LIGHT RAIL TRANSIT

CAR SPECIFICATION GUIDE

Prepared by
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Washington, D.C.

Prepared for
Research and Special Programs Administration
TRANSPORTATION SYSTEMS CENTER
Cambridge, MA 02142

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16. Abstract

This Light Rail Transit Car Specification Guide is not a procurement document in itself. It is intended to be used as a guide by light rail transit operators and purchasers of such equipment in the preparation of technical specifications. Because of differing site-specific needs, this Specification Guide has been organized to provide ample freedom of choice among a wide range of options. Thus both an operator whose needs dictate a sophisticated vehicle and the operator whose requirements can be met by a very simple vehicle, can use this document as a guide in drafting their individual specifications.

This Car Specification Guide has evolved from the original U.S. Standard Light Rail Vehicle (SLRV) Specification developed in 1972, and incorporates a number of revisions reflecting: (1) changes which may reduce vehicle purchase costs and complexity; (2) provisions for a number of Purchaser selected options; (3) a wider specification so that a new vehicle design is not required and permits designs of vehicles which are already in passenger service; and (4) clarification of requirements so that compliance with the specification can be measured or proven to be met.

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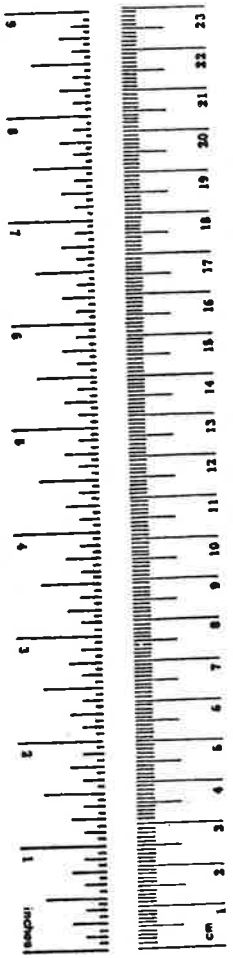
METRIC CONVERSION FACTORS

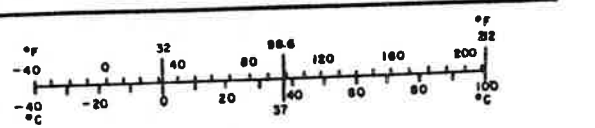
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This Light Rail Transit Car Specification Guide has evolved from the original U.S. Standard Light Rail Vehicle (SLRV) Specification developed in 1972, and incorporates a number of revisions reflecting: (1) changes which may reduce vehicle purchase costs and complexity; (2) provisions for a number of Purchaser selected options; (3) a wider specification so that a new vehicle design is not required and permits designs of vehicles which are already in passenger service; and (4) clarification of requirements so that compliance with the specification can be measured or proven to be met.

The Specification Guide is not a procurement document in itself. It has been prepared to provide a wide range of options from which the Purchaser may choose a specific vehicle to meet site specific needs. Choices which may be made by the Contractor are called "alternatives". The Purchaser has the option to restrict this range of alternatives. Where no options are chosen an elementary or "baseline" vehicle results which is considered to be the most simplified version. In general, selection of an option by the Purchaser increases the sophistication of the vehicle. Where a choice is to be made the text reads "Baseline" or "Option". It is important to note that choices of certain options will automatically dictate other requirements or suboptions so that compatible requirements result.

The Urban Mass Transportation Administration of the U.S. Department of Transportation (DOT) sponsored the work, through its Office of Rail and Construction Technology. The effort was carried out by N.D. Lea & Associates, Inc. under contract to the Transportation Systems Center (TSC) of DOT.

The Project Manager wishes to acknowledge the conscientious direction and assistance received from Mr. Charles O. Phillips of the TSC who performed as the Contracting Officer's Technical Representative for the contract. Particular thanks and recognition are extended to Mr. Jason Baker also of TSC, who played a key role throughout the many reviews, iterations and composure of the Specification.

Grateful appreciation is also expressed to the Port Authority of Allegheny County (PAAC), Pittsburgh, Pennsylvania, particularly Mr. Robert Sedlock and his consultants. The PAAC participated in a cooperative effort with N.D. Lea & Associates, Inc. to review changes and updates to the SLRV Specification that would be consistent with Pittsburgh needs. They also provided results of their efforts to prepare an LRV Specification. As a result, the two specification efforts were blended such that it was possible for the Pittsburgh Specification to be taken as a subset of this General Specification.

Finally, the Project Manager wishes to thank the Authorities' Conference Committee and the transit operators and supply industry who provided many detailed and constructive comments. These valuable contributions have enabled the final product to more strongly recognize the needs and limitations of the transit industry.

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USE OF THE LIGHT RAIL TRANSIT CAR SPECIFICATION GUIDE

INTRODUCTION

This Light Rail Transit Car Specification Guide is not a Procurement Document in itself. It is intended to be used as a guide by light rail operators and purchasers of such equipment in the preparation of technical specifications. Because of differing site-specific needs, this Specification Guide has been organized to provide ample freedom of choice among a wide range of options. Thus, both an operator whose needs dictate a sophisticated vehicle and the operator whose requirements can be met by a very simple vehicle, can use this document as a guide in drafting their individual specifications.

A "baseline" vehicle has been described in this Specification Guide as well as numerous options. The "baseline" specification calls for a very simple, or elementary vehicle which can be modified by the judicious selection of options. These options provide additional operational capabilities as might be required to satisfy local needs. The "options" are choices for the Purchaser to decide when preparing a site-specific specification. Choices which remain for the Contractor to decide are called "alternatives".

THE BASELINE VEHICLE

The "baseline" vehicle is capable of providing safe, dependable and comfortable service in uncomplicated operational situations. Some key characteristics, capabilities and limitations of the "baseline" vehicle, which can be changed by options, are summarized as follows:

- Unidirectional operation, with doors on only one side;
- Non-articulated;
- Single-unit operation (towbars only for emergency push-pull);
- Passengers load from low-level only (railhead or curb level height);
- 600 Vdc primary power and trolley pole;
- No cab signals;
- No traffic signal pre-emption equipment;
- No load leveling;
- No load weigh compensation;
- No wheel spin/slide protection;
- Simple single stage non-articulated track brake;
- Partially enclosed operator's position;
- Operator controls front and rear doors separately;
- Heating and ventilation only (no air conditioning);
- No communications equipment, only space provisions and limited wiring;
- Stepped resistance propulsion control;
- Hand controller;
- Resilient wheels; and
- Low duty cycle friction brakes.

OPTIONS

To provide additional operational flexibility and capabilities, the Specification Guide includes a number of options. These are presented in the form of either modifications to the "baseline" specification or additional provisions. Table 1 lists the options which have been identified and indicates how each option differs from the "baseline". Remarks have been added as necessary for clarity, and section references are indicated.

Options have been numbered sequentially as they first appear in the Specification Guide. In some instances suboptions have been identified, as in the case of alternative coupling arrangements. These have been indicated by a decimal system.

INSTRUCTIONS FOR USING THE SPECIFICATION GUIDE

The text of the Specification Guide has been drafted and arranged to facilitate the substitution of the appropriate technical description of an option in place of the baseline provisions, whenever optional features have been determined to be required by the Purchaser. In instances where no substitution is required, i.e. none of the baseline language need be replaced, simple additions have been indicated.

Throughout the Specification the following system of notation has been used:

1. Provisions of the Specification which relate to the "baseline" vehicle and which would be modified or replaced if an option is selected have been marked with the symbols @@@@@@ at the beginning and end of the affected passage. In addition, the word Baseline (underlined) has been inserted for emphasis at the beginning of each passage.

2. When an option has been selected, the appropriate language which should be substituted for the "baseline" provisions is indicated by the symbols ###### at the beginning and end of the passage. In addition the option number (underlined) is shown at the beginning of the affected passage.

3. Where special comments, instructions or information for the user of the Specification Guide are considered appropriate, the symbols ****** have been used to set such material apart from the provisions of the Specification. For example, in the middle of page 1-1 an instruction has been included for the guidance of the users of the Specification.

4. No notations have been used for Specification language which would not be affected by the selection of any of the many options which have been identified.

Because the selection of a simple option may necessitate language changes in several parts of the Specification, references to each option together with necessary language modifications have been made wherever required throughout the Specification. Additionally, on Table 1 opposite each option, the numbers of all sections where optional language must be either substituted for the baseline provisions or merely added to the general text, have been indicated. For example, if Option 2, an articulated vehicle, is selected, changes are required in many parts

of the specification. Thus, the performance, general design, and testing provisions of Section 2 must be modified. The articulation section itself is specified as optional text in Section 3, and other sections as well, are affected.

To assist users in selecting the specification language which corresponds with the options which have been selected, the following procedure is suggested:

Step 1 - Select from Table 1 the options which reflect the required performance and operational capabilities.

Step 2 - Using the section numbers indicated on Table 1 opposite the selected options, identify the specification text which should be deleted, substituted or added. In most instances the appropriate text may be located readily between the symbols @@@@@@ or ######.

Step 3 - All instructions which are indicated between the symbols ****** should be checked carefully and followed meticulously. They of course do not form a part of the actual Specification and should not be included in the final text.

This document is intended to be a Specification Guide to the majority of needs of light rail operators. It does not universally include all possible options that might be needed or identified. In some cases the user may find that the baseline text or optional text must be modified to satisfy a site-specific need. Therefore, selection of appropriate options and analysis of text applicability must be made by qualified personnel. Once these decisions are made it should be relatively simple to develop the site-specific car specification.

TABLE 1: TABLE OF OPTIONS

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
1	Operating Direction	Unidirectional	Bidirectional	Selection Dictates Option 4	2, 5, 6, 8, 9 & 12
1.1	Operator's Position	(Suboption)[1]	Two Operator's Positions		2
1.2			Single Operator's Positions		2
1.3	Bidirectional Vehicle Door Control	(Suboption)	Door Control Interlocked with Vehicle Direction Switch	-	6
OR 1.4			Not Interlocked with the Direction Switch	-	6
2	Articulation	Nonarticulated	Single Articulated	-	2, 3, 8, 11 & 17
3	Coupling	Single-Unit Operation, Portable Towbar for Dead Car Retrieval	Mechanical Coupler	Must Select Either Suboption 3.1 or Suboption 3.2	2, 4 & 12

1. Suboptions do not have a baseline, they are in addition to or a choice that is made after an option has been selected.

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
3.1			Single-Unit Operation, Mechanical Coupler Only for Dead Car Retrieval	Further Suboptions Involved	2 & 4
OR	Train Operation	(Suboption)			
3.2			Multiple-Unit Operation, Trains up to Four Cars	Further Suboptions Involved	2, 3, 4, 6, 7, 8, 9, 10, 12 & 17
3.1.1			Manual	Required if Suboption 3.1 Selected	4
OR	Coupler Centering	(Suboption)			
3.2.1			Automatic		4
3.1.2			Manual	Required if Suboption 3.1 Selected	4
OR	Coupler Control	(Suboption)			
3.2.2			Automatic		4
3.2.2.1	Coupler Control	(Suboption)	Fully Automatic	-	4
3.1.3			Not Required	-	4
OR	Symmetry	(Suboption)			
3.2.3			Symmetry Required	-	4

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
3.2.4	Trainlines	No Electrical Connections	Electric Couplers	Select Option 3.2.6	4
3.2.5	Trainlines	No Pneumatic Connections	Pneumatic Connector	-	4
3.2.6	Electrical Isolation	(Suboption)	Manually Operated Device	-	4
3.2.6.1		(Suboption)	Automatic Isolation Device	In addition to Option 3.2.6	4
3.2.7	Coupling With Existing Cars	Not Required	Required	-	4
3.2.8	Train Operation With Existing Cars	Not Required	Required	-	4
3.2.9	Destination Signs	Curtain, Split Flap or Flip-Dot Types	Curtain Types Only	-	3
3.2.10	Destination Signs	Manually Operated	Remotely Operated and Trainlined	Cannot be selected Unless Option 3.2.4 is Selected	3 & 4
4	Door Locations	Right Side Only	Both Sides	Required if Option 1 Selected	2 & 6

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
5	Passenger Loading		Wheelchair Access	Used only with Low Level Passenger Loading	2 & 3
6.1	Passenger Loading	Low Level Only	High Level Only	-	2 & 3
6.2	Passenger Loading	Low Level Only	High/Low Level	-	2, 3 & 6
7	Environmental Factors, Track and Wayside Limitations	Standard Set of Conditions Specified	Purchaser May Provide Site-Specific Conditions	-	2
8	Primary Power Nominal Voltage	600 Vdc	750 Vdc	-	2 & 10
9	Cab Signals	No Requirements	Provide Space to Install	-	2 & 11
9.1	Cab Signals	No Requirements	Contractor to Supply and Install Equipment	-	2
9.2	Cab Signals	No Requirements	Contractor to Install Purchaser Provided Equipment	-	2 & 11
10	Traffic Signal Pre-emption Equipment	No Requirements	Provide Space to Install	-	2

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
10.1	Traffic Signal Pre-emption Equipment	No Requirements	Contractor to Supply and Install Equipment	-	2
10.2	Traffic Signal Pre-emption Equipment	No Requirements	Contractor to Install Purchaser Provided Equipment	-	2
11	Time to Accel-erate to 80 km/h (50 mph)	58 sec.	37 sec.	-	2
12	Performance: Load Compensation	Not to be Supplied	Contractor May Supply	Selection Requires Option 12.1 Text Also	2
12.1	Performance: Load Compensation	Not to be Supplied	Required	-	2 & 11
13	Track Brake	Single-Stage Braking Force	Three-Stage Braking Force	-	2
14	Wheel Spin/Slide Protection	Not Required	Required	-	2, 3, 9 10 & 12
15	Contract Drawings	Bidder to Propose	Enclosed with Technical Specifi-cation	-	3
16	Carbody Materials	LAHT Steel or	Purchaser May	-	3

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
17	Rubrails	Not to be Provided	Required	-	3
17.1	Advertising Card Holder	Not Required	Required	-	3
18	Side-Window Lacing	Glazing Strips Laced From Outside	Glazing Strips Laced From Inside	-	3
19	Side-Window Glazing	Single Glazed	Double Glazed	-	3
20	Side Windows	Top Portion Openable	Fixed	-	3
21	Seats	Requirements Specified	Purchaser May Specify Different Requirements	-	3
22	Passenger "Stop Request" Lighted Signs	Not Required	Required	-	3
23	Operator's Position	Partially Enclosed	Fully Enclosed	-	5
23.1	Operator's Seat	Requirements Specified	Purchaser May Specify Different Requirements	-	5

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
24	Door Control	Operator Controls Front and Rear Doors Separately	Purchaser to Specify	-	6
25	Air Conditioning	Ventilation Only	Ventilation and Air Conditioning	-	2 & 7
26	Heating	-	Resistor Waste Heat in Addition	Addition	7
27	Layover Heat	Not Required	Required	-	7
28	Headlights	Side-By-Side Headlights	Center Headlight	-	8
28.1	Headlights	-	Standard Railroad Light in Addition to Headlights	Addition	8
29	Power Collector	Trolley Pole	Pantograph	-	9
29.1	Pantograph Control	Manual By Use of Rope	Automatic	-	9
30	Battery Box Heater	None	Required	-	9

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
31	Communications	Space Provisions, PA Speakers and Limited Wiring Only	Purchaser to Specify	-	9 & 13
32	Controller	Hand Controller	Foot Controller	-	9
33	Backup Controller	Required	Not Required	Only Applicable to Cars having a Single Operator's Position (Option 1.2)	9
34	Propulsion Control	Switched Resistors	Chopper Thyrister	-	10
34.1	Regenerative Braking	(Suboption)	Required	-	10
OR					
34.2			Not Required	-	10
35	Propulsion Duty Cycle	-	Tow Empty Car Up a 9% Grade, in Addition to Regular Duty Cycle	Addition	10
36	Load Leveling	Not Required	Required	-	2 & 11
37	Wheels	Resilient	Purchaser to Revise Specification for Solid Wheels	Details of Solid Wheels Not Specified	11 & 12

OPTION NO.	FUNCTION OR SUBSYSTEM AFFECTED	BASELINE PROVISIONS	OPTIONAL PROVISIONS	REMARKS	SECTION REFERENCE
38	Friction Brake Duty Cycle	In Event of Dynamic Brake Failure -- to be Reduced and Vehicle Taken Out of Service	Full Service May Continue	-	12
39	Track Brake	Non-Articulated Shoes	Articulated Shoes	-	12

Technical Specifications - Section 1

GENERAL REQUIREMENTS

This specification defines the functional requirements and design parameters which the offered vehicles must meet. For all parts and components, designs which have established a documented operating history satisfactory to the Purchaser are required. To this end, waivers of design approvals and qualification testing of components and/or subsystems may be requested by bidders in their proposals for equipment which they believe to be proven in equivalent climatic and operating environments. This does not restrict the procurement only to service proven equipment. Designs with no service experience will be given consideration by the Purchaser if accompanied by presentations containing sufficient information for the Purchaser to analyze the projected advantages of use of such designs, such as reduction in initial cost, reduced operating and maintenance costs, improved reliability and commonality with other rail transit systems.

This section covers only those general requirements which are of a technical nature. The special Provisions and General Provisions of the Contract cover the non-technical requirements.

******Purchaser to add a complete description of the system where the vehicles will be operated, including improvements being made, if any, which may affect vehicle design. The system description should include all route layouts and profiles with data on service frequency, schedules, speeds, passenger loadings, operating rules, etc. (that can be used for dynameter or computer simulator analysis). Formulae are to be provided for relating vehicle-miles travelled to vehicle-hours, cycles of door operation, etc., accounting for time that vehicles are parked with all auxiliaries turned on. Detailed operating environment is to be defined in Paragraphs 2.1.4 through 2.1.6.******

1.1 Definitions and Abbreviations

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.

1.1.1 Definitions

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 attainable longitudinal tangential force at the wheel-rail interface and normal force.

Approved - Reviewed and found consistent with but not as demonstrated compliance with specified requirements.

Bidder - An individual, firm, partnership, corporation, or combination thereof submitting a proposal for the work contemplated, acting directly or through a duly authorized representative.

Blending - In braking, a simultaneous dynamic and friction brake application, with the friction brake supplementing the dynamic brake. Continuous blending involves each brake continuously proportioned to achieve the required total braking effort.

Car; Vehicle - A complete assembly, ready to transport passengers.

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 configured for braking. Free coast is where there is no minimal braking effort, i.e., only natural drag.

Contract - The written agreement covering the commercial and technical terms of the procurement.

Contract Documents - The Notice to Bidders and Invitations to Bid, the Contract Forms, the General Terms and Conditions, the Technical Specifications and the Contractor's Proposal including any quoted performance.

Contract Drawings - An initial set of drawings showing the general car layout and arrangement, either provided by the Purchaser with the specification, or by the Bidder with his bid.

Contractor - The person or persons, firm, partnership, corporation, or combination thereof which has entered into a procurement contract with the Purchaser to supply the vehicle.

Contractor's Drawings - 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.

Days - Unless otherwise designated, days as used in the specification will be understood to mean calendar days.

Days, Working - Those calendar days during which regular business is conducted; excludes legal holidays, Saturdays and Sundays.

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.

Engineer - The person or firm designated by the Purchaser as his authorized technical representative.

Failsafe - A characteristic of a system which ensures that the occurrence of any failure, or combinations of failures, shall not result in an unsafe condition.

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.

Inspector - The person or firm designated by the Purchaser or by the Engineer as its quality control representative. The Inspector's authority is derived through the Engineer.

Interface - The points where two or more physical systems or system subunits come into physical or functional contact.

Jerk - Time rate of change of acceleration and deceleration, equal to the second derivative of velocity with respect to time.

Load Compensation - A function incorporated in the traction system which permits control of tractive effort in order to achieve a constant effort-to-weight ratio. Load weight is one approach.

Notice of Completion - The formal, written notice issued by the Purchaser when all of the procurement under the contract has been completed.

Owner - See Purchaser.

Party, Parties - Organizations entering into an agreement. Used synonymously with Contractor and Purchaser.

Proof (used as a suffix) - Apparatus is designated as splashproof, 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.

Purchaser - The person or persons, firm, partnership, corporation, agency, transit authority, or combinations thereof which has entered into a procurement contract with the Contractor to purchase the vehicle.

Purchaser or Owner - The agency which is procuring the cars (See "Parties").

Redundancy - The existence in a system of more than one means of accomplishing a given function, either automatically or manually without a significant loss of time or service.

Reliability - The probability that a system or system subunit will perform satisfactorily for a given period of time when used under stated conditions.

Service, as in Service Use, Service Braking - The operation of the cars under normal conditions with passengers.

Service Braking - The braking mode normally used to decelerate the car by force applied through the wheels to the rail, to the limits of practical adhesion, and without the use of supplemental brake systems.

Slide, Wheel - During braking, the condition existing when the rotational speed of the wheel is slower than that the small amount of slip which is required for adhesion.

Speed, Balancing - The steady-state speed attained by the vehicle or train when resisting forces exactly equal tractive forces on level tangent track.

Speed, Schedule - The average speed of a vehicle or 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.

Spin, Wheel - During acceleration, the condition existing when the rotational speed of the wheel is faster than the small amount of slip which is required for adhesion.

Step Signal - A signal having a constant value prior to a certain instant and a different value immediately thereafter.

Stop, Emergency - The stopping of a vehicle or train by an emergency brake application. Once initiated, the brake application cannot be released until the train has stopped.

Stop, Service (Full) - The stopping of a vehicle or train by application of service braking. Brake application can be released and reapplied.

Tight (used as a suffix) - Apparatus is designated as watertight, dusttight, etc., when so constructed that the enclosing case will exclude the specified material.

Time, Dead - Time from the occurrence of a step change of the control signal to the beginning of change of the controlled variable (i.e., time during which no action occurs).

Time, Down - The lapsed time during which equipment is not capable of doing useful work because of maladjustment, malfunction or maintenance in progress. A malfunction is any anomalous situation in which a system or systems subunit fails to function as intended.

Time, Reaction - The time which elapses between the moment an action is called for and when the desired action is initiated.

Time, Warmup - The elapsed time from application of power to an operable device until it is capable of performing its intended function.

Traction System - The system of wheels, motors, driving mechanisms, brakes, direct controls, and other equipment that propels or retards a car in response to input control signals.

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 housing.

Vehicle - See "Car".

Vital Circuit - Any circuit upon which the safety of the system is dependent.

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.

Weight, Actual - The measured weight of a finished car 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:

a) AW0 Empty car ready to run;
b) AW1 Car with seated load;
c) AW2 Car with full load; and
d) AW3 Car with crush load.

Work - Where the context will allow, the term "work" shall mean the production of goods and services furnished in accordance with the contract.

1.1.2 Abbreviations

AAR	Association of American Railroads
AATCC	American Association of Textile Chemists and Colorists
AFI	Air Filter Institute
AISC	American Intitute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standard Institute
APTA	American Public Transit Association
AREA	American Railway Engineering Associaton
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association of Americas
AWG	American Wire Guage
AWS	American Welding Society
daN	deca-Newton, a unit of force equal to 10 Newtons and approximately one kg
DOT	United States Department of Transportation
DB	Dry Bulb
FAA	Federal Aviation Administration

FCC	Federal Communications Commission
FMVSS	Federal Motor Vehicle Safety Standards
FRA	Federal Railroad Administration
ICC	Interstate Commerce Commission
IEC	International Electrotechnical Committee
IEEE	Institute of Electrical and Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
JIC	Joint Industrial Council
kg	kilogram, unit of mass in the metric system
NCA	Noise Criterion, Alternate
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NFPA	National Fire Protection Association
PCC	Electric Railway President's Conference Committee
SAE	Society of Automotive Engineers
SIL	Speech Interference Level
UMTA	Urban Mass Transportation Administration
USAS	United States of America Standard
WB	Wet Bulb

1.2 Description of Work

The description of all work can be found in _____*_____ of the Special Provisions of the Contract.

1.3 Shipment

1.3.1 The cars shall not be shipped by travelling (rolling) on their own wheels. They may be shipped resting on their own wheels with the suspension system blocked. It is required that all subsystems be protected from damage during shipment. If shipped by sea, all cars or components thereof shall be enclosed to protect against damage from handling and from exposure to the marine environment.

* Purchaser to provide reference.

1.3.2 All rotating equipment shall be shipped without the brushes on the commutators and with moving parts blocked to prevent bearing damage. All parts that must be removed to permit shipment shall be securely boxed and shipped with the car to which they belong.

1.3.3 The cars shall be secured against unlawful entry during transit by sealing closed all doors and exterior compartments. Any special temporary fittings such as straps, grab handles and locking devices required for shipment of the cars shall be provided and removed by the Contractor.

1.3.4 The Purchaser shall identify existing equipment and facilities at the Owner's site for unloading and receiving the cars and the Contractor shall assess its suitability. Responsibility for the cars until they have been accepted is defined in _____*_____ of the General Provisions of the Contract.

1.4 Intent of Specifications and Specification Drawings

1.4.1 The intent of the Specifications and Specification Drawings is to describe items to be procured.

1.4.2 The definite means for arriving at a firm understanding of the exact intent and meaning of these specifications and for resolving conflicts are defined in _____*_____ of the Special Provisions of the Contract.

1.4.3 In the event of discrepancies between the Specifications and the Drawings, the Specifications shall be the determinant.

******Purchaser may wish to prioritize conditions where the Specifications or Drawings will be the determinant.******

1.4.4 Where differences between small- and large-scale drawings exist, the large-scale drawings shall govern. Schedules on drawings shall take precedence over conflicting notations of drawings. In the event of discrepancy between any drawings and the figures written thereon, unless otherwise directed, the figures shall govern over scale dimensions.

1.5 Design Concurrence, Contractor's Drawings and Data Requirements

A procedure of design drawings submitted by the Contractor to the Purchaser, followed by Design Review meetings between Contractor and Purchaser shall be utilized in the design concurrence process. The bidder shall submit with his bid a plan and schedule for this procedure. Said plan shall reflect the requirements outlined below. It is the intent of this Specification that the costs and time associated with the design concurrence procedure be minimized. To this end waiver of design submittals and concurrence will be granted for service proven designs. Concurrence by the Purchaser means that the Contractor may proceed with procurement of materials and components and fabrication. It does not imply demonstrated compliance with the specification. Any concurrence or approvals by the Purchaser shall be given or withheld only on the basis of the requirements of this specification.

* Purchaser to provide reference.

1.5.1 The Specification Drawings shall be supplemented by additional drawings furnished by the Contractor. The Contractor shall prepare and submit for concurrence by the Purchaser two complete sets (one reproducible) of assembly and, where necessary, subassembly drawings showing arrangement necessary in every respect to convey concept, overall assembly aspects, interfaces and systems operation. These drawings shall show the floor plan, reflected ceiling plan, underfloor and roof equipment arrangement, inside longitudinal sections or both sides of the car, exterior side elevations of both sides of the car, elevation views of both ends of the car and sufficient transverse sections through the car to show all variations in cross section, such as at windows and at doors. One of the transverse sections shall show an outline of extreme movements permitted by the car suspension. All subassembly drawings shall be submitted to the Purchaser for reference use, except where a service proven design is supplied.

Drawings that show details necessary to conduct manufacturing or fabrication are not required to be submitted, but shall be made available for inspection by the Purchaser at the Contractor's facility upon request.

All drawings submitted by the Contractor shall include, in a proper manner the drawing number, title, date, contract number, reference to next higher assemblies and signature of the Contractor's responsible engineer -- and shall be accompanied by a letter of transmittal in duplicate listing title, drawing number and date. Within an agreed upon number of Purchaser-working days after receipt, the Purchaser shall respond to the Contractor at an address within the U.S. he designates, stating those drawings concurred with or not accepted, and in the latter case stating the specific problems requiring correction. It shall be the responsibility of the Purchaser to adhere to the concurrence suspense date for each lot of drawings submitted for approval. If he does not, it shall be the responsibility of the Contractor to notify the Purchaser if these delays will impact the production schedule. As predetermined by the Purchaser and the Contractor, only an agreed maximum number of concurrence-required drawings can be submitted by the Contractor for approval during each concurrence period.

Drawings that have been resubmitted by the Contractor shall show information as to complete revision, new revision letter, date of revision, identification and explanation of what has been revised and signature of Contractor's responsible engineer authorizing the revision. No additional revision(s) shall be made under a revision letter previously submitted. These actions shall be necessary for each and every change.

Drawings that have been revised shall be assumed to be non-concurred until definite concurrence by the Purchaser has been made; this includes those drawings that have been revised by the Contractor after concurrence by the Purchaser.

The Purchaser may waive the requirements for his concurrence of the design where "service proven equipment" is to be supplied. The determination of "service proven equipment" will be made by the Purchaser based upon information supplied by the bidder with his bid, discussions with and other data from previous purchasers of that equipment. In general, the Purchaser

will base his decision to waive design concurrence on the historical success of that equipment in passenger service on other rail transit vehicles. For identifying "service proven equipment" that the bidder might request said waivers, the following guideline is suggested: the product must have been a permanent part of a transit railcar operated in scheduled service for a minimum of 4 million miles. The bidder shall name those items of "service proven equipment" in his bid where he is requesting design approval waivers and supply supporting data.

The minimum information on "service proven equipment" to be supplied with the bid are as follows:

1) Names, addresses and telephone numbers of previous purchasers of the equipment;

2) Unit designation, number of units, length of time and/or miles in service for each, reliability and/or failure data;

3) Any differences, modifications or improvements to the equipment being proposed; and

4) Place and date of manufacture of the representative equipment in items 1 and 2 above and where the new equipment will be manufactured.

******The Purchaser shall include an instruction in the Bidding Instructions that the bidder provide incremental reductions in his bid price for each item where a waiver may be granted. This way, the bid price can more accurately reflect what is acceptable to the Purchaser.******

1.5.2 Fabrication affected by concurrence-required drawings shall be held in abeyance until the Purchaser has made the necessary approval.

1.5.3 At the completion of the Contract, the Contractor shall supply reproducibles, for said vehicle, of all the following, where such are "car-specific" items: 1) all Contractor's and suppliers' drawings, details, bills of material and catalog cuts that are required by the Purchaser for future installation, maintenance and repair purposes; 2) all assemblies, subassemblies and arrangements of the car; 3) all items which are special purpose or fabricated by the Contractor; and 4) all material furnished to the Contractor by his suppliers. In every case, outline drawings shall not be considered acceptable. This information shall be detailed to the extent necessary for complete maintenance, repair and overhaul of the vehicle.

1.5.4 All contractor drawings shall be prepared similar to the Air Transport Association of Americas (ATA) Specification No. 100 "Specification for Manufacturer's Technical Data" and shall be prepared so that reduction can generally be made to an 11-inch (280 mm) vertical dimension. In no case shall any drawing, diagram, sketch or the like (including Bill of Materials) which is supplied by the Contractor or his suppliers as part of the Contract requirements exceed 30 by 60 inches (760 by 1,525 mm). The following ANSI standards for the preparation of drawings shall apply:

a) Y1.1 Abbreviations for Use on Drawings and in Text;
b) Y32.2 Graphic Symbols for Electrical and Electronic Diagrams; and
c) Y32.14 Graphic Symbols for Logic Diagrams.

All drawings shall be dimensioned in the system of units for which the equipment was designed. By agreement between the Purchaser and the Contractor, translated units may also be shown on the drawings.

Where the Contractor is a foreign concern and where the primary language is other than the American English language (i.e., per latest unabridged edition of Webster's) and original design work is not carried out in the American English language, then all drawings and documentation required to be submitted shall be translated into the American English language and conform with the technical usage as practiced in the United States of America. The above requirements to use ATA and ANSI standards may be waived providing a similar standard is used and each translated drawing includes a legend cross referencing all abbreviations and graphic symbols used on the drawing to those required by the ATA and ANSI standards. Said translations are to be made by technical personnel experienced in rail transit vehicles working in the American language. Copies of both the original and translated documents shall be submitted. Drawings shall be bilingual.

1.5.5 Electrical schematic drawings shall indicate all wire numbers, references to other drawings of any and all manufacturers to which connections are made, nominal voltages, currents and frequencies, significant resistance values, and the rating of all loads. Devices shall be labeled in agreement with the identification appearing on the actual device, and their locations on the cars shall be shown.

1.5.6 The Contractor shall submit microfilm copies of all documentation in accordance with ******requirements prepared by the Purchaser.******

1.5.7 In addition, the following data and documentation shall be submitted.

The dates for these submittals are delineated in _____* _____ of the Special Provisions of the Contract.

(a) At the completion of the first car, three sets of unmounted photographs, showing at least ten views, size 200 mm (8 in) by 250 mm (10 in);

(b) Clearance diagrams which reflect all side or roof mounted equipment, suspension limits and wear, to be submitted during design concurrence period;

(c) Single line, control schematic and functional block diagrams for each subsystem, showing all values, operations and control components;

* Purchaser to provide reference.

(d) General control circuit interface data such as type of signal, range, circuit loading and impedance, type of transducer or pickup and mechanical requirements;

(e) Graphs and curves showing response and functional characteristics of major subsystems and components;

(f) Documentation of analyses conducted by the Contractor, as specifically called for in this Specification;

(g) Propulsion system technical data (measured or calculated from measured data) shall be submitted as follows:

(1) Capability curves of tractive effort versus command-signal and speed for both positive and negative traction mode;

(2) Single line diagram of power circuits and functional diagram of the control loop including input and output signals;

(3) Propulsion motor characteristics based on performance criteria, specified wheel size, and offered gear ratio, showing motor voltage, speed and efficiency versus motor current and tractive effort versus motor current for both propulsion and braking modes;

(4) Detail of coupling and mounting interface between gearbox and traction motor;

(5) Anticipated resilient characteristics, including natural frequency of gear and motor unit suspension;

(6) Number and connection of power semiconductors used in propulsion circuits together with current and voltage rating of each; and

(7) Propulsion system estimated energy consumption as required in Paragraph 2.2.16.

(h) Friction Brakes System Technical Data shall be submitted as follows:

(1) Capability curve and bandwidth of tractive effort versus command signal and speed, variation with duty cycle, wear, batch, etc.;

(2) Functional diagram showing control loop and values of all input and output signals;

(3) Curves of operating pressures versus torque for full operating speed range;

(4) Tabulation of all electrical loads, giving both maximum instantaneous and average demand;

(5) Documentation of safety analyses required in Subsection 16.4;

(6) System flow diagram, if applicable, showing functional arrangement of all valves, reservoirs, adjustment points and operating units;

(7) Brake unit mounting details;

(8) Description of friction material proposed together with experience data from comparable applications;

(9) Curve showing any friction brake and dynamic brake blending.

(i) Truck Technical Data shall be submitted as follows:

(1) Drawings showing both truck assemblies including safety bars in plan, side and front view. The drawings shall identify all welds and indicate relation of welded seams to the neutral axes of the weldment. General arrangement, load paths, provision for equalization, and interfaces shall be clearly shown.

(2) The following truck data shall be submitted for both trucks:

- o Height, overall, above top of rail;
- o Width, overall;
- o Length, overall;
- o Wheelbase; and
- o Weight, calculated, grouped into axle assembly, frame, suspension parts and body-mounted portions.

(3) A list of car body motion limits in relation to truck shall be provided as follows:

- o Vertical (up and down);
- o Lateral;
- o Longitudinal; and
- o Roll angle and roll center.

(4) Suspension data shall be provided as follows:

- o Type of primary and main suspension;
- o Manufacturer of air spring (if used);
- o Damping constant of each shock absorber;
- o Spring constant of body suspension (expressed as a curve, if not linear); vertical, lateral (at working height with ends of springs maintained parallel);
- o Relationship of air spring pressure to vertical force at constant height and also at various heights;
- o Total air spring volume, including auxiliary cushion volume;
- o Air spring damping orifice sizes and damping rates, vertical and roll;
- o Air supply requirements; and

- o Vertical spring constants or load-deflection curves of all resilient truck components other than the body suspension system.

(5) Material specifications and static and dynamic design stress levels of truck frame components, axles and springs shall be included.

(6) Design and material specifications shall be provided for:

- o Axles;
- o Wheels;
- o Journal bearings;
- o Hydraulic shock absorbers;
- o Elastomeric journal bearing support; and
- o Safety bar assembly.

(j) Auxiliary Electrical System Technical Data shall be submitted as follows:

(1) Operating characteristics of auxiliary system power supply components;
(2) Low-voltage power supply/battery charger operating characteristics;
(3) Battery discharge curves and charging requirements; and
(4) Tabulation of all low voltage dc loads, giving:

- o Maximum and average current;
- o Circuit breaker ratings;
- o Continuous or intermittent load; and
- o Emergency loads.

(k) Tabulation of all primary power voltage loads, giving:

- o Maximum and average current;
- o Circuit breaker and fuse ratings; and
- o Continuous or intermittent load.

1.6 Purchaser Furnished Materials

Section 18 delineates any Purchaser furnished materials.

Conditions concerning delivery of these materials to the Contractor are defined in _____*_____ of the Special Provisions of the Contract.

1.7 Inspection

Inspection requirements are covered in _____*_____ of the General Provisions of the Contract.

* Purchaser to provide reference.

Technical Specifications - Section 2

SYSTEMS REQUIREMENTS

This section establishes the system performance criteria for the Light Rail Vehicle, including performance, reliability, vibration, acoustical, dimensional and environmental requirements. The requirements for verification and proof of design are also defined.

2.1 General Design Criteria

The Light Rail Vehicle shall be designed and manufactured to operate successfully within the environment of city street, private right-of-way, and subway operation. A specific definition of this environment is given in Paragraphs 2.1.4, 2.1.5, and 2.1.6. The maximum design speed shall be 80 km/h (50 mph).

The vehicle shall have the following basic characteristics:

a) @@@@@@@Baseline - Unidirectionally operated.@@@@@@@

######Option 1 (Bidirectionally Operated) - Operating performance and control shall be equal in both directions.######

######Option 1.1 (Two Operator's Positions) - Each end of the vehicle shall be equipped with an operator's control position.######

######Option 1.2 (Single Operator's Position) - Only one end of the vehicle shall be equipped with an operator's control position. It is intended that two such cars be operated coupled back-to-back.######

b) @@@@@@@Baseline - Nonarticulated, supported on two trucks each having two axles.@@@@@@@

######Option 2 (Articulated) - The vehicle shall have a single articulated joint and three trucks each having two axles.######

c) @@@@@@@Baseline - Vehicles shall be operated as single-units equipped with portable towbars.@@@@@@@

######Option 3 (Couplers) - The vehicle shall be equipped with automatic mechanical couplers,###### ######Option 3.1 - for retrieval only of an inoperative car and not for train operation.###### ######Option 3.2 (Train Operation) - For operation as single units and in trains of up to four cars each.###### ######

d) @@@@@@@Baseline - Doors shall be provided only on the right side of the vehicle.@@@@@@@

######Option 4 (Doors on Both Sides) - Doors shall be provided on both sides of vehicle. ******Note: This option is required if Option 1 is chosen.******######

e) @@@@@@@Baseline - Passengers will board the vehicle only from low level (i.e. rail head or curb height).

######Option 5 (Wheelchair Access) - Provisions shall be made for loading passengers in wheelchairs.###### @@@@@@

######Option 6.1 (High Level Loading) - Passengers will board the vehicle from high level platforms only, i.e. the loading level is even with the car floor.######

######Option 6.2 (High/Low Level Loading) - It shall be possible to load passengers from both low and high levels (low level is rail head or curb height and high level is the same level as the car floor).######

2.1.1 Fail-Safe Design. All equipment affecting personal safety and/or identified in this specification as being vital or fail-safe shall be designed according to either the Fail-Safe Principle and/or the Checked-Redundancy Principle as defined below.

2.1.1.1 Fail-Safe Principle. The fail-safe principle applies to hardware configurations and states that the occurrence of any failure of a hardware element, (as defined by Paragraph 2.1.1.4 Component/Equipment Failure List), or any combinations of such failures, will cause the configuration to revert to a state that is known to be safe.

2.1.1.2 Checked-Redundancy Principle. The checked-redundancy principle refers to either hardware or software configurations and states that any frequent failure or combinations of such failures, (as defined by Paragraph 2.1.1.4 Component/Equipment Failure List), that can result in an unsafe condition shall not occur at an interval less than 10^6 years.

The checked-redundant control configuration, whether it comprises hardware or software elements, incorporates at least two parallel control units operating from a common input and a means of comparing the output of the control units. If there is "agreement" from the comparison, then the vehicle is allowed to respond in accordance with the output of the control units. If there is "disagreement" the vehicle shall be stopped and not be allowed to proceed without deliberate action to bypass the fault. The following characteristics must be incorporated into the checked-redundancy design:

(1) The checking process shall, in itself, be fail-safe or checked redundant. "Agreement" shall not be indicated unless the control unit outputs agree;

(2) The checking process shall cover the comparison of all control units related to safety;

(3) The checking process shall be sufficiently sensitive to cause "disagreement" for all control unit output errors;

(4) The parallel control units must be completely independent from each other so that no common environmental or power fluctuations, errors, faults, etc; can cause related errors in the output of the control units;

(5) The checking process shall be sufficiently frequent and comprehensive to insure that during any one year of operation, the probability of occurrence of a combination or sequence of compensating errors causing agreement between comparisons shall be controlled to produce a risk comparable to that of traditional fail-safe design.

(6) Unless "agreement" occurs, timely action must result which assures safety.

2.1.1.3 Additional Safety Requirements. In addition to hardware or software failures the fail-safe or checked-redundancy designs shall protect against human error and external influences such as high temperature or shock, or other adverse conditions which are outside of the range within which the equipment is designed to operate. Human error as used herein means those errors wherein the vehicle operator operates the controls or functions of the vehicle in an improper sequence or abnormal manner causing potential conflict of functions to exist. In this situation, the function creating the highest degree of safety shall automatically govern. An example is, if simultaneous power and braking were called for, then braking only would result. It does not include operator error when operating the equipment according to proper sequence or normal function, but in violation of the Puchaser's rules; and errors by maintenance personnel when testing, maintaining and repairing equipment, which might occur if unauthorized procedures are used or deliberate attempts to defeat system integrity are made.

Failure in a circuit or equipment which results in an indication of a dangerous or restrictive condition, whether or not there is actual danger, shall be considered to have occurred in a safe manner. Conversely, a failure which results in an indication of a safe or nonrestrictive condition when, in fact, a dangerous condition may exist shall not have met the fail-safe or checked-redundancy requirement.

2.1.1.4 Component/Equipment Failure List. In designing for a fail-safe configuration, components shall be selected so that the occurrence of any failure or combination of failures listed in the Component/Equipment Failure List shall not result in an unsafe condition.

In a checked-redundant configuration involving hardware components, the Component/Equipment Failure List shall be used to define the elements subject to failure. Each of the components has a probability of failure which must be taken into account to determine the probability of failure of the checked-redundant configuration.

In a checked-redundant configuration involving software applied to a computer, the probability of an error in the software program is a statistical function of the computer and can be used to determine the probability of an unsafe condition occurring in the configuration.

The Component/Equipment Failure List is composed of all items used in railway-type command and control systems. This table is based upon AAR standards. This list itemizes "frequent failure modes", that is, the

failure modes that are likely to occur more than once in 10^6 years. Not listed for each item are certain failure modes that occur so rarely that they can be neglected in the circuit design considerations. They occur less than once in 10^6 years.

The following items comprise the Component/Equipment Failure List:

(1) Relays (vital or safety-type as defined by the AAR) - back contacts closed when coil terminals energized, high contact resistance;

(2) Relays (vital, European type) - back contacts closed when coil terminals energized, high contact resistance, front contacts closed when coil terminals de-energized;

(3) Relays (non-vital) - back contacts closed when coil terminals energized, high contact resistance, front contacts closed when coil terminals de-energized, front contact(s) closed at same time as back contact(s);

(4) Transformers (special vital-type) - open-circuited primary, open-circuited secondary, short-circuited turns, and combinations of the foregoing;

(5) Transformers (non-vital) - open-circuited primary, open-circuited secondary, short-circuited turns, primary to secondary short circuits, and combinations of the foregoing;

(6) Inductors (safety type used in Vehicle Control) - open-circuited coil;

(7) Capacitors (special vital-type) - short circuit, open circuit, leakage, nominal change in value;

(8) Capacitors (non-vital) - short circuit, open circuit, leakage, significant change in value;

(9) Resistors (special vital-type) - increase in resistance, nominal decrease in resistance;

(10) Resistors (non-vital) - increase in resistance, significant decrease in resistance;

(11) Semiconductor Devices - short circuit, open circuit, leakage, and change in dynamic characteristics;

(12) Diodes - short circuit, open circuit, and reverse leakage;

(13) Coils (special vital-type) - open-circuited turns;

(14) Coils (non-vital) - open and short-circuited turns;

(15) Printed Circuit Board (vital-type) - open-circuited in any conductor or connector terminal, short-circuited to ground for any conductor or connector terminal;

(16) Printed Circuit Board (non-vital) - open-circuited in any conductor or terminal, short circuit to ground for any conductor or connector terminal, short circuit between adjacent connector terminals, signal feed-back from output to input;

(17) Loss and degradation of power sources;

(18) Abnormal signal levels, frequencies, and delays;

(19) Absent input signals;

(20) Open and short circuits in internal and external circuitry at inputs and at outputs;

(21) Drift and instability of amplifiers, receivers, transmitters, oscillators, switching circuits, and power supplies;

(22) Deterioration of contacts, connectors, terminals, solder connections, printed circuits, circuit adjusting devices, and mechanical devices;

(23) Loss of electrical power or pressure in a braking system; and

(24) Primary power voltage lower or higher than normal.

2.1.1.5 Safety Principle Analysis. During the Design Review/Approval process outlined in Subsection 1.5, the Contractor shall submit documentation of data and/or analyses (see Paragraph 16.4.1) that the equipment he proposes is in accordance with the safety principles of Paragraphs 2.1.1.1 through 2.1.1.4.

2.1.2 Crashworthy Design Requirements. All systems shall be designed for operation in the most restrictive specified ambient conditions and assuming maximum power supply tolerances ("worst case" design).

The following guidelines are suggested to achieve crashworthy design goals for front end collisions of empty cars:

@@@@@@@Baseline - Vehicle-ends to withstand 2.5 mph impact with solid object and sustain zero damage.

Vehicle-ends to withstand 10 mph impact with solid object with permanent deformation confined to forward two feet and damage confined to forward four feet of vehicle, measured from extreme end of car, and with no hazardous high voltage electrical damage. Said damage shall be repairable without replacing structural or electrical parts, including wiring, aft of these four feet of damage.@@@@@@@

#######Option 3 (Couplers) - Vehicle-ends to withstand 2.5 mph impact with solid object and sustain zero damage.

Vehicle-ends to withstand 5.0 mph impact with damage confined to replaceable energy absorbing elements in the draft gear assembly.

Vehicle-ends to withstand 10 mph impact with solid object with permanent deformation confined to forward two feet and damage confined to forward four feet of vehicle, measured from extreme end of car, and with no hazardous high voltage electrical damage. Said damage shall be repairable without replacing structural or electrical parts, including wiring, aft of these four feet of damage.######

Verification of the extent to which crashworthy design goals have been achieved shall be accomplished either by actual specimen tests or by analysis.

The ends of the car body shall incorporate an anticlimb feature of such design that in accidental contact between cars, ######Option 3 - when couplers are not engaged or when the impact force is sufficient to release draft gear,###### the anticlimb elements will mate to prevent understructure override or telescoping and allow energy distribution (See Paragraph 3.7.1).

2.1.3 Design Life. The Light Rail Vehicle shall be designed for a normal service life of 30 years with an annual mileage estimated to be 64,000 km (40,000 mi) per car.

2.1.4 Environmental Factors.

@@@@@@Baseline - The vehicle shall be capable of being operated, stored and maintained at the specified performance levels without impairment resulting from the natural or induced environment within which the Purchaser intends to operate the vehicle in revenue service.

The following environmental factors shall be used as design guidelines and shall be considered as operational requirements. The Contractor shall be responsible to advise the Purchaser if there are any special environmental factors to which his equipment may be sensitive that are not listed below.

a) Temperature

Minimum ambient temperature	-28°C (-20°F)
Maximum ambient temperature	46°C (115°F)

b) Humidity

Minimum humidity	5%
Maximum humidity	100%

c) Precipitation

Maximum precipitation conditions are as follows:

Maximum rainfall rate	100 mm/hr (4 in/hr)
Maximum snowfall rate	125 mm/hr (5 in/hr)
Maximum snowfall accumulation (if applicable)	_____ mm (_____ in)

The fordability performance shall be as follows:

With maximum allowable wheel and rail wear, the vehicle must be able to operate successfully under the following condition with no damage to undercar equipment and no entry of moisture into any compartment, component or device that will cause the equipment on the vehicle to malfunction, be damaged or cause premature wear or failure:

In water, 100 mm (4 in) above the minimum rail height, for a distance of 120 m (400 ft), to stand, or creep through at up to 8 km/h (5 mph); and

In snow (if applicable), 100 mm (4 in) above the minimum rail height on level track, to operate at ____ km/h (____ mph).@@@@@@

d) Wind Velocity

Continuous	65 km/h (40 mph)
Gusting	110 km/h (70 mph)

######Option 7 - ******Purchaser to specify above environmental factors. Any more stringent factors must be developed by the Purchaser and are to be included.******######

f) Road Contamination

******The vehicle shall operate under the dust, trash and leaf accumulation conditions and snow melting chemicals specified by the Purchaser.******

g) Air Contamination

******The vehicle shall operate under the air contamination levels, such as dust, acids, salts, etc., as specified by the Purchaser.******

h) Electromagnetic Interference

******The vehicle shall operate under the electromagnetic interference levels as specified by the Purchaser.******

2.1.5 Track and Wayside Limitations. The following provides the basic track and wayside limitations under which the vehicle ######Option 3.2 - or train,###### shall operate.

@@@@@@@Baseline

a)	Minimum lateral radius at centerline of tracks	12,800 mm (42 ft)
b)	Maximum superelevation	152 mm (6 in)
c)	Radius of minimum vertical curve - crest	94,500 mm (310 ft)
d)	Radius of minimum vertical curve - sag	140,200 mm (460 ft)

e) Track gauge — 1,435 mm (4 ft 8.5 in)

f) Maximum sustained grade — 6%

g) Maximum grade — 9% for ____m (____ft) max. length

h) Type of rail

i) Maximum running rail wear:

Vertical	13 mm (0.5 in)
Horizontal	13 mm (0.5 in)

j) Minimum track condition

Gage of tangent track will be at best _____ m (_____ ft) but not more than _____ m (_____ ft).

Alignment of tangent track: The deviation of the mid-offset from 18.9 m (62 ft) line is not more than _____ mm (_____ in).

Runoff in any 9.4 m (31 ft) of rail at the end of a raise does not exceed _____ mm (_____ in).

Deviation from uniform profile on either rail at the midordinate of a 18.9 m (62 ft) chord is not more than _____ mm (_____ in).

Deviation from designated elevation on spirals is not more than _____ mm (_____ in).

Variation in cross level on spirals in any 9.4 m (31 ft) is not more than _____ mm (_____ in).

Deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals is not more than _____ mm (_____ in).

The difference in cross level between any two points less than 18.9 m (62 ft) apart on tangents and curves between spirals is not more than _____ mm (_____ in).

Rail end batter does not exceed _____ mm (_____ in).

k) Type of switches — single point, spring return

######Options 5 and 6

l) Station platform height above top of running rail — 860 mm (34 in)######

@@@@@@

######Option 7 - ******Purchaser to specify his own site specific track and wayside limitations in accordance with the above where pre-existing conditions must be met.******######

2.1.6 Clearance Requirements. The vehicle and attached equipment shall be designed to operate within the dynamic clearance envelope shown in the contract drawings under all conditions of wear or failure, other than structural failures. Included in the derivation of the dynamic clearance envelope drawing are wheel flange wear of 10 mm (0.4 in) and wheel radial wear of 25 mm (1.0 in) and failed secondary suspension. No rail wear allowance is included.

General dimensions shall be as shown below or as specified elsewhere in this specification.

******Purchaser to complete the following blank items making sure compatibility with requirements of paragraph 2.1.5 above.******

a)	Length of car on centerline over anticlimber	Min. ___mm (___ft) Max. ___mm (___ft)
b)	Length of car over drawbar pulling faces	Min. ___mm (___ft) Max. ___mm (___ft)
c)	Width of car, overall	Min. ___mm (___ft) Max. ___mm (___ft)
d)	Wheel diameter, new wheels	Min. 640 mm (25 in) Max. 740 mm (29 in)
e)	Maximum design radial wheel wear	25 mm (1.0 in)
f)	Overhead contact wire range	From ___mm (___ft) To ___mm (___ft)
g)	Maximum height, top of rail to top of power collector (locked down) at AW0.	_____
h)	Maximum height of car from top of roof equipment to top of rail	_____
i)	Height of car floor from top of rail	_____ mm (_____ ft)

######Option 7 - ******Purchaser to specify consistent with site specific platform height. If load leveling (Option 36) is not required, Purchaser to specify height only for car weight AW3. If load leveling is required the tolerance on height should be -0, +38 mm (1.5 in).******######

j)	Minimum running clearance after all wear and deflection; Trucks Undercar equipment, vertical curve	 60 mm (2.5 in) 50 mm (2 in)

######Option 3 (Couplers)

k)	Height of centerline of coupler face from top of rail	450 mm (17.7 in)
l)	Minimum clearance from top of rail to coupler over crest and sag vertical curves######	100 mm (4 in)
m)	Height, floor to bottom of window sheet opening (minimum)	750 mm (2.45 ft)
n)	Height, floor to top of window sheet opening (minimum)	1,900 mm (6.23 ft)
o)	Height, floor to headlining of car (minimum at car centerline)	2,030 mm (6.67 ft)
p)	Minimum width of side door openings. Must also allow minimum 815 mm (32 in) width for wheelchair entry	1,340 mm (4.4 ft)
q)	Height, door openings over threshold (minimum)	1,900 mm (6.25 ft)
r)	Height from top of rail to centerline of anticlimber	685 mm (27 in)
s)	Minimum double-seat width	860 mm (34 in)
t)	Minimum aisle width	813 mm (32 in)

2.1.7 Weights. For design performance purposes the weight of each vehicle shall be defined as follows:

a)	AW0: Empty car operating weight	Maximum 1,490 daN/m (1,000 lb/ft) per unit length of complete empty vehicle, ready to run
b)	AW1: Seat load car weight	70 daN (154 lbs) per seated passenger plus AW0

c) AW2: Normal load car weight — 70 daN (154 lbs) per standing passenger with 4 passengers per square meter of floor space* ($2.7\ ft^2$ per standing passenger) exclusive of seating area, and floor area where passengers are not permitted to stand, plus AW1

d) AW3: Crush load car weight — 70 daN (154 lbs) per standing passenger with 8 passengers per square meter of floor space ($1.35\ ft^2$ per standing passenger) exclusive of seating area, plus AW1

2.1.8 Passenger Capacity. ******Purchaser to specify capacity of vehicle for seated and standing passengers.****** The space per standing passenger shall not be less than that defined in paragraph 2.1.7 above.

2.1.9 Vibration and Shock Criteria.

a) Carbody-Mounted Equipment

Components mounted on the carbody shall be designed and mounted to withstand continuous sinusoidal vibration, independently applied along the three major axes, or 0.2g rms input if the natural frequency of the component is less than 20 Hz, and 0.2g rms response if the natural frequency is above 20 Hz. They shall also be designed to withstand independently applied half-sine shock impulses.

The nominal stress in any member based on its net cross section shall not exceed the endurance limits of the material. Equipment attachments may yield but not rupture. Different components inside the equipment shall remain contained within the equipment itself.

b) Truck Frame-Mounted Equipment

Components mounted on the truck frame shall be designed and mounted to withstand, without fatigue or deterioration of structure integrity or operational reliability for the 30-year design life of the car, the normally occurring shock and vibration levels with load AWO presented

* Floor space is defined as those areas designated for standing passengers, which exceeds the seating areas, operator's areas and door areas.

by the support points on the truck frame. The normally occurring shock and vibration levels are as follows: _____*.

The components shall be designed to withstand, without exceeding endurance limits, independently-applied minimum vibratory response which has been measured to be: _____*. The loads due to driving or braking motor torques shall be considered in each case.

Components mounted on the truck frame more than 1 foot (305 mm) away from the journal bearings shall be designed to withstand the independently-applied shock response loads which have been measured to be: _____*. The nominal stress in any member based on its net cross section and due to these shock loads or a motor flashover, shall not exceed the endurance limit of the material. Truck design shall not impose any load on equipment they cannot withstand. The equipment attachment may yield but not rupture.

c) Axle-Mounted Components

Axle-mounted equipment shall be designed to withstand, without exceeding endurance limits, vibratory response loads and shock response loads which have been measured to be: _____*. The nominal stress in any member, based on its net cross section shall not exceed 50 percent of the material yield strength when subjected to the specified shock loads.

2.1.10 Identification. All vehicles will be identical in their identification designations. Vehicle car body and equipment shall be identified in accordance with the following convention.

a) From the horizontal centerline of the vehicle the half sections of the vehicle shall be designated "A" and "B".

b) Operation of the vehicle from the A-Section shall define that end to be "Forward".

c) With the Operator in the A-Section Cab, items located on the Operator's right shall be designated "Right" and items on his left shall be designated "Left".

d) Multiple items such as doors, windows, etc., shall be numbered consecutively, either "Right" of ""Left", from forward to rear.

2.1.11 Selected Interfaces

a) @@@@@@@Baseline - The vehicle equipment shall be designed and tested for nominal 600 Vdc operation. The equipment shall operate with the below specified voltage variations and power isolation gaps without damage or failure of the equipment to function as specified.

* Purchaser completing detail.

The average primary line voltage at the trolley wire is 575 Vdc. The full load line voltage will range between 475 v and 590 v with occasional swings due to unusual load demands as low as 450 v and as high as 720 v if vehicle power regeneration is utilized. Below 450 Vdc the propulsion and auxiliary power converter output current may be reduced. The propulsion and auxiliary power converter low voltage cut out value shall be 400 Vdc. @@@@@@

######Option 8 - The vehicle shall be designed and tested for nominal 750 Vdc operation. ******Purchaser to specify average and full load voltages, voltage swings and cut-out voltage.******######

******Purchaser to define substations, e.g., frequency and type of rectification.******

b) @@@@@@@Baseline - Interfaces are not required for any cab signal equipment.@@@@@@@

######Option 9 - Space shall be provided for future implementation of cab signals and speed control equipment. These provisions shall be limited to mechanical aspects only, i.e. space to mount the equipment and run its associated wiring. Design of the propulsion control equipment must not preclude future installation and operation of cab signals.######

######Option 9.1 - The Contractor shall supply and install cab signal equipment, as separately specified by the Purchaser.######

######Option 9.2 - The Contractor shall install cab signal equipment provided by the Purchaser.######

c) Provisions shall be made for installation of Purchaser provided fare collection equipment in an approved location. Design details shall be supplied by the Purchaser. The Contractor shall provide all wiring, power supply, mounting hardware and support structure as required.

d) Provisions shall be made for electrical interface with primary power for moving cars in and out of the repair shops with the power collector in the locked down position. Details of the shop power supply feed equipment shall be made available by the Purchaser to the Contractor as required.

e) @@@@@@@Baseline - No provisions shall be made for installing traffic signal pre-emption equipment.@@@@@@@

######Option 10 - Space shall be provided for future implementation of traffic signal pre-emption equipment. These provisions shall be limited to mechanical aspects only, i.e. space to mount the equipment and run its associated wiring.######

######Option 10.1 - The Contractor shall supply and install traffic signal pre-emption equipment as separately specified by the Purchaser.######

######Option 10.2 - The Contractor shall install traffic signal pre-emption equipment provided by the Purchaser.######

2.2 Performance Requirements

The following paragraphs establish the performance required of the Light Rail Vehicle as an integrated system. Equipment shall be designed for compatible interfaces to successfully produce the specified performance values. The basis of design shall be as follows:

a) All acceleration and braking rates shall be based on level tangent dry track in still air except as otherwise noted;

b) All specified acceleration requirements shall be based on AW0 through AW2 car weights. All specified braking requirements shall be based on AW0 through AW3 car weights;

c) The propulsion and braking system* shall permit a crush loaded (AW3) operative car to push or pull a crush loaded (AW3) inoperative car between any two adjacent stations, at degraded performance, followed by a run, also at degraded performance, with both vehicles empty (AW0) to the nearest maintenance or storage facility making all safety stops and speed reductions without subjecting the traction equipment to injurious temperatures;

######Option 3.2 - The above "push or pull" strategy shall apply to two trains with as many as four cars each (i.e. resultant train of eight cars, four of which are inoperative);######

d) @@@@@@@Baseline - Equipment shall be designed for specified performance at 550 Vdc to 720 Vdc and with reduced performance outside this range. Equipment shall be tested for specified performance at 575 Vdc;@@@@@@@

######Option 8 - ******Purchaser to specify details in accordance with a nominal 750 Vdc primary power system;******######

e) Equipment controls shall be operable from the maximum converter output voltage level to 60 percent of the open circuit voltage of the batteries;

f) All specified performance requirements shall be maintained over the specified range of wheel wear;

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* Assumes adhesion is not lost. This is a capacity and duty cycle type of requirement.

2.2.1 Acceleration Requirements. The Light Rail Vehicle shall provide acceleration capabilities as follows:

a) Full acceleration of 1.34 m/s^2 (3.0 mphps) ± 10% at car weight AW2 from 0 to at least 36 km/h (22 mph). The maximum step change in acceleration, either modulation changes or variations about the average rate due to propulsion control shall not exceed 0.27 m/s^2 (0.6 mphps);

######Option 12.1: Load Compensation - The instantaneous acceleration shall not very more than 20% for a variation in car weight from AW0 to AW3.******

b) @@@@@@@Baseline - For the nominal line voltage at the trolley wire and car weight of AW2, the time to reach 80 km/h (50 mph) from a standstill shall not exceed 58 seconds;@@@@@@@

######Option 11 - For the nominal line voltage at the trolley wire and car weight of AW2, the time to reach 80 km/h (50 mph) from a standstill shall not exceed 37 seconds;#######

c) An initial acceleration rate of at least 0.22 m/s^2 (0.5 mphps) ± 10% shall be available to the operator at the minimum power position of the master controller.

2.2.2 Balancing and Continuous Speed Requirements. The vehicle operated singly shall have a balancing speed of no less than 80 km/h (50 mph) on level tangent track with any condition of wheel wear, nominal line voltage, weight AW2 and still air. The propulsion system shall contain a feature which removes power from the traction motors when they approach the maximum permitted rotational speed. Propulsion and drive unit apparatus shall be designed to operate continuously at the balancing speed as achieved under the above conditions without damage, heating or wear in excess of values used to calculate design life.

2.2.3 Deceleration Requirements

2.2.3.1 The service braking system, excluding track brakes, shall provide braking capability over the entire speed range up to overspeed cut-off, and independent of trolley voltage, in accordance with the following definitions:

a) Maximum allowable instantaneous deceleration at car weight AW2 — 1.83 m/s^2 (4.1 mphps)

b) Minimum guaranteed instantaneous full deceleration at car weight AW2 except during required jerk limiting — 1.25 m/s^2 (2.8 mphps)

c) Minimum instantaneous deceleration available to operator at car weight AW2 — 0.09 m/s^2 (0.2 mphps)

d) The maximum allowable dead time between brake command and initial response is 0.4 seconds (reference Paragraph 2.2.8).

e) Service braking shall include both dynamic and friction brakes, blended if necessary, jerk limited per Paragraph 2.2.6 and meet the above performance. In the event of dynamic brake failure, the friction brake system shall have the capability of providing a minimum guaranteed instantaneous deceleration of 1.25 m/s^2 (2.8 mphps) over the entire speed range for car weight AW2, except during the required jerk limiting. Friction brake duty cycle (capacity) is specified in Paragraph 12.5.5.

f) @@@@@@@Baseline - For any braking command, braking tractive effort may be constant for all car weights from AW0 to AW3, with deceleration rate changing inversely proportional to car weight.@@@@@@@

######Option 12.1 - Load compensation shall be provided as specified in Paragraph 2.2.7. It shall provide braking response as required above. The instantaneous deceleration rate shall not vary more than 20% for a variation in car weight from AW0 to AW3.######

2.2.3.2 The emergency braking system shall utilize the capabilities of the service brake plus the application of magnetic track brakes and automatic application of sand to the tracks. Emergency brake application shall not be jerk limited and shall be interlocked to effect an irretrievable stop and balance all doors. Emergency braking rates shall be available as follows for vehicle weights up to AW3.

a) At brake entry speed of 80 km/h (50 mph) the average emergency braking rate ($V^2/2D$) shall be not less than 2.64 m/s^2 (5.94 mphps).

b) At brake entry speed of 48 km/h (30 mph) the average emergency braking rate ($V^2/2D$) shall be not less than 2.45 m/s^2 (5.51 mphps).

@@@@@@@Baseline - Only one stage of track brake effort shall be available to the operator as an addition to the friction/dynamic brake effort.@@@@@@@

######Option 13 - Three stages of track brake effort shall be available to the operator as an addition to the friction/dynamic brake effort as he requires. These stages shall provide 70, 90 and 100% of maximum track brake attraction force. The maximum track brake attraction force shall be applied during emergency braking.######

During emergency brake application, the service friction brake system, with dynamic brakes and track brakes inoperative, under a single point failure shall not experience more then _____*_____% loss of braking.

* Purchaser to supply this value based upon the site specific safe stopping distance.

2.2.4 Wheel Spin/Slide Protection

@@@@@@Baseline - Wheel spin/slide protection shall not be provided.@@@@@@

######Option 14 - A system shall be provided to detect and control wheel slide and spin on each car. The spin/slide system shall be fail-safe; such that the normal system failure mode will render the spin/slide system ineffective and will not prevent the application of service brakes at any rate less than desired.

2.2.4.1 The spin/slide system shall be functional under all acceleration and all service braking commands. Corrections for wheel slide shall not be attempted if an emergency brake application is commanded. Failure of any component in the spin/slide system shall not prevent development of an emergency brake application as specified in paragraph 2.2.3.2.

2.2.4.2 Upon detection of a spin during acceleration, power shall be reduced on the affected car on a non-jerk limited basis until the spin is corrected. Power shall be re-applied automatically under jerk limited control.

2.2.4.3 Upon detection of a slide during service braking the dynamic braking shall be reduced on the affected car until the slide is corrected. Friction braking shall be reduced or removed from the affected truck until the slide is corrected. After the slide has been corrected, service braking shall be automatically reapplied at a deceleration consistent with providing maximum performance without exceeding the jerk limit. The jerk limit may be exceeded only with the approval of the Purchaser.

2.2.4.4 Spin-slide efficiency is defined as the average car deceleration or acceleration rate (mphps) expressed as a percentage of the rate which available adhesion is capable of supporting. An equivalent definition is the percentage of theoretical distance traveled based on available adhesion (Perfect Stop/Perfect Start) to the actual distance traveled during any continuous sequence of wheel slip operation (Actual Stop/Actual Start). At a coefficient of adhesion of 0.1 or greater, the efficiency of the Light Rail Vehicle wheel spin/slide protection system shall be at least 40% in acceleration and 75% in braking over the speed range between maximum and approximately 8 km/h (5 mph).

2.2.4.5 Detection of a spin or slide shall permit limited slip of up to 20% in all modes and at all vehicle speeds. The wheel spin/slide protection system shall function properly with differences up to 50 mm (2 in) in diameter among the wheels of a vehicle (but not on same axle). Calibration adjustments for wheel diameter variations shall be included easily accessible with the spin/slide control enclosure.######

2.2.5 Blending

2.2.5.1 Continuous blending of dynamic and friction service brakes is not required. Dynamic brakes shall produce as much of the braking rate

as capable down to the fade out point. Friction brakes shall normally supplement the dynamic braking by providing the braking force for vehicle speeds below the dynamic brake fade out point. Both systems shall be controlled by the same Master Controller in a manner that a smooth transition occurs in the transfer between dynamic and friction brake systems and deceleration is automatically maintained as called for by the position of the controller when dynamic braking fails. At the respective dynamic and friction brake "lock out" and blend points, the momentary variations in deceleration shall not exceed $\pm$ 0.22 m/s^2 ($\pm$ 0.5 mphps). When emergency brakes are commanded, this "lock-out" feature shall be by-passed.

2.2.5.2 As an alternative to the requirements of Paragraph 2.2.5.1 above, the Contractor may supply continuously blended dynamic and friction service brakes. If this is done, the dynamic brake and friction brake systems working in unison shall provide the desired braking rate throughout the operating range.

The blending circuit shall be designed so that absence of any braking input signal shall result in full friction brake application. In addition, the blending circuit shall perform the indicated functions within the jerk limit and performance criteria specified.

######Option 2 (Articulated Car) - During blending, the friction brakes of the center truck, in response to the service brake command signal, shall provide a nominal portion of the required brake effort, commensurate with its share of the total vehicle load at AW2.######

2.2.6 Jerk Limit. In response to a step input command signal, the rate of change of acceleration or deceleration shall be not less than 1.12 m/s^3 (2.5 mphpsps) or more than 1.79 m/s^3 (4.0 mphpsps) for car weight AW2 under all normal operating conditions. Rate change requests less than the jerk limit shall follow the command signal within specified accuracy limits. Jerk rate achieved by dedicated circuits shall produce essentially linear outputs and shall be designed such that maximum available braking rate shall not be reduced due to failure within the circuits.

a) The jerk rate limits specified shall apply to all normal power and service braking applications and to re-applications of power and braking when controlled by the spin/slide protection system.

b) Release and application of power when traversing primary power isolation gaps need not be jerk limited.

c) Emergency brake applications shall not be jerk limited.

d) Friction brake release at zero speed need not be jerk limited.

e) For immediate changes from power to brake (with no stop in coast position), the power release shall not be jerk limited.

2.2.7 Load Compensation Requirements

@@@@@@Baseline - Load compensation shall not be provided.@@@@@@

######Option 12 - Load compensation is not required. However, if the Contractor wishes to supply such compensation, the following requirements (Option 12.1) shall apply.######

######Option 12.1 - A load compensation system shall be provided to maintain the propulsion and braking requirements of paragraph 2.2.1 and 2.2.3 for any vehicle load between AW0 and AW3.

Failure of the load compensation system shall not result in acceleration or braking effort less than normally provided for AW3 car weight.######

2.2.8 Control Response Time. The maximum allowable dead times (exclusive of jerk limit response time) for all detection and control systems in response to a step input command shall be as follows:

a)	Modulation within a power or dynamic brake mode (Rheostatic propulsion control)	0.2 second
	Modulation with a power or dynamic brake mode (Chopper propulsion control)	0.1 second
b)	Power mode to coast mode	0.2 second
c)	Coast mode to brake mode	0.2 second
d)	Modulation of friction brake effort at any brake request level	0.2 second
e)	Emergency brake request from any mode	0.2 second
f)	######Option 14 - Spin-slide control	0.1 second######

2.2.9 Control and Interlock Signals. Propulsion and braking systems shall respond to either local or trainlined traction command signals within limitations and accuracy indicated.

a) Mode Selection. Selection of propulsion or braking mode shall be a direct result of the Master Controller position. The Master Controller shall be designed and circuitry arranged to follow the fail-safe principle so that loss of signal shall initiate a maximum service brake application.

b) Emergency Command signals shall override jerk limit and slip control to apply service brakes and track brakes and accomplish an irretrievable stop. The emergency signal shall originate from the Master Controller position, "dead man" control, or the emergency switches or valves located within the car.

######Option 3.2 - The emergency command shall be a trainlined function. In multiple-unit operation, an undesired separation of the trainlined electric and/or pneumatic functions shall cause an emergency brake application on all cars in the train.######

c) ######Option 3.2 - Direction signals shall be a pair of trainline functions, individual energization of which shall determine the direction of operation. Activation or non-activation of both functions at the same time shall inhibit propulsion.######

######Option 1 - Direction signals shall originate at the forward operator's console. Selection shall be "forward" or "reverse". The reverser control shall be mechanically or electromechanically interlocked with the transfer switch to prevent local reverser operation when not in the "operate" position of the switch.######

d) ######Option 3.2 - Propulsion and Braking trainlined electrical command signals shall be essentially linear and fail-safe in design.######

2.2.10 Audible Noise and Vibration

2.2.10.1 Definitions

a. Unless otherwise specified, noise is defined as per the latest version of ANSI S1.2 and S1.13 to mean sound pressure level measured in decibel (dB) referenced to 20 micropascals.

b. Overall noise levels are measured in dB on the A-scale with slow meter response setting for stationary vehicle measurements, with fast meter response for moving vehicle measurements. A sound level meter in accordance with the latest version of ANSI S1.4 is to be used. For octave and 1/3 octaveband measurements, filters in accordance with the latest version of ANSI S1.11 are to be used.

c. For measurements under steady operating conditions the period of observation shall be 5 seconds.

d. All measurements of exterior noise levels shall be made on level ground at a distance of 15 m (50 ft) from the centerline of the track, 1.5 m (5.0 ft) height above ground, in an essentially free-field environment such as outdoors, away from any reflecting surfaces other than ballast, ties, track and the adjacent ground.

e. All measurements of interior noise levels shall be made at points 300 mm (1 ft) away from any vertical surface at a height of 1.2 m (4 ft) above the vehicle floor in a fully equipped car with no personnel on board other than the person performing the measurements.

f. Specified noise limits are for normally operating equipment and do not apply to that which operates occasionally, such as a circuit breaker or pneumatic pressure relief device.

2.2.10.2 Pure Tones. The noise limit must be reduced by 3 dB if significant pure tones in the range of the one-third octaveband center frequencies from 250 Hz to 4,000 Hz are present in the noise. Pure tone noise shall be considered significant in this context if any one-third octaveband sound pressure level is 5 dB, or more, higher than the arithmetic average of the two adjacent bands containing no pure tones.

2.2.10.3 Interior Noise. With all auxiliary equipment simultaneously operating under all normal operating conditions, the speech interference level (SIL) at all locations in the car shall not exceed 70 dB. SIL shall be the preferred speech interference level consisting of the arithmetic average of the sound pressure levels measured at the octaveband center frequencies of 500, 1,000 and 2,000 Hz.

2.2.10.4 Wayside Noise Limits. Average noise levels emanating from the car shall not exceed the following levels with all auxiliary equipment operating simultaneously:

Vehicle stationary, empty	65 dBA
Vehicle moving, empty, on tangent track at 65 km/h (40 mph)	75 dBA

The track conditions for these measurements shall be as specified in Section 2.2.11 with newly ground rail.

2.2.10.5 Equipment Noise

2.2.10.5.1 Equipment Noise Prior to Installation on Car

a) Noise levels produced by each traction motor shall not exceed 85 dBA at 5 m (16 ft) from the center of the motor, in any direction, while operating at all speeds from zero to the equivalent of 80 km/h (50 mph) car speed and at loads equivalent to maximum dynamic braking in either direction.

b) Noise levels produced by each propulsion system gearing shall not exceed 85 dBA at 5 m (16 ft) from the geometric center of each gearbox, in any direction, and with gears rotating in either direction at all speeds from zero to the equivalent of 80 km/h (50 mph) car speed and at all loads equivalent to maximum dynamic braking.

c) Noise produced by the individual operation of all under car equipment which normally operates (except traction motors, gears and equipment which only operates occasionally, such as a circuit breaker or pneumatic venting device) shall not exceed 80 dBA at 5 m (16 ft) from the center of the equipment while it is operating under normal conditions and loads.

Under car equipment includes air comfort systems, motors, and generators, blower, brakes, compressors, valves, and other noise generating components.

2.2.10.5.2 Equipment Noise After Installation on Car

a) Noise levels produced by traction motor(s) and gear set(s) of a complete truck, mounted under the car body, with all wheels spinning under no-load conditions at all speeds from zero to the equivalent of 80 km/h (50 mph) shall not exceed 85 dBA at a distance of 5 m (16 ft) from the center of the truck on the horizontal plane passing through the axle shafts.

b. Noise levels produced by the individual operation of all under car equipment and operating systems which normally operates, except traction motors, gears and equipment which only operates occasionally, such as a circuit breaker or pneumatic venting device, shall not exceed 65 dBA at 5 m (16 ft) from the car centerline on either and on the horizontal plane passing through the shaft or equipment centerline while the equipment is operating at normal conditions with the car at rest. The equipment must be complete, installed under the car, and all components of each system operating during tests for noise levels.

2.2.10.6 Noise Analysis. The Contractor shall provide the Purchaser with a noise analysis of the car to show how the noise levels required in Paragraphs 2.2.10.3 and 2.2.10.4 he will achieve by using the noise levels specified in Paragraph 2.2.10.5 and other means, such as location and insulation. This analysis shall be submitted for its approval along with other drawings and documentation as outlined in Subsection 1.5.

An analysis and the requirements in Paragraph 2.2.10.5 can be waived if the Contractor can provide verifiable noise data that show that the requirements in Paragraphs 2.2.10.3 and 2.2.10.4 will be met. These data must be collected under acceptable similar conditions as are specified in Paragraphs 2.2.10.1, 2.2.10.3 and 2.2.10.4. They must be for an operating car built by the Contractor, and the car must be of an acceptable similar design to the car in this contract.

2.2.10.7 Vibration. Equipment and auxiliaries mounted anywhere on the car, car body, or trucks shall not cause vertical or horizontal vibrations anywhere on the vehicle floor, walls, ceilings, panels, and seat frames in excess of 0.04 g peak at any frequency up to 60 Hz. The vibration of any traction motor, shall conform with the requirements of IEEE No. 11.

2.2.11 Ride Criteria. The ride quality of the vehicle shall be evaluated on test sections of ballasted track at a location agreed upon by the Purchaser and Contractor with welded rail maintained within the alignment limits as follows:

a)	Gauge	± 3 mm (± 1/8 in)
b)	Warp (tangent)	± 6 mm (± 1/4 in) of cross level in 945 mm (31 ft)
c)	Superelevation	± 6 mm (± 1/4 in of cross level in 945 mm (31 ft)
d)	Horizontal alignment (tangent)	± 6 mm (± 1/4 in) in 1,890 mm (62 ft)
e)	Horizontal alignment (curve)	± 6 mm (± 1/4 in) from designated ordinate, 1,890 mm (62 ft) chord

The track modulus (or rail support modulus of elasticity) will be at least 525 N/mm (3,000 lbs/in). Under these conditions, vertical and horizontal accelerations measured over the truck center on the floor of a car uniformly loaded shall not exceed the acceptable limits indicated on the ride criteria graph, Figure 2-1.

2.2.12 Weight Distribution. Design of the vehicle and arrangement of attached equipment shall be such that the following limits of weight variation and balance are maintained, and shall be met with vehicle standing on level, tangent track.

a) The weight balance between all motored trucks shall be within five percent with AW0 vehicle weight.

b) ######Option 2 (Articulated Car) - Weight carried by the center truck shall be no less than 20% and no greater than 32% of total vehicle weight with all seats occupied and uniform standee load distribution on standee area at AW2.######

c) In addition to meeting the weight distribution limits above, a vehicle uniformly loaded to AW2 shall not have any wheel support load that exceeds 110% of the load on any other wheel of the same truck.

d) Load on wheels on one side of any truck shall not differ by more than 2% from load on opposite side wheels for vehicle weight of AW0.

2.2.13 Electromagnetic Interference. The Contractor shall ensure that the electrical, electronic, and communication subsystem shall operate without suffering or causing harmful interference because of electromagnetic radiation or response. The Contractor shall control the electromagnetic radiation and the susceptibility of purchased and subcontracted equipment and components, and shall install and progressively test the various subsystems to demonstrate protection against false energy miscodes and improper codes.

The testing methods should be those indicated in the document entitled "Recommended Practice - Rail Transit Intra System Electromagnetic Compatibility Vehicular Electrical Power and Track Circuit Signaling Subsystem" prepared by the Transportation Systems Center, for the UMTA Office of Rail and Construction Technology.

2.2.14 Maintainability. The objectives of the maintainability program shall be:

a) Enhancement of vehicle availability;
b) Minimization of maintenance costs;
c) Minimization of vehicle downtime; and
d) Utilization of present labor skill for existing properties, minimization of special and high skill levels required for maintenance.

Modular design principles shall be employed to the greatest extent practical. Modular design shall be defined as:

> Packaging electrical and mechanical components together in replaceable sub-assemblies according to the logical function which they perform and using standardized dimensions and components to achieve flexibility in use. Components or sub-assemblies requiring occasional removal shall be plug-in units, adequately identified and secured and keyed to prevent misapplication.

The need for adjustments shall be avoided wherever possible. Adjustment points shall be readily accessible, adequately identified and self-locking to prevent inadvertent operation and drift.

2.2.14.1 Accessibility. All systems and components serviced as part of periodic preventive maintenance shall be readily accessible for service and inspection. Removal or physical movement of components unrelated to the specific maintenance and for repair tasks involved shall be unnecessary. Relative accessibility of components, measured in time to gain access, shall be inversely proportional to frequency of maintenance and repair of the components.

2.2.14.2 Interchangeability. Assemblies or components that are functionally interchangeable shall be physically interchangeable. Modular or plug-in assemblies that are not functionally interchangeable shall not be physically interchangeable.

2.2.14.3 Maintainability Design Checklist. The following list shall be considered in the design for maintainability:

a) Systematic fault isolation procedures shall be developed for inclusion in the maintenance manuals.

b) Built-in test points shall be provided and marked. These are to be used with standard test equipment and any special (portable) test equipment.

c) Failure indicators shall be provided and identified.

d) All test points, fault indicators, modules, wire junctions, pipes, tubes, wires, etc. must be identified by name plates, color coding, number coding, or other means to assist the maintenance personnel.

e) The placements of components in equipment cabinets, enclosures, or confined places shall give the most accessible positions to those items requiring the most frequent maintenance or adjustment.

f) Door panels and openings shall be of sufficient quantity, size and placement to permit ready access from normal work areas.

g) Standard commercially available industrial components and hardware shall be used wherever possible.

h) Captive fasteners shall be used on covers and access panels where periodic maintenance and inspection is to be carried out. Fasteners exposed in the passenger compartment shall be tamperproof; unless specified otherwise.

i) Access shall be provided, to the greatest extent possible, to structural components to allow inspection for cracks and corrosion.

j) Major components shall be designed for ease of removal. Provide handles as applicable, on heavy equipment or less accessible components.

k) Means shall be provided to verify the operability of redundant hardware components, and their switching devices, during maintenance, troubleshooting and testing.

l) Shall require minimum special tools.

2.2.14.4 Maintainability Assurance Procedure. At every design review meeting the Manufacturer shall discuss the progress made and improvements proposed on maintainability issues for approval by the Purchaser.

2.2.14.5 Corrective Maintenance. The Manufacturer shall, as part of the Technical Proposal, submit proposed Mean Time to Restore (MTTR) in vehicle-hours and the Mean Person Time to Restore (MPTTR) quotes for:

- The entire vehicle, excluding Purchaser provided equipment;
- ######Option 3 - coupler, draft gear, and train line connecting apparatus######
- Doors and controls; ######Option 6 - including movable steps######
- Air comfort system; ######Option 25 - including air conditioning######
- Auxiliary electric equipment and wiring;

- o Propulsion system and control;
- o Truck assemblies not including propulsion or brakes covered elsewhere; and
- o Friction brake system and controls.
- o ######Option 2 - articulation section changeout######

These quotes shall either be based on analysis of or on data from similar or identical vehicles in revenue service.

2.2.14.6 Preventive Maintenance. Elapsed time to perform preventive maintenance (exclusive of servicing) on the vehicle shall not exceed four hours. Preventive maintenance shall not be required more often than every two months, each preventive maintenance occurrence shall not require more than ten person hours per vehicle. Inspections or checks performed daily or whenever a car is put into service are not considered as part of this preventive maintenance.

2.2.14.7 Servicing. Servicing (exclusive of interior and exterior cleaning and fare box service) shall be restricted to the replenishment of consumables, such as oil, grease and other fluids, cleaning or replacement of filters, and inspection of brake pads. Servicing shall not be required more often than every 30 days and shall not require more than one hour in elapsed time nor more than 2 person hours per vehicle. Refilling of sand boxes and windshield washing fluid containers shall not be covered under this requirement but shall depend on demand.

2.2.14.8 Maintenance Plan. A maintenance plan, outlining all schedules and activities for preventive maintenance and servicing, including inspection frequencies and inspection activities shall be submitted for approval together with the proposed maintenance manuals and drawings. This plan shall outline each task, time required, tools necessary, personnel and skill levels required. In addition, the maintenance plan shall provide a troubleshooting guide as part of the maintenance manual which assists maintenance personnel in locating faulty components.

2.2.14.9 Maintenance Demonstration. As part of the maintenance personnel training program all servicing, preventive maintenance, troubleshooting, change-out of components and assemblies, and vehicle movement in disabled conditions shall be demonstrated.

2.2.14.10 Maintainability Verification. The quoted and approved MTTR's as per Paragraph 2.2.14.5 shall become contractual requirements and shall be verified during the same time period during which reliability measures are verified as per Paragraph 2.2.15.

2.2.15 Reliability. The vehicle and subsystem reliability requirements are established in the following paragraphs.

2.2.15.1 Definitions.

The reliability terminology used in this specification conforms to the definitions in the American Public Transit Association (APTA), February, 1978 publication, Rapid Transit Systems Glossary of Reliability, Availability, and Maintainability Terminology for Rail Rapid Transit, which defines reliability as the probability that a system or system subunit will perform satisfactorily for a given period of time when used under stated conditions.

The following are in addition to the APTA definitions:

- Cumulative MDBF - The total accumulated operating distance divided by total accumulated failures of the system or system subunit.

2.2.15.2 Vehicle Reliability. The vehicle shall meet or exceed an overall reliability of _____ MDBF. In addition, the Manufacturer shall, as part of the Technical Proposal, quote a MDBF for:

- ######Option 3.2 - coupler, draft gear, and train line connecting apparatus;######
- Doors and controls, ######Option 6 - including movable steps;######
- Air comfort system, ######Option 25 - including air conditioning;######
- auxiliary electric equipment and wiring;
- Propulsion system and control;
- Truck assemblies not including propulsion or brakes covered elsewhere; and
- Friction brake system and controls.
- ######Option 2 -Articulation Section######

These quotes shall either be based on analysis or on data from similar or identical vehicles in revenue service. A subsystem in the above context shall be the complete set of equipment such as all two or three truck assemblies, all doors and controls, all propulsion units and controls, etc.

The relationships between vehicle distance traveled, vehicle time, door cycles, etc. shall be consistent with the system description and operations information provided by the Purchaser in Section 1.

2.2.15.3 Reliability Verification. The MDBF's quoted per Paragraph 2.2.15.2 shall become contractual requirements and shall be verified while the vehicles are operated in revenue service on the Purchaser's property. The Purchaser shall record and maintain all data necessary for reliability verification. A pass/fail criteria which allows for reliability growth shall be applied as follows:

a) Verification Period.

The verification period begins after a burn-in period which is 2,500 km (1,500 mi) after acceptance of a vehicle. A vehicle must complete its burn-in period before it is included in the population under test. The verification period terminates whenever the requirement has been demonstrated or at the end of the normal warranty period of the last vehicle accepted, whichever is earlier.

b) Definition of Parameters.

Cumulative MDBF = D/F

Where

D = Total accumulated operating distance for the population of systems or system subunits under test.
F = Total accumulated failures of the population of systems or system subunits under test.

$$\text{Current MDBF} = \frac{\text{Cumulative MDBF}}{(1-S)}$$

Where "S" is the reliability growth parameter, which is defined in (f) below:

c) Earliest Possible Acceptance Demonstration Point.

This is the first point at which it shall be possible to demonstrate that a quoted MDBF has been met. It is a distance equal to the product of the number of systems or system subunits in the population under test and the quoted MDBF for the system or system subunits. This point will increase in distance directly with the addition of vehicles to the population under test, however, the average for that population remains constant. Because of the procedures in (f) below, this point cannot occur earlier than in five weeks of test date.

d) Measurement Intervals.

The data shall be computed at weekly intervals.

e) Sample Size.

The sample size shall be as agreed upon between the Purchaser and the Contractor, in accordance with Section 4.5 of "Reliability Verification Demonstration Plan for Rapid Rail Vehicles".*

f) Procedure.

The logarithm of the cumulative MDBF (log D/F) of a system or system subunit shall be plotted on the ordinate against the logarithm of the

* "Reliability Verification Demonstration Plan for Rapid Rail Vehicles", Report No. R-340U, April 1981, Prepared by Dynamic Research Corporation for the U.S. DOT, Transportation Systems Center, Contract DOT-TSC-1559.

cumulative operating distance (log D) on the abscissa. A "best fit" linear regression of the data points shall be made. The slope of the resultant straight line shall be "S" which is to be used in computing the current MDBF. There shall be at least five data points (resulting from five weeks data) for the first linear regression calculation of "S".

g) Pass Criteria.

Each system or system subunit shall have demonstrated acceptable reliability when its current MDBF has equalled or exceeded a ratio (R_a)* of the quoted MDBF at or after the earliest possible acceptance demonstration point, or has remained equal to or greater than a ratio (R_f)* of the cumulative MDBF for the entire verification period.

h) Fail Criteria.

If the current MDBF of a system or system subunit becomes less than a ratio (R_f) of the cumulative MDBF then the requirements of Paragraph 2.2.15.4 shall be applied. R_f shall be greater than or equal to one.

2.2.15.4 Reliability Improvement Effort. The Manufacturer shall establish and maintain a reliability improvement effort for each of the systems or subsystems when the fail criteria of Paragraph 2.2.15.3 is met. The intensity of the effort shall be such that each of the systems or subsystems shall demonstrate the quoted reliability before the end of the warranty period. Such efforts may include design changes and recommendations to the Purchaser for training and changes in procedures. All efforts shall be reviewed with and agreed to by the Purchaser.

2.2.15.5 Reliability Committee. A reliability committee shall monitor the vehicle reliability program and determine verifications (See General Provisions).

2.2.15.6 Transit Reliability Information Program (TRIP). The UMTA Transit Reliability Information Program (TRIP) uses a Generic Part Number (GPN), a twelve-character code which provides a universal, computer-recognizable identity for components which are used on more than one car design, but which perform equivalent functions. TRIP also uses a seven-character Generic Serial Number (GSN) to uniquely identify: Transit Authority, car-type and car number.

Together, the GSN and GPN describe specific, as opposed to generic, equipment applications.

The contractor shall generate a GPN for each component of the car. This set of GPN's shall then be made available for reliability analyses of and comparisons with equivalent components and assemblies having known field histories.

* Ratios R_a and R_f are to be agreed upon between the Purchaser and Contractor in accordance with Section 4.6.1 of the report "Reliability Verification Demonstration Plan for Rapid Rail Vehicles".

Additional information concerning the TRIP Program, the GPN, and the GSN can be obtained by contacting the:

TRIP Program Manager, Code 722
Office of Ground Systems Center
Transportation Systems Center
Kendall Square, Cambridge, MA 02142

2.2.16 Energy Consumption

2.2.16.1 Purpose. For the purpose of determining a value for vehicle energy consumption (kWh/veh.km), an energy consumption verification test shall be defined. The actual operating route shall be adequately represented on a flywheel dynamometer test stand or propulsion load simulator, by a sequence of flywheel-loaded synthetic runs, collectively called a synthetic route. The synthetic route is to be arranged to represent the actual route between the (TBS)* and (TBS) stations.

2.2.16.2 Requirements. The Bidder is required to:

a) Submit with his proposal a calculation of total vehicle inertia and energy consumption (and other test related data as indicated in Appendix Section A.2) for each and any configuration of the propulsion system offered, over the synthetic route. The Bidder shall use a (TBS)* value of line receptivity as a limit for regenerated energy; and

b) If awarded the contract, subsequently verify such calculations by test stand demonstration at his facility, and meet the bid obligation or accept the penalty.

The synthetic route to be defined is used only for the purpose of evaluation and comparison of the propulsion system energy consumption rate as delivered, to the bid value. The synthetic route does not in any way dictate the overall performance of the propulsion system.

2.2.16.3 Synthetic Route Demonstration Test. A definition and description of the energy consumption verification test is contained in Appendix A of the Specification.

2.2.16.4 As-Delivered Vehicle Energy Consumption. The successful Bidder will determine the as-delivered energy consumption rate for the as-delivered car weight and the actual as-delivered rotational inertia. This determination shall be made immediately after cars have been weighed, which will be not later than the date of acceptance of the (TBS) cars. The data will be obtained by interpolating no fewer than (TBS) test stand tests using a range of predicted weights and inertias.

*(TBS): To be specified by the Purchaser. These are numerical values or names, to be used as references, etc.

2.3 Design Verification Requirements

Proof and verification of vehicle design shall be demonstrated to the Purchaser by the use of three basic engineering tools:

a) Testing of components, systems, combination of systems and completed vehicles;

b) Submittal of drawings, photographs, calculations, analyses and design data (see Subsection 1.5); and

c) Production of models, mock-ups and samples.

2.3.1 Testing. The complete Light Rail Vehicle system shall be subjected to a comprehensive test program to substantiate the design and performance characteristics, assure operational compatibility with the transit system, and in some cases, determine the service lives of systems and components to optimize reliability and maintainability characteristics. The non-technical requirements concerning test plans, procedures, reports, conditions and allowance for waivers of test requirements are given in the General Provisions.

2.3.1.1 Component/System Acceptance Tests Component acceptance tests shall be performed on all units of the indicated items prior to vehicle installation. These tests shall not be waived by the Purchaser.

a) DC Traction Motor routine acceptance tests shall be performed in accordance with the requirements of IEC349 or IEEE No. 11.

b) Traction gear acceptance tests shall be performed on all gear units. The units shall be tested at no-load at 80 km/h (50 mph) equivalent car speed for 10 minutes in each direction. During the routine tests, the noise and vibration produced by each gear unit and the gear sump oil temperature shall be continuously monitored. All gear units which produce oil temperature or noise beyond the limits established in these specifications shall be rejected.

c) Motor Generator/Alternator acceptance tests shall be in accordance with IEEE No. 11.

d) Static Converter acceptance tests shall include the following:

All units shall be subjected to a high potential test in accordance with the recommendations of IEEE #16 or IEC 77.

Output voltage shall be adjusted to be within $\pm 1\%$ of the specified nominal output voltage.

Output current limit shall be adjusted to be within ± 1 ampere of the contractor's stated nominal rated output current. In the event the converter design for current limit function incorporates two

or more break points, the current or voltage setting at the additional points shall be adjusted to be within ±1% the contractor's stated nominal value.

Over voltage and under voltage shut off points shall be adjusted to be within ±1% of the specified values.

Each converter shall be run for one half hour at rated output voltage and current with nominal input voltage.

Proper functioning of safety interlocks shall be demonstrated by exercising the function.

All other features such as time delay relays, layover shutdown, etc. shall be exercised and adjusted if required to be within ±1% of specified values where appropriate.

e) Watertightness Tests. All car bodies shall be subjected to a complete test for watertightness. All exterior appointments which may affect watertightness of the car body such as destination signs, indication lights and crew switches shall be installed at the time of this test. The test shall be made before installation of sound deadening material, thermal insulation and interior finish which would conceal the interior of the sides and ends. The water shall be sprayed from a nozzle configuration that will fully test the sides, roof and ends of the cars. The orifice opening in the nozzles shall be 6 mm (0.25 in) diameter. The spray-cone from each nozzle shall overlap the adjacent cones.

All spray applications shall run for 10 minutes before the inspection for leaks begins and shall run continuously during the inspection.

The pressure of the water during the test shall simulate the conditions existing at a car speed of at least 88 km/h (55 mph).

f) Pneumatic Systems, if included, are to be tested for leaks during production at 100% of main reservoir pressure.

2.3.1.2 Acceptance/Qualification laboratory tests shall be performed on the following items:

a) DC Traction Motor qualification tests shall be performed in accordance with the requirements of IEC 349 or IEEE No. 11, except that stray load losses may be calculated as a percentage of no load core loss. A total qualification type test shall be conducted on at least 1% of the traction motors to be supplied, picked at random by the Purchaser.

This qualification test of the traction motor shall not be waived by the Purchaser.

b) Traction gear unit qualification test shall be a 100 hour test on one gear unit which shall be axle mounted with load simulation or on a propulsion load simulator. The test shall subject the unit to conditions that are in general 20% more severe than would occur under the most extreme operating conditions (i.e., power is increased by 20%). Decelerations shall include the effect of dynamic braking.

The test shall be started with the unit at room temperature, 15^{o} to 32^{o} C (60^{o} to 90^{o} F). A fan or other device shall be provided so that the temperature rise as (measured in the oil sump) shall not exceed the gear oil supplier's recommendations for maximum temperature consistent with the specified life between oil changes, as called out in the contractor's maintenance manuals. The direction of rotation shall be reversed every successive hour until the 100-hour test is completed. Noise tests as specified in this section shall also be performed.

During the test, the gear unit shall display no signs of excessive heat, noise, or vibration. If during test the gear unit indicates distress, only three intervals of 20 minutes each shall be allowed for maintenance and repair purposes. After completion of the test, the gear unit shall be disassembled and all parts examined. Any sign of unusual deterioration of any part shall be investigated jointly with the Purchaser. The Supplier shall submit to the Purchaser, for approval, his report of the test results and his recommendations for such modifications as may be necessary to meet the requirements of these specifications. This report shall include test records of running time, oil temperatures, vibration and sound level readings taken at such intervals as required to verify compliance with these specifications.

c) Motor generator/alternator qualification tests shall include normal commercial tests in accordance with IEEE No. 11. In addition the qualification tests shall include heat runs and tests to determine the effects of high transient line voltages.

d) Static Converter qualification tests shall be run on one converter low voltage power supply. The unit shall first have successfully completed the acceptance tests outlined in Paragraph 2.3.1(d). The qualification tests shall include the following:

(1) A continuous heat run at nominal input voltage and rated output voltage and current. The heat run shall be of sufficient duration to allow all critical elements to stabilize in temperature. Temperature rises over ambient shall be within contractor's limits as set forth in the test plan.

(2) The unit under test shall be run for one hour at an input voltage just within the upper limit of the specified operating range and at rated output current and voltage.

(3) The unit shall be run for one hour at an input voltage just above the lower limit of the specified input range for which

rated output voltage and current is to be delivered. Tests shall be at said rated output voltage current.

(4) The unit shall be cycled off and on into rated load by interruption of the source voltage supply external to the converter. Rate of cycling shall be approximately one second on, one half second off, and shall proceed for two minutes.

(5) The unit shall be started into an open circuit five times in succession.

(6) The unit shall be started into a short circuit (as nearly representative of a "bolted fault" as the test set up allows) five times in succession.

(7) The unit shall be started into an overload (approximately 120% of rated current). The overload shall then be removed and the unit shall automatically provide rated output voltage.

(8) Noise measurements shall be made sufficient to demonstrate compliance with section 2.2.10.5.1C of the specification.

(9) At all operating points representing deliverance of rated output voltage or routine current limit operation, output voltage wave forms shall be monitored by an oscilliscope to determine compliance with the specified levels of ripple. Similarly, output voltage during normal operation at various operating points shall be monitored for compliance with the voltage regulation requirement.

e) A battery sample taken from the production lot shall be tested to establish proof that the batteries will meet the requirements of these specifications. The testing shall include a discharge cycle, charge retention on open circuit, and vibration and impact resistance tests.

f) Friction brake system qualification tests shall include the following tests on one of the first production units to determine the following characteristics:

(1) Response. The friction brake system shall be tested to verify the response to all control inputs.

(2) Linearity. Dynamometer test runs shall be made for simulated car weight AW1 from each of the entry speeds of 16, 48, 80 and 88 km/h (10, 30, 50 and 55 mph). For each entry speed, input signals calling for 25, 50, 75 and 100% of full service braking effort shall be used. Results shall be plotted to show proportionality between input signal and output braking effort over the speed range.

(3) Brake System Capacity. The system shall be tested on a dynamometer or flywheel to verify the brake system capacity. The disc or shoe surface temperature shall be measured and recorded throughout the test. At the completion of this test the brake unit shall remain in an undamaged, operable condition.

(4) Proof Pressure. If a pneumatic braking system is supplied, all pneumatic brake system components shall be tested at 150% of main reservoir pressure.

(5) Brake System Endurance Test. A complete friction brake system shall be subjected to an endurance test of one half million cycles of normal apply and release applications. All performance shall be in accordance with the performance requirements.

(6) Brake System Environmental Test. If a pneumatic system is used, a test setup in an approved environment laboratory shall be made to simulate the severe climatic conditions the system would encounter in service, including conditions of high humidity with rapid temperature fluctuations near and below freezing. If it is impractical to test a complete braking system, parts of the system may be simulated. During environmental tests, ambient temperature and humidity shall be recorded.

g) Traction Control System Tests. Tests shall be made using motor currents with simulation of propulsion and braking system components as required. For qualification testing, one control unit shall be subjected to maximum specified range of line and control voltages.

h) Combined Systems Lab Test. The equipment provided for these tests shall include a complete propulsion system exclusive of gear drive, friction brake system, exclusive of truck mechanical parts (i.e. caliper disc and actuator), auxiliary electrical power system (loads may be simulated), load weighing (if required) and Operator's controls. Using simulated traction loads (including a friction brake dynamometer), the tests shall demonstrate the ability of included systems to meet the specified performance requirements at the specified operating parameters. This test shall be performed prior to vehicle installation. Minimum test results shall include:

(1) Torque control vs. traction system response (acceleration, braking and speed modulation);

(2) Response time of systems to step input command;

(3) Demonstration of jerk limits;

(4) Accuracy of torque response;

(5) Compatibility of dynamic and friction brake during any blending;

(6) Response of controls to wheel slip and spin conditions;

(7) Power interruption effect on all systems;

(8) Duty cycle simulation; and

(9) Simulated fault conditions.

The test hardware shall be arranged to simulate the actual vehicle installation and wire runs.

Where the equipment supplied has been approved as "service proven equipment" per Paragraph 1.5.1, these tests may be split into the following combined tests:

(a) Propulsion/converter (including firing logic) combined with braking resistors and traction motors;

(b) Friction brake system; and

(c) Auxiliary electrical system with Operator's controls.

i) Truck Qualification Tests. One complete truck frame and truck bolster (or equivalent interface member) shall be subjected to static and fatigue tests as described below. Dummy axles, journal bearings, springs and associated hardware shall be applied as required.

(1) The Static Test Loadings shall include a vertical load equal to at least 200% of the normal truck load and loads in other directions which shall simulate in magnitude the highest loads encountered in normal service. The proposed arrangement and magnitude of loadings for these tests shall be submitted to the Owner for approval.

(2) Using standard experimental stress analysis techniques, areas of stress concentration shall be located. Strain gauges shall be positioned at known strain points and readings taken to determine that stresses are within the design requirements for principal loadings encountered in service. An adequate number of strain guages shall be supplied at points of stress concentration.

(3) A Fatigue Test using mean vertical loads equal to the maximum car weight with normal maximum passenger load and corresponding lateral, longitudinal, and accessory support loadings shall be performed. The proposed arrangement and magnitude of loadings for this test shall be submitted for approval. The Fatigue Test will be run for two million cycles.

(4) ######Option 2 - Articulation Truck. The above testing assumes that all trucks are of identical design. In the event that the truck under the Articulation Section is significantly different in design, the tests described above shall be repeated for this second type of truck.######

(5) ######Option 36 (Load Leveling) - Pressure Test. If the truck bolster is used as part of the air suspension volume, it shall be tested and stamped to satisfy requirments of ASME Unfired Pressure Vessel Code, Section VIII. During the static tests, the bolster pressure shall be the maximum required by the ASME code, and during fatigue testing, the service pressure required for load equivalent to the maximum sprung weight per truck on the body suspension.######

(6) Shock and vibration tests shall be performed to demonstrate the conformance of trucks and truck components to the requirements of Paragraph 2.1.10.

Certified reports of these tests shall be submitted for approval.

j) ######Option 3 - coupler and draft gear qualification tests shall include tests pertaining to the performance and capacities of the following:

(1) Coupler draft and buff loading;

(2) Draft gear deflection and emergency release;

(3) Anchor-casting static loading;

(4) Gathering range and mechanical coupling;

(5) ######Option 3.2.4 - Electrical coupling;######

(6) ######Option 3.2.5 - Pneumatic coupling;###### ######

k) Windshield qualification tests shall be in accordance with Paragraph 17.3.3.

l) Door ######Option 6 - and high/low level step system###### qualification tests shall include an accelerated life-test of 1.5 million cycles for doors and 500,000 cycles for steps on one of each of the respective systems. These tests shall be completed before the first car is ready for final assembly. Failures recorded during testing must correlate within specified reliability values. Door speed and noise tests shall be performed at the beginning and end of the life-test for comparative evaluation.

m) Equipment noise qualification tests prior to installation shall be performed on equipment produced early in the production phase. Test conditions shall be those applicable to pre-installed equipment as stated in the noise criteria (see Paragraph 2.2.10.5.1 and 2.2.10.6).

n) Traction motor vibration tests prior to installation shall be performed in conjunction with other tests on one motor randomly selected.

o) Packaged components and assemblies that do not receive testing as parts of a system shall be tested at the point of manufacture as part of the quality assurance program. Test results shall be available for the Purchaser's inspection.

p) Roof mat material shall be tested in accordance with ASTM D178-77, latest revision, to withstand 10,000 volts for a period of one minute.

2.3.1.3 Vehicle Systems Testing. The following tests shall be conducted on the first car constructed.

a) Car Body Compression and Vertical Load. The car shall be squeeze-tested as a bare car body structure by the Contractor to prove compliance of the structure with this specification. The test shall be made at the Contractor's plant or approved facility with testing capability equal to AAR's test facility in Chicago, Illinois.

(1) The car shall be a structurally complete shell excluding only such items as exterior and interior trim, windows, doors, seats, lights, interior lining, etc. Underfloor apparatus may be substantially complete, if desired.

(2) @@@@@@@Baseline - The car shall be tested as a complete unit.@@@@@@@

######Option 2 (Articulated Cars) - For testing purposes the car shall be separated into an "A" or "B" Section and the Articulated Section which shall be used in conjunction with its truck or a simulated truck to provide an appropriate mounting point in the testing machine since no anticlimber or draft stop exist on that end of the Section.######

(3) During the test the body shall be supported on trucks to allow longitudinal movement. The body shall be loaded with sufficient dead weight to bring the total weight up to the normal ready-to-run value. This loading shall be distributed approximately according to the distribution of the weight in the finished car.

(4) The compressive force of the testing machine shall be applied by hydraulic power and the force measured by means independent of those producing the force, eliminating error due to friction. Sufficiently recent calibration of the longitudinal force measuring device must be available to insure accuracy to within plus or minus 1%.

(5) A test load equal to 110% of the draft gear collapse force shall be applied to the coupler fixation base plate in the underframe by means of a ram. This load shall be applied horizontally at the vertical centerline of draft. No allowance shall be made for the camber of the car body. The ram shall be supported at the end sill but shall remain free to move longitudinally with respect to the end sill. Cushioning means such as lead sheets, shall be provided to assure uniform bearing. The regular draft gear carrier shall be installed and shall support the inner end of this ram. In a similar manner, a test of equal to 1.8 g (1.8 times the actual empty car weight) (unless Purchaser accepts lesser design compression strength) shall be applied to the anticlimber at the longitudinal centerline of car over an area not to exceed six inches high by twelve inches wide.

(6) For the Compression Tests, loads shall be applied in increments of the maximum load as follows: 25, 50, 75, 87.5 and 100%, and shall be returned to zero after each load increment to check the possible beginning of permanent deformation. Deflection and strain readings shall be taken before the test, at all load increments and at zero loadings after each increment. To avoid disturbing the precise location of load application devices, a load not exceeding 2% of the applicable maximum longitudinal loading may be used in place of zero loading at all zero loading conditions.

(7) Strain gauges shall be applied at approved points. These strain gauges shall be used with calibrating means to suit the material used and other factors which might affect the accuracy of the readings. Using standard experimental stress analysis techniques, areas of stress concentrations shall be located for subsequent strain gauge installation. SR-4 electric strain gauges, Huggenberger mechanical strain gauges, or other gauges specifically suitable for the application shall be used as required. Sufficient number of strain gauges per section shall be used. Vertical deflection shall be measured in the region of the side sill by precise optical methods or by means of a wire stretched between corner posts. This wire shall be fastened at one end and held tight by means of a weight with the wire passing over a pulley at the other end. Deflections may be measured using scales with mirrors located at the desired measurement locations. Deflections shall be measured to the nearest 0.25 mm (0.01 in), and the deflections shall be considered as the average of

the readings taken on both sides. The deflection measured at any preliminary load application may be disregarded to eliminate the influence of whatever friction may be present. Deflection between bolsters and center of the section shall be determined by plotting the data determined above. Alternate means of measuring carbody vertical deflection which provides equivalent accuracy will be acceptable.

(8) Vertical Load. The car shall be given a vertical load test as a bare body structure to provide compliance of the structure with these specifications. The test shall be conducted in an approved test facility similar to that noted in the Compression Test above. The test may be conducted on an individual section basis or as a complete car as appropriate. However, a sufficient number of strain gauges shall be applied to the whole car at approved points of stress concentration. Each tested carbody section shall be subjected to a vertical load equal to the weight of the corresponding crush-loaded carbody section (applied in increments in a manner similar to the Compression Test loading).

The Purchaser reserves the right to test a second car during the construction period. Should such a test as above be ordered, it shall be at Purchaser's cost.

b) ######Option 25 - Air Conditioning Test (Ref. Section 7.3). The Air Conditioning system in one of the cars shall be tested in an approved climate laboratory capable of being heated to and maintaining a temperature of 38° C (100° F) and of maintaining any level of humidity between 25% and 90%. Temperature in the climate laboratory shall be uniform throughout; a maximum of 2.8 C° (5 F°) variation will be permitted from the rail to 2 feet above the roof and from end to end of the car. Fans may be used to circulate air.

(1) The testing shall begin after the car has been exposed to temperatures at 38° C (100° F) for at least sixteen (16) hours and with the interior temperature of the car at 38° C (100° F). The length of time required to stabilize temperatures, after air conditioning equipment is energized, shall be measured. Testing shall include a functional check of all apparatus including thermostats and controls, an air balance test, a pressurization test, and a temperature and relative humidity check to show compliance with the specified cooling requirements. The proportion of fresh and recirculated air and the total volume of air delivered by the evaporator blowers shall be measured and recorded.

(2) The speed, supply voltage and current demand of the equipment shall be measured and continuously recorded for all of the test conditions. Arrangement of recording ammeters shall be such as to allow determination of the individual current demands and supply voltage of the freon compressor

evaporator motor, heat units, and condenser motor. Tests shall be made with the apparatus running at the average primary line voltage and the minimum swing voltage as given in Paragraph 2.1.10.

(3) After temperatures have leveled off (for each test condition) the temperatures at a minimum of 16 "key" locations including the Operator's position, shall be recorded every minute for 30 consecutive minutes in order to determine temperature swing as the cooling apparatus cycles. Tests shall be run at ambient temperatures of 18° C DB/16° C WB (65° F DB/60° F WB), 27° C DB/24° C WB (80° F DB/75° F WB), 35° C DB/26° C WB (95° F DB/78° F WB).

Performance of this test does not relieve the Contractor from making a final adjustment in service should it be required on account of car dynamics, solar load, etc.

A sample of refrigerant shall be taken from the Air Conditioning System of the first car after the other tests have been completed and analyzed for contaminants by an approved laboratory. If this test should reveal an unacceptable level of contaminants, as specified by the air conditioning apparatus Supplier, the charging procedure shall be changed as necessary and another test shall be made to verify the new procedure, continuing until an acceptable result is obtained.######

c) Heating System Test (Ref. Section 7.2). The heating system shall be tested on one car in an approved climate laboratory capable of being cooled to and maintaining a temperature of -1° C (30° F). Temperature in the climate laboratory shall be uniform throughout; a maximum of 2.8 C° (5 F°) variation will be permitted from the rail to 610 mm (2 ft) above the roof and from end to end of the car. Fans may be used to circulate air. The climate lab shall be capable of reasonably simulating the effect of wind wipe on the car for speeds of at least 80 km/h (50 mph).

(1) The testing shall begin with the interior temperature of the car at -1° C (30° F) and the length of time required to stabilize temperatures, after heating equipment is energized, shall be measured.

(2) Testing shall include functional checks of all apparatus including thermostats and controls, and a temperature check to show compliance with the specified heating requirements. The various phases of this test will cover car body temperature stabilization periods and distribution. Test shall be made at outside temperatures just above and just below the operating temperatures of the fresh air thermostats in addition to a test at -1° C (30° F).

(3) The speed, supply voltage, and current demands of the equipment shall be measured and continuously recorded for all of the test conditions. Arrangement of recording ammeters shall be such as to allow determination of the individual current demands and supply voltage of the cab heater, floor heat, and each heat unit. Heating tests shall be run at average primary line voltage and the minimum swing voltage (see Paragraph 2.1.10) for each outside temperature condition including at least -1° C, 7° C and 16° C (30° F, 45° F and 60° F).

(4) After temperatures have leveled off (for each test condition) the temperature of at least sixteen (16) "key" locations including the operating compartment, shall be recorded every minute for 30 consecutive minutes to determine temperature swing as the heating apparatus cycles. Heat transfer through the car body shall be verified by test.

Performance of this test does not relieve the Contractor from making final adjustment in service should it be required on account of car dynamics, solar load, etc.

d) Handbrake/Parking brake systems test shall be performed on one car. The system design shall be demonstrated by measuring the horizontal force required to move the car with the handbrake applied on the maximum grade specified. The test shall be performed with new bedded-in brake shoes and fully worn shoes (Ref. Section 12.6.7).

e) Radio frequency interference tests shall be performed on one completed car. The tests shall be performed on the Purchaser's or the Contractor's track in all operating modes. Readings shall be taken at various speeds, and car loads with auxiliary electrical apparatus operating. The test procedures shall generally be those established in Military Standard 461A for measurement of vehicle radio frequency interference over the frequency range of 0.015 MHz to 600 MHz. The tests shall be performed with antennas mounted at a distance of 30 m (100 ft) transverse to the moving vehicle. Loop antennas mounted on moving vehicle may also be used for measurements taken in the frequency range of 0.014 MHz to 3.0 MHz. The dipole antenna shall be polarized both vertically and horizontally to define plane of maximum interference. Each test run shall be repeated at least twice to determine average values. Sequenced operation of car equipment shall be made to define the noise generating source in case of measurements exceeding the limits defined in the Performance Requirements, Paragraph 2.2.13.

f) Ride quality tests shall be performed on one of the first production cars. The tests shall prove compliance with ride quality specifications of Paragraph 2.2.11. The tests shall be conducted on the Contractor's track. Car weight shall be AW1.

Within the track alignment limits indicated, the cars shall be operated at varying speeds up to 80 km/h (50 mph.)

The cars shall be instrumented to record vertical, lateral, and longitudinal acceleration (magnitude and frequency) for vibrations up to 0.20 g and 10 Hz. Both sensors shall be mounted on the floor, one over the pivot point of one end truck and the other at the center of the car. A safe running check with simulated suspension system failure shall also be performed over the entire speed range if air suspension is supplied.

g) Noise tests after equipment installation shall be performed on one of the first cars and shall be in accordance with Paragraph 2.2.10 and the following test conditions.

Conformance with the specifications is to be based on measurements taken in essentially a free-field environment such as outdoors, away from any reflecting surfaces other than the ground on which the car is resting. All measurements shall be made at locations where reflected sound such as reflections from nearby walls, floor or other equipment, will not influence the directly radiated sound from the equipment measured by more than two dB. All measurements shall be made with an ambient sound level in the vicinity of the test measurement locations of not less than ten (10) dB below the noise produced by the equipment being measured, when evaluated using the same scale or octave band. Where auxiliary methods of driving or loading equipment such as motors or dynamotors are required, these devices shall be temporarily enclosed or baffled to eliminate their effect on the equipment noise being measured. For equipment noise measurements with the car stationary or on jacks, the car shall be located out-of-doors on an at-grade tie and ballast trackbed.

For the preceding tests, completed test reports shall include the following:

(1) Description of noise or vibration source being measured, including pertinent statistical information;

(2) Description of the environment where noise or vibration source is measured, including a sketch showing source position;

(3) Operating conditions of noise or vibration source during measurements;

(4) Pertinent meteorological data, if applicable;

(5) Locations and orientations of microphones with respect to noise source;

(6) Equipment used for making measurements;

(7) Description and measurement of ambient noises;

(8) Data obtained, including range of variation;

(9) Instrument settings, corrections and calibration records; and

(10) Summary of results and conclusions.

h) A vibration test shall be performed on one of the first five cars selected at random. Measurements and recordings shall be made of peak-to-peak amplitudes, peak accelerations and peak velocities of vibrations at the floor deck, seat frames, walls and ceiling panels in the vicinity of each operating or energized car component (Ref. para. 2.2.10.7).

i) Vehicle running tests shall be performed on systems related to propulsion and braking on the selected car. The tests shall verify the requirements of Paragraphs 2.2.1 through 2.2.9. Braking tests shall use system combinations of friction brake only, blended brake (if supplied) and emergency brake.

Test conditions shall include nominal new wheel diameter, maximum difference from average of any axle speed on car not exceeding $\pm$ 1.0 percent. Acceleration and braking rates shall be assumed to be measured at car axles without consideration of vehicle characteristics.

Data shall include:

(1) Recorder traces of control and mode signals together with traction response at various rates and speed levels;

(2) Traction response to step input command signal;

(3) Jerk limit accuracy;

(4) Torque response accuracy;

(5) Average stopping distances from various speeds;

(6) Blended brake accuracy (if supplied);

(7) Maximum undercar temperatures;

(8) Recorder traces showing response to spin or slide conditions (if required); and

(9) Effect of power interruptions.

j) Clearance Tests. Complete dimensional and clearance checks of the car and car-mounted equipment shall be made on the first completed car (Ref. Section 2.1.6).

k) Weight distribution tests shall be performed on the first completed car to verify compliance with the requirements of Paragraph 2.2.12. The weight under each wheel and under each truck shall be measured and recorded with the cars empty and with the cars uniformly loaded to weight AW2.

l) Light intensity readings shall be taken (without light from other sources) on one of the first cars to verify requirements in Paragraph 8.1.1.

2.3.1.4 Acceptance Tests. Each car shall be subjected to the following acceptance tests, either at the Contractor's facility, the Purchaser's facility, or both as indicated. Each of these tests shall be performed and none shall be waived.

a) Car wiring acceptance testing shall be performed at the Contractor's facility on all cars after the wiring and equipment installation is completed and shall consist of:

(1) Wiring Continuity Checks. All circuits shall be tested to ensure continuity and correct polarity of equipment and devices. All frame grounds and terminal connections shall be checked for tightness.

(2) Insulation Resistance Tests. A 500 Volt megohmeter shall be connected between all car circuits and the car body. The low- and high-voltage circuits shall be tested individually or in convenient groups. The battery shall be disconnected from the circuits and all semiconductor devices shall be protected against the test voltage. With the test voltage applied, the minimum value of insulation shall be one megohm. The value of the test voltage and duration of application shall be as recommended by the cable and equipment manufacturer. All circuits shall function and perform normally after this test.

(3) High Potential Tests. A high potential tester shall be connected between all primary power circuits, their connected apparatus and the car body. The battery and all semiconductors shall be protected against and shall not be subject to the high potential test. The car shall be solidly grounded. The value of the high potential and the duration of application shall be two times the normal voltage plus 1,000 volts, for one minute or as recommended by the cable and equipment manufacturer. All circuits shall function and perform normally after this test.

b) Weighing. All completed cars shall be weighed at the Contractor's facility. The scale used in weighing cars shall be maintained within tolerances set forth in Chapter 12, Part 5, Section C of the AREA Manual. Certified weight tickets shall be furnished on all cars.

c) Functional Checks. The following tests shall be made on all cars prior to track operation, both at the Contractor's facility and Purchaser's facility:

(1) High potential test on power collector and other primary circuits;

(2) Functional checks and adjustments as required on all systems installed;

(3) Functional checks of control, auxiliary and annunciator circuits, trainlines and warning devices; and

(4) Complete pressure systems tests at the maximum pressure that pressure relief valves will allow.

d) Water tightness of the roof and windows shall be tested first at the Contractor's facility (per Paragraph 2.3.1.9, p) and then at the Purchaser's site using the car wash facility. If a car wash facility does not exist then the test shall consist of subjecting the roof and windows to a jet of water at 2.7 atm (40 psig) from an open end 3/4 inch I.D. hose at a distance of 6 feet. Any leaks shall be made weather tight to the satisfaction of the Purchaser.

e) Doors shall be checked and adjusted on each car to assure smooth and proper functioning of their control and interlocks.

f) Thermostats for heating and airconditioning (if supplied) shall be checked and adjusted to give the desired temperature range as specified.

g) Performance Tests. Compliance with the performance specifications of Subsection 2.2 shall be demonstrated by the Contractor on each car prior to acceptance. A method for calculating car performance at (AW2) 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 (if supplied).

For each test the following parameters shall be recorded simultaneously on a multiple-channel recording oscillograph:

(1) Acceleration and deceleration;

(2) Car speed (independent of any wheel slip);

(3) Line voltage;

(4) Traction motor current;

(5) Propulsion and braking command signals;

(6) Brake pressure (if pneumatic); and

(7) Time.

All charts obtained from the recordings shall be forwarded to and become the property of the Purchaser.

Any adjustments required to obtain values corresponding to the specification rate of acceleration, speed, or deceleration shall be noted in an individual car logbook.

h) Clearance runs shall be made at the Purchaser's site at the expense of the Purchaser.

2.3.2 Mock-Ups and Samples. Mock-ups shall be displayed and samples shall be furnished by the Contractor to facilitate physical design concept interchange between Contractor and Purchaser only if the vehicle is of new design, or if a portion of the vehicle is redesigned to reflect specific purchaser requirements, and shall include all or part of the following:

2.3.2.1 Front End Mock-Up. The Contractor shall construct a full scale mock-up of the front end of the car extending from (and including) the first row of passenger seats to the face of the anticlimber. ******Insert "coupler" for "anticlimber" if Option 3 is selected.******

The mock-up shall be complete with regard to both, exterior and interior details, and shall show the results of human factor engineering in the location and arrangement of all devices including (but not limited to) control console, doors, lockers, windscreens, windows, windshield wipers, destination signs, fare collection, seats, etc.

The mock-up shall be available before the end arrangement is finalized, but no later than six months after award of contract.

The front door system portion included with this mock-up shall be accurate in all mechanical details and be representative of all the actual components which shall be used in actual production.

2.3.2.2 Under Floor Arrangement. To determine efficiently the routing and placement of under floor equipment, wiring, piping and ducting, a full scale mock-up of the car under floor arrangement shall be made. This shall include any coupler equipment provided. Actual or simulated equipment shall be installed on the mock-up in order to design ducting, interconnect wiring and piping. Accessibility and maintainability of under floor equipment shall be demonstrated on the mock-up.

2.3.2.3 Samples of all interior materials, seats, decorations and signs shall be furnished during the vehicle design period for the Purchaser's subjective evaluation and approval.

2.3.2.4 Two scale models for the illustration of changes of interior or exterior arrangements on proven vehicles not involving major redesign work are permissible.

2.3.2.5 Side Door ######Option 6 - and High/Low Step###### Mock-Up. A full size mock-up of the complete door and the High/Low step system including the actuating mechanisms shall be provided by the Contractor prior to actual construction of the cars. This mock-up must be accurate in all mechanical details and be representative of the actual components which shall be used in actual production, including finished exposed surfaces and housings. It shall encompass enough of the door and High/Low step section so that gaps and relative positions between the steps, the car floor, the station platform and the street level can physically be measured and evaluated.

CAR BODY

This section specifies the requirements of the car body which includes the basic shell and all related elements of the Light Rail Vehicle. The general arrangement and overall dimensions for the car body are provided on the contract drawings.

@@@@@@Baseline - The Bidder shall include proposed contract drawings with his bid.@@@@@@

######Option 15 - The contract drawings are included as an Appendix to this Specification.######

3.1 General Design

######Option 2 (Articulated Vehicle) - Each of the two body sections shall be considered a car body for purposes of interpreting the requirements of this design criteria.######

The car body, and attached equipment shall be designed to provide positive clearance with the trucks under worst case operating conditions. Worst case conditions will result from such factors as horizontal and vertical curves, worn wheels, maximum passenger load, sway, suspension system failures, etc., either singly or in combination.

3.2 Materials

@@@@@@Baseline - The car body shall be constructed of Low Alloy High Tensile (LAHT) steel, or stainless steel, or a combination of these materials. The stepwell shall be constructed of stainless steel and/or fiber glass. All exterior surfaces of the car body shall be painted if the material is LAHT; if the material is stainless steel painting is not required.

All materials used shall be in compliance with the requirements of Section 17.@@@@@@

######Option 16 - ******Purchaser may restrict car body material(s) from above Baseline choices and specify any special requirements for painting.******######

3.3 Construction Methods

The primary structure of the car body shall be of welded construction. The exterior skin shall be applied in such a manner that it acts integrally with the primary structure. Riveting and welding visible from the wayside or inside the car shall be permitted only when no other alternative is economically viable. Exterior spot welds or rivets on the sides, roof, and ends of cars shall be arranged in regularly spaced patterns. Exposed rivets shall be arranged so that they can be integrated into the painting scheme; otherwise they are to be covered by decorative body molding. Exterior exposed spot welds, or rivets shall be undetectable when viewed from a distance of five feet for bare stainless steel or painted LAHT.

Screws, bolts, rivets or welding may be used to join secondary structure, or the attachment of brackets and equipment to primary structure. Sheet metal and self tapping screws shall not be used to secure access panels or other frequently removed items.

Adequate drainage shall be provided in all body structure members. Enclosed structural cavities shall be vented to prevent condensate build up. Any enclosed structural cavities of steel members shall be treated with a rustproof coating.

If the car body is a new design a sample side shall be constructed, including the specified color scheme, if any, prior to the start of car body fabrication. Sample side shall be presented to Purchaser for approval.

If the car body is of an existing design, Contractor shall present the first painted car to Purchaser for review and approval.

3.4 Stress Levels

With the maximum vertical static load (AW3) applied to the ready-to-run car, no stress shall be produced in excess of 50% of the guaranteed minimum yield strength published by the manufacturer of the material used. Under the combined maximal vertical load and an end load, applied horizontally at the end sills, equal to two times the empty car weight (AWO), the following conditions shall be met:

a) Stress in the principal framing members shall be not greater than the guaranteed minimum yield point published by the manufacturer of the materials; or for materials whose yield point is not clearly defined, the 0.2% offset yield method shall be used.

b) After removal of load, any residual strain readings as indicated by the applied strain gauges shall be within the overall accuracy of the strain instrumentation.

3.5 Design Calculations

The Contractor shall submit summary stress calculations of the car structure and major equipment supports that show the stresses and margins of safety for all specified loading conditions. These calculations shall be submitted to the Purchaser for his information and shall show the following, as a minimum:

a) A structural diagram (layout) of the car body (including sheathing) showing all members, and indicating the material, weight and applicable standard code designation of each. Methods of joining shall be completely defined.

b) Diagram(s) displaying externally applied loads to the car body, as well as reaction forces and movements at all structural joints.

c) The locations where stress levels approach within 15% of the allowable stress criteria specified in Section 3.4. Tabulate the calculated stress value and the design or operating condition (loads) which precipitates them.

d) An assessment of the structure to withstand collision between a car travelling 64 km/h (40 mph) and another at rest, with emphasis on the anticlimber and articulation joint, if used.

e) An analysis of the attachment of the coupler/draft gear, if applicable, to the car underframe.

f) A tabulation of deflections and natural frequencies of the car body under each of the indicated load, or combination of load conditions.

If the proposed design is of an existing vehicle, the Contractor may provide data from tests, historical data from operations, or analysis similar to the above to satisfy these requirements.

######3.6 Option 2 (Articulation Section) - The articulation section utilized on these cars shall be considered an integral part of the car body. Passenger access from section to section shall be provided without use of train doors and with maximum ease and safety. Considerations shall be given to ensuring that the articulation section is weather-sealed and that it does not degrade the ventilation, heating and lighting requirements of the car interior. When on level tangent track the articulation section floor shall be level with the body section floor.

3.6.1. The articulation section, mounted on its truck, shall provide attachment and support for the "A" and "B" body sections.

3.6.2. Only service proven designs (as defined in Paragraph 1.5.1) shall be permitted. Openings, spaces, or edges which can in any way endanger passengers, either inside or outside, shall be eliminated. Particular attention shall be directed to gaps resulting when the unit is at its limits of horizontal and/or vertical articulations.

The completed design must permit the "A" and "B" body sections and the articulation section to rotate freely with respect to each other, externally and internally, in both the horizontal and vertical planes.

The articulation section and its attachment to the adjacent car body sections shall meet all applicable car body static strength requirements. In addition, it shall have strength to resist dynamic buffing loads equal to or greater than adjacent car body sections, so that in the event of collision, the articulation section will not be the first structure to fail. The articulation joint and its attachment shall provide anticlimbing and antitelescoping protection at this location.

The degree of weight transfer which occurs when the vehicle traverses both vertical and horizontal curves simultaneously shall be determined. Adequate tracking shall be provided under all conditions of operation. The Contractor shall calculate the conditions under which wheel load reduction will occur prior to fabrication and present the results to the Purchaser.

It shall be possible to disconnect the articulation section from the "A" and "B" sections with minimum time and effort for maintenance purposes (see Paragraph 2.2.14).

3.6.3 Suitable duct runs, with non-conducting inserts for flexible hoses, wiring and cabling must be provided across the articulation section below the floor line. The routing shall minimize excess length and unnecessary flexing. There shall be readily accessible primary and low voltage quick disconnects located on body sides of the articulation section to allow for rapid car section separation.######

3.7 Underframe

3.7.1 End Structures. The end frame shall consist of the draft sill, end sill, anticlimber and body bolster. The end frame shall include vertical structural members, which in conjunction with vertical and horizontal shear panels, will provide adequate protection for the operator.

An anticlimber extending laterally over at least the middle half of the width of the vehicle, shall be integral with the end frame. A separate energy absorbing device may be used to meet crashworthy design goals of Paragraph 2.1.2.

3.7.2 Sills and Bolsters. The side sill shall be designed to resist combined vertical and buff loads specified in Section 2.0, in addition to any loads induced by the anticlimber. No damage or permanent deformation shall result from the application of loads which may occur simultaneously.

The body bolster shall be a structure of sufficient strength and stiffness to transfer all loads between the truck and car body. Special consideration shall be given to the design to account for dynamic loads, clearance for all truck positions, integrity of truck attachment, and accessibility for truck maintenance and de-trucking.

3.7.3 Underfloor Equipment Supports. Where possible, heavy underfloor apparatus shall be supported directly by side, center or body sills. Underfloor equipment shall not be supported by bolts in tension, unless provided with safety straps and approved by the Purchaser prior to production. Dissimilar metals shall be avoided at connections requiring frequent disassembly for maintenance, or removal and replacement of equipment. Equipment and apparatus supported on or by resilient mounts shall also be provided with safety straps.

No underfloor equipment or apparatus shall be supported by bolts in holes tapped in the floor structure or the car structure.

3.7.4 Undercoating. A corrosion-resistant undercoating, as specified in Section 17, shall be applied to the entire underframe including the top of subfloor sheets, and inside of side and end sheets. Undercoating is not required on stainless steel, or fiber glass members except for sound deadening purposes as the manufacturer may find necessary to meet the noise limits of Paragraph 2.2.10.

3.8 Roof and Wall Structure

Roof sheets shall be of sufficient stiffness so as not to be permanently deformed when passing through a mechanical car washer. In addition, they shall also be capable of supporting without permanent deformation concentrated loads of 1,100

N (250 lbs), 760 mm (30 in) apart as might be applied by no more than three men working on the roof. The assembly must provide flush contoured appearance from a high station platform.

3.8.1 Skirts. Side skirts shall be provided below the rub rail around the whole car except for the space at the car ends required for proper coupler swing clearance, and with some opening if necessary for truck swing. They shall not be load bearing members and shall be designed for ease of removal and repair in the event of damage or accident. The skirts shall be constructed of metal or molded fiber glass, but in any case must provide a surface finish of the same standard as the rest of the exterior.

3.8.2 Side Panels. Side sheets, presenting a flush appearance shall be attached to the outside of the posts from the edge of the roof to the rub rail. Proper protection shall be provided against electrolytic action if dissimilar metals are used.

3.9 Exterior Accessories

3.9.1 Roof Mat. A roof mat shall be installed to provide an antislip walking surface and an electrically insulated area on the roof of each car. The mat shall extend over the entire roof except at the area of the pantograph or trolley pole base. The mat shall be cemented in place with a suitable adhesive material so that its edges will be securely fastened.

The roof mat shall be 3/16" thick and shall be made of material which will maintain a high dielectric value when exposed to the elements, including bright sunlight. This mat material shall be capable of withstanding a test of 10,000 volts for one minute as prescribed in latest revision of A.S.T.M. D178-77, Standard Specification for Rubber Insulating Matting.

3.9.2 Equipment Well and Roof Shroud. The roof mounted equipment shall be shrouded and may be installed in a recessed well. The shroud or well shall be generally parallel with the car sides and ends. It shall permit water run off and equipment cooling.

3.9.3 ######Option 17 (Rub Rails) - Rub rails shall be incorporated the length of the car. The ends shall be tapered or capped to prevent snagging. The rails shall be mounted so as to permit moisture to drain and not corrode the side sheets.

######Option 17.1 (Advertising Card Holders). The rails shall also incorporate a lip turned up on the lower rail and down on the upper rail, and the rails shall be spaced 762 mm (30 in) vertically so as to entrap and hold a standard 3,658 X 762 mm (144 in X 30 in) advertising card.###### ######

3.9.4 Rain Gutters. Rain gutters shall be installed on the roof along the sides of the main body sections and over the destination sign area on both cab ends. These may be separately formed and attached or may be integral with the roof structure such as can be obtained with aluminum extrusions. The Contractor may also use lower rub rail elements to provide combined rub rail and gutter. Gutters will also be provided behind any shroud sections. The gutters shall direct water away from the sides of the car.

3.9.5 Jacking Pads

@@@@@@@Baseline (Non-Articulated Car) - The entire car body shall be designed to be jacked and raised as a unit by jacking pads situated at suitable locations. The pads shall be located such that a truck can be removed by jacking only one end. The bottom of the jack pad shall have a non-skid surface to provide frictional resistance against incidental horizontal loadings.

Diagonal jacking of a body with trucks attached shall not cause any structural or cosmetic damage.@@@@@@@

######Option 2 (Articulated Car) - The entire car body structure, "A", "B", and articulation sections shall be designed so that it may be jacked and raised as a single integrated unit by means of jacking pads installed at suitable locations for use by jacks or other lifting devices. In addition, the pads shall be located such that the "A" and "B" body sections may be lifted sufficiently to permit disconnection of the articulation unit and then further to permit the "A" and "B" body sections to be fully raised individually. The articulation section shall also be provided with jacking pads such that it may also be lifted individually. The bottom of the jack pad shall have a non-skid surface to provide frictional resistance against incidental horizontal loadings.

Diagonal jacking of a body section with trucks and adjacent body section attached shall not cause any structural or cosmetic damage.######

3.10 Floor and Framing

The floor panels shall be constructed so that all applicable fire, noise, and vibration requirements are met.

All exposed edges of the floor, including openings for ducts and conduits, shall be weatherproofed and sealed, as well as the joints between floor sections. The passenger compartment floor shall be flat and level throughout and shall not exhibit any visible buckles or waviness.

######Option 2 - Floor hatches or access panels shall be provided for positioning re-railing jacks in event of a derailment and/or if required for motor maintenance.######

3.10.1 Strength Requirements. The floor deck shall deflect not more than 1/250 of the short span between supports from the sum of dead loads plus uniform live passenger load of 490 daN/m^2 (100 lbs/ft^2) arranged to produce the maximum deflection.

3.10.2 Covering. The floor covering under the seats shall be 3 mm (1/8 in) minimum thickness smooth rubber sheet or approved equal. Along the center aisle including the door to door area lengthwise between doors floor covering shall be 4.8 mm (3/16 in) minimum thickness ribbed rubber sheet. The ribbing shall run fore and aft along the floor, and in the transverse area between the doors, the ribbing shall run in a transverse direction. The floor covering for the center aisle shall be laid so that it can be replaced later without removal of the seats. In an articulation section the ribbing shall run lengthwise. The floor covering shall be installed to facilitate easy replacement. At all door openings and step wells the floor covering shall connect properly with the threshold plates (or their equivalent moldings, if any).

3.11 Car Interior

The interior of the vehicle shall be free of sharp corners or edges. Surfaces requiring paint shall be avoided. Samples of all materials shall be furnished in accordance with Paragraph 2.3.2.3.

All interior lining attachments subject to vibration shall be installed with an anti-squeak tape or other equal material.

Walls and ceilings shall meet, at a minimum, the graffiti resistance rating of 2 as per APTA Transit Security Guidelines Manual, Section 21, with the walls preferably having a rating of "one".

3.11.1 Ceiling. Ceiling sheets shall be made of materials which meet the flammability and smoke emmission requirements as set forth in Section 17. All joints shall be at carlines or purlins and shall be covered with battens.

3.11.2 Side and End Walls. The interior side and end finish above the window sills shall be made of materials which meet the flammability and smoke emmission requirements as set forth in Section 17. The material shall be integrally colored, so as not to require painting. All joints shall be properly supported and covered with battens.

The interior side and end finish below the window seats shall be of a pattern and finish compatible with the other materials in the car. All joints shall be properly supported and covered with battens.

3.12 Insulation

Both thermal and acoustical insulation shall be provided throughout the car as required to meet the performance objectives indicated for interior noise levels and interior air comfort. Insulation materials shall comply with flammability and smoke emmission requirements in Section 17.

3.13 Windows

The various windows in the car shall have the dimensions and location as generally shown on the contract drawings.

All windows shall be a minimum of 6.35 mm (0.25 in) thick and meet the requirements of FMVSS 205 and ANSI Z26.1. The windshield(s) shall be laminated safety float glass. All other windows shall be either laminated safety float glass or polycarbonate. Any windows with plastic shall meet the flammability and smoke requirements of Section 17.

All windows shall be supported directly to the structure with rubber glazing strips. The ends of the glazing rubber shall be adequately sealed to prevent leakage. All windows shall be sealed, but arranged for emergency egress, generally following FMVSS No. 217, and as approved.

@@@@@@Baseline - The glazing strips shall be laced from the outside of the car.@@@@@@

######Option 18 - The glazing strips shall be laced from the inside of the car.######

All sash frames and glazing strips shall be so arranged such that they are easily removable from the outside for repair or replacement. In all cases they shall have internally rounded corners, both inside and outside the car, to facilitate cleaning.

3.13.1 Side and Door Windows. The side and door windows in the passenger section shall be neutral gray tinted and have visible ray light transmittance of 22% to 28%.

@@@@@@@Baseline - All side windows shall be single glazed.@@@@@@@

######Option 19 - All side windows shall be double glazed.######

@@@@@@@Baseline - All side windows shall incorporate a manually operated inside cant section. The mechanism to open and close these top window panels is to be operated by the passengers, requiring only reasonable manual force. A latch with a special key shall be provided so the operator may lock this mechanism closed.

The mounting and opening of these panels shall be such that the opening can be selected in any position between maximum opening or closing and shall not move from that position due to any movement of the vehicle.

The maximum size of the opening panel, and the limit of opening shall be designed with consideration of:

- o safety
- o air comfort
- o environmental conditions, including provisions to minimize spray through opening, or leakage at hinge line, from rain, snow or car washing operations.@@@@@@@

######Option 20 - All side windows shall be fixed (i.e. not openable).######

3.13.2 Windshield. If a single-piece windshield is provided, it may cover the destination sign. If a two-piece windshield is provided, a separate one-piece glass cover meeting the safety standards for the side windows shall cover the destination sign. The windshield shall permit a operator's field of view as referenced in SAE Recommended Practice J1050. The vertically upward view shall be a minimum of 15^{o}, measured above the horizontal and excluding any shaded band. The vertically downward view shall permit detection of an object 3½ feet high no more than 2 feet in front of the vehicle. The horizontal view shall be a minimum of 90^{o} about the line of sight. Any binocular obscuration due to a center divider may be ignored when determining the 90^{o} requirement provided that the divider does not exceed a 3^{o} angle in the operator's field of view. Windshield pillars shall not exceed 10^{o} of binocular obscuration. The windshield shall be designed and installed to minimize external glare as well as reflections from inside the vehicle. When the vehicle is operated at night with the passenger interior lighting on, essentially no reflections shall be visible to the operator in the windshield in the area directly forward of the driver's barrier. Reflections in the remainder of the windshield shall be minimized.

The windshield shall be easily replaceable from outside the vehicle by removing zip-locks from the windshield retaining moldings. Bonded-in-place windshields shall not be used. The glazing material shall not be tinted. The upper portion of the windshield above the operator's field of view shall have a dark, shaded band, which will provide a nominal luminous transmittance of 5% when tested according to ASTM D 1003-61.

3.13.3 Operator's Side Windows. The operator's side windows in the cab(s) shall be clear with a visible ray light transmittance of at least 82%. They shall be a two-piece design and shall consist of one fixed section and one sliding section. The sliding section shall be arranged to slide freely in either direction and easily openable or closeable using only the left hand while seated in the operator's seat. It shall also include the necessary locks, be effectively weatherstripped, reinforced for hard usage and designed to eliminate rattling.

3.14 Passenger Seats

All materials for the seats and any inserts shall meet the flammability and smoke requirements in paragraph 17.3.6.

@@@@@@@Baseline - Each car shall have a complete set of seats as indicated in the drawings, and shall be made vandal resistant. The Contractor shall select the seats in accordance with Purchaser's subjective evaluation and approval.

The general shape and dimensions shall be as indicated. Minimum seat depth shall be 510 mm (20 in) and seat spacing shall be not less than 740 mm (29 in).

3.14.1 Construction. The minimum simultaneous strength requirements shall be as follows:

a) The two passenger seat design and attachment to the car shall withstand a longitudinal force (acting in the direction from front of seat to back of seat and equally distributed along the grab handle) of 133 daN (300 lbs) per passenger - a total of 266 daN (600 lbs) - with a deformation of less than 20 mm (0.75 in) with no failure or permanent deformation.

b) All seat designs shall withstand a vertical load applied at the front edge at the center line of each sitting position of 178 daN (400 lbs) with no permanent deformation or other failure.

The seats shall be supported on the wall side by the wall structure and on the aisle side by under seat equipment boxes, ceiling supported stanchions, stainless steel legs, or stainless steel pedestals.

All transverse seats shall be furnished with horizontal grabrails running across the top of the seat back or into the aisle end top corner of the seat back. The horizontal grabrail or seat back, however configured, shall be designed to safely decelerate the heads of passengers during a vehicle collision meeting an HIC number of 400 maximum. A hemispherical head form 165 mm (6.5 in) in diameter with a total equivalent weight of 5.1 daN (11.5 lbs) at an impact velocity of 6.7 m/s (22 ft/s) shall be assumed for design purposes.

Crash pads shall be required for the top rear side of the seat back to provide additional occupant protection. The crash pads shall be so designed to distribute impact forces over an area while deforming to absorb energy.

The top member of seat frames of transverse seats shall be fitted with a stanchion socket on the aisle end as shown on seating drawings. Each passenger seat frame and its support shall be constructed as an integrated unit.

Seats which provide access to underseat equipment boxes shall be designed to allow easy and frequent removal without wear or damage to any part. The underseat equipment boxes shall be equipped with a simple latch device to prevent unauthorized access.

3.14.2 Materials. Seats and backs shall be fiber glass reinforced polyester plastic. The plastic material shall be integrally colored to match the interior scheme of the car. All exposed metal shall be of stainless steel including stanchions and equipment boxes.

3.14.3 Cushion Inserts. Separate padded seat and back inserts not less than 13 mm (1/2 in) thick shall be provided for each passenger seat. Seat and back inserts shall be securely attached and shall be detachable by means of a simple release mechanism employing a special tool so that they are easily removable by the maintenance staff but not by the passenger. Design of the seat assembly shall be such that the seat may be used with or without cushion inserts.@@@@@@

######Option 21 - ******The Purchaser shall specify the seat requirements.******######

3.15 Door Assemblies

Door design shall be the same for all doors in the car. The number and location of the side door panels shall be as shown on the contract drawings. Doors and associated hardware shall be designed to be interchangeable between door locations within a vehicle and between vehicles. Doors may be folding, blinker, sliding or plug type. The design must be such that forces on the inside door surface, which might be caused by panicking passengers in an emergency, will not inhibit normal or manual opening of the door.

######Option 6.2 - With high/low level loading, doors which extend to the low level step shall not extend outward from the car during opening, and when fully open, more than the dynamic envelope for the car.######

3.15.1 Strength. Doors shall be constructed to provide proper strength and rigidity to sustain a concentrated load of 890 N (200 lbs) applied perpendicularly to the plane of the door at the center of the front edge with a maximum deflection of 6 mm (0.25 in) without a set while the door is supported at both ends.

3.15.2 Materials and Appearance. The surface finishes of the door panels shall be compatible with the other parts of the car. Interiors may be faced with other materials, but must be of the same color and texture as the rest of

the car interior. Flush mounted stainless steel "kick plates" approximately 200 mm (8 in) high above floor level shall be installed on the inside surface at the bottom of each door leaf (both high and low level steps). Maximum window area shall be provided in each door leaf.

3.15.3 Operation. Doors shall provide a maximum of clear space within the door frame opening when opened as required in Paragraph 2.1.6. Sensitive edges and obstruction detection equipment shall provide passenger safety.

3.15.4 Operation and Control shall be as described in Section 6.

3.16 Steps

Step arrangements, numbering and location shall be as shown on the contact drawings.

3.16.1 Design Requirements

@@@@@@@Baseline (Low Level Only) - Low level loading shall be accomplished with no more than four step risers. The distance from the first step riser (external to the car) to the street surface (i.e., top of rail) shall not exceed 250 mm (10 in). Each internal step riser (wholly within the car) shall be approximately 200 mm (8 in), but shall not be greater than 250 mm (10 in) high. Where a vehicle is to be loaded only from low level platforms such as curb level, and not from street level, the distance from the first step riser to the top of the rail can be greater than 250 mm (10 in) so long as the distance from the first step riser to the top of the loading platform does not exceed 250 mm (10 in). Two example preferable configurations are as follows:

Example 1: 860 mm (34 in) Floor Height, Loading From Street Level

Four steps - First step 250 mm (10 in) high, second, third and fourth (internal) steps each approximately 200 mm (8 in) high.

Example 2: 990 mm (39 in) Floor Height, Loading From a 150 mm (6 in) High Low-Level Platform

Three steps - First step 380 mm (15 in) from top of rail and 230 mm (9 in) from top of low-level platform, second, third and fourth steps each 200 mm (8 in) high.

The step edges should be aligned along a straight line. The steps shall be permanently fixed. The steps and wells shall be formed of reinforced corrosion resistant material designed to support a static load of 2,200 N (500 lbs), and a dynamic load of 4,450 N (1,000 lbs) applied and released in a smooth fashion in 0.5 g maximum. Loads shall be considered to be applied to the geometric center of any step.

The top surface shall be covered with long-wearing, anti-slip material such as ribbed rubber sheet, with appropriate nosing. Adequate drainage from the steps and wells shall be provided. The nosing shall be integrally colored yellow and shall provide a color band 100 mm (4 in) wide.@@@@@@@

######Option 6.1 (High Level Only) - Although no steps will be included in the high level only locations, if installed, a threshold and loading area shall be required. This threshold and loading area shall be a single surface permanently set flush with the normal interior floor level and covered with the same material. The threshold shall incorporate an appropriate nosing at the door side which shall be integrally colored yellow and shall provide a color band 100 mm (4 in) wide. The outside of each doorway shall be appropriately equipped with handholds and ladder rungs, preferably built into the body design, for emergency use.######

######Option 6.1 (High and Low Level) - In order to accommodate both subway platform and street level loading a step to threshold changeover shall be provided at designated door locations. The changeover shall be controlled from a finger switch on the cab console (see Paragraph 6.1.3). These two modes and the changeover cycle shall not interfere with the operation and physical position of the doors. The steps must also be capable of remaining in either position for extended periods of time whether or not power is available to the car. Provisions shall also be made to accomplish the change-over manually.

In the low level position the step heights shall be as specified for the above Baseline (Low Level Only).

Only service proven designs (see Paragraph 1.15.1) shall be permitted.

Interlocks shall be provided such that when changing from one mode to the other, the doors cannot be opened until the steps are either fully raised or fully lowered. Similarly the step mode cannot be changed unless the doors are fully closed.

The changeable steps shall function in the following basic manner: when changing from low to high level or vice versa the top surface of both steps shall remain horizontal at all times and a device to shield the vertical space between the two steps shall be present at all times. No gaps greater than 3 mm (1/8 in) shall be permitted and similarly no linkage shall be exposed at any time. The steps shall withstand a static load of 2,200 N (500 lbs) during operation and a dynamic load of 4,450 N (1,000 lbs), in either the high or low position, applied and released in a smooth fashion in 0.5 g maximum. Loads shall be considered to be applied to the geometric center of any step.

The top surface shall be covered with long-wearing, anti-slip material such as ribbed rubber sheet, with appropriate nosing. Adequate drainage from the steps and wells shall be provided. The nosing shall be integrally colored yellow and shall provide a color band 100 mm (4 in) wide.

The entire mechanism shall be constructed such that it shall operate for extended periods of time without unusual maintenance requirements and in an environment in which dirt, debris, and water may be common occurences. In addition, its operation shall be integrated with that of the doors and together they shall provide for simplicity, reliability, ruggedness, and ease of maintenance.######

3.16.2 Wheelchair Access. @@@@@@An apparatus shall be furnished to provide access for wheelchair users and passengers with walking difficulties to the vehicle from a low level platform or the street. The apparatus shall be installed at the door location within close proximity to the operator's station for ease of observation and operation of the apparatus by the operator.

The apparatus shall be provided for a minimum 815 mm (32 in) clearance width (free from intrusion) for the wheelchair and its occupant when accessing the vehicle.

The platform shall be a minimum of 46 in long exclusive of ramp/safety barrer. The platform shall retract into vestibule steps or stowed in a position so as not to interfere with persons boarding or leaving the vehicle.

The apparatus shall be modular in construction and be designed such that the moving platform and retracting parts can be removed easily and quickly with simple hand tools should it become disabled.

Redundant safety features shall be incorporated into the system so that the platform cannot collapse with a wheelchair or standing occupant and an attendant on it, and shall be capable of withstanding a maximum lifting load of 600 pounds. There shall be manual operating features to allow the apparatus to be operated should the operating power and/or operating source be disabled. The operating power for the apparatus shall be from the low voltage power supply. The control apparatus shall be installed in a location for easy access for maintenance and repair. If the control apparatus is mounted under the vehicle, it shall be installed in a compartment sealed from the environment.

The operation of the apparatus shall be interlocked so that it cannot be operated until the vehicle has stopped and the doors opened to their fullest. The apparatus shall also be interlocked with the propulsion system so that the vehicle cannot be powered until the apparatus is properly retracted and the doors closed.

The controls for operating the apparatus shall be located on the operator's console. The number of switches to operate the lift shall be no more than three (3) plus a hold-down power switch.

######Option 1 (Bi-directional Operation) - In bid-directional operation, where vehicles are not permanently paired, wheelchair access apparatus shall be provided at both ends of the vehicle. Power to the respective lift apparatus control shall be activated only when that console is activated. Deactivation of the apparatus control power shall not void the operation of the lift apparatus under emergency conditions.######

######Option 4 (Doors on Both Sides) - Wheelchair access apparatus shall be provided at both door locations on both sides within close proximity to the operator's station.###### ######

3.17 Interior Accessories

3.17.1 Stanchions, Rails and Windscreens. Locations and sizes of various stanchions, rails and windscreens shall conform with Federal Regulations 49, Chapter 6, Article 609.19. The outside surfaces of stanchions shall be clad with stainless steel. All fasteners shall be stainless steel and vandal-proof. The grab rails shall be of the same material construction as that of stanchions and shall be designed not to require any lateral supports.

The windscreens shall be constructed of plymetal or other approved material faced with melamine of the same color and texture as the other interior linings below the belt line. The plymetal shall be "L" shaped extending from floor to ceiling against the interior side wall and to the floor in the outer area. The lower portion of the "L" shall not extend higher than 75 mm (3 in) above the surface of the seats. As an alternative the windscreen may be made entirely from a transparent polycarbonate or acrylic material, 13 mm (0.5 in) thick, satisfying the fammability and smoke requirements of Section 17. The hand grip attached to the windscreen shall be of the same material as that of stanchions. The windscreens shall not block the operator's view of seated passengers or door areas.

3.17.2 Underfloor and Underseat Equipment Boxes. Underfloor boxes, except as approved by the Purchaser, shall be provided with top-hinged access panels which shall have suitable means for ready removal where necessary, and shall be water and dusttight where required. Where equipment is located under seats, an equipment box shall be provided. Such enclosures shall be corrosion resistant and protected internally according to the requirements of the equipment as specified in the appropriate equipment Sections.

3.17.3 Passenger Station Stop Request Signal. A passenger station stop request signal shall be provided which shall permit any passenger in any car of a train to alert the operator to stop and shall consist of the following:

a) Stop request push buttons and wiring or a single vinyl covered, stainless steel pull cord on each side of the car suspended just above the top of the side windows and attached to the side walls with fittings. The cord shall be connected to a rugged but attractively housed electromechanical switch surface-mounted on the side walls. No more than one pull cord and one switch per car side may be used between door locations.

b) An audible non-repeating chime signal and console light shall be installed in each operator's cab area. Tone shall be distinct from other audible alarms and sounded only once until canceled by door cycling.

######Option 22 - Passenger stop request lights shall be installed in the vehicle, visible from all seating locations. They shall be lighted with the words "STOP REQUESTED".#######

c) ######Option 3.2 - Operation of chimes and stop request lights shall be trainlined so that when any pull cord on any car is activated, they shall function on all cars.######

3.17.4 Graphics

######Purchaser to prepare these requirements.######

3.17.5 Destination Signs. Illuminated end and side destination signs, installed in dust-proof enclosures shall be provided for each car and shall be located as shown on the drawings. Either a curtain type, split-flap or dot matrix type may be provided. In either case, the sign shall be service proven. The signs and sign mechanisms shall provide for easy access from inside the car to the curtain or display device, the mechanisms and the lamps, as well as provide an easy access to the glass for cleaning. The destination signs shall be easily readable in the daylight from outside the car without illumination. All car borne curtain type destination signs shall be manually operated.

######Option 3.2.9 - ******Purchaser may eliminate the split-flap and matrix type signs and confine the requirements to only curtain types. Subsection 3.17.5 to then be appropriately edited by the purchaser.****** ######

The side destination signs shall be installed behind a side window on each side of each car. They shall be readable from both inside and outside the car. The sign enclosure shall be hinged and shall be equipped with a latching device to hold the side sign firmly in the closed position without rattle.

Curtain type end destination signs shall be back lettered and easily readable through a peephole. The peephole shall be covered with a transparent plastic material. A pointer, easily visible through the peephole, shall be mounted to indicate proper alignment of the sign exposure. The end destination sign enclosure shall be provided with an access door with a hidden continuous hinge. The access door shall be equipped with latching devices to hold the door firmly in the open position and firmly in the closed position. The door shall be reinforced structurally to prevent drumming and shall be rattle-proof.

The curtain for all signs shall have translucent letters on a black background. Diagonal red stripes may be specified on certain exposures to overlay route letters and adjacent background. The curtain shall not deteriorate under the heat of the sign lamps, shall be relatively unaffected by sunlight and ozone, and shall not become brittle with age.

Dimensions of the lettering represent an absolute minimum. The lettering shall be of the following types:

a) End Signs (Exterior)

Route letter - Vertical block approximately 230 mm (9 in) high.

Designation - Vertical block approximately 150 mm (6 in) high.

Destination - Inclined block (with top of letters inclined 6^{o} to the right from the vertical) approximately 150 mm (6 in) high if single line and 100 mm (4 in) high if two lines are required.

b) Side Signs (Exterior)

Route letter - Vertical block approximately five and 140 mm (5.5 in) high.

Designation - Vertical block approximately 100 mm (4 in) high.

Destination - Inclined block (6^{o} as above) approximately 100 mm (4 in) high if single line and 65 mm (2.5 in) high if two lines are required.

c) Side Signs (Interior)

Route letter - Vertical block approximately 75 mm (3 in) high.

Designation - Vertical block approximately 50 mm (2 in) high.

In the interest of simplicity and reliability it is intended that the interior and exterior exposures on curtain type side signs be provided on the same curtain and that one drive mechanism per curtain be utilized. Thus, a typical side sign when unrolled would appear to have half of the wording upside down with respect to the other half properly spaced so that they read correctly and simultaneously on interior and exterior side signs when installed.

@@@@@@@Baseline - Each destination sign shall be manually operated from inside the car by a crank handle at the sign.@@@@@@@

######Option 3.2.10 - Destination and route signs shall be remotely-controlled. They shall position themselves in accordance with the positions of a selector switch mounted in a control console that is in "operate" or "standby". One switch shall select route sign position and a second switch shall select destination sign position. The signs shall remain at the last selected position when the control console is deactivated. The control signals shall be trainlined. ******Note: This suboption does not apply for single-unit operation.****** ######

3.17.6 Run Number Sign. An illuminated three digit manually operated run number sign shall be provided and installed to the right of the operator position in each cab. Size and location shall be such that the sign can be easily read through the windshield from street level.

3.18 Special Provisions for Elderly and Handicapped Persons

In addition to the above, both the interior and exterior of the carbody must conform in all respects to the Federal Regulations, Transportation for Elderly and Handicapped Persons, Title 49, Chapter VI, Part 609, Light Rail Vehicles Section 609.19, issued by the Urban Mass Transportation Administration on April 27, 1976.

Technical Specifications - Section 4

TOWBARS, COUPLERS, DRAFT GEAR & ASSOCIATED EQUIPMENT

This section defines the requirements pertaining to either the towbar or coupler and draft gear systems to be provided for each Light Rail Vehicle. The towbar or coupler system shall allow the cars to be coupled as closely as practicable within the specified clearance limitations and still allow sufficient horizontal and vertical freedom for normal operations through the horizontal and vertical curves provided for in the specifications.

@@@@@@4.1 Baseline (Portable Towbar) - In order to provide for emergency towing, each car shall be provided with a portable towbar.

4.1.1 General Design. The towbar shall be made of high strength, steel and, at each end, it shall be provided with a suitably located hole to receive a coupling pin. In use, the towbar shall be connected to each opposing car by means of a clevis and pin arrangement which shall be incorporated as a recessed part of each anticlimber. The coupling pin shall be retained to the anticlimber, against loss or unauthorized removal, preferably by means of a flexible stainless steel cable and attaching hardware.

4.1.2 Strength Requirements. The towbar and its attachments shall be designed to withstand, without permanent deformation, an axial pull or buff load of not less than a load equal to 1.73 AW0.

4.1.3 Storage. Suitable means shall be provided under each Light Rail Vehicle for the secure and rattle-free storage of the towbar. The towbar shall be readily accessible and it shall be suitably protected against dirt and wheel wash.@@@@@@@

######4.2 Option 3 (Automatic Mechanical Coupler) - At the ends, each car shall be provided with a coupler and draft gear system.

######Option 3.1 - These couplers shall be used only for retrieval of a dead car and not for operating trains in regular service.######

******If this option is selected the suboptions listed below, and indicated in the following paragraphs, are required:

- Option 3.1.1 Manual Coupler Centering, and
- Option 3.1.2 Manual Control

In addition, the Purchaser has a choice among the following suboptions:

- Option 3.1.3 or 3.2.3 relative to Symmetry, and
- Option 3.2.7 Coupling with Existing Cars.******

######Option 3.2 - These couplers shall enable train operation in regular service of up to four cars per train.######

******If this option is selected, the Purchaser has a choice among the following suboptions:

- o Option 3.2.1 Automatic Coupler Centering,
- o Option 3.2.2 Automatic Coupler Control,
- o Option 3.1.3 or 3.2.3 Symmetry,
- o Option 3.2.4 Electric Couplers,
- o Option 3.2.5 Pneumatic Coupler,
- o Option 3.2.6 Manual Isolation Device,
- o Option 3.2.6.1 Automatic Isolation Device,
- o Option 3.2.7 Coupling with Existing Cars, and
- o Option 3.2.8 Train Operation with Existing Cars.******

4.2.1 General Design. The coupler shall be fully automatic and shall be of a hook or latch type, slack-free design. The coupler assembly shall be of cast and/or fabricated steel. All bearing or wear surfaces of the coupler assembly and its attachments shall be provided with shims, replaceable bushings, stainless steel wear plates, or other means to compensate for wear. All important surfaces of the drawbar and coupler shall be bushed with readily replaceable, bushings.

If a slide or radial bar is used, it shall be of abrasion resisting stainless steel and shall be attached to the car body in a manner so as to be readily removable. Means shall be provided so that the slide bar attaching bolts cannot inadvertently drop down and interfere with the radial movement of the draftgear. The radial bar shall be provided with lateral end stops which shall include elastomeric bumpers. Removable wear plates shall be provided on the draftgear and they shall be resiliently attached to the draftgear to reduce noise transmission.

Provision shall be made for the lubrication of the copuler, if required, to maintain trouble free performance for its expected life.

4.2.2 Strength Requirements. The coupler, coupler carrier, drawbar, anchorage and their attachments to the car body shall be able to withstand a buff or draft load not less than a load equal to 1.33 times the buff release load without permanent deformation.

With proper blocking between the coupler/drawbar and the end sill, the coupler assembly and its attachments to the car body shall, without permanent deformation, have sufficient strength to allow the car end and its adjacent truck to be lifted for emergency re-railing purposes.

Each coupler shall be able to withstand a downward load of 1,600 N (360 lbs) without permanent deformation.

4.2.3 Geometric Requirements. When coupled, the coupler assemblies shall allow cars to negotiate the track super-elevation and horizontal and vertical curves as specified and with normal irregularities. In addition, they shall accommodate the maximum coupler height variations between cars which may be encountered as a result of uneven wheel wear between cars, dynamic and static truck spring deflection, broken bolster springs, and if used, air

springs in the fully inflated or deflated condition. A lateral stop shall be provided to positively limit the coupler swing and prevent damage to the car body and/or equipment.

The coupler gathering range shall not be less than 57 mm (2.25 in) in both vertical and lateral directions, separately or combined.

4.2.4 Coupler Centering

######Option 3.1.1 (Manual Coupler Centering) - The coupler shall be manually centered from track level. The uncoupled drawbars shall be held in a fixed position against the stop on the right side of each car by an anchor chain having a ring which can be engaged on a recessed hook, or by other appropriate means.######

######Option 3.2.1 (Automatic Coupler Centering) - The coupler shall be provided with a device to automatically maintain the coupler head in its centered position when not coupled. The position shall be maintained to a degree of accuracy that will allow coupling within the specified gathering range. The centering device shall be designed to allow the coupler to be manually released and manually positioned. Repositioning of the coupler to the centered position shall re-engage the centering device.######

4.2.5 Coupler Control. The couplers and their associated locking and electrical apparatus shall be controlled on a non-trainlined basis. If two vehicles become electrically or mechanically uncoupled due to component failure, the emergency brakes shall be applied on both cars.

######Option 3.1.2 (Manual Control) - Mechanical coupling shall be automatic. Uncoupling shall be controlled manually at the coupler head and separately for manual operation of electical isolation apparatus (reference Paragraph 4.4.3), in either case without the use of tools.######

######Option 3.2.2 (Automatic Coupler Control) - Remote coupler control shall be provided on each operator's console to control coupler uncoupling and also, if provided, trainlined pneumatic and electrical connections. The remote coupler control shall not be a trainlined function. It shall operate only the coupler at that end of the car where the control is located, i.e., the respective operator's console (or back-up controller specified in paragraph 9.5.6).

The design shall provide for one coupling switch and two uncoupling switches. Operation of the coupling switch shall engage the electric and, if provided, pneumatic connections and release the centering device if required. Operation of the first uncoupling switch shall disengage the electric and, if provided, pneumatic connections whereas operation of the second uncoupling switch shall disengage the coupler hook. A spring loaded, hinged cover shall be provided over the second uncoupling switch. The sequence of the two uncoupling switches shall be interlocked so that the electric and pneumatic connections shall be disengaged before the drawbar hook is uncoupled and only that portion of the train which is not desired to move will be placed in the emergency braking mode when the first uncoupling switch is actuated.

When the second switch is actuated the couplers shall disengage and the centering device shall be activated. The coupling and uncoupling circuits shall be arranged so that they can be energized only when the master controller is in the "Operate" position. Provision shall also be made for manual operation at the coupler head.######

######Option 3.2.2.1 - Coupling and uncoupling of electric and any pneumatic connections shall be automatic and part of the coupling or uncoupling sequence.######

4.2.6 Coupler Vertical Positioning. The coupler and drawbar assembly shall be flexibly supported at its nominal height above rail. The supporting device shall contain suitable means for vertical height adjustment of the mechanical coupler to compensate for wheel and other pertinent wear.

4.2.7 Drawbar Anchorage. The drawbar anchorage shall be equipped with suitable shims, bushings, or wear plates to compensate for wear. If necessary, suitable provision shall be made for lubrication.

4.2.8 Gages. At least one set of gages which will provide "Go", "No Go" acceptance standards for every surface critical to the proper operation of the coupler shall be provided to the Purchaser.

4.2.9 Symmetry

######Option 3.1.3 - Symmetry is not required.######

######Option 3.2.3 (Symmetrical Coupler) - The couplers used on both ends of the vehicle shall be identical. It shall be possible to couple either end of one vehicle with either end of another vehicle.###### ######

######4.3 Option 3 (Draft Gear) - ******(Must be included if Option 3 is selected.)******

4.3.1 General. The draft gear shall be cushioned by use of pre-loaded, double-acting cushioning units. The cushions shall, with a margin of safety, be capable of withstanding loads resulting from the service operating conditions described in this specification and also, in an emergency, they shall have capacity to allow a train of four operating cars to push or pull a dead train of four fully loaded cars over all grades and curves on the system of the Purchaser.

4.3.2 Buff Release Feature. The draft gear shall be provided with a buff release feature which shall release under a buff load of approximately 1.3 AW0. After the automatic release occurs an energy-absorbing mechanism shall collapse to linearly absorb and dissipate energy as the coupler head moves back until the anticlimbers mate. The device shall be designed to absorb approximately the amount of energy equal to the release buff load multiplied by a distance of 300 mm (1 ft) of the available travel length. The travel length shall be at least 25 mm (1 in) in excess of the travel required to permit the anticlimbers to engage. No special tools and a minimum of hand labor shall be required to restore the draft gear to normal operating conditions.######

4.4 Electric and Pneumatic Coupling

@@@@@@Baseline - No electrical or pneumatic connections (trainlines) shall be made.@@@@@@

######4.4.1 Option 3.2.4 (Electric Couplers) - An electric coupler, consisting of an insulation block with the proper number of butt contacts, including spares (see Paragraph 9.5.7), to provide all the electric connections between cars enclosed in an approved housing, shall be mounted on the coupler head.

4.4.1.1 Contacts. Each butt contact shall be coin-silver faced and shall have sufficient capacity to handle the maximum current to which it will be subjected. The contacts shall be replaceable by removal through the electric coupler block without disassembly of the coupler or its wiring. The contacts shall be designed to maintain a positive pressure between coupled-contact interfaces without the pressure initiating means taking a permanent set in service. Connections to the back of the coupler contacts shall be by means of compression-type terminal connections.

4.4.1.2 Contact Block. The electric coupler contact block shall be of a mechanically strong, high dielectric strength non-hygroscopic material. A rubber (elastomeric) insulation block gasket shall be attached to the face of the electric coupler in such a manner that when the drawbars are coupled the gasket material shall form a waterproof seal to protect the contacts. The contact block shall be readily removable for repairs or replacement.

4.4.1.3 Connections. Connections to the back of the electric coupler contacts shall be designed to prevent interference between adjacent connections and shall be accessible for maintenance. Connections from electric coupler to car body shall be by means of multiple-conductor cable, with locking type plugs and receptacles used at both ends of the cable. The method of connection and support shall be so arranged that wiring shall be free of stress in all operating positions and prevent chafing. Cable entry to the coupler's electric portion shall be by a watertight bushing.

4.4.1.4 Electric Coupler Cover. Each electric coupler shall be provided with a weather-proof cover which shall also protect the coupler contacts from dirt, dust, and car wash water, when in the uncoupled condition. The covers shall be spring closed and shall open automatically when cars are coupled. The inside of the covers shall be treated so as to eliminate pocket areas which might accumulate snow and ice. The covers shall be provided with adequate protection against damage caused by maintenance personnel using the coupler as a step.

4.4.1.5 Creepage. Electric coupler design shall provide for maximum creepage distance between adjacent electrical connectors and between electrical connectors and any metal part connected to the car body. Where creepage paths involve surfaces not readily accessible for cleaning the minimum distance shall be 38 mm (1.5 in) otherwise

supplier shall supply evidence that no breakdown will occur in operational environment. Assignment of trainline functions to buttons shall be such as to minimize the hazards presented by creepage between adjacent buttons. Battery trainlines shall be surrounded by spare trainlines and final arrangement shall have Purchaser approval prior to manufacture.######

######4.4.2 Option 3.2.5 (Pneumatic Connector) - A pneumatic connector shall be provided on the mechanical coupler head to provide for the necessary pneumatic trainline connections between cars. The air connections shall be effectively guided to provide free movement without locking or binding. The hoses shall be so arranged as to be free of stress in all operating positions and as to prevent chafing.######

4.4.3 Electrical Isolation

######Option 3.2.6 (Manual Isolation Device) - A manually operated drawbar cut-out switch shall be provided and located under both ends of each vehicle. The device shall provide for the required number of trainline circuits and spares. In the uncoupled position all loop circuits shall be completed as required for normal operation. The switching contacts shall be of the self-wiping type and the silver contacts shall have sufficient capacity to handle the required electrical currents. The device shall be operated from track level by a mechanically interlocked lever-handle operable from each side of the car. Each handle shall be pulled out when the cars are coupled and pushed in when the cars are uncoupled. Means shall be provided to obtain positive positioning of the device. If pneumatic train line connections are used, cut-out cocks shall be provided and the operation of the cocks shall be mechanically interlocked with the operation of the device.

######Option 3.2.6.1 (Automatic Isolation Device) - In addition to being manually operable, the drawbar cut out switch shall be remotely controllable as described under Option 3.2.2. The device may be operated electrically or pneumatically. If operation is by pneumatic means, great care shall be exercised to insure that water cannot become entrapped in the air lines that might cause malfunction under freezing conditions.###### ######

4.5 Coupling with Existing Cars

@@@@@@Baseline - The ability to couple with the Purchaser's existing cars is not required.@@@@@@

######Option 3.2.7 (Coupling With Existing Cars) - The cars shall be required to couple mechanically but not electrically or pneumatically with existing cars owned by the Purchaser.######

######Option 3.2.8 (Train Operation With Existing Cars) - The cars shall be required to couple mechanically and operate in multiple-unit operation with existing cars owned by Purchaser.****** (Note: Purchaser must revise this entire Section 7 in accordance with requirements for compatibility with existing vehicles.)******######

OPERATOR'S CAB

This section outlines the requirements for the operator's cab area as well as the equipment and controls located therein.

5.1 Operator's Position Requirements

The Operator's space, seat and control devices shall be of appropriate human factors design and dimensioned to assure safe and optimal operator performance for operators in the range of the fifth to the ninety-fifth percentile of the general operator population, both male and female. A mock-up shall be provided as specified in Paragraph 2.3.2.

@@@@@@@Baseline - A complete operator's position shall be located at the front end of the vehicle, to the left of the centerline.@@@@@@@

######Option 1 (Bidirectionally Operated) - A complete operator's position shall be located at each end of the vehicle, to the left of the centerline when facing that end.######

@@@@@@@Baseline - The Operator's position shall be partially enclosed, or separated from the passenger area by a panel behind the operator's seat. This panel shall be designed to prevent the passenger compartment lights from interfering with the operator's vision during night operation. A tinted glass panel or a curtain in the upper portion will fulfill this requirement. When the Operator's position is not manned, controls and switches shall not be accessible to unauthorized personnel.@@@@@@@

######Option 23 (Enclosed Cab) - The Operator's position shall be fully enclosed as indicated in the contract drawings to prevent unauthorized access. The enclosure shall be designed so that the Operator's view is not obstructed nor shall the passenger's view be unduly obstructed. Moveable panels shall provide access for Operators in both normal and emergency situations. The panel opening shall be adequate in normal operation for the Operator to observe fare collection, dispense transfers and provide passenger information. The panel/windscreen section directly behind the Operator shall be designed to prevent the passenger section light from interfering with the Operator's vision during night operation. A tinted upper panel or a curtain would fulfill this requirement.######

5.2 Equipment Requirements

5.2.1 Control Console and Master Controller. A control console as specified in Sections 9 and 13 and master controller as specified in Section 9 shall be provided.

5.2.2 Fare Collection System. Provisions shall be made in the cab design to accommodate standard fare collection systems if desired and furnished by the Purchaser. A means to secure the fare collection system, when it is not in use, shall be incorporated in the design.

5.2.3 Cab Seat. @@@@@@The operator area of each cab shall be equipped with an operator's seat. The seat and back cushion shall be upholstered with materials complying with flammability and smoke emission requirements in Section 17. The seat shall be adjustable vertically and in a forward-backward direction to accommodate the population in Subsection 5.1. The back support shall also be adjustable. The seat shall be equipped with arm rests.

The seat shall swivel at least 45^{o} to the left and 90^{o} to the right with a weak spring return to a detent at the straight ahead position. Seat adjustment controls shall be operated from a seated position. The seat frame shall be of corrosion resistant tubular construction and be designed for hard usage. Where it is necessary for the operator to reach pole-mounted wayside push buttons or switches the seat location shall be appropriately adjusted to suit the Purchaser's accommodation to the left or right of the vehicle.

Adequate foot space shall be provided to accommodate the operator's feet and any foot-operated controls.@@@@@@

######Option 23.1 (Purchaser Specified Cab Seat) - ******Purchaser to specify a different type or variation of the cab seat, or may wish to leave these details up to the Contractor.******######

5.2.4 Cab Window. (Specified in Paragraph 3.13.3) Equipment near and below the left cab window shall be immune to rainwater entry and damage due to wind (ambient or due to car motion).

5.2.5 Storage. Storage provisions by means of hooks, latchable cabinets and retention brackets shall be provided for the operator's coat, operator's personal effects, and operator's emergency tools such as flashlight, switch irons and flags.

5.2.6 Waste Receptacle. A detachable waste receptacle of approximately 8 liters (2 gallons) capacity shall be provided in the general area of the fare collection system within reach of the operator.

5.2.7 Air Comfort. An adjustable forced air outlet as detailed in Paragraph 7.1.4 shall be provided. A cab heater as detailed in Paragraph 7.2.3 shall be provided.

5.2.8 Windshield and Side Window Defroster/Demister. A defroster/demister detailed in Paragraph 7.2.4 shall be provided in each cab.

5.2.9 Visor. Adjustable visors shall be provided in the cab(s) such that the operator can limit sunlight coming through the windshield and side window(s). They shall permit vertical and horizontal adjustment and may be full window or windshield width. Visor material shall be polarized to permit proper vision of the signal aspect.

5.2.10 Interior Mirror. One or more interior mirrors shall be provided in the cab(s). They shall be designed to permit easy adjustment by the operator to give a good view to the rear of the operator's seat and the vehicle interior and the interior of the door areas.

5.2.11 Exterior Mirror. One mirror shall be provided on each side of the operator's cab on the exterior of the vehicle. It shall be adjustable from the outside and provide a clear view of the side and along the side of the car from the operator's seat. When the vehicle is underway these mirrors may not extend beyond the car's dynamic envelope. If necessary the mirrors shall be spring loaded to deploy when the front door(s) opens.

5.2.12 Windshield Wiper. Windshield wipers shall be provided at each windshield of the cab(s). At least 80% of the width and 60% of the height of the windshield(s) must be swept over a complete cycle.

Where multiple wipers are used and their paths overlap they must be synchronized so they do not collide.

The drive units shall provide two speeds of operation and the wiper blades shall return to a "Park" position at extreme ends of their sweep in the "Off" position. They shall include an intermittent, 3-5 second delayed mode of operation. Drive units shall operate on low voltage dc power or air pressure. Wiper operating mechanisms and drive units shall be readily accessible for repair and replacement. The operating mechanisms shall be enclosed.

5.2.13 Windshield Washer. A washer device shall be provided to spray the windshield(s) in a pattern that will permit the windshield wiper blades to clear the windshield(s) efficiently. Commercially available automotive type washer solvents shall be used with the unit(s). Low voltage control shall be available on the console. Washer fluid reservoir(s) capacity shall be at least 4 liters (1 gallon) per cab.

5.2.14 Warning Devices. Warning devices shall be provided at the cab and end(s) of the car and shall be a "Horn" or "Gong/Bell" type. ******Purchaser chaser to specify tone of horn, if required.******** Control of the gong/bell may be by foot pedal or finger switch. Control of the horn may be incorporated with a gong/bell pedal such that further depression of the pedal activates the horn, or by separate finger switch. Actuation of these warning devices shall require a minimum foot or hand/finger movement from the normal operating position. Sound from the warning devices shall emanate at the front end toward the direction of travel. The horn shall produce a repetitive sound at a level of 96 dBA measured with a sound level meter on slow response at a distance of 30 m (100 ft) in "front" of the vehicle. The gong/bell shall produce a repeating sound at a level of 84 dBA measured with a sound level meter on slow response at a distance of 3 m (10 ft) in "front" of the vehicle.

5.2.15 Control Console Layout. All controls located in the operator's cab(s) as required by these specifications shall be situated such that they can be reached by either hand or foot as specified. Controls shall be located such that they are conveniently reached, based on their importance or frequency of use, categorized as follows:

a) Quick access for emergency -
(stop button);

b) Frequent use -
(track switch, warning devices, door control, headlight dimmer, directional (turn) indicator, radio selector, microphone, etc.);

c) Moderate use -
(windshield wiper, cab light, console illumination, head and tail lights, interior lights, radio volume, demister, cab heater, etc.);

d) Infrequent use -
(reverser, propulsion reset, coupler control, pantograph control, train activation, air comfort, etc.); and

e) Special use (sealed or covered) -
(door bypass/cut out switches, traction interlock bypass).

All controls and gauges requiring identification shall have their identification marks engraved in the panel, or otherwise permanently applied, but shall not be silk screen painted.

Indicator lights and gauges, where applicable, shall be located with their associated controls. Warning function indications shall be located in the primary field of vision of the operator. Audio signals shall be distinctively different in order to be recognized by the operator.

5.2.16 Fire Extinguisher. A class C fire extinquisher shall be located in the operator's cab.

Technical Specifications - Section 6

DOOR CONTROL AND SIGNAL SYSTEM

This section defines the requirements for door system operation and control, high-low step control, if so equipped, and associated signal and safety circuit devices.

6.1 Door Operation

6.1.1 Mechanism. The door operator mechanism shall be designed to control individual door panels at each door location simultaneously, but in no case shall it drive any of the high/low level step apparatus, if so equipped.

All operating mechanisms shall be enclosed to be clear of the door areas and step well, out of reach of passengers and protected from adverse environmental conditions.

The operating mechanism shall be driven by low voltage electrical power or air and shall be located for ease of access for maintenance.

Forces generated by the operating mechanism shall not exceed 130 N (30 lbs) measured at any point of its travel. The mechanism and/or operating linkages shall provide sufficient damping force to keep the doors from oscillating about the open or closed end stops. The doors shall be held closed by the operating mechanism, and in the event of a loss of power at any door, the geometry of the linkage shall allow the doors to be opened manually.

In the interest of passenger safety, a force perpendicular to the door panel such as a passenger leaning or falling against the panel, shall not cause the door to open. In an emergency, persons shall be able to open any door manually by taking overt action to release the door lock or linkage. The geometry of the mechanism shall not restrict manual opening of the door under forces caused by panicking passengers pushing against any of the inside surfaces. This manual release shall be marked as approved by the Purchaser. Manual release shall also be interlocked with the propulsion system and service brakes to inhibit propulsion and cause an irrevocable full service stop. If the car is placed in an emergency braking mode, manual passenger door operation shall be possible when the vehicle speed is 3 km/h (2 mph) or less.

The operating times of any door, from the time of actuation of the door control switch to the point of completion including cushioning shall be 1.5 seconds opening to 2.0 seconds closing, $\pm$ 25%.

The kinetic energy of the vehicle doors, including all parts rigidly connected to the door, computed for the average closing speed, should not exceed 9.5 Joules (7 ft-lbs).

Removal of any lower door track shall not entail the removal of step tread covering to gain access to attachment screws.

6.1.2 Obstruction Protection. All door locations shall contain an obstruction protection device. When activated, this device will cause motion of door panels in the opening direction, and should retain doors open for an adjustable time period of one to five seconds, then the door will attempt to close again. This fixture shall be designed such that entrapment of any object greater than 13 mm (0.5 in) in diameter will cause activation of the sensitive edges and motion of the door panels in the opening direction.

######6.1.3 Option 6.2 (High/Low Step Operating Mechanism) - The High/Low step requirements are specified in Paragraph 3.16.1.

A loading and unloading elevation selector switch and indicator (one per side if equipped with doors on both sides) will be located at the operator's console to select high or low level loading.

In the selected position, all step mechanisms will properly adjust and lock. It will not be possible to change the step mechanism orientation at a particular door location, unless that door is closed and locked.

Door and step operating mechanisms shall be electrically interlocked so that the door will not open unless the step is in its commanded position.######

6.2 Door Control

6.2.1 Door Control

@@@@@@@Baseline - The operator will control opening and closing of all door locations separately from control switches on the operator's console. These switches shall be arranged so that they can be operated simultaneously.@@@@@@@

######Option 4 (Door Locations on Both Sides) - The operator's console will be equipped with separate sets of switches per side, geographically oriented, to control door opening and closing.######

######Option 1 (Bidirectional Operation) - ******Loading and unloading platform configurations at various operating authorities will require the selection of one of the following two bidirectional options:******

Option 1.3 (Right-Hand Loading/Unloading Platforms) - Door operation will be interlocked with the vehicle direction switch to correctly orient door location operation with the loading platform.

Option 1.4 (Center and Right-Hand Loading/Unloading Platforms) -Door operation will not be interlocked with the vehicle direction switch. The operator will be required to select right or left hand door operation in order to correctly orient door location operation with the loading platform.######

######Option 3.2 (Train Operation) - Simultaneous door operations, high and low level loading step mechanisms if so equipped, door status indicators, and emergency door control switches shall be trainlined.######

######Option 24 (Optional Door Control) - ******The Purchaser may specify forms of door control other than the baseline covered above. These may include selective door control by the operator and/or passenger activated door control.****** ######

6.2.2 Motion Detection Door Interlock. The door controls shall be interlocked so that the doors cannot be opened with the normal door control circuit until the vehicle has reached essentially zero speed (less than three miles per hour).

6.2.3 Crew Switch. A key operated crew switch shall be installed near the front corner of the car in a suitable and protected location. Control shall be available to open or close the door in any vehicle mode. If the normal power supply is not available (dead battery), means shall be available for manual unlock and open functions.

6.3 Signals, Interlocks and Indicators

The following signals, interlocks and indicators will apply to the baseline door control and any selected options.

6.3.1 Door Status. An operator control console mounted door status indicator will show "red" for any door open and "green" for all doors closed and locked.

######Option 3.2 (Train Operation) - The door status indication shall be trainlined. In addition, red indicator lamps at the exterior of each door location, and visible to the operator, looking down the side of the car will light to indicate when a particular door location is not closed and locked.######

6.3.2 Door Status Interlock. The Door Status circuit shall be a fail-safe "Loop Circuit". It shall be interlocked with propulsion and brake control to effect a full service brake signal whenever a door is opened. Propulsion command signals shall not be effective until all doors are locked in the closed position.

6.3.3 Emergency Interlock Overrides. An emergency key operated switch (separate from the operate key) shall be provided at the operator's console which will override all door interlocks, allowing the operator to move the vehicle in the event of an emergency.

A tamperproof mechanism shall be provided to mechanically lock a door location closed and place the door in an "out-of-service" mode and by-pass the interlock function of the associated door. An indication that a particular door location is out-of-service shall be made both inside and outside at the door location. The inside indication shall be prominently located and shall state "Not in Service". Changeable step operation, if so equipped, shall also be made inoperative at the respective location.

A door placed in an out-of-service mode will likewise be removed from the door status circuit and emergency door control circuits.

An additional sealed (tearable plastic) control switch (one per side, if equipped with doors on both sides) will be geographically located on the operator's console to open and close all doors on a given side of a car. This switch shall function regardless of all other interlocks and controls.

6.3.4 Warning Signal. A tone, audible in the operating environment, shall sound at each door location one to two seconds prior to door closing. A door placed in the "out-of-service" mode (as explained in Paragraph 6.3.3) will not be part of the door operating alarm circuit.

######Option 6.2 (High/Low Steps) - This same tone shall warn passengers of a step level change.######

Technical Specifications - Section 7

AIR COMFORT SYSTEM

This section specifies the Air Comfort System requirements for the vehicle. As a minimum the system shall include heating and ventilation equipment, and temperature controls. The system shall be designed for satisfactory operation in the climate extremes defined in Paragraph 2.1.4.

7.1 Ventilation Requirements

Average air velocities throughout the car shall not exceed 0.30 m/sec (60 ft/min) at any position inside the car body that is 150 mm (6 in) from the floor and 300 mm (12 in) from the ceiling, sides or ends of the car. Ventilation during heating shall be provided to insure a minimum of 30 complete air changes per hour in the passenger compartment with at least 10% outside fresh air. A positive static pressure of at least 1.5 mm (1/16 in) water within a closed and moving vehicle shall be maintained. These minimum ventilation requirements do not account for any ventilation which occurs from opening doors or windows.

The volume of air during ventilation only for cooling purposes, i.e., when heating is not turned on, shall not be less than 60 complete air changes per hour in the passenger compartment with at least 25% fresh air and capable of being vented with 100% fresh air.

######Option 25 (Air Conditioning) - When the air conditioning system is "On" the volume of air shall be not less than 30 complete air changes per hour in the passenger compartment, with at least 25% outside fresh air.######

The vehicle forced air ventilation system shall consist of a roof mounted section providing fresh and recirculated air. The fresh air intake shall not be positioned to draw air from the track or similar dust and debris areas. The intake shall be designed to exclude rain and snow, without filters used solely for this purpose that require maintenance. The intakes shall be drained to the outside of the car. The air intakes and discharges shall not cause negative internal car pressure when the vehicle is in motion.

The forced air flow pattern shall take into account the opening of windows and shall ensure that the air flow from the ventilation system will not flow directly out these windows if and when opened by passenger choice.

7.1.1 Blower units shall be designed for the primary line voltage or auxiliary ac operation.

7.1.2 Air filters shall be provided to filter both fresh and recirculated air. Filters shall be commercially available, disposable media, standard size, at least 50 mm (2 in) deep with capacity for at least 30 days normal operation between changes. Filters shall be readily accessible for maintenance. The maximum filter force air velocity shall be 1.5 m/sec (300 ft/min). The average efficiency to 13 mm (0.5 in) water gage, at constant velocity of 1.5 m/sec (300 ft/min), shall be 70% minimum as tested in accordance with AFI Code, Section 1 using standard AFI contaminant. The filter holder shall seal

adequately at the filter edge to minimize filter bypass. Support of the filter elements shall be provided to prevent blowout under clogged filter conditions.

7.1.3 Air ducting shall be insulated and constructed of fire retardant materials in accordance with the flammability requirements of Paragraph 17.3.6. Ducts shall be designed to provide specified air volume without exceeding 9.14 m/s (1,800 ft/min) air velocities within the ducts.

Ducting exposed to passenger view shall be faced with material that matches the adjacent interior vehicle panel surfaces and integrated with interior design.

7.1.4 Diffusers, Grilles and Outlets. Air shall be distributed to the car interior through diffusers designed to distribute the air evenly over the length of the car and discharge the air generally parallel to the ceiling in such a manner that no seated or standing passenger shall feel an impingement of greater than 0.25 m/sec (50 ft/min).

The diffusers shall be factory adjusted and shall not be adjusted in service. The diffuser shall be service proven and shall have been demonstrated to meet the required performance prior to delivery. In the cab areas, air flow adjustment shall be provided by use of an exposed hand control, where in the fully open position the air flow shall be at least 1.7 m^3/min (60 cfm).

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

7.2 Heating Requirements

All vehicle heating shall be accomplished by thermostatically-controlled electric floor and overhead forced-air heater units. Forced-air heat shall be integrated with the ventilation system of Subsection 7.1. Electric heaters shall operate from 600 Vdc power using low voltage dc power for control. The system shall be designed to maintain an inside temperature of 18° C (65° F) with an outside ambient of -15° C (5° F). If the exterior ambient temperature falls below -15° C (5° F), the heating system shall maintain a temperature in the car not less than 33° C (60° F) above the outside ambient. The capacity of the heating system shall not include heat from variable internal loads such as passengers, auxiliary electrical equipment or solar gain.

######Option 26 (Resistor Waste Heat) - The heating source shall be waste heat from the propulsion control and braking resistors supplemented by heating elements and shall meet temperature requirements of Subsection 7.4. The damper shall be automatically controlled.######

7.2.1 Heating Elements shall be rated for operation over the voltage range indicated in Section 2. All elements shall be adequately protected from the accumulation of dirt and debris. They shall be thermally protected against overheating as specified in Paragraph 7.2.6. Enclosure surfaces that may come in contact with passengers shall not exceed 52° C (125° F). Open resistance wire elements will be acceptable only for closed forced-air systems.

######7.2.2 Option 25 (Air Conditioning) - If an integral heating/air conditioning system is provided, heating elements installed in ductwork or evaporators shall be mounted downstream of cooling elements and designed to perform the reheat function required for humidity control.######

7.2.3 Operator's Heater. The Operator's position shall be provided with a floor level heater having 1.25 kW capacity.

The heater housing shall be constructed of heat resistant, non-combustible material. The operator shall be provided with a four-position switch for control. It shall provide Off, Low, Medium and Full Heat. The heater case and housing shall be permanently grounded.

Overhead ventilation is also required to be supplied to the cab, as specified in Paragraph 7.1.4.

7.2.4 Windshield and Side Window Defroster/Demister. A blower and heater assembly shall be provided in each cab for defrosting/demisting of the front and side windows. A variable damper designed for use by the operator shall allow varying proportions of defrosting/demisting air to the side or front window. The damper control shall have suitable detenting so that once set by the operator, it will not shift setting due to fan operation or normal car vibration.

7.2.5 Lay-Over

@@@@@@@Baseline - Layover heat shall not be provided.@@@@@@@

######Option 27 (Layover Heat) - The heating control system shall be designed to allow for partial system operation to automatically maintain car temperature at approximately 7^{o} C (45^{0} F).

7.2.6 Protection. All heating units shall be individually and adequately protected against operation at over-temperature. Where heaters are used in conjunction with fans or blowers, interlocks shall be provided to remove primary line power to heater elements when the fan or blower is not operating. Fusible links that will not allow damage to the plenum or ductwork shall be provided. In addition, the entire system shall be fused at the primary supply. Wire for all heater installations shall be as defined in Subsection 17.10.

7.3 Air Conditioning

@@@@@@@Baseline - The vehicle shall not be air conditioned.@@@@@@@

######Option 25 - A cooling system, designed integrally with heating and ventilation, shall be provided. Installation shall be made at the time of original manufacture of the vehicle.

The cooling system shall include evaporators, condensers, compressors, refrigerant, piping and all accessories required to accomplish the intended function. The cooling system shall be provided as two separate units, one for each one-half of the car.

7.3.1 Criteria. The following criteria shall be used for cooling system design:

a) Interior car temperature	26^{o} C (78^{o} F) or 11 C^{o} (20 F^{o}) below outside ambient above 37^{o} C (98^{o} F)
b) Passenger load	AW2 passenger load
c) Supply power	Primary line power or aux. ac

Resilient mounting shall be utilized on all units which incorporate rotating parts. Access panels and sufficient space shall be provided for adjustment, routine maintenance or replacement.

7.3.2 Evaporator units shall be supplied as an integral design with ventilation blowers and heater units. At least two evaporator units shall be furnished for adequate air distribution in the vehicle. Blowers shall be operable when other cooling system components are not being utilized or have failed.

For modulated operation, at least two refrigerant distribution headers shall be provided, each operated by a solenoid valve.

Split high-low side evaporators shall have couplings that meet applicable standards on all refrigerant lines, and flexible refrigerant fittings shall be used between components.

Heaters used in the evaporator units shall be equipped with fusible links to provide overtemperature protection.

Adequate condensate drainage under worst case conditions of braking and grades shall be provided.

7.3.3 Compressor/Condenser. Each one-half of the car shall be equipped with one dry type condenser and direct or gear driven compressor designed as an integral unit.

The unit shall be capable of operating at reduced capacity with an inlet air temperature of 52^{o} C (125^{o} F) and shall continue to operate for short durations not to exceed 10 minutes with an inlet air temperature of 57^{o} C (135^{o} F).

7.3.3.1 The condenser air inlets shall be screened to prevent entry of rocks and other debris.

7.3.3.2 Compressors. Power input shall be primary line voltage or auxiliary ac.

7.3.4 Refrigerant lines shall be installed with adequate insulation, support and protection. All permanent joints in refrigerant lines shall be silver

brazed with filler metal conforming to latest applicable ASTM standards. Joints are not permitted where inaccessible. Refrigeration piping shall be in accordance with USAS Code B31.5, latest edition. The refrigeration system shall be dry and clean prior to filling with refrigerant. Design shall include valving of liquid lines to prevent loss of refrigerant when replacing major components.######

7.4 Temperature control shall sense and control the vehicle interior environment. The system shall be of modular design utilizing low voltage dc power. Air temperature within a closed car shall be maintained within 2 C^{o} (3.6 F^{o}) at any point in the car, between the low railing sections and at least 12 inches from the ceiling and 6 inches from the floor and walls. Sensitivity of temperature sensing devices shall be at least $\pm$ 0.5 C^{o} (1 F^{o}).

The entire heating and cooling control schedule band shall be manually adjustable over a range of $\pm$ 4 C^{o} (7.2 F^{o}). This requirement may be satisfied by use of "plug in" thermostats.

7.5 Electrical Control

Normal activation of the entire air comfort system shall be automatic whenever the operator's console ######Option 3.2 - or any one operator's console in the train###### is activated. An adjustable timing feature shall permit the air comfort system to continue operating for a period of one to 15 minutes after the operator's console is deactivated. Circuit breaker control shall be available in the electric locker to disconnect individual units of the system.

For pre-conditioning or test purposes, a method shall be made available on the electric locker panel to activate the system while in "Lay-up" mode.

7.6 Test and Data Requirements

Refer to Section 2 for environmental testing and system data requirements.

Technical Specifications - Section 8

LIGHTING SYSTEMS

This section specifies the requirements for all lighting systems on the vehicle.

8.1 Criteria

The lighting fixtures shall be designed to provide ease of cleaning, changeout, adjustments and housing removal. All lights shall operate from the low voltage power source. Alternatively, except for emergency lighting, all interior lighting may be powered by 120/208 Vac auxiliary power, if supplied. All lamps and ballasts shall be of a American standard type commercially available in the U.S.

Noise generated by lighting system components shall not be distinguishably audible under the Paragraph 2.2.10 requirements for interior noise levels.

8.1.1 Interior Lighting Requirements. Light intensities are specified at rated voltage. The average intensity of the illumination within the car at an elevation of 830 to 1670 mm (33 to 66 in) above the floor and on the upper surface of a transverse 45° plane at the passenger seats shall be at least 325 lux (30 foot-candles) and 160 lux (15 foot-candles) at the operator's seat when the operator's light is turned on.

The average intensity at the floor in the aisles shall be at least 160 lux (15 foot-candles).

######Option 2 (Articulated Car) - The average intensity at the floor in the articulation section shall be at least 110 lux (10 foot-candles).######

The average intensity at the platform with the door open shall be at least 10 lux (1 foot-candle) for a distance of 900 mm (3 ft) from the lowest step edge.

The average intensity on step treads with the door open shall be at least 20 lux (2 foot-candles).

8.1.2 Headlights. Headlights shall be adjustable and shall provide illumination as prescribed for buses in the latest SAE Standards for "Sealed-Beam Headlight Units for Motor Vehicles".

######Option 28.1 (Standard Railroad Lamp) - A 200-watt standard railroad lamp shall be provided for private right-of-way ("interurban") operation. This lamp shall operate off the low voltage power supply via a separate switch on the console when the normal headlights are illuminated. The aim of the "interurban" headlight shall be adjustable and shall be set to outline a person of average size standing erect at a distance of 245 m (800 ft) in front of the car on level, tangent track in clear atmosphere. The lamp shall operate at rated voltage from an adjustable series resistor with the low voltage supply functioning normally. The lamp shall be located on the roof, centered over the destination sign. It shall be interlocked with the reverser switch to be "On" only with the switch in the "Forward" position. ######

8.2 Interior Lighting Systems

All light fixtures shall either be recessed or integrated with air diffusers. Master circuit breakers for normal and emergency interior lighting circuits shall be provided in the electrical locker.

8.2.1 Main Interior Lighting Fixtures. The passenger section ######Option 2 - except in the articulation unit####### shall be illuminated by continuous fluorescent fixtures mounted in the ceiling. The fluorescent fixtures shall not extend into the cab area(s).

The light fixtures shall be dust and moisture resistent and may be combined with the air diffusers. All exposed portions of the fixtures (except lenses) shall be unpainted stainless steel or brushed aluminun. In addition to the support obtained from lock type terminal pins and sockets, the lamps shall also be supported by clamps around the tube ends. The lamps shall be of warm white color utilizing standard pins and no longer than 1,220 mm (48 in). Lamps shall be designed for average life of 20,000 hours.

The fixtures shall utilize approved diffusers contained in a hinged door with either locking devices or captive fasteners. Lens materials shall be non-yellowing polycarbonate meeting the flamability requirements of Section 17. The fixtures shall be arranged on circuits with adjacent lamps or pairs of lamps connected to different circuits. The metal fixture housing and reflectors shall be grounded.

8.2.2 Fluorescent Lighting Power Supply. The fluorescent lighting system shall not be powered directly from primary line power.

8.2.2.1 Inverter Ballast units shall be designed for mounting at the fixture to operate one or two rapid start or instant start fluorescent lamps. Output frequency shall be not less than 25,000 Hz with the nominal LVDC voltage. The units shall not cause a reduction in normal expected lamp life.

The circuit shall be solid state with internal short circuit, overload, open load circuit and over-temperature protection. Where two lamps are used, each ballast be rated to operate without failure if one lamp burns out. Efficiency shall be not less than 75% with input power and environmental conditions indicated.

The ballasts shall be arranged to avoid interference with the operation of signal devices or systems, two-way radio, intercom or the public address system. The ballasts, when in operation, must be inaudible to the passengers or train crew, and shall also be out of the animal audio range.

8.2.2.2 Central Inverters. Solid state inverters with minimum output frequency of 1500 Hz may also be used to provide fluorescent lamp power. The central inverters, if used, shall be mounted under the vehicle floor. Adequate internal short circuit, overload, open circuit and over-temperature protection shall be provided. At least two inverters shall be supplied, one for powering emergency lights.

Lock type plug connectors shall be utilized at the fixtures for ease of maintenance.

8.2.3 Main Interior Lighting Control. Main interior lighting shall be locally controlled by a switch on the console of the cab(s). The switch shall be arranged to function in the operating cab when the car is activated and master key is in the "Standby" or "Operate" position. The control system shall operate on the auxiliary low voltage supply.

######Option 3.2 - Main interior lighting control shall be trainlined.######

8.2.4 Front Door Interior Lighting. If it is determined that additional lighting is required at each front door area in order to meet the intensity criteria and increase the fare collection visibility, separately controlled incandescent fixtures shall be provided. They shall be of recessed ceiling type and focused to illuminate the desired area. These lights shall be on only when the front door is open.

8.2.5 Stepwell Lighting. Stepwell lights shall be provided to achieve the lighting levels in Paragraph 8.1.1. Stepwell lights and outside door area lights may be combined when feasible. They shall be "On" when the door begins to open and "Off" when the door is fully closed at the door adjacent to the operator position; they shall be "On" at all times when the main interior lighting is on at all other door positions. The lights shall be mounted below the lower window level and shielded to protect the eyes of entering or exiting passengers.

8.2.6 Operator's Cab Lighting. The operator's cab(s) shall be equipped with a light, controlled by a separate switch on the console, to achieve the intensity in Paragraph 8.1.1.

8.3 Exterior Lighting

The exterior lighting assemblies shall be set in waterproof enclosures. Lens retention and bezel retention shall be by captive fasteners. All exterior lights shall be incandescent. Fixtures shall be flush mounted. Relamping shall be accomplished from the outside, except for lights in Paragraphs 8.3.7 and 8.3.8 where relamping shall be from the inside. All exterior lights shall operate from low voltage dc with each lamp having its own dropping resistor, if required.

######Option 1 (Bidirectional Operation) - Lights that determine "Front" and "Rear" of the car shall be interlocked with the cab Transfer Switch and Reverser Switch.######

######Option 3.2 (Train Operation) - Control of all exterior lights shall be interlocked so that lights between cars of the train are "Off", lights determining "Front" of the train are "On" on the front of the first car of the train, and lights determining "Rear" of the train are "On" on the rear of the last car of the train.######

8.3.1 Headlights. Two sealed beam type headlights shall be provided at the "Front" end of the vehicle mounted @@@@@@side-by-side horizontally separated from each other by a distance of not less than ___* .@@@@@@@ ######Option 28 (Center Headlights) - above/below each other at the center of the car end.######

* Purchaser to specify.

The headlights shall be controlled by a three-position switch in the cab(s) which shall also dim the lights. The headlights shall be removable and adjustable from outside the car.

######Option 1 (Bidirectional Operation) - Headlights shall be provided at both ends of the vehicle.######

8.3.2 Stoplights. Two red, 25 watt stoplights shall be provided at the "Rear" end of the vehicle. The lights shall be installed as far out to the sides as possible. The stoplights shall be "On" whenever any braking system is activated. The stoplights shall be independent of any directional indicator lights. A circuit breaker for the stoplight circuit shall be provided in the electrical locker. The stoplights may be combined with the taillights using double filment bulbs.

######Option 1 (Bidirectional Operation) - Stoplights shall be provided at both ends of the vehicle.######

######Option 3.2 (Train Operation) - The circuit shall be arranged so that the stoplight on the last car of the train will operate whenever braking is commanded by the lead car of the train.######

8.3.3 Taillights. Two red, 20 watt taillights shall be provided at the "Rear" end of the vehicle. The lights shall be installed just inside of the stoplights and shall be tied in with the headlight switch such that they are "On" whenever the headlights are "On" in the "Bright" or "Dimmed" position. A circuit breaker for each car's taillight system shall be provided in the electrical locker.

######Option 3.2 (Train Operation) - The circuit shall be arranged so that the taillights for the last car of the train are on whenever the headlights of the first car is on.######

######Option 1 (Bidirectional Operation) - Taillights shall be provided at both ends of the vehicle.######

8.3.4 Directional Indicators. The directional indicator system (turn signals) shall consist of two amber, 25 watt lights at the front of the vehicle, in the same position as the stoplights on the rear end of the vehicle, one amber, 20-watt marker-light type light on each side of the vehicle about midway, and two amber, 25 watt lights at the rear of the vehicle.

The front end directional indicators shall have an inherent marker function which shall be tied in with the headlight switch such that they are both "On" whenever the headlights are "On" in the "Bright" or "Dimmed" position. Otherwise they shall be "On" as respectively commanded by the directional indicator switch. The directional indication shall supersede the continuous marker light indication.

The side-mounted directional indicators shall work in a directional indication mode only.

@@@@@@Baseline - Two spring-loaded floor switches shall be provided at the operator's position, one for "Right" and one for "Left", to operate the respective turn signals. A pull switch shall be located on the operator's

console to active all six directional indicator light positions in an emergency flashing mode.@@@@@@@

######Option 32 - A directional indicator switch shall be located on the console in the cab(s). This switch shall be a three-position switch with a "Left", "Middle-Off", and a "Right" position to indicate the respective intended directional change of the vehicle. The switch shall be combined with a "Pull" position to activate all six directional indicator light positions in an emergency flashing mode.######

An indicator light on the console shall show the proper functioning of the directional indicators or emergency flash mode. A circuit breaker for the directional indicator circuit shall be provided in the electrical locker.

Where vehicles are intended for operation on exclusive right-of-ways only, the directional indicator system can be omitted in such a way that all six positions function in an emergency flashing mode only. In this case, the directional marker switch can be reduced to an emergency flasher switch with an "On" and "Off" position.

######Option 1 (Bidirectional Operation) - Directional indicator/stoplight combinations shall be used on both ends instead of separate directional indicators at the front.######

8.3.5 Marker Lights

@@@@@@@Baseline - One 20 watt red marker light shall be located near each upper end corner of the rear of the vehicle (two per car).

The marker light circuit shall be provided with a circuit breaker located in the electrical locker.@@@@@@@

######Option 1 (Bidirectional Operation) - One 20 watt red marker light shall be located near each upper end corner of the vehicle, front and rear (four per car). The marker light circuit shall be provided with a circuit breaker located in the electrical locker.######

8.3.6 Reflectors. Three amber reflectors on each side of the vehicle, at the ends, and the middle of the parallel portion of the sides, shall be mounted below the window line flush with the surface.

8.3.7 Destination Sign Lights. Each destination sign shall be provided with a fluorescent lamp suitably arranged for even illumination. All signs shall be visible from the outside of the car and the side signs shall also be visible from the inside. Relamping shall be from the inside. A circuit breaker for each car's destination sign lighting system shall be provided in the electrical locker. Sign light control shall be grouped with interior lighting on a common switch.

8.3.8 Run Number Sign Lights. These lights shall be electrically controlled with the destination sign light circuit and shall not reflect into the operator's eyes.

8.4 Emergency Lights

8.4.1. The following lights shall remain functional under emergency power conditions:

a) All lights near doors;
b) Other main interior lights such that total lighting is 25% of normal lighting;
c) All stepwell lights and outside door area lights where separate;
d) Operator's cab(s) light(s);
e) Directional indicator lights in the emergency flashing mode;
f) All marker lights; and
g) All stoplights.

8.4.2. In the event of loss of power supplied by the low voltage power source, all lights shall remain illuminated for at least 3 seconds. The emergency relay shall then operate and illuminate the emergency lights only as described in Paragraph 8.4.1 above, except for the directional indicator lights in the emergency flashing mode, which are set by the operator.

ELECTRICAL EQUIPMENT

This section specifies the Current Collection, Primary Power Conversion, Low Voltage dc Supply (LVDC), Storage Battery, Auxiliary Circuits and Wiring. All circuits shall be adequately protected and insulated from ground. Provisions shall be made for grounding enclosures and chassis.

9.1. Current Collection

@@@@@@Baseline - Trolley Pole(s). Each car shall be equipped with one ######or if Option 1 is selected - two###### lightweight Trolley Base(s) of approved type. The base, mounted on a double insulator, shall be designed to insure adequate tension of the collector on the wire when operating under wire installed at the Purchaser-specified height above the rail head. The base shall be positioned as specified by the Purchaser.

Reinforced butt welded steel trolley pole(s) with 1,570 mm (62 in) reinforcement, 4,110 mm (13.5 ft) long, or otherwise specified by the Purchaser, shall be fitted with the specified collecting devices to be furnished with each car. An additional bridle rope loop shall be installed 400 mm (16 in) from the trolley end of the pole.

A Trolley Catcher shall be installed at a location selected by the Purchaser. Provision shall be made for drainage of the mounting brackets. The catcher shall be equipped with 9,140 mm (30 ft) of No. 9 trolley rope and shall be able to hold up to 8,200 mm (25 ft) of rope wound in the catcher.

Hooks for holding the trolley pole(s) in the lowered position shall be furnished and installed. The hook shall be securely and permanently fastened to roof framing at the rear of the car and shall be adequately secured to the body through an electrically insulated spacer.

A trolley rope guard shall be installed at the ends of the car to prevent chafing of trolley rope by the car body and to permit free movement of the trolley rope through all normal trolley positions.

A lightning arrester and adequate circuit protection shall be installed on each car. The arrester shall be a nonlinear resistance type, or capacitor type (incorporating a built-in resistor) or an approved equal. The lightning arrester shall be attached to a trolley board of the trolley mounting base. A sealant of an approved type shall be applied between the lightning arrester and the trolley mounting board and shall also be applied to the bolts used to attach the lightning arrester to the trolley mounting boards.@@@@@@

######Option 29 (Pantograph) - A single pantograph assembly of approved type, fitted over a truck (or if Option 2 - Articulated Vehicle is selected: so located along longitudinal center line of roof to mate properly with the Purchaser's overhead trolley wire geometry).

A shoe device, permanent but easily replaced in the event of damage, affixed to the top of the pantograph, shall contain a renewable insert (the actual contact with

the wire) of a self-lubricating type material (carbon graphite, etc.) such that no special treatment (such as lubrication) is required. The pantograph shall be designed for proper collection at specified speeds and operating conditions and to track properly at all operable speeds and at minimum but adjustable contact pressures that shall not vary more than 10% over the entire working range. The device shall be free to pivot fore and aft as necessary to track the wire and all special work and shall be able to conduct the necessary full starting current loads for short periods of time or frequently repetitive cycles as well as the normal operating loads under all conditions of acceleration with all auxiliaries operating. The surface contact area shall be in accordance with the Manufacturer's recommendations. The suggested maximum length of the shoe assembly is 790 mm (31 in) with curved horns extending no more than 200 mm (8 in) on either side. It is the intent of the Specification that the shoe and the related pantograph apparatus be kept to the smallest physical size.

@@@@@@Baseline - The pantograph shall be raised to the wire contact position by use of a spring and damper and lowered to the stored and latched position by means of a rope and a trolley catcher.@@@@@@

######Option 29.1 (Automatic Pantograph Control) - The pantograph assembly shall be automatically raised to the wire contact position or lowered to the stored position at the car body roof through a battery operated control circuit by means of a cab-located momentary contact switch.######Option 3.2 (Train Operation) - This control circuit shall be trainlined and include a signal light on the console to indicate when all pantographs in the train are raised to the contact position.######

The circuit shall be operable only from the operating cab and only when the Operate Switch in this cab is in the "Operate" position. The raised position of the pantograph shall be effected and held by means of spring pressure. An electric or pneumatic mechanism shall lower the pantograph into a locked down position. An automatic, positive action latch shall be provided to effectively hold the pantograph in the lowered position. An effective and non-binding linkage system, for the purpose of positive operation of electric circuit interlocks, shall be included in the pantograph assembly.

An insulated rope or a hand pump shall be provided inside the car to lower and lock down the pantograph. In the case of electrical or pneumatic power failure a second insulated rope shall be provided to release the lock down latch from inside the car.######

Appropriate lightning arrester and circuit protection, weather protected, mounted in or adjacent to the pantograph base on the roof, shall be provided.

The power feed, installed without taps to other circuitry or splices in between, shall be from pantograph to arrester and directly to the location of fuse and fuse box. This feeder shall be routed separately through the car side walls and be suitably insulated and protected.######

9.2 Primary Power Conversion

Auxiliary electrical power conversion and utilization shall be accomplished by one of the following methods:

a) A motor/generator set operating directly from primary line power with output suitable for supplying all low voltage control and auxiliary circuits. Bearings shall be sealed lubrication type. The set shall be self-ventilated and rated in accordance with IEEE No. 11 for Class H Insulation. Commutator brushes shall not require replacement at intervals less than one year. Adequate circuit protection shall be provided.

b) A static inverter operating from the primary line power and supply ac auxiliary loads as required plus low voltage dc loads by use of a static rectifier. The ac output shall be 120/208 volt, 3 phase, 60 Hz, or as required by other auxiliary systems. Voltage regulation shall be provided to maintain variations of less than ± 5%. Frequency shall be regulated within ± 2.5%. The output to the battery charger power supply shall be isolated from the primary line power.

c) A motor/alternator, operating from the primary line power and supplying ac auxiliary loads as required plus low voltage dc loads by use of a static rectifier, shall be provided. The dc portion of the machine shall meet the requirements indicated for a motor generator. The ac output shall be 120/208 V, 3 phase, 60 Hz or as required by other auxiliary systems. Voltage regulation shall be provided to maintain variations of less than ± 5%. Frequency shall be regulated within ± 5 Hz. Circuit protection shall include a primary fuse, inverse time-delay load protection and over-temperature protection.

d) A static converter, operating from the primary line power and supplying isolated low voltage dc power to the battery and control circuit loads, shall be provided. Semiconductor assemblies shall be functionally grouped and mounted in modular form for ease of maintenance. The output to the battery charger power supply shall be isolated from the primary line power.

9.3 Low Voltage DC Supply

The detailed requirements for the low voltage dc supply have been prepared on the basis of nominal 37.5 Vdc. As an alternative, with approval of the Purchaser, the Contractor may supply a nominal 28 Vdc supply. If so, the Contractor shall propose similar requirements for adjustability, regulation, input voltage variation, etc.

The low voltage dc (LVDC) power supply shall be of sufficient capacity to charge the battery and maintain substantially constant voltage for traction control, trainline control, vehicle lighting, and auxiliary circuit power requirements. The regulated output shall be continuously adjustable between approximately 35 and 40 Vdc. Voltage regulation shall be at least ± 4% with input voltage variation of ± 20% and a load variation of zero to maximum connected load and temperature compensated. Circuit protection shall be provided to adequately protect power supply components, prevent overcharge of the battery and limit the maximum charging current. Indication of battery charge shall be a voltmeter on the operator's console. The LVDC power supply shall be capable of powering its loads with a fully discharged battery.

9.3.1 Emergency Power shall be provided by the battery. Where the energy storage capability will not meet the requirements of Paragraph 8.4.2 a voltage sensor/timing circuit shall be included. Upon a total loss of power at the low voltage dc power supply bus, resulting from primary power conversion

output failure, the timer circuit shall begin an 3 second delay. At the end of this delay, the circuit shall cause emergency loads only to be fed from the storage battery. Upon restoration of low voltage dc power output, for not less than one second, the circuit shall reset and reconnect the normal low voltage loads (Section 14). The emergency load shall include the following:

a) Lighting per Subsection 8.4;
b) Door Control and Door Operator Power;
c) Communications (if applicable);
d) Braking Control and Actuating Power;
e) Cab Signal Power (if applicable);
f) Operator's Console Indicators, Lighting and Interlocks;
g) Propulsion Logic;
h) Horn/Gong;
i) Air Compressor Control (if applicable);
j) Track Brakes; and
k) Track Switch.

9.4 Storage Battery

An alkaline or lead-acid storage battery with tubular or flat pocket plates, and rated for emergency duty cycle service in the indicated operating environment over a normal service life of not less than 5 years, shall be provided. The battery shall be controlled at rated charge by connection to the regulated dc output of the low voltage dc power supply. It shall retain a peak charge while in normal operation without periodic higher rate equalizing charges.

During power supply failure or shutdown, the battery shall supply power, at 32 Vdc nominal, to the control and lighting loads. With the battery charged at 85% of capacity it shall be capable of supplying sufficient discharge current to carry all low voltage loads continuously for 3 seconds, followed by the indicated emergency loads continuous for one hour, within the ambient temperature range. At the end of this discharge sequence, the voltage, as measured at the battery terminals, shall be not less than 24 v or one volt per cell, whichever is greater. Discharge beyond the rating of the battery shall not permanently damage the cells or reduce capacity.

Vent caps shall be of the captive type and shall be sprayproof while still allowing gas to escape from the container. All external metal parts shall be protected from corrosion. Intercell connectors, jumpers, and lugs shall be provided.

Electrolyte capacity shall be sufficient to require additional water during normal maintenance period only. Overtemperature protection shall be provided at the battery box.

The battery shall be installed under the car in a battery compartment box, utilizing a welded steel structural frame and reinforced glass fiber outer covering. The box, provided with means for adequate ventilation of the battery, shall be mounted on a roll-out tray, effecting ready accessibility from the side of the car for maintenance and inspection of the battery. Access to the battery shall be by means of a cover arranged to be removable. The cover shall be equipped with anti-rattle devices and furnished with suitable latches.

######Option 30 (Battery Heater) - The battery box shall be equipped with a heating device.######

All cells shall be transparent and arranged to facilitate electrolyte level inspection without removal of any component other than the access panel. All cells shall be accessible from the side of the car for removal as required and for normal maintenance with an automatic filler device.

9.5 Auxiliary Circuits

All circuits shall be protected as required below. Where two or more circuits are commonly protected, they shall be grouped so that only those circuits where circuit failures which cause the car to be disabled are commonly protected.

9.5.1 Control. The system shall include a sufficient number of primary power circuit contactors of proper capacity to control auxiliary loads as required. A low voltage dc switch panel, located at each operating cab area, shall control the contactors. Primary line voltage shall not be routed to or through the passenger or operating cab areas for any purpose other than heating system use.

Where ac auxiliary systems are used, they shall be controlled by low voltage switches located in the cab area.

9.5.2 Protection. Protection for all primary power auxiliary circuits shall be provided by means of a weatherproof enclosed fuse box underneath the car. All primary power fuses shall be rated for 1000 Vdc. The fuse box cover shall be labeled in at least 1/2 inch high lettering:

DANGER: HIGH VOLTAGE

The fuse panel base, polished on both sides, shall be transite, ebony asbestos, or an approved equal.

Each fuse or fusetron, whichever is recommended by the manufacturer, shall be separated from its adjacent fuse or fusetron by a suitable barrier of insulating and heat resistant material.

9.5.3 Low Voltage Breaker Panel. The auxiliary electrical system shall incorporate a low voltage "switch and circuit breaker" panel located in each cab area. Each panel enclosure shall include a door with continuous hinge, anti-rattle device, and standard key operated, automatic latching lock. All LVDC circuits requiring protection shall be equipped with heavy duty, vibration proof, single-pole circuit breaker type switches of proper capacity, with instantaneous magnetic type trip or approved equal. Each circuit breaker shall be easily removable, shall have its current rating clearly and permanently marked on the operating handle, and shall clearly show "Open" and "Closed" positions. Each circuit, controlled by a circuit breaker switch, shall be clearly identified by a suitable name plate for each panel. The LVDC negative return ground terminal (reference Paragraph 17.10.10) shall be located inside a separate panel located next to the LVDC Breaker Panel.

######Option 1 (Bidirectional Vehicles) - Except for duplex convenience outlets and work lights required at both ends, it is not desired that the following switches, breakers, and indicators be duplicated in the electrical lockers located at both ends but rather that similar or related functions be grouped together at one end:

Air Compressor Relay Control, BR
Air Conditioning Control, BR
Ammeter Jacks (Motor Current)
Bus/Control, BR
Cab & Console Panel Lights, BR
Cab Signal Cut-Out (Sealed)*, SW
Cab Signal System,* BR
Communications*, BR
Convenience Outlets, BR
Coupler Control*, BR
Destination Sign Control*, BR
Door Control, BR
Door Interlock, BR
Door Interlock By-Pass (Sealed)*, SW
Door Signal, BR
Door Step By-Pass (Sealed)*, BR
Door Step System*, BR
Exterior Lighting (as req'd), BR
External Door Control, BR
Fare Collection Equipment*, BR
Four Spare Main Feed Breakers (provision for), BR
Friction Brake Control and Indication, BR
Friction Brake Cut-Out Battery (Sealed)*, SW
Heating System Control, BR
Horn/Gong, BR
Hydraulic Pump Relay Control*, BR
Interior Lighting and Destination Sign, BR
LVDC Power Control, BR
Master Controller, BR
M-G (M-A) Set Relay Control*, BR
Pantograph Control*, BR
Passenger Stop Request, BR
Propulsion Control/Logic, BR
Propulsion Cut-Out, SW
Sander, BR
Sander Cut-Out (Sealed), SW
Sign Lighting, BR
Spin/Slide Cut-Out (Sealed), SW
Stop Lights, BR
Track Brake, BR (one breaker per truck)
Track Switch Contactor, BR
Ventilation Blower Control, BR
Wiper/Washer System (if not pneumatic), BR######

(Key: BR-Breaker; SW-Switch; * if applicable.)

Low voltage devices shall be isolated from primary power relay control components.

At least one duplex LVDC convenience outlet shall be provided in each electrical locker. The outlets shall be rated at 50 amperes and shall provide for use of plugs with grounding connections.

If ac auxiliary power is furnished on the vehicles, convenience outlets may be installed for 120 Vac equipment, as approved by the Purchaser.

It shall not be possible to close the locker door with any cut-out switch placed in the cut-out position.

9.5.4 Operator's Console. An operator's console shall be furnished at each Operator's position. The console shall include a Master Controller, Door Control Switch, Track Switch Control Switch, Pantograph Control Switch (if installed), Coupler Control Switch (if required), Speedometer, Communications Control Panel, Transfer Switch, Reverser Switch, various operator

convenience pedals and switches, and both audible and visual performance warning indicators. In the case of pneumatic brakes a brake pressure indicator shall be provided with a clearly identifiable red band, to identify the low pressure band. The pointer shall be of a fluorescent type. Location and general arrangement of all the above shall be as shown in the Specification Cab-Layout Drawings and approved by the Purchaser.

Console material shall be corrosion resistant, flat black (non-reflective), and designed for extended trouble-free life. Any visible fasteners on the console face shall be of tamper-proof-head design and finished to match the console face. Switches and push buttons shall be generally rear-mounted on hinged panels with only operating handles protruding above the surface and shall be arranged such that unobstructed operation of the controller handle is always available.

Console switches shall be heavy duty toggle type with wide and extended actuating surfaces for functional ease; but inadvertent movement of the switches shall be prevented through proper placement, action direction and design. The function and handle position of each console switch shall be clearly identified. The "Off" or "Normal" positions are toward the operator; activation requires application of pressure in the forward direction. Door control switches shall be oriented toward left or right sides of the console to control doors on their respective sides of the vehicle.

Where illumination is utilized for console switches and indicators, rheostatic dimmer control shall be provided. The following switches shall be individually illuminated: Operator's Cab Light Switch; Emergency Stop; Track Brake Switch; Track Switch; Headlight Control; Door Switches; and Horn/Gong.

In accordance with the Cab Layout Drawings, the following switches and foot pedals as defined elsewhere in this specification shall be included on each Operator's Control Console (foot pedals are considered part of cab equipment although not console mounted).

FUNCTION	IDENTIFICATION	POSITIONS
Cab Heat	Cab Heat - Off/Lo/Med/Hi	4
Cab Light (Operator's Overhead)	Cab Light - Off/On	2
Coupler Control*	Coupler Control - Uncouple	MS
	Coupler Control - Norm/Isolate	2
Door Control-Center*	Doors Right Side - Center - Open/Close	MS
	Doors Left Side - Center - Open/Close	MS
Door Control-Front	Doors Right Side - Front - Open/Close	MS
Door Control-Rear	Doors Left Side - Rear - Open/Close	MS
Emergency Stop	Emergency Stop - Push to Stop/Pull to Reset	2
Gong	Gong - On	MS
Headlights	Head Lts. - Off/Lo/Hi	3
Horn	Horn - On	MS
Interior Lts., Sign. Lts. & Destination	Interior Lts. - Off/On	2
Interurban Light*	Interurban Lt. - Off/On	2
Marker (Exterior) Lts.*	Marker Lts. - Off/On	2
Panel Illumination	Panel Lts. - Off/On	2
Pantograph*	Pan. - Down/Up	2
Passenger Loading (High/Low Level)*	Load - Hi/Lo	2
Passenger Stop Request Switches	Pass. Stop - Norm/Reset	MS
Propulsion Reset	Propulsion - Norm/Reset	MS
Sander	Sander - On	MS
Track Switch	Track Switch - Power	MS
Windshield Demister	Demist - Off/Lo/Hi	3
Windshield Washer	Wash - Off/On	MS
Windshield Wiper	Wipe - Off/On	Variable
Turn Signals	Right, Off, Left**	3**
Emergency Flasher	Off/On	2

(Note: MS -Momentary Switch; * - If installed; ** - If foot switches are installed they shall be two MS types.)

An analog type speedometer shall be provided and installed as shown on the cab-layout drawings (******Purchaser to prepare cab-layout drawings******).

An Indicator Panel, with adequate shielding for operation in bright sunlight, shall be provided and shall include the following:

Cab Signal Cutout (Red)*
Cab Signal Speedometer Display (Red)*
Door Interlock Bypass (Red)
Doors Closed (Green)
Dynamic Brake Off (Red)
LV Power Supply Failure (Red)
Overspeed (Red)
Pass. Emergency Stop (Red)
Pass. Stop Request (Yellow)
Propulsion Disabled (Red)
Slide (Red)*

Friction Brake On - Car (Red)
Friction Brake On - Train (Red)
High/Low Step Position (Red)*
Speed Sensor Failure (Red)
Track Brake On (Red)
Directional Signal (Green)
High Beam (Blue)

(* - If installed)

######Option 31 - Communications shall require installation of the following items: a) Handset; b) Speaker; c) Selector Control; d) Volume Control; and e) Transmit Indicator.######

9.5.5 Master Controller Group

9.5.5.1 Controller - @@@@@@@Baseline (Hand Controller) - A single-handle, all-electric type, manual Master Controller shall be provided in each operator's cab, for controlling both propulsion and braking.

The controller handle shall consist of a single shaft with a "T" shaped handle or inverted "L" shaped handle modified to function the same as a "T" shaped handle, arranged to move fore and aft in a vertical plane at a comfortable height on the Console; the entire handle shall be human engineered to minimize strain and fatigue on the operator. The exact size of the shaft and handle, spring-loading characteristics, handle travel between detents, and other operational features shall be reviewed for approval. The handle shall be designed so that, if released, it will rotate about an axis through its shaft and activate the "Dead-Man" feature. The emergency brakes shall be applied whenever the handle is not held properly. The "Dead-Man" feature shall be rendered ineffective if emergency braking, full service braking or full service and track braking have been commanded.

The movement of the handle shall be such that the power positions are reached by motion of the handle away from the operator and braking positions reached by motion toward the operator.

The Master Controller detents (identified positions) shall be as follows:

a) Maximum Power;
b) Minimum Power;
c) Coast;
d) Minimum Brake*;
e) Full Service Brake (Handle Lock);
f) Full Service and Track Brake; and
g) Emergency.

######Option 14 (Spin/Slide Protection) - In the "Full Service and Track Brake" position, the slip protection circuit shall remain operable.######

* Minimum braking is here defined as the "minimum instantaneous deceleration available to the operator" as required per Paragraph 2.2.3.

Continuously variable tractive effort shall be available between the maximum power position and the minimum power detent. Continuously variable braking effort shall be available between the minimum brake and full service brake detent positions. The Master Controller shall use easily replaceable cam-operated switches of modular construction, to carry out its controlling functions.

Master Controller circuits shall interlock with the propulsion overload reset trainline so that the reset function will be effective only when the Master Controller Handle is placed in "Coast" or "Brake" position and the Reverser key is in "Forward" or "Reverse".

The Master Controller Handle shall be locked in "Full Service Brake" unless the Operate Switch (key) is in "Operate" and the Reverser Switch (key) is in "Forward" or "Reverse"; and, correspondingly, the Master Controller must be in "Full Service Brake" position before either key, Operate or Reverser, can be rotated from any position.@@@@@@@

######Option 32 (Foot Controller) - The vehicle shall be controlled by the actions of the operator on three foot pedals at the operating cab. Left-to-right the pedals shall be Deadman, Brake and Power. The size, location and operating pressures of these pedals shall be identical to those on PCC cars as specified per April 1, 1947 and revised December 15, 1948. The floor area shall contain a raised area around each pedal shaft entrance to prevent entrance of dirt and water into the Master Controller area beneath the floor. The Master Controller and connecting arms shall be so designed and located such that dirt and water which may enter will not fall onto, or run into, the Master Controller itself.

The Deadman pedal shall normally be held down by the operator's left foot, by a force not exceeding 5.5 daN (12 lbs). Releasing this pedal when the brake pedal is not in the latched position described below, shall immediately remove power and cause an emergency brake application. The deadman pedal shall be ineffective on a non-active operator's position (i.e., when the Reverser Switch is in the neutral position. ######Option 1 (Bidirectional Car) or when the Transfer Switch is in "Standby or Lay-up" Positions######).

There shall be a latch position on the brake pedal. This shall be arranged so that when the brake pedal is depressed beyond the latch position and the Deadman pedal is released, the brake pedal will lock or latch in a position which calls for not less than 75% of full service braking. This shall permit the operator to leave his seat without causing an emergency braking application. In this latched position the track brakes shall not be energized and all door control circuits remain in their normal states for normal operation of doors. Subsequent full depression of the Deadman pedal shall unlock the brake pedal and allow the car to operate.

The brake pedal shall have another latch so that fully depressing the pedal to the emergency position shall cause it to latch there. Release shall be effected by rocking of the pedal on its supporting shaft to disengage the latch.

The above two brake pedal latching features may be accomplished by mechanical or other means.

The "Standby" or "Lay-up" position of the pedals shall be the position of the pedals in their relaxed condition. Proper pedal storage in the "Lay-up" (or "Park") position at an inoperative cab shall be required for release of brakes on the vehicle, whether operated singly or in a train. Additionally, release of brakes shall only be possible with the pedals of a cab which has an Operate key inserted in the Control Switch and has the switch turned to the "Operate" position or from trainline commands on trailing cars. In the "Off" and "Lay-up" positions brake release shall not be possible from that cab.

The control functions of the pedals shall be as follows:

Coast -
- o Deadman pedal depressed
- o Brake pedal released
- o Power pedal released

Power -
- o Deadman pedal depressed
- o Brake pedal released
- o Initial depression of Power pedal to provide minimum power. Full depression to provide maximum power. Continuously variable tractive effort shall be available for positions in between.

Service Braking -
- o Deadman pedal depressed
- o Power pedal released
- o Initial depression of brake pedal to provide minimum braking.* Braking effort shall be continuously variable up to the maximum specified service deceleration rate. Further depression shall maintain this braking effort and initiate the track brake. Full depression shall initiate a latch and emergency braking.

######Option 14: (Spin/Slide Protection) - With the Brake pedal in the position calling for track brakes (not emergency) the slip protection system shall be operable.######

Emergency Braking - Brake pedal fully depressed and latched.######

######Option 1 (Bidirectional Car) - 9.5.5.2 Transfer Switch. The Transfer Switch, part of the Master Controller group, shall be a key-operated, three position ("Lay-up", "Standby", "Operate") rotary type, of approved design, and only operable by means of a master control key supplied with the switch. In the "Lay-up" position all switches, control devices, foot pedals, etc., shall be electrically and mechanically

* Minimum braking is here defined in the "minimum instantaneous deceleration available to the operator" as required per Paragraph 2.2.3.

inoperable; with all systems deactivated including all battery systems except for external door control. In the "Standby" position, control of any trainlined functions and any uncoupling shall not be possible. In the "Operate" position - key cannot be removed in this position -the switch shall energize the control and console circuits, those applicable, on the operating end only. The Transfer Switch circuitry and directional circuitry shall be arranged to absolutely allow operation from only one Operator's position. The parking brakes shall be on when the switch is in the "Lay-Up" position and no other cab is in the "Operate" position.######

9.5.5.3 Reverser Switch. A three position, key operated ("Forward", "Neutral", "Reverse"), rotary type Reverser Switch shall be provided in the Master Controller group. The Reverser Switch key shall be removed only when in the "Neutral" position.

@@@@@@Baseline - The directional circuitry shall be such that operation shall not be possible unless the Reverser Switch is keyed and placed in the "Forward or "Reverse" position. When the Reverser Switch is in the "Neutral" position, the parking brakes shall be set up.@@@@@@

######Option 3.2 (Train Operation) - The directional circuitry shall be such that operator's position (cab) of the train shall be designated by the first Reverser Switch that is keyed (i.e. this action shall inhibit all other Reverser Switches in the train). When the keyed Reverser Switch is in, or all Reverser Switches are in the "Neutral" position, the parking brakes shall be set up.######

9.5.5.4 General. The location of the Master Controller, Transfer Switch and Reverser assembly, on the Console, shall be at the option of the Purchaser. In emergencies, operation shall be possible from any cab in the car or train, wherein appropriate operating procedures shall be provided and approved to prevent unauthorized use of this feature.

@@@@@Baseline - 9.5.6 Back-up Controller - On unidirectional cars, a Back-up Controller shall be installed in the center of the rear compartment behind a locked but removable seat-back. The key operating the forward-end Reverser shall be utilized to unlock the seat-back. This same key shall be utilized to energize the Back-up Controller which shall only be operable by means of its own lever only when the forward-end Reverser Switch is in "Neutral". The Back-up Controller shall be a lever-operated, four position switch, spring loaded to return to position number 2 from any other position. The switch functions shall be as follows:

Position 1 - Full service plus track brake;
Position 2 - Full service brakes;
Position 3 - Vehicle in coast; and
Position 4 - Minimum power to rear.

In addition, separate apparatus shall be provided in the compartment with the Back-up Controller to provide Emergency Braking

features equivalent to the Master Controller being positioned at "Emergency".

######Option 3.2.2 (Automatic Coupler Control) - The back-up controller shall also indicate the coupling control switches to control coupling and uncoupling at its end of the car. These switches shall be active only when the back-up controller is activated.######@@@@@@

######Option 3.3 - ******If Option 1.1 is chosen, the back-up controller shall be deleted.******######

9.5.7 Circuit Requirements. The following vehicle control circuits are vital to safety and shall be subjected to maximum design analysis and manufacturing quality control. Routing of these circuits shall be such that interference from other circuitry will be minimized. The functions are:

a) Brake Command;
b) Door Control;
c) Door Indication & Interlock;
d) Emergency Stop; and
e) Propulsion Command.

######Option 3.2 (Train Operation) - Electrical connections shall be made between all cars for control of appropriate overload, fault, and status indicators, including at least the following functions:

Braking - Emergency, Friction, Parking and Track;
Communications Systems - P.A. and Intercom;
Control Station Interlock;
Direction Control;
Door Control and Status - Door & Control Interlock and Door Control;
Mode Selection;
Pantograph Control (if installed);
Passenger/Operator Emergency Stop;
Passenger Stop Request;
Propulsion - P-Signal, Disabled and Reset; and
Sander Control.

At least eight spare trainline wires, four of which shall be shielded, shall run from end to end of the car then through the electric coupler. They shall be marked as specified.######

9.5.8 Track Switch Equipment. ******Owner to prepare these requirements.******

9.6 Miscellaneous

Except for wall-mounted control panel equipment, components of the Auxiliary Electrical System shall be constructed for continuous duty underneath the car.

All compartments containing primary power shall be suitably marked:

"DANGER: HIGH VOLTAGE"

Lettering should be not less than 1/2" high and be of such a color as to show clearly against the background. The lettering shall be in conspicuous locations both inside and outside the compartment.

All switches and fuses shall be provided with an appropriate nameplate clearly identifying the circuit which each controls and identifying the position of the switch handles.

Technical Specifications - Section 10

PROPULSION SYSTEM & CONTROL

This section establishes the requirements for the Light Rail Vehicle Propulsion System. The propulsion system shall be furnished as a complete set of equipment and shall include power modulation devices, traction motors, drive gear units, control logic, circuit protection devices and all accessories necessary to meet the specified requirements of propulsion and dynamic braking.

10.1 Acceptable System Configurations

The propulsion system concept chosen shall have been proven in either American or foreign revenue service of similar severity and shall perform within the capability, accuracy, reliability and other requirements indicated.

******Purchaser to decide if type of Propulsion Control is to be specified (i.e., Baseline or Option 34). If not, then text for both the Switched Resistor and Chopper Controlled Systems should appear. A statement that the Contractor has these alternatives should be added.******

@@@@@@Baseline (Switched Resistor System) - Power modulation shall be accomplished only by service proven designs (see Paragraph 1.5.1). Requirements for the minimum number of resistance steps shall be determined by the sensitivity, accuracy and jerk limit requirements of Section 2.2.1. Continuous control of dynamic braking shall be provided over the braking capability range with full retarding effort available down to a car speed of approximately 8 km/h (5 mph).@@@@@@@

######Option 34 (Chopper Controlled System) - Power modulation in both propulsion and dynamic braking shall be accomplished only by use of service proven (see Paragraph 1.5.1) thyristor-chopper control designs. The chopper firing rate shall be established in coordination with the Purchaser so that interference with other vehicle systems and wayside cab signal equipment (if installed) shall not inhibit normal functioning of such systems and equipment. Line filtering shall be provided to suppress transients. Dynamic braking shall be continuously available throughout the capability range down to a car speed of 8 km/h (5 mph).

######Option 34.1 - The dynamic brake shall be regenerative and shall return electric power to the power line until the specified maximum voltage is reached, at which point the generated power shall also be supplied to the braking resistors.

The control system shall continuously monitor line voltage, shall supply to the line the maximum amount of energy possible within the voltage limits prescribed and shall divert to the braking resistors only the generated energy in excess of that accepted by the line.######

######Option 34.2 - Regenerative braking is not required, however, if the Contractor chooses to supply regenerative braking, it shall return electric power to the power line until the specified maximum voltage is reached, at which point the generated power shall also be supplied to the braking resistors. The control system shall continuously monitor line voltage, shall supply to the line the maximum

amount of energy possible within the voltage limits prescribed and shall divert to the braking resistors only the generated energy in excess of that accepted by the line.######

Separate field excitation may be employed, only if it take its power from a point where it can use regenerative power in event of primary power loss.

10.1.1 The number of traction motors provided with each vehicle propulsion system shall be determined by factors related to ease of control, size, weight, reliability and maintenance. In any case, all traction motors shall be identical and completely interchangeable.

10.2 Duty Cycle Rating

The continuous thermal rating of the propulsion systems shall be based on the following worst case duty cycle. The propulsion motor temperature rise for this rating shall be limited to the allowable temperature rise of the next lower insulation class below the full insulation class used in the motor insulation system. For this duty cycle the continuous current rating of the motor shall be greater than the rms current produced, with 650 Vdc at the trolley wire. ######Option 8 - ******Purchaser to change this voltage limit if specifying nominal 750 Vdc primary power.****** ######

a) Track profiles, Schedules and run times per drawings _____ through _____.
b) Assume no layover time at either end of the line.
c) Dwell time of _____ seconds per passenger stop.
d) _____ additional (non-passenger) stops with dwell time of _____ seconds, per round trip, spaced and located as given on the track profiles.
e) Speed on curves less than _____ ft radius at _____ mph.
f) AW2 load.
g) Running at full acceleration and braking without coasting.

In addition, consideration must be given to the abnormal load rating caused by surface operations in heavy rush-hour traffic. The traction motor rating shall be based on the temperature rises allowed for its full insulation class, but in no case less than Class H temperature rise. If a system meeting the continuous thermal rating requirements above were to exceed the full insulation class temperature rises, electric brakes may be cut out or other reduced performance may be utilized to keep temperature rises within the allowable full class values.

######Option 35 - The duty cycle shall account for towing one empty dead car with another empty car up a 9% grade at slow speed in an emergency.######

10.3 Interference Limits

10.3.1 Switching line transients generated by the propulsion system shall be suppressed so that they do not exceed ± 20% of no load voltage. If a chopper control system is furnished, the firing rates and attenuation at frequency shall be established in coordination with the Purchaser so that electromagnetic interference does not inhibit normal functioning of other equipment on the vehicle or along the wayside.

10.3.2 Radio frequency interference limits as specified in Paragraph 2.2.13 shall not be exceeded by the propulsion system during normal operation. The system shall, however, be designed to operate in an environment of high ambient electrical noise.

10.4 Audible Noise

These requirements are specified in Paragraphs 2.2.10.5 and 2.2.10.6.

10.5 Performance Characteristics

10.5.1 Sensitivity of Response. The propulsion system shall establish the tractive effort in response to the command signal within ± 5% for all values of command. The indicated sensitivity shall be independent of ambient temperatures within the range specified in Section 2. Variation of the low voltage supply within the limits specified in Subsections 9.3 and 9.4 shall not produce a tractive effort error with respect to the commanded value. The command signal shall be taken as the signal presented to the propulsion system control and the output shall be the motor current. It is not intended that the control system compensate for non-linearities in traction motor characteristics. However, the percent of reduction in motor current shall be equal to the percent of reduction in command for all values between the maximum tractive effort current and the minimum current level established by the propulsion controller, at which point a discontinuity is permissible.

This linearity of response shall be achieved within the tolerance bands and low voltage supply potentials stated above. The propulsion system shall respond to all command changes greater than 5% of the full range value at any constant combination of low voltage supply potential and ambient temperature within the specified limits except in the discontinuous range below minimum achievable armature current.

10.5.2 Jerk Limit. The propulsion system shall be jerk limited as required in Paragraph 2.2.6.

10.5.3 Load Weighing. These requirements are specified in Paragraph 2.2.7.

10.5.4 Dynamic Brake Feedback. Dynamic brake effort signal feedback shall be supplied as necessary to meet the requirements of Paragraph 2.2.5.

10.5.5 Dynamic Brake Capability. The propulsion system shall provide deceleration rates as specified in Section 2 from 80 km/h (50 mph) to the fade out speed given in Paragraphs 10.1. Above 80 km/h (50 mph) dynamic brake rates may be governed by limitations of the motor armature. However, such lower levels of braking effort which lie within the capability of the motors shall be met when commanded.

10.5.6 Mode Change. The propulsion system shall directly utilize mode selection signals as indicated in Section 2. An energized signal shall correspond to a power or coast mode. De-energization shall correspond with the braking mode.

######10.5.7 Option 3.2 (Train Operation) - For operation in trains up to four cars, the propulsion system shall respond to the trainlined tractive effort command signals. Direction control shall be trainlined.######

10.5.8 Direction change shall be provided by traction motor rotation reversal. The reversing circuit shall respond to the direction control signals as indicated. A change of direction shall be possible only when the car is at rest and the propulsion power circuits are de-energized. An interlock between direction control and the master controller signal shall be provided to prevent erroneous operation. Failure of the reversing equipment shall prevent the propulsion system from moving the car.

10.5.9 Cut-out Control. Provisions shall be included to allow a car to be isolated from propulsion control signals and main power for towing purposes. With the system cut-out through a switch or circuit breaker in the electrical locker, it shall be possible to operate the car in a train at normal speeds in either direction with no damaging effects. All other systems shall remain operational and propulsion cut-out shall not affect the operation of the Master Controller on the cut-out car. Switch position shall clearly indicate the cut-out condition.

######10.5.10 Option 14 (Wheel Spin/Slide Protection) - The propulsion system shall respond to signals indicating wheel slide or spin. In both propulsion and braking modes the receipt of this command shall immediately cause propulsion control to release or reduce tractive effort in order to correct the wheel slide or spin as required. Timing devices used to control wheel slip shall be of fail-safe design.######

10.5.11 Overspeed protection shall be provided as defined in Paragraph 2.2.2.

10.5.12 Circuit Protection and Visual Annunciation. Adequately rated sensing and fault clearing devices shall be provided to protect propulsion system components. Fault clearing devices shall be adequately shielded to prevent damage to adjacent equipment or vehicle structure. The propulsion system shall be protected from fault or overload damage by at least a combination of a line switch and fuse. This combination shall protect the propulsion control system and shall be capable of clearing without damage, fault currents of up to 50,000 amperes. A fault or overload condition shall cause opening of the line switch. The arc chute shall open to the atmosphere in a manner that provides positive protection and insulation of the car body and nearby equipment. The reset function shall be remote and available for reset of the overload when not in power or braking. The reset switch shall be a momentary switch on the operator's console.

Visual annunciation shall be provided to indicate "Propulsion System Overload" to the operator at the operating console.

The car shall be protected from major power cable faults or line switch malfunction by an approved fuse in the cable from the power collector located directly adjacent to it. The thermal time constant of the fuse and the rapidity of response of the line breaker shall be sufficiently great that it shall not open due to any fault normally protected by the line switch unless there is line breaker malfunction. The fuse interrupting capability shall be greater than that of the line switch.

######Option 3.2 (Train Operation) - Propulsion fault indication shall be trainlined to light the "Propulsion System Overload" light on the controlling console of the train. Also an outside blue light on the right side of the faulted car shall illuminate. This blue light shall be visible from the forward end of the train when looking down the right side. Reset shall also be trainlined. These indicators shall extinguish only after the fault has been reset.

10.5.13 Adjustments. Tractive effort output shall be adjustable and jerk rate limit functions may be adjustable in order to set initial performance. Critical adjustments shall be made available above floor level in a maintenance accessible location by use of tamper-proof screw-head devices as approved.

10.6 System Components

10.6.1 D.C. Traction Motors. All traction motors shall be service proven designs (see Paragraph 1.5.1), identical and completely interchangeable. The motor shall have the following basic design features:

Type - dc series wound, or separately excited.

Insulation - Motor insulation shall be IEEE No. 11, Class H insulation system or better, with Class F or better resin. After assembly, the complete motor shall be vacuum-pressure impregnated.

Enclosure - Splash-proof.

Ventilation - Either blower forced-ventilated or self-ventilated with air ducted from points above or just below the belt line of the car. Air intakes shall be designed for installation of replaceable filter elements at a later date if deemed necessary. If filter elements are used, they shall have a service life of at least 12,800 km (8,000 mi). The air intake shall be designed and positioned not to ingest water or debris, however, screens shall be provided to prevent ingestion of debris.

Inspection covers shall be provided.

Metal covers in quantity of 5% of total number of motors shall be provided to protect the motor air intake area when trucks are being steam cleaned.

Duty - Thermally rated in accordance with the duty cycle as defined in Subsection 10.2.

Mounting - Each traction motor shall be resiliently mounted. Unsprung mass shall be kept to a minimum. Safety straps or hangers shall be provided as required to prevent damage in the event of motor mount failure. Each motor shall be resiliently supported with a support natural frequency of one-half or less of the maximum motor speed. The maximum double amplitude of vibration shall not exceed 0.038 mm (0.0015 in) measured in any direction of the motor.

Shaft Coupling - A splined, taper fit or flexible coupling shall be provided between traction motor and gear unit shafts.

Motor Standard - IEEE No. 11, Rotating Electric Machinery, except as otherwise specified.

Commutator brushes shall not require replacement at intervals less than 64,000 km (40,000 mi) of operation and shall be accessible through removable covers on the motors from an inspection pit and/or hatches, if required, in the floor.

Armatures shall be dynamically balanced according to IEEE No. 11, latest revision by using metal correction weights either welded or wedged in place. Placement of these weights shall not interfere with any maintenance operation. Armatures shall be banded on both ends and shall be mechanically arranged to permit replacement of the armature shaft without disturbing the commutator or windings.

Connections between commutator risers and armature coil leads shall be "TIG" welded in a manner that shall prevent separation under all conditions including extreme over-temperature.

Commutator risers shall be of sufficient size to allow for three armature rewinds.

Antifriction bearings shall be provided. Grease cavities shall contain sufficient lubricant to allow operations for three years without relubrication. Motor bearings shall be provided with lubrication fittings as required.

10.6.2 Gear Drive. Each motored axle shall be driven by a gear unit which may be either parallel or right angle single reduction or double reduction drive designed and manufactured for bidirectional service. The gear drive chosen shall be a service proven design (see Paragraph 1.5.1) with its operating history under similar service conditions. Removable and accessible airtight inspection covers shall be provided on the housing for visual inspection of the gears.

10.6.2.1 The gear unit output torque shall be coupled to the axle through an elastomeric type of coupling. The design shall not require lubrication and the elastomer application shall be at stress levels providing service life of 640,000 km (400,000 mi) or more. The elastomer elements shall be shielded from heat radiation of any friction brake discs. The coupling design shall provide enough clearance between quill and axle to prevent contact between them with one wheel raised 50 mm (2 in) on a crush loaded (AW3) car. All critical parts of the coupling shall be visible for inspection without disassembly or removal of any part.

10.6.2.2 Gear units shall be equipped with antifriction bearings throughout. Bearing design and selection shall require inspection or adjustment no more frequently than once every 400,000 km (250,000 mi). Bearings shall be designed to have a B-10 life of at least 800,000 km (500,000 mi) of service.

10.6.2.3 Gears shall be designed and applied to require inspection and adjustment no more frequently than once in every 400,000 km (250,000 mi) and have a life of at least 800,000 km (500,000 mi).

10.6.2.4 The lubrication system shall have openings with removable plugs located with easy access for filling and draining.

10.6.3 Dynamic brake and motoring resistors shall be edge-wound ribbon type or of equal strength construction and sufficient capacity to provide the full service braking power dissipation during operation over the specified profile with vehicle weight AW3. The grids shall be isolated from their frames and the frames isolated from the car body with high temperature insulation. Provision shall be made for grid expansion to prevent warping. The resistor grids shall be either force-ventilated with interlocks to prevent overheating or self-ventilated. If resistors are roof mounted, covers shall be provided to protect from overhead vandal damage.

10.6.4 Static Power Devices. Where chopper propulsion control is provided the power semiconductor assemblies shall be functionally grouped, keyed and mounted in modular form to facilitate maintenance and easy removal. Forced air shall be used where required for heat sink temperature stabilization.

10.6.5 Contactors. All propulsion system contactors shall be installed for free-air ventilation and readily accessible for routine inspection and maintenance.

10.6.6 Main Switch. A single pole main power switch shall be provided. The switch shall, in the open position, disconnect primary power from the propulsion system only. Auxiliary power shall not be disconnected from the line. The switch shall be rated for maximum continuous current at the nominal primary line voltage. It shall be mounted in an enclosure, accessible from the side of the car and shall be arranged so that when the enclosure cover is opened the switch shall open. An approved locking device shall be provided to secure the cover in the closed position.

10.6.7 Line Filters. (Applicable to chopper propulsion control systems). Appropriate devices shall be provided to limit the current inrush to the filter capacitors during initial charging to nominally 250 amperes. The design basis for the current limiting value shall be nominal primary line voltage, nominal filter parameters (inductance and capacitance) and minimum damping resistance. A bleeder resistor to discharge the capacitor bank when not energized shall be provided in accordance with NEC 460-6. In addition, a placard containing instructions for grounding the capacitor terminals shall be positioned adjacent to the indicator lamp to warn maintenance personnel to wait 5 minutes after lamp is extinguished before commencing work. The indicator lamp shall be visible when the door to the undercar enclosure which houses the capacitor bank assembly is removed. In addition to filtering the power component of the propulsion system, the filter shall suppress high frequency voltage transients caused by commutating thyristors.

10.6.8 Ground Brush. Each axle of all trucks shall be provided with a Ground Brush and Brushholder to shunt return current to the axles around the anti-friction bearings and provide grounding for car structures. The brush and its holder shall be protected from mechanical injury, dirt and oil by a housing having a cover easily removable for access.

10.6.9 Speed sensing devices shall be installed to meet other requirements as specified. They may be installed on the axles, gear units or incorporated as integral with traction motor and shall be interchangeable. Mounting shall be such as to avoid lubricant loss. Speed sensors shall be connected to the car body by hose-encased or shielded wires terminated in a waterproof quick-disconnect device or multi-pin connector to facilitate truck removal.

10.6.10 Current Measurement. Each motor pair circuit shall also contain an ammeter test shunt to which a standard meter can be attached when required. Leads from these test shunts shall be run through conduit to an insulated box inside the car.

10.6.11 Wiring & Cable. All propulsion system wire and cable shall be according to Subsection 17.10.

Primary power wiring shall be flexible copper with insulation properties in accordance with or better than the current IPCEA Publication requirements.

Motor lead cables from trucks to car body shall include waterproof quick disconnect devices for ease of truck removal. Cables and connectors shall be grouped to prevent incorrect connection and adequately supported to prevent undue stress and fatigue.

10.7 Packaging

The propulsion system control and power devices shall be assembled in weather-proof enclosures suitable for undercar mounting and street service.

Appropriate corrosion resistant screens and guards shall be provided to protect underfloor equipment from wheel splash, flying ballast or other similar objects. Screens and guards shall be easily removable for maintenance and shall not prevent adequate cooling of underfloor mounted equipment. Air exiting from any ventilation equipment shall not be directed onto the track, with consequent disturbances of dirt and debris.

TRUCK ASSEMBLIES

This section specifies the design and functional requirements of the truck assemblies for the Light Rail Vehicle. The word "truck" includes all truck components from the rail to and including the first components rigidly fastened to the car body. It does not include gears, motors, wiring, brake system, train control components or their mounting brackets, except that any mechanical interface requiring welding or drilling on the truck shall be part of the truck.

11.1 General Design Requirements

@@@@@@Baseline - Each car shall be equipped with two, two-axle trucks. @@@@@@

######Option 2 - Each car shall be equipped with three, two-axle trucks; one mounted under the articulation unit center line, one under the outboard end of the "A" body section and one under the outboard end of the "B" body section.######

Structural components shall be designed so that vibration and shock do not exceed the limits given in Paragraph 2.1.8.

Components shall be interchangeable between motored trucks and interchangeable between all trucks to the greatest extent practical.

The trucks shall not be acceptable unless they are a service proven design (see Paragraph 1.5.1) and manufactured by a supplier with five (5) years experience in electric railway passenger vehicle truck design and manufacture on a fleet of at least 100 vehicles.

The truck structure in normal service under the stated conditions and with proper inspection and maintenance shall have a service life equal to that of the car body, without structural repairs or alteration.

Provisions shall be made to permit the use of a wheel truing machine to turn wheels without removal of trucks. Access to axle centers shall be available if necessary for truing alignment.

Threaded fasterners, adjustment points, and structurally critical locations shall be accessible for inspection and work using conventional means and tools.

The completely assembled trucks must not exceed the clearance limits required between truck and car body, or between truck and roadway for safe operation with full allowance made for wheel wear, static and dynamic spring deflection, spring breakage, horizontal and vertical curves and any other possible movement of the trucks and associated parts. The minimum clearance above the top of the running rail (except directly over the rail) shall be 60 mm (2.5 in) after all the above factors have been taken into consideration.

11.2 Suspension System

Each truck shall have a body suspension system consisting of coil springs, air springs, or a combination of air springs with coil spring backup. The springs shall be augmented by elastomeric stops to support the car body in the event of failure. Safe operation of the car shall be assured at all speeds when any or all springs are inoperative. If a primary suspension is supplied for equalization purposes, then elastomeric blocks will suffice for this function. They shall not be considered adequate if the truck is frame equalized.

11.2.1 Load Weigh. (See Paragraph 2.2.7)

@@@@@@@Baseline - Load weigh is not required.@@@@@@@

######Option 12.1 (Load Weigh) - A method of indicating passenger load to propulsion and brake control shall be provided. Load weigh system design will be dependent on suspension design but shall meet the accuracy and fail-safe requirements as outlined in Subsection 2.2. If air suspension is provided, each air spring assembly shall have a suitable connection for a pressure transducer or air pipe connection for a load weigh signal to the friction brake and propulsion systems.######

######11.2.2 Option 36 (Load Leveling). Air spring pressure shall be controlled by leveling valves. These valves shall control the height of the floor to compensate for changes in passenger load and distribution. The leveling valves shall have an inherent response delay of from two to four seconds, after which the car floor height shall stabilize to compensate for weight changes of at least 2,700 N (600 lbs) per truck. The air spring pressure shall reflect the supported weight on each truck with a repeatable accuracy of $\pm$ 5% on any car (truck-to-truck variation).

Valve arm free-play shall not exceed $\pm$ 3 mm ($\pm$ 1/8 in).

Sudden loss of suspension air presure on either side of a truck shall initiate rapid venting of the opposite bag.

When the car is standing on a 150 mm (6 in) superelevated curve, the floor of an evenly loaded or empty vehicle shall be held at a difference from the superelevation not greater than 4%.

The suspension system shall maintain the top of the car floor, over the truck center when car is standing level, as specified in Paragraph 2.1.6 i).######

11.2.3 Provision shall be made in the truck design for up to 51mm (2 in) of vertical mechanical adjustment to compensate for wear of wheels and wear or settlement of other truck parts. The adjustments shall be readily accomplished with standard maintenance shop equipment, and shall not impair the operation of the truck.

The body suspension system shall have a natural frequency in the vertical direction not exceeding 1.5 Hz.

11.2.4 The car body-truck interface member shall be of cast steel or welded steel construction. Unless otherwise approved, welded members shall be stress relieved after all primary welding is complete and critical areas of welds or castings shall be magnetic particle and radiographically inspected.

11.2.5 Suspension. Lateral and vertical stops shall be designed with a progressive rate so as to produce a low force at initial contact, which shall build up as the stop is compressed. If the stop is to withstand motion other than in its primary direction, suitable measures shall be incorporated to prevent wear. Stops shall develop sufficient force to limit motion properly but shall not go solid under any normal operating conditions. These cars (unlike other railroad or rapid transit cars) will be operated around curves with little or no superelevation and of relatively sharp radius. The lateral stops shall provide proper cushioning under these conditions, even though the suspension shall be designed to prevent contact at normal operating speeds.

11.3 Truck Frame

11.3.1 Truck frames shall be cast steel or fabricated and welded steel. Cast steel shall be suitable for welding. All castings shall be carefully inspected for defects by visual and magnetic particle methods. During initial production, the soundness of truck frame castings and major structural welds, particularly in areas of high working stress, shall be verified by radiographic inspection of not less than 10 truck frames selected at random throughout the production run. Repair of casting defects shall be in accordance with AAR Specification M-201-66. The quality of all repairs of defects which might impair the strength of the casting shall be verified by magnetic particle inspection or by radiography. All welding shall be as indicated in Subsection 17.4. Where pockets or partially enclosed spaces exist, adequate drainage shall be provided so that no moisture collects.

11.3.2 Positive mechanical connections shall be provided between car body and trucks, such that the trucks shall be raised with the car body when it is lifted. These connections shall be detachable by conventional hand tools to permit detrucking.

11.3.3 Tram. The truck frame assembly, when loaded with its share of car weight AW2, shall maintain the axles parallel to within $\pm$ 0.5 mm (0.020 in) at the journal centers and shall limit the difference between diagonally opposed bearing locations to 2.5 mm (0.10 in). The difference in load transfer, measured at the rail of the four wheels of the truck shall not exceed 4,450 N (1,000 lbs). Tram marks located within 0.13 mm (0.005 in) of their true position, shall be provided.

When loaded as above, and with a horizontal, longitudinal couple equivalent to a 13,300 N (3,000 lbs) times 1,500 mm (59 in), applied at diagonally opposite wheel or journal centers, the truck assembly shall not allow a relative longitudinal displacement of the side frames greater than 5 mm (0.20 in), measured at the journal centers.

11.3.4 Equalization. Equalization shall be provided between the side frames by means of elastomer or steel coil springs at each journal bearing or by a system of ball-joint linkages connecting the side frames.

Truck equalization shall be such that with the truck on level track under AW0 car load, lifting any wheel of a truck vertically shall not change the weight distribution of any wheel of that truck more than an average of 1% per 2.54 mm (0.1 in) raised, up to a maximum of 50.8 mm (2 in).

There shall be no sliding surfaces involved in the method of returning the journal bearings to their proper positions. Side bearings shall not require lubrication. Provisions shall be made in the truck design to compensate for "creep" and keep the truck properly leveled.

11.3.5 Each side frame shall be fitted with two lifting surfaces approximately 150 mm (6 in) long by 100 mm (4 in) wide to support the truck and car during wheel grinding or propulsion checkout. The exact location and size of these surfaces shall be subject to the Purchaser's approval.

11.4 Shock Absorbers & Radius Rods

11.4.1 Vertical and lateral shock absorbers shall be provided on each truck if required to meet ride quality requirements. Lateral shock absorbers shall be the rotary type. Vertical shock absorbers shall be the telescopic type.

11.4.2 Radius rods may be provided on each truck connecting the interface member to the car body or truck frame as appropriate to the design. Anchor brackets shall be designed to withstand the loads imposed by collisions at speeds up to 24 km/h (15 mph). It is desired that the radius rods become distorted before the anchor brackets under extreme loading conditions in excess of those defined above.

Adequate clearance shall be provided between the radius rods and all parts of the car body and apparatus. The radius rods shall not be located in front of any electrical arc chutes.

11.5 Journal Bearings

Journal bearings shall be tapered or cylindrical roller bearings, grease lubricated, sealed by labyrinth seals and having a B-10 service life of 800,000 km (500,000 mi) at 90% of the assigned car weight AW2.

Journal bearings may be supported in cylindrical grommets of elastomeric material positively retained in the ends of the side frames by means of fitted caps bolted to the side frames.

The clamping arrangement shall be so designed that the weight of the car will keep the bearing in place, should the cap fastening fail or become loose.

11.6 Wheels

@@@@@@Baseline - The cars shall be equipped with multiple wear resilient wheels of a basic three element design which shall be capable of safe operation up to and including maximum speed. The basic design shall have been in existence for at least five years and commercially available to any transit authority. Further, the design shall have been proven in revenue service (see Paragraph 1.5.1). Wheel diameter shall be as specified in Paragraph 2.1.6.

11.6.1 Current Shunts. Multiple return current shunts with welded or brazed metal connections or sealed pressure contact type shall provide an electrical path around the resilient elements.

11.6.2 Tolerance limits of wheel diameter shall be + 6 mm - 0 mm (+ 0.25 in - 0 in). Wheels shall be supplied in marked pairs matched in diameter to within 0.3 mm (0.012 in). When the wheel-axle assemblies are rolled on the journals, the treads shall not show total indicator readings greater than 0.3 mm (0.012 in).

11.6.3 The tire shall be constructed of rolled steel in accordance with ASTM A551-65, Class DHT, 321 to 363 BHN and the tread/flange contour shall be as shown on Drawings ___. Further, the tire shall be capable of normal service within a maximum radial wear of 25 mm (1.0 in) when properly trued over its life span. The overall design shall be such that the wheel may be turned on an ordinary wheel lathe or on modern truing machines such as "Hegenscheidt" or "Stan-Ray". Further, the tire design shall be such that it may be removed when it has reached the condemning limit without damage to the elastomeric cushioning and the hub and such that a new tire may be fitted to them; thus returning the wheel assembly to essentially new condition. The tire renewal process shall be repeatable for an indefinite period (but no less than five times) and shall be accomplished in a simple and effective manner. The Contractor shall supply at least two sets of any specialized tools and gauges which are required to accomplish the re-tiring.

11.6.4 Wheel-Axle Assembly. The wheels shall be fitted to the axle in a manner approved by the Purchaser. Provisions shall be made for hydraulically assisted wheel removal including an internal annular groove in the hub, a port connecting the groove to the outside of the hub, a threaded connection for the pressure application device at the outer end of the port, and a secure closure for the threaded connection, which shall be removable with standard tools and be of non-metallic non-corrosive material. Wheel-axle dimensions shall be as shown on Drawing _____.

11.6.5 Identification. Wheels shall be run stamped in accordance with AAR Specification M107-71. Wheel and axle data, including pressure graphs required for installation, shall be provided to the Purchaser.@@@@@@

######Option 37 (Solid Wheels) - ******The Purchaser may specify solid wheels or ring damped wheels. In either case, the Purchaser must revise Paragraphs 11.6.1 through 11.6.5 appropriately and should re-examine and possibly modify vibration, shock and noise requirements and may consider allowance of tread brakes. If tread brakes are permitted they shall be equipped with snow brakes (wheel scrubbers).****** ######

11.7 Axles

Axles shall be manufactured in accordance with ASTM A-729, and ultrasonically inspected in accordance with AAR Specification M-101A. The axle shall be of hollow or solid construction. If the axles are solid, both ends of each axle shall be furnished with standard lathe axle centers and threaded holes fitted with rubber plugs. If axles are hollow, the internal bore must be machined smooth, and the internal ends leveled for lathe centering.

In no case shall the maximum static unit stress at the centerline of the bearing exceed 34,474 kPa (5,000 psi), the axle being considered as a simple beam under normal (AW2) load.

Axles shall have an exterior finish in accordance with Section 1 of the AAR Wheel and Axle Manual, as a minimum, and shall have been subjected to a magnetic particle inspection following machining.

Axles shall have standard 60-degree lathe centers and shall be marked in accordance with AAR Standards.

Axles shall be rejected which are galled or otherwise scarred when pressing on wheels or gear components. In the absence of visible evidence of such galling or scarring, the use of excessive pressing force shall be taken as cause for rejection of the assembly.

Each axle shall be assigned a unique serial number which shall be legibly and permanently stamped on the gear seat end of each axle. The serial number shall be prefixed by the letters "ML". The numbering shall start with the number, 1, and shall continue in consecutive order. The Manufacturer's name, the date of manufacture, and the heat number shall be stamped on the opposite end of the axle with characters not less than 6.35 mm (0.25 in). The Contractor shall furnish the Purchaser with a record of the Manufacturer's serial and heat numbers listed together with the appropriate serial numbers of the cars and trucks on which they have been installed.

11.8 Track Brakes

The track brake shall be supported from a basically unsprung element of the truck in accordance with the requirements of Paragraph 12.6.8.

11.9 Cab Signal Receivers

@@@@@@@Baseline - No requirements.@@@@@@@

######Option 9 - The truck design shall not preclude future mounting of cab signal receivers.######

######Option 9.2 (Cab Signals) - The Contractor shall mount Purchaser provided signal receiver units on the truck.######

11.10 Odometer

An odometer registering the total kilometers of operation in both directions shall be furnished and applied to one truck axle in a location approved by the Purchaser.

11.11 Safety Bars (Life-Guards)

As a protection against foreign objects, people, or animals becoming caught under the front of the car and trucks, "Safety Bars" shall be provided at the outer facing ends of the end trucks. These shall be at least 1,525 mm (5 ft) wide (centered on

the truck) and 150 mm (6 in) high and may be made of wood, reinforced glass fiber or other approved material. They shall be mounted to maintain adequate clearances including 60 mm (2.5 in) from bottom of bar to top of rail and be arranged for ease of replacement in the event of damage.

11.12 Test and Data Requirements

All truck system required data is listed in Section 1, and stress calculations and tests are established in Section 2.

FRICTION BRAKE SYSTEM

This section defines the friction braking system for the Light Rail Vehicle.

12.1 System Description

The total friction brake system shall be service-proven and shall include an energy source, reservoirs, control logic, brake units at each axle, track brakes, sanding devices and all accessories necessary to control retarding torque to the axles in response to electrical control signals specified. Basic performance and environmental requirements with regard to accuracy, rates, jerk limiting, load weigh, blending, slip-spin, maintainability and reliability shall be as defined in Subsection 2.2. The friction brake system shall perform the following basic functions:

a) Supplement dynamic brake to provide full service deceleration;

b) Provide emergency deceleration with the assistance of track brakes and sand;

c) Provide full service and emergency braking in the event of dynamic brake failure; and

d) Act as a parking brake system.

The friction brake system shall be interlocked with propulsion control to prevent application of power when the friction brake is applied on any truck on a single car or train.

12.2 System Design

The friction brake system shall be a fail-safe design as set forth in Paragraph 2.1.1. Redundant systems, where used, must include annunciation of failure to the Operator.

12.3 Acceptable Configurations

The friction brake system provided for the Light Rail Vehicle shall include one or more inboard disc and caliper units per axle of all trucks. ******(Note: If Option 37, Solid Wheels, is selected the Purchaser may wish to allow tread brakes). ****** Friction brake discs and pads shall be interchangeable among all trucks.

12.4 Power Source

The friction brake electronic control equipment shall use the vehicle low voltage supply as a power source. In the event a pneumatic or hydraulic system is furnished, power to the compressor or pump power shall be either primary line voltage or auxiliary system ac.

12.5 Performance Characteristics

12.5.1 Control. The friction brake system shall be controlled on a per truck basis from the Master Controller command signals and, if supplied, signals from dynamic brake feedback, load weigh, spin/slide protection and blending signals, as required. Accuracy of control shall be in accordance with the performance requirements indicated in Section 2. The capability of providing performance shall be verified by dynamometer or flywheel test as indicated.

######Option 3 (Train Operation) - Friction brake control shall be trainlined as required per Paragraph 9.5.7.######

12.5.2 Jerk Limit. Tractive effort produced by the friction brake system shall be jerk limited according to Paragraph 2.2.6.

12.5.3 Weight Unbalance. With friction units acting on each axle of the vehicle, the system shall be designed to allow for the unbalance of weight between end trucks and the center truck. Control of the unbalanced effort shall be accomplished by design of the control system or the actuating unit. Brake pads shall be identical and interchangeable for all axles.

12.5.4 Performance. The friction brakes shall provide a deceleration capability and response as specified in Paragraph 2.2.3. Response to an emergency command signal shall result in an application of all friction braking, at maximum force, including sanders and track brakes as required to attain specified emergency deceleration rates. Jerk limitation and slip protection (if supplied) shall not be used in emergency braking.

12.5.5 Thermal Capacity (Duty Cycle)

@@@@@@Baseline - With dynamic brakes inoperative, the friction brake system shall have the capacity to bring a loaded car (AW2) to rest with at least the minimum instantaneous deceleration as specified in Paragraph 2.2.3.1 b) from a car speed of 55 mph on level tangent track. It shall have the capacity for two such successive applications, without extra time for cooling in between. Afterwards of two such applications the friction brakes shall have the capacity to provide deceleration rates specified in Paragraph 2.2, maintain the average line speed at any time during a round trip over that line in the light rail system which requires the most braking energy, not counting braking energy for passengers stops, with an empty car (AW0) not exceeding safe speed limits and making only the necessary stops. It is assumed that a car having experienced a failure of dynamic brakes shall proceed to the next station, unload all of its passengers and then proceed to the maintenance facility at a speed not greater than the average line speed over the shortest distance.@@@@@@

######Option 38 (Full Service Duty Cycle Friction Brakes) - The friction brake system shall have the capacity to bring a crush loaded car (AW3) to rest with at least the minimum instantaneous deceleration as specified in Paragraph 2.2.3.1 b) from a car speed of 90 km/h (55 mph) on level tangent track, starting at all disc temperatures from ambient to 316 ^{o}C (600^{o} F). In addition, the friction brake system shall have sufficient accuracy and thermal capacity to allow normal continuous car operation over that line in the light rail system which requires the most braking energy, a design load weight (AW2), and with dynamic brakes inoperative.######

12.5.6 Storage Capacity. If a pneumatic or hydraulic actuation system is chosen, the friction brake system shall have sufficient storage capacity after loss of compressor or hydraulic power unit drive power, for 5 full brake applications and releases, keeping brakes applied for at least 30 seconds per application and brakes released for 2 minutes between applications. This shall be demonstrated by test. Full brake applications shall be at a torque equivalent to nominal rate for car weight of AW3. Whenever the brake reservoir pressure reaches the minimum value necessary for a nominal full service brake stop for a car weight AW3, further propulsion shall be inhibited. Normal torque modulation shall be available. It shall be assumed that the power loss occurs when the main air or oil storage reservoir is at its minimum cut-in pressure level. A buzzer shall sound at the Operator's position to warn of minimum service pressure level.

12.6 System Components

12.6.1 Disc & Hub. The disc and hub shall have the thermal characteristics and strength to resist warping and cracking due to thermal stress. If mounted inboard, the disc shall be constructed of two mechanically locked, matched and balanced segments to facilitate maintenance. The segments shall be keyed to each other and to the hub in such a manner that improper assembly shall not be possible. When assembled, the disc shall statically balance within 720 mm-gr (10 in-oz).

12.6.2 Caliper & Pads. The disc brake caliper shall be a floating type designed to follow the disc and move normal to the disc with each brake application as required. The caliper shall include an automatic slack adjustment feature which shall take up for brake pad wear as well as assure drag-free running. The disc brake pads and holders shall be designed for quick replacement without disassembly of the caliper unit. Brake pads shall be designed for a minimum fleet average life of 40,000 km (25,000 mi) in normal service with dynamic brake system availability of 90%.

12.6.3 Blending Circuit. If the Contractor supplies continuous blending, the brake blending circuit shall be a solid state or electropneumatic electrical summing network which shall continuously monitor the jerk limited command signal, dynamic brake feedback signal, load weigh signal (if required), and the friction brake effort to produce the overall deceleration requirements as defined in Paragraph 2.2.3. Design of the circuit shall employ fail-safe principles in that failure of any circuit component shall not result in braking effort less than requested. The blending circuit may be supplied as an integral part of the propulsion system.

######12.6.4 Option 14 (Spin/Slide Protection Circuit) - The friction brake system shall respond on a per truck basis to signals indicating wheel slide. The receipt of this signal shall immediately cause brake control to release or reduce braking effort on the affected truck in order to correct the slide as required to perform the wheel protection defined in Paragraph 2.2.4.######

12.6.5 Air Compressor. If supplied, the air compressor shall be a package unit complete with motor, starter, automatic air drier, lubrication systems, filters, silencers, cooling system, safety valves, automatic drain valves, piping, wiring and all accessories required for a complete installation. The

compressed air system shall be equipped with a "low air" alarm. The automatic air drier shall be the desiccant-type with a purge cycle piloted by the compressor governor to drain water from the drier and purge water from the desiccant. The desiccant element shall have a one year service life. Care must be taken that the service life is not reduced by oil fouling. The drier shall, in combination with other compressor elements, guarantee a water free pneumatic system. Power shall be made available at all times for heaters if required to prevent freezing of air lines.

12.6.6 Hydraulic Power Unit. If supplied, the power unit shall be complete with positive displacement pump, oil reservoir, close-coupled motor drive, motor starter and controls, external or internal pressure relief valve, and all accessories necessary for a complete installation. Pump and reservoir may be an integral unit providing all code and safety requirements are met. Hydraulic fluid shall be a non-aqueous fluid with fire resistant quality equal to or exceeding Brayco 776.

12.6.7 Parking Brake. A parking brake function, which shall be an integral part of the service brake, shall be provided on each vehicle. The parking brake shall have the capability to hold a fully loaded car on the maximum grade (specified by Purchaser) without power available. Design shall be such that the parking brake can be released with no power source available. It shall also be semi-automatic in that it shall be applied when the vehicle is placed in the lay-up mode and the cab transfer key has been removed from the master controller. Parking brake shall be interlocked with propulsion control to prevent application of power when the parking brake is set on a single car or train.

12.6.8 Track Brake. Each vehicle shall be fitted with two magnetic track brake assemblies per truck. One assembly shall be mounted between the wheels on both sides of each truck and shall be arranged parallel to the rail so that a maximum contact area is provided between the brake shoe and the rail head when energized. Each shall be designed to contact the rail through a magnetic coil winding pulling the shoe down to the rail when energized and held off by a spring-operated retrieving mechanism. The mounting devices shall be rigidly attached to the truck.

a) The track brake system shall be effective at all speeds from maximum down to a full stop over all conditions of curves and grades. Although simultaneous activation with the other braking systems shall be required in the emergency mode, controlled blending and load weigh shall not be supplied for the track brakes.

b) The track brakes shall be constructed of material sufficiently strong to survive the railway environment of both paved and open track construction and shall be fully water-tight. The coil shall be enclosed in a non-magnetic corrosion resistant case with all coil voids filled with approved material to form a hermetically sealed unit. The coil shall be electrically isolated from all grounds and shall be terminated in an insulated two pin built-in coupler socket. Flexible leads with coupler at the car body end shall be used to connect the unit to the appropriate car wiring. The connection at the track brake shall be sealed.

c) All forces generated by interaction between the track brake shoe and the rail shall be transmitted to the truck through bonded rubber elements. If it is necessary to remove the track brake to renew the rubber elements, then they shall be applied to the track brake shoe assembly rather than the truck. Track brake mounting which does not require rubber elements but which provides for quiet operation will also be acceptable as approved by the Purchaser.

d) The portion of the track brake shoe which comes in contact with the rail shall be made readily renewable. A non-magnetic filler material between the pole faces shall also provide a wearing surface. The exposed combination shall present a smooth surface to the rail head to help prevent the formation of ridges on the rail head and provide maximum contact. The track brake shoe shall be confined within the dynamic clearance limits over the rail head swept by the wheels. The track brake shoe shall not protrude laterally beyond the rail head on the gauge-side more than the distance traveled by the gauge-side of the wheel flange in the zone between the head of the rail and 50 mm (2 in) above it, and shall not protrude laterally on the outside of the rail more than the distance traveled by the outer edge of the wheel tire in the zone between the rail head and 13 mm (0.5 in) above it. In the de-energized mode, the face of the shoe shall be carried at a distance of no less than 9.5 to 13 mm (0.375 to 0.5 in) above the rail head within ± 6 mm (± 0.25 in) for all values of load to AW3. Provision for wear adjustment shall be included. The spring suspension shall be selected to support the track brake unit above the rail head at all times and under all normal track conditions when not energized.

e) The track brakes shall operate from the battery and shall be arranged to operate from the Master Controller as specified in Paragraph 9.5.5.1.

f) Track brake cut-out shall be provided in the electric locker area but shall be sealed in the functioning mode.

g) An audible indication of the energized mode shall be provided on the cab console.

h) @@@@@@Baseline - The track brake shoe shall be of a single piece construction.@@@@@@

######Option 39 - The track brake shoe shall be of an articulated construction.######

12.6.9 Sanding Devices. Sand boxes shall be designed in such a way to preclude dust from entering car during filling operation, and exclude moisture from entering box. Alternatively, the design shall assure the continuous flow of sand at all weather conditions.

@@@@@@Baseline - Each car shall be provided with two sandboxes and two sanding nozzles arranged to deposit sand on both rails just ahead of the leading truck.@@@@@@

######Option 1 (Bidirectional Operation) - Each car shall be provided with four sandboxes and four sanding nozzles arranged to deposit sand on both rails just ahead of the leading truck in each direction of travel. Sander controls shall be interlocked with the reverser to deposit sand ahead of the wheels only.######

Truck mounted nozzles connected by flexible hoses to the car body lines are required. Nozzles shall be designed to reject water caused by wheel splash and located sufficiently far from wheel and rail to prevent plugging with snow or ice.

a) The nozzles shall apply sand at a restricted flow not exceeding __*__ cu in/sec and not less than __*__ cu in/sec.

b) The sanders shall be operated by air pressure or electrically with sand reservoirs, traps, piping and nozzles for each of the sander locations. The sand reservoirs may be located under passenger seats on both sides of the car. The boxes shall be of stainless steel, designed and arranged to permit easy filling from outside the car. Capacity shall be at least 0.06 m^3 (2 ft^3) per box and the design shall be such that foreign matter cannot get into the box under normal operation. Sand box covers shall be locked using the Reverser Switch Key.

c) The sand boxes shall feed by gravity to adjustable flow sand traps mounted under the car. Sand traps with an Authority approved railroad or transit service history shall be provided. The output of the trap shall be through piping or hose of an approved design arranged to minimize all small radius bends. Standard pipe tees and 90° elbows shall not be used.

   The entire system shall be waterproof in design to prevent clogging of the lines and provide proper flow.

d) Sander control shall be from the low voltage power supply and shall function properly over the range of 24 to 40 Vdc. A single rate of flow shall be provided when actuated. This rate shall be mechanically adjustable by shop personnel. The sanders shall be operated from the Master Controller in the emergency mode but shall cease operation at zero speed. In addition, a separate console switch, controlling the local car sanders only, shall be available for use by the operator at any time regardless of the braking or propulsion mode then in effect and shall operate the sanders at that cab end only at any car speed including zero.

* Purchaser to specify.

######Option 3.2 (Train Operation) - In any of the above modes, only the leading pairs of sanders in the direction of travel shall be actuated with the selection of the appropriate pairs being made by trainlines energized through circuitry in the energized cab. ######

e) A sander cut-out shall be provided in the electric locker on a local car basis and shall be sealed in the functioning mode.

12.6.10 Annunciators. The friction brake system shall include devices and circuits to indicate the following functions:

a) Yellow indication on operator's console for "Brakes ON" (includes parking brake) and green indicator for "Brakes RELEASED."

######Option 3.2 (Train Operation) - This indication shall be trainlined.######

b) Gauge indications on console representing air or hydraulic pressure, if supplied.

c) An audible indication (buzzer) of track brake activated.

d) Any system cut-out or bypass action.

12.6.11 Friction Brake Cut-Out. The friction brake system design shall include a method to release and cut-out the brakes, if required, to allow a vehicle to be towed. An electrical cut-out control, if applicable, shall be accessible at the electric locker area and sealed in the normal functioning mode. A manual cut-out, accessible from either side of the car, shall be provided as approved by the Purchaser. This manual cut-out shall be hand operated without the use of special tools.

12.6.12 Test Points. The friction brake electronic control system shall include test points to be used by portable test equipment. Exact parameters to be checked will be determined by the Contractor and reviewed by the Purchaser during detail design. In the case of pneumatic brakes, test tees shall be provided for test gauges.

12.7 Packaging & Installation

12.7.1 Code Requirements. Design and installation of air brake system components shall conform in all respects with the latest revision of Section VIII of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels.

Design and installation of hydraulic brake system components shall conform with the latest revision of the Joint Industry Conference (JIC) Hydraulic Standards for Industrial Equipment, with the following modifications:

a) Mounting of pumps and relief valves inside reservoirs will be permitted only when the pump assembly is readily removable for repair, inspection and replacement.

b) If a filter is used in the fluid return line, it shall be of the by-pass type and shall not restrict the return flow from the brake cylinders (reference Paragraph H6.1.6).

c) Couplings between hydraulic tubing and flexible hose shall be of the self-sealing quick-disconnect type to prevent escape of fluid when disconnected (reference Paragraph H4.1.8).

12.7.2 Support. Adjacent air or oil hoses, pipes and tubes shall be supported to prevent vibration, rubbing and chafing. Routing that requires other piping or cables as sole means of support will not be acceptable.

12.8 Test and Data Requirements

Data submittals and test requirements are outlined in Section 2.

VEHICLE COMMUNICATIONS

******This section specifies only the BASELINE accommodations which the Contractor shall supply with the vehicle. ######Option 31 - Functional and design requirements of a vehicle communications system, if required, shall be developed by the Purchaser.##########*****

13.1 General

The Contractor shall provide the following accommodations for communications equipment.

a) Speakers, enclosures and wiring as specified below for a public address system, which may be installed at a future date.

b) Space in the operator's cab and space on the console for future installation of two-way radio equipment with train to wayside data transmission capability.

c) Space in the operator's cab and space on the console for future installation of public address equipment.

d) Low voltage dc power wiring for future installation of radio and intercom equipment.

e) Antenna provisions including wiring from the space for the radio and in the operator's cab to the vehicle roof as specified below.

f) ######Option 1.1 - Spare communications cables shall be provided in ceiling between the two operator cabs.######

13.2 Speakers and Enclosures

There shall be at least one speaker per 3,050 mm (10 ft) of overall car length. They shall be mounted in the ceiling panels to provide even coverage throughout the car.

Each speaker shall be mounted in a suitable acoustical enclosure lined with sound absorbing material over at least 50 percent of the inside surface. Each enclosure shall have a minimum of 14,750 cu cm (900 cu in) inside volume and shall provide a 13 mm (0.5 in) clearance between the back of the speaker and the inside of the enclosure. The speakers and enclosures shall be securely mounted above the headlining. The speaker enclosure may project into the main overhead air duct if necessary but such projection shall be held to a minimum. The speakers shall be connected electrically so that they are in phase and are properly matched for impedance as well as for the desired power. The enclosure and speaker shall be removable from the car as a complete unit. The speakers shall be specifically designed for transportation service and shall be 200 mm (8 in) types with an overall depth not to exceed 50 mm (2 in). They shall employ at least 110 grams (4 oz) minimum of magnetic material in an efficient magnetic structure.

The speakers shall be wired with twisted pair cable of AWG #18 standard wire terminated at a terminal strip or protected connectors in the space provided in the operator's cab for the amplifier.

13.3 Antenna Provisions

Space and accommodations shall be provided for future mounting of a rigid, railroad mobile type antenna on the roof. The method of mounting and these accommodations shall be waterproof. Wiring for the antenna shall be provided for an FM transceiver operating over a range of ___ MHz centered at ___ MHz.

EMERGENCY SYSTEMS

This section outlines the emergency features to be provided.

14.1 Emergency Braking

See Subsection 2.2 and Section 12.

14.2 Emergency Power & Lighting

See Subsection 8.4 and Paragraph 9.3.1.

14.3 Emergency System Components and Provisions

14.3.1 Passenger emergency switches shall be installed inside of the car at the upper right hand corner of each doorway; easily accessible to permit operation by a passenger. The switch shall be actuated by a T-handle which shall be pulled down. Once pulled, it shall not be possible to reset the switch, except with the operator's key. The T-handle shall be painted red. Labeling next to each switch shall read

"PULL HANDLE TO STOP VEHICLE IN AN EMERGENCY"

The emergency switches shall be wired in such a manner that they shall automatically cause the vehicle or train to apply emergency braking and indicate with a light on the operator's console.

######Option 3.2 - The indicator light function shall be trainlined.######

14.3.2 An Operator's emergency switch shall be provided in each cab area in a readily accessible and identified location. Activation of any operator's emergency switch shall cause action as described above for passenger emergency.

14.3.3 Emergency Jack. Provision shall be made to store a car jack and blocks as furnished by the Purchaser. The equipment box shall be located under a passenger seat near the vehicle right front end. The box shall be of corrosion-proof material, faced to match the interior vehicle finish, and large enough to accommodate a jack, handle and associated wooden blocks. Access shall require a standard car key and shall be identified per graphic standards of Section 3.

14.4 Emergency Towing

A train of up to four cars shall be capable of pushing or pulling a dead train of up to four cars with the two trains mechanically but not electrically coupled.

14.5 Testing

Emergency systems shall be functionally tested prior to vehicle acceptance.

Technical Specifications - Section 15

IN-SERVICE SUPPORT

This section defines only the technical aspects of in-service support requirements. The total set of in-service support requirements are defined in _____*_____ of the Special Provisions to the Contract.

15.1 Manuals.

The Contractor shall prepare and deliver, in ******quantities to be specified by the Purchaser****** Operator's Instructional Manuals, Running and Servicing Manuals, and Heavy Repair Maintenance Manuals. In the organization of these manuals, the car shall be treated as an integrated system and not as a grouping of disassociated parts. As appropriate, each of the manuals shall highlight the precautions to be taken by operating and/or service personnel to assure their safety while performing these service operations. Simple declarative statements shall be employed to convey such instructions. The material shall be indexed with a Purchaser-approved standard numbering system. Revisions required by changes to equipment and procedures shall be maintained by the Contractor during the warranty period.

The Operator's Instructional Manual shall contain all information needed for optimum operation of the car. It shall include:

- o General car familiarization material;
- o Location, function and operation of all controls, gauges, indicators and switches;
- o Emergency procedures; and
- o 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 each component and subsystem.

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

MIL-M-38784 shall be used as the standard for the format of the manuals and MIL-M-15071 for technical content guidelines. Where practical, standard operating and maintenance information provided by subsystem suppliers may be directly incorporated in its original format. Within the period specified in the Contract Terms and Conditions, the contractor shall submit for the Purchaser's approval, Tables of Contents and Sample Formats for each manual.

*Purchaser to provide reference.

******The size of each manual, the method of binding, the type of cover, and the number of copies to be furnished shall be specified by the Purchaser.****** Manuals shall be provided first in draft form for use and correction during initial training and operational testing. Final printing shall incorporate all corrections made during initial training and operational testing.

15.2 Diagnostic Test Equipment

The Contractor shall provide all equipment specified in this section to properly perform all in-service testing of cars. The Contractor shall perform all necessary modifications to test equipment resulting from modifications in car design.

15.2.1 Shop Level Test Equipment. Bench test equipment shall be supplied, ******in quantities to be specified by the Purchaser******, by the Contractor for the purpose of testing, troubleshooting, and calibrating electric, electronic, mechanical, and electromechanical components of each car subsystem. Test units shall be for use in and compatible with the Purchaser's maintenance and repair facility which the Purchaser shall specify. Bench test units shall contain provisions for rapid testing, trouble shooting, and calibration of electronic circuit boards, plug-in relays, sensors, transducers, etc., used in car-mounted systems. Bench test units may use shop-supplied compressed air and electric power. Design of the tester shall be such that input signals or supplies such as compressed air can be varied over the full working range of the device. The bench test device, when used in accordance with instructions supplied by the Contractor, shall test and calibrate the car equipment equal in quality to that performed by the original supplier, with the exception of tests of an environmental nature.

Performance of the tests shall not be automatically accomplished by the test device. Instead, they shall be performed by manual manipulation of dials, levers, buttons, and other appropriate controls by test technicians who shall establish input levels and provide internal connections between the equipment under test and appropriate power supplies, input signal generating devices, and output signal, and response measuring devices. Bench test devices shall be of a higher technical quality than the equipment being calibrated.

15.2.2 Portable Test Equipment. The Contractor shall provide portable test units (PTU) ******in quantities to be specified by the Purchaser******, to simulate dynamic system operation of the propulsion system by dry sequencing. These plug-in type units shall contain all control logic, sequencers, generators, indicators, switches, and coupling devices necessary to provide a thorough check of the propulsion system. These test units shall be designed to perform a number of sufficient tests to provide a 95% confidence level that the propulsion system shall function properly in revenue service. Test units shall use low voltage dc and logic control power available from the propulsion control equipment. Under no circumstances shall the car be capable of being propelled when the PTU is connected to the car propulsion equipment. The test circuits shall allow critical control and power circuit simulation and readout so that system status can be determined.

The PTU shall be designed with the following guidelines considered as a minimum:

- The connection to the subsystem under test shall be by multi-pin connectors.

- Use of the test device shall not require removal or disconnection of any component, printed circuit board, wire chassis, terminal, or cable.

- The PTU shall produce the operating commands and other input signals necessary to fully exercise all functions and components of the subsystem under test.

- The PTU shall measure or indicate all signals, responses, and outputs of a properly functioning subsystem by means of lamps, meters, oscilloscopes and gauges.

- The PTU, when used in accordance with instructions supplied by the Contractor, shall enable the Purchaser to fully check out and calibrate the subsystem under test and to locate and replace any removable component which shall have failed.

- Indicators and input signal generators shall be built into the PTU to the maximum extent possible.

- The PTU shall have an accuracy commensurate with the tolerance specified.

- Power for PTU operation shall be derived from low-voltage car power.

The test device shall be housed in an enclosure with a removable cover suitable for use in the maintenance and repair facilities environment. The weight of the portable test device shall not exceed 50 pounds (22.7 kg).

Portable Test Units for other major subsystems shall also be provided. ******These are to be specified by the Purchaser dependent upon Options selected.******

15.2.3 On-Board Test Support Detail. The Contractor shall provide test receptacles which shall permit monitoring of system performance and control logic during actual operation and during simulation by the PTU. Since this equipment shall add wiring and weight which could act to reduce car reliability, a detailed analysis of equipment requirements will be made by the Purchaser and supplied to the Contractor.

Test receptacles shall neither interfere with nor alter the safety requirements of normal operation. At least 50 strategic test points shall be supplied. Ten spare test points for possible future use shall also be provided. Selection of test points as well as physical receptacle design and wiring shall be coordinated with the Purchaser.

The test receptacle and portable test units combined shall be capable of locating faults to the replaceable assembly level.

15.3 Replacement Parts

15.3.1 Initial Supply. Replacement parts shall be supplied by the Contractor based on the Contractor's quoted reliability and maintainability (see Paragraphs 2.2.14 and 2.2.15) so that the Purchaser shall have a 90% probability of having sufficient spares on hand to sustain operations throughout the warranty period. On this basis and within the period specified in the Contract Terms and Conditions, the Contractor shall submit to the Purchaser a list of replacement parts and special test and support equipment. The list shall state the quantities that the Contractor recommends as an initial supply and such other information as may be required. The list shall be updated as changes occur.

15.3.2 Parts Catalog. Within the period specified in the Contract Terms and Conditions, the Contractor shall submit to the Purchaser a Parts Catalog which shall enumerate and describe every component with its constituent parts, the vendor's number, the Contractor's number, and the commercial equivalents. Cutaway and exploded drawings shall permit identification of all parts not readily identified by description. Parts common to different components (for example, bolts and nuts) shall bear the same contractor's number with a reference to the other components in which they shall be found. Each part or component shall be identified as being part of the next larger assembly.

Within the period specified in the Contract Terms and Conditions, the Contractor shall submit a sample format of the Parts Catalog to the Purchaser for approval.

Prior to printing, the approved draft of the Parts Catalog in final form shall be supplied to the Purchaser so that the Purchaser can insert the proper order or control numbers for each part.

15.3.3 Future Availability. For the period of time set forth in the terms and conditions, replacement parts shall be available for purchase by the Purchaser.

15.4 Gauges and Special Tools

The Contractor shall examine the existing equipment and tool inventory of the maintenance and repair facilities of the Purchaser and shall submit to the Purchaser a list of additional gauges required and tools recommended to be purchased to effectively maintain and repair the cars.

Any special tools required for maintenance and repair shall be supplied by the Contractor. The quantity shall be consistent with the needs to meet reliability and maintainability quotes of Paragraphs 2.2.14 and 2.2.15.

MANAGEMENT

The general management requirements are defined in ___*___ of the Special Provisions of the contract. This section provides only those requirements that are of a technical nature.

16.1 Technical Documentation Management

16.1.1 Identification. The Contractor's technical documentation shall define the configuration of all system equipment: test, production, or in operational use. Configuration shall be identified to the lowest level required to ensure repeatable performance, quality and reliability. The Contractor shall maintain release records which shall detail the relationships between identification elements. Such relationships shall be limited to configuration requirements defined by engineering data and shall not reflect manufacturing status.

Contractor's release records and documentation shall indicate the following:

- Composition of any part number at any level in terms of subordinate part numbers;
- All next-assembly part numbers of any part; and
- The specification document, specification control drawing, or source control drawing numbers associated with any sub-supplier, vendor or contractor part numbers.

The Contractor's release records and documentation shall identify engineering changes and retain the record of superseded configuration requirements affecting items formally released for test or production. The Contractor shall employ a system of identifying numbers for specifications, drawings, and associated documents which shall ensure that differing parts, assemblies, and installations will be uniquely identified.

The Contractor shall permanently mark all hardware components as specified in Subsection 16.6. Such markings shall coincide with engineering data. Equipment nameplates shall provide space for several numbers to be added in accordance with Subsection 16.6.

16.1.2 Changes. Changes to this specification shall be controlled by the processing of engineering change proposals (ECP's).
An engineering change to any part, assembly, or equipment item of the car shall be designated as a Class I change when one of the following criteria shall be affected:

* Purchaser to provide reference.

- o Delivered manuals;
- o Delivered product (retrofit);
- o Electromagnetic interference characteristics;
- o Form, fit, function or interchangeability;
- o Reliability or maintainability;
- o Safety;
- o Schedules or deliveries;
- o Spares provisioning;
- o Sources of repairable items (source control drawings); or
- o Weight or balance.

All other changes shall be designated as Class II changes.

All Class I ECP's together with documentation and cost information, shall be submitted to the Purchaser for review prior to implementation. Time for review and schedule relief shall be considered by the Purchaser in his review. Class II ECP's shall be submitted to the Purchaser for information, provided that changes do not deviate from the specification requirement. The Contractor shall maintain an Engineering Change Status Report which shall list all approved changes, their status and completion dates. Reports shall be submitted monthly. Implementation of an ECP shall be incorporated in all cars.

16.2 Contractor As-Built Specification

Prior to completion of the contract, the Contractor shall provide a final technical specification, marked FINAL CONTRACTOR AS-BUILT TECHNICAL SPECIFICATION, with all approved changes and revisions incorporated. The format shall be the same as this specification.

16.3 Record Drawings

At the completion of the contract, the Contractor shall provide the Purchaser with a complete set of record reproducible drawings accurately representing the car in its final, as-built configuration.

16.4 Safety

The Contractor shall furnish to the Purchaser qualitative and quantitative analyses of safety considerations in the car design as required per ___*___ of the Special Provisions of the contract.

16.5 Quality Assurance

The Contractor shall establish and maintain a quality assurance system which shall provide objective, verifiable evidence of compliance with contract requirements and the Contractor's design control procedures. The requirements for the Quality Assurance Program are defined in ___*___ of the Special Provisions of the contract.

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* Purchaser to provide reference.

16.6 Car Component Serialization Program

The Contractor shall assign discrete serial numbers in sequence for the model series of the following:

- Air compressors;
- Air conditioning apparatus;
- Axles;
- Batteries;
- Converters;
- Couplers;
- Destination Signs;
- Door Operators and Controls;
- Gear Units;
- Journal Bearings;
- Motors in any of the above;
- Principal units of automatic train control;
- Principal units of radio and public address equipment (not including speakers);
- Principal units of traction and braking apparatus;
- Temperature control apparatus;
- Traction motors, including armatures;
- Truck castings and weldments;
- Wheels; and
- Any other item of equipment customarily serially numbered.

Within the period specified in the Contract Terms and Conditions, the Contractor shall furnish to the Purchaser a list of the items to be serialized and a description of the serialization method to be used. The Purchaser will submit comments within 30 days following receipt of such information.

Serial numbers shall be recorded in the Car History Book specified in Subsection 16.7.

16.7 Car History Books

The Contractor shall provide the Purchaser with a Car History Book for each car at time of delivery. Each Car History Book shall contain the following car-specific information:

- Certified weight;
- Description of modifications and completion dates of incorporation;
- List of defects noted and the disposition of each;
- List of serial-numbered apparatus;
- Provisions for recording inspection, servicing and major overhaul events;
- Shipping documents;
- Summary detail of each test performed on the complete car or any part thereof; and
- Wheels, journal bearings and gear mounting records.

The Contractor shall furnish to the Purchaser for inclusion in the Car History Book documentation recording changes made during the warranty period.

MATERIALS AND WORKMANSHIP

17.1 General

All materials chosen for use in the fabrication of the light rail vehicle shall be such that they will economically and safely perform satisfactorily under their operating environment and in accordance with their intended function.

Material composition, properties and performance shall conform to the applicable standards. Whenever a commercial material is not covered by a specification, the material shall be identified by the commercial trademark, and name and address of the Supplier. A description of the material composition shall also be available for approval. Use of substitute materials shall be with the approval of the Purchaser.

17.2 Metals

17.2.1 Steel. All materials and workmanship shall conform to the requirements of the indicated standard for the designated steel.

	Material	Applicable Standard	Notes
1.	Steel Castings		
	General Purpose Castings	ASTM A27, Grade 65-35 or Grade 70-36	general application except traction motor manufacture
	High Strength Steel Castings	ASTM A148, Grade 80-40 or Grade 90-60	for application in members subjected to higher mechanical stresses than above, e.g., traction motor
	Low Alloy Nickel	AAR M-201	for truck frames and bolsters
2.	Stainless Steel	AISI committee on Stainless Steel procedures shall be AISI type 301, 302, 304, 304L, 316, 316L or 347	
3.	Heat-Treated Alloy Steel	ASTM A514, Grade F	suitable for welding and other structural purposes
4.	Low Alloy, High Tensile Steel	ASTM A242	shall be nickel-containing low alloy, corrosion resistant steel having a high tensile strength

Material	Applicable Standard	Notes
5. Steel Forgings		
Carbon Steel Forgings	ASTM A236, Grade F	double normalized and tempered; shall be used in high duty service equipment
Alloy Steel Forgings	ASTM A238, Grade F	normalized, quenched and tempered; shall be used in special heavy duty service equipment
6. Steel Bolts		
Carbon Steel Bolts or High Strength Structural Belts	ASTM A325	shall be used for structural joints
Alloy Steel Bolts	ASTM A354, Grade BD or ASTM A490	shall be used for high strength structural steel joints
7. Rivet Steel	ASTM A572 or A31	shall be used for riveted construction and pressure vessels

17.2.2 Aluminum. All aluminum materials and workmanship shall conform to, and shall be designated according to the requirements of the Aluminum Industry Association.

The forming of aluminum parts, their joining by bolting, riveting and welding, and the protection of contact surfaces shall conform to the requirements of the Aluminum Company of America's "Specification Covering Use of Aluminum in Passenger-Carrying Railway Vehicles."

Aluminum alloy castings shall conform to the requirements of ASTM B26, B108 and B85 and shall be tempers 354-T5, 6061-T6, 356-T6, A356-T6. Aluminum alloy forgings shall conform to the requirements of ASTM B247 and shall use 6061-T6 alloy. Aluminum alloy extrusions shall be 6063-T5, 6061-T6 or 5083-H111. Sheet and plate aluminum alloy shall be 5083-H321, 5052-H32 or H34, 5005-H34, 3003-H14 or 6061-T6.

17.2.3 Fasteners. All mechanical fasteners shall conform to ANSI standards, unless otherwise indicated or approved. All fasteners shall be stainless steel, or chromium, galvanized or cadmium-plated steel, or zinc plated steel per Fed. Spec. QQ-Z-325 depending on specific application. Cadmium plating shall conform to ASTM A165, Type NS. Chromium plating shall be according to ASTM A166, Type DC. Galvanizing shall be hot-dip with a minimum thickness of 0.025 mm (0.001 in) purest quality zinc. Fasteners shall be of the

mechanical or threaded type. All threaded fasteners shall conform to ANSI class 2 requirements, unless otherwise indicated. All threaded fasteners shall be self-locking or provided with locking devices. Locking devices shall be either lockwire, lockwashers or locknuts as appropriate for the desired function or service. Lockwire, if used, shall be stainless steel. Lockwashers smaller than 2 mm (0.075 in) shall be commercial standard, and those 2 mm (0.075 in) and longer shall conform to Military Std Part MS35340. Locknuts shall be of the nylon collar insert type or deformed type. The bolt shall have chamfered ends and at least 1½ threads shall project through the nylon locking collar or outer interference thread. Bolts for use with locknuts shall not be heated or drilled for cotter pins. All locknuts shall comply with the Industrial Institute requirements with regard to locking ability.

17.2.3.1 Bolts and Nuts. Steel bolts shall conform to the requirements of ASTM A325 or A490, as applicable. Nuts shall meet the requirements of ASTM A194, A325 or A563, as applicable. All steel screws, bolts, and nuts shall be cadmium plated, or zinc plated with a chromate treatment, except for stainless-to-stainless joints where stainless steel bolts and nuts shall be used.

17.2.3.2 Rivets. Aluminum alloy rivets shall conform to 6061-T6 or 6053-T61. Steel rivets shall conform to ASTM A572.

17.3 Non-Metals

In addition to the following requirements for non-metals, all combustible materials used in vehicle fabrication shall satisfy the flammability and smoke emission requirements cited in Paragraph 17.3.6.

17.3.1 Elastomers. Elastomeric parts may include door and window seals, glazing strips, truck bumpers and snubbers, structural and compressible gaskets, and mounting pads. All parts shall be composed from neoprene or other suitable elastomers compounded and cured to perform satisfactorily under the environmental conditions in which the car may be operated.

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

Physical Property	Test Method	Performance Requirement Value
Hardness, durometer A	ASTM D2240	45 to 75
Ultimate Elongation	ASTM D412	300%, minimum
Tensile Strength	ASTM D412	10.3×10^6 Pa (1,500 psi) minimum
Tear Resistance	ASTM D624	35,000 N/m (200 lb/in) minimum
Brittleness Temperature	ASTM D746	-40° C (-40° F)

Physical Property	Test Method	Performance Requirement Value
Resistance to oil aging	ASTM D471	+80% change in volume, maximum
Resistance to heat aging:	ASTM D573	
- Max. change in elongation		-40%
- Max. change in tensile strength		-15%
- Max. change in hardness, durometer A		-5 to +15
Ozone resistance	ASTM D1149	No cracks
Resistance to permanent set	ASTM D395 (Method B)	25% compression set, maximum

17.3.2 Resilient Foam. All foam materials shall be graded and labeled in accordance with the requirements indicated and in standard with the recognized industry associations or underwriters. Molded material shall have a high resistance to flexing, tearing, wetting and exposure to flame. Dimensions of latex foam rubber products shall conform to the requirements of ASTM D1055.

17.3.3 Glass. Laminated safety sheet glass shall be used exclusively and shall be made up of two layers of glass laminated to a center sheet of plasticized polyvinyl-butyral resin of not less than 1.1 mm (0.045 in) thickness. There shall be no remarkable variations in color in the individual sheets of laminated plate or sheet glass when examined over a white background.

Edges of the glass shall be smooth cut after fabrication. Any overlap of one sheet of glass with respect to the other at an edge shall not exceed 0.8 mm (1/32 in). The overall dimensions of individual sheets as supplied shall be held within 1.6 mm (1/16 in) of the dimensions ordered, and its thickness tolerance shall not exceed 0.8 mm (1/32 in).

Laminated glass materials used in manufacturing windshields, car side windows and car interior windows, including cab door window shall be designed to meet the requirements of the following sections of ANSI Z26.1:

Test as per ANSI Z26.1	Windshields	Car side Windows	Car Interior Windows
Light Stability	X	X	X
Luminous Transmittance	X	X	X
Humidity Test	X	X	X
Boil Test	X	X	X
Impact, Dart, 30 ft (9.14 m)	X	X	X
Impact, Ball, 30 ft 9.14 m)	X	X	X
Abrasion Resistance	X	X	X
Deviation & Distortion	X		
Penetration Resistance	X		

Impact tests shall be in accordance with those prescribed for "passenger cars" in Federal Register, Vol. 44, No. 251, Part 223, Appendix A.

17.3.4 Plastic Sheets and Laminates. Plastic sheets and laminates used in the fabrication of the vehicle shall be of the highest quality and shall meet the flammability and smoke emission requirements set forth in Paragraph 17.3.6.

17.3.4.1 Fiberglass - Reinforced Plastics. Fiberglass reinforced plastic used in fabrication of car structural members shall be a laminated polymeric reinforced material having the following composition: Fiberglass reinforcement shall be mat, fabric, woven roving, continuous roving, chopped-strand preforms, swirl mat or chopped-spun roving, as required to meet the physical and process requirements indicated. The glass content shall be 30 to 40% by weight, except as otherwise approved. Resins shall be of good commercial grade, selected to meet the physical requirements indicated. Resins shall be pigmented to match the colors indicated. Gelcoats shall be resistant to scuffing, weather, perspiration, and cleaning agents. Gelcoats shall be pigmented to match the colors indicated. The minimum thickness of gelcoat shall be 0.38 mm (0.015 in) 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, inhibitors, pigments, and flame-proofing materials shall be added to the resin mixes as required to obtain finished products with the characteristics indicated. The method of producing fiberglass reinforced plastics shall be such that glass fiber reinforcement is distributed throughout the final product in such a manner to avoid resin-rich sections. Reinforced plastic parts shall be thicker at attachment joints and edges, as required. No exposed sharp edges on parts shall be allowed. Plastic laminates which are to be painted shall be sanded and filled before the prime and finish coats are applied. Finished surfaces shall be uniform, smooth, and free of porosity and crazing.

When tested in accordance with the relevant specification, the fiberglass reinforced plastic shall have the following minimum properties:

Physical Property	Test Method	Minimum Performance Requirement Value
Thickness	None	3.2 mm (1/8 in)
Compressive Strength	ASTM D695	138 X 10^6 Pa (20,000 psi)
Tensile Strength	ASTM D638	97 X 10^6 Pa (14,000 psi)
Flexural Strength	ASTM D790	159 X 10^6 Pa (23,000 psi)
Impact Strength (notched)	ASTM D256	5.3 N-m/cm (10 ft-lb/in)
Hardness	None	45 Barcol
Heat Resistance	None	79° C (175°F) continuous

Fiberglass used in the manufacture of such non-structural products as passenger seats shall meet the following requirements. The composition of weight shall be as follows: polyester resin (45% minimum), glass fibers (25% minimum), and fillers (30% minimum). When tested in accordance with the applicable specifications, the fiberglass shall have the following properties:

Physical Property	Test Method	Minimum Performance Requirement Value
Tensile Strength	ASTM D638	69×10^6 Pa min (10.0×10^3 psi minimum)
Flexural Modulus	ASTM D790	69×10^8 Pa min (1.0×10^6 psi minimum)
Flexural Strength	ASTM D790	138×10^6 Pa min (20.0×10^3 psi minimum)
Moisture Absorption	ASTM D570	0.5% (maximum)
Impact Strength (unnotched)	ASTM D256	(15.1 lbs/in minimum)
Hardness	-	50 Barcol
Specific Gravity	-	1.75-1.90

17.3.4.2 Thermoplastic. Thermoplastic material shall have the following properties when tested in accordance with the applicable specification.

Physical Property	Test Method	Performance Requirement
Tensile strength at 23°C (73° F)	ASTM D638	38×10^6 Pa (5,500 psi), minimum
Specific Gravity	ASTM D792	1.33 to 1.36
Flexural Modulus of Elasticity at 23°C (73° F)	ASTM D790	$2,240 \times 10^6$ Pa (325,000 psi), minimum
Flammability	ASTM E162	Flame Spread Index, Is = 35 (maximum)
Thickness	None	3.2 mm (1/8 in)

Physical Property	Test Method	Performance Requirement
Shrinkage after heating for 10 minutes at 193° C (380° F)	-	15%, maximum
Impact Strength (notched)	ASTM D256	4.2 Nm/cm (8 ft-lb/in) of notch

17.3.4.3 High-Pressure Laminated Melamine Plastic. High-pressure laminated melamine plastic shall be two-ply laminated material consisting of a hard plastic film facing permanently bonded to a base sheet. The laminated melamine plastic shall conform to the flammability requirements of ASTM E162.

17.3.5 Marking Films. All marking film material shall satisfy the requirements of MIL-M-43471, Type II. Application techniques shall be in accordance with the manufacturer's recommendations. The processed film shall be sufficiently opaque so that when applied, it shall completely hide a contrasting black printed legend and white surface. When tested in accordance with ASTM D523, the processed film shall have an initial 60° gloss value of 40. The adhesive shall form a durable bond to clean, smooth, corrosion and weather resistant surfaces to which they are applied. They shall possess uniform thickness, be non-corrosive to applied surfaces, and shall have no staining effect on the film. Film markings shall withstand immersion in either SAE No. 20 or distilled water for 24 hours at a temperature of 21 to 32° C (70 to 90° F), without any significant deterioration in adhesion, color or general appearance. The adhesive properties of the film shall be retained after one week of continuous exposure to a temperature of 66° C (150° F).

17.3.6 Flammability and Smoke Emission Requirements. All combustible materials used in vehicle fabrication shall satisfy the flammability and smoke emission requirements cited in this section.

17.3.6.1 Material Requirements. When tested in accordance with the various specifications shown hereunder, the materials shall exhibit the indicated properties.

CATEGORY	MATERIAL APPLICATION	FIRE TEST	MAXIMUM TEST LIMITS
Seating	Cushion[1; 2]	ASTM D-3675 NFPA 258	Is ≤ 25 $D_s(4.0) \leq 250$; $D_m \leq 300$
	Frame[1]	ASTM B-162 NFPA 258	Is ≤ 35 $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Shroud[1]	ASTM E-162 NFPA 258	Is ≤ 35 $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Upholstery[1; 2; 3]	FAA 25.853 NFPA 258	Flame Time ≤ 10 sec; burn length ≤ 6 inch $D_s(4.0) \leq 250$ coated $D_s(4.0) \leq 100$ uncoated; $D_m \leq 300$
Panels	Wall[1]	ASTM E-162 NFPA 258	Is ≤ 35 $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Ceiling[1]	ASTM E-162 NFPA 258	Is ≤ 35 $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Partition[1]	ASTM E-162 NFPA 258	Is ≤ 35 $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Windscreen[1]	ASTM E-162 NFPA 258	Is ≤ 35 $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	HVAC Ducting[1]	ASTM E-162 NFPA 258	Is ≤ 35 $D_s(4.0) \leq 100$; $D_m \leq 300$
	Window[4]	ASTM E-162 NFPA 258	Is ≤ 100 $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$

CATEGORY	MATERIAL APPLICATION	FIRE TEST	MAXIMUM TEST LIMITS
	Light Diffuser	ASTM E-162 NFPA 258	$I_s \leq 100$ $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
Flooring	Structural	ASTM E-119	Pass
	Covering	NFPA 253	C.R.F. $\leq 0.5 w/cm^2$
Insulation	Thermal[1; 2]	ASTM E-162 NFPA 258	$I_s \leq 25$ $D_s(4.0) \leq 100$; $D_m \leq 300$
	Acoustic[1; 2]	ASTM E-162 NFPA 258	$I_s \leq 25$ $D_s(4.0) \leq 100$; $D_m \leq 300$
	Elastomers[1]	ASTM C-542	Pass
Miscellaneous	Exterior Shell[1]	ASTM E-162 NFPA 258	$I_s \leq 35$ $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Component Box[1] Covers[1]	ASTM E-162 NFPA 258	$I_s \leq 35$ $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$

NOTES:

1. Materials tested for surface flammability shall not exhibit any flaming, dripping or flaming running.

2. The surface flammability and smoke characteristics shall be demonstrated to be permanent by washing, if appropriate, according to Federal Test Method 191 method 5830.

3. Same as footnote 2, above except that flammability and smoke characteristics shall be demonstrated by dry cleaning, if appropriate, according to AATCC-86.

4. For double window glazing, the interior glazing shall meet the materials requirements specified herein.

5. The provisions for these fire tests are discussed in the next section.

6. The specific optical density (D_s) is expressed in minutes (e.g., $D_s(4.0)$ 200 = optical density at 4 minutes is equal to or less than 200.

17.3.6.2 Fire Test Provisions. The above fire tests shall be made in accordance with the following provisions.

For all materials, except flooring and elastomers, maximum test limits shown in the table for smoke generation in accordance with NFPA 258 apply in either flaming or non-flaming modes, whichever is greater.

For upholstery, materials of the same lot shall be tested for vertical flame resistance, in accordance with FAR 25.853, with a minimum of five specimens from each of the warp and fill directions and their results averaged (arithmetic mean). Materials that cannot be washed or dry cleaned must be so labeled and meet the applicable requirements after having been cleaned as recommeded by the manufacturer.

Structural flooring assemblies shall meet the requirements in the table during a nominal or minimum test period, whichever is greater. The nominal test period shall be twice the maximum expected period of time, under normal circumstances, for a vehicle to come to a complete, safe stop from maximum speed, plus the time necessary to evacuate all passengers from a vehicle to a safe area. The minimum test period shall be 15 minutes.

Floor coverings shall be tested in accordance with NFPA-253 with its padding, if used in actual installation.

Thermal and acoustic insulation materials shall be tested for surface flammability, as specified in the table, using wire mesh screening (as per section 5.92 of ASTM E-162).

17.3.6.3 Electrical Insulation. Selection criteria and specifications for electrical insulation are contained in the following report:

UMTA-MA-06-0025-79-1, "Flammability Tests", December, 1978.

Specifically, the following tests shall be used:

1. Vertical Flammability Test for Wire Sizes 20 AWG - 4 AWG, Section 4.1.5.1, with Pass/Fail Criterion Section 4.1.6.1;

2. Vertical Flammability Test for Wire Sizes Larger than 4 AWG, Section 4.1.5.2, with Pass/Fail Criterian Section 4.1.6.1;

3. Horizontal Flammability Test, Section 4.1.5.3 with Pass/Fail Criterion Section 4.1.6.2;

4. Smoke Emission Test, Section 4.2.5 with Pass/Fail Criterion that heavy insulations which smoke as heavy or worse than PVC and chlorinated sulfonated polyethylene shall not be used.

As a guideline for further consideration of the selection of electrical wire insulation the following report shall be used: UMTA-MA-06-0025-79-2; "Toxicity", December, 1978.

17.3.7 Plywood. Plywood subject to moisture exposure shall be isolated from contact with aluminum by not less than two coats of an aluminum paint formulated for application to wood. All plywood shall conform to the flammability and smoke emission requirements identified in Paragraph 17.3.6. Treated plywood shall be primed or sealed as soon as possible after fabrication and shall be stored under cover. Metal-faced plywood core panels (plymetal) shall conform to the requirements of MIL-P-8053C. Honeycomb core panels shall satisfy the requirements of MIL-C-7438D, MIL-H-21040A and MIL-A-9067C.

17.4 Welding and Brazing

17.4.1 Welding. All welding, unless otherwise specified, shall be in accordance with the requirements of the applicable American Welding Society (AWS) specifications or other approved specifications. All welders shall have been tested to determine their ability to operate the welding equipment to be used in making the required welds and to produce satisfactory welds. The owner shall have the right to require the making of test welds by any operator to ascertain his competence and to determine the suitability of the welding procedure used.

17.4.1.1 Welding Materials. The choice of welding rod or wire filler metal shall be made with adequate consideration of the make, type, size, composition, and suitability to the application and shall be in accordance with Chapter 94 of the AWS Welding Handbook. Welding electrodes for steel, for manual shielded metal-arc welding, shall conform to applicable AWS standards or the E60 or E70 series. Bare electrodes and granular flux used in the submerged-arc or gas metal arc process shall conform to the provisions of AISC Section 1.17.3. The welding materials for stainless steel shall conform to the provisions and recommendations of Section IX of the lasted edition of the ASME Boiler and Pressure Vessel Code.

17.4.1.2 Welding Procedures. Welding procedures covering all types of welding shall be followed by the Contractor. Before welding of any sort is started, parts to be joined shall be properly cleaned. Corrosion, rust, oil, water and other foreign material shall be removed by an approved process or method. All parts to be joined by welding shall be adequately supported throughout the welding operation to ensure minimal distortion. The method used in depositing weld metal shall be chosen such that warping and locked up stresses shall be reduced. To achieve this, tack welding, offset welding, skip welding and other devices and sequences well known in the art shall be used where appropriate. A stress relieving process suitable for the type of material shall be employed to remove any locked up stresses. The weld metal shall be made to penetrate into the bottoms of angles and vees and complete fusion at these points shall be ensured.

Fillet welds shall be extended around the ends of members wherever practicable. Manual welds which have a thickness greater than ¼" shall be made with at least two beads. Machine welds of any thickness may be made with one or more beads as approved by the Purchaser. In any

welding operation, the scale shall be completely cleaned off the underlying bead and surrounding metal before the next bead is applied. All grinding of welds shall be performed in the direction of the weld. All welding shall be such that complete and adequate fusion with the base material is achieved throughout the weld.

Resistance welding operations shall be undertaken only with equipment fitted with time, current, and pressure control. Accurate control of cleanliness, time, current, electrode size and shape, and pressure required to produce welds of specified strength shall be maintained. The Contractor shall determine experimentally or otherwise, the proper setting of the controls and shall provide against unauthorized changes. Similarly, the shape, size, and surface conditions of electrodes required to give satisfactory welding and acceptable finish shall be determined and a complete record made thereof. Sample welds shall be subject to Purchaser's approval and shall be made and tested by either the shear-strength or the tear-test method and complete records of the test results shall be maintained by the Contractor. All surface marks resulting from welding shall be treated in order to eliminate any visible defects in the finished surface.

17.4.2 Brazing. All brazing shall be in accordance with the requirements and recommendations of the American Welding Society as specified in the AWS Welding and Brazing Handbook. The Contractor shall maintain quality-control procedures necessary to ensure high quality brazing.

17.5 Paint and Painting

All interior and exterior surfaces of the car body as required shall be painted in accordance with Purchaser's instructions as to color scheme, stripping, and lettering using products supplied or recommended by a paint manufacturer approved by the Purchaser. The surfaces to be painted shall be free of rust, scale, grease, and other foreign material just before the application of the primer or finish coat. All body dents, roughness, or other surface imperfections shall be made good prior to application of the first priming coat.

All paint shall be mixed, thinned, or otherwise prepared for application in accordance with the paint manufacturer's recommendations. Thinning materials or paint additives shall be those recommended or approved by the paint manufacturer.

Painting materials shall be either brushed or sprayed as recommended by the paint manufacturer. There shall be uniform application of each coat over all surfaces to be painted, such that a neat appearance free from runs, sags, 'orange peel', or other application defects shall be achieved. When aluminum is to be painted for decorative purposes, it shall be free from grease or soil and primed with a conversion coating or a wash primer. Top coatings must not contain lead, mercury or copper. All painted surfaces which become scratched or damaged during shipment, storage, handling or installation shall receive touch-up paint as required to present a satisfactory appearance. Touch-up paint shall be identical in all respects to original paint.

17.6 Bearings and Lubrication

All rotary shafts shall be supported by cylindrical or tapered roller bearings where practicable. As an option, ball bearings may be used, subject to the Purchaser's approval. All bearings vulnerable to airborne and liquid contamination shall be sealed. Standard grease fittings or plugs shall be provided for all bearings not internally splash or bath lubricated. Subject to Purchaser's approval, ball-bearings of one-inch shaft size and smaller may be factory "lubricated for life". Bearings shall be installed and removed without major disassembly of related components, and in no case shall thrust be carried across the rolling elements in pressing a bearing into its seat. Bearings and lubricants shall perform satisfactorily within their operating environment.

If space limitations preclude the use of anti-friction bearings, sleeve bearings shall be used to support rotary shafts. Sleeve bearings and bushings shall be assured full fluid film lubrication by oil bath, wick, drip oiler, or other Purchaser-approved methods. Self-lubricated (sintered metal) shall not be used for shafts with speeds greater than 500 rpm. Sleeve bearings supporting ferrous shafts shall be composed of bronze, brass, or aluminum alloys as approved by the Purchaser.

All lubricants shall be products approved by the manufacturer of the parts concerned and shall conform to the applicable ANSI specifications. Multi-purpose lubricants shall be used where possible.

17.7 Protection of Metals

All metals to be used in the fabrication process shall be surface treated with due consideration for the severity of exposure to which the surface is subjected. The joining of incompatible metals and materials shall be minimized as much as possible and where unavoidable, adequate care shall be taken to prevent any chemical interaction between the materials.

Following fabrications, all low-alloy steel areas shall be painted with one coat of an approved primer followed by one coat of approved sealer to prevent rusting. Exterior steel surfaces, including roof, underframe, underside of flooring, and equipment shall receive a minimum of two coats of primer. Exterior surfaces, except the underframe and underside of flooring, shall then be given a coat of surfacer and a minimum of two coats of synthetic enamel.

Areas exposed to corrosive substances or fluids shall be protected with coatings resistant to those substances or fluids.

All ferrous metal, unless specified elsewhere to be protected by other methods, or as not requiring protection, shall be galvanized by the appropriate methods in accordance with the requirements of ASTM A123 or ASTM A386. Minor damage to galvanized coatings shall be repaired in accordance with MIL-P-21035.

Except as otherwise indicated, all aluminum exposed to view in the finished work on the interior of the car body, shall have a protective anodic coating.

17.8 Piping and Pressure Vessels

All piping and pressure vessels shall be of high quality. Piping may be seamless copper, stainless steel or precision steel. Piping, valves, fittings, installation methods, and testing shall be in accordance with ANSI B31.1. Running joints must not be used; unavoidable joints in pipes shall be made in an approved manner. Joints shall be located where they can be easily accessible. Pipes must be adequately supported throughout their length and at connections, and must not interfere with the removal of other components. Copper tubes or pipes shall not be in contact with aluminum parts.

17.9 Thermal and Acoustic Insulation

Thermal insulation materials of the rigid, non-rigid, or spray-on type shall be used. The materials shall not absorb fluids and gases, and shall possess the required properties to meet the noise, vibration and heat loss limits recommended. Installation of insulating materials shall be done in accordance with the manufacturer's recommendations. Thermal insulating material shall have a thermal conductivity of not greater than 13,000 J/hr-m^2-C^o/cm (0.25 Btu/hr-ft^2-F^o/in) when tested in accordance with ASTM C177.

Sound damping material used in fabrication of the car shall be resistant to dilute acids, greases, gasolines, aliphatic oils and vermin, and must not support combustion. It shall not be affected by sunlight and ozone, and shall not become brittle with age. Application of this damping compound shall be in accordance with the manufacturer's recommendations.

17.10 Wiring

17.10.1 General. The following standards shall apply to all wiring, including that within enclosures supplied by others.

All car and control circuit wiring shall be at least equal to that specified in the latest revision of the National Fire Protection Association's National Electric Code (NFPA 70), Table 310-16 and Note 8.

Wiring insulation shall meet the requirements of paragraph 17.3.6.3.

When measured individually either with a 500 volt Megohmeter, a resistance bridge instrument or the voltmeter-ammeter method, insulation resistance to ground of all wiring shall be:

a) 10 megohms minimum for nominal low voltage dc control and for wire normally operating between nominal low voltage dc and nominal primary line voltage; and

b) 2 megohms minimum for wire normally operating above nominal primary voltage.

The layout of wiring shall be designed in advance of its installation and in cooperation with those furnishing the related equipment. Insofar as it is practical, all wiring shall be fabricated on the bench into convenient units and installed in prefabricated groupings and standardized locations.

All car wiring connected to a given piece of electrical apparatus shall be insulated for the highest voltage so connected.

Wires connected to transient-generating apparatus, such as unsuppressed contactor coils, shall not create electrical interference in other circuits.

Wires operating with potential differences of 50 volts or more shall not be cabled together.

Wiring for any communications and cab signal (if used) shall be done in an approved manner to conform with the requirements established by the Manufacturer of such equipment.

All circuits and branches must be separable to isolate them when searching for grounds. Therefore, soldered connections are not acceptable. All circuits subject to annual high potential test shall be so arranged that they can be conveniently set up for said test.

17.10.2 General Purpose Cable and Wire. Except for high temperature, public address and intercom applications, all circuits of the car wiring installation shall be connected using general purpose cable. Primary power circuits shall use wire rated at 1,500 Vdc minimum. All other circuits shall use wire rated at 600 Vac minimum.

Conductors shall be annealed tinned copper wire meeting the requirements of ASTM B33. The conductors shall have a minimum stranding conforming to ASTM B172 Class K, for AWG 4/0 to AWG 8, ANSI C7.14 Class K for AWG 10 to AWG 22 and Class L for AWG 24.

Minimum wire size, as related to control and auxiliary circuits, shall not be reduced such that vibration or other causes could produce destruction.

In general, wires for control and auxiliary circuits shall not be smaller than No. 12 AWG, except within equipment enclosures and for special apparatus where special types of wire are recommended for use by the Manufacturers and approved by the Purchaser for inter-connection of the various pieces of equipment.

No. 14 AWG wire, with an approved insulation, may be used for interconnection of cab signal (if used).

When bundled, No. 16 AWG wire may be used in circuits where the current is low and physical strength is not necessary.

The stranding and nominal O.D. of flexible cables shall be as required for IPCEA Class H.

17.10.3 High-Temperature Wire and Cable. At locations subjected to high temperature, all wire and cable shall be insulated and jacketed with asbestos of silicone rubber. This type of wire shall not be bundled together or run with any other type of cable. Conductor material shall be tinned copper wire. Class K stranding shall be used for sizes No. 20 AWG to No. 10 AWG, and Class H shall be used for larger sizes.

Asbestos wire and cable, which is preferred for heating circuits, shall be constructed and tested in accordance with IPCEA 28. The type used shall be rated for maximum conductor temperature of 110°C.

Silicone wire shall be rated for maximum conductor temperature of 110°C.

17.10.4 Communication Wire and Cable. Communication wire and cable shall consist of twisted pairs of not less than No. 16 AWG soft annealed, tinned copper. Each twisted pair shall be shielded with a woven wire sheild providing not less than 85% coverage. Shield wire shall be soft annealed, tinned copper.

17.10.5 Conduit and Raceways. All car wiring shall be housed in metal or approved plastic raceways. All plastic materials shall satisfy the flammability and smoke emission requirements indicated in Paragraph 17.3.6. Open metal raceways and their elbows, couplings, nipples, bushings, locknuts, universal joints, expansion joints, and other conduit fittings shall be designed that the sections can be mechanically and electrically coupled while protecting the wires from abrasion.

Wire in conduit, ducts and raceways shall be free of kinks, insulation abrasions and insulation skinning. Except in most unusual cases, and then only when approved by the Purchaser, no conduit, duct or raceway shall contain more wires than will give a maximum of 40% fill.

Wire shall be bundles if in a conduit, duct or raceway. Each wire must be capable of being removed for replacement without disturbing other wiring in the enclosure. Where wire is in open areas, bundling shall be permitted - wire removal capability (damage wire) shall be the criterion.

Pulling compound, if used, shall be non-conductive, non-hydroscopic, non-odorus, and shall not attract vermin.

Flexible conduit shall be aluminum or steel alloy tubing with watertight compression fittings or approved equal. Both inside and outside surfaces shall be protected against corrosion. The flexible metal conduit shall conform to the requirements of UL-1.

Electrical metallic tubing shall be fabricated from high-strength aluminum or steel and shall conform to the requirements of ANSI C80.3. Their interior surfaces shall be smooth and free from injurious defects. Fittings for EMT shall be corrosion-protected metal and shall conform to the requirements of UL-797.

Rigid aluminum conduit shall consist of seamless, rigid, aluminum alloy conforming to ANSI C80.5. Rigid steel conduit shall be mild steel and shall satisfy the requirements of ANSI C80.1.

Conduit, if required in the truck area and approved by the Purchaser, shall be standard weight galvanized steel with threaded fittings. All covers shall be gasketed, using approved materials. Interiors of junction boxes shall be suitably protected by insulating paint against condensation and corrosion. When more than one supplier is used, all fittings which require covers and are of the same size shall be supplied by the same manufacturer.

17.10.6 Junction Boxes. Pullboxes, outlet and junction boxes shall be provided specifically for application with the conduit and cable systems with which they are to be used. Boxes, covers, and fittings of ferrous metal shall be galvanised inside and outside after fabrication.

Exposed exterior boxes shall protect enclosed equipment against splashing water, water seepage, and falling or hose-directed water normally encountered in vehicle operations. Boxes shall be of sufficient size to provide free space for conductors in accordance with NFPA Code 70.

17.10.7 Splicing, Taping & Soldering. Splicing and taping will not be acceptable except in unusual cases where it is unavoidable and then normally only under a controlled process, such as with approved solderless connectors, and only with the approval of the Purchaser.

17.10.8 Terminals. Conductors shall be terminated by mechanical means, using solderless terminals, of the ring type, "Weidmuller" type with crimp-on ferrule or approved equal. Soldered terminals shall not be used, except in specific cases and only when approved by the Purchaser. Multipin Connectors, MIL-C-5015 environmentally protected, or equal, may be used for low voltage dc circuits. Conductors shall be attached to the terminals according to the method prescribed by the terminal Manufacturer. No more than two conductors shall be attached to a single terminal point.

Terminals used on conductors sized No. 10 AWG or smaller shall be of the insulating type and designed to securely grip and hold the insulation on the conductor.

Conductors subject to motion relative to the terminal shall be protected by proper means to eliminate fracture of the conductor at or near the terminal.

17.10.9 Undercar Wiring. All undercar wiring of No. 8 AWG or smaller shall be run in an approved manner in plastic coated metal raceways and wire ducts with removable metal covers of adequate size and approved design, and securely fastened - but easily removable when necessary. The enclosures shall - to prevent vibration, rattling or drumming - be securely anchored in an approved manner. On leaving such enclosures to enter other equipment, this wiring shall be routed so as to obtain maximum protection. Additional protection in the form of added insulation shall be used in the exposed areas.

When of adequate physical strength, No. 6 AWG or larger wires may be supported in place at frequent intervals without using any type of enclosure, by using molded rubber cable support blocks. Openings of which are contoured to the shape of the cable, and provided that strain relief bushings are used at locations where entering or leaving enclosures. Box connectors shall be the insulated throat type and strain relief bushings shall be provided with non-metallic end bushings.

When approved by the Manufacturer of the signal equipment, if such is used, the Contractor may install signal wiring in common ducts with other wiring at battery potential, provided that approved type separators are used to isolate the signal circuit wiring.

Lead wires to electrical components shall be carried in a wire duct or conduit to a point as close to the compartment as possible. The length of the leads between the end of the duct or conduit to each compartment shall be as approved by the Purchaser.

Wires or cables shall not pass over or through the battery compartment, or, if in conduit or ducts, over the main motor resistors.

Wiring run through the floor must be run in conduit or ducts and may not be run through partitions without suitable bushings being provided at such points of passage.

In no case shall wires or cables carrying primary line voltage be tied to or directly supported by conductive members at ground potential. The wires or cables shall be securely anchored in an approved manner and shall be covered at the point or points of contact with an approved insulating material.

All wires and cables shall have sufficient slack to prevent breaking or pulling out of bushings or terminals, and a service-ability loop for three reworks of end of wire or cable. Drip loops shall be provided.

All wiring shall be installed in an approved manner to prevent chafing with each other, between wire and interior surfaces of, and adjacent components in compartments, or against any metallic parts.

######Option 2 (Articulation) - Electrical connections between "A" and "B" and Articulation Body Sections shall be carried in body-mounted devices. Multi-conductor cables shall be used across the Articulation Section and connections on either side shall be by means of wiring on terminal blocks, except that connectors shall be used for low voltage dc wiring. Such devices shall be MIL-C-5015 Environmentally Protected Connectors or approved equal. Sufficient conductors, plus eight spare circuits of which four shall be shielded, shall be provided to make all of the necessary electrical connections between the body sections.######

17.10.10 Grounding. This section specifies the requirements for grounding protection. The carbody shall not be used to carry current for either the negative return of primary power or negative return of low voltage dc. Carbody and equipment grounding shall not be designed to normally carry current and shall be totally separate from negative power returns except at the Ground Brushes (reference Paragraph 10.6.8). A differential current sensing means shall be used to remove power from the car in the event of a primary power ground fault.

A grounding strap shall bond each truck frame to the carbody. Grounding straps shall also bond all sections of the carbody which might become isolated. When installed, all electrical and electronic unit metal enclosures shall provide a low impedance path from the equipment enclosure to the car structure. The bonding method shall produce a dc resistance of not greater than 0.0025 ohms from the enclosure to the structure, and a minimal ac impedance of less than 0.025 ohms at 150 kHz or of a comparable level at higher frequencies.

The preferred bonding method shall be direct bonding of the equipment enclosure to a carbody frame member by metal-to-metal contact between the two surfaces. Where direct bonding is not feasible, conductors of sufficient cross-sectional area to carry lightning discharge current or fault current of the equipment shall be used and shall limit the voltage drop across the bond to 25 Vdc.

Truck-mounted components shall be bonded to the truck frame. In addition, the traction motor frame shall be bonded directly to the ground brush. Ground brushes, as specified in Paragraph 10.6.8, shall be provided between the truck frame and each axle to provide an electrical path through the wheel rims to the running rails.

Negative returns for all primary powered equipment shall be segregated from all other grounding connections. These circuits shall be installed between the ungrounded terminals of the equipment and a suitable grounding plate on a carbody frame member. The grounding plate shall be isolated from the carbody and shall pass the Isolation Resistance Test (IEEE STD 32-1972). A grounding strap with ample capacity for the service intended shall bond the grounding plate to a truck frame. The maximum dc contact impedance in traction circuit grounds and other intentional circuit grounds shall not exceed 0.0005 ohms.

All load circuits connected to the low voltage dc (LVDC) bus shall be two-wire, with separate negative return to a common ground. The LVDC negative return shall be grounded to the carbody at the battery by means of a single removable ground strap through which no intentional current shall flow. The LVDC common ground shall be isolated from the carbody and shall pass the Isolation Resistance Test (IEEE STD 32-1972). Connections shall be made to the LVDC common ground in the low voltage breaker panel (see Paragraph 9.5.3). These connections shall be in close proximity to their associated circuit breakers.

######Option 3.2 (Train Operation) - The propulsion and braking trainlines shall have their negative return through a return trainline which shall be connected directly to battery negative at the operating cab through the Reverser Switch circuitry. All other trainline circuits shall be returned directly to battery negative on the local car.

Wire shields used in trainline circuits shall be connected through the car coupler contacts. The wire shields shall be carried through all applicable connectors and junction boxes. Circuits shall be categorized. Shields contained in one circuit category shall not be interconnected with shields contained in another category. Shields on low-level signal leads shall not be interconnected with shields on high-level signal leads in the same category. Each group of shields shall be carried through on a connector pin or pins, or on terminal strips which shall be in the immediate proximity of the categorized group of circuits. Loops due to interconnections of shields shall not be permitted.######

17.10.10.1. Suppression or Protection. All circuits requiring wire shielding shall have the shield terminated as specified in this subsection.

Shields used to suppress the electrical field at frequencies below 150 kHz audio frequency (AF) shall be terminated only at the low potential side of the interference circuit at the termination which exhibits maximum susceptibility.

Shields used to protect against the effect, or to exclude electrostatic voltages at frequencies below 150 kHz, shall be terminated to either the low potential side or at the balance point of the protected circuit at the termination which exhibits maximum susceptibility.

Shields used to suppress or protect against electric fields above 5 kHz shall be terminated at both ends of the low potential or balance points.

Cable shields used to exclude electromagnetic interference (EMI) at frequencies of 150 kHz and above shall be grounded to the car structure at more than one point. These shields shall be connected at the equipment cases at each end of connectors, as a minimum, and at 900 mm (3 ft) intervals, as a design goal, and shall not be carried through connectors by isolated means. The type and quality of the shields (single braid, double braid, or solid sheath) shall be determined by the attenuation requirements.

17.10.10.2 Double Shields. Cables requiring both audio frequency (AF) and radio frequency (RF) shields shall be electrically isolated from each other. The resistance between these circuits shall be at least 500 megohms when 500 Vdc is applied. Double shielding shall be required on circuits that are both AF-susceptible and RF-susceptible.

Coaxial cables used as constant impedance transmission lines shall be terminated as dictated by the circuit termination design and shall not be considered to be shielded conductors. Triaxial cables may be used as coaxial constant impedance transmission lines with the outer conductor employed as an RF shield.

17.10.10.3 Passenger and Operating Personnel Safety. The Contractor shall ensure that all metal parts inside and outside the car, including equipment boxes, panels, and test receptacles in the passenger or operator areas, and which could be contacted by passengers or operating personnel, shall never exceed carbody potential.

17.10.11 Wire & Terminal Marking. All electrical conductors, whether individual wires or cables, shall be assigned circuit designations for the entire car. The system of designating wires and circuits shall be the prerogative of the Purchaser ******who shall acquaint the Contractor of this system in the bid document prior to any wiring, including the layout on the bench.******

The individual conductors within any cable shall be appropriately color-coded and full reference to these color codes shall be included on all documents relating to the cables. The Contractor shall insure that his own forces and his suppliers adhere to the same method of marking and color-coding and that all designations are consistent across all appara-

tus inter-connections whether or not from the same suppliers. Where this is impractical, a decal shall be provided indicating the terminal and wire numbers at that terminal board.

Markings shall be placed at close intervals for a distance of eighteen inches at the terminal ends of all individual wires and cables and at intervals of not more than every three feet for the remainder of the wire or cable length. This marking technique shall not in any way cause damage, or otherwise render ineffective, the conductor or its insulation. As an alternative, all wires may be plainly and permanently marked within one inch of each termination with approved wire tags.

The markings shall be of a type that are permanent in nature and readily identifiable after all connections are in place. The only exceptions to the marking requirement shall be in the case of short connecting leads wholly within complete components such as motor windings, electronic circuit packages, etc. But in all cases, all input, output, power, and control terminals shall be identified on the basis of the system selected.

All electrical connections terminals, whether strip type, plug, socket, etc., shall be assigned circuit designations on the basis of the system selected for the entire car as described above.

Placards shall be installed adjacent to or beneath terminal boards that are installed in high maintenance or difficult access areas. The placards shall be clearly and permanently marked showing the designation of the wires to be attached to each terminal. The areas which have been identified as high maintenance or difficult access areas include: power control units no. 1, no. 2 and no. 3; the sanding and brake control panel; the low voltage power supply; terminal boards located in the overhead cab area; at the overhead door control relay panels; and, if used, the chopper assembly.

OWNER FURNISHED EQUIPMENT

(This section is to be prepared by the Purchaser).

APPENDIX A

VEHICLE ENERGY CONSUMPTION VERIFICATION TEST

A.1 Synthetic Route and Lab Test Definition

For the purpose of determining a value for vehicle energy consumption (kWh/veh.-km), a synthetic route will be defined. A synthetic rather than an actual route will be used, as its design permits an energy consumption verification test of the propulsion system at the Bidder's facilities.

A.1.1 General

The actual operating route will be adequately represented on a test stand, by a sequence simulating the propulsion loads encountered on the actual route between the (TBS)* and (TBS) Stations, of the (TBS) Purchaser.

A.1.2 Route Formulation

The synthetic route consists of a series of speed-time constrained runs, arranged to represent the electrical demands and characteristics of the actual (TBS) Route. Each run is defined as a tabulation of time and speed called Type I, II and III.

The propulsion system shall be programmed to accelerate and decelerate the flywheel in accordance with the speed-time tabulations defined in Table A-1. The runs are also plotted as curves, but for formal test procedures, the tabulations will be used. Type I shall be repeated (TBS) times, followed by Type II repeated (TBS) times, then by Type III repeated (TBS) times. Between each run a (TBS)-second pause shall be made to represent station dwell times. Additional (TBS)-second intervals shall be allowed at the completion of each run to represent the dwell times at terminal stations.

The runs shall be made with both:

- full service braking utilizing full rheostatic braking, followed by friction braking to standstill; and
- full service braking with regeneration if and where available from the propulsion system, with the remainder of the total required braking supplied by rheostatic braking, followed by friction braking to standstill.

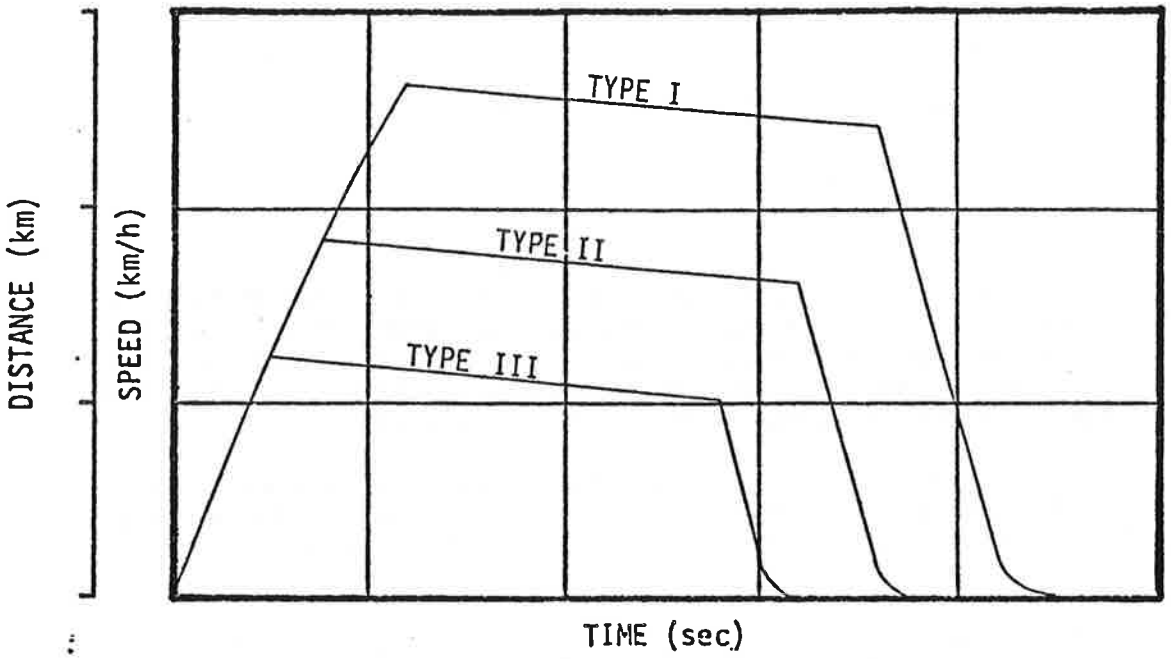
For the purposes of evaluation, it will be considered that:

a) the line voltage shall not exceed (TBS) volts $\pm$ (TBS) volts; and

b) the line is 100% receptive, (with a current/voltage limit of (TBS) amps/volts) during regenerative braking, with factor applied.

*(TBS): To be specified by the Purchaser.

TABLE A-1. SYNTHETIC RUN CHARACTERISTICS



TYPE I		TYPE II		TYPE III	
SPEED (km/h)	TIME (sec)	SPEED (km/h)	TIME (sec)	SPEED (km/h)	TIME (sec)

Speed Tolerances: ±(TBS) km/h on all speeds except corner points marked * where tolerance is ±(TBS) km/h.

A.1.3 Distance Conversion

Vehicle distance shall be based on a wheel diameter of (TBS) millimeters.

A.1.4 Test Stand Input Data

A.1.4.1 Test Stand Inertia and Vehicle Data

The propulsion system test load shall have a total rotational inertia, including the traction motor armatures, gearboxes, couplings, shafts, axles, wheels, etc., which is equal to the total inertia of the empty vehicle weight plus effective rotational inertia, plus AW-(TBS) passenger load, to within $\pm$ (TBS) percent as measured.

The rotational inertia of the traction motor assemblies including armatures, shafts, axles, wheels, etc. shall be required. The method of calculation and result shall be submitted for approval prior to commencement of the test.

The total vehicle weight and test stand inertia will be calculated as shown in Table A-2. The tolerance by which the bid test stand inertia departs from the bid figure shall not exceed (TBS) percent.

A.1.4.2 Test Stand Drag

The test stand shall be programmed to give the test stand load, traction motor, and other associated hardware a run-down speed-time characteristic equal to that of a typical vehicle (including no load gearbox loss effects). This run-down characteristic is tabulated and graphically represented in Table A-3. (Test stand accuracy shall be sufficient to ensure that the starred (*) tolerances $\pm$ (TBS) km/h are achieved; elsewhere, the actual run-down characteristics must be within $\pm$ (TBS) km/h of those tabulated.)

A.1.4.3 Power Supplies

All energy recordings shall be made at the inputs to the traction control system from the (TBS) Vdc, (TBS) Vac, and (TBS) dc power supplies. The (TBS) Vdc input power supply shall consist of a transformer, polyphase rectifier, dc series contactors and shunt resistance as required to maintain the direct voltage at (TBS) volts $\pm$ (TBS) volts at all times. Other power supplies that meet the voltage requirements may be submitted for approval.

A.1.4.4 Braking Requirements

Regenerative braking is to be measured with a (TBS) kilowatt receptive line and with the voltage held constant at (TBS) Vdc $\pm$ (TBS) volts. Measurements for regenerated energy during braking are to be recorded separately.

TABLE A-2. VEHICLE WEIGHT AND TEST STAND INERTIA CALCULATION FORM

I. Vehicle Weight

(a) Gross empty vehicle performance weight minus equipment list weight of propulsion supplier = _____kg

(b) AW-(TBS) passenger weight = _____kg

(c) Propulsion system equipment list guaranteed bid weight = _____kg

(d) Total vehicle weight (a + b + c) = _____kg = _____kg

II. Test Stand Inertia

(a) Effective rotating inertia

Equivalent rotating inertia of total traction motor armatures

$$I_a * \left[\frac{\text{gearbox ratio X 2}}{\text{wheel diameter in meters}}\right]^2$$

= _____kg

(I_a in kg-m^2 is the total moment of inertia of the traction motors.)

(b) Equivalent rotating inertia of four wheel-axle assemblies including gearboxes = _____kg

(c) Total effective rotating inertia = _____kg (a + b) = _____kg

(d) Total effective vehicle inertia I(d) + II(c) = _____kg

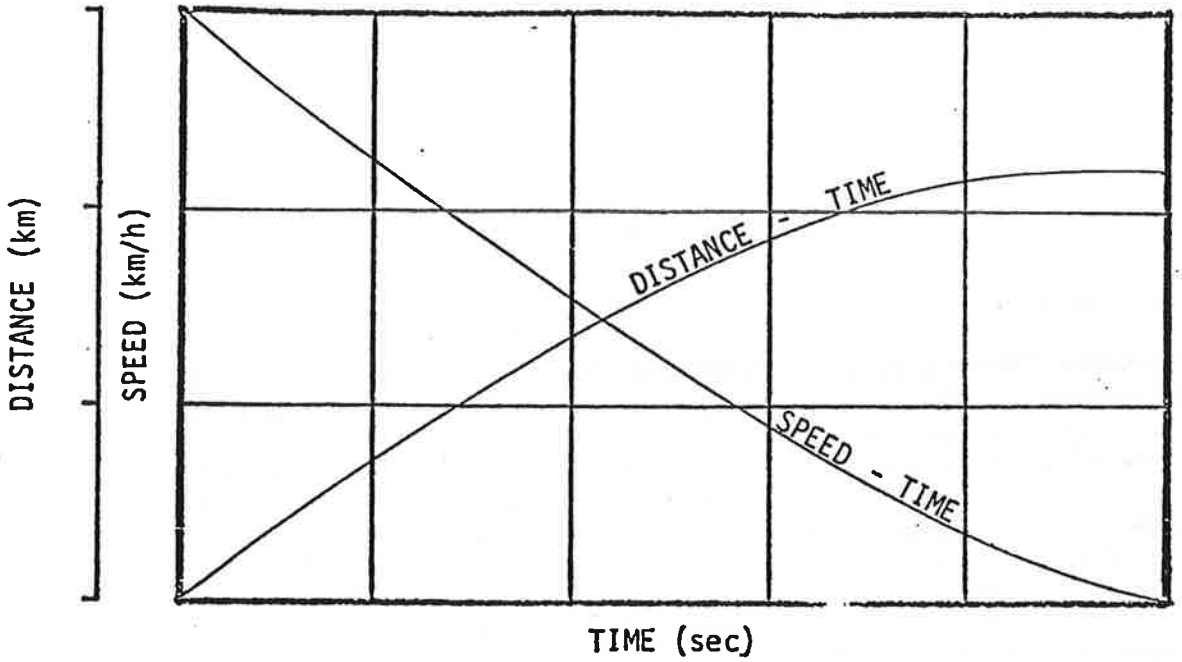
(e) Test stand inertia is equal to

$$\left(\begin{matrix}\text{Total effective}\\ \text{vehicle inertia (d)}\end{matrix}\right) \text{X} \left(\frac{\text{wheel diameter in meters}}{\text{gearbox ratio X 2}}\right) \text{ kg-m}^2$$

Test stand inertia* = _____kg-m^2

*This value of inertia is
(i) to be used for the predicted energy consumption of the synthetic route.
(ii) to be used as the test stand inertia for the energy consumption test.
(iii) to be verified on the test stand to within (TBS) percent as measured.

TABLE A-3. RUN-DOWN SPEED-TIME CHARACTERISTICS



DISTANCE (km)	SPEED (km/h)	TIME (sec)

Speed Tolerances: ±(TBS) km/h on all speeds except corner points marked * where tolerance is ±(TBS) km/h.

A.1.4.5 Other Conditions

The propulsion system shall be in the hot condition prior to the start of each synthetic run test.

The test will be conducted with hardware selected at random from the first (TBS) car sets of production hardware and simulated wiring and control interfaces.

A.2 Energy Consumption

The propulsion system and its necessary auxiliaries shall draw all power from the specified power supplies. The net energy drawn by the propulsion system and its necessary auxiliaries (including external motor cooling fans) shall be measured from the initiation time of the first Type I run to (TBS) seconds after the completion of the final Type III run. A properly calibrated odometer, driven through appropriate gears, shall measure the equivalent distance traveled. The energy consumption for each synthetic route test shall be the net energy drawn during the test from the supply by the propulsion system and its necessary auxiliaries divided by the total distance driven for the test. The energy thus calculated/measured for the total (TBS) equivalent runs will, solely for comparative purposes and later verification, represent the energy consumption for the journey from one point to another and back over line route as specified with an assumed AW-(TBS) passenger loading throughout.

A.2.1 Energy Consumption Calculation

The Bidder is required to submit with his proposal, calculations for the test stand inertia (Table A-2) and for the synthetic route energy consumption of the proposed propulsion system (Tables A-4 through A-7).

The Bidder shall, at time of Tender, provide details of the test system, test stand inertia, test load, and its parameters, which will be used at time of post-production verification.

A.2.2 Energy Consumption Measurement

The successful Bidder will perform a verification test of the synthetic route performance specified in Subsection A.1 on the (TBS) production set of propulsion hardware. The tests will be run under the jurisdiction of the Purchaser and will be run jointly with the Bidder.

The Bidder will be responsible for supplying the complete test apparatus, as well as any necessary indicating, integrating, and recording instrumentation to the satisfaction of the Purchaser's Engineer. Subject to prior approval by the Purchaser's Engineer, the Bidder may delegate some or all of the above work, but not the responsibility, to the approved sub-supplier or vendor.

A number, not fewer than (TBS) consecutive identical tests shall be run. Documentation of each of these runs shall be submitted to the Purchaser, per Table A-7.

Observations differing from the arithmetic means by more than ± (TBS) percent shall be discarded and the arithmetic means of the remaining tests, which shall be not fewer than (TBS), shall be regarded as the final figure. Only the measured values will be considered and no adjustments will be permitted.

The flywheel run-down characteristics shall be recorded before and after each route run. The kWh meter reading shall be recorded at the beginning and end of each synthetic route test.

The complete test procedure, instrumentation, and calibration must be approved by the Purchaser prior to conducting the test. The following minimum data shall be continuously recorded:

(a) Traction motor armature voltage;
(b) Traction motor armature current;
(c) Traction motor speed;
(d) Input voltage;
(e) Input current;
(f) Dynamometer armature voltage; and
(g) Dynamometer armature current.

TABLE A-4. CALCULATION OF PROPULSION SYSTEM ENERGY CONSUMPTION BID VALUE (*)

I. Calculation for Total Energy (**) Drain From (TBS)-Vdc Bus (***)

(a) Motoring

Kinetic energy	_____ kWh/veh.-km
Work against train resistance	_____ kWh/veh.-km
Propulsion system loss energy (from Table A-5)	_____ kWh/veh.-km

(b) Coasting

Propulsion system loss energy	_____ kWh/veh.-km
Other (specify)	_____ kWh/veh.-km

(c) Station Dwell

Propulsion system loss energy	_____ kWh/veh.-km
Other (specify)	_____ kWh/veh.-km

(d) Braking

Propulsion system loss energy	_____ kWh/veh.-km
Other (specify)	_____ kWh/veh.-km
Total energy drawn from (TBS)-Vdc bus (a + b + c + d)	_____ kWh/veh.-km

II. Calculation for Total Energy Drawn From Auxiliary Supplies During Complete Energy Consumption Test

(a) Total energy drawn from auxiliary power supply at _____ (specify voltage)	_____ kWh/veh.-km
(b) Total energy drawn from low voltage supply set at (TBS) Vdc ± (TBS) percent	_____ kWh/veh.-km
(c) Total energy drawn from auxiliary airflow supply	_____ kWh/veh.-km
(d) Other (specify)	_____ kWh/veh.-km
Total energy drawn from auxiliary supplies (a + b + c + d)	_____ kWh/veh.-km

TABLE A-4. (Continued)

III. Calculation for Total Energy Returned to (TBS)-Vdc Bus

(a) Kinetic energy available at initiation of braking _____ kWh/veh.-km

(b) Work against train resistance during braking _____ kWh/veh.-km

(c) Propulsion system loss energy during braking _____ kWh/veh.-km

Total loss energy during braking (b + c) _____ kWh/veh.-km

Total energy returned to (TBS)-Vdc bus for a completely receptive line (a - b - c) _____ kWh/veh.-km

(d) Receptivity (TBS) _____ kWh/veh.-km

(e) Total energy returned; (c) or (d) whichever is smaller _____ kWh/veh.-km

IV. Calculation for Propulsion System Energy Consumption Bid Value

The nominal energy consumption value for the propulsion system is the sum of the final total energy values from Items I, II and III.

Nominal propulsion system energy consumption value (I + II - III) _____ kWh/veh.-km

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NOTES:

(*) Test stand inertia of (TBS) is as calculated in Table A-2.

(**) The term "total energy" is defined to mean the energy total for the (TBS) specified speed-time profiles including the (TBS) dwell intervals.

(***) The term "(TBS)-Vdc Bus" is synonymous with the third rail for the purpose of the energy consumption calculation and test.

TABLE A-5. CALCULATION SHEET FOR PROPULSION SYSTEM LOSS ENERGY DRAWN FROM (TBS)-VDC BUS DURING MOTORING

(Suggested form - not required)

(To be entered into Section I.(a) of calculation for energy consumption bid value in Table A-4.)

TYPE RUN _____

I.	Traction Motor Loss Energy (4 Motors) (As specified by ANSI C35.1)	
	I^2R losses in armature windings	_____ kWh/veh.-km
	I^2R losses in field windings	_____ kWh/veh.-km
	Brush friction, armature bearing friction, and windage losses (include self-ventilation fan losses)	_____ kWh/veh.-km
	No load core losses	_____ kWh/veh.-km
	Brush-contact losses	_____ kWh/veh.-km
	Strayload losses	_____ kWh/veh.-km
	Field shunt losses	_____ kWh/veh.-km
	Total Motor Loss Energy	_____ kWh/veh.-km
II.	Chopper/Cam Controller Loss Engery (Including controller resistance loss energy)	_____ kWh/veh.-km
III.	Armature Circuit Loss Energy (Components conducting armature current other than traction motors and chopper/cam controller)	
	Semiconductors	_____ kWh/veh.-km
	Contactors (contact drops)	_____ kWh/veh.-km
	Inductors	_____ kWh/veh.-km
	Resistors	_____ kWh/veh.-km
	Connector box	_____ kWh/veh.-km
	Wire	_____ kWh/veh.-km
	Other (specify)	_____ kWh/veh.-km
	Total Armature Circuit Loss Energy	_____ kWh/veh.-km
IV.	Input Circuit Loss Energy	
	Semiconductors	_____ kWh/veh.-km
	Contactors (contact drops)	_____ kWh/veh.-km
	Filters (inductors, capacitors, etc.)	_____ kWh/veh.-km
	Resistors	_____ kWh/veh.-km
	Wire	_____ kWh/veh.-km
	Other (specify)	_____ kWh/veh.-km
	Total input circuit loss energy	_____ kWh/veh.-km
V.	Other (Specify)	_____ kWh/veh.-km
	Total Propulsion System Loss Energy (I + II + III + IV + V)	_____ kWh/veh.-km

TABLE A-6. CALCULATION SHEET FOR PROPULSION SYSTEM LOSS ENERGY DRAWN FROM (TBS)-VDC BUS DURING BRAKING
(Suggested form - not required)

(To be entered into section III.(c) of calculation for energy consumption bid value in Table A-4.)

TYPE RUN _____

I.	Traction Motor Loss Energy (4 motors) (as specified by ANSI C35.1)	
	I^2R losses in armature windings	_____ kWh/veh.-km
	I^2R losses in field windings	_____ kWh/veh.-km
	Brush friction, armature bearing friction, and windage losses (include) self-ventilation fan losses)	_____ kWh/veh.-km
	No load core losses	_____ kWh/veh.-km
	Brush-contact losses	_____ kWh/veh.-km
	Strayload losses	_____ kWh/veh.-km
	Field shunt losses	_____ kWh/veh.-km
	Total Motor Loss Energy	_____ kWh/veh.-km
II.	Chopper/Cam Controller Loss Energy (including controller resistance loss energy)	_____ kWh/veh.-km
III.	Armature Circuit Loss Energy (components conducting armature current other than traction motors and chopper/cam controller)	
	Semiconductors	_____ kWh/veh.-km
	Contactors (contact drops)	_____ kWh/veh.-km
	Inductors	_____ kWh/veh.-km
	Resistors	_____ kWh/veh.-km
	Connector Box	_____ kWh/veh.-km
	Wire	_____ kWh/veh.-km
	Other (specify)	_____ kWh/veh.-km
	Total Armature Circuit Loss Energy	_____ kWh/veh.-km
IV.	Input Circuit Loss Energy	
	Semiconductors	_____ kWh/veh.-km
	Contactors (contact drops)	_____ kWh/veh.-km
	Filters (inductors, capacitors, etc.)	_____ kWh/veh.-km
	Resistors	_____ kWh/veh.-km
	Wire	_____ kWh/veh.-km
	Other (specify)	_____ kWh/veh.-km
	Total Input Circuit Loss Energy	_____ kWh/veh.-km
V.	Other (specify)	_____ kWh/veh.-km
	Total Propulsion System Loss Energy (I + II + III + IV + V)	_____ kWh/veh.-km

TABLE A-7. SYNTHETIC RUN DOCUMENTATION

PROPULSION SYSTEM _____ MFR _____ TYPE _____

SPEED TIME AND ENERGY CALCULATIONS

	TYPE I		TYPE II		TYPE III	
	SPEED	TIME	SPEED	TIME	SPEED	TIME
RUN CHARAC-TERISTICS						
STOP TIME						
DISTANCE						

	NO REGEN.	W/REGEN.	NO REGEN.	W/REGEN.	NO REGEN.	W/REGEN.
KWH per run						
KWH per vehicle kilometer						

RUN TYPE	NO. OF RUNS	KILOMETERS	TIME	SCHED. SPEED	KWH	KWH/veh-KM
I						
II						
III						
TOTAL						

APPENDIX B

REPORT OF NEW TECHNOLOGY

There has been no new technology developed in this report. This report was developed to be used as a guide for light rail transit operators and purchasers of such equipment in the preparation of technical specifications. Because of differing site-specific needs, this Specification Guide has been organized to provide ample freedom of choice among a wide range of options.