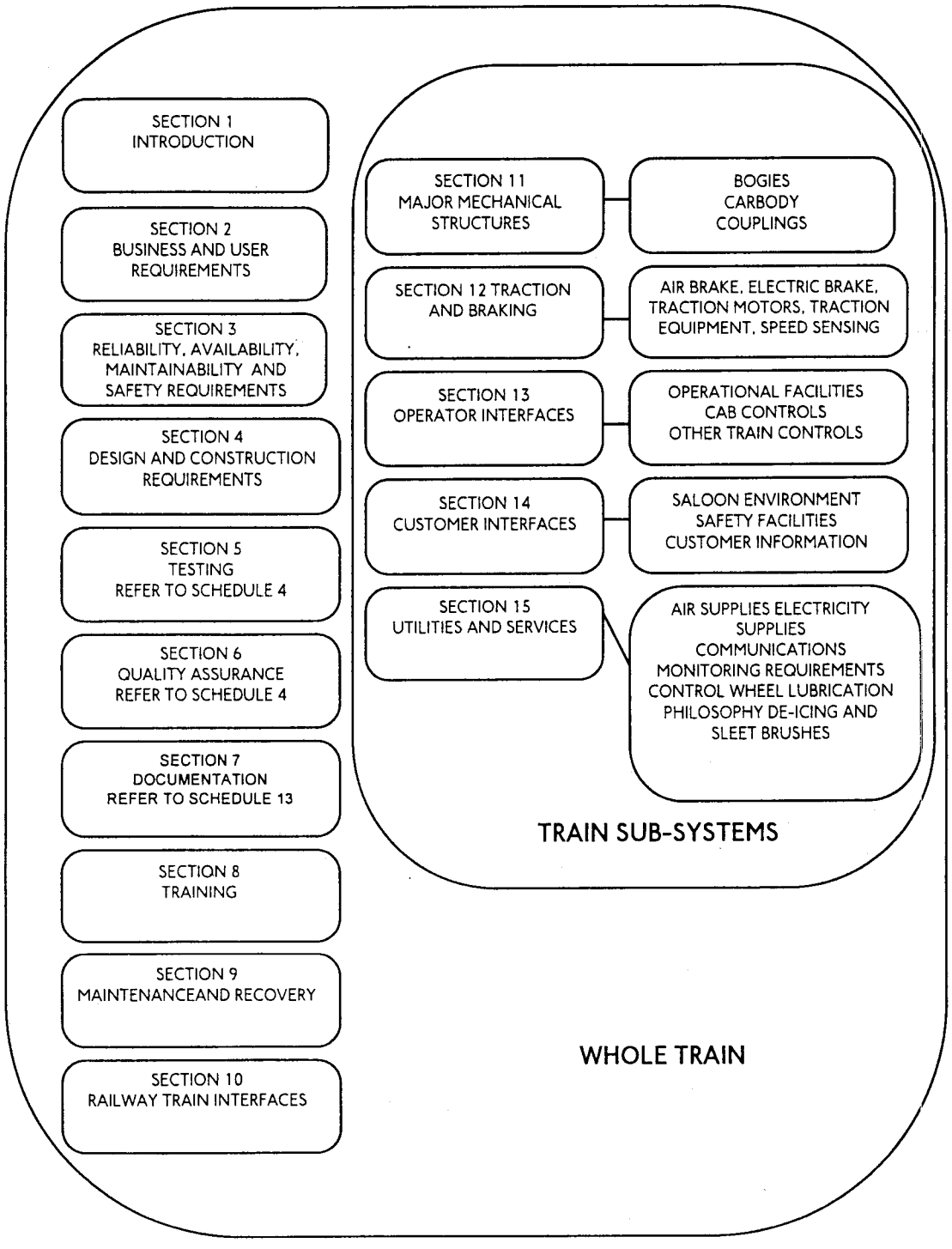
TECHNICAL SPECIFICATION

FOR

NORTHERN LINE ROLLING STOCK

Specification Index in Diagrammatic Form



1. INTRODUCTION

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1.1 INTRODUCTION AND SCOPE

1.1.1 General Description of the Works

The Company has a requirement for a fleet of new Trains in order to replace existing assets on the Northern Line. Schedule 6 - Part A covers the design, manufacture, testing and commissioning of electric-multiple Unit Trains which are to be provided by the Contractor.

1.1.2 The Structure of Schedule 6 - Part A

Schedule 6 - Part A is a performance specification in respect of the Trains and the requirements for the whole Train are set out in sections 1 to 9 of Schedule 6, Part A. Sections 10 to 15 describe the performance requirements of sub-systems of the Train. Where the Train is required to operate within existing procedures or to interface with existing assets, Schedule 6 - Part A contains detailed engineering or other criteria.

The structure is demonstrated graphically in the index to Schedule 6, Part A.

Schedule 6 - Part A must be read in conjunction with all other documents comprising the Contract

1.1.3 The Contractor's Responsibilities

The Contractor shall comply with Schedule 6 - Part A and any appendices, to the satisfaction of the Company.

The Contractor shall inform the Company, in writing, if, in the opinion of the Contractor, Schedule 6, Part A does not meet the Company's objectives.

1.1.4 Best Practice

Refer to Clause 13 of this Contract.

1.2 DEFINITIONS, REFERENCES AND ASSOCIATED DOCUMENTS

1.2.1 Abbreviations, Definitions and References

Technical terms are defined in Company Standard RSE/STD/000-Part 2, Section 4.1 and BS 4727.

All references in Schedule 6, Part A to *sections and sub-sections* are, unless the Contract otherwise requires, references to sections and sub-sections of Schedule 6, Part A.

1.2.2 Standards, Specifications and other Relevant Documents

The Trains shall comply with applicable requirements of all Company Standards, specifications and the other documents listed in Schedule 6, Part J, except where excluded by Schedule 6, Part A. The Contractor and the Company shall produce and maintain a matrix of non-compliance for documents called up in Schedule 6, Part J. The matrix, Appendix 1 of Schedule 6, Part J shall contain detailed statements from the Contractor of why compliance cannot be provided, in addition to details of any waiver granted by the Company for the Contractor to maintain non-compliance.

In addition, the Trains shall comply with applicable requirements of all recognised International Standards, National Standards and industry-specific Standards, codes of practice and similar guidance documentation.

The Contractor shall formally advise the Project Manager of all instances of apparent conflict within or between, or omissions from, the above-mentioned documents and Standards. In the event of conflict the Project Manager shall decide which Standards/documents shall apply: in general it shall be assumed that the more onerous of equivalent but conflicting provisions will prevail.

1.2.3 Statutory Regulations

The Contractor shall formally advise the Project Manager of all instances of apparent conflict between legislative requirements and any other requirements of this Contract. The Project Manager's formal advice of resolution of such matters shall be binding.

1.3 PRINCIPAL DESIGN OBJECTIVES

The Company in pursuance of obtaining serviceable and reliable Trains has set out the following design objectives:

1.3.1 Safety of Operation in all Modes

The Trains shall be designed and proved by analysis, audits and tests to provide a safe means of mass transit to the satisfaction of the Project Manager. Section 3 of Schedule 6 - Part A and Schedule 4 defines the Company's requirements in this respect.

1.3.2 Achievement of Specified Performance, Availability and Reliability

The Trains shall be designed and manufactured to allow the Services to be provided.

The availability and reliability of the Trains shall comply with the requirements of section 3 of Schedule 6 - Part A and Schedule 4.

The Trains' performance shall be consistent under varying Passenger loads and the range of railway environmental conditions as specified.

The design life of the Trains shall be at least 36 years.

1.3.3 Structured Approach to the Train as a System

1.3.3.1 General

The Contractor shall design the Train as a whole system which comprises a number of sub-systems which provide specified functions or facilities or contribute to the Train achieving specified performance requirements.

The design of the Train shall be such that the selection of particular equipment for use within the Train or within sub-systems shall not compromise the Train achieving the specified performance.

Integrated, reliable and appropriate control and monitoring shall be provided along with wide ranging diagnostic facilities.

1.3.3.2 Monitoring

The Contractor shall ensure that the Trains are equipped to monitor the state of the Trains' sub-systems. The state of the sub-systems shall be reported and recorded.

A selection of reported and recorded information shall be made available to the Train Operator.

When the monitored state is beyond agreed tolerances the Trains' control systems shall be equipped with facilities to shut down sub-systems or parts of sub-systems.

Status, fault and diagnostic data shall be passed through data highways.

The particular requirements for monitoring are defined in section 15 (sub-section 155).

1.3.3.3 Control

The particular requirements for control are defined in section 15 (sub-section 155).

A number of "dedicated function" Train wires shall be provided for safety and these shall be used to provide a minimum level of control in emergency of failure situations to allow the Train to be driven out of service. Other control functions shall be passed via data highways.

High levels of integrity and reliability, defined in section 3 of Schedule 6, Part A, are required in respect of control functions.

1.3.4 Enhanced Passenger Benefits

The Contractor shall ensure that specified standards of ride comfort, noise level management, climate control, information to Passengers, and interior and exterior visual design and aesthetics are provided.

The Trains' design shall allow the requirements of Schedule 6, Parts G and H to be readily achieved.

The Contractor shall ensure that the Trains' design shall be such as to achieve the following for each Train entering service:-

i) no graffiti internally or externally, or evidence of graffiti following its removal, as far as reasonably practicable.
ii) cleanliness, internally and externally, meeting the levels specified in this Contract,
iii) comfortable seats in good condition,
iv) lighting meeting levels specified,
v) the saloon climate meeting levels specified,
vi) the internal noise levels shall not exceed the levels specified,
vii) the ride quality shall be that specified or better.

1.3.5 Energy Consumption Reduction

The Trains shall use design techniques and construction methods which give efficient use of energy consumed during the operation of the Trains whilst achieving the specified Train performance.

1.3.6 Automation

The Trains shall be designed to include facilities for ATC.

1.3.7 Use of Proven Technology/System and Products

The Contractor shall propose technology and equipment proven in the railway environment wherever possible. Where this is not possible or practicable, the Contractor shall ensure that the proposed implementation shall not cause a degradation of standards.

1.3.8 Reduction of Hardware and Software Obsolescence

The Contractor shall demonstrate that consideration is given to overcoming obsolescence in all areas of the design and construction of the Trains.

The Contractor shall consider modular construction techniques to permit system replacement at minor or major Train overhaul, and to allow changes in business requirements to be easily implemented.

1.3.9 Compromises of the above Requirements

If, in complying with any of the above objectives the Contractor compromises the attainment of any other of the above objectives, the Project Manager's approval shall be required prior to proceeding.

1.4 THE TRAIN

1.4.1 Description

Each Train shall have six Cars and a cab at both ends.

The dimensions of the Cars shall be determined by consideration of the Northern Line information and kinematic profile as defined in Schedule 6 - Part A in sections 2 and 4 respectively. The saloon floor height shall be maintained at a nominal distance of 755 mm ARL.

It is preferred that each Car shall be carried on two four-wheeled bogies.

Autocouplers shall be used between Units. The Northern Line has a loop link at Kennington in which Trains become reversed with respect to other Trains on the Northern Line. The Trains' wiring configuration and Autocouplers shall be arranged to permit Units to couple at any relative orientation to each other.

Two bi-parting and two single sliding doors are required on each side of each Car. The doors shall be under the control of the Train Operator and Passengers. Each double doorway shall have a width of at least 1388 mm and single doorways 694 mm. The height shall be at least 1800 mm. Through access of at least 675 mm (with the exception of the M door where this dimension shall be 584 mm) along the entire length of the Train and egress from the ends of the Train onto the track is also required by staff and Passengers in emergencies.

Traction equipment, the auxiliary supply source, the Control Supply battery and at least one compressor are required on each Unit. The number of axles to be motored shall be determined by the Contractor.

The interior design shall provide the maximum space for Passengers whilst being aesthetically pleasing. Seats for a minimum of 240 Passengers per Train shall be provided, these shall be distributed along the interior sides of the Cars between doorways. The Contractor shall provide four locations per Car for use by Passengers in wheel-chairs. Exact locations of the wheelchair facilities shall be agreed with the Project Manager.

1.4.2 Car Type Definitions

Various Car types shall be provided. These shall be designated:-

i) Driving Motor (DM) Car - its main features being a driving cab at the outer end, traction equipment, current collection shoe gear and sleet brushes, shore supply receptacle and a coupling mechanism,
ii) Uncoupling Non-Driving Motor (UNDM) Car - a Car with no cab but complete with traction equipment, current collection shoe gear and shore supply receptacle,
iii) Trailer (T) Car - a trailing vehicle,
iv) De-icing Car - as per types i) to iii) but with De-icing Equipment fitted, refer to section 15 (sub-section 153).

All Unit coupling locations not fitted with a cab shall be provided with a Shunt Control Position and an Autocoupler.

1.5 THE TRAIN: ITS INTERFACES AND INTERFACE ACTIVITIES

1.5.1 Interfaces

The Train will interface with many other systems used on the Company's Railway, these are set out in section 10. Section 10 of Schedule 6, Part A also defines the temporary requirements that will exist as the Trains are initially put into service.

1.5.2 Interface Activities

Interfaces will exist between the Trains provided under this Contract and the Trackside Equipment where the Train or the Trackside Equipment is mutually dependent or interactive for satisfactory operation. The Contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory operation, at the interface, of the Trains or the Trackside Equipment for which it is responsible. For the Contract Duration, the interfaces shall be discussed and agreed, with the Project Manager.

Any further interfaces identified during detail design shall be incorporated in these activities. In certain cases the Project Manager reserves the right to instruct the Contractor to discuss the interface directly with other contractors. Under these circumstances the Contractor shall inform the Project Manager in writing of all such

discussions and conclusions. Final interfaces shall be agreed with the Project Manager.

2. BUSINESS AND USER REQUIREMENTS

2. BUSINESS AND USER REQUIREMENTS

The Train Operator will normally be the only member of Company staff on the Train and, within the Company, has responsibility for ensuring the safety of the Train and Passengers. Train Operators are trained for their task and can be assumed to be familiar with the following:-

i) the Company's Rule Book,
ii) the topography of the Company's Railway,
iii) the operation of the Train and its controls, subject to training.

Train Operators have limited training in fault finding. Faults shall be overcome by operating switches, air cocks or resetting miniature circuit breakers from within the Train. The Contractor shall ensure that the monitoring system (section 15 (sub-section 155)), in addition to the Operating Manual and Train Operators' Handbook gives clear and concise fault location information.

The Train Operator shall not have to get onto the track to take actions to enable the safe movement of the Train. Hence isolation cocks or switches that enable safe movement of the Train must be accessible from within the Train and preferably from within the cab.

The Company's single-bore tube tunnels are not large enough to accommodate side walkways. This situation causes particular problems for emergency egress.

2.1 MODES OF OPERATION

2.1.1 Train Preparation

The Train shall have facilities for preparation and testing prior to entry into service. The Contractor shall ensure systems are provided to perform pre-running diagnostic checks and safety checks.

The scope of pre-service tests are defined Schedule 6, Part G.

2.1.2 Train Movement Modes

The Train shall be able to move in a range of modes. Automatic train protection systems will be available on the Northern Line either by tripcocks or other means.

2.1.2.1 Automatic Train Operation

The Trains will at a later date than initial entry into service operate with an ATC system, incorporating ATO under the supervision of a Train Operator, and an ATP system.

2.1.2.2 Manual Control

Two modes of manual control shall be provided. Manual driving facilities will be necessary in case of ATC equipment failure, for shunting and for driving prior to the commissioning of the ATO and new ATP signalling system.

2.1.2.2.1 Full Speed Manual

When the ATP track code is available, the Train Operator shall be able to drive the Train up to the speed permitted by the ATP equipment.

"Full Speed Manual" driving shall permit full performance to be achieved in order to maintain the timetabled run times.

2.1.2.2.2 Restricted Manual

In "Restricted Manual" the Train shall only be capable of being manually driven up to a maximum speed of 17 km/h.

Under ATP failure conditions, the Train shall be able to run the full length of the line with "Restricted Manual" performance and a Crush Load.

"Restricted Manual" driving will be required for all Train movements in Depots and Outstations and is also provided for failure conditions.

2.1.2.2.3 Running on Existing Line Signalling

Prior to the installation of the ATP and ATO systems the Trains will be driven manually at full speed using "Full Speed Manual" and shall be protected by the Company's conventional signalling system. The danger signal protection is provided by trainstops and tripcocks, these are fully described in section 10 (sub-section 101). The Contractor shall design the Train to operate safely and reliably on the existing and new signalling systems.

2.1.2.2.4 Shunting

Shunt Control Positions, as specified in section 13 (sub-section 134) shall be capable of operating only with "Restricted Manual" performance.

2.2 NORTHERN LINE TRAIN SERVICE

The Trains shall achieve an improvement of 11% in the modelled on-train run time. The modelled on-train run time shall assume no signalling constraints but shall observe permanent way speed restrictions. The modelled on-train run time means

the summation of the interstation journey exclusive of station stop times, i.e. wheels rolling to wheels stopped.

The present modelled return trip on-train run time for Existing Trains in a Full Load condition is 10369 s. A return trip is defined as:-

i) Edgware to/from Kennington via Charing Cross,

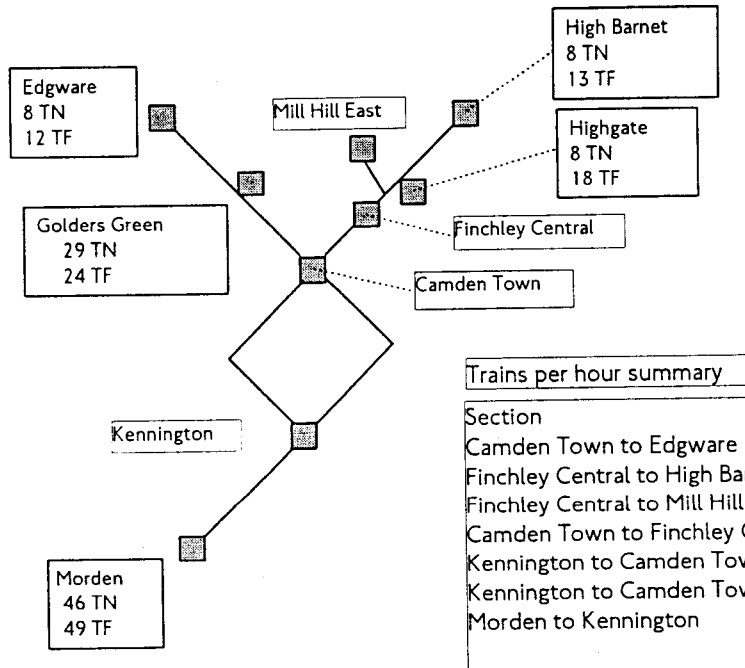
AND

ii) High Barnet to/from Morden via Bank.

The performance of the Trains shall be assessed by the method defined in Schedules 10 and 11. The target future modelled on-train run time for the defined return trip shall be an 11% improvement on 10369 s.

Figure 2.2 defines the increase in trains per hour for each branch of the Northern Line, the number of Trains required for the train service and the train holding capability expected at the Depots, Outstations or stabling sites. The 2002 figure assumes that a new signalling system has been installed.

Figure 2.2 - Service Level Requirements and Stabling Locations



Trains per hour summary

Section	Now	2002
Camden Town to Edgware	19	20
Finchley Central to High Barnet	14	
Finchley Central to Mill Hill East	5	
Camden Town to Finchley Central	19	20
Kennington to Camden Town (City)	19	25
Kennington to Camden Town (Charing X)	19	25
Morden to Kennington	28	35
Total Number of Trains for Service	82	96

The Trains per hour (TPH) figures are peak values for one direction of running.

The Contractor shall read these requirements in conjunction with Clause 5 of the Contract.

2.3 THE NORTHERN LINE

2.3.1 General Description

The Northern Line is defined on Contract Drawing 6235 11 000 N001 000 00 Drg 00-001

2.3.2 Distances, Curvature and Gradients

2.3.2.1 Curvature and Gradient

Contract Drawings P21048, P21049 and P21050 in addition to table "Alignment Data: Northern Line (Nordata)" (set out in Appendix 2 to Schedule 6, Part J) defines the general nature of the Northern Line.

2.3.2.2 Dwell Times

The quoted station dwell times are the maximum morning peak values and are provided for information only and may be subject to change in the future.

Table 2.3.2a - North West Branch to Kennington

Station	Road NB/SB	Dwell Time (s)
Edgware	NB	37.2
	SB	18.8
Burnt Oak	NB	18
	SB	18.8
Colindale	NB	18.6
	SB	19
Hendon Central	NB	18.5
	SB	22.2
Brent Cross	NB	17.9
	SB	19
Golder's Green	NB	22.5
	SB	24.5
Hampstead	NB	18.1
	SB	19.1
Belsize Park	NB	18.4
	SB	21.8
Chalk Farm	NB	18.1
	SB	21.4
Camden Town (Plat.1)	NB	22.5
Mornington Crescent		
(Plat.2)	SB	32.5
Euston (CX Branch)	NB	24.4
	SB	39.1

Warren Street	NB	24.1
	SB	24.7
Goodge Street	NB	24.5
	SB	24.3
Tottenham Court Road	NB	28.3
	SB	30.1
Leicester Square	NB	29.4
	SB	26.5
Charing Cross	NB	29.4
	SB	24.2
Embankment	NB	31.8
	SB	25.3
Waterloo	NB	34.3
	SB	25.1
Kennington (CX Branch)	NB	55.5
	SB	33.3

Table 2.3.2b - North East Branch to Kennington

Station	Road NB/SB	Dwell Time (s)
High Barnet	NB	37.8
	SB	18.9
Totteridge & Whetstone	NB	18
	SB	19.1
Woodside Park	NB	18.2
	SB	19.3
West Finchley	NB	17.5
	SB	18.6
Mill Hill East	NB	37.4
	SB	19.4
Finchley Central	NB	22.6
	SB	22
East Finchley	NB	17.7
	SB	22.1
Highgate	NB	17.6
	SB	24.3
Archway	NB	18.7
	SB	27.4
Tufnell Park	NB	17.8
	SB	23.8
Kentish Town	NB	18.1
	SB	24.3

Camden Town (Plat. 3)	NB	22.5
(Plat. 4)	SB	32.5
Euston (City Branch)	NB	24.4
	SB	39.1
King's Cross	NB	28.8
	SB	35.9
Angel	NB	25.5
	SB	25.7
Old Street	NB	24.5
	SB	23.6
Moorgate	NB	29.1
	SB	27.4
Bank	NB	45.6
	SB	35
London Bridge	NB	41.7
	SB	26.2
Borough	NB	24
	SB	21.7
Elephant & Castle	NB	29
	SB	22.9
Kennington (City Branch)	NB	55.5
	SB	33.3

Table 2.3.2c - Kennington to Morden

Station	Road NB/SB	Dwell Time (s)
Oval	NB	27
	SB	20.9
Stockwell	NB	38.7
	SB	21.8
Clapham North	NB	26.8
	SB	18
Clapham Common	NB	27.3
	SB	18.3
Clapham South	NB	27.1
	SB	18.3
Balham	NB	27.3
	SB	18.8
Tooting Bec	NB	23.9
	SB	17.9
Tooting Broadway	NB	22.6
	SB	21.7
Collier's Wood	NB	21.6
	SB	18.1
South Wimbledon	NB	20.9
	SB	27.8
Morden	NB	21.6
	SB	37

2.3.3 Table 2.3.3 a) - Brake Rates Profile (for Performance Calculations)

Section	Brake Rate m/s/s	
	NB	SB
Edgware - Burnt Oak	0.75	0.75
Burnt Oak - Colindale	0.75	0.75
Colindale - Hendon Central	0.75	0.75
Hendon Central - Brent Cross	0.75	0.75
Brent Cross - Golder's Green	0.75	0.75
Golder's Green - Hampstead	0.75	1.15
Hampstead - Belsize Park	1.15	1.15
Belsize Park - Chalk Farm	1.15	1.15
Chalk Farm - Camden Town	1.15	1.15
Camden Town - Mornington Cresent	1.15	1.15
Mornington Cresent - Euston	1.15	1.15
Euston - Warren Street	1.15	1.15
Warren Street - Goodge Street	1.15	1.15
Goodge Street - Tottenham Court Road	1.15	1.15
Tottenham Court Road - Leicester Square	1.15	1.15
Leicester Square - Charing Cross	1.15	1.15
Charing Cross - Embankment	1.15	1.15
Embankment - Waterloo	1.15	1.15
Waterloo - Kennington	1.15	1.15

Table 2.3.3 a) - Brake Rates Profile (for Performance Calculations)

Section	Brake Rate m/s/s	
	NB	SB
High Barnet - Totteridge & Whetstone	0.75	0.75
Totteridge & Whetstone - Woodside Park	0.75	0.75
Woodside Park - West Finchley	0.75	0.75
West Finchley - Finchley Central	0.75	0.75
Finchley Central - East Finchley	0.75	0.75
East Finchley - Highgate	0.75	1.15
Highgate - Archway	1.15	1.15
Archway - Tufnell Park	1.15	1.15
Tufnell Park - Kentish Town	1.15	1.15
Kentish Town - Camden Town	1.15	1.15
Camden Town - Euston	1.15	1.15
Euston - King's Cross	1.15	1.15
King's Cross - Angel	1.15	1.15
Angel - Old Street	1.15	1.15
Old Street - Moorgate	1.15	1.15
Moorgate - Bank	1.15	1.15
Bank - London Bridge	1.15	1.15
London Bridge - Borough	1.15	1.15
Borough - Elephant & Castle	1.15	1.15
Elephant & Castle - Kennington	1.15	1.15
Kennington - Oval	1.15	1.15

Oval - Stockwell	1.15	1.15
Stockwell - Clapham North	1.15	1.15
Clapham North - Clapham Common	1.15	1.15
Clapham Common - Clapham South	1.15	1.15
Clapham South - Balham	1.15	1.15
Balham - Tooting Bec	1.15	1.15
Tooting Bec - Tooting Broadway	1.15	1.15
Tooting Broadway - Collier's Wood	1.15	1.15
Collier's Wood - South Wimbledon	1.15	1.15
South Wimbledon - Morden	1.15	0.75

2.4 OPERATOR RESPONSIBILITIES

2.4.1 General

This section of Schedule 6 - Part A outlines the duties of the Train Operator and the facilities required on the Trains in a descriptive manner.

Train Operators may undertake the following duties:-

i) depending on the Train operational mode the Train Operator shall either be driving the Train or else initiating the start command to the ATO equipment, refer to section 13 (sub-sections 131 and 132) and other in transit duties as defined in the following sub-sections of section 2,

ii) setting up of the door system to allow opening and closing of the Train doors at stations, refer to section 14 (sub-section 140) and other station duties defined in the remaining sub-sections of section 2,

iii) communicating information on the Train state, or the railway or other information to the Passengers, the Line Controller or other operational staff or contractors, refer to section 15 (sub-section 154 and 155) and 13 (sub-section 131),

iv) operate on-train systems e.g. lighting, climate control as specified in section 13 (sub-sections 131 to 134),

v) undertake emergency duties as outlined in the following sub-sections,

vi) the Train Operator is required to check constantly for persons or obstructions on the track and to give warning of the Trains approach by sounding the horn or whistle, and/or to apply the Train brakes to avoid collision.

2.4.2 Stations

2.4.2.1 Normal Station Stop

As the Train enters the Stopping Zone of the station CCTV images of the platform shall be displayed on monitor(s) in the cab. The Train Operator checks that the Train has stopped in the correct position and then performs saloon door open duties.

A display in the cab shall provide a countdown timer for indicating when the Train Operator should start the door closing sequence, and an audible warning will sound when this is reached. The Train Operator then checks that it is safe to close the Train doors and presses the close button which starts the door closing sequence, disables the Passengers' door controls and sound a 'doors closing' audible warning in the saloon.

When the doors are proved closed the "All Doors Closed" visual shall illuminate. The Train Operator checks that it is safe to proceed by viewing the CCTV monitor(s) and then presses the "Start" buttons or drives the Train using the traction brake controller. The CCTV images shall remain displayed on the monitor allowing the Train Operator to check for safe exit of the Train from the station.

2.4.2.2 Reversing (change of journey direction)

2.4.2.2.1 Terminal Stations

On arrival at a terminal station and after setting up "Selective Close" the Train Operator selects "Shutdown". The Train Operator may then leave the Train unattended. On resumption of duty the Train Operator walks to the cab at the other end of the Train. The Train Operator takes control of the Train and then proceeds with any remaining station duties before departure.

2.4.2.2.2 Stations with Reversing Sidings

At present, on arrival at a reversing station the Train Operator will open all the saloon doors on the platform side of the Train and shall make appropriate announcements over the public address. The Train Operator will then close the Train doors, check on the CCTV monitor(s) that it is safe to proceed and drive the Train forward into the siding.

The Train Operator will select "Shutdown" and then walk through the Train to the cab at the other end of the Train. The Train Operator then enables the cab, selects a manual mode, drives into the station platform and then continues with normal station duties before departure.

2.4.3 Depots, Outstations and Sidings

At the beginning of service the Train Operator shall collect the Train from the specified location and drive it onto the running line.

At the end of service, after ensuring that all Passengers are detrained, a Train is stabled in a Depot, Outstation or a Siding. At the approach to the Depot or Outstation there will be a point at which the Train will stop and from which the

Train Operator or other appointed person will drive in a manual mode to the appointed stabling road.

In Depot or Edgware Outstation the Train will often be required to run onto a Shed Road where there are no current rails. During this movement the Train shall remain fully operational until the Train Operator or other appointed person has completed his duty by shutting down the controls in the cab. The stabling light shall remain on once the Train is "Shutdown".

2.4.4 Enabling of Control Position

The Controlling Position shall be enabled by the Train Operator with the use of a security key. The detailed logic and conditions for enabling a Controlling Position are defined in section 13 (sub-section 132).

2.4.5 Abnormal Train Operation

To enable the Train Operator to rectify a defective Train in Passenger service the Trains' monitoring system shall provide sufficient diagnostic information to allow the Train Operator to activate isolating devices or reset switches to effect a repair or else get the Train back to a Depot, Outstation or siding for more comprehensive repair. The monitoring system requirements are defined in section 15 (sub-section 155).

Equipment shall be provided on the Trains that will allow communications to take place and remain available throughout a variety of emergency situations. Refer to section 15 (sub-section 154).

The Contractor shall provide the emergency equipment and storage for this equipment as specified in section 13.

2.4.5.1 Failure Procedures in Service

The most serious incidents, carrying the highest risk to Passengers well-being and providing greatest demands on the Train Operator's skills and ability, are those that cause the Train to stop and be unable to continue under its own power in a single-track tube tunnel between stations. This situation is dealt with by:-

i) electrical or pneumatic isolation of the fault,
ii) assistance from the following Train,
iii) detraining Passengers onto the track.

Additionally, situations where the Train Operator becomes incapacitated during transit may require any combination of the above relief measures to be used. The minimum isolating and switching facilities to be provided on the Trains by the Contractor are specified in section 13 (sub-section 132).

2.4.5.2 Assistance from a Following Train or Existing Train

The following Train or Existing Train draws up to the defective Train and couples to it. The Call-on light (section 13 (sub-section 131) refers) is used during this activity as a signal to the Train Operator of the Train or Existing Train in the rear that the Train ahead will not move and can be coupled to. After coupling, the Train or Existing Train in the rear pushes the combined train to the next station where Passengers can alight. After unloading Passengers, the stalled Train is pushed out to a Depot or siding to clear the line.

The Contractor shall ensure that two coupled Trains or a Train coupled to an Existing Train can be pneumatically and electrically isolated from each other so that faults are not transferred to the assisting Train or Existing Train.

Alternatively, if the defective Train cannot be moved, the following Train or Existing Train and subsequent following Trains or Existing Trains move up to form a continuous stationary train extending back to the first station to the rear of the defective Train. The Passengers then walk back through the Trains or Existing Trains to gain access to a platform.

These methods permit a well controlled detrainment. It is however lengthy and provides serious inconvenience and discomfort to the Passengers. The Contractor shall design the Train so that the risk of emergency lighting or ventilation failure is remote. Additionally, the capacity of the Trains standby supplies shall be adequate to support Radio communication, emergency lighting, ventilation and other emergency facilities for an extended period (section 15 (sub-section 152 refers).

A public address system shall be supplied that can be used by either the Train Operator or the Line Controller to keep the Passengers informed.

2.4.5.3 Detraining Passengers onto the Track

Serious failures, such as fire, loss of Traction Supply or derailment, prevent assistance from following Trains or Existing Trains. In these circumstances Passengers have to be evacuated via the track.

In order to evacuate the Train, the Train Operator has to ensure that the Traction Supply is switched off; lay a Short Circuiting Device across the current rails and then deploy a ramp or steps from the M door of the cab to the track. Passengers then leave the Train via the ramp or steps and walk to the station ahead or behind

The Contractor shall provide a detrainment facility and Short Circuiting Device as specified in section 13.

The Contractor shall design the detrainment device to allow the evacuation of a Fully Laden Train in one hour.

This performance requirement will be subject to a controlled test, the scope of which shall be agreed with the Project Manager.

2.4.5.4 Detrainment of Passengers on Double Track Sections

If a Train becomes stalled on a twin track section of the Northern Line the Passengers can be transferred to another Train or Existing Train standing on the adjacent track. The assisting Train or Existing Train is moved alongside so that pairs of double doors align. Appropriate doors are opened using the air cocks on the outside of the Car and then the gap between the adjacent Cars is bridged using the detrainment facility or a J door.

The Contractor shall design the detrainment facility or the J door to allow its use in this mode.

2.4.5.5 Derailments and other Incidents

During design of the Train, the Contractor shall assume that minor derailments (one axle or one bogie derailed) are an occasional occurrence, particularly in Depots. The Train shall be capable of surviving this type of situation such that when re-railed the Train can be driven or propelled to a Depot for inspection.

2.4.5.6 Traction Supply Isolation

In the event of prolonged arcing under a Car the Train Operator is required to ensure that the Traction Supply is switched off. The Train Operator may use the Tunnel Telephone wires (two parallel conductors running along all tunnels) to discharge traction current. The cab design shall permit this action to be undertaken through the cab door or cab window.

In other emergency situations the Train Operator is required to discharge the Traction Supply using a Short Circuiting Device. The Contractor shall ensure each cab has a Short Circuiting Device and the design of the cab shall allow ease of deployment.

2.4.5.7 Exceptional Weather Conditions

The Contractor shall supply De-icing Equipment and associated sleet brushes. Additionally each cab shall be provided with ice scrapers. These are defined elsewhere in Schedule 6, Part A.

2.5 TRAIN PERFORMANCE

2.5.1 Motion

2.5.1.1 Data and Formulae for Performance Calculations

Train and Passenger weight definitions to be used for all design/performance calculations and testing are defined in Company Standard RSE/STD/016-Part 5.

Loading definitions are as follows:-

i) Average Load = 345 Passengers per Train,
ii) Full Load = 1056 Passengers per Train.

Company Railway data for performance calculations and run-time simulations are specified in section 2.3.2.1 of this Schedule 6, Part A.

Performance calculations shall be based on the half worn wheel diameter.

Traction supply voltage at collector shoes shall be taken as 575 V.

The line current limit (including auxiliaries) for both motoring and braking shall be 3.5 kA, this shall be reduced during interrunning with Existing Trains to 2.7 kA.

The station dwell times are specified in section 2.3 (sub-section 2.3.2).

The average service brake rates are specified in section 2.3 (sub-section 2.3.3).

The Contractor shall state and allow for the effect of Train resistance. Where the Contractor is unable to predict the Train resistance the following values may be assumed:-

Train resistance (in N) = $A + BV + CV^2$,

where A, B, and C are constants as specified in table 2.5.1.1 and V is the Train speed in km/h.

Table 2.5.1.1 - Constants for Train Resistance Calculation for a 6-car train

	A	B	C
Tunnel Section - Motoring	750	3.64	3.21
Coasting	4487	3.64	3.21
Open Section - Motoring	750	1.69	1.45
Coasting	4487	1.69	1.45

The above constants are based on existing Company rolling stock.

The Contractor shall verify the Train resistance of the "as built" Train by conducting Train resistance tests as defined in Schedule 4.

2.5.1.2 Performance Calculations - Contractor's Declarations

The Contractor shall undertake the calculations detailed below for the Train "as built":

i) interstation run time,
ii) interstation motoring energy,
iii) interstation regenerated energy,
iv) interstation rheostatic brake energy,
v) total return trip time including intermediate stops,
vi) total return trip motoring energy,
vii) total return trip regenerated energy,
viii) total return trip rheostatic brake energy,
ix) total return trip RMS motor current,
x) curves of wheel rim tractive effort and line current against speed in motoring and braking, at the specified performance line voltage, for full and inter-running performance,
xi) variation of line current, including auxiliaries, with supply voltage,

These calculations shall be undertaken using the data or assumptions detailed below:-

i) the torque-speed and current-speed curves in motoring and braking shall be those recorded during type tests,
ii) the measured "as built" Train resistance,
iii) the measured "as built" Train weight,
iv) the greatest RMS motor current quoted for the listed duties shall not exceed the continuous rating,
v) the Contractor shall state and allow for the effective mass of the rotating parts.
vi) the Contractor shall state and allow for the effect of voltage drops between the collector shoes and traction motor, due to the resistances, inductances and capacitances etc, within the propulsion equipment,
vii) the calculations shall be undertaken for both normal and emergency duties where this is appropriate.

The results of the calculations shall be presented to the Project Manager for approval.

2.5.2 Normal Traction Performance

2.5.2.1 General

The Train performance shall achieve the modelled on-train time reduction defined in section 2 (sub-section 2.2) under all load conditions from Tare Load to Full Load.

Acceleration rates specified shall be achieved at all Passenger loads from Tare Load to Full Load inclusive.

Acceleration rates shall have a tolerance of ± 0.05 m/s^2.

The jerk rate, with a tolerance of 0.05 m/s^3 shall be adjustable over the range 0.4 to 1 m/s^3. It shall be initially set to 0.75 m/s^3. The final in service settings shall be determined during commissioning, agreed with the Project Manager and implemented by the Contractor.

The following shall be achieved on tangent, level track:-

i) a Tare Load Train shall be capable of propelling itself from rest with only the leading set of current collection shoes in contact with the Traction Supply,

ii) a Unit shall be capable of propelling itself and the rest of a Tare Load Train while operating in "Restricted Manual" with the shoes of that Unit or the shed receptacle only in contact with the Traction Supply.

2.5.2.2 Normal Service Requirements

2.5.2.2.1 Automatic and Manual Modes

The following shall all be achieved on tangent, level track:

The Trains' acceleration from rest shall be variable from 0.3 m/s^2 up to a limit of 1.3 m/s^2 for all loading up to and including Full Load.

The Train in the Full Load condition shall attain a speed of at least 50 km/h in less than 200 m or within 24 s when accelerating from rest in tunnel running. The maximum speed shall be 100 km/h.

The Train, operating with 450 V at the shoes and accelerating from rest, shall travel 60 m in less than 13.0 s with a Full Load in tunnel running.

2.5.2.2.2 Manual Characteristics

The Train Operator using the traction brake controller shall be able to control the acceleration of the Train variably from 0.3 m/s^2 up to 1.3 m/s^2.

2.5.2.3 Inter-Running Performance

The inter-running performance shall be as specified in section 10 (sub-section 101).

2.5.3 Normal Braking Performance

2.5.3.1 General

All decelerations specified shall be achieved with all Passenger loads up to and including Crush Load.

The tolerance on decelerations shall be ± 0.05 m/s^2.

2.5.3.2 Emergency Brake

The emergency brake performance shall be as specified in Company Standard RSE/STD/006.

2.5.3.3 Service Brake

The Train shall achieve the following service braking rates:-

i) continuously variable between 0 and 1.34 m/s^2 in ATC mode so as to achieve average tunnel braking rates of at least 0.85 m/s^2 up to a maximum of 1.15 m/s^2 and an average open section braking rate of 0.75 m/s^2,

ii) manual control shall be as specified in Company Standard RSE/STD/006.

The jerk rate for the application and release of brakes shall be separately adjustable over the range 0.4 to 1.0 m/s^3. They shall initially be set to 0.5 m/s^3. The in service settings shall be determined during commissioning and agreed with the Project Manager. The Contractor shall make any necessary adjustments to the Trains.

2.5.3.4 Electric Brake Capability

The electric brake, whether rheostatic or regenerative, shall provide the highest possible proportion of total Train brake energy using available adhesion. The design target shall be that the Train electric brake absorb an average 80% of the service braking energy under Full Load conditions for each full round trip in normal service.

The use of regenerative braking shall be optimised to utilise fully the line receptivity available.

2.5.4 Emergency Traction and Braking Duties

2.5.4.1 General

The Train shall be capable of performing all emergency duties as specified in sub-sections 2.5.4.2 to 2.5.5 inclusive, without damage to equipment or the need for additional maintenance or inspection.

The dynamic brake may be automatically disabled under the duties described in sub-section 2.5.4.3.

2.5.4.2 Defective Traction Equipment Capability

With one traction package inoperative, a Crush Laden Train, positioned, initially, wholly on a 1 in 30 up gradient, shall be able to start and subsequently be capable of running from any point on the Northern Line to a Depot assuming a Crush Load and 30 s station dwell times.

With two traction packages inoperative, a Crush Laden Train, positioned, initially, wholly on a 1 in 30 up gradient, shall be able to start and continue to the next station. Once emptied of Passengers the Train in Tare Laden condition shall be capable of continuing on the line to a Depot, Outstation or siding.

2.5.4.3 Push Through Capability

With the maximum number of parking brake units fully applied as a result of a single point failure in the pneumatic or parking brake control systems, and Passenger loadings anywhere between Tare Load and Crush Load, in any distribution, the Train shall be able to proceed from any point on the line to the next station with one traction equipment inoperative, in addition to any traction equipment rendered inoperative by the fault which has caused the parking brakes to apply. The requirements of this clause need not be met if an otherwise operative traction package is over a conductor rail gap, in which case an assisting Train or Existing Train may be used.

Having moved the Train to the next station and detrained the Passengers, it shall be possible to move the Train to a Depot, Outstation or siding without rectifying the fault and without the use of an assisting Train or Existing Train, except to restart the Train from rest with one otherwise operative traction package over a conductor rail gap.

The Train wheels on which a parking brake has applied shall rotate without sliding under the conditions specified in Company Standard RSE/STD/006.

Where air operated switchgear is used, special consideration must be given to meeting this requirement in the event of a main-line burst. This situation is usually the reason why the parking brakes apply when they are not required. Refer to sections 13 and 15 for requirements in respect of main-line protection and, air isolating and diverting facilities.

2.5.4.4 Defective Dynamic Brake Capability

In the event of a defective dynamic brake, braking performance shall be as specified in Company Standard RSE/STD/006.

2.5.4.5 Restricted Manual Operation

The Train shall be able to run continuously on the line, with "Restricted Manual" and Passenger loads up to and inclusive of Crush Loading.

2.5.5 Default Traction Performance

In the event of a failure of the tractive effort demand signal the equipment shall default to: maximum traction effort ON and OFF under hard wired control.

3. RELIABILITY, AVAILABILITY, MAINTAINABILITY AND SAFETY REQUIREMENTS (RAMS)

3. RELIABILITY, AVAILABILITY, MAINTAINABILITY AND SAFETY (RAMS) REQUIREMENTS

3.1 INTRODUCTION

The Contractor shall comply with the requirements of Schedule 4 in respect of RAMS.

3.2 Predictions

For the purposes of design forecasting, the following shall be assumed:-

i) all faults in braking, door and communications systems, together with any propulsion faults which may cause loss of time-keeping, shall be deemed to introduce delay. Peak schedules do not allow recovery from service disturbances,

ii) any fault which cannot be overcome by the Train Operator without needing to leave the cab shall be deemed to introduce a delay greater than 2 minutes,

iii) any fault which is capable of being overcome by the Train Operator, without leaving the cab, using facilities permanently provided in the cab, including cab displays, may be deemed not to introduce a delay greater than 2 minutes, provided that the total time for rectification is no greater than 2 minutes from the time of that fault,

iv) notwithstanding (iii) above, any fault necessitating Train Operator use of hard-wired back-up facilities within systems defined as High Integrity, in section 3.2.3, shall be deemed to cause premature withdrawal from service,

v) any false alarm shall be deemed to have the same operational effect as if it were not false.

All predictions shall be as service distance-based failure rates related to the targets set in section 3 (sub-section 3.3), with Vital Components/Vital Systems/Vital Functions and High Integrity Components/High Integrity Systems/High Integrity Functions separately visible. To permit this form of prediction, assumptions as to frequency of 'demand' type events shall be agreed with the Project Manager, wherever necessary, and documented. Where reasonably available, the Project Manager will provide such information based on the Company's operational experience and such information shall be used in all forecasting.

Where calculations are derived from time-based source data (e.g. MTBF) the Contractor shall ensure that failure rates when stabled (i.e. de-energised, energised-but-unstressed) are shown separately from those when in-service (i.e. stressed). The combination of these into service distance-based failure rates shall be performed consistently, regardless of equipment source of supply, using an apportionment method (i.e. 'running-to-standing ratios') which shall be approved by the Project Manager. Where calculations are based on frequency related data (e.g.

failures per 10^6 operations), the Contractor shall use a consistent and documented method, acceptable to the Project Manager, to relate such data to the duty cycle and service-distance-based failure rates.

Where two or more system functions are mutually exclusive (e.g. Passenger operation and Train Operator operation of doors), the Contractor shall use a documented apportionment method to be agreed with the Project Manager.

Presentation as event probabilities is not acceptable.

Where it is considered by either party that detection method or external circumstances significantly affect the outcome of particular failures or combinations thereof, then an apportionment technique shall be used with assumptions noted and agreed with the Project Manager. Where appropriate, techniques such as event tree analysis shall be used to support this.

All use of 'service factors' in calculations, for example to compensate perceived pessimism in source data, shall be subject to review and approval by the Project Manager. Such approval will require evidence of reasonableness, for example forecast-v-service comparisons for identified similar equipment in identified similar environments. Unsupported or "generic" statements are not acceptable.

3.3 Failure Rates

i) the total failure rate for Vital Components, Vital Systems, and Vital Functions shall not exceed 1 in 10^9 train-km, taking all failure mechanisms in aggregate.

ii) the total failure rate for High Integrity Components, High Integrity Systems and High Integrity Functions shall not exceed 1 in 10^7 train-km, taking all failure mechanisms in aggregate.

iii) failure rates for other systems and functions are determined by the reliability targets set in section 3 (sub-section 3.7.1).

3.4 Accepted Classifications

The Company currently classifies a number of systems, functions, components and failure modes according to the table below. This classification does not remove or reduce the responsibility of the Contractor to carry out a safety analysis of all systems, functions and components as set out in section 3.3 of Schedule 4. Final classification is subject to approval by the Project Manager. Use, in the table, of the words "include" or "including" shall not be construed as limitation.

Where analysis results in an indeterminate level of severity, the more or most severe category shall be assumed.

System, function or component	Classification	Comment
Wheelset integrity	Vital	Subject to approved axle non-destructive test programme
Wheelset electrical conductivity	Vital	Per-Car track shunting resistance must not exceed maximum permissible value, refer to section 4.3.4.
Axle rotation	Vital	Must not lock under failure of bearings, gears or motor
Structural integrity of car body and bogie	Vital	Subject to approved non-destructive test programme Excludes damage due to derailment or collision, within specified crashworthiness criteria Excludes damage due to incorrect lifting or jacking
Emergency brake application	Vital	Includes failure to respond to trainstop, Train Operator vigilance device, emergency brake control, loss of ATP safety codes, loss of Train continuity (however caused) and inhibition of traction by emergency brake application
Automatic Train Protection (ATP) system	Vital	Including tripcock
Evacuation system	Vital	Must not suffer any blockage, subject to regular deployment testing of permanently installed evacuation aids

Underframe equipment security	Vital	May be achieved by secondary securing devices, subject to detectability of failure of main fixing Excludes collector shoes and other small components where shown not to present a significant hazard if detached
Train mobility	Vital	Train unable to move, even with assisting Train or Existing Train, as a result of a single failure
Saloon door opening	Vital	Must not open without valid command
Doors closed interlocks	Vital	Must not give false 'closed' signal
Brake release	High Integrity	Ability to release both service and emergency brakes from cab (after resetting initiation condition(s) in the case of emergency brake application)
Service brake	High Integrity	Including hard wired control circuitry
Traction	High Integrity	Ability of Train to move unassisted. Includes hard wired control circuitry
Overspeed protection (non-ATP)	High Integrity	Includes post-trip speed limiting
Vehicle coupling	High Integrity	Includes Autocoupler uncouple control
Suspension height (active suspensions)	High Integrity	Including overheight protection system
Control Supply	High Integrity	Loss of supply to other High Integrity users
Compressed air supply	High Integrity	Total supply loss (whole Train)
Emergency lighting	High Integrity	Includes inability to sustain for specified period for any reason

Emergency ventilation	High Integrity	Includes inability to sustain for specified period for any reason
Saloon door operation	High Integrity	Includes emergency opening, locking and push-back features
Saloon door control	High Integrity	Includes end door cut-out and correct side door enable and Zero Velocity Interlocking. Excludes Vital door functions listed above
Radio	High Integrity	Including Deadman Alarm
Passenger Emergency Alarm	High Integrity	Excludes talk-back facility
Public Address	High Integrity	Clarity and audibility
Head, tail, stabling and calling-on lights	High Integrity	Excluding bulbs
Shoegear retraction	High Integrity	Includes latching
State selection	High Integrity	Sets and maintains correct Train state including inter-cab interlocking functions

3.5 Design Measures

The safety measures to be implemented by the Contractor as part of the design shall include, without being limited to:-

i) redundancy,
ii) safety proving tests, interlocks and diagnostics,
iii) electrical isolation,
iv) automatic imposition of operating limits,
vi) all software shall be compliant with sections 5.2 and 9.1.2 of Standard BRB/LUL/RIA 13; software associated with Vital Systems shall be compliant with Standard BRB/LUL/RIA 23 and relevant provisions of General Technical Guidelines on Programmable Electronic Systems in Safety Related Systems issued by the Health and Safety Executive.
vii) proving of Vital Systems or Vital Functions defined in section 3 (sub-section 3.2.1) of Schedule 6, Part A.
viii) preventive maintenance regimes supported by condition monitoring.

3.6 Monitoring, Fault Detection and Protection Systems

In general, monitoring, fault detection and protection systems shall have a reliability of at least a factor of ten better than that of the system or function monitored. The Company is particularly concerned that excessive incidence of false alarms or spurious tripping has the potential to generate unsafe working practices. It is recognised, however, that a figure of 1 failure in 10^{10} train-km is unlikely to be achievable for all Failure Modes of monitoring and fault detection associated with Vital Systems or Vital Functions. In such cases, the Contractor must demonstrate that the predicted rate of failure to protect is visible in the overall safety analysis for the Vital System or Vital Function, whilst the false alarm rate shall not exceed 1 in 10^8 train-km, equivalent to the monitoring and fault detection failure rate for High Integrity Systems and High Integrity Functions. Conversely, whilst 1 failure in 300,000 train-km would just meet these requirements for systems or functions which are neither Vital Systems or Vital Functions nor High Integrity Systems and High Integrity Functions, improvements on this figure will be viewed favourably.

For monitoring and fault detection systems, failures are defined as:-

i) failure to detect loss or deterioration outside defined performance limits of the system or function monitored,

ii) false indication of loss or deterioration outside defined performance limits of the system or function monitored.

The Contractor shall ensure that the failure modes and rates of monitoring, fault detection and protection systems are separately visible in all safety and reliability analyses, to the satisfaction of the Project Manager. Failure to achieve and maintain the agreed targets to within 90% confidence level will be deemed evidence of design defect. In such instances, the Contractor shall institute a programme of corrective action at no cost to the Company. The method of calculating confidence levels shall be subject to the approval of the Project Manager.

3.7 AVAILABILITY AND RELIABILITY

3.7.1 Performance

3.7.1.1 For the purposes of this section, "failure" means the occurrence of any failure or combination of failures, leading to one of the following:-

i) any delay to the service of 2 minutes or more,

ii) premature withdrawal of a Train from service,

iii) any Train not being available for service when required.

3.7.1.2 The reliability of the Train working with the Trackside Equipment shall be such that failures in groups (i) and (ii), as defined above, shall not in aggregate occur more than once per 30,000 Train-km worked. This shall be taken as the fleet average for

a Train of standard formation, inclusive of failures described in section 3.4. In addition to this, Item (iii), measured as the percentage of Trains presented for service at the specified times and locations, shall reach 100% within 26 weeks of the introduction of the first Train into Passenger service and shall be maintained at this level throughout the Contract Duration. Maintenance procedures, equipment, manning, spares inventory, and management support shall be arranged and maintained to ensure that this target is met.

3.7.1.3 The Company considers that provision of monitoring systems which detect not only failures but also degradation in the performance of key systems significantly assists in maintaining the required level of availability. Systems which self-compensate for degradation also enhance availability, since the programming of maintenance tasks can be better planned. The Contractor shall include appropriate discussions of this topic as part of reliability management reporting.

3.7.1.4 The reliability of the fleet shall be calculated in respect of all Trains in Passenger service six weeks after entry into Passenger service of the 40th Train that receives a Take Over Certificate or Qualified Take Over Certificate, and subsequently at four weekly intervals. The first six periodic calculations shall include all qualifying failures from first entry into Passenger service up to the reporting date. After this, the periodic calculations shall cover the six periods up to and including the reporting date. If vehicles are withdrawn from Company jurisdiction for any reason, distance run and failures accumulated during such periods of withdrawal shall not be included in the calculation. "Qualifying failures" shall be taken as all events covered by paragraph 3.7.1.1 (i), (ii) and (iii) above, including "no fault found" allocations where directed by the Project Manager.

3.7.1.5 The Contractor shall investigate and analyse all "no defect found" categories where faults cannot be reproduced after return to the Depot, where:-

i) the occurrence of the incident is confirmed from any on-line monitoring system whether supplied under this Contract or not, or;

ii) the Project Manager, after due discussion with involved parties, at his sole discretion so directs.

3.7.1.6 Reporting shall include brief summaries of all proposed programmes of corrective action, together with forecasts of effects and overviews of proposed effectiveness monitoring.

4. DESIGN AND CONSTRUCTION REQUIREMENTS

4. DESIGN AND CONSTRUCTION REQUIREMENTS

This section defines the standards and methods that apply to the Train, its systems and sub-systems.

The Contractor shall ensure that no item that requires removal for maintenance or repair shall require pipes or wires or other equipment to be removed except those connections to that equipment.

4.1 STANDARDISATION OF APPROACH

All equipment and components that are identical in performance shall be physically interchangeable. However equipment or components which are physically the same or visually similar, but have different operating characteristics, shall not be interchangeable.

4.2 USE OF EXISTING PROVEN EQUIPMENT AND SYSTEMS

The Contractor shall offer equipment that has been proven in similar applications or else demonstrate to the satisfaction of the Project Manager that equipment is appropriate to meet the specification.

4.3 DESIGN CONSTRAINTS

4.3.1 Weight and Weight Distribution

4.3.1.1 Train Weight

The Contractual Weight shall be as set out in Schedule 10 - Part C-1.

4.3.1.2 Weight Distribution

The weight distribution limits, as a design target to be achieved to the satisfaction of the Project Manager, shall be as defined in IEC 165/1133

4.3.1.3 Weight Transfer

The Contractor shall ensure and verify that the Train is designed to minimise the effects of weight transfer in acceleration and deceleration, calculations to support the verification shall be made available to the Project Manager.

4.3.2 Size

The Trains' dimensions must satisfy the kinematic profile requirements as specified in section 4 [sub-section 4.9] *AND* the need to maximise Passenger accommodation as specified in sections 11 and 14.

4.3.3 Appearance

The general external and internal appearance of all Cars shall be similar and provide a consistent appearance. Specific requirements in this respect are defined in sections 11 [sub-section 112] and 14 [sub-section 141].

4.3.4 Track Shunting Resistance

The maximum value of track shunting resistance shall be 0.5 ohms. The Company will agree with the Contractor the method of test to be adopted.

4.4 ENVIRONMENT

4.4.1 General

The Trains shall operate satisfactorily under all conditions as specified in Company Standard RSE/STD/008-Part 1.

The Contractor shall demonstrate compliance with the various requirements of this section of Schedule 6, Part A by successfully completing a programme of functional tests as specified in section 4 of Schedule 4.

4.4.2 Dust, Debris and Dirt

The Train's interior must be designed to minimise dust ingress into the Passenger saloon and the Train Operators' areas. It is recognised that total prevention of dust entry is impossible, therefore it is expected that the interior design of the Train will not allow dust to settle noticeably or to be attracted to surfaces (e.g. lighting diffusers) within cleaning cycles commensurate with maintaining required levels of cleanliness within the Train.

4.4.3 Water and Moisture

The Train shall operate without failing due to moisture ingress in precipitation as specified.

The Train shall operate normally in conditions of heavy dew contamination.

The Train shall operate normally in conditions of heavy condensation caused by Passenger respiration and perspiration.

4.5 NOISE

4.5.1 General

The Trains shall be designed to reduce or limit acoustic noise as specified in Company Standard RSE/STD/010-Part 1. All noise measurement with Cars running shall be performed over the Northern Line on track conditions defined in Company Standard RSE/STD/010-Part 1, the particular locations for tests shall be agreed with the Project Manager.

4.5.2 Equipment Noise Prior to Installation on Car

The noise produced by the individual operation of all potential noise generating equipment including, but not limited to, auxiliary converters, chopper equipment, resistor blowers, air compressors, door operators, lighting inverters, air conditioning and ventilation equipment prior to installation onto Cars, shall be declared by the Contractor during design scrutiny. All equipment shall be type tested against these levels prior to installation onto Cars. All duct work, baffles, or appurtenances thereto forming an integral part of the installed assembly shall be included as part of the equipment for the purpose of noise tests.

4.5.3 Driver's Exposure to Noise

In the cab, the Train Operator's noise dose must not exceed an 8 hour L_{eq} of 80 dB(A) for a worst case shift. Details of shifts including details of journeys, speed profiles, track conditions and use of horn/whistle shall be used to derive representative tests.

4.6 VIBRATION AND RIDE

4.6.1 Vibration

4.6.1.1 Vibration with Car Stationary

Equipment mounted at any position on the Cars or bogies shall not cause vibration on any portion of the Car floor, side walls, ceiling panels, stanchions, hand holds or seat frames in excess of $1 m/s^2$ between 10 to 1000 Hz. Particular attention shall be paid to rotating machines such as the compressor and ventilation fans to ensure that appropriate vibration isolation mountings are employed. The Contractor shall prove the design by means of calculation and testing.

4.6.1.2 Vibration with Car Moving

All equipment mounted on the Train shall comply with the requirements of Standard BRB/LUL/RIA 20.

4.6.2 Ride Quality

4.6.2.1 General : all ride measurements and frequency weightings shall be in accordance with BS 6841. All ride measurements for this purpose shall be carried out on the Northern Line. If air suspension is used, all airbags shall be in a correctly inflated condition for the ride measurement test.

4.6.2.2 For standing Passengers : the RMS of the root sum-of-squares of the frequency weighted accelerations in the longitudinal, lateral, and vertical directions, measured at any point on the saloon floor, shall not exceed 0.5 m/s^2 over the period of any station to station journey section.

4.6.2.3 For seated Passengers : the RMS of the root sum-of-squares of the frequency weighted accelerations in the longitudinal, lateral, and vertical directions, measured at any Passenger/seat interface shall not exceed 0.5 m/s^2 over the period of any station to station journey.

4.7 POWER SUPPLY DATA

General parameters for the Traction Supply system are given in Company Standard RSE/STD/019-Part 1.

Full details of the Northern Line supply system will be provided to the Contractor.

The layout of the current rails is defined in Company Standard RSE/STD/008-Part 1.

The current rails can vary in position in the following range:-

Lateral displacement:	±35 mm from nominal position,
Vertical displacement:	+42, -12 mm from nominal position,
Vertical discontinuities in rail head:	up to 5 mm.
Vertical angular displacement:	±20° relative to installed running rail cant

The vertical profile of the current rails, except at current rail ramps, may vary at rates of up to 25 mm/m in either direction in some cases changing instantaneously from positive to negative in sign.

4.8 TRACK DATA

4.8.1 The existing track data is specified in Company Standard RSE/STD/008 Part 1. Standards for track component parts are set out in Company Standards TE-DS-0101-A1 and TE-DS-0102A and Contract Drawings P45902, P67747 and P40023.

4.8.2 The Company and the Contractor shall ensure that the track to train interface is maintained such that the Trains' performance is not degraded or that the track condition causes premature Train equipment failure.

4.8.3 The Contractor acknowledges that the condition of the track is that in existence now (with such parameters measurable described within this section). The Trains shall be required to run on this track environment for the whole of their design life.

4.8.4 Maintenance Thresholds

4.8.4.1 The maintenance thresholds for track geometry on the Northern Line are set out in tables 4.8.4.1 a) and b). Track may be in any condition between newly laid condition and Minimum Acceptable Condition Standards (MACS) as defined in section 4.8.5 and the Safety Intervention Thresholds (SIT) as defined in section 4.8.4.2 with a normal distribution around the maintenance thresholds. This envelope of track condition shall have maintenance periodicity thresholds applied that enable the Company to have time to correct any excursion. Within this envelope, the reliability of the Trains shall as specified in section 3 of this Schedule 6, Part A.

Table 4.8.4.1 a) Maintenance Thresholds - Deviation From New Condition

Data for Positive Exceedences as measured by the TRV

Category	B
TW2M (2 m twist)	11
LTOP (Left Top)	15
RTOP (Right Top)	15
ALIN (Alignment)	10
GAUG1432 (Gauge)	*
CORR (Corrugation)	*
ALPP	25
TW10M (10 m Twist)	33
WUNLOAD (wheel unloading)	60
DN XLVL	10

Table 4.8.4.1 b) Maintenance Thresholds - Deviation From New

Data for negative exceedences as measured by the TRV

Category	B
TW2M	-11
LTOP	-15
RTOP	-15
ALIN	-10
GAUG1432	*
CORR	*
ALPP	-25
TW10M	-33
WUNLOAD	-60
DN XLVL	-15

N.B. 1) Items marked * are measurements (not exceedences) made by the TRV.
2) All dimensions in millimetres except WUNLOAD which is %.

4.8.4.2 Safety Intervention Thresholds

4.8.4.2.1 General

SITs are applied to WUNLOAD (WU), TW2, ALIN , LTOP and RTOP. Where SITs are exceeded rectification work to repair the condition in that location is as detailed in table 4.8.4.2.1 below:-

Table 4.8.4.2.1 - Safety Intervention Thresholds and Corrective Action Timetable

≥ 90% - 100% WU	Initiate corrective action within 24 hours.
≥ 70% - 89% WU	Initiate corrective action within 4 weeks of receipt of analogue data from the track assessment engineer in order of priority.
≥ 60% - 69% WU	Initiate corrective action within 8 weeks of receipt of analogue data from the track assessment engineer in order of priority based upon percentage increase in WU since last TRV run.
≥ 20 mm 2 m Twist	Initiate corrective action within 4 weeks of receipt of analogue data from the track assessment engineer.
≥ 30 mm Alignment	Initiate corrective action within 8 weeks of receipt of analogue data from the track assessment engineer.
≥ 20 mm Top	Initiate corrective action in order of priority after completion of above.

4.8.4.2.2 Sections of permanent way exist where it is not possible to correct SITs due to structure gauge or other conditions.

4.8.4.2.3 A TW10M exceedence does not independently invoke rectification work, rectification work is carried out if the TW10M exceedence contributes to a WU exceedence.

4.8.4.2.4 The SIT wheel unloading percentage ranges expressed in table 4.8.4.2.1 are the percentages of the maximum wheel unloading criterion as specified for the Trains in Section 11 [sub-section 113.3.3] of this Schedule.

4.8.5 Minimum Acceptable Condition Standard (MACS)

The Company shall undertake immediate remedial action upon finding any of the conditions defined in the following MACS table.

Critical Aspect	Critical Condition	Substantiating Condition
Plain Line Running Rail	Running rail head side-cut	Wear over limit
	Vertical wear of running rail	Wear over 21 mm where Company trains operate
	Broken running rail	Portion of rail missing. Rail cracked through full section
	Defective running rail	Visible crack not through full rail section. Wheel burns on squats
	Flame cut rail ends or fishbolt holes	Any part of rail end or fishbolt hole flame cut
Check Rail	Check rail gauge	Check rail gauge not within tolerance range of 1373 mm to 1397 mm
	Flange gap	Flange way gap not within +6 mm - 0.0 mm of the required dimensions (44 mm, 47 mm or 60 mm as specified)
	Height of check rail above head of low rail	Height difference exceeds 25 mm
	Missing keys or clips	3 consecutive keys or clips missing on one rail
	Broken check rail	Continuity of check face broken.
		Portion of rail missing and check face unbroken.
		Cracked through full check rail system.

Critical Aspect	Critical Condition	Substantiating Condition
	Flame cut check rail	Any part of check rail flame cut
	Cracked check rail	Visible crack not through full section of check rail
Fishplates	Broken fishplates	Both fishplates broken.
Alignment of rail joints	Horizontal steps at joint	Step of 5 mm or more on running face of rail at joint, at running on end
	Rail end dip	Rail dip exceeds 8 mm #1
	Rail end batter	Rail batter exceeds 6 mm #2
	Wide gauge	Gauge greater than 1470 mm
	Tight gauge	Gauge greater than 7 mm tight
Switch Rail	Switch tip does not fit hard against stock rail	Gap exceeds 3 mm
	Flange way clearance	Clearance less than 50 mm
	Locked wheel ramp missing or not correctly positioned	Ramp missing. Top of ramp not between 38 mm and 48 mm of rail crown
Lead rail	Lead rail out of gauge	Lead rail out of gauge by 3 mm or more vertically
	Broken on defective lead rails	As for broken or defective section of plan line running rails (see above)
Crossing nosing	Track gauge outside limits through the crossing length	Track gauge greater than 1442 mm flat bottom (FB) or 1445 mm bull head (BH) or less than 1429 mm (FB) or 1432 mm (BH)
	Crossing nosing with piece broken out	Broken out more than 10 mm deep and 50 mm long within 100 mm of the blunt nose
	Crown of nose worn or battered, shelling surface	Wear greater than 20 mm at nominal point of nose
Wing Rails	Wear	Wear greater than 20 mm at the throat
Cover Check Rail	Tighter gauge	Gauge less than 1388 mm
	Missing keys	3 consecutive keys missing
	Chogs or chog bolts missing	Any chogs or chog bolts missing

Slipper Runs	Security	Less than 2 coach screws remaining unbroken
	Height	Slipper run out of gauge. 5 mm or more below lead rail height or 30 mm or more above lead rail height.
Conductor rails and ramps	Lateral gauge	Out of gauge laterally by more than 35 mm
	Vertical gauge	Out of gauge vertically by more than 25 mm
	Inadequate	Conductor rail lifting clear of insulator or free to move laterally or longitudinally
Train Arrestors	Gauge	Buffer beams height not above rail level 648 mm ± 75 mm
		Track gauges not in range 1430 mm to 1460 mm at arrestor

Notes:

The Company reserves the right to amend this list.

#1 and #2 the Company will normally instigate maintenance activities in these MACS categories for exceedences greater than 3 mm.

4.8.6 Track Damage

The Contractor shall ensure that the design of the Train and / or the provision of the Services do not result in damage (or increased rates of wear) being caused to the track during its operation over that track greater than that caused by Existing Trains. Track condition data recorded by the TRV and visual inspection of unrecorded parameters shall be utilised in evaluating track damage. TRV data provided by the Company prior to the Trains first being introduced onto the Northern Line shall form the basis for evaluation of the "recorded" criteria. For three months prior to the delivery of the First Train, the Company shall carry out regular checks of "unrecorded parameters" to form the basis for their evaluation.

4.8.6.1 The Company shall, on an annual basis or more frequently as agreed between the Contractor and the Project Manager, measure, using the TRV, the track standard. Should general deterioration from previously recorded data be identified then the Company shall identify the cause and institute remedial action. Should the cause be found to be wholly or in part due to the Trains, the responsibility for the costs of correction shall be chargeable to the Contractor as appropriately apportioned.

4.8.7 Control of Track Lubrication

The Contractor shall install and maintain a track and wheel lubrication system as specified in Schedule 6, Part A section 15 [157]. The settings of the lubrication system and the number in use shall be agreed between the Contractor and the Project Manager from time to time taking into account the number of Trains in service and the presence or otherwise of track based lubrication systems.

4.8.8 Temporary Track Support

During periods of maintenance work the track may be supported by temporary installed supports. These supports shall be as defined in Company Standard TE-MTS-0106-A1. The Contractor shall ensure that the design of the Train does not cause damage to the track, or such supports, or to itself, when traversing such an area provided that the Train is driven in accordance with imposed speed restrictions or other special running conditions.

4.8.9 Rail Inclination

Rail inclination is nominally 1 in 20 between limits of 1 in 18 and 1 in 22. The Contractor shall ensure that the Train can operate safely at normal operating speeds over the track falling within this rail inclination range.

4.9 KINEMATIC PROFILE

4.9.1 The Train shall be designed to comply with Company Standard RSE/STD/003-Part 3, except the kinematic profile will be that defined on Contract Drawing 88155.

4.9.2 The minimum Depot curve radius, for design purposes, is 61 m. Under-carbody equipment and the bogies shall be gauged to this minimum Depot curve radius to ensure clearances to conductor rails are not infringed with the Train in the Tare Laden condition. The Contractor shall provide the Project Manager with details of the dynamic movements of a Crush Laden Train traversing a curve of this radius.

4.9.3 The minimum operating curve radius is 90 m. This radius shall be used to assess all Car body and bogie movements in the Crush Laden condition.

4.9.4 The cant deficiency shall be 90 mm for design purposes.

4.9.5 The minimum speeds for gauging in outside sections only shall be 106 km/h. In tunnel sections the maximum speed shall be 78 km/h. Where permanent speed restrictions are in force, that speed shall only be applied if the cant deficiency is 90 mm or less. If a greater cant deficiency is derived then the speed that results in a cant deficiency of 90 mm shall be applied over that speed restriction distance.

4.9.6 Kinematic gauging assessment shall be Carried out with the Train in Tare Laden and Crush Laden conditions and for both inflated and deflated suspension conditions.

4.10 CONSTRUCTION

4.10.1 Materials

4.10.1.1 General

All materials used in the manufacture of the Trains shall comply with Company Standard RSE/STD/013 - all parts. Materials shall perform the duties for which they are designed, meet fire requirements and retain the required appearance under service conditions, with minimum maintenance throughout the Contract Duration.

Where different materials are joined or are in contact the requirements of Company Standard RSE/STD/008-Part 1 shall be met.

4.10.1.2 Fire Safety Requirements

4.10.1.2.1 General

This section details the specific requirements to be achieved for fire safety in both design and materials, to prove suitability and to demonstrate compliance with the all standards specified in Schedule 6, Part A.

The Contractor shall confirm fire safety conformity, particularly relating to:-

a) non-metallic materials,
b) safety critical electrical circuitry,
c) flammability, smoke emission and toxicity.

The information to be supplied shall be supported by test certificates from accredited laboratories or test houses which substantiate the material or design characteristics and behaviour.

Test results for all materials shall be submitted in accordance with criteria given in Company Standard RSE/STD/013.

Where the use of non-compliant materials is unavoidable, the Contractor shall restrict fuel load density by limiting such use to the minimum required. Use of non-compliant materials shall be subject to the Contractor obtaining a concession from the Project Manager. Reference to such materials in the Materials Inventory, referred to in sub-section 4.10.1.2.7, shall include details of the concessions.

The Contractor shall demonstrate measures proposed for minimising combustible material build-up in all areas of the Car and devise cleaning methods to be adopted for its removal.

4.10.1.2.2 Equipment

Where equipment with potential ignition sources is installed within the saloon, the Contractor shall ensure that suitable shields or enclosures are provided to segregate the equipment from combustible materials. The Contractor shall propose tests to demonstrate compliance for all Car types.

4.10.1.2.3 Cables

All cables shall comply with Company Standard RSE/STD/024-Part 6.

4.10.1.2.4 Battery

The battery shall be supplied in accordance to the requirements stated in section 15 [sub-section 152.5].

4.10.1.2.5 Heating Equipment

Heating elements shall be supplied in accordance to the requirements stated in section 14 [sub-section 145].

4.10.1.2.6 Arc, Arc Splash, Fire and Thermal Barriers

All arc, arc splash, fire and thermal barriers shall be in accordance with Company Standard RSE/STD/014 - Part 1. The Contractor shall identify all locations where these barriers will be located together with proof of compliance.

Fire barriers shall be provided in accordance with BS 6853.

4.10.1.2.7 Materials Inventory

The Contractor shall supply and maintain a comprehensive Materials Inventory of all materials used for all Car types for the Contract Duration. The format of the Materials Inventory shall be agreed with the Project Manager and shall include material type, manufacturing trade name, relevant fire safety test data and quantity.

The Materials Inventory shall include a hazard load analysis by Car type to assess fire risk.

The Materials Inventory shall be submitted as set out in Schedule 5.

4.10.2 Miscellaneous Components and Equipment

4.10.2.1 Switches and Indicators

All switches and Indicators shall conform to the requirements of Company Standard RSE/STD/024-Part 10.

For standardisation, as few types of switch as possible shall be used.

The Contractor shall take measures to obtain extended life of indicator lamps and to prevent excessive brightness in low ambient light levels. LED indicators shall be fully protected against power supply transients as defined in Standard BRB/LUL/RIA 12. Status of indications shall be visible in direct sunlight by design, position or shielding to the satisfaction of the Project Manager.

4.10.2.2 Keypads

All keypads used on the Trains shall be highly robust and capable of satisfactory operation under the extremes of environmental conditions defined in Company Standard RSE/STD/008-Part 1.

Materials used in the construction of keypads shall comply with the requirements of Company Standard RSE/STD/013-Part 1. Keypads shall not be degraded by cleaning materials used as defined in Company Standard RSE/STD/008-Part 2.

Membrane keypads shall provide positive tactile feedback to the user.

4.10.2.3 Fuses and Miniature Circuit Breakers

All fuses and miniature circuit breakers used on the Trains shall comply with the requirements of Company Standard RSE/STD/024-Part 9.

4.10.2.4 Relays and Contactors for Control Circuits up to 250 V AC/DC

All relays and contactors for control circuits up to 250 V AC/DC used on the Trains shall conform to the requirements of Company Standard RSE/STD/024-Part 11.

4.10.2.5 Low Voltage Auxiliary Machines

4.10.2.5.1 General

This section covers the standards for design, construction and testing of motors fed from low voltage AC or DC supplies, e.g. those used for driving fans for traction equipment cooling or Passenger saloon heating/ventilation. For the performance

requirements of a particular machine, reference should be made to the specification for the application of that machine.

4.10.2.5.2 Design Requirements Applicable to all Machines

4.10.2.5.2.1 General

All low voltage machines shall be either AC induction or brushless DC types.

Such machines shall be designed to the requirements of BS 5000 - Parts 10 & 11 except where stated.

4.10.2.5.2.2 Insulation

The machines shall be insulated to a class appropriate to their intended duty and location. During normal service, the temperature rise of any winding shall not exceed 90% of that given in table 1 of BS 5000 - Part 11.

4.10.2.5.2.3 Cooling

All low voltage machines shall be self cooling and sealed to IP65 of BS EN 60947.

4.10.2.5.2.4 Electrical Connections

The connections to the machine shall be clearly identified to prevent misconnection. Machines over 20 kg shall employ a machine mounted terminal box or socket; smaller machines may use flying leads for connection to Car wiring.

The length of "flying lead" connections on the motor shall be kept to a minimum, to avoid damage during transit or storage.

Where Car wiring connections terminated on the motor are employed, they shall be connected to the machine such that they may be replaced without the need to dismantle the machine other than removing connection box covers.

4.10.2.5.2.5 Machine Mounting

Machine installations shall be designed to permit the machines to be removed and refitted easily without any need for adjustment of their position or that of the driven equipment.

4.10.2.5.2.6 Machine Support Feet

Any machine weighing more than 20 kg shall be provided with feet or flats to provide adequate stability to prevent rolling when placed on the workshop floor or workbench.

4.10.2.5.3 Testing Requirements

Tests shall be made at the manufacturer's works to demonstrate the ability of the machine to comply with the requirements of Schedule 6 - Part A. The tests shall be performed in accordance with BS 5000 - Part 10, clause 11.

4.10.3 Paints and Finishes

All paint and coating systems used on the Train shall comply with the requirements of Company Standard RSE/STD/012-Part 1.

4.10.4 Markings, Labels and Notices

The Cars shall be marked with identification numbers and other legends for equipment and components as specified Company Standard RSE-ST-01306. The graphics and labelling design shall be agreed with the Project Manager.

4.10.5 Electrical Installation and Wiring

Cabling, wiring installations, connectors and general electrical practices to be adopted shall comply with the requirements of Company Standard RSE/STD/024.

4.10.6 Pipes and Fittings

All pipes and fittings used for pneumatic services on the Trains shall comply with the requirements of Company Standards RSE/STD/004 and RSE/STD/006.

4.10.7 Welding

All welded structures shall be manufactured in compliance to Company Standard RSE/STD/015-Part 3 for steel and BS 8118 for aluminium.

Sample welded structures will be required by the Project Manager for inspection and approval. The welded structures used on the Trains shall be in accordance with the approved samples.

Welding test data and samples may be required to be reviewed by the Company from time to time during the Contract.

4.10.8 Equipment Surface Temperatures

Where equipment enclosures are likely to get hot and are likely to be accessible to Passengers or staff the maximum surface temperature of such equipment shall not be more than 50°C.

4.11 DESIGN ASSURANCE

The requirements in respect of this are defined in paragraph 2 of Schedule 4.

4.12 ELECTRONIC EQUIPMENT AND SOFTWARE STANDARDS

4.12.1 Electronic Equipment

All electronic equipment shall comply with the requirements defined in Company Standard RSE/STD/031.

4.12.2 Software

The software used throughout the Train subsystems shall be to a common industry standard or standards.

The software and its documentation shall comply with the requirements of Standard BRB/LUL/RIA 23, Schedule 13 and Company Standard RSE/STD/031-Part 1 (with the following amendment: clause 9.1.2 (g2) - precise instructions to allow a user to create the final format of the software (i.e. ROM, EPROM or Disk etc.) from the source code supplied. Each command shall be clearly explained.

Compliance with Standard BRB/LUL/RIA 23 shall be demonstrated by the application of a software management standard, this shall be provided to the Project Manager for review prior to its use. This software management standard shall include the requirement for the identification and justification of integrity levels for both hardware and software for all systems containing software, and the techniques that are to be applied to monitor and assure that these integrity levels are both suitably and adequately applied.

Where computer to computer communications or networks are used, the network functions shall be layered according to the ISO OSI 7-layer model for networks defined in BS 6568. It is accepted that not all layers will be used, but development and enhancement at any one layer shall be accomplished without modification being required to any other layer.

Adequate information regarding all software shall be maintained and retained by the Contractor to modify or re-write all software. All such information shall be

made available to future owners and/or maintainers of the Trains and may be subject to the requirements of Schedule 17.

Software shall be divided into at least two groups:-

i) high level software which describes the performance in Train terms (applications software),

ii) low-level software to control networks, logging, housekeeping, downloading and other functions supporting the applications software (operating system).

Applications software shall be able to be modified by rolling stock engineers with basic skills in software but the operating system may require more specialised personnel to modify it. It shall not be necessary to change low-level software when modifying high-level software. Where there are specific requirements for a different skill level to accomplish a modification, these skill levels, and any training required shall be notified to the Company.

The Contractor shall ensure that the design of the Trains shall allow easy and quick application software updating or change facilities in such systems as the destination indicator or saloon indicator systems or any other system that could reasonably be expected to be subject to regular change due to operational needs.

The Contractor shall ensure that adequate unused memory is installed to allow for development and modification without the need for hardware modification.

Where there are limitations to the available memory or timing constraints, normally due to processor limitations, these will be highlighted by the Contractor.

4.13 DESIGN STYLING AND HUMAN RESOURCES

The Contractor shall be required to undertake design exercises with industry recognised consultants to produce an aesthetically pleasing design, the design shall be subject to approval by the Project Manager. The Company requires direct involvement in these exercises to ensure the product delivered is consistent with the Company's design requirements and compliant with the requirements of this Contract.

General arrangements of the saloon interior, cab and Train exterior will be required for review followed by the construction of mock ups.

The Train shall provide a safe and comfortable environment for both Passengers and Train Operators under normal and emergency conditions, section 3 refers.

Industry recognised ergonomic design standards shall be used in all areas of the Train where staff and Passengers require to use or operate facilities and/or systems.

Generally, the Contractor shall ensure all edges, internal and external corners and junctions of planes shall be softened throughout with consistent radii. All edges and corners shall be designed consistent with the needs of high Passenger safety, especially during any accident. The Contractor shall satisfy the Project Manager that all aspects have been taken into account.

The Contractor shall conduct human factor/interface demonstrations to the satisfaction of the Project Manager. These shall include:-

i) demonstration of use of all Train controls, this shall include cab and Train mock-ups for Train Operators,
ii) demonstration of all Passenger interface ergonomics,
iii) demonstration of a Fully Laden Train detrainment in a tunnel or simulated tunnel environment, this shall include all items of equipment that would normally be used in such an event.

These demonstrations may be performed using mock-ups or production samples

4.14 ELECTROMAGNETIC COMPATIBILITY (EMC)

Refer to section 10 [sub-section 104].

5. TESTING

The Trains shall be tested in accordance with the requirements of Schedule 4.

6. QUALITY ASSURANCE

The requirements for quality assurance are set out in Schedule 4.

7. DOCUMENTATION

Documentation shall be supplied in accordance with Schedule 13.

8. TRAINING AND ASSOCIATED FACILITIES

8. TRAINING AND ASSOCIATED FACILITIES

8.1 CONTRACTOR'S RESPONSIBILITIES

The Contractor shall submit an outline training programme within 6 weeks of the signature of this Contract, for the training of Company staff for the operation of the Trains.

The agreed training programme shall be developed in accordance with the requirements specified in Schedule 6, Part A. All training equipment including manuals shall be submitted for the Project Manager's approval prior to training.

8.1.1 Training Courses

The Contractor shall provide details of the training courses it proposes to offer. The courses shall cover all aspects of the Trains as described in Schedule 6, Part A:-

i) introductory courses - overview of operations,
ii) technical appreciation - module operations, operational diagnostics, testing and routine inspections,
iii) specialist technical appreciation - (in conjunction with maintenance manuals prepared under the Contract), equipment standards and fault finding to allow the Company to have a full appreciation of the systems operation and maintenance,
iv) training of the Company's Operator training staff, this shall include fault and failure training,
v) training of the Company's train audit staff,
vi) training of the Company's breakdown/recovery staff.

Allocation of days of training to each of the items above shall be agreed with the Project Manager. The Contractor shall perform a training needs analysis to determine the exact requirements.

Training of instructors may take place at the Contractor's or sub-contractors premises as far as is reasonably practicable, however the Contractor may request permission to use Company premises.

8.1.2 Documentation

Full training documentation shall be provided by the Contractor. This includes training manuals and audio-visual training aids for use in conjunction with each of the above courses.

The Contractor shall provide 5 sets of full documentation, training manuals and audio-visual training aids for the subsequent use of Company or other's training staff, this shall include any manuals that would be used during normal operations.

8.1.3 Timing

The Contractor shall submit a detailed programme for approval not later than 20 weeks from the signature of this Contract. Course attendees on each training day shall be agreed and the training programme finalised not later than 26 weeks before the physical delivery of the First Train.

8.1.4 Training Equipment

The Contractor shall provide a list of training equipment which is recommended to be held by the Company for use by Company instructors to train other staff.

If any equipment involves computers or similar equipment, then the Contractor shall indicate any compatibility requirements.

8.2 CAB SIMULATOR

8.2.1 General

8.2.1.1 The Contractor shall provide and maintain a cab simulator for use by the Company in training its staff in the operation of the Trains.

8.2.1.2 The Contractor shall agree with the Project Manager the scope of the training requirements to be provided by the cab simulator.

8.2.1.3 The cab simulator shall consist of two replicas of a cab interior and two instructor interfaces, one for each cab. Each cab and its instructor interface shall operate independently of the other except for when specified otherwise in the Contract. Each cab shall face a projection screen which shall be visible through any cab front door and window. Projected onto this screen shall be a computer generated image of the Northern Line showing the view that a Train Operator will have when driving a Train. The size of the projected image shall be agreed with the Project Manager.

8.2.1.4 The cab simulator shall model the actual functionality of a Train including the effects of gradient and Passenger load and the operation of cab equipment in all modes of operation available on a Train. Projected views shall be synchronised so as to provide realistic visual feedback of the effects on the view ahead of the Trains movement as determined by trainee or instructor action.

The projected image, representative of the Northern Line, shall include major features such as large buildings, cuttings, embankments, in their relevant locations, etc., that are in the viewing range of the Train Operator.

The features to be included shall be subject to approval by the Project Manager.

8.2.1.5 The cab simulator shall provide audio feedback to the trainee. The feedback shall represent actual tunnel and open section running and shall include sounds caused by the Train/track interface (wheel rail interface, points and crossings, track joints), lineside features (bridges, stations, other close by buildings), passing Trains travelling in the opposite direction.

Audio feedback shall be provided for Train generated noises including motor/traction package noise, saloon audio systems (auto announcer, saloon door warnings, etc.).

The sounds shall be realistic and shall be at volumes consistent with the sound levels experienced in actual running on the Northern Line, and shall include the effects on those sounds of acceleration and deceleration.

All sounds used and their usage shall be subject to approval by the Project Manager.

8.2.1.6 The cab simulator shall provide tactile feedback to the trainee of the acceleration and deceleration rates in effect at any given moment in the operation of the simulator. The method of providing this feedback shall be agreed with the Project Manager.

8.2.1.7 Communication between the instructor and trainee during an exercise shall be by the simulated Radio system (Enhanced Existing VHF or Final UHF Trunked Radio as appropriate).

8.2.1.8 The instructor interface shall be menu driven and user friendly. It shall require the minimum practicable number of actions to enable or disable any facility provided or any routine provided within that facility.

8.2.1.9 Each instructor interface shall be provided with a monitor providing feedback to the instructor of the actions of a trainee whilst in a cab. The instructor shall be provided with separate monitors showing the view ahead as seen by the trainee, any view seen on the CCTV monitor in the cab and any information on the cab information monitor.

8.2.1.10 The instructors shall be provided with a simple mechanism for determining the section of the railway over which the trainee is to be required to be trained, and shall be provided with information containing the location of the Train in the simulated area and its speed.

The instructors shall be able to generate faults that can occur on a Train. The instructor shall be able to select which Car that the fault is to occur on and shall be able to cause, either when setting up the training exercise, or at any time during the

exercise, that fault to be simulated, with the actual effects on a Train being simulated in the cab simulator.

8.2.1.11 The instructors shall be able to, either when setting up a training exercise or during an exercise, set the status of any signal within the exercise area. This shall include faulty signal status (such as both red and green aspects showing simultaneously or no aspect being shown at all). When passing any signal at any signal status, the simulated Train shall react as it would on the real railway.

8.2.1.12 The instructor shall be provided with facilities for selecting the traction characteristic to be simulated (Existing Train performance or final performance) and the Passenger load of each Car in the Train being simulated.

8.2.1.13 The instructor shall be provided with the facility to pre-record and save on the system up to 10 exercises. These exercises shall be able to be loaded onto a recording format for saving off system or may be overwritten by new exercises when required.

The instructor shall be provided with a paper print out of the history of the most recent exercise undertaken by a trainee. This shall include details of Train Operator actions and instructor generated faults. The print out shall be generated on specific request by the instructor.

8.2.1.14 Facility shall be provided to allow the instructor to change data related to Train performance, ATP signalling and ATO.

8.2.1.15 The trainees (up to 10 simultaneously) shall be provided with a facility to, at any time during the exercise, to identify up to 3 locations within the exercise and be able, during replay of the exercise to select those locations.

Selection of a location shall cause the replay to fast forward/reverse to that location and then pause, replay slowly frame by frame or at normal speed as selected by the instructor.

All facilities shall be protected against unauthorised use. Levels of access to the facility for operation or change shall be subject to approval by the Project Manager and shall include physical protection and multilevel password control as appropriate.

8.2.2 Cab Simulator Environs

8.2.2.1 The cab simulator shall be provided with an air conditioning system. The system shall ensure that the cab simulator maintains a working environment suitable for the personnel and equipment within it. The system shall not use Freon as a coolant.

The cab simulator shall be suitable for operating from a single phase of three phase 240 V AC 50 Hz electrical supply subject to the normal tolerances of such a system.

8.2.2.2 A camera or cameras shall be located in each cab to provide real time monitoring of trainee by the instructor on a dedicated monitor in the instructor interface area. A video recorder per interface shall be provided to record and playback these pictures if required.

8.2.2.3 The cab simulator shall be provided with a UPS suitable for ensuring the cab simulator can operate for 15 minutes following the loss of mains power. Alarms shall be fitted to enable the instructor to know that the UPS is providing power so that any cab simulator computer equipment can be shutdown without damage or loss of data.

8.2.2.4 The Company shall undertake for any enabling works for any facility or utility required for the correct working of the cab simulator.

8.2.2.5 The Contractor shall provide suitable lighting, emergency lighting, fire alarm systems, fire extinguishing equipment and emergency exits to ensure that the risk to personnel and equipment is minimised to the satisfaction of the Project Manager. A first aid equipment enclosure and first aid equipment shall be located within the instructor interface area of the cab simulator.

8.2.2.6 Each instructor interface area shall be provided with adequate space and chairs of good quality and ergonomic standard to ensure the instructors remain comfortable over a normal working shift.

8.2.2.7 The Contractor shall install filing cabinets and/or other storage equipment to allow archiving of records and manuals and desk space for the instructors.

8.2.2.8 The cab simulator shall be capable of operating continuously for 20 hours per day, seven days a week.

8.2.2.9 The Contractor shall agree with the Project Manager the periodicity of any maintenance requirements. These shall be interlaced with the requirements for training so as to not disrupt any Company training programme.

8.2.3 Cab Simulator and Modification

8.2.3.1 The Contractor shall, throughout the Contract Duration, make any modifications necessary to the cab simulator to ensure that it matches the Train's modification status. The Contractor shall discuss and agree with the Project Manager the extent of any modifications required. This requirement shall include any manuals or documentation provided as training materials.

9. MAINTENANCE AND RECOVERY

The Contractor shall be responsible for maintaining the Trains for the Contract Duration. The Contractor shall design the Trains to allow the requirements of Schedule 6, Parts G and H to be achieved.

The Contractor shall demonstrate that the Train can be recovered satisfactorily from a number of potential failure or breakdown conditions. These shall include, but not be limited to, the following:-

i) re-railing following a range of Car related derailments,
ii) a Push Out situation with a percentage of parking brakes applied,
iii) a Push Out using an Existing Train,
iv) a Push Out of an Existing Train by a Train.

The Contractor shall, from time to time, participate in and provide staff, Trains and/or Existing Trains to take part in emergency training exercises.