUIREMENTS

The couplers, when coupled, shall be capable of negotiating horizontal and vertical curves as outlined in this specification, as well as any normal track irregularities.

4.1.4 COUPLER ADAPTERS (Optional)

If required by the purchaser, an adapter shall be provided to permit emergency coupling with existing equipment having a different type of coupler. One coupler adapter shall be provided for each (car, pair, etc.), stored in an approved location. The adapter shall not weigh more than _____ pounds. It must have sufficient strength to permit _____ cars, each having a gross weight of _____ pounds, to be pushed or pulled up a _____% grade with an adequate margin of safety.

4.2 CAB END CONNECTIONS

4.2.1 MECHANICAL COUPLER

4.2.1.1 Operation

The operation of the couplers shall be completely automatic when coupling within a gathering range of _____ inches in either direction and _____ degrees rotation in either direction, with one of the couplers on vertical and horizontal center line.

When cars are brought together so that the couplers are fully engaged mechanically, the couplers shall lock, and air and electrical connections shall be made automatically. A locking device shall hold the couplers in close face-to-face alignment at all times to prevent damage to the electrical and pneumatic connections. Air or _____ actuated uncoupling shall be provided.

4.2.1.2 Coupler Controls

Coupler control shall be arranged so that the complete coupling and uncoupling operations can be performed entirely from the motorman's cab if the lateral displacement of the couplers is less than _____ inches. For commuter cars, three uncoupling devices shall be provided at the cab end of each car: one in the engineman's cab located so as to be covered by the door when the cab is not in use; and one underneath the car at each side. The latter is to provide complete mechanical uncoupling means from the side of the car and in accordance with the regulations of DOT. If the mechanism to accomplish this involves the use of a removable handle, provisions for storage shall be included on one car unit of the married pair. The handle shall be made of an insulating material with sufficient dielectric strength to be safe for use within 650-volt territory (third rail prime power).

Operation of the uncoupling valve or switch on either car of a married pair shall effect an uncoupling. No brake application shall be caused on the part of the train from which an intentional uncoupling is made. On the other cars in the unattended section of the train, an emergency brake application shall be made.

Provision shall be made for disconnection of the electrical trainline connections without mechanical uncoupling. Disconnection controls may be combined with the coupler control. Disconnection of any air connection shall be between the carbody piping and any hoses, so that hoses can be removed without bleeding car air. Uncoupling valves or switches shall be designed to return from the uncoupling position when released.

4.2.1.3 Materials and Configuration

The coupler and yoke shall be of annealed high tensile cast steel. The shank pin used to attach the coupler to the yoke shall be no less than _____ inches in diameter. All bushings used in the draft attachments shall be _____ or equal. The draft sill shall be designed to accept the draft gear and yoke. The draft stop and other appurtenances and attachments of draft sill to other body structure shall be capable of withstanding buff loads as specified in section 4.1.2.

4.2.1.4 Draft Gear

Draft gear shall be provided at each end of each car to carry coupler loads to the car underframe as specified in paragraph . They shall be of the _____ type. Vertical movement of yoke and coupler shall be taken about the front and rear follower blocks of the draft gear.

4.2.1.5 Coupler Carrier

The coupler must be flexibly supported at its nominal height by the coupler carrier which will support the weight of coupler, shank, electric and pneumatic couplers. The carrier must be so designed that the coupler head is permitted the required range of movement in a vertical plane. The carrier must also allow a sufficient range of movement in a transverse direction to enable the coupler head to move in a horizontal plane to the required extent. Coupler carriers shall be equipped with shims, replaceable bushings and wear plates for compensating for wear and shall operate with minimum production of noise.

4.2.1.6 Coupler Centering

A coupler centering device shall be provided to automatically align the coupler on the car centerline at the end of the uncoupling cycle so that cars are ready for recoupling. It shall also hold the uncoupled couplers on the front and rear of the train in the centered position to prevent unwanted lateral movement.

Stops shall be provided to protect the centering device from damage due to impact by coupler shank when couplers experience lateral displacement due to operation conditions such as encountered in turnouts and crossovers. Override of the centering device shall be provided to allow for manual positioning of the coupler when coupling cars on curves.

4.2.1.7 Coupler Indicator (Optional)

Each coupler shall have a mechanical indicator which will show visually that lockup of mating couplers has been completed. The indicator shall be clearly visible from both sides of the car.

4.2.1.8 Protective Heaters (Optional)

If the design of the coupler is such that its operation will be affected by accumulations of ice or snow, electric heaters shall be provided within it. Drainage for rain and melted ice and snow shall be provided wherever it can accumulate.

4.2.1.9 Coupler Gages

The contractor shall supply _____ sets of gages approved by the coupler manufacturer for checking dimensions and surfaces critical to the operation of the coupler.

4.2.2 ELECTRIC COUPLER

4.2.2.1 Configuration

An electric coupler, capable of automatically making all of the necessary electrical connections between cars plus _____ spare connections, shall be provided at the cab end of each car. Electric coupler contacts and trainlines shall be so arranged that single-unit cars or pairs of cars may be turned with respect to other cars or pairs of cars, and specified functions will not be affected. The electric coupler shall be mounted on and supported by the mechanical coupler in a manner that shall provide for easy removal and replacement of the entire assembly.

4.2.2.2 Operation

The electric couplers shall maintain positive contact under all conditions, and shall be capable of withstanding all of the coupler impacts to which the car couplers will be subjected in service. Provision shall be made to safeguard the electric couplers from damage in the event of improper alignment when coupling. Operation of the contacts shall be sufficiently rapid to avoid damage by arcing. When required, electrical isolation shall be provided as specified by the purchaser.

4.2.2.3 Loop Circuits

Contacts for the necessary number of loop circuits, plus spare loop circuit(s), shall be provided within the electric coupler or in a separate rotary switch unless otherwise specified. Loop circuit contacts shall be closed when uncoupled.

Contacts for the ATC system (if required) shall be provided as shown in the contract drawings. Those piloting the coupler relay shall be double-break type. The coupler relay shall be of the vital type. Any failure shall cause the COUPLED condition to be indicated.

4.2.2.4 Contacts

There shall be a sufficient number of contacts to provide for regular trainline circuits plus at least _____ spares. Each electric contact shall be of sufficient capacity to handle the maximum load to which it will be subjected and shall have a _____ contact face. The spring used in conjunction with the contacts shall be fabricated of (beryllium copper).

4.2.2.5 Wiring Connections

Connections to the back of the electric coupler contacts shall be by means of an approved type of connector or compression type terminals, and shall be accessible for maintenance.

Individual contacts shall be clearly and permanently identified with non-conductive materials.

Connections from electric couplers to car body shall be by means of multiple-conductor cables or individual cables in supporting hoses, with locking-type plugs and receptacles used at the trainline junction box end of the cables. Plugs and receptacles shall conform to the environmental and performance requirements of Military Specification MIL-C-005015E, parts MS3400 and MS3406, Classes "F" or "R". The cables shall contain conductors for, and the plug/receptacles and terminal blocks shall contain studs for, the spare contacts. Connectors shall be keyed or otherwise arranged to preclude their insertion into incorrect receptacles. Critical circuits shall be located away from high current or inductive trainlines and coupler pins in order to minimize the effects of inductive and capacitive coupling between wires.

4.2.2.6 Protection (Optional)

Electric coupler contacts shall be protected by covers which will automatically swing clear when cars are coupled. On minimum radius curves, the covers shall not exceed the allowable clearance envelope of the car.

Suitable seals shall be provided between the covers and the electric couplers to exclude moisture, dust and snow. If necessary, an electric heater shall be provided to prevent freezing.

4.2.2.7 Trainlines

_____ spare wires shall be run from end to end of the car. They shall be No. ____ and ____ of them shall be shielded. They shall be plainly identified by means of non-conductive wire markers at each end unless otherwise specified. The wires shall terminate in the trainline junction box at each end of the car.

4.2.3 PNEUMATIC COUPLER (If required)

A pneumatic coupler shall be provided as part of the mechanical coupler head. It shall accomplish the function of connecting air lines between cars. Accidental uncoupling shall cause venting of air from a control line which shall automatically apply brakes to both portions of an unintentionally uncoupled train. Intentional uncoupling shall cause the brakes to be applied on the unattended section of the train only. No air shall be vented at any time from a separate main reservoir equalizing line where another pipe is used for initiation of brake applications. If the coupler design does not completely exhaust the air trainline under these circumstances, satisfactory valving shall be provided to insure an emergency application.

4.3 NON-CAB END CONNECTIONS

Married pairs of cars shall be provided with mechanical, pneumatic, and electrical connections as specified by the purchaser. These connections shall be designed to operate satisfactorily under all specified operating conditions and shall be adequately protected from all environmental conditions under which the cars operate.

4.3.1 MECHANICAL

4.3.1.1 Coupler

A _____ type coupler (or drawbar) shall be provided at the non-cab ends of a married pair of cars.

4.3.1.2 Materials and Configuration Same as 4.2.1.3

4.3.1.3 Draft Gear Same as 4.2.1.4

4.3.1.4 Coupler Carrier Same as 4.2.1.5

4.3.1.5 Coupler Gages Same as 4.2.1.9

4.3.2 ELECTRICAL

4.3.2.1 Trainlines

At the non-cab end of each car, electrical connections shall be made by means of electrical couplers or jumper cables with end connections as specified by the purchaser. If used, one end of the jumper cable shall be semi-permanently interfaced into the receptacle of one car by means of a clamp, or other restraining device. The number of cables used shall provide sufficient wires to make all necessary connections plus at least ___ spare wires. Independent jumper cables shall be used for low level communication circuits, if specified by the purchaser. All low energy level wires shall be adequately shielded. All jumper cables shall be adequately supported and shall be of sufficient length so that no excessive strain will be imposed on the wires. The lower end of jumper loop shall not be exposed to damage when adjacent coupled cars are at maximum curvatures.

4.3.2.2 High Voltage Bus and Jumper (Optional)

A roof-mounted high voltage bus and jumper shall be connected between the two-car unit for energizing the transformer on the adjacent car. The jumper assembly and support must be properly insulated for ___ volt service. A warning decal, white letters on red background, shall be applied at the non-cab end of each car adjacent to the ladder leading to the roof, and must read

as follows:

"DANGER: VOLT ROOF BUS JUMPER. BEFORE WORKING ON ROOF OR POWER CIRCUITS OF EITHER CAR, PANTOGRAPH MUST BE LOWERED AND GROUNDED."

4.3.3 PNEUMATIC (If required)

At the non-cab end of the car, the pneumatic connections shall be made with a pneumatic coupler or standard AAR hose connections. If hose connections are used, angle cocks shall be provided on each car to shut off air when disconnecting hoses. The hose locations shall be at the standard AAR passenger car location.

MISCELLANEOUS CAR BODY ITEMS

5.1 SIGNS

The following types of signs will be provided in accordance with the contract drawings and the detail specification: interior signs including informational and advertising displays, destination signs, car number/car identification labeling, and decorative/logotype/emblem symbols.

5.2 FIRE EXTINGUISHER

An approved dry chemical fire extinguisher, of the stored-pressure type, containing not less than ___ pounds of extinguishing agent, shall be installed at the location specified by the purchaser in the detail specification. The extinguisher shall be wall-mounted in an enclosed area behind a transparent door or panel and clearly labeled. The mounting brackets and attachments shall be designed for the following loads acting independently:

___ lbs. vertical
___ lbs. longitudinal
___ lbs. lateral

5.3 CAB ACCESSORIES

Accessories and equipment shall be installed in the cab in accordance with the detail specification.

5.4 STANDARD KEYS

Standard keys for control and door operation shall be provided in accordance with the detail specification and as shown in the contract drawings.

5.5 HORN

A horn shall be provided in accordance with the requirements of the detail specification and as shown in the contract drawings.

5.6 PASSENGER EMERGENCY VALVE (Optional)

One passenger emergency valve shall be provided as specified by the purchaser.

5.7 CREW EMERGENCY VALVE (Optional)

One crew emergency valve shall be provided as specified by the purchaser.

5.8 ELECTRICAL OUTLETS (Optional)

Standard 110V AC outlets shall be provided if specified by the purchaser.

5.9 TOILET ROOM ACCESSORIES (Optional)

Toilet room accessories will be provided in accordance with the contract drawings including the following: toilet, lavatory, water system, mirror, lights and ventilation.

5.10 DRINKING WATER (Optional)

Drinking water storage and dispensing facilities shall be provided in accordance with the contract drawings.

5.11 PANTOGRAPH POLE (If required)

A pantograph pole shall be provided and stored according to the contract drawings to permit operating crew members to safely disconnect the car from the prime electrical power source.

5.12 THIRD RAIL SHOE PADDLES (If required)

Third rail shoe paddles shall be provided if specified by the purchaser and shall be stored in accordance with the contract drawings.

DOOR OPERATION AND CONTROL

6.1 GENERAL

Power-operated side doors shall be provided for passenger entrance and exit as per the detail specification. The design and operation of doors, operators, and controls will comply with the requirements of section 15.5.

6.2 DOOR CONTROL SYSTEM

The door control system shall be activated as per the detail specification. Interlock provisions shall be provided to prevent opening of the doors while the train is moving and to prevent the train from starting while the doors are open.

6.3 DOOR SIGNALS

Audible and/or visual door signals to indicate DOOR OPEN and DOOR CLOSED positions to the train crew shall be provided as per the detail specification.

6.4 DOOR SAFETY DEVICES

Door safety devices shall be provided as specified by the purchaser.

SECTION 7

HEATING, COOLING AND VENTILATING

7.1 GENERAL

This section specifies the air comfort system requirements for the vehicle. The system shall include heating and ventilating equipment, temperature controls and an air conditioning system (if specified). The air comfort system shall be designed for continuous control of heating, ventilating and air conditioning. Temperatures shall be continuously maintained within the allowable limits. A system utilizing only heating and ventilating shall maintain specified temperature and adequate air flow whenever heat is required and specified ventilation at all other times. Air conditioning units shall be efficiently placed on the vehicle to maintain effective cooling. Installation design shall provide maximum accessibility to all units without causing interference to maintenance features of other systems. All units of the system shall conform to the vibration, noise and electrical interference requirements of Sections 2.7, 2.8 and 9.9.

7.2 DESIGN CONDITIONS AND REQUIREMENTS

7.2.1 DESIGN EXTERIOR AMBIENT CONDITIONS

Exterior ambient conditions for design purposes shall be as follows:

a. Summer - surface

- ___°F dry bulb temp., ___°F wet bulb temp.
- ___° Latitude, maximum solar heat rate
- ___°F condenser ambient
- ___ MPH wind velocity

b. Summer - tunnel

- ___°F dry bulb temp., ___°F wet bulb temp.
- ___°F condenser ambient

- c. Winter - surface
 - ____ °F dry bulb temp., ____ °F wet bulb temp.
 - ____ ° Latitude, minimum solar heat rate
 - ____ MPH wind velocity

- d. Winter - tunnel
 - ____ °F dry bulb temp., ____ °F wet bulb temp.

7.2.2 DESIGN INTERIOR ENVIRONMENT WITH PASSENGERS

7.2.2.1 Interior Ambient Conditions

Interior ambient conditions for design purposes are as follows:

a. General

- ____ Avg. rush-hour passenger density
- ____ Avg. time between stations
- ____ Avg. time in station (doors open)
- ____ Time in tunnel as a percent of total operating time

b. Summer

- ____ °F dry bulb maximum
- ____ °F dry bulb minimum
- ____ Percent relative humidity maximum
- ____ CFM Total air circulation minimum
- ____ CFM Fresh air minimum
- ____ °F temp. difference (between car ambient and supply air temp. in tunnel)
- ____ °F temp. difference above ground

c. Winter

- ____ °F dry bulb maximum
- ____ °F dry bulb minimum
- ____ Percent relative humidity maximum
- ____ CFM Fresh air minimum

7.2.2.2 Temperature Variations and/or Limits

- a. Ambient temperature differences in the vertical plane shall not exceed ____ °F when measured at the center aisle at any height between ____ from the floor surface to ____ from the ceiling surface.
- b. Ambient temperature differences in the horizontal plane shall not exceed ____ °F when measured at the center aisle at any station location from 12 inches from one end surface to 12 inches from the opposite end surface.
- c. Temperature differences between the insulated wall, ceiling or floor surfaces and the average ambient temperature measured in the vertical plane at any mean representative horizontal station shall not exceed ____ °F.

- d. Surface temperature of any exposed protective device, grille, or shield used for the heating element or media shall not exceed ___°F.
- e. The temperature differential of the air exhausting from any outlet into the compartment must be reduced by at least one-half when measured ___ inches from the face of the air outlet.

7.2.2.3 Filtered ventilation fresh air of not less than ___ CFM shall be distributed within the passenger and operator's compartments. Interior air used for recirculation purposes in a forced-air system shall be filtered. Contaminant retention capabilities of the filters or filtering method used shall have an equivalent weight efficiency of ___ percent minimum as established by the Air Filter Institute Test Code, Section 1.

7.2.2.4 No condensation shall be formed on any interior surface of the vehicle as a result of the air comfort system.

7.2.2.5 Operator's windshields shall be completely defogged and defrosted in windshield wiper swept area during all vehicle operations and at all atmospheric conditions. The heating system shall be capable of simultaneously preventing the formation of ice on the exterior surfaces of the transparent areas, or fog or frost on the interior surfaces.

7.2.2.6 Noise levels of the heating, cooling, ventilating, and distribution system shall meet the requirements of section 2.8.

7.2.2.7 The ventilating system shall provide an interior pressurization of ___ inches H₂O minimum when the vehicle is operating at any speed from zero through maximum speed.

7.2.2.8 The recovery time shall be less than ___ minutes after all doors on one side of the vehicle have been open for a one-minute period and then closed.

7.2.2.9 Air velocities exceeding ___ ft./min. shall not be directed in any space occupied or traversed by passengers.

7.2.2.10 The heating and cooling systems shall provide the design interior environments of section 7.2.2.1 in ___ minutes under the design exterior ambient conditions of section 7.2.1.

7.2.3 DESIGN INTERIOR ENVIRONMENT DURING LAYOVER OPERATION,
NO PASSENGERS

7.2.3.1 Fresh air ventilation is not required.

7.2.3.2 Inside air temperature shall be maintained at ___°F. ± ___°F. at the control thermostat.

7.3 AUTOMATIC HEATING, AIR CONDITIONING AND VENTILATING CONTROL

7.3.1 GENERAL

The contractor shall furnish and install temperature control equipment as required for proper operation of the system and as described in this section.

A heating, ventilating and air conditioning control system shall be provided for each air conditioning unit as defined by the purchaser. The systems shall be designed with maximum regard for passenger comfort. The controls, equipment and apparatus shall be designed for long life and dependability with the further objective that they be as light in weight and as compact as possible. The separate systems shall employ separate temperature sensing and control apparatus. The control apparatus for both systems shall be mounted in a panel. The temperature sensing elements shall be mounted above each of the recirculating air grilles and ahead of the filters.

The control equipment shall be designed so as to transmit temperature changes to the heating, ventilating and air conditioning equipment with a minimum of time delay.

Wherever practicable, the control apparatus shall incorporate static electronic components such as diodes, transistors, saturable reactors, etc., in lieu of electromechanical devices. Electronic components which are sensitive to damage from transient voltage "spikes" shall be adequately protected from harmful voltages which may be induced by devices in related circuits or admitted on wiring connected in common with other electrical equipment. The electronic control assemblies shall be constructed as plug-in units attached with quick fasteners or other approved means to prevent the units from vibrating loose from the fixed jacks.

All equipment shall be designed to minimize adjustments necessary for operation. The need for adjustments shall be avoided wherever possible by the use of appropriate circuitry, stable components, and high-tolerance circuits. Adjustable components shall not be used unless absolutely required and approved by the purchaser. Any adjustable components used during design development to determine the correct operational settings shall be eliminated in the final design. All plug-in cards of the same part number shall be interchangeable without any additional adjustment.

Temperature sensing devices shall be accessibly located, shock-mounted, provided with mountings and terminals or connectors of an approved design, shall not be unduly influenced by local sources of heat, sun load or outside air and shall be reasonably

tamper-proof. All equipment shall be of rugged industrial quality suitable for transportation service, easily removable and every precaution shall be taken to ensure maintenance-free operation under heavy vibration operating conditions. All parts requiring periodic cleaning, inspection and maintenance shall have maximum accessibility.

All electric contactors, relays, and panel boards shall be subject to approval and shall be protected from moisture, dust and dirt. No controls, except the temperature sensing units, shall be permitted in the plenums or mixing chambers.

The control system shall be designed in such manner that failure of either the heat thermostat or the air conditioning and ventilation thermostat will not adversely affect the proper functioning of the other.

The control point of this system shall not be affected by normal battery voltage variations between ___ and ___ volts.

7.3.2 HEATING CYCLE

The heating cycle shall be thermostatically controlled. The heat circuit shall be energized below ___°F car plenum temperature. This control temperature shall have a maximum tolerance of ±___°F. The blower fans shall operate at their reduced capacity during the entire heating cycle.

The heating cycle shall have a system differential between ___°F and ___°F. This differential is not included in the above tolerance.

7.3.3 VENTILATING CYCLE

When the car plenum temperature rises above ___°F the control system shall change over from the heating cycle to the ventilating cycle. The heat circuit shall be de-energized and the blower fan speed shall be increased to full capacity.

7.3.4 AIR CONDITIONING CYCLE

When the car plenum temperatures increases to ___°F, the first stage of air conditioning shall be energized. If used, the reheat cycle shall also be energized at this control point. When the car plenum temperature increases to ___°F the reheat cycle shall be de-energized. When the car plenum temperature increases to ___°F, the full cooling cycle of air conditioning shall be energized.

7.3.5 LAYUP PROVISIONS

When cars are "laid up" provision shall be made to thermostatically control the car space temperature to a minimum of ____°F. This control system shall take over automatically when the regular heating, air conditioning, and ventilating systems are de-energized. The layup heat shall consist of floor heat only.

7.3.6 CONTROL UNIT

An approved panel shall be provided to house the heating, air conditioning and ventilating control equipment. This unit shall include the train line relay, heater and fan contactors, control relays, and all other necessary equipment for the proper functioning of the heating, air conditioning and ventilating systems specified. Adequate electrical insulation shall be provided wherever necessary between the carbody and the control panel. The dirt, dust and waterproof cover shall be made of fiberglass reinforced plastic of an approved color. Control panel location shall be specified by the purchaser.

7.3.7 TRAINLINE CONTROL (Optional)

The ventilating and air conditioning systems shall be arranged for trainline control of all units in the train from the motorman's cab of each car. Individual car temperature control shall be automatic as provided in 7.3.2, 7.3.3, 7.3.4 and 7.3.5.

Trainline control shall consist of a battery-operated relay on each car, which shall be actuated by the momentary ventilating and air conditioning switch located on the motorman's console of each car.

7.4 EQUIPMENT

7.4.1 CAR HEATERS

7.4.1.1 General

The car heating system shall be thermostatically controlled, fully automatic and shall consist of floor and/or ceiling heat. The floor heaters shall be located so as to preclude down drafts and shall be constructed of corrosion-resistant material. The heating elements shall be mounted in the heater cases so as to prevent vibration but to permit expansion and contraction. Heater leads shall be of sufficient length to permit the removal of the elements. The leads shall be provided with _____ tips.

7.4.1.2 Control of Heaters

Purchaser may specify local or trainline control. Where trainline control is specified, all heaters in the train shall be controlled from the operating cab of the lead car. Individual car temperature control shall be automatically provided as described in section 7.3.7.

The trainline control shall consist of a battery-operated relay on each car which shall be actuated by the heat, air conditioning and ventilating switch in the motorman's console in the operating cab of each car.

7.4.2 COMPRESSOR CONDENSER UNITS

Each car shall be equipped with ___ compressor condenser unit(s) mounted to the car in such a manner as to prevent vibrations from being transmitted to the car structure.

For modulating cooling, the compressor shall be designed to reduce pumping capacity by automatically unloading in response to system pressure preset by the manufacturer. Positive pressure lubrication shall be provided with protected visual means to indicate lubrication. If specified by the purchaser, compressors shall be designed to permit easy replacement of the compressor seal without the need for removing the compressor from its mount.

7.4.2.1 Compressor Motors

Each compressor shall be driven by a totally enclosed motor rated for continuous duty. The motor shall have a nominal rating of ___ volts (DC or ___ Hz, ___ phase AC) and shall have the capacity to drive the compressor under any load condition. The motor shall operate successfully over a voltage range between ___ and ___ volts.

The motor shall provide satisfactory operation under any condition or load and shall be suitable for continuous service when crossing the gaps in the contact rail or at any time when a sudden change in operating conditions may cause large voltage transients. The circuit breaker used for the protection of the apparatus shall not be unduly loaded during this short period. Protective circuitry shall be provided to prevent the compressor motor from starting across the line. Motors shall be protected from overheating with applied safety appliances.

The armature and field coils shall be thoroughly insulated with Class "H" insulation or better, and be held securely in place and protected against mechanical injury. The motor shall be able to withstand the vibration environment specified in section 2.7.

7.4.2.2 Condenser

The condenser coil shall be constructed of _____ tubing with _____ inch _____ fins spaced no more than 8-9 fins per inch. No crevices, closures, etc., for dirt to accumulate shall be permitted to hinder the rapid cleaning of the coils. A fan for even air distribution over the heat exchange surface shall be directly connected to the compressor motor.

7.4.3 RECEIVER TANK

One horizontal receiver tank shall be provided, mounted on each compressor condenser unit arranged so that the sight glasses are visible in a manner approved by the purchaser. Shutoff valves shall be provided at the inlet and outlet, and a purge valve shall be provided for service use. Visual indication of clear sight glass shall be provided at the end and the side of the tank to indicate the refrigerant level. The glass shall be readily replaceable in the event of breakage and the receiver tank shall be readily replaceable without unsoldering any fittings.

7.4.4 FILTER DRIER

An approved, replaceable core drier shall be provided, mounted in the liquid line on the compressor condenser unit and shall include a shutoff valve at the inlet and outlet.

7.4.5 REFRIGERATION CONTROL BOX

Weatherproof control boxes, one for each system, shall be provided for safety pressure switches, test switch, pressure gages, hand valves, charging connections, etc. To prevent the possibility of improper connections, different size piping shall be used for the high and low pressure lines. The box shall be mounted on the compressor condenser unit so that it may be readily visible from the side of the car. A safety trunk arm shall be provided to hold the cover of the box in an open position.

7.4.6 STRAINER AND VALVES

One strainer shall be provided for each system in an approved location before the expansion valve of the evaporator. The strainer shall be equipped with a removable and replaceable screen. Shutoff valves shall be provided on both sides of the strainer.

7.4.7 MOISTURE INDICATOR

Moisture indicators, one for each system, shall be provided and located in an approved location.

7.4.8 LIQUID LINE SOLENOID VALVE

Electrically operated valves shall be provided in the main liquid line before the evaporator. A locking-type plug connector shall be provided.

7.4.9 CONTACTOR PANEL

One panel shall be provided in a weatherproof box for each system, and shall be mounted on the compressor condenser unit so as to be readily visible from the side of the car. All motor starting contactors and relays for the proper operation of the system shall be provided on this panel, exclusive of the temperature control. A safety trunk arm shall be provided to hold the cover of the box in an open position.

7.4.10 CAB AIR CONDITIONING

Air conditioning shall be provided in the operating cab of the car.

7.4.11 EVAPORATOR BLOWER UNITS

Each car shall be equipped with cooling units mounted as specified by the purchaser.

7.4.11.1 Evaporators

The evaporator coil shall be constructed of _____ tubing. Fin spacing shall be as specified in section 7.4.2.2. The evaporator shall be arranged for modulated control, each section fed through its own expansion valve. Expansion valves shall be so located to be readily accessible for maintenance and removal. A (material) drain pan shall be provided under the evaporator coil for overhead installations. Sufficient baffles to prevent condensate spillage and adequate drainage shall be provided.

7.4.11.2 Fan/Motor Assembly

The motor shall have a nominal rating of ___ volts (DC or ___ Hz, ___ phase AC) and shall have ample capacity to drive the fans under any load condition. The motor shall operate successfully over a voltage range between ___ and ___ volts.

The motor shall be able to withstand the vibration environment specified in section 2.7 and shall be provided with a ground connection from the motor frame to the car body.

The fan assembly shall be rated at ___ cubic feet per minute at ___ inches of water static pressure which shall be reduced to ___ cubic feet per minute for winter operation. Total evaporator capacity for the car shall be ___ CFM and ___ CFM for summer and winter respectively.

7.4.11.3 REHEAT (Optional)

A total of ___ (KW, BTU) of (electric, recovered) heat shall be provided downstream of each evaporator. Type, location and arrangement shall be as specified by the purchaser.

7.4.12 EXTERIOR AIR INLET AND EXIT PORTS

All air inlet and exhaust ports terminating on the exterior of the vehicle shall be protected to prevent the ingestion of foreign particles, ice, water, etc., into the ventilation system. The ports shall not be blocked by any ice or snow accumulations sufficiently to prevent the proper operation of the environmental systems or any equipment of the system on the vehicle. As an option, purchaser may specify provisions for manual closing of the air inlet ports for winter operation.

7.4.13 REFRIGERANT PIPING

All refrigerant piping shall be refrigeration grade _____ tubing unless otherwise specified. Tubing shall be preformed wherever possible, and shall be assembled with as few fittings as practicable. Piping shall be supported by brackets and clamps no more than ___ inches from joints, fittings, valves and bends of 45 degrees or more, and no more than 24 inches apart on straight pipe runs. All piping shall be protected from chafing and dissimilar metals in an approved manner. Piping runs shall be arranged to create no traps or other inconsistencies in the flow of the refrigerant. Flexible connectors, as approved by the purchaser, shall be provided for each pipe at each resiliently mounted unit.

Fittings shall be approved refrigeration grade _____ material, and shall be located at identical positions in each car. Fittings, joints, etc., shall be in readily accessible locations for both testing and repair.

7.4.14 ACCESS DOORS

Access doors shall be provided in the low ceiling area (if applicable) for the maintenance and removal of the air conditioning equipment. Doors shall be provided with hinges, an approved locking arrangement and safety catches. Doors shall be sealed or weather-stripped in an approved manner to prevent air leaks.

7.4.15 DUCTING AND GRILLES

7.4.15.1 Flexible transition ducts shall connect the overhead air distribution duct. Transition ducts shall be fire-resistant and shall be able to withstand, without damage, the maximum temperature developed by the overhead heat unit before over-temperature cutoff in the event of blower failure.

7.4.15.2 Recirculation air grilles shall be provided at locations to be approved by the purchaser near the air conditioning evaporation units. The grilles shall be hinged and provided with safety catches and an approved locking arrangement to provide access to the evaporator unit. Grilles shall be designed to pass the required quantity of air without producing objectionable noise.

7.4.15.3 Air ducting shall be adequately insulated and constructed of fire-retardant materials. Ducts shall be designed to provide the specified air volume without exceeding ___ feet per minute air velocities within the ducts.

7.4.15.4 Air movement within the car shall normally be accomplished by the blower fans which shall be mounted resiliently and may be supplied as a part of overhead evaporator units, if used. Fresh air shall enter through screened openings in the roof at both ends, shall be mixed with recirculated air passing through a ceiling grille and filter, be cooled or heated at both ends and enter into the plenum chamber. The plenum chamber shall be longitudinally divided by a diagonal member so that a separate duct is formed for each blower.

7.4.15.5 Diffusers, grilles and outlets shall be designed to provide evenly distributed air at velocities less than 1200 feet per minute. Installations shall be flush-mounted with exposed surfaces designed to complement other interior features.

A method of air flow adjustment by use of a standard screw-driver shall be provided to balance and equalize air flow in all passenger areas. In the cab areas, air flow adjustment shall be provided by use of an exposed hand control.

Grilles and outlets that are designed for access shall be provided with safety catches and limit chains or cables.

7.4.16 AIR FILTERS

Air filters shall be provided to filter both fresh and return air. Filters shall be standard size, commercially available, non-reusable and capable of ___ days normal operation between changes. Filters shall be mounted in dust-tight frames, shall be readily accessible and capable of being easily changed by unskilled labor. Condenser intake surface shall be screened as specified by the purchaser.

7.4.17 EMERGENCY VENTILATION SYSTEM (Optional)

A battery-operated, supplemental ventilation system shall be provided. System shall have a capacity of ____ CFM and shall provide temporary ventilation for a period of ____ hour(s). System components shall be accessible for inspection and maintenance.

7.5 DESIGN DATA SUBMITTAL

All heat load calculations, in addition to manufacturer's selection tables, curves, etc., necessary for design and selection of evaporator coils, condenser coils, compressor, expansion valves and other major cooling system components, shall be submitted for approval by the purchaser.

7.6 TEST AND DATA REQUIREMENTS

Refer to section 17 for environmental testing and test data requirements.

LIGHTING

8.1 INTERIOR LIGHTING

Passenger area lighting shall be provided by fluorescent and/or incandescent lamps. The location and arrangement of lighting fixtures shall be as per detail specification or as approved by the purchaser. Lamps shall be provided with lenses or shields which are retained by a minimum number of screws and are easily removed for service/relamping and designed to be insect-proof and to prevent the accumulation of moisture or dust. The lighting system will not produce objectionable levels of brightness or glare.

If required, lighting shall be provided in the intercar closure/ vestibule to adequately illuminate the area.

The lighting system shall provide the following minimum levels of intensity with new lamps:

<u>Location</u>	<u>Intensity</u>
Passenger area 33" above floor at a 45° angle:	___ft. candles
Passenger area 50" above floor at a 45° angle:	___ft. candles
Intercar Closure/Vestibule (if used) Area - Floor:	___ft. candles
Other Surfaces:	___ft. candles

8.2 EXTERIOR LIGHTING

Exterior lighting shall be as specified by the purchaser in the detail specification. All external lighting fixtures shall be watertight and shall provide ready access for lamp replacement in a manner described in the detail specification.

8.3 EMERGENCY LIGHTS

The number and location of emergency lights shall be in accordance with the detail specification. Unless otherwise specified, a number of the normal lighting fixtures may be designated as emergency lights. The emergency lighting system shall be supplied from the low voltage power system. Activation of the system shall be accomplished automatically when high voltage power is interrupted.

MISCELLANEOUS ELECTRICAL EQUIPMENT

9.1 GROUNDING, BONDING AND LIGHTNING PROTECTION

9.1.1 GENERAL

Grounding and bonding shall meet the following requirements:

- a. Provide a good conductive path from all metal structure to the low voltage side of all voltage sources, so that no metal part can be on a potential with respect to other metal parts and thus create a life hazard.
- b. Provide a fault current path for tripping electric protection devices.

9.1.2 POWER SUPPLY

The ground side of the primary power supply (ground side of the traction motor) shall be connected to a suitable bonding point on each truck. A suitable set of slip-rings and brushes, in accordance with the detail specification, shall be provided between the truck frame and each axle to provide a path through the wheel rims on the running rails.

9.1.3 AUXILIARY SERVICES

At the purchaser's option, all auxiliary services shall be:

- a. Two-wire systems with low point connected to a bus plate, isolated from the car structure, and bonded to one truck, or

- b. Two-wire systems, ungrounded other than through the ground-sensing relay, or
- c. Single-wire systems with ground return through the car structure.
- d. If more than two wires, the neutral wire shall be connected to the bus plate, isolated from the car structure and bonded to one truck.

9.1.4 PASSENGER SAFETY

All metal parts of the car which can be touched by the passengers shall be at ground potential.

9.1.5 ISOLATION (If required)

The isolation between the bus plate and the carbody, with the bond to the truck disconnected, shall be higher than (2 MEG) ohms and able to withstand (*) volts test voltage.

* 200V for 0 - 35V systems
 500V for 36 - 250V systems
 1200V for 250 - 600V systems

9.1.6 PANTOGRAPH (If required)

Each pantograph shall be provided with a lightning arrester in accordance with the detail specification.

9.2 WEATHERPROOFING - ELECTRICAL EQUIPMENT BOXES

9.2.1 DOORS

All doors to the equipment boxes shall be weatherproof. The seals shall be made of material per specification _____ and installed in the equipment box in such a manner that they cannot be inadvertently dislodged.

9.2.2 CONDUIT ENTRY (If required)

All entries of conduits into the equipment boxes shall be weatherproof. A suitable replaceable grommet shall be installed in such a manner that it cannot be dislodged without removing the conduit.

All conduits shall be installed in such a manner that a gradual slope will lead to the lowest point, where a drain hole will be provided. The conduit incline shall not be less than ___ degrees and shall slope upward on both sides of the drain hole.

Where a single wire enters an equipment box without a conduit, the entry shall be made waterproof by a suitable strain-relief bushing.

9.3 ELECTRICAL DISTRIBUTION SYSTEM

9.3.1 GENERAL

The car electrical distribution shall be in accordance with Book I, AAR Electrical Manual, Section 1, Chapter 3, titled "Car Electrical Distribution System."

9.3.2 WIRING

The car wiring shall be in accordance with AAR Section 10, "Wire, Cable and Insulating Materials" or specification _____.

9.3.3 WIRE HARNESES, CONDUITS, WIREWAYS

9.3.3.1 Wire Harnesses

All low voltage wires arranged in bundles containing more than two wires shall be in a prefabricated, bench-assembled, completely interchangeable harness. The finished harness shall include machine-applied wire terminations. Each wire of the harness shall be permanently marked along its entire length.

9.3.3.2 Conduits and Wireways

No wiring shall be left exposed to the elements. The use of conduit or wireways to protect wiring shall be optional as specified by the purchaser.

- a. Conduit: Conduit applications shall be held to a minimum. When required, conduit, fittings, and boxes shall be in accordance with specification _____. A minimum of 50 percent of the cross-sectional area of the conduit shall be allowed for air space, but in no case shall wire be unsupported. Flexible wire mesh reinforced conduit may be used at those locations where components are subject to vibration.
- b. Wireways: Separate wireways shall be provided for wiring of high voltage DC, low voltage DC and AC. A minimum of one-third of the cross-sectional area of the wireways shall be air space, but in no case shall wire be unsupported. Wireway material and fabrication shall be in accordance with specification _____, which defines requirements for wireway materials, colors, wireway accessibility, removable covers, dust/dirt-proof requirements, entrance and exit fittings and wire clamping.

9.4 CONNECTORS

9.4.1 GENERAL

All connectors shall be compatible with the type of wiring selected and subject to approval of the purchaser.

9.4.2 WIRE TERMINATIONS

All wire terminations shall be of the compression type and shall meet the requirements of MIL-T-7928 "Crimped Terminals, and Tools for Crimping."

9.5 SWITCHES, RELAYS AND CONTACTORS

9.5.1 SWITCHES

Switches for control of AC or DC electrical power shall meet the requirements of MIL-S-3930 and the detail specification. For control of power levels beyond the capability of the MIL-S-3930 switches; a suitable relay or contactor shall be used as specified in 9.5.2.

9.5.2 RELAYS AND CONTACTORS

The terms "relay" and "contactor" both denote a magnetically operated device for repeatedly establishing and interrupting an electric power circuit. Although the terms are often used interchangeably, the term "relay" is ordinarily employed for devices below 5KW power handling capability, whereas the term "contactor" is usually applied to devices for controlling power above 5KW. Low current relays (less than 10 amperes per pole) shall meet the general requirements of MIL-R-5757. Higher current relays and all contactors shall meet the general requirements of MIL-R-6106.

9.6 PROTECTION

9.6.1 CIRCUIT BREAKERS

Circuit breakers in the service power distribution shall meet the requirements of the detail specification. Circuit breakers for nominal current above 50 amperes shall meet the same requirements as the power circuit breakers.

9.6.2 FUSES

Fuses shall be used only in power circuits and shall conform to the requirements of the detail specification.

9.7 LOW VOLTAGE SUPPLY

9.7.1 GENERAL

Each single car or married pair shall be equipped with a nominal ___ volt supply system consisting of one or more storage batteries, battery box(es) and a battery-charging system. The battery shall be of the _____ type meeting the requirements of AAR Electrical Manual, Section 1, Chapter 1, and the environmental conditions defined in the detail specification.

Systems and components which shall be supplied with battery voltage include, but are not limited to, the headlights, tail lights, marker lights, threshold lights, emergency lights, cab ceiling light, fluorescent lights (if DC), instrument lights, temperature controls, destination sign controls, door operators and door controls, communications system, ATC power supply (if required), propulsion and braking controls, and evaporator fans (if DC). All systems or components supplied directly from the battery shall be capable of operation in a voltage range between ___ and ___ volts.

The batteries of all cars on a train may be connected in parallel through B-plus and B-minus trainlines of adequate capacity to provide an emergency feed to a car with battery failure and as an option to allow for charging the batteries on one pair of cars from the battery-charging system of another pair of cars. The B-minus trainlines (shall/shall not) be grounded to the carbody.

The contractor shall be responsible for coordinating the design of all circuits and equipment operated at battery voltage to prevent damage or disturbance to function caused by electrical transients or radio frequencies in the battery circuit. The contractor shall also be responsible for ensuring that equipment and circuits operated from the bus shall be so designed that sustained presence of any battery voltage from the maximum down to zero shall not cause any damage.

9.7.2 CAPACITY

The rated capacity shall not be less than ___ ampere hours with a ___ hour discharge rate. As an alternate, the battery shall, at normal operating temperature (___ to ___°F), have sufficient capacity to:

- a. Carry all ___ volt loads and operate and sustain operation of the car lighting for interruptions in the main power supply of up to ___ seconds duration with no noticeable flickering or dimming of the lights; or
- b. Provide all ___ volt loads (exclusive of fluorescent lighting) when operating on the lead car of a ___ car train in the absence of battery charging voltage from the lead car for a period of ___ hours, including ___ station stops; or
- c. Maintain a terminal voltage adequate to operate all connected systems after ___ hours operation on a stored car with the motor-generator inoperative, assuming normal loading with all lighting turned off, heating control in layover position, and the control key removed; or
- d. Carry emergency lighting, communication systems, running lights and any loads that cannot be shed by the use of cab circuit breakers and switches, on a ___ car train for ___ hours.

All foregoing conditions assume beginning with a battery charged to 80 percent of capacity. Conditions "a" and "b" assume an ATC battery load (if required) of ___ amperes plus ___ amperes load on the ATC power supply. Condition "c" assumes an ATC load on the battery of ___ amperes.

9.7.3 BATTERY CHARGER

A battery charger capable of meeting all of the electrical requirements as regards current and voltage regulation shall be provided. The battery charger shall have inherent current control to limit battery charging current to a value that is safe for both the battery and the charger, regardless of battery state or charge.

As an option, the battery shall be provided with an approved overtemperature protective system to guard against possible damage to the battery, the battery enclosure, and other car components resulting from excessive battery charging.

9.7.4 WATERING

The battery in normal service shall require watering no more than once every _____ miles or ___ days.

9.7.5 BATTERY BOX

The battery shall be carried in an enclosure located _____. The enclosure shall be constructed of _____ and shall be ventilated. The interior shall be fireproofed with _____. Access for servicing or removing the batteries shall be provided. All metal parts shall be corrosion-resistant.

9.7.6 BATTERY DISCONNECT (Optional)

A battery circuit breaker of adequate capacity and approved design shall be provided in the operating compartment of each car to serve as a main service breaker for the battery system on each car.

9.8 AUXILIARY POWER SUPPLY

Auxiliary power shall be supplied by one or a combination of the following: motor-generator set, static converter, motor-alternator set or static inverter.

9.8.1 MOTOR-GENERATOR (Optional)

9.8.1.1 General

The motor-generator set shall comply with the requirements of the detail specification and shall operate from the prime power source ___ volts DC to ___ volts DC (___ volts DC nominal). One motor-generator set shall be provided for each single-unit car and each married pair.

9.8.1.2 Capacity

The motor-generator set shall have sufficient capacity to supply all the low voltage requirements (___ to ___ volts DC) of a pair of cars including battery charging plus ___%.

9.8.1.3 Design

The motor-generator set shall be a totally enclosed unit designed for quiet and safe operation within the prime power voltage limits specified in Section 9.8.1.1. It shall be dynamically balanced, supported on suitable vibration-isolating mountings and equipped with a ground connection. It shall be self-ventilated and rated in accordance with IEEE and/or ANSI standards for the type of insulation used, which shall be Class H or better. The set shall be arranged for ready removal and replacement, ordinary inspection, servicing and adjustment. If longitudinal mounting is used, thrust bearings shall be employed.

9.8.1.4 Voltage Regulation and Control

The output voltage of the motor-generator shall be fully adjustable between the limits of ___ and ___ volts. The adjusting mechanism shall be provided with a positive locking device or other approved means of preventing the adjustment, once established, from being disturbed.

Control shall be provided to maintain the motor-generator set output voltage within \pm ___ percent over the entire range of connected loads over an input voltage range from ___ to ___ volts. The voltage setting of the generator shall be as recommended by the battery manufacturer.

9.8.1.5 Lubrication

The motor-generator set shall be equipped with sealed, relubricatable, anti-friction bearings of an approved type. Grease cavities shall contain sufficient lubricant to allow operation for ___ years without relubrication unless otherwise specified. Bearing housings shall be provided with tapped holes closed with pipe plugs to permit the addition of a measured amount of lubricant at ___ intervals. Plugs shall be readily accessible without removal of the motor-generator or any other apparatus. As an option, grease fittings with pressure relief valves may be specified.

9.8.2 STATIC CONVERTER (Optional)

9.8.2.1 General

A static converter may be provided as an option to the motor-generator set and shall meet the same general requirements.

9.8.2.2 Design

The converter shall be designed for mounting _____ the car and shall have its control components mounted on plug-in cards for easy maintenance. A means for adjustment of voltage output shall be provided. It shall be self-protecting against transient overloads and shall not create interference in the train communications or electronic systems.

9.8.3 MOTOR-ALTERNATOR (Optional)

9.8.3.1 General

A motor-alternator set, operating on prime power voltage, may be proposed as an alternative to the motor-generator set and shall meet the same general requirements.

The motor-alternator shall provide 230-volt, three-phase, 60 Hz power for the drive motors of the hydraulic power units, air compressor, air-conditioning compressors, air-conditioning condenser cooling fans and the battery-charging system.

9.8.3.2 Capacity

The motor-alternator shall have sufficient capacity to start the various compressors individually and to supply simultaneously all the loads listed in paragraph 9.8.3.1, without load shedding, over the accepted voltage range of prime power. Controls shall be provided by the supplier of the motor-alternator set to insure that compressors will not attempt to start simultaneously. Preference in starting shall be given to the braking compressor.

9.8.3.3 Design

Same as paragraph 9.8.1.3.

9.8.3.4 Voltage Regulation and Control

Motor speed regulation shall be provided to maintain alternator frequency at $60 \pm$ ___ Hz, and shall use only static devices. The motor circuits shall be suitably protected to prevent its acting as a generator while passing through primary power gaps.

Voltage regulation shall be provided to maintain alternator output voltage within \pm ___ percent over the entire range of connected loads and over an input voltage range from ___ to ___ volts.

Starting control shall be arranged to permit starting the motor-alternator even if battery power is not available. If specified, a control switch shall be provided in the circuit breaker panel to permit shutting the set down if cars are stored in a quiet area.

9.8.3.5 Lubrication

Same as paragraph 9.8.1.5.

9.8.4 STATIC INVERTER (Optional)

9.8.4.1 General

A static inverter may be provided as an option to the motor-alternator set and shall meet the same general requirements. A static inverter may also be used in conjunction with a motor-generator set or static converter to provide power for fluorescent lighting. Operation of a static inverter directly from the prime power source must include provision for maintaining fluorescent lighting during prime power gaps of up to 10 seconds.

9.8.4.2 Design

Same as paragraph 9.8.2.2.

9.9 INTERFERENCE AND COMPATIBILITY

9.9.1 CONTROL AND TEST PLANS

The contractor shall submit electromagnetic interference and interface compatibility control and test plans to the procuring agency for approval prior to the first design review. The intent of these plans is to ensure that proper emphasis is placed on the control of interference and adequate attention given to interface and FCC requirements from the earliest stages of train design.

9.9.2 ELECTROMAGNETIC INTERFERENCE

The electromagnetic interference control and test plan shall describe the contractor's approach to ensure that the electrical, electronic and communication systems and subsystems will operate in their intended operational environments without either suffering or causing harmful interference because of unintentional electromagnetic radiation or response. This plan will describe the methods by which the contractor intends to control the electromagnetic interference and/or the susceptibility of purchased and subcontracted equipment and components. In addition, it will describe how the contractor intends to install and progressively test the various systems and subsystems to demonstrate protection against false energy miscodes, improper codes and cross-talk from adjacent and nearby track circuits. Testing for these purposes must be performed under the appropriate fault conditions.

9.9.3 INTERFACE COMPATIBILITY

All equipment shall be protected from damage due to electrical line transients up to ___ volts (5 times normal voltage) with a duration of 200 microseconds, or double normal voltage for 200 milliseconds. All equipment shall function normally when the prime power DC voltage has an AC ripple voltage of up to 50 volts RMS at any frequency from 50 to 2000 Hz.

The contractor shall, at designated design reviews, demonstrate through display of technical information and test results, the functional compatibility of the various subsystems, as well as the compatibility of the total system with its operating environment. The considerations necessary to evaluate the functional interfaces between subsystems include power source levels and variations, load and source impedances, grounding and continuity, subsystem controls, etc.; interfaces between the total system and its operating environment include types of communications, physical constraints to radio communications, communication range requirements, train control system, interference between train and wayside systems, etc.

POWER AND TRACTION

10.1 PRIME POWER

Prime power for propulsion, auxiliaries, and control shall be provided by one or more of the following sources;

10.1.1 ALTERNATING CURRENT

Prime power will be supplied at a nominal ___ volts, ___ phase, ___ Hz alternating current. The power supplied shall conform to the limits defined in specification _____.
(This specification defining alternating-current power supply should cover nominal voltage, voltage limits, minimum voltage, nominal frequency and frequency limits, source impedance, maximum current per collector, harmonic content, permissible transients/spikes, insulation, ground return, etc.)

10.1.2 DIRECT CURRENT

Prime power will be supplied at a nominal ___ volts. The power supplied shall conform to the limits defined in specification _____. (This specification defining direct-current power supply should cover items similar to those under paragraph 10.1.1.)

10.1.3 SELF-GENERATED POWER

10.1.3.1 Gas Turbine Engine

The prime power source shall be a gas turbine engine(s) as specified in the detail specification. Gas turbine engines shall conform to specification _____. (A specification defining the gas turbine engine should cover maximum power requirements, duty cycle, specific fuel consumption, airflow rate, gas generator speed, power turbine speed, maximum weight, engine/component overhaul life, etc.)

10.1.3.2 Diesel Engine

The prime power source shall be a diesel engine(s) as specified in the detail specification. Diesel engines shall conform to specification _____. (A specification defining the diesel engine should cover maximum continuous power requirements, duty cycle, specific fuel consumption, maximum output speed, maximum weight, engine/component overhaul life, torsional limits, etc.)

10.1.3.3 Engine Subsystems

10.1.3.3.1 Fuel System - The fuel system shall be fully defined by function of its components as integrated within the propulsion system. The fuel system shall include tanks and piping exterior to the engine; quantity and pressure gaging; and functional equipment and arrangement necessary for required fuel feed to the engine as required by the engine specification. An installation drawing shall be supplied by the contractor, supplemented by diagrams as required to show the operation of the fuel system. The following fuel system characteristics shall be included: external envelope, equipment installation, and removal clearance. The fuel system shall be designed for use with _____ type fuel.

10.1.3.3.2 Air Induction System (Diesel Engines) - The air induction system shall be designed to give minimum disturbance to intake flow and minimum induction of spray or dust. The duct areas and routing shall provide the maximum practical engine intake, air pressure, and velocity in accordance with engine specification _____ and shall preclude erratic metering. Pockets which may collect fuel or water shall be avoided and drain lines shall be provided at the lowest point to drain all free fuel or water to the open air clear of all parts of the railcar.

10.1.3.3.3 Air Induction System (Gas Turbine Engines) - The design of the air induction system shall prevent engine compressor stall or other engine malfunction due to erratic or adverse airflow distribution under all operating conditions.

The maximum permissible variation in total pressure at the engine compressor inlet face shall not exceed the requirements of engine specification _____. The air intakes and areas immediately forward of air intakes shall be kept free of bolts, fasteners, etc., which if loosened could enter the intake duct.

10.1.3.3.4 Exhaust System (Diesel Engines) - The open end of exhaust pipes shall have a minimum clearance of _____ from _____ parts of the railcar and the exhaust gases shall not impinge on the external surface of the railcar within _____ from the exhaust outlet.

10.1.3.3.5 Exhaust Systems (Gas Turbine Engines) - The exhaust outlet shall be so located that the portion of the jet within an included angle of 15 degrees shall not impinge on any part of the railcar. Where this is not practical, protection shall be provided as necessary. The exhaust system outlet areas shall conform to the requirements of engine specification _____.

10.1.3.3.6 Lubricating System - The engine lubricating system, comprising the tanks, measuring devices, coolers, and pumps not integral with the engine, piping exterior to the engine, strainers, pipe fittings, valves, etc., shall conform to the requirements of engine specification _____.

10.1.3.3.7 Starting System - The engine starting system shall provide the capability required to start the engines as specified in the engine specification. The power source for the starting system shall be as prescribed in the detail specification and the starting torque requirements of engine specification _____. The starter control shall be within convenient reach of the engineman but not subject to accidental movement unless a guard is provided. Starter controls shall be arranged so that all operations necessary to start the engine can be conveniently carried out by one man.

10.1.3.3.8 Engine Control System - The engine control system shall provide for safe and precise engine operation within the engine operating limitations. Control levers shall permit either individual or multiengine control of engines and shall be grouped in the cab in a location readily accessible to the engineman. It shall be possible to shut down the engine(s) in the event of total electrical system failure.

10.2 CURRENT COLLECTION

Prime power current shall be collected by one of the following means:

10.2.1 PANTOGRAPH (Optional)

Each car shall be provided with a single pantograph overhead current collector mounted on the car roof over one truck. Married pairs may be designed to require only one pantograph if specified in the detail specification. The pantograph shall be compatible with the characteristics of the catenary system described in the detail specification. The pantograph shall conform to the requirements defined in specification _____. This specification should cover:

- Current per pantograph
- Sliding-contact design details
- Force against the trolley wire
- Insulation and insulator rating (___times nominal voltage)
- Catenary maximum and minimum height
- Pantograph indicator light
- Lightning arrestor
- Pantograph connection to power cable (pothead)
- Ground lead

10.2.2 THIRD RAIL CONTACT SHOES (Optional)

Each car shall be provided with four contact shoes to collect third-rail power mounted one on each side of each truck. The shoes shall be compatible with the characteristics of the third-rail power system described in the prime power specification. The shoes shall conform to the requirements defined in the detail specification.

10.2.3 TROLLEY POLES (Optional)

Trolley poles shall be raised and lowered as required by the detail specification. The trolley shall be held against the catenary wire at proper pressure with provision for adjustment. The trolley shall operate satisfactorily in the range between ___ feet and ___ feet catenary height. Design, location, and method of attachment of the trolley poles shall be specified by the purchaser.

10.2.4 SLEET SCRAPERS (Optional)

If required by the detail specification, sleet scrapers shall be provided which shall maintain contact with the third rail or catenary at speeds up to ___ miles per hour. Means shall be provided to automatically or manually retract each scraper from the rail or catenary and latch it safely in the retracted position. Design, location, and method of attachment shall be specified by the purchaser.

10.3 INTERMEDIATE POWER (Optional)

Intermediate power systems shall be provided as required to convert prime power into mechanical, hydraulic, or electric power and/or to provide tractive power to the wheel-axle assemblies.

10.3.1 MECHANICAL DRIVE

Mechanical drive transmissions shall be provided as per the detail specification. The transmissions shall include reduction gears, clutch and controls, drive shafts, cooling and lubrication system as required. Mechanical drive transmissions shall conform to the requirements of the detail specification.

10.3.2 HYDRAULIC DRIVE

Hydraulic drive transmissions shall be provided as per the detail specification. The transmissions shall include power train, controls, drive shafts, fluid, pumps, reservoirs, and cooling systems. Hydraulic drive transmissions shall conform to the requirements of the detail specification.

10.3.3 AC GENERATOR

AC generator(s) shall provide ___ KVA of ___ volt, ___ Hz, ___ phase current at a power factor of _____. The voltage characteristics in terms of rms, wave shape, and harmonic content shall conform to the requirements of specification _____. In addition, the thermal characteristics of the generator shall be defined (to be developed from such specifications as IEEE Standards No. 11, Rotary Machinery, and No. 16 Control Apparatus High Potential Test, etc.). The generator shall be brushless and shall meet the environmental requirements (vibration, shock, temperature, etc.) of specification _____ (to be developed). It shall be mounted on suitable shock mounts and equipped with a frame grounding connection.

10.4 ENERGY CONVERSION, ELECTRICAL SERVICE (Optional)

The primary power described in 10.1.1 (AC), 10.1.2 (DC), or the intermediate power provided by the generator described in 10.3.3 (AC) shall be converted into lower AC or DC voltages to suit the car's service current requirements, such as auxiliary motor drives, battery charging, etc. This conversion may be accomplished by motor-generator set, motor-alternator set, or by a section of secondary winding on the main transformer. The service voltage supplied under 0 to maximum service load under specified variations of the primary power voltage should not exceed ___ percent plus and ___ percent minus of the nominal service voltage.

10.4.1 TRANSFORMER

The transformer shall have a suitable tap arrangement to adapt (manually/automatically) to frequency and voltage changes of the prime A.C. power. The transformer shall have the capability to operate on either of the following primary voltages:

- a. Nominal frequency ___ Hz; nominal voltage ___ v (rms)
- b. Nominal frequency ___ Hz; nominal voltage ___ v (rms)

The cooling shall be by means of a circulating pump and heat exchanger with cooling fans. The transformer shall be mounted on resilient mounts. The transformer tank shall be pressure-tested to withstand ___ psi and shall be provided with a pressure-relief device to discharge between the tracks. The short-circuit current (with secondary windings short-circuited) shall not exceed ___ amperes. The inrush current shall not exceed ___ percent of the nominal current and shall not damage the transformer.

10.4.2 RECTIFIER

The rectifier performance shall be defined by the system performance (overloads, ripple, etc.).

10.5 TRACTION

The analysis of the traffic flow and track profile will determine the continuous and hourly power rating required. The selected traction motor with a critical traffic profile (maximum performance required as a routine) will then serve as a basis for the design of the traction system, starting with the prime electric power, through conversion, rectification, and control, to end at the traction motors.

10.5.1 ACCELERATION AND DECELERATION CONTROL

Type of propulsion control shall be specified by the purchaser. Possible configurations shall include, but not necessarily be limited to, the following:

- a. Cam control of series motors
- b. Accelerator control of series motors
- c. Chopper control of series motors or separately excited motors
- d. Pulse width modulation control (controlled slip induction motor)
- e. Self-synchronous motor control

The control to the traction motors and braking power shall be defined in detail by the contractor. The control shall meet the acceleration, speed and jerk rates defined in paragraph 2.2.1.7. The switching shall be from the control position through the trainlines. The intelligence for switching shall be:

- a. Manual train control under direct control of the motorman through a master controller.
- b. Through the ATC (Automatic Train Control) if used. The interface between the trainlines and the ATC system shall be as defined in drawing _____. One ATC system shall be provided for each single car or married pair.

10.5.2 OVERLOADS

The traction system and each of its components shall withstand continuous operation at ___ percent overload of the continuous rating of the traction system as described in section 10.5 without any shortening of the life of components.

10.6 TRACTION MOTORS

10.6.1 GENERAL

These general requirements listed herein are applicable to any of the following four types of traction motors:

- a. DC Series (brush type)
- b. DC Shunt, separate field excitation (brush type)
- c. AC Induction (brushless)
- d. AC Self-Synchronous (brushless)

Each (axle/2 axles) shall be driven by a traction motor with the characteristics necessary to produce the tractive effort levels defined in section 10.5.

All traction motors of the same part number shall be physically and electrically interchangeable between cars and positions. The traction motors shall conform to the following specifications:

- a. IEEE, Standard No. 11, Rotating Machinery
- b. IEEE, Standard No. 16, High Potential Test
- c. As specified in the detail specification

10.6.1.1. Mounting

Traction motor mounting requirements shall be specified by the purchaser. Each motor shall drive through a suitable gear drive as specified in the detail specification.

10.6.1.2 Rating

The traction motors shall be capable of meeting the ratings defined in paragraph 10.5. In determining the duty cycle of the traction motor, the layover time of ___ minutes at either end of the line can be considered. Station stop time of ___ seconds per station may be used.

10.6.1.3 Ventilation

Motors shall be either self-ventilated or provided with ventilation as specified in the detail specification. Mass rate of flow shall be defined by the motor manufacturer. Air inlet openings, wherever located, shall be provided with protective screens large enough to prevent blockage by the accumulation of leaves and debris.

As an option, purchaser may specify that air for the traction motors shall be properly filtered to prevent the ingress of sand, dust, metal particles and other fine debris. Replacement shall be required no more frequently than every _____ miles. The system shall be designed so as to not require the use of auxiliary winterization apparatus such as snow screens. The arrangement for motor ventilation must have the approval of the purchaser.

10.6.1.4 Insulation

The motor insulation system shall be unaffected by airborne foreign material including, but not limited to, dust, water, and snow. Insulation shall be Class H or better and the frame and armature shall be given vacuum-pressure impregnation insulation treatment.

10.6.1.5 Armature Balance

Armatures shall be dynamically balanced with a maximum unbalance of ___ inch-ounce, if specified, using metal correcting weights either welded or soldered in place. As an option, purchaser may specify separate balancing of fan and armature.

10.6.1.6 Armature Shaft Design (Optional)

Armature shafts shall be designed so that damage to the drive portion of the shaft assembly shall not require replacement of the armature, windings and/or commutator.

10.6.1.7 Maximum Safe Speed

The motor shall have a maximum safe speed ___ percent higher than required to meet all requirements of the traction specified, with any permissible condition of wheel wear.

10.6.1.8 Connections

Terminals and/or terminal block shall be clearly marked for positive identification. The design of the terminals and/or terminal block shall be submitted to the purchaser for approval. As an option, purchaser may specify quick-disconnect terminals with easy access.

10.6.1.9 Bearings and Seals

a. Bearings

Traction motors shall be equipped with anti-friction bearings of sealed lubrication type. Grease cavities shall contain sufficient lubrication to allow operation for _____ miles without lubrication. As an option, purchaser may specify bearing housings with tapped holes closed with wire pipe plugs to permit the addition of a measured amount of lubricant at _____ mile intervals. The bearings shall be designed for a B-10 life of _____ miles. Arrangements which use gear lubricant for traction motor bearing lubrication at the pinion end are permitted if approved by the purchaser.

b. Seals

Motor dynamic seals shall be radial lip seals, face seals, or labyrinth seals as specified in the detail specification.

10.6.1.10 Overspeed Protection (Optional)

If specified by the purchaser, traction motor overspeed protection shall be provided. This protection shall be activated in the following cases:

- a. When motor speed exceeds a specified value
- b. When motor acceleration exceeds a specified value

The prime contractor shall furnish the operating characteristics of the overspeed protection to the purchaser for approval.

10.6.2 DC SERIES AND SHUNT MOTORS

10.6.2.1 General

The motor shall be fully compensated (commutating poles and compensating windings) for black to pinpoint commutation throughout the load and speed range and in both directions of rotation. Commutator bars shall be as specified in the detail specification.

10.6.2.2 Brushes and Brush Holders

Brushes shall fit and operate properly under the environmental conditions to which they will be subjected. Brush holders shall be adjustable to accommodate ___ inch radial wear of the commutator. Design of the brush holder installation shall provide for easy access to the brushes. The brushes shall fit in the holders closely without binding. Brush tension shall be adjustable. Brush tension setting shall be retainable for the life of the brush. Brushes shall have a useful life of _____ miles, commensurate with acceptable wear of the commutator. Provisions shall be made in the design to prevent resonant frequencies of brush holder and brush assembly.

10.6.3 AC INDUCTION AND SELF-SYNCHRONOUS MOTORS

AC induction and self-synchronous motors may be used for propulsion in conjunction with Pulse Width Modulation (PWM) or other appropriate inverter and control systems. The complete system shall be defined in detail by the contractor.

10.7 ELECTRICAL BRAKING (Optional)

10.7.1 GENERAL

An electrical braking system shall be provided as per the detail specification. The electrical braking system shall use the traction motors as generators and shall operate in conjunction with the friction or magnetic braking system. The electrical load developed by the traction motors shall be handled by one or both of the following means.

10.7.2 DYNAMIC BRAKING

The electrical braking load shall be dissipated in car-mounted resistor grids. Heat generated by the resistor grids shall be removed by either forced or self-ventilation as specified in the detail specification. The resistor banks shall be located (under/over) the car.

10.7.3 REGENERATIVE BRAKING

The electrical braking load shall be conditioned as necessary and fed back into the prime electrical power source. Regenerative braking systems shall conform to the requirements of specification _____.

10.7.4 BRAKE BLENDING

The braking shall meet the performance requirements of sections 2.2.4 and 2.2.6 with respect to deceleration and jerk

rate after the dynamic braking fades out. The friction braking shall be blended with dynamic braking for speeds below ____ mph. (See also paragraph 2.2.4.1.6.)

10.8 GEAR UNITS

Gear boxes of a type and arrangement to be specified by the purchaser shall be provided to transmit the torque from the traction motor to the car axles. The gearing may be either right angle or parallel type.

10.8.1 GEAR CASE

The gear box housing shall be of cast or fabricated steel. Suitable orifices and plugs shall be provided in the housing for lubrication and breathing. Any breather shall be so arranged as to prevent the entrance of water. A suitable bolted cover for inspection and disassembly of the gear unit shall be provided. Provision shall be made to prevent oil leakage around the bolted cover and the high and low speed shafts. Magnetic plugs shall be provided in the case drain holes.

10.8.2 MOUNTING

The gear unit shall be arranged to provide resilient attachment to the axle or the traction motor.

10.8.3 GEARS

Pinions shall be of forged steel and gears of rolled or forged steel. Pinions and gears shall be heat-treated to provide suitable physical properties. Gear life shall be no less than ____ miles (if specified).

10.8.4 BEARINGS AND SEALS

High and low speed bearings shall be tapered roller type with ample capacity for the service intended. The bearings shall be designed for a B-10 life of ____ miles. Oil seals shall be of the metal labyrinth type without rubbing surfaces.

10.8.5 LUBRICATION

The gear units shall be so designed that adequate lubrication will be provided to all bearings and gears under the most severe operating conditions. Lubricant shall be taken from the purchaser's lubrication chart, unless otherwise specified.

10.8.6 COUPLINGS

The coupling from the traction motor to the transmission shall be of a type approved by the purchaser. It shall be suitably balanced so that no objectionable noise or vibration is produced within the car at speeds up to ___ miles per hour with fully worn wheels. Adequate provisions shall be made to accommodate lateral, vertical, longitudinal and angular motion of the axle relative to the traction motor as required without imposing stress on its armature bearings.

10.8.7 GROUND BRUSH AND COVER

A ground brush holder shall be mounted on the gear unit to shunt ground current to the axles around the anti-friction bearings. The number of ground brushes required shall be specified by the purchaser. The brushes shall be held securely by suitable spring pressure against a (machined bronze, cast brass, etc.) ring mounted on the axle. The brushes shall have ample capacity for the service intended and shall be mounted so as to provide an easy means for electrical connection to the ground lead. The brushes and brush holder shall be protected against mechanical injury, dirt, oil and water, by a housing having a cover easily removable for access.

10.9 TEST POINTS (Optional)

Readily accessible test points shall be provided in a test panel for use in manual check of propulsion and control systems. The panel shall be designed so that it can be adapted to future diagnostic aids without additional wiring within the propulsion and control system.

10.10 TECHNICAL DATA

In addition to the submittal of performance data required by section 2.2.9, contractor shall furnish, or cause to be furnished by the appropriate supplier, description of the functioning of the propulsion, braking and control systems proposed. This shall include schematic diagrams, drawings and material lists to assist in defining the system operation.

10.11 DESIGN RESPONSIBILITY

The contractor shall require that the manufacturers supplying parts or apparatus covered by this section shall cooperate fully to the end that all apparatus shall be properly installed and the completed car shall function in accordance with the requirements of this specification.

As an option, purchaser may require that the contractor utilize the systems engineering concepts of section 16.3.

TRUCKS AND SUSPENSION SYSTEM

11.1 GENERAL

The truck and suspension system includes all truck components from the rail up to the body bolster, including any suspension system components rigidly mounted to the car body. It does not include gears, motors, wiring, brake system, power collectors, automatic train control components, or their mounting brackets, except that any mechanical interface requiring welding or drilling on the truck shall be considered part of the truck.

Each car shall be supported on ___ (number of trucks) swiveling trucks, each having ___ traction motors. The truck centers shall be ___ feet ___ inches apart, ± a tolerance of ___.

The truck shall be designed in such a manner as to ensure satisfactory operation for the guaranteed life, under the operational environment of this specification. Trucks shall have sufficient strength to withstand all stresses which may develop in service at speeds up to and including ___ mph. The truck shall also react the truck-mounted equipment loads; e.g., brakes, power drive, suspension, etc.

The clearance of the completely assembled trucks, with motors, brakes, and other equipment, must be greater than ___ inches between the truck and car body and ___ inches between the truck and roadway with maximum load, wheel wear, and suspension system wear over minimum lateral and vertical curves, as well as on tangent track. Bolts shall be accessible without removing truck components or the truck from the car.

11.2 CONSTRUCTION

11.2.1 STRENGTH REQUIREMENTS

The truck frame assembly shall be designed to resist the following loads without yield or failure and shall be of sufficient rigidity to attain the required performance. Commuter car design conditions shall equal or exceed the strength requirements as specified in the DOT regulations and AAR specifications for train weight over 600,000 lbs.

- a. A lifting load at the appropriate carbody attachments of _____ pounds.
- b. A shear load of _____ pounds applied to the appropriate carbody attachments.
- c. A static load condition comprised of the following loads in pounds:

Vertical load (downward) = (X.XX) J
Lateral load = (X.XX) S
Longitudinal load = (X.XX) W

where load factors (X.XX) will be specified by the purchaser.

W = Weight on truck
S = Sprung weight per truck
J = Journal reaction per truck

All combinations of the above loads will be considered during design.

- d. Design fatigue load schedule comprised of the following loads in pounds:

Vertical component ± X.XX S
Lateral component ± X.XX S
Longitudinal component ± X.XX S

Phasing of the above load components shall be combined to produce the maximum fatigue stress in each structural item in the assembly. Values (X.XX) and point of load application will be specified by the purchaser. Design life for steel will be taken as _____ cycles and for aluminum, _____ cycles.

- e. The truck frame assembly, with a centrally applied vertical load of _____ pounds, shall maintain the axles parallel to each other within \pm _____ inches at the journal centers, shall limit the difference between diagonally opposed bearing locations to _____ inches, and shall not permit the range of wheel support loads to exceed _____ pounds when measured at the rail on horizontal tangent track.
- f. For a fabricated truck, a centrally applied vertical load of _____ pounds plus a horizontal, longitudinal couple equivalent to _____ inch/pounds, applied at diagonally opposite journal centroids, shall not allow a relative longitudinal displacement of the side frames greater than _____ inches at the journal centers.
- g. The truck frame assembly with a centrally applied vertical load of _____ pounds shall have the capability of having any wheel lifted such that the weight distribution of any wheel of the truck shall not change more than an average of _____ percent per _____ inch raised, up to a maximum of _____ inch(es).

11.2.2 MATERIAL

Frame material shall be specified by the purchaser and shall conform to the material requirements in paragraph 2.4.

11.2.3 PILOTS (Optional)

Requirements for pilots shall be specified by the purchaser.

11.2.4 JOURNAL BEARING LOCATION

The requirement for mounting journal bearings inboard or outboard of the wheels shall be specified by the purchaser.

11.2.5 CENTER PLATE AND CENTER BEARINGS

Center plate and center bearings shall be as specified by the purchaser.

11.2.6 STOPS

Lateral, vertical and longitudinal stops (if used) shall be as specified by the purchaser.

11.2.7 BOLSTER ANCHOR RODS (Optional)

Two bolster anchor rods shall be provided per truck, one on each side of the truck. The rods and attachments shall be capable of withstanding the static and fatigue loads expected in service.

Under conditions of severe shock loading on the truck, the rods shall be designed to fail before the car body is permanently deformed. Adequate clearance shall be provided between the anchor rods and all parts of the truck. Provision shall be made to prevent inadvertent contact between the rods and the third rail in the event of rod failure.

11.2.8 HUNTING

The truck suspension design shall prevent unstable oscillations in the operating speed range, and shall minimize the effect on ride quality of stable hunting motion at all operating velocities.

11.2.9 TRUCK-CAR SEPARATION (Optional)

Means shall be provided to protect against accidental separation of truck and car body.

11.2.10 EQUIPMENT MOUNTING

Requirements for incorporating provisions in the trucks for mounting equipment shall be specified by the purchaser.

11.2.10.1 Track Trip System (Optional)

Provisions shall be included for emergency interruption of vehicle power and application of the emergency brake to be compatible with existing track trips.

11.2.10.2 Derailment Detection System (Optional)

Two frangible derail detectors shall be mounted in each truck. They shall be attached to the truck side frame and, when failed, shall interrupt vehicle power and apply emergency braking in a manner similar to the "Track Trip" System.

11.2.11 FRAME INSPECTION

The methods of inspecting truck frames, particularly in areas of potential stress concentrations and the number of truck frames from the initial production run to be inspected shall be specified by the purchaser.

11.3 SUSPENSION SYSTEM

11.3.1 REQUIREMENTS

Each truck shall have a suspension system. The type of suspension, i.e., air springs, steel coils and air springs, or rubber, or other type systems, shall be specified by the purchaser.

11.3.2 STRENGTH

The suspension system shall be designed to provide a satisfactory life under the operating conditions specified. The design life shall be presented to the purchaser by the contractor for approval.

Parameters to be considered for calculation of life shall include, but not be limited to, the following: static load, overloads, dynamic load, normal operating deflection range, environmental factors and material shelf life.

11.3.3 COMBINATION SUSPENSION SYSTEM

When combination systems such as coil springs and air springs are specified, the weight to be carried by each type of spring arrangement shall be specified by the purchaser.

11.3.4 LEVELING VALVES (Optional)

Requirements for leveling valves for maintaining a uniform car body height shall be specified by the purchaser.

11.3.5 FAILURE RESPONSE

Requirements for system compensation and reaction in the event of a spring failure shall be specified by the purchaser. Safe operation of the car with a failed or inoperative spring shall be demonstrated.

11.3.6 FLOOR-TO-RAIL CLEARANCE

The distance between the rail and the top of the car floor over the truck center that is to be maintained by the suspension system shall be specified by the purchaser. This shall be demonstrated on level track. (The loading condition shall be specified.)

11.3.7 ADJUSTMENT PROVISIONS

Requirements for vertical adjustment of the suspension system to compensate for wheel wear and/or wear of other truck parts shall be specified by the purchaser.

11.3.8 NATURAL FREQUENCY

Limits for the natural frequency of the body suspension system may be specified.

11.3.9 MOTION DAMPING

Requirements for motion damping and the type of damping systems to be used may be specified.

11.3.10 MATERIAL AND FABRICATION

Material and fabrication requirements for the suspension system components shall be specified and shall conform to the requirements in Section 2.4.

11.4 WHEELS AND AXLES

11.4.1 WHEELS

11.4.1.1 Material and Construction

The wheel material and method of fabrication, including heat-treating and temperature requirements, shall be specified by the purchaser.

11.4.1.2 Strength

Strength of wheels shall be based on AAR specifications unless otherwise specified. Special design strength requirements shall be specified by the purchaser.

11.4.1.3 Tread and Flange Contour

Tread and flange contours shall be specified by the purchaser and, unless otherwise specified, shall be in accordance with AAR standards for cylindrical or tapered contours as applicable.

11.4.1.4 Dimensions

Wheel diameter shall be ___ inches \pm ___ inches (tapes).

11.4.1.5 Wheel Wear

Wheels shall be of _____ (single or multiple) wear design and shall be designed for a condemning limit of ___ inches in diameter.

11.4.1.6 Wheel Matching

Wheels shall be supplied in marked pairs and be matched in diameter (circumference) to within ___ inches (tapes).

11.4.1.7 Wheel Mounting

Wheels shall be mounted on the axles in accordance with AAR standards, as prescribed in the detail specification. Mounting forces shall be specified.

11.4.1.8 Tolerance

Wheel design tolerance limits shall be specified by the purchaser.

11.4.1.9 Wheel Marking

Requirements for wheel marking, unless otherwise specified, shall be in accordance with the AAR Wheel and Axle Manual, _____ Edition, latest issue, or ASTM A-25.

11.4.1.10 Wheel Balance (Optional)

Wheels shall be dynamically balanced to within ____ pounds at the outside diameter of the rim.

11.4.2 AXLES

11.4.2.1 Strength

Strength requirements shall be specified by the purchaser or shall be based on AAR standards.

11.4.2.2 Material and Construction

The material and fabrication methods, including heat-treating requirements, shall be specified by the purchaser or shall be based on AAR standards.

11.4.2.3 Inspection

Requirements for inspection shall be based on AAR standards and/or shall be specified by the purchaser.

11.4.2.4 Marking

Requirements for marking such as manufacturing serial number, heat-treat log, etc., shall be specified by the purchaser.

11.5 JOURNAL BEARINGS

11.5.1 STRENGTH

Journal bearings shall be designed for a B-10 life of ____ miles at a load of ____ pounds which will be derived from the car weight with ____ seated passenger load. An average speed based on the requirements of section 2.2 shall be used.

11.5.2 LUBRICATION

Bearing lubrication requirements shall be specified by the purchaser.

11.5.3 MOUNTING

The requirements for supporting the bearings and method for retention in the side frames shall be specified by the purchaser.

FRICTION BRAKING SYSTEM

12.1 GENERAL

A friction braking system shall be provided on each car with the capability of service and emergency braking in accordance with the requirements of section 2.2.4. The braking system shall consist of two primary sections:

- a. A fully variable service brake providing specified deceleration.
- b. A fail-safe emergency brake.

The type of service and emergency brake system desired, such as pneumatic tread brakes, electrical disc brakes, electro-magnetic track brake, etc., shall be specified by the purchaser.

12.2 STRENGTH REQUIREMENTS

The following design conditions shall apply for the friction braking system:

- a. The brake system shall be designed to withstand the loads induced in the system when complying with the performance requirements of section 2.2.4. The effects of elevated temperatures shall be included in the affected component analysis.
- b. The brake system, including mechanical linkages, shall be designed for ___ cycles of operating loads without failure.

12.3 BRAKE CONTROL SYSTEM

The brake control system shall be fail-safe and shall have sufficient capacity to make an emergency stop at any point in the purchaser's system during a normal run with a dynamic brake failure within the requirements of section 2.2.4.2. The friction brake system shall provide smooth blending with auxiliary forms of braking such as dynamic or regenerative, where used (See section 10.7)

12.3.1 HYDRAULIC BRAKE SYSTEM (Optional)

The hydraulic system installed on each car for brake application shall have sufficient capacity to provide a minimum of ten 30-second normal brake applications in a time period of ___ minutes. Pressure reservoirs and/or accumulators shall be constructed in accordance with ASME requirements.

12.3.2 PNEUMATIC BRAKE SYSTEM (Optional)

The pneumatic system installed on each car shall have sufficient capacity to supply the full braking requirements of ___ cars. Brake pneumatic system isolation shall be provided by a non-return check valve installed between the main reservoir and the supply reservoir. Air for braking only shall be taken from the supply reservoir. As an option, the system shall incorporate automatic drain valves to exhaust moisture with minimum loss of air, including provisions to prevent freezing.

Description of main system components shall include, but not necessarily be limited to:

- Air compressor
- Compressor motor
- Compressor contactor
- Compressor intake filter
- Reservoirs
- Master controller
- Operating units
- Cutout cocks
- Air gages
- Trip cocks

Strength requirements of the airbrake system components shall comply with local government and state codes. Purchaser may, as an option, require that airbrake components conform to the requirements of the latest revision of Section VIII of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels.

12.3.3 ELECTRICAL BRAKE SYSTEM (Optional)

The electrical friction brake system shall be as specified by the purchaser.

12.3.4 VARIABLE LOAD CONTROL (Optional)

The braking system shall be provided with variable load control to maintain a constant braking rate regardless of car loading. See section 2.2.8.

12.3.5 INDICATING LIGHTS (Optional)

Each cab shall be equipped with brake "ON" - "OFF" indicating lights.

12.4 HANDBRAKE/PARKING BRAKE (Optional)

Purchaser may specify a manual or servo controlled handbrake/parking brake. A manually applied brake shall be designed such that a _____ pound force applied _____ inches from the extreme end of the brake handle, or on the rim of the handwheel, will hold a _____ loaded car on a _____ % grade. A lever-type handbrake/parking brake shall require no more than _____ strokes of the handle to engage the brake.

12.5 ELECTRO-MAGNETIC TRACK BRAKE (Optional)

_____ electro-magnetic track brakes shall be provided on each car, _____ per truck. Control switch arrangement, circuitry and circuit protection, power supply and other details shall be as specified by the purchaser.

12.6 SPECIAL FEATURES

Where required by weather conditions, special features such as snow brake for snow operation, and air dryer for freezing conditions, shall be specified in the detail specification. Provisions shall be made for cutout of friction brakes on individual cars to permit emergency movement of a train.

SECTION 13

COMMUNICATIONS

13.1 GENERAL

This section includes the requirements for public address, intercommunications and train-wayside radio systems. All communications systems shall be intelligible and acceptable under all operating conditions.

13.2 PUBLIC ADDRESS SYSTEM (Optional)

13.2.1 GENERAL

A complete public address system in accordance with AAR Communication Manual, Section 12-4, or as specified by the purchaser, shall be installed in each car to provide the following channels of communication:

- a. Public address speech communication from train crew to all passengers.
- b. Capability for public address communication from the central office to all passengers.

13.2.2 REQUIREMENTS

In addition to the specific type of equipment to be supplied, the following may be defined in the detail specification:

- a. Location and type of controls.
- b. Responsibility for furnishing and installing conduit, wiring, racks, and supports.

- c. Circuit protection requirements.
- d. Interface requirements and compatibility with other train systems.
- e. Responsibility for tests necessary to verify proper system operation and installation.
- f. Number and location of speakers.
- g. Equipment access requirements for maintenance purposes.

13.3 INTERCOMMUNICATIONS SYSTEM

13.3.1 GENERAL

A complete intercom system shall be installed in each car as specified by the purchaser to provide the following:

- a. Two-way private communication between train crew members.
- b. Communications between passenger and crew (optional)

13.3.2 REQUIREMENTS

In addition to the specific type of equipment to be supplied, the following may be defined in the detail specification:

- a. Location and type of controls.
- b. Type of call device
- c. Responsibility for furnishing and installing conduit, wiring, racks, and supports.
- d. Circuit protection requirements.
- e. Interface requirements and compatibility with other train systems.
- f. Responsibility for tests necessary to verify proper system operation and installation.
- g. Number and location of phone stations or call boxes.
- h. Equipment access requirements for maintenance purposes.

13.4 TRAIN-WAYSIDE COMMUNICATIONS (Optional)

13.4.1 GENERAL

A complete communication system shall be installed in each car to provide two-way voice communication between the train crew and the following:

- a. Central office
- b. Wayside stations

13.4.2 REQUIREMENTS

The specific type of communication equipment to be supplied shall be as defined in the detail specification and may include the following:

- a. Location and type of controls.
- b. Responsibility for furnishing and installation of conduit, wiring, racks and supports.
- c. Type of antenna and responsibility for furnishing and installing.
- d. Circuit protection requirements.
- e. Interface requirements with other train systems.
- f. Responsibility for tests necessary to verify proper system operation and installation, including antenna testing.
- g. Equipment access requirements for maintenance purposes.

As a minimum requirement, all radio equipment shall conform to Electronic Industries Association Specifications RS152, RS204 and RS220, or as specified by the purchaser. In addition, VHF-FM radio equipment shall be in accordance with AAR Communication Manual, Section 12-10, unless otherwise specified. Performance of installed radio equipment shall meet applicable Federal Communication Commission (FCC) requirements.

AUTOMATIC TRAIN CONTROL SYSTEM

14.1 GENERAL

This section covers all Automatic Train Control (ATC) apparatus, carborne and wayside, necessary to provide the following functions:

- a. Cab signals
- b. Overspeed protection
- c. Brake assurance
- d. Speed regulation
- e. Automatic Train Operation (ATO)

The ATC system definition will be supplied by the purchaser and may include the following:

- a. Description of ATC equipment to be furnished and by whom.
- b. Constraints placed on contractor to accommodate equipment.
- c. Obligation of contractor relative to interface and compatibility between ATC and ATO systems.
- d. Responsibility for tests necessary to verify proper system operation and installation.
- e. ATC monitoring and safety check system.

14.2 CARBORNE EQUIPMENT

The carborne equipment shall be as specified in the detail specification and may include the following:

- a. Cab Signal Aspect Display
- b. Speed Determining and Display Units
- c. Receivers and Decoding Units
- d. Brake Assurance Units
- e. Overspeed Protection Units
- f. Speed Regulation Equipment
- g. Train-to-Wayside Communication Equipment (See section 13.4)

14.3 WAYSIDE EQUIPMENT

The wayside equipment shall be as specified in the detail specification and shall include all necessary power supplies, track relays, transmitters, receivers and cab signal command encoders for _____ complete track circuits. Equipment racks and enclosure may also be specified.

14.4 DESCRIPTION OF OPERATION

ATC system operation shall be described in the detail specification and may provide modes of operation similar to the following.

14.4.1 WAYSIDE SIGNAL - SPEED REGULATION

This is the normal operating mode for operation on existing lines with wayside trip stops. Speed regulation shall be provided for each speed notch on the master controller.

14.4.2 WAYSIDE SIGNAL - MANUAL

This mode of operation bypasses the speed regulation control and allows the motorman to operate the train using the master controller.

14.4.3 CAB SIGNAL - SPEED REGULATION

This is the normal operating mode for operation on lines having a continuous train control system.

14.4.4 CAB SIGNAL - MANUAL

This mode of operation bypasses the speed regulation control and allows the motorman to operate the master controller and call for the points of power as indicated on the controller drawings. All restrictions imposed by the overspeed protection subsystem shall be imposed when operating in this mode.

14.4.5 AUTOMATIC TRAIN OPERATION

In this mode, starting shall be initiated by the motorman using the ATO control. The speed regulation subsystem shall respond to the cab signal train protection speed commands to request the train propulsion system to provide the negative and positive tractive effort required. The Cab Signal, Over-speed and Brake Assurance subsystem, shall monitor the speed regulation performance and provide enforcement of the commands received from the wayside. This mode of operation shall include programmed station stops.

SYSTEM SUPPORT

15.1 GENERAL

This section is comprised of the following subsections:

- 15.1 General
- 15.2 Reliability
- 15.3 Maintainability
- 15.4 Value Engineering
- 15.5 System Safety
- 15.6 Human Factors Engineering
- 15.7 Spare and Replacement Parts
- 15.8 Publications
- 15.9 Training
- 15.10 Support Equipment
- 15.11 In-Service Support

The degree of applicability of this section shall depend on the size and technical risk of the new equipment order. In order to present reasonable system support guidelines for the small order of new equipment which is similar to equipment already in use, various portions of the subsections of this section of the optionalization and resultant alternative system support specification is as follows:

Assume a small order of approximately 100 cars or less, where previous cars have operated at acceptable maintenance cost levels but schedule interruptions due to equipment breakdown are greater than desired. The car configuration is conventional and similar to those presently in service. The new cars are not to incorporate advanced systems and therefore risks are generally considered to be low.

Since maintenance costs are acceptable, the alternative approach to Reliability/Maintainability will be aimed at schedule reliability only. Therefore specification of failure rates, MTBFs, maintenance goals and other reliability and maintenance items is not necessary. Similarity to existing equipment will eliminate the necessity for specifying many items under Human Factors Engineering, Training and Support Equipment. In recognition of the alternative approach to System Support, many items in this section have been marked "Optional."

15.2 RELIABILITY

This section presents the vehicle and subsystem reliability requirements to insure that, in addition to meeting the performance requirements, the vehicle shall have high standards of reliability and shall achieve on-time performance and operating goals.

15.2.1 DEFINITIONS

a. Independent Failure

The failure of a system, component or piece of equipment such that it is incapable of performing its function as specified. Failures are not independent when they are caused by the failure of another component, abuse or incorrect maintenance procedures.

b. Mean Time Between Failures (MTBF)

The mean operating time or mileage between independent failures. It is expressed mathematically as:

$$\text{MTBF} = \frac{\text{Total Operating Time or Mileage}}{\text{Number of Independent Failures}}$$

c. Failure Rate

The frequency of failures, expressed as failures per hour, failures per thousand miles, etc. Failure rate is the mathematical reciprocal of MTBF.

d. Schedule Reliability

The probability (expressed as a decimal fraction) of completing a scheduled run on time, with the assumption that only vehicle equipment failures interrupt the schedule.

15.2.2 VEHICLE RELIABILITY REQUIREMENTS

The following reliability requirements have been established for the vehicle operating as a single unit or as part of a multiple-car consist.

Schedule Reliability _____
MTBF _____ (Optional)

15.2.3 SUBSYSTEM RELIABILITY GOALS (Optional)

The following reliability goals have been established for the various subsystems and components of the vehicle.

<u>Subsystem</u>	
_____	_____ Miles/Hours
_____	_____ Miles/Hours
_____	_____ Miles/Hours
_____	_____ Miles/Hours

15.2.4 RELIABILITY PLAN

A plan setting forth the reliability program that will be followed shall be submitted for approval by the purchaser. The plan shall, as a minimum, identify the organization responsible for managing the reliability program and how the contractor will meet the reliability requirements during design, test, manufacture, and service. The plan shall further describe how compliance by subcontractors to reliability requirements will be assured. The reliability plan shall be submitted ___ days after contract. Progress reports detailing the implementation of the approved reliability plan shall be submitted to the purchaser (monthly, bi-monthly, etc.).

15.2.5 RELIABILITY ANALYSIS (Optional)

A reliability analysis shall be made on the final design. This analysis is to demonstrate that the vehicle will meet the reliability goals. The analysis shall contain, as a minimum, a description of the data base used, adjustment factors used and rationale for their use, reliability block diagrams, system failure criteria, system failure modes and effects, and predicted schedule reliability and subsystem MTBFs. This analysis shall be approved by the purchaser prior to release of the design to manufacture.

15.2.6 RELIABILITY TEST PLAN

A reliability test plan shall be prepared and submitted by the contractor ___ days after contract. This plan must be approved by the purchaser prior to the start of the reliability demonstration test. The reliability test plan shall outline the requirements of the reliability demonstration test. It shall include as a minimum, the failure reporting procedures to be used, the success/failure decision criteria for the test, the failure criteria for the equipment under test, and the mathematical verification that the test will demonstrate the required values to the specified confidence level. (Reference MIL-STD-781B)

15.3 MAINTAINABILITY

The objective of the maintainability program is to minimize maintenance costs (labor and material), vehicle down time, the need for specially or highly skilled repairmen and human error during the performance of maintenance, troubleshooting, component removal and installation, repair and inspection tasks.

15.3.1 DEFINITIONS.

a. Availability

Availability is the fraction of the total time (day, month or year) that the vehicle is actually being operated or is capable of being operated, if required.

b. Direct Manhours Per Car Mile (MH/CM)

Direct manhours per car mile (MH/CM) or per operating hour is the ratio of the direct manhours spent maintaining the vehicle and its subsystems and inspecting or cleaning to the total car miles (or operating hours) during a given time period. The direct manhours include only that time actually spent working on the cars.

c. Material Cost Per Mile

Material cost per mile (or per operating hour) is the cost of all materials used directly in the maintenance of the vehicle. These materials include the replacement parts used to effect repairs, the costs of repairs or overhauls done by vendors, manufacturers, etc., and the oils, greases, and so forth used in servicing the vehicle. The total of these material costs is divided by the total car miles (or operating hours) during a given period.

- d. Maintenance manhours per maintenance task is the average direct manhours required to perform a specified maintenance task.

15.3.2 VEHICLE MAINTENANCE GOALS (Optional)

The following maintenance goals have been established for the vehicle, whether it is operating as a single unit or as part of a larger consist.

Availability	_____
Direct Manhours/Car Mile	_____
Material Cost/Car Mile	_____

15.3.3 SUBSYSTEM MAINTENANCE GOALS (Optional)

The following maintenance goals have been established for the various subsystems and components:

<u>Subsystem</u>	<u>Direct Manhours/ Car Mile</u>	<u>Material Cost/ Car Mile</u>
<u>Maintenance Task</u>		<u>Manhours/ Maintenance Task</u>

15.3.4 MAINTENANCE CONCEPT

The car builder shall develop and deliver to the purchaser a detailed maintenance concept. The maintenance concept shall contain an inspection plan, a component overhaul program, and a component repair plan. These plans shall prescribe schedules, required facilities and special equipment required. The maintenance concept shall be developed in close coordination with the purchaser. It shall be developed continuously throughout the program and shall be submitted incrementally for approval. The maintenance concept will serve as the basis for the maintenance manuals.

15.3.5 FAULT ISOLATION/TROUBLESHOOTING PLAN (Optional)

A fault isolation/troubleshooting plan shall be developed and implemented by the contractor. This plan shall detail fault isolation and troubleshooting aids, whether the aids consist of equipment installed on the vehicle, checkout/test equipment used in the maintenance shop, or a system of logical fault isolation procedures to be followed by the repairman. This plan shall contain fault isolation methods that will enable the repairman to successfully locate failures to the extent that the

failure can be corrected by an on-car repair or by replacement of the failed module. The fault isolation techniques developed for this plan shall be included in the maintenance manuals.

15.3.6 MAINTAINABILITY CHECKLIST

In addition to the maintainability requirements listed in previous sections, (15.3.2 through 15.3.5), the following checklist is to be used during the design of the vehicle:

- a. At least one of the following fault isolation/troubleshooting aids shall be provided for each functional subsystem:
 - o Systematic fault isolation procedures shall be developed for inclusion in the maintenance manuals
 - o Built-in test points
 - o Failure indicators
 - o Built-in test equipment
- b. All test points, fault indicators, modules, wire junctions, pipes, tubing, etc., must be identified by nameplates, color coding, number coding, or other means to assist the maintenance repairman.
- c. The placement of components in equipment cabinets, enclosures, or confined places shall give the most accessible positions to those items requiring the most frequent maintenance.
- d. Door panels and openings shall be of sufficient quantity, size, and placement to permit ready access from normal work areas.
- e. Assemblies or components that are functionally interchangeable shall be physically interchangeable. Assemblies or components that are not functionally interchangeable shall not be physically interchangeable.
- f. Standard commercially available components and hardware shall be used wherever acceptable, in consideration of reliability and system safety requirements.
- g. Access shall be provided to all structural components to allow inspection for cracks and corrosion.

15.3.7 MAINTAINABILITY DEMONSTRATION (Optional)

A maintainability demonstration shall be conducted to verify that the delivered cars comply with the stated maintainability goals. The demonstration will be conducted in two phases. The first phase will be a demonstration of _____ (number) maintenance tasks randomly selected from the list in section 15.3.3. These tasks shall be demonstrated with a trained crew of maintenance men supplied by the purchaser. The second phase shall be conducted concurrently with the reliability test (section 15.2.6). During this period, measurements shall be made of the availability, direct manhours/car mile, and material cost/car mile for the goals listed in sections 15.3.2 and 15.3.3.

The car builder shall be responsible for submitting a maintainability test plan that details the test and measurement procedures to be used. The test plan shall be approved by the purchaser before the start of the demonstration program.

15.4 VALUE ENGINEERING

The contractor shall implement a value engineering program on all phases of the design and production of the vehicles. The value engineering program will be directed toward the reduction of cost to the purchaser or enhancement of value in terms of safety, service life, reliability, maintainability, and operating cost. Proposals submitted in detail to the purchaser will be evaluated and accepted or rejected per the applicable terms of the contract. (An incentive clause is anticipated to be included in the contract of which this specification would be a part.)

15.5 SYSTEM SAFETY

The contractor shall establish and maintain an effective system safety program that is planned and integrated into all phases of car design, test, production, and operation. The program shall provide a disciplined approach to methodically evaluate the system to identify and eliminate or control all hazards in a timely, cost-effective manner, consistent with the following goal and priorities:

a. System Safety Program Goal

The goal of the system safety program shall be to provide optimum safety for personnel, equipment and property in the following categories under the complete range of track and environmental conditions specified in this document:

1. Passengers: in transit, boarding and alighting.
2. Operations and maintenance personnel, during the performance of transit system duties.
3. Test personnel, during the performance of System Tests specified in Section 17.4.
4. Vehicles.
5. Transit system equipment/property other than vehicles.

b. System Safety Program Priorities

The following hazard levels shall be used in identifying and assessing the impact of hazards:

1. Catastrophic: will cause death or severe injury to personnel.
2. Critical: will cause personnel injury or major equipment/property damage.
3. Marginal: will cause minor equipment/property damage.

The above levels are defined as singular or combination conditions of design characteristics, procedural deficiencies, personnel error, environment, and/or hardware failure or malfunction that will produce the impacts described. Identification and elimination or control of these conditions shall be given priority in the order shown.

15.5.1 DEFINITIONS

a. Safety

Freedom from those conditions that can cause injury or death to personnel and damage to or loss of equipment or property.

b. System

For the purpose of this specification, the vehicle, passengers, operator, maintainer, the operating and maintenance procedures and the maintenance and test equipment integrated into an operational configuration for the specified operational environment.

c. System Safety

The optimum degree of safety attained through specific application of management and engineering principles throughout all phases of a system's life cycle.

d. Hazard

Any real or potential condition that can cause personal injury or death, or damage to or loss of equipment or property.

e. Crash Safety

A manned system characteristics that allows the occupants to survive the crash impact with minimum injury and to evacuate the vehicle.

15.5.2 SYSTEM SAFETY PLAN

A system safety plan shall be prepared and approved by the purchaser. The plan shall be submitted ___ after contract go-ahead. The plan shall describe an integrated effort within the total program and shall include, but not be limited to, the following:

- a. Specific information showing how the contractor will attain the system safety program goal, and will verify this attainment.
- b. A detailed listing and description of specific tasks.
- c. The method of control to assure execution of each task.
- d. Procedures for problem identification and resolution.
- e. Procedures for recording and reporting the status of actions to resolve problems.
- f. Proposed demonstration tests.
- g. Method of assimilation and dissemination of specific safety requirements to designers and other personnel to expedite correction of identified hazards.
- h. Identification of special safety studies, research, and tests.
- i. Utilization of historical safety data to take advantage of previous experience.

- j. Identification of the organization that will maintain management and technical cognizance of the implementation and conduct of the system safety program, and its relationship to the total contractor organization.

15.5.3 SYSTEM SAFETY CRITERIA

System designs and operational procedures shall consider, but are not limited to, the following:

- a. Avoiding, eliminating or reducing hazards identified by analysis, design selection, material selection or substitution.
- b. Controlling and minimizing hazards to personnel, equipment, and material which cannot be avoided or eliminated.
- c. Incorporating failsafe principles where failures would disable the system or cause personal injury, damage to equipment, or inadvertent operation of critical equipment.
- d. Locating equipment components so that access to them by the required personnel during operation, maintenance, repair or adjustment shall not require exposure to hazards such as entrapment, chemical burns, electrical shock, cutting edges, sharp points, or toxic atmospheres.
- e. Avoiding undue exposure of operating and/or maintenance personnel to physiological and psychological stresses which might cause errors leading to mishaps.
- f. Providing suitable warning and caution notes in operations, assembly, maintenance and repair instructions, and distinctive markings on hazardous components, equipment or facilities for personnel protection. These shall be standardized by the procuring activity.
- g. Minimizing damage or personal injury in the event of an accident.

15.5.4 SYSTEM SAFETY PRECEDENCE

Actions for attaining the safety goal in order of preference are specified below:

- a. Design for minimum hazard during all operational phases. The major effort throughout the design development shall be to select appropriate safety design features; e.g., failsafe, redundancy.
- b. Safety devices - known hazards which cannot be eliminated through design selection shall be controlled through the use of appropriate safety devices.
- c. Warning devices - where it is not possible to preclude the existence or occurrence of an identified hazard, devices shall be employed for the timely detection of the condition and the generation of an adequate warning signal. Warning signals and their application shall be designed to minimize the probability of incorrect personnel reaction to the signals and shall be standardized by the purchaser.
- d. Special procedures - where it is not possible to reduce the magnitude of a hazard through design or the use of safety and warning devices, the contractor shall develop special procedures. Precautionary notations shall be standardized in accordance with the directives of the purchaser.

15.5.5 SAFETY ANALYSES

Analysis shall be performed to identify hazardous conditions for the purpose of their elimination or control.

15.5.5.1 Subsystem Hazard Analysis

A subsystem hazard analysis shall be performed to determine, from a safety consideration, the functional relationships of components and equipment comprising each subsystem. The analysis shall consider all modes of failure and the effects on safety when failures occur in subsystem components.

15.5.5.2 System Hazard Analysis

Reviews or studies shall be conducted to define the safety integration and interface requirements of the total system. Analyses shall be performed of subsystem interfaces to determine the safety problem areas of the total system. Such analyses shall include, but not be limited to, review of subsystems inter-relations for:

- a. Compliance with safety criteria
- b. Possible independent, dependent, and simultaneous failures that could present a hazardous condition
- c. Insuring that the normal operation of a subsystem cannot degrade the safety of another subsystem
- d. Crash safety

15.5.5.3 Operating Hazard Analyses

Analyses shall be performed to determine safety requirements for test, operations and maintenance personnel, procedures and equipment. These requirements shall apply to all aspects of operations, maintenance and training. Engineering data, procedures, and instructions developed from the design and initial test programs shall be used in support of this effort. Results of these analyses shall provide the basis for:

- a. Design changes, where feasible, to eliminate hazards or provide safety devices and safeguards.
- b. WARNING and CAUTION notes, special inspections and emergency procedures to be called out in operating and maintenance instructions.
- c. Identification of a hazardous period timespan and actions required to preclude such hazards from occurring.

15.5.6 SAFETY TESTING

Safety tests of critical devices and components shall be proposed by the contractor in the system safety plan to demonstrate verification of safety characteristics.

15.5.7 TRAINING

Safety information on approved methods and procedures shall be provided for the training of system operating and maintenance personnel. Protective devices and emergency equipment shall be identified and included in training.

15.6 HUMAN FACTORS ENGINEERING (HFE) (Optional)

Human factors engineering shall be applied early to the design and development program to assure a reliable, efficient and safe interface between man as an operator, maintainer, and passenger, and the equipment. The application of human factors procedures and criteria shall ensure optimum equipment design and working conditions. This in turn will enhance operator performance and passenger acceptance and result in minimum maintenance activity and time. Three areas of major HFE activity are:

- a. The identification and investigation of areas where interactions of individuals and car elements affect performance, passenger acceptance and cost. Particular attention shall be directed to the problems of the aged and the handicapped.
- b. The determination of man-equipment functional requirements and translation of them into engineering design information. Apply HFE design information and criteria to equipment design, maintenance and system safety programs.
- c. Evaluate the finished article to verify that acceptable levels of human performance, for both operator and maintainer, can be achieved and that the passenger environment fulfills the pre-established acceptance criteria.

Factors which shall be considered include, but are not limited to, the following:

For the Operators and Passengers

- a. Temperature and Ventilation
- b. Seating Comfort
- c. Noise Control
- d. Day-Night Visibility
- e. Emergency Visibility
- f. Ingress-Egress Provisions, Normal
- g. Ingress-Egress Provisions, Emergency
- h. Graphics

For the Aged and the Handicapped

- a. Wheelchair-compatible door openings, aisles and seat spacing
- b. Audible and visual door closing warning signals
- c. Sensitive door edges
- d. Public address and passenger-crew intercom systems
- e. Stanchions and seat-back handles

For the Maintenance Personnel

- a. Working space
- b. Equipment arrangement
- c. Sill steps, grab irons and/or ladders
- d. Safety notices

Human engineering design criteria in MIL-STD-1472A and AFSCM DH 1-3 are recommended as a guide for equipment design and installation to ensure ease of maintenance.

15.6.1 PRELIMINARY HUMAN FACTORS REPORT

A preliminary report shall be submitted ___ days after contract award. The report shall include the following:

- a. A brief description of the rail car.
- b. A proposed plan insuring systematic analysis of critical human factors considered, including equipment design, passenger acceptance, maintainability, operator controls, and operational safety. The plan shall describe major tasks HFE will perform during the program and a schedule for timely completion.

15.6.2 FINAL HUMAN FACTORS REPORT

A final report shall be submitted before _____, summarizing the HFE effort for the entire program. The report shall include the following:

- a. Reasons a particular alternative was chosen or recommended.
- b. A description of the major assumptions made concerning human capabilities and limitations, including data assuring that operator performance and passenger acceptance have been considered.
- c. The results of any approved mockup or simulation program to determine the requirements for layout and design.
- d. The results to date of any analysis performed to determine the requirements for development of specialized training and training equipment.

15.7 SPARE AND REPLACEMENT PARTS (Optional)

The contractor shall prepare and submit to the purchaser a spare and replacement parts list for the vehicle and special test and support equipment. This listing will become a working document to be used by the purchaser in the procurement of spare and replacement parts.

15.7.1 SPARE AND REPLACEMENT PARTS LIST FORMAT

The spare and replacement parts list shall group listed parts by the subsystems defined by sections 3 through 14 of this specification. The listing for each item shall give complete ordering and procurement information for that item. Each item listing shall contain at least the following information: item name, description, rating, current price, manufacturer's name, part number, and drawing reference number. Items that are common to more than one subsystem shall be suitably cross-referenced.

15.7.2 SPARE PART QUANTITIES

The contractor shall recommend the minimum quantity of spare parts required to perform normal maintenance and to maintain the operation of the vehicles without experiencing undue loss of the use of the vehicles due to the lack of spare parts. The items to be considered for this listing are those items whose repair time or procurement time is great enough such that excessive vehicle time would be lost waiting for the item to be repaired or a new item procured.

15.8 PUBLICATIONS

15.8.1 GENERAL

The publications shall be designed for continuous, long-term service except for the loose-leaf feature required below. Draft copies or galley proofs shall be submitted to the purchaser for approval not less than (90) days before the deadline date for final printing.

All publications shall be in loose-leaf form, on good grade paper with punch holes reinforced with plastic, cloth, or metallic material. Five- or seven-ring binders are acceptable in lieu of reinforced paper.

Pocket-size manuals shall be (3-1/2) inches wide, (8) inches high, and not more than _____ inches thick.

All other manuals shall be (8-1/2) inches wide by (11) inches high.

All covers shall be resistant to oil, moisture, and wear to a high degree commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. Line drawings are required.

15.8.2 ORGANIZATION

The manuals shall be in four general categories as follows:

- a. Motorman's Instruction Manual
- b. Running Maintenance and Servicing Manual
- c. Heavy Repair Maintenance Manual
- d. Parts Catalog

The car shall be treated as a whole and not as a grouping of disassociated parts. The material in all manuals and the parts catalog shall be similarly organized and indexed, with a standard numbering system which will be as directed by the purchaser.

All sections shall be subdivided, to the extent required by the subject matter, into the following topics:

General Subsystem Description and Operation

Block Diagrams

Signal Flow Diagrams

Functional Schematics

Functional Wiring and/or Piping Diagrams

Troubleshooting Techniques

Lubrication and Cleaning, including frequency, methods, and trade identifications of recommended materials; component location and description

Inspection and maintenance standards including wear limits, settings, and tolerances

Installation and Removal

Test and Evaluation Procedures

15.8.3 CONTENT

The Motorman's Instruction Manual shall contain all information needed for the optimum operation of the vehicle. It shall include general vehicle familiarization material; location, function, and operation of all controls, gages, indicators, and switches; emergency procedures; and trouble symptoms and diagnosis methods.

The Heavy Repair Maintenance Manual shall contain a detailed analysis of each component of the car so that maintainers can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace, and overhaul it.

The Running Maintenance and Servicing Manual shall enable the maintainer to have with him, in convenient form, all information needed for on-car servicing, including lubrication, inspection, running maintenance and adjustment, and on-line trouble diagnosis.

The Parts Catalog shall enumerate and describe every component with its related parts, including the supplier's number, the contractor's number, the commercial equivalents, and provision for entry of the purchaser's number. Cutaway and exploded drawings shall be used to permit identification of all parts not readily identified by description. Parts common to different components (as, for example, bolts and nuts) shall bear the same contractor's number with a reference to the other components in which they are found. Each part or component shall be identified as being part of the next larger assembly.

15.8.4 SUBMITTAL

Within _____ days after award of the contract, the contractor shall submit to the purchaser for his approval, tables of contents and sample formats for all the manuals and the parts catalog.

Following the issue of each publication, the contractor shall provide revised pages covering any changes, whether required by change of design or procedures or due to error, and the revisions shall be kept current during the warranty period. Manual and catalog revisions shall be supplied to the purchaser before or coincidental with the arrival of the altered parts or components.

15.9 TRAINING

15.9.1 GENERAL

The contractor shall provide an adequate educational program for the purchaser's personnel to permit satisfactory use, servicing, and maintenance of the equipment. In this program shall be included formal and informal instruction, mockups, models, manuals, diagrams, and parts catalogs. The contractor shall assume no knowledge of the features of the cars on the part of the purchaser's personnel and shall design the program to bring the level of knowledge to one fully adequate for the objective. He may assume that maintenance personnel have the basic skills pertinent to their crafts.

Prior to the award of the contract, the purchaser shall be provided with information in sufficient detail to permit an appraisal of the depth, extent, and quality of the program.

The contractor shall, within ___ days after award of the contract, submit to the purchaser for approval, an outline of his educational program and a schedule for its presentation. The schedule shall provide for completion of the classroom instruction for the first group of students no later than ___ weeks after delivery of the first cars and for delivery of all manuals, catalogs, and prints prior to the start of the classroom instruction. Instructions for subsequent groups of students will be scheduled at a later date. The purchaser will approve the outline and schedule within ___ days or require such changes as he may deem desirable, within the intent of this specification.

The following quantities are enumerated as a guide to the magnitude of the effort required:

Number of operating personnel, including supervision, to be instructed.....

Number of maintenance personnel, including supervision, to be instructed.....

15.9.2 CLASSROOM INSTRUCTION

Classroom instruction shall include not only physical analysis and functioning of the parts under discussion, but also the essentials of their routine care, including lubrication schedules, materials, and methods, where applicable. The contractor's recommendations for test frequency, limits, and methods, including instruments required, shall be covered when applicable. When methods of access, removal, dismantling or application are not self-evident to a reasonably intelligent individual, the instruction shall cover these matters. (Overhaul procedures need not be included.)

The classroom instruction shall be conducted at one designated location of suitable character, with classes not exceeding _____ students and not exceeding _____ hours per normal working day. The location and class times, however, shall be specified by the purchaser.

15.9.3 FIELD INSTRUCTION

The extent of instruction in the contractor's and subcontractor's shops shall be at the discretion of the contractor. The purchaser shall request access to these shops for limited numbers of supervisory and technical personnel to familiarize them with assembly methods. The contractor shall make a reasonable effort to comply with such request, but not to the detriment of production.

The purchaser shall make available, upon proper notices, pairs of cars and trains at accessible shop locations for instructional purposes and will arrange for road operation as well, furnishing power, dispatching, and operational supervision as necessary.

15.10 SUPPORT EQUIPMENT (Optional)

Support equipment is defined as the tools, test equipment, jacks, jigs, fixtures, hoists, cranes, etc., that are required in order to maintain and operate the cars.

The contractor shall furnish to the purchaser a list of all support equipment required to operate and maintain the cars. This list shall be delivered (time after design approval) to the purchaser. The list shall be organized as follows:

- a. Common hand tools required by:
 1. Mechanic
 2. Electrician
 3. Electronics repairman
- b. Tools required to perform inspections and other preventive maintenance
- c. Equipment to facilitate the movement and lifting of heavy equipment
- d. Test sets and instruments
- e. Machine shop, sheet metal shop, upholstery shop, etc., equipment
- f. Support equipment which is required for corrective maintenance and is not called out in any preceding category. List these items by the subsystem for which they are required.

15.11 IN-SERVICE SUPPORT

The car contractor shall provide to the purchaser _____ field service engineers who are competent and fully qualified in the maintenance and operation of the cars. These field service engineers shall assist the purchaser in overcoming any difficulties in the operation or maintenance of these cars. They shall further serve as on-site representatives of the car contractor for any component failure claims or warranty claims against the contract. These field service engineers shall be available from the delivery of the first car and then for _____ after the last delivery.

MANAGEMENT SYSTEMS

16.1 GENERAL

The management systems shall be sufficiently comprehensive to enable the purchaser to ascertain, with a high degree of confidence, that the contractor will meet the requirements of this specification, and to enable him to monitor the contractual effort to determine the degree to which objectives of the contract are being achieved. The management systems shall include plans for program management, system engineering, manufacturing, configuration management, interface management, data management, and reporting.

16.2 MANAGEMENT PLAN (Optional)

The management plan shall include, but is not necessarily limited to:

- a. An organizational chart including a definition of the responsibilities and qualifications of all personnel thereon.
- b. The internal methods and communications to be used to control the program schedule, technical performance, program changes, subcontracts, material procurement and field service support.
- c. A master program schedule showing key milestones and events.
- d. A flow chart of all project tasks indicating task integration.

- e. Program reviews to determine whether the planned technical program effort should be revised as the program progresses.
- f. Design reviews conducted on a periodic basis to assess the degree of completion of technical efforts related to major milestones.

16.3 SYSTEM ENGINEERING (Optional)

The contractor shall consider the car, in its design and manufacture, as a single system rather than as an assembly of independently engineered and manufactured elements. This shall be accomplished through the use of a system engineering program to:

- a. Transform specification requirements into a description of system performance parameters and a system configuration through the use of an iterative process of definition, analysis, design, test and evaluation.
- b. Integrate related technical parameters and assure compatibility of all physical, functional, and program interfaces in a manner which optimizes the vehicle design.
- c. Integrate reliability, maintainability, safety and human factors into the total engineering effort.

The system engineering shall be a closed loop, iterative process. The closed loop shall feed design solutions back into the system for functional analysis to determine that requirements are met or to assess the impact of various solutions upon the original requirements.

This requirement does not impose a specific engineering process or management technique, organizational structure, or form of internal documentation. It shall be structured to suit the project and to conform to the contractor's organization and methods.

16.4 CONFIGURATION MANAGEMENT

Configuration management comprises the three elements of product identification, change control and configuration accountability as described below.

16.4.1 CONFIGURATION IDENTIFICATION

The contractor's technical documentation shall be to acceptable commercial standards and shall be capable of defining the approved configuration of system equipment under development, test, production, or in operational use. The technical documentation shall identify the configuration to the lowest level required to assure repeatable performance, quality and reliability.

The contractor shall employ and maintain release records for technical documentation which will portray the relationship between identification elements. Such relationships:

- a. Are limited to configuration requirements defined by engineering data.
- b. Do not reflect a hardware or other product condition that varies from engineering requirements contained in these data.
- c. Do not reflect manufacturing status.

The contractor's release records and documentation shall be capable of determining the following:

- a. The composition of any part number at any level in terms of subordinate part numbers (excluding standards).
- b. All next-assembly part numbers of any part (excluding items assembling into standards).
- c. The specification document, specification control drawings, or source control drawing numbers associated with any subcontractor, vendor or supplier part numbers.

The contractor's release records and documentation shall be capable of identifying engineering changes and of retaining the record of superseded configuration requirements affecting items which have been formally accepted by procuring agencies.

The contractor shall employ a system of identifying numbers for specifications, drawings, and associated documents which will assure that differing parts, assemblies and installations are uniquely identifiable.

16.4.2 CHANGE CONTROL

The contractor shall apply orderly controls to the management of engineering design changes, changes to terms and conditions of the contract, and to changes of quantities or schedules.

The contractor shall assure that proposals for change, when submitted, have been screened at management levels high enough to assure that only essential changes are proposed. Such proposals must have received the necessary coordination in the contractor's organization to assure that all potential impacts of the change have been considered. This includes system safety, reliability, maintainability, and human factors in addition to production schedules, incorporation points, tests, procurement, retrofit requirements, documentation, including handbooks and manuals, and effect on spare parts, either existing or proposed.

16.4.3 CONFIGURATION ACCOUNTABILITY

The contractor shall maintain records such that the configuration of any item being delivered is definable in terms of its component part numbers; differences between the as-built configuration and the engineering released documentation are known and accounted for; and the status of change approvals and incorporations is known and recorded at any point in product development, test, production, or operational usage.

16.5 INTERFACE MANAGEMENT (Optional)

16.5.1 SYSTEM-EQUIPMENT INTERFACE

The contractor shall establish methods and procedures for controlling physical, functional, or environmental interfaces between the system/equipment for which he is responsible and the system/equipment under control of other agencies with which that equipment must be compatible; e.g., the contractor will be required to define and ensure interface compatibility with all wayside equipment on lines over which cars are to be operated.

16.5.2 INTERFACE COMMUNICATION

The contractor shall establish methods and procedures to assure formal, accountable channels of communication for the exchange of technical information establishing and/or defining interfaces. This includes both initial definition and formal change information when a change on one side of the interface will require corollary change to the other.

16.6 DATA MANAGEMENT (Optional)

The contractor shall develop data management procedures to provide a control function for the management of the program. The intent of these procedures should be to:

- a. Provide uniformity, yet flexibility, in determining and acquiring data for the development and management of the program.

- b. Assure continuity of data flow throughout the development of the car system until the requirements for those data no longer exist.
- c. Attain positive control of data generation through continuous review of data requirements and deletion of nonessential data.
- d. Provide clear and relevant information necessary for decision-making purposes.

The general term "data" includes management and engineering reports and documentation contractually required for delivery. These data would include:

- a. Administrative reports - Reports which require financial information on contract or production progress, cost information or schedules.
- b. Technical reports - Any technical document written to permanently record technical information, conclusions and recommendations developed on technical and engineering activities relating to a single task or the project.
- c. Other data - Data needed to develop, test, operate, maintain, repair, modify, support or repro cure systems and equipment. Such data may appear in the form of reports, technical manuals, charts, photographs, films, lists, tapes, drawings, specifications, parts breakdowns, etc. The requirements for the submittal of design, performance, and test data to the purchaser for approval shall be as specified in the detail specification.

16.7 REPORTS (Optional)

During the performance of this contract the contractor shall submit regular progress reports every ___ days which shall provide detailed information on:

- a. Work completed
- b. Work in progress
- c. Major problems
- d. Schedule deviations from the master schedule
- e. Technical performance variations from the specification requirements
- f. Organizational changes
- g. Subcontractor program progress

TESTING

17.1 GENERAL

The complete rail car, its subsystems and their components, shall be subjected to a comprehensive test program to:

- a. Substantiate the design and performance characteristics.
- b. Assure operational compatibility with the transit system.

The contractor shall conduct the test program in accordance with the following requirements.

17.1.1 TEST PLAN

An overall test program plan shall be prepared containing all tests necessary to demonstrate that the rail car will perform satisfactorily under all specified operating conditions. The plan shall include an outline of the test program, test equipment and facilities to be used, and any additional data required to illustrate the test program, including a detailed testing schedule listing significant milestones in the test program. The test plan shall be submitted to the purchaser for approval prior to the initiation of the test program to provide a basis for measurement of contractor technical achievement during program implementation.

17.1.2 DETAILED TEST PROCEDURES

A detailed test procedure for systems and components shall be prepared and submitted to the purchaser for approval prior to the start of the testing required by this section. The basic test procedures shall be developed in accordance with DOT/TSC Specification GSP-064, wherever possible.

The test procedure shall outline each test to be conducted and shall refer to the applicable requirement of the detail specification. The procedure shall specify test objectives, success/failure parameters, the number of units to be tested, sequence of testing, equipment to be used for testing, test specimen configuration, instrumentation requirements, description of test setup, test methodology to be used in performance of test, type of data/report to be issued, and, if an outside testing agency is to be used, the name and location of same.

17.1.3 SEQUENCE OF TESTING

The order of testing to be conducted shall be as specified in the detail specification.

17.1.4 TEST COMPLETION AND STANDARDS FOR INTERPRETATION

The rail car development and qualification tests will be considered complete when the following requirements are fulfilled.

17.1.4.1 Test Components

Components to be used for testing must be representative of production components. Any deviations from this requirement must be subject to approval from the purchaser. Components used for testing must be clearly identified as test components and, at the completion of testing, disposed of in accordance with the directions of the purchaser.

17.1.4.2 Final Test Report

A final test report shall be prepared documenting the results obtained and submitted for approval. The report shall be identified by a contractor document number and shall refer to the contractor part number and serial numbers of the test hardware. All pertinent test results (as well as a discussion of any deviations from the approved test procedure) shall be included. The test report shall also include any photographs and any additional data necessary to support the test results. Test data shall be presented in accordance with DOT/TSC Specification GSP-064, wherever possible. Supplier test reports shall be approved by the contractor prior to submittal to the purchaser.

___ copies of the report shall be submitted to the purchaser within ___ after receipt of written notice of the contract award or ___ days after completion of testing.

17.1.4.3 Test Failure and Discrepancy Analysis

In the event that failures occur during any testing, a failure report shall be submitted to the purchaser. This report shall identify the unit being tested, identify the cause(s) of failure, indicate whether corrective action is necessary, and the extent of such action. Where no change is determined necessary, justification for the decision shall be provided. Where a failure occurs during testing, the testing shall be suspended pending evaluation by the purchaser as to the effect on testing completed and the need to conduct additional tests using the reworked parts.

17.2 COMPONENT QUALIFICATION TESTS

Component qualification tests shall be conducted by the contractor as specified by the purchaser and shall include, but not be limited to, the following representative tests:

17.2.1 PROPULSION SYSTEM

- a. Traction motor performance, noise and vibration tests
- b. Traction gear unit performance, noise and vibration tests.

17.2.2 ELECTRICAL SYSTEM COMPONENTS

- a. Motor generator/alternator, type and performance tests
- b. Static inverter/converter type and performance tests
- c. Battery performance
- d. Developmental and qualification tests of other components separately assembled

17.2.3 TRUCK SYSTEM

- a. Truck side frame and bolster, static and fatigue tests

17.2.4 COUPLER AND DRAFT GEAR SYSTEM

- a. Draft and buff load test of coupler
- b. Gathering range and mechanical and electrical coupling test
- c. Anchor casting static load test
- d. Draft gear deflection limits and emergency release tests
- e. Coupler assembly wear and life expectancy tests

17.2.5 ATC TESTS (if applicable)

- a. Equipment developmental tests
- b. Qualification tests
- c. Functional tests

17.2.6 AUXILIARY EQUIPMENT NOISE TESTS

Noise tests shall be conducted to meet the requirements of paragraph 2.8.3.3 and Table 2-1. Components to be tested prior to installation shall include the following:

- a. Hydraulic power unit
- b. Air compressor
- c. Air conditioning system motors and fans
- d. Auxiliary motors and blowers

17.2.7 WINDSHIELD

- a. Static load test
- b. Horizontal and vertical impact tests

17.2.8 SIDE DOOR SYSTEM

- a. Life cycle test
- b. Performance tests
- c. Noise tests

17.2.9 RELIABILITY DEMONSTRATION TESTS

Reliability testing shall be conducted in accordance with the contractor's reliability test plan of Section 15.2.6 and shall be accomplished in conjunction with the vehicle qualification and acceptance testing.

17.3 SUBSYSTEM QUALIFICATION TESTS

17.3.1 Propulsion System

The following subsystems shall be tested in the laboratory prior to installation in the prototype car:

- a. Propulsion control system
- b. Friction brake control system
- c. ATO control system (if applicable)
- d. Other

17.3.2 Friction Brake System

- a. Brake caliper fatigue test
- b. Complete system endurance test
- c. Response test to dynamic brake and slip-slide control signals
- d. Braking effort versus time for constant input signal
- e. Brake system capacity
- f. Hydraulic system ultimate pressure test (if applicable)

17.3.3 CAR BODY SYSTEM

- a. Body compression tests
- b. Vertical load test
- c. Water leak test
- d. Other

17.3.4 AIR CONDITIONING SYSTEM TEST

- a. Duct baffle adjustment
- b. Pulldown test
- c. Rated capacity test
- d. Door cycling test
- e. Reduced output test
- f. Partially loaded test
- g. Reheat test

17.3.5 HEATING SYSTEM TEST IN ENVIRONMENTAL CHAMBER

17.3.6 SAFETY TESTS

Tests shall be conducted in accordance with the contractor's system safety plan. Refer to section 15.5.2.

17.4 VEHICLE AND SYSTEMS QUALIFICATION TESTS

The types of tests outlined in this section shall be conducted on the rail car as specifically required by the purchaser. Qualification tests to be performed by the contractor shall include, but not be limited to, the following representative tests:

17.4.1 PROTOTYPE TEST VEHICLES

17.4.1.1 The first (quantity) cars shall be designated prototype test cars and shall be made available _____ months after contract award for development and qualification testing. These tests shall be conducted on the _____ segment of the _____ line of the (Purchaser) and/or at the Department of Transportation's High Speed Ground Test Center, Pueblo, Colorado.

17.4.1.2 All operating parts, devices, controls and apparatus shall be tested and adjusted to proper, approved operating condition by the contractor at his expense prior to shipment to the purchaser's tracks for compliance testing.

17.4.1.3 Reassembly and operational tests as required at the purchaser's site shall be performed by the contractor at his expense.

17.4.1.4 Removal from and return to the designated delivery point for correction of defects shall be accomplished by the contractor at his expense.

17.4.2 TEST REQUIREMENTS

The following system tests shall be conducted by the contractor:

<u>TESTS</u>	<u>FREQUENCY OF TESTS</u>
Prototype Vehicle Checkout Tests	Each prototype
Propulsion/Traction System Test	
Standard Train	One train
<u>(2 or 3) Car Units</u>	One unit
Single Car	One car
Brake System Tests	
Friction Brakes	All cars
Handbrake Specification	First car
Handbrake Function	All cars
Friction Brake Forces	First car
Stopping Distance (if specified)	
Standard Train	___ Trains
<u>(2 or 3) Car Unit</u>	___ Units
Single Car	___ Cars
Performance Tests, Standard Train	___ Trains
" " <u>(2 or 3) Car Unit</u>	___ Units
" " Single Car	___ Cars
Drift Tests	
Standard Train	___ Trains
<u>(2 or 3) Car Unit</u>	___ Units
Single Car	___ Cars
Ride Quality Tests	
Standard Train	___ Trains
<u>(2 or 3) Car Unit</u>	___ Units
Single Car	___ Cars
EMI Tests	
<u>(2 or 3) Car Unit</u>	___ Units
Single Car	___ Cars
Interior Noise Tests	
<u>(2 or 3) Car Unit</u>	___ Units
Single Car	___ Cars
Wayside Noise Tests	
Standard Train	One train
<u>(2 or 3) Car Unit</u>	One unit
Single Car	One car

<u>TESTS</u>	<u>FREQUENCY OF TESTS</u>
Sound Level Tests on Signals	___ Cars
Interior Lighting Intensity Tests	___ Cars
Car Weighing	All Cars

17.4.3 TEST FACILITIES

17.4.3.1 System tests shall be conducted by the contractor on level tracks of suitable gauge, length and alignment. The electrical power provisions shall conform to paragraph 2.2.1.1.1; ___ volts (DC or ___ Hz AC). The systems tests conducted at the contractor's selected location shall be used for functional checks and equipment setup prior to specification compliance and acceptance testing.

17.4.3.2 For purposes of specification compliance, system tests shall be conducted on the purchaser's tracks from ___ to ___. Standard industry methodology shall be used as necessary to adjust recorded performance to level, tangent track equivalent.

17.4.3.3 Maintenance facilities, storage, and office space will be provided by the purchaser for the contractor during the on-site performance testing.

17.4.4 ADDITIONAL TESTING BY PURCHASER

Prior to final acceptance, the purchaser at his expense may make additional operating tests of individual cars or in trains of up to and including ___ cars. These tests may be witnessed by a representative of the contractor who may also participate and provide technical assistance at the request of the purchaser. Defects disclosed by such tests shall be corrected by the contractor at his expense.

17.4.5 REPORTS OF TEST

Written reports of all tests performed on the cars and their components during construction, setup, compliance and acceptance testing by the contractor shall be submitted to the purchaser.

Tests performed on all cars or all components shall be included in the individual car log books. The written reports of test shall include a description of the test, a summary of test results, and all raw data collected during the test. These reports shall become the property of the purchaser.

17.4.6 SYSTEM TEST DESCRIPTIONS

17.4.6.1 Prototype Vehicle Checkout Tests

- 17.4.6.1.1 Wiring Continuity, Insulation and High Potential Tests
- 17.4.6.1.2 Controls and Wiring Operational Demonstration
- 17.4.6.1.3 Main Power System Traction Motor Direction Checks
- 17.4.6.1.4 Operational Check of Traction Control, Auxiliary Electrical, Air Conditioning, and Coupler Systems
- 17.4.6.1.5 Service Brake and Handbrake Application Adjustment
- 17.4.6.1.6 Dimensional and Clearance Check
- 17.4.6.1.7 Suspension System Stability Check
- 17.4.6.1.8 Operational Test of Doors, Lights, Signals, Windshield Wipers and Defrosters
- 17.4.6.1.9 Equalization Test of Communication Systems

17.4.6.2 Propulsion/Traction System Test

Tests of the propulsion/traction system prototypes, including the wheel slip-slide protection system, acceleration and deceleration rate limiting (jerk rate) systems, automatic speed regulation and car load weighing system, shall be performed by the contractor. These tests shall prove the several subsystem functions and demonstrate subsystem compliance with the performance requirements of sections 2.2.5, 2.2.6 and 2.2.8.

17.4.6.3 Brake System Tests

a. Friction Brake

The friction brake system and associated apparatus shall be tested and adjusted on all cars until performance complying with the brake subcontractor's specification and the requirements of section 2.2 of this specification are obtained.

b. Handbrake/Parking Brake

On the first car the adequacy of the system design shall be demonstrated by measuring the horizontal force required to move the car with the handbrake applied with a force of ___ pounds at the hand grip. This test shall be performed both with new brake shoes and with fully worn brake shoes. Car weight for this test shall be (AW ____).

c. Handbrake/Parking Brake Function

The handbrake on all cars shall be functionally tested with new brake (shoes or pads).

d. Brake Forces

Tests shall be conducted on the friction brake system to determine the actual force produced at each friction brake location with brake cylinder pressures from _____ pounds to _____ pounds in increments of _____ pounds. The brake force produced by the handbrake when applied with a _____ pound force at the hand grip shall also be measured. These tests will be performed on a static car.

e. Stopping Distance (if specified)

(Two) full stops from speeds of _____ mph to _____ mph with intervals of _____ mph shall be made at each brake system combination with an individual car at weight AW _____, a (2 or 3) car unit at weight AW _____ and a standard train of cars each at weight AW _____. The stopping distance will be averaged for the (two) stops on level, tangent track. Stops showing unreasonable variation will be repeated. The stops shall be made using the following brake system combinations:

- o Service friction braking only
- o Blended dynamic and service friction braking
- o Emergency friction braking only

Data from the following parameters shall be recorded throughout the stop for all of the above tests:

Speed)
Distance) Independent of wheel slip-slide
Time
Instantaneous Deceleration
Wheel (disc) Temperature: _____ Wheels; _____ Cars
Brakeline Pressure: _____ Cars
Brake Cylinder Pressure: _____ Cars
_____ Line Pressure: _____ Cars
Dynamic Brake Current: _____ Cars

The foregoing tests shall be made using worn-in brake (shoes or pads) such that (shoe/drum) (pad/disc) contact area is no less than _____ percent of total (shoe or pad) face area.

17.4.6.4 Vehicle Performance Tests

- a. Compliance with the performance specifications of section 2.2 shall be demonstrated by the contractor on single cars, (2 or 3) car units and standard trains, as defined in section 2.2.1.2. The first car, (2 or 3) car unit and standard train shall be tested at car weight AW _____. For testing of succeeding cars, methodology for calculating car performance at AW _____ based on test data obtained at (empty) weight may be used along with empty car test data to prove compliance. Allowances shall be made for the car load weighing system.
- b. For each test the following parameters shall be recorded simultaneously on a multiple-channel recording oscillograph:
 - o Horizontal acceleration and deceleration
 - o Car speed (independent of wheel slip-slide)
 - o Line voltage
 - o Line current
 - o Traction motor voltage
 - o Traction motor current
 - o Trainline signals (propulsion and braking)
 - o Brake cylinder pressure
 - o Time
 - o Event marker

All charts obtained from the cited recordings shall be forwarded to and become the property of the purchaser. Copies of all test charts may be made by the contractor for his own records.

- c. Acceleration, speed and deceleration tests shall be made on the specified test track of paragraph 17.4.3.2. Any adjustments required to obtain electrical values corresponding to the specification rate of acceleration, speed or deceleration, shall be noted in the individual car log book. The acceleration, speed and deceleration of each car, unit or train shall be as specified in Sections 2.2.2, 2.2.3 and 2.2.4. The instrumentation of paragraph 17.4.6.4.b shall provide the data necessary to set up each car for specification compliance.

- d. A sample service use schedule of _____ round trips from _____ to _____, including stops at (all) stations from proposed regular schedule speeds with _____ second stops at each station, shall be conducted on single cars, (2 or 3) car units, and standard trains. Data from the instrumentation of paragraphs 17.4.6.3 and 17.4.6.4.b shall be recorded to determine power usage and brake performance.

These tests shall be accomplished using the following brake system combinations:

- o Service friction braking only
- o Blended dynamic and service friction braking

17.4.6.5 Drift Tests

The contractor shall perform drift tests on single cars, (2 or 3) car units and standard trains to verify the coefficients used in the performance calculations. Sufficient data to allow calculation of the various coefficients shall be obtained from these tests. The data and calculations shall be submitted to and become the property of the purchaser.

17.4.6.6 Ride Quality Tests

17.4.6.6.1 Tests of single cars, (2 or 3) car units and standard trains shall be conducted on the tracks supplied by the purchaser (paragraph 17.4.3.2) to prove compliance with the ride quality specifications of section 2.7.2. Car weights shall be empty weight and AW _____.

17.4.6.6.2 The purchaser shall specify a length of track which he considers to be minimum quality or shall modify a length of track to represent minimum-quality track in both vertical and horizontal alignment. These deviations shall be introduced into both level, tangent tracks and curves of _____ foot minimum radius. Train speeds over the above deviations shall be specified by the purchaser.

17.4.6.6.3 The car(s) shall be instrumented to record vertical, lateral and longitudinal acceleration (magnitude and frequency) for vibrations up to _____ g and _____ Hz. The sensor locations shall be specified by the purchaser.

17.4.6.7 EMI Tests

Electromagnetic interference testing shall be conducted in accordance with the contractor's EMI test plan. (Refer to section 9.9.)

Tests shall demonstrate that the electrical, electronic and communication systems are protected against false energy miscodes, improper codes and interference from nearby track circuits. Testing shall be conducted under the appropriate fault conditions.

17.4.6.8 Interior Noise Tests

Interior noise tests shall be conducted to meet the requirements of paragraphs 2.8.3.1, 2.8.3.4 and Figure 2-9. Test speeds and external environment shall be specified by the purchaser.

17.4.6.9 Wayside Noise Tests

Wayside noise tests shall be conducted to meet the requirements of paragraph 2.8.3.2 and Figure 2-10. Test speeds and external environment shall be specified by the purchaser.

17.4.6.10 Sound Level Tests on Signals

Sound level tests on signals shall be specified by the purchaser.

17.4.6.11 Interior Lighting Intensity Tests

Interior lighting intensity tests shall be conducted to meet the requirements of Section 8.1.

17.4.6.12 Car Weighing

17.4.6.12.1 The contractor shall weigh each complete car at time of shipment to the purchaser. Weight records shall be submitted to the purchaser with copies to be included in each car log book. Car configuration for weighing shall be empty but ready to run.

17.4.6.12.2 The scale(s) used to weigh the cars shall be maintained with the tolerances set forth in Chapter 14, Part 5, Section C of the A.R.E.A. Manual.

17.5 ACCEPTANCE TESTING

17.5.1 GENERAL

Acceptance testing is that testing conducted on all components, subsystems and the complete vehicle to determine suitability for acceptance by the purchaser. The purchaser will retain the right to witness any or all acceptance testing as desired.

17.5.2 COMPONENT AND SUBSYSTEM ACCEPTANCE TESTING

The contractor shall conduct acceptance tests on all subcontractor furnished components and subsystems to be delivered under the contract. See section 18.2.5.

17.5.3 VEHICLE ACCEPTANCE TESTING

The purchaser shall conduct acceptance tests on each completed rail car after receipt at the designated delivery point and prior to final acceptance. Each car shall be inspected by the purchaser and any part, device or apparatus requiring adjustment, replacement or repair, shall be put in proper operating condition by the contractor at his expense.

The purchaser may conduct operating tests of each car separately or in trains of not more than ___ cars. The contractor may assign a competent representative to witness these tests. Any defects disclosed by the operating tests, in apparatus, material or workmanship shall be corrected at the contractor's expense.

Removal from and return to the designated delivery point for correction of defects shall be accomplished by the contractor at his expense.

17.5.4 ACCEPTANCE TEST PROCEDURES

The contractor shall prepare acceptance test procedures for all components, subsystems and the complete vehicle and submit them to the purchaser for approval prior to testing. The procedures shall outline the testing to be conducted, the equipment to be used, and the sequence in which testing shall be performed.

17.5.5 ACCEPTANCE TEST RECORDS

Adequate records shall be maintained to establish that acceptance testing was conducted satisfactorily. All records shall be available to the purchaser upon request.

QUALITY ASSURANCE

18.1 GENERAL

This section defines the essential elements of the contractor's quality program which must be maintained to assure an acceptable level of quality. This concept of total quality assurance is based on the principle that quality is a basic responsibility of each segment of the contractor's organization and shall be evidenced by:

- a. Producibile and inspectable designs.
- b. Establishment of firm procurement and job performance specifications.
- c. Firm procedure for transmission of quality requirements and standards to subcontractors and suppliers and assuring their compliance.
- d. Adequate testing to assure repetitive product conformity to design requirements.
- e. Total program surveillance and verification of physical conformance and configuration accountability.

18.1.1 EVIDENCE OF COMPLIANCE

The contractor's quality assurance system shall establish and maintain objective evidence of compliance with all of the requirements of the procurement specification and the contractor's design control media.

18.1.2 CALIBRATION/CERTIFICATION OF MEASURING EQUIPMENT AND TOOLS

The contractor shall demonstrate an effective time- and/or usage cycled calibration/certification system with primary standards traceable to the National Bureau of Standards. The system shall assure the accuracy of equipment and tools used to support this procurement.

18.1.3 QUALITY ASSURANCE RECORDS

Adequate records shall be maintained by the contractor to provide evidence of quality and accountability. These records shall include results of inspections, tests, process controls, certification of processes and personnel, discrepant material (including disposition), and other quality requirements defined in the contract. These records shall be maintained complete and available to the purchaser at all times during the performance of the contract and for such retention periods as may be specified in the contract.

18.1.4 QUALITY PUBLICATIONS

The contractor shall establish and maintain written procedures defining his quality assurance system. The procedures shall encompass all phases of the system to include, but not be limited to, control of suppliers, receiving inspection, production and process control, functional test, discrepancy control, measuring and test equipment calibration/certification, drawing control, quality assurance records, shipping inspection, and other quality provisions to meet the requirements of the contract.

Management responsibility for the quality assurance function shall be set forth on the contractor's policy and organization chart. The responsibility for the quality assurance function shall be so placed that schedules and costs will not compromise quality.

18.2 QUALITY ASSURANCE SYSTEM REQUIREMENTS

18.2.1 QUALITY PROGRAM PLAN

The contractor shall establish a quality control program to assure compliance with the requirements of the contract. The quality program, including regulating methods, procedures and processes to be used to ensure compliance with the specification of the contract shall be documented and subject to review and approval of the purchaser.

18.2.2 PROCUREMENT QUALITY CONTROL

The contractor shall outline the method(s) to be used for the selection and control of subcontractors. These methods shall identify the means for:

- a. Selection of qualified procurement sources.
- b. Evaluation and assessment of contractor's quality system.
- c. Transmission of all design, reliability and quality requirements to procurement sources.
- d. Monitoring of contractor quality performance.
- e. Evaluation of procured articles against purchase order requirements.

18.2.3 RECEIVING INSPECTION

The contractor's receiving inspection shall provide for the inspection of all incoming materials. Inspection shall be by a valid statistical sampling plan or 100 percent. All material certifications and test reports used as the basis for acceptance of materials shall be preserved. A material identification system shall be used to preclude the use of wrong materials during manufacture.

18.2.4 STATISTICAL SAMPLING PLANS

Statistical quality assurance sampling plans used in acceptance of parts, materials, and/or processes by the supplier shall be fully documented and based on generally recognized and accepted statistical quality assurance systems.

18.2.5 INSPECTION AND ACCEPTANCE TESTS

The contractor shall inspect and physically or functionally acceptance-test all items to be delivered under the terms of the contract. Inspection shall occur at appropriate points in the manufacturing sequence to assure quality consideration for compliance with drawing and test specifications, process specifications, and quality standards. Inspection shall be by a valid statistical sampling plan or 100 percent. Nonconforming materials shall be identified as discrepant, segregated and reviewed for disposition.

18.2.6 CHANGES TO DRAWINGS AND SPECIFICATIONS

The contractor shall assure that inspection and acceptance tests are based on the latest specified revision or change to drawings and specifications. An acceptable change control system as defined in section 16.4.2 of this document shall be maintained.

18.2.7 IDENTIFICATION OF INSPECTION STATUS

The contractor shall maintain a system for identifying progressive inspection status of components or materials as to their acceptance, rejection or no-inspection status.

18.2.8 SHIPPING INSPECTION

The contractor's quality assurance system shall provide and enforce procedures for the proper inspection of product(s) to assure completion of manufacturing prior to shipment. All shipments shall be packed and marked as required to preclude damage during shipment to destination.

APPLICABLE DOCUMENTS

19.1 EFFECTIVE DATE OF DOCUMENTS

The documents specified herein shall be of the issue in effect on the date of formal invitation to bid, unless otherwise specified in the detail specification. Later revisions of such documents may be used subject to approval by the procuring agency.

19.1.1 SPECIFICATIONS

Applicable federal, industrial and technical society specifications referred to and thus forming a part of the specification shall be listed in the detail specification under this section. Copies of applicable portions of specifications unique to the contractor used as reference sources shall be supplied for review by the purchaser.

19.1.2 STANDARDS

Applicable federal, industrial, purchaser and technical society standards referred to and thus forming a part of the specification shall be listed in the detail specification under this section.

19.2 DOCUMENT APPROVAL

Contractor documents approved by the purchaser shall not be changed without prior approval of the purchaser. The approval of contractor documents for a specific contract shall not constitute approval for other contracts held by the same contractor or for contracts held by other contractors.

GENERAL INFORMATION

20.1 DEFINITIONS AND ABBREVIATIONS

20.1.1 GENERAL

Wherever in the specifications and other contract documents the following abbreviations and terms, or pronouns in place of them are used, the intent and meaning shall be interpreted as follows.

20.1.2 DEFINITIONS

A-Car - A self-propelled car having a control cab at one end and comprising one-half of a married pair.

Addenda - Written interpretations of or revisions to any of the contract documents issued by the purchaser before the bid opening.

Adhesion, Coefficient of - During rolling contact, the ratio between the longitudinal tangential force at the wheel-rail interface and normal force.

Alignment, Horizontal - The horizontal location of a track as described by curves and tangents.

Automatic Train Control (ATC) - The system for automatically controlling train movement, enforcing train safety and directing train operations. ATC includes subsystems for automatic train operation, train protection and line supervision from a wayside control center.

Automatic Train Operation (ATO) - The subsystem within automatic train control which performs the functions of speed control, programmed stopping, and door operation.

Auxiliary Systems - An auxiliary system is any mechanism or structure other than the car body, traction motor or propulsion system gearing which performs a function at some time during the operation of the car; e.g., heating and air conditioning system, pumps, car door operation, motor alternator, air compressor or hydraulic power unit and car lighting.

B-Car - A self-propelled car having a control cab at one end and carrying shared auxiliary equipment that is not on an "A" Car. Comprises the second half of a married pair.

B-10 Life - The number of hours up to which 10 percent of the bearings in a bearing population will have failed. Conversely, the bearing life which 90 percent of the bearings in a population will meet or exceed.

Bidder - Any individual, firm, partnership, corporation or combination thereof, submitting a proposal for the procurement contemplated, acting directly or through a duly authorized representative.

Blending - In braking, a simultaneous dynamic/regenerative and friction brake application with the effort of friction brake continuously proportioned to achieve the required total brake effort.

Braking, Closed Loop - Modulated braking effort under continuous direction of the automatic train control and/or manual train control system.

Braking, Dynamic - Braking supplied by the torque required to drive the traction motor as a generator when wheel speed exceeds the traction motor output speed called for by the electrical input to the motor.

Braking, Emergency - Irretrievable* unmodulated (open loop) braking to a stop usually at a higher retardation rate than is obtained with a maximum service brake application.

Braking, Maximum Service - The normal maximum unmodulated (open loop) braking effort employed to stop a train. The brake can be released and reapplied.

Braking, Open Loop - Unmodulated braking at either the maximum service brake or emergency brake effort permitted by the braking system without continuous direction from the train control system.

*Once initiated, the brake application cannot be released until the train has stopped.

Braking, Programmed - Automatically modulated (closed loop) braking with the requirement that a stop be completed at a designated point within a specified distance.

Braking, Regenerative - Dynamic braking where the voltage generated by the traction motor (when driven as a generator) is conditioned and returned to the DC bus.

Braking System - The system of wheels, motors, driving mechanism, brakes, controls and appurtenances that retards the car in response to input control signals.

C-Car - A self-propelled vehicle not equipped with a control end.

Car Weight, Crush Load - The weight of a car with full seated passenger load plus the maximum number of standing passengers possible to contain within the car.

Car Weight, Full Load - The weight of a car with full seated passenger load plus a standing passenger load as specified by the purchaser.

Car Weight, Light - The weight of an empty car, ready to run. For I.C. and diesel-powered commuter cars, includes full fuel, lubricants and coolants.

Car Weight, Normal Load - The weight of an empty car plus the full seated passenger load.

Change Notice - A notice issued to the contractor by the purchaser specifying a proposed change to the contract documents.

Change Order - An order executed by the purchaser and issued to the contractor amending the contract drawings or specifications.

Coast - The mode of operation of a car or train in which propulsion (positive traction) is inactive and usually a certain minimum braking effort is in effect.

Component Testing - Testing planned and conducted by or under the direction of the purchaser during the development phase to assure that the components of the planned product conform to specifications and criteria set forth in the Statement of Work. Completion of all component testing, to the satisfaction of the purchaser, will indicate whether the assembled end product is ready for system testing.

Consist - The number and specific identity of cars that make up a train.

Contract - The written agreement covering the performance of the procurement.

Contract Drawings - The official drawings listed, or amendments thereto, and supplemental drawings approved by the purchaser which show the character, dimensions and details of the procurement.

Contractor - The person or persons, firm, partnership, corporation, or combination thereof, which has entered into a procurement contract with the purchaser.

Contractor's Drawings - Items such as detail drawings, calculations and catalog cuts which are prepared by the contractor to supplement or detail contract drawings or specifications, and which are contractual requirements, or are prepared at the contractor's option to detail his work.

Coupler - An appliance for mechanically coupling cars together automatically by impact. Must be capable of uncoupling automatically or manually without going between the cars. Term is also applied to automatic connectors as in "Electric Coupler" and "Pneumatic Coupler" which couple electric and pneumatic trainlines together between cars.

Coupler, Retractable - A coupler which swings out of the way or retracts when not in use.

Days - Unless otherwise designated, days as used in the specification will be understood to mean calendar days.

Dispatching - The process of starting a train into revenue service from a terminal zone or transfer track.

Drive - A system consisting of one or several motors, their direct control equipment (power circuits), and the associated mechanical devices required to produce a useful output.

Dwell - The period of time measured from the instant a train berths at a station until the instant it resumes moving.

Engineer - The person or firm designated by the purchaser as his technical representative.

Extra Work - Work not covered by any of the items for which there are bid prices, and work specifically designated as extra work in the contract drawings or specifications.

F-End - The cab end of a car where automatic coupling exists. Also called "A" or "No. 1" end.

Failsafe - A characteristic of a system which ensures that any malfunction affecting safety will cause the system to revert to a state that is known to be safe.

Freewheeling - The mode of operation of a vehicle in which both propulsion and braking are inactive, that is, tractive effort is zero.

Gauge, Track - The distance between the inside face of rails, usually measured 5/8-inch below the top of the centerline of heads of running rails and at a right angle thereto.

Headway - The time separation between two trains, both traveling in the same direction on the same track. It is measured from the time the head-end of the leading train passes a given reference point to the time the head-end of the train immediately following passes the same reference point.

High Voltage - The prime power voltage supplied to the car by the catenary or third rail, usually between 500 and 1500 volts DC.

Indicated - As used in this specification "indicated" shall be understood to mean "as shown on the contract drawings, as described in the specifications, or as required by other contract documents."

Intercar Closure - A flexible enclosure providing a weather-proof passageway between coupled cars.

Interface - The points where two or more subsystems, systems, persons or firms must meet to assure continuity of the project.

Jerk Rate - Time rate of change of acceleration or deceleration normally measured in miles per hour per second per second.

Load Weighing - A function which measures car weight to permit control of tractive effort in order to achieve a constant effort-to-weight ratio.

Low Voltage - The voltage used for most auxiliary systems on the car, usually between 24 and 72 volts DC or 110 to 240 volts AC.

Manual Train Control (MTC) - Train movement is completely controlled by the motorman.

Married Pair - Two cars which must be operated as a unit.
(See "A" car and "B" car)

Motorman - The operator of a self-propelled car, also called "attendant." In commuter cars, usually called "engineman."

Multiple-Unit (MU) - Two or more units or married pairs of cars.

Notice of Completion - The formal written notice issued by the purchaser when all of the procurement under the contract has been completed.

Performance - The measure of output or results obtained by a component, system, person, team., etc., as in "Performance Specification." Vehicle performance refers to the design requirements which must be demonstrated by operation of a car or cars, as in "Performance Characteristics" or "Performance Testing."

Profile Grade - A straight line representing an established grade line, in relation to the horizontal.

-Proof (used as a suffix) - Apparatus is designated as splash-proof, dustproof, etc., when so constructed, protected or treated, that its successful operation is not interfered with when subjected to the specified material or condition.

Proposal - The bid or offer of the bidder for the work when made out and submitted on the prescribed proposal form, properly signed and certified, and which includes the schedule of bid items.

Propulsion System - The system of wheels, motors, driving mechanism, controls and appurtenances that propels a car in response to input control signals.

Prototype - A car built to test a new design and which performs essentially the same as the production vehicle.

Purchaser - The operating agency which is procuring the cars.

R-End - The rear or non-cab end of a car where only semi-automatic coupling exists. Also called "B" or "No. 2" end. In a married pair, usually semi-permanently coupled to the other car.

Redundancy - The existence in a system of more than one means of accomplishing a given function.

Reliability - The probability of performing a specified function, without failure and within design parameters, for the period of time intended under actual operating conditions.

Requirements - The criteria which must be met when designing a vehicle.

Roll - Transverse rotational motion of a car body about a longitudinal axis below the car floor.

Single Unit Car - A self-propelled car equipped with a control cab at both ends.

Slide, Wheel - During braking, the condition existing when the rotational speed of the wheel is slower than that for pure rolling contact between tread and rail.

Slip, Wheel - During acceleration, the condition existing when the rotational speed of the wheel is faster than that for pure rolling contact between tread and rail.

Specification, Detail - The document which defines the detail from which a car is designed.

Specification, Guideline - The document which defines the format, definitions and methods for the preparation of a detail specification.

Speed, Balancing - The steady state speed attained by the train when resisting forces exactly equal tractive forces.

Speed, Limit, ATC or MTC - The upper limit of train speed as endorsed by the train protection system.

Speed, Limit, Civil - The maximum safe speed allowed in a specified zone as determined by the physical limitations of the track structure.

Speed, Schedule - The average speed of a train from terminal to terminal obtained by dividing the distance between these points by the time taken to make the trip, including time for intermediate station stops.

Standard Train - For performance test purposes, the planned train arrangement for the transit property writing the specification. Includes number and types of cars such as single units, married pairs, non-control cars, etc.

Step Signal - A signal having a constant value prior to a certain instant and a different value immediately thereafter.

Subsystem - A major part or an assembly of parts of a vehicle.

Super Elevation - On a curve, the vertical distance that the outer rail is above the inner rail.

System - For the purpose of this specification, the vehicle, passengers, operator, maintainer, the operating and maintenance procedures and the maintenance and test equipment integrated into an operational configuration for the specified operational environment.

System Testing - This involves tests which are planned and conducted for each project end product. System testing will be conducted under controlled conditions in an environment closely approximating the conditions which would exist on an operating transit property. Completion of system testing, to the satisfaction of the purchaser, will indicate that the technical development phase has been completed and the system product is ready for operational demonstration testing in a typical normal operating environment.

Third Rail - The bus bar alongside a track that carries electric energy for the propulsion of trains, including support, insulation and coverboards.

-Tight (used as a suffix) - Apparatus is designated as water-tight, dust-tight, etc., when so constructed that the enclosing case will exclude the specified material.

Time Constant - Time interval from the beginning of change of a controlled variable in response to a step-forcing function to the attainment of a stated percentage of the final value.

Time, Dead - Time from the occurrence of a step change of the control signal to the beginning of change of the controlled variable.

Time, Down - The lapsed time during which equipment is not capable of doing useful work because of misadjustment, malfunction or maintenance in progress.

Time, Reaction - Time from the occurrence of a step change of control signal to the first attainment of the new steady-state value of the controlled variable, within a designated accuracy.

Time, Recovery - The time required for a system or condition to return to its original state (or some stated percentage of its original value) after being disrupted or destabilized.

Time, Warmup - The elapsed time from application of power to an operable device until it is capable of performing its intended function.

Tram - A condition of ideal truck geometry in which the axles are perfectly parallel and the wheels longitudinally in perfect alignment. The centers of the journal bearings represent the corners of a perfect rectangle. Tram is checked by measuring the diagonal and longitudinal distances between reference points on the axle bearing housings.

Vital Circuit - Any circuit and its elements, the function of which affects the safety of train operations.

Warp, Track - The vertical distance between the plane of any three of four rail head contact points (two on each rail) forming a rectangle and the remaining point.

Weights, Actual - The measured weights of finished cars ready to run.

Weights, Assigned - The loaded car categories assigned by the purchaser as the basis for traction system design and for subsystem and vehicle testing as indicated. Four weight categories are assigned:

- AW0 - Empty car, ready to run
- AW1 - Normal load
- AW2 - Full load
- AW3 - Crush load

Weights, Estimated - The contractor's estimate of total car weight stated in his proposal for the cars.

Weight, Reference - The contractor's assigned reference weight to be used for bid evaluation.

Work - Where the context will allow, the term "work" shall mean the production of goods and services furnished in accordance with the contract.

20.1.3 ABBREVIATIONS

- AAR - Association of American Railroads
- AISI - American Iron and Steel Institute
- ANSI - American National Standards Institute
- AREA - American Railway Engineering Association
- ASME - American Society of Mechanical Engineers
- ASTM - American Society for Testing and Materials
- ATC - Automatic Train Control
- AWS - American Welding Society
- CFR - Code of Federal Regulations
- DOT - Department of Transportation
- EMI - Electromagnetic Interference
- FRA - Federal Railroad Administration
- IC - Internal Combustion
- IEEE - Institute of Electrical and Electronic Engineers
- IRT - Institute for Rapid Transit
- MTC - Manual Train Control
- SAE - Society of Automotive Engineers
- TSC - Transportation Systems Center, DOT
- UMTA - Urban Mass Transportation Administration

20.2 INTERPRETATIONS

The contract documents are complementary and are intended to provide for a complete product. Should it appear that the work to be done or any of the matters relative thereto are not sufficiently detailed or explained in the specifications or the contract drawings, the contractor shall apply to the

purchaser for such further written explanations as may be necessary and shall conform to them as part of the contract. In the event of any doubt or question arising with respect to the true meaning of the specifications or the contract drawings, reference shall be made to the purchaser whose decision thereon shall be final.

20.2.1 Complete engineering design shall be provided.

20.2.2 All work required shall be accomplished to provide technical data, samples, mockups, material tests, component tests, and subsystem tests indicated.

20.2.3 Combined systems testing of traction equipment and auxiliary electrical system shall be performed.

20.2.4 Development, manufacture, and testing shall be accomplished for diagnostic test equipment and delivery made of sets of equipment to the purchaser at the destination indicated.

20.2.5 Mobilization and production tooling for manufacture of transit vehicles shall be implemented.

20.2.6 Manufacture of equipment and systems shall be accomplished as required for testing and demonstration.

20.2.7 Delivery of cars shall be made to the purchaser at the destination indicated.

20.2.8 Technical personnel and all instrumentation and test apparatus required shall be provided to demonstrate on the purchaser's property the ability of cars to perform in accordance with these specifications and all rework required for acceptance of the cars as revenue vehicles.

20.2.9 Final design, drawings, and data shall be provided as required for cars as reworked and approved following performance demonstration.

20.2.10 Reports on design, manufacture, and testing of cars, with drawings and data, for cars as reworked and approved following performance demonstration, shall be provided.

20.3 . PRECEDENCE OF DOCUMENTS

20.3.1 The order of precedence of documents pertaining to the design, construction, management, support, testing and data requirements of the rail car shall be established in this section.

20.3.2 The intent of the contract drawings and specifications is to describe complete items to be procured. When the contract drawings or specifications describe items in general terms but not in complete detail, the best general practice shall be followed and only materials and workmanship of first class quality shall be used.

20.3.3 In the event of discrepancies between the specifications and the drawings, the specifications shall be used.

20.3.4 In case of differences between small-and large-scale drawings, the large-scale drawings shall govern. Schedules on drawings shall take precedence over conflicting notations on drawings. In the event of discrepancy between any drawing and the figures written thereon, the figures, unless otherwise directed, shall govern over scale dimensions.

20.4 SPECIFICATION REVISIONS

The purchaser may order changes to the specification, including but not limited to design changes, performance of extra tests, elimination of any item or portion of the procurement, or modification of the method of shipment and packing.

20.5 CHANGES TO SPECIFICATION REQUIREMENTS

20.5.1 CHANGE NOTICES

Each proposed change to the contract documents will be described in a change notice issued by the purchaser which will be sent to the contractor before a change order is issued.

20.5.2 CHANGE ORDERS

All change orders will be given in writing. Change orders will specify all additions to and omissions from the procurement or other alterations therein by reason of the changes, any adjustment in compensation to the contractor by reason of the changes, and any extension of the date or dates of delivery granted for the changes.

20.5.3 ADJUSTMENTS IN COMPENSATION FOR CHANGES

An adjustment in compensation shall mean an increase or decrease in contract prices due to changes or the establishment of new prices in payment for changes.

20.5.4 SUPPLIER COST-REDUCTION PROPOSALS

The contractor may submit cost-reduction proposals for changing the requirements of the contract. The proposals shall be written in detail, submitted to the purchaser, and

be based upon a sound study made by the contractor indicating that the proposal:

- a. Would result in a net reduction in the total contract amount
- b. Would not impair any essential function or characteristic of the vehicle, such as safety, service life, reliability, economy of operation, ease of maintenance, and necessary standardized features
- c. Would not detrimentally affect the delivery dates indicated
- d. Would require a change in the contract documents

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