DRAFT

GOVERNMENT OF INDIA

MINISTRY OF RAILWAYS

Specification and Standard

For

IGBT Based WAG9 Locomotive

Specification No. RDSO/2011/EL/SPEC/0111, Rev.'1'

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Approved by	Signature
EDSE(C)/RDSO	

ELECTRICAL DIRECTORATE

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1.	June'12	6, 30, 31, 32, 33, 34, 35, 36, 39, 40, 42, 44 and 45	1	Definition of Company and Procured revised; clauses 4.6.1, 4.6.12, 4.9, 4.10, 4.14, 4.15.1, 4.16, 4.17.1, 4.18, 4.22, 4.26, 4.27.4, 4.27.6, 4.31.4 and 4.34 revised
2.				
3.				
4.				

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ABBREVIATIONS

The following abbreviations are used in this and Specification and Standard.

Abbreviation	**Full Name**
AC	Alternating Current
ASIC	Application Specific Integrated Circuit
BS	British Standard
CLW	Chittaranjan Locomotive Works
CSC	Constant Speed Control
DC	Direct Current
EMC	Electro-magnetic Compatibility
EMI	Electro-magnetic Interference
EN	Euro Norm (European Standard)
GPS	Global Positioning System
GTO	Gate Turn-Off Thyrister
HP	Horse Power
HT	High Tension (Voltage) (according to Indian Electricity Rules)
HV	High Voltage
IC	Integrated Circuit
IEC	International Electro Technical Commission
IEEE	Institution of Electrical and Electronic Engineers
IGBT	Insulated Gate Bipolar Transistor
IP	Ingress Protection
IR	Indian Railways
IS	Indian Standard
ISO	International Standard Organization
LED	Light Emitting Diode
OHE	Over Head Equipment
PCB	Printed Circuit Board
PTFE	Polytetrafluoroethylene

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RAMS	Reliability, Availability, Maintainability and Safety
RDSO	Research Designs & Standard Organisation
SMI	Special Maintenance Instruction
MS	Modification Sheet
TC	Technical Circular
STR	Schedule of Technical Requirement
UHF	Ultra High Frequency
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
VCB	Vacuum Circuit Breaker
VCU	Vehicle Control Unit
VHF	Very High Frequency
WAG	Wide Gauge AC Goods locomotive

DEFINITIONS AND INTERPRETATION

Definitions

In this Specification and Standard, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

Term	**Definition**
Company	Shall mean firm or company with whom the order for supply of Locomotives has been placed or intended to be placed.
Category Book	shall mean list of equipments procured by CLW from trade for manufacturing of WAG9 locomotive containing equipment name, specification/drawing number, quantity required per loco and other details
Design Package	shall have the meaning set forth in Clause 1.5.3 of this Specification and Standard
FB cubicle	shall mean filter cubicle
Government	President of the Republic of India as represented by the IR entering into the contract
HB cubicle	shall mean auxiliary cubicle
IP	shall mean degree of protection provided by enclosures according to IEC 60529
Locomotive(s)	shall mean IGBT based WAG9 locomotive(s) manufactured in accordance with this Specification and Standard
L-10	shall mean life of bearing in accordance with ISO 281
Manufactured	shall mean system/subsystem/equipment manufactured by the Company after the clearance given by the Government after capacity and capability assessment by RDSO/CLW to verify that the Company complies with RDSO's/CLW's STR where ever applicable; and after successful type tests. This shall be only applicable for the items where the Company is not an approved source of RDSO/CLW
Procured	shall mean system/subsystem/equipment purchased by the Company in accordance with CLW's or RDSO's specification from latest approved sources of CLW or RDSO. The latest approved sources are available on RDSO's official website www.rdso.indianrailways.gov.in and CLW's official website www.clw.indianrailways.gov.in. This shall be only applicable for the items where the Company is not an approved source of RDSO/CLW. In case the Company is approved source of RDSO/CLW, it can use its own make system/subsystem/equipment
Propulsion Equipments	shall mean traction converter, auxiliary converter, vehicle control unit along with associated cooling systems, driver display and traction motor speed sensor
Routine Tests	shall have the meaning set forth in Clause 5.1.2 of this Specifications and

	Standard
SB cubicle	shall mean control cubicle
Tests	shall mean the tests set forth in Chapter 5 to determine the conformity of the Locomotive with the provisions of this Specifications and Standard
Type Tests	shall have the meaning set forth in Clause 5.1.2 of this Specifications and Standard

Interpretation

Unless specifically identified to the contrary all obligations in this Specifications and Standard shall be obligations of the Company and for the avoidance of doubt where in this Specification and Standard it states that the Locomotive or any constituent parts shall or will meet a certain requirement, the achievement of this requirement shall be an obligation of the Company.

CHAPTER -1

GENERAL DESCRIPTION

1.1 Introduction

1.1.1 This Specification and Standard define the design, manufacture, delivery, testing and commissioning of the Locomotive.

1.1.2 The purpose of this Specification and Standard is to develop additional indigenous sources for manufacture of electric locomotives. It is the intention to develop Locomotives generally similar in structure and construction to WAG9 type, the manufacture of which is being done at CLW. The Company shall ensure identical or same design of superstructure, bogie, electrical equipments etc. and propose equivalents and alternate designs only where the existing sources of equipment are inadequate.

1.2 Standards

1.2.1 The standards/legislation applicable and relevant to the Locomotives and to the Propulsion equipments shall be:

(a) Standards mentioned in Annex 1 of this Specification and Standard;

(b) IEC publications;

(c) EN;

(d) UIC;

(e) AAR;

(f) IEEE; and

(g) IS.

1.2.2 In the event of any contradiction in the aforesaid standards, the following standards shall have priority in the order listed:

(a) Standards mentioned in this Specification and Standard;

(b) IEC/EN/UIC/AAR publications; and

(c) IS.

1.2.3 For the avoidance of any doubt, in case of any conflict between the requirements of these standards and Specification and Standard, the stipulations of this Specification and Standard shall have precedence. Clarification of any conflict shall be sought from the Government.

1.2.4 The Propulsion Equipments shall comply with and enable the Locomotive to comply with the following standards:

Item No	Standard Title		Standard No
1.	Railway applications – Rolling Stock - Testing of rolling stock on completion of construction and before entry into service	:	IEC 61133
2.	Railway Applications – Power Converter installed on board rolling stock – characteristics and test methods	:	IEC 61287
3.	Electronic equipment used on rail vehicles	:	IEC 60571
4.	Electronic traction – Rotating electrical machines for rail and road vehicles – Part 2: Electronic convertor-fed alternating current motors	:	IEC 60349 –2
5.	Railway application – rolling stock – Part 1: combined testing of inverter fed alternative current motors and their control system	:	IEC 61377-1
6.	Electric railway equipment – Train bus – Part 1: Train communication network	:	IEC 61375-1
7.	Rotating electrical machines – Part 18: Functional evaluation of insulation systems	:	IEC 60034-18
8.	Railway applications - electromagnetic compatibility - emission and immunity of the signalling and telecommunications apparatus.	:	EN 50121
9.	Railway applications – electromagnetic compatibility – Part 3-2: rolling stock – Apparatus	:	EN 50121-3-2
10.	Railway applications – electromagnetic compatibility – Part 2: emission of the whole railway system to the outside world	:	EN 50121-2
11.	Railway applications – compatibility between rolling stock and train detection system	:	EN 50238
12.	Railway applications – Traction transformers and inductors on board rolling stock	:	IEC 60310
13.	Low-voltage switchgear and control gear – Part 1: General rules	:	IS 3231 / ICE 60947
14.	Conductors of insulated cables	:	IEC 60228 / IS

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Item No	Standard Title		Standard No
			10810
15.	Railway applications – rolling stock equipment – shock and vibration test	:	IEC 61373
16.	Programmable controllers – Part 3: Programming languages	:	IEC 61131
17.	Railway applications – electric equipment for rolling stock	:	IEC 60077
18.	Railway application – rolling stock protective provisions against electrical hazards	:	IEC 61991
19.	Rotating electrical machines	:	IEC 60034
20.	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V	:	IEC 60871
21.	Environmental testing – Control cubicle	:	IEC 60068
22.	Degree of protection provided by enclosures (IP Code)	:	IEC 60529
23.	Railway applications. Rolling stock. Rules for installation of cabling.	:	EN 50343
24.	Electronic components – Reliability – Reference conditions for failure rates and stress models for conversion	:	IEC 61709
25.	Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)	:	En 50126/ IEC 62278
26.	Railway applications – Rolling stock equipment – Capacitors for power electronics	:	IEC 61881

Table 1 - Standard

1.2.5 The latest version of the aforesaid standards which have been published at least 30 (thirty) days before the date of opening of tender shall be considered applicable.

1.2.6 Where the aforesaid standards are based on ambient and environmental conditions which are less onerous than those stated in this Specification and Standard, the conditions stated in this Specification and Standard shall be applied in the design and testing of the Product and the requirements of the aforesaid standards shall be adjusted accordingly.

1.2.7 The requirements listed in this Specification and Standard are the minimum requirements. The Company may adopt alternative internationally recognised codes, standards and specifications if it can demonstrate to the Government that such alternative is more onerous or more pertinent to the Products or the Locomotive than the standards specified in this Specification and Standard. The Company shall seek the prior approval of the Government for any alternate standard which is proposed to be used.

1.3 Quality of materials, manufacturing processes and workmanship

1.3.1 All materials (including surface coatings, metals, insulants, adhesives, fluids, grease etc.) used in the construction of the Locomotive shall not give rise to health hazards for crew and staff. The materials shall also be suitable for standard repair operations such as those currently used by the Government (e.g. welding, cutting etc.) without the need for staff to be protected by other than standard means.

1.3.2 Materials shall be suitable for disposal without any special precautions.

1.3.3 Materials used for the Locomotive shall be appropriate for achieving the Design Life of the Locomotive.

1.3.4 The welding of the locomotive shell shall be undertaken in accordance with the Welding Procedure Specification numbers A0326-0001 to A0326-0030 and A0713-0001 to A0713-004 (which are referenced in Annex 1 of this Specification and Standard) or equivalent procedures developed in accordance with internationally recognised standards.

1.4 RAMS

1.4.1 The Company shall conduct a RAMS assessment for the Propulsion Equipments in accordance with the requirements of EN50126, to demonstrate that the targets and requirements stipulated in Chapter-3 of this Specification and Standard have been satisfied.

1.4.2 The Company shall produce all necessary reliability, availability, maintainability and safety documentation to address the requirements of EN50126 and to assist the Government to maintain the performance of the Products over the entire Design Life of the Locomotives.

1.5 Design Approval

1.5.1 The Company shall produce to the Government, the Design Package within 120 (0ne hundred and twenty) days of the date of the Agreement.

1.5.2 The Design Package shall contain sufficient design documentation to demonstrate how the Company proposes to satisfy the requirements of this Specifications and Standard. As a minimum this package will include the following.

1.5.1.1 Clause by Clause commentary against the Specifications and Standard describing the proposed design of the Propulsion Equipments;

1.5.1.2 list of standards applied to the design and construction of Propulsion Equipments;

1.5.1.3 a list of any single point failures that will cause a loss of power of $1/6^{th}$ (one sixth) or greater of the traction power (as per Clause 3.12.2 of the Specifications and Standard;

1.5.1.4 all design documentation necessary to verify compliance with the Specifications and Standard, including the specific requirements detailed in Annex 3 of this Specification and Standard;

1.5.1.5 Type Test procedures;

1.5.1.6 Routine Test procedures;

1.5.1.7 Quality Assurance Plan (QAP);

1.5.1.8 maintenance manual; and

1.5.1.9 operating manual.

1.5.3 As a minimum, the QAP shall include following.

1.5.3.1 Inspection plan and bill of material for raw material required for Manufactured items;

1.5.3.2 process of manufacturing for Manufactured items;

1.5.3.3 inspection plan for Procured items; and

1.5.3.4 stage inspection plan for Locomotive.

1.5.4 All designs and drawings shall be supplied in hard copy, in duplicate, and in electronic form on compact disk (CD) / digital video disk (DVD), along with the software and two sets of hardware to read and edit the same. All drawings shall be provided in auto cad format.

1.5.5 One set of maintenance and operating manual shall be supplied per 05 (five) Locomotives in hard copy.

1.5.6 All designs and drawings shall be in English.

1.5.7 Approval of design shall be given by RDSO within 60 (sixty) days of submission of all design details in accordance with this Clause 1.5 of this Specification and Standards.

1.5.8 Approval of design means approval of general design features. Notwithstanding the approval, the Company shall wholly and completely be responsible for the performance of the Locomotive.

1.5.9 For the purpose of technical decisions on improvement / modifications etc. on the Locomotive, RDSO shall be the final authority from Government's side.

CHAPTER-2

OPERATING AND SERVICE CONDITIONS

2. General

2.1 The Locomotives shall achieve the safety and reliability targets defined in Chapter-2 of this Specification and Standard whilst satisfying the operating and service requirements detailed in this Chapter-2 of this Specification and Standard.

2.2 Whilst the majority of the interfaces and environmental conditions are described in the following clauses, the Company shall independently ensure that all interfaces, operating and service conditions are considered.

2.3 The environmental conditions described in this Chapter-2 of this Specification and Standard shall override any environmental conditions described in any specifications referenced in Annex-1 of this Specification and Standard.

2.4 Operating Routes

The existing WAG9 locomotive is permitted to operate on all 25kV electrified routes in India. The Locomotive shall be able to operate on these routes under the operating and service conditions described in this **Chapter 2** of this Specification and Standard.

2.5 Gauging

The Products and in particular the locomotive shell and any externally mounted equipment shall satisfy the requirements of RDSO Drg No. SKEL-3917.

2.6 Electrification Supply System (including regeneration)

2.6.1 The overhead line power supply conditions within which the Locomotives shall operate are:

Description	**Values**
Nominal supply voltage	22.5 kV, 50 Hz, single phase, AC
Normal variation in supply voltage	19 kV to 27.5 kV
Occasional maximum voltage	31 kV
Occasional minimum voltage	16.5 kV
Variation in supply frequency	± 8% (46 to 54 Hz)
Neutral Sections	After every 25 to 50 Km
Types of Neutral sections	(i) 41 m in length having insulated over lap on both end and neutral wire in between which is not earthed; and
	(ii) Short neutral sections of approximately 4.61 m and 9.6 m length having an insulated portion (of PTFE) on both sides and middle portion of neutral section which is solidly earthed.

Description	Values
Pantograph bounce	Up to 45 ms

Table 3 – Electrification Supply

Note: The occasional maximum and occasional minimum voltage may persist for 15 minutes.

2.7 Signal and Telecommunication

2.7.1 The tracks are equipped with DC track circuits, $83^1/_3$ Hz AC track circuits as well as other AC track circuits at higher frequencies. Similarly, other devices such as axle counters, block instruments and points machines may also be employed. On the communication network, control circuits, teleprinter circuits, as well as VHF/UHF and micro-wave circuits are employed.

2.7.2 The Locomotive shall:

(a) by compliance with Clause 2.8.3 of this Specification and Standard, be compatible with the signalling and telecommunications systems on the operating routes identified in Clause 2.4 of this Specification and Standard or on adjacent lines and shall not affect the safe operation of these systems even under fault conditions of the Locomotive; and

(b) not place staff working on signalling and telecommunication equipment under personal risk even under fault conditions of the Locomotive.

2.7.3 The Locomotive shall not cause electrical interference exceeding the levels specified below at any point on the operating routes identified in Clause 2.4 of this Specification and Standard or on adjacent lines under all modes of operation (including multiple operation), including failure modes:

No	Interference Current	Overall Limit
1.0	Psophometric current AC traction	10.0 A
2.0	DC component in AC mode	4.7 A
3.0	Second Harmonic component (100 Hz) and $83^1/_3$ Hz component in AC traction	8.5 A
4.0	1400 Hz up to 5000 Hz	400 mA
5.1	>5000 Hz up to 32000 Hz	270 mA
5.2	39500 Hz up to 43500 Hz	270 mA

Table 4 - Interference Current Limits

(Note: The measurement of the interference current shall be taken in the track return current circuit of the Locomotive.)

2.7.4 The Company shall undertake FFT (Fast Fourier Transformation) analysis of the total current from 1000Hz to 5000Hz and 5kHz to 50kHz separately to find out the frequencies which produce the highest currents within each bandwidth. In the frequency bands >32000Hz to <39500Hz and >43500Hz to 50000Hz the frequencies at which the current values exceed 270mA shall be identified. This

test shall be included within the tests listed within Schedule 7 and the results shall be provided in a Type Test report.

2.7.5 EN 50238 is currently under revision and shall include interference current limits for track circuits and axle counters. Where these overall interference current limits are more onerous than those stated in Clause 2.7.3 of this Specification and Standard these limits shall be applied subject to provisions made in Clause 1.2.6 of this Specification and Standard.

2.8 EMC

2.8.1 The Locomotive shall comply with the EN 50121 series of Railway Electromagnetic Compatibility standards and EN 50238.

2.8.2 The Company shall prepare, implement and maintain an EMC Management Plan in accordance with the standards referenced in Clause 2.8.1 of this Specification and Standard.

2.9 Temperature

2.9.1 The Locomotive shall remain fully operational across the following ambient temperature range:

(a) maximum temperature: 50 ºC (degrees Celsius); and

(b) minimum temperature: -10 ºC (degrees Celsius).

2.9.2 The maximum temperature of any exposed surfaces shall be limited through the application of suitable measures to ensure the reliable operation of the Products and eliminate hazards to operating and maintenance staff and other third parties.

2.9.3 When developing the Propulsion Equipments, it shall be noted that:

(a) the existing WAG9 locomotive experiences touch temperatures of 75 ºC (degrees Celsius) in direct sunlight and 55 ºC (degrees Celsius) in the shade;

(b) the temperature inside the existing WAG9 locomotive reaches 70 ºC (degrees Celsius) in summers when standing in direct sunlight in un-energised conditions; and

(c) the temperature inside the existing WAG9 Locomotive adjacent to the electronic cards reaches 65 ºC (degrees Celsius) in summer whilst operating in service.

2.10 Humidity

The Locomotive shall remain fully operational with ambient humidity levels up to 100%.

2.11 Sand and dust

It shall be possible to operate the Locomotive through extremely dusty terrain (including deserts), where the dust concentration may reach a high value of 1.6 mg/m^3 and have a high saturation of conductive particles.

2.12 Rainfall

2.12.1 The Locomotive shall remain fully operational during the rainfall typically experienced across the operating routes identified in Clause 2.4 of this Specification and Standard.

2.12.2 The Locomotive shall be able to operate at 10 km/h in flood water of 102 mm above rail level.

2.13 Snowfall

The Locomotives shall remain fully operational during the snowfall which may be experienced on any part of the operating routes identified in Clause 2.4 of this Specification and Standard.

2.14 Salinity

The Locomotives shall be required to operate in a humid and salt laden atmosphere with pH value of 8.5, sulphate of 7 mg per litre, concentration of chlorine 6 mg per litre and conductivity of 130 micro Siemens/cm. The design of the Propulsion Equipments shall fully consider the risk of corrosion and measures shall be implemented to ensure and maintain the Design Life of the Locomotive.

2.15 Solar Radiation

The Locomotive shall be exposed to solar radiation and the design of the Propulsion Equipments shall take this into consideration to ensure that this does not have a detrimental effect on the operation of the Locomotive. A minimum value of $1kW/m^2$ shall be applied.

2.16 Altitude

The altitude at which the Locomotive shall operate shall vary from sea level to 160m above mean sea level.

2.17 Vibration

2.17.1 The vibration and shock levels recorded on the traction motors fitted to the existing WAG9 locomotive are generally more than the limits given in IEC 61373. High level of vibrations above 30g and 39g have been measured at the traction motor rotor and stator respectively, which occasionally increase up to 300g and 89g respectively with worn gear-pinion.

2.18 Train and Locomotive Resistance Data

The train resistance and locomotive resistance data as followed by IR is given below:

i) Train resistance (of BOXN wagon excluding Locomotive)

a) Main starting resistance on level tangent track (including acceleration reserve) = 4.0 (in kg/tonne)

b) Main running resistance on level tangent track = $0.6438797 + 0.01047218 V + 0.00007323 V^2$ (in kg/tonne), where V is speed in Km/h

ii) Grade resistance = 1/G x 1000 (in kg/tonne), where G is gradient (e.g. G=200 in case of 1 in 200 gradient)

iii) Curvature resistance = 0.4 x curvature in degree (in kg/tonne)

iv) Locomotive resistance:

a) Starting resistance on level tangent track = 6.0 (in kg/tonne)

b) Running resistance on level tangent track = 0.647 + 13.17/W + 0.00933V + 0.057/WN x V^2 (in kg/tonne)

Where W = Axle load of the Locomotive in tonne

N = Number of Axle

V = Speed in Km/h

CHAPTER-3

PERFORMANCE REQUIREMENTS

3. General

3.1 The Locomotive shall achieve the performance requirements contained in this Clause **3** of Specification and Standard.

3.2 Unless explicitly stated in this Clause 3 of Specification and Standard the performance of the Propulsion Equipments and the subsequent performance of the Locomotives shall satisfy the performance requirements stated in this Clause 3 of Specification and Standard across all likely combinations of operating and service conditions stated in Clause 2.4, 2.6 and Clause 2.9 to 2.17 inclusive of this Specification and Standard .

3.3 Where specific requirements relating to the performance of the Propulsion Equipments are not provided in this Specification and Standard the performance shall be at least as good as the current design of the Existing WAG9 Locomotive.

3.4 Dimensions

3.4.1 The outline dimensions of the Locomotives shall be as per the existing WAG9 locomotive.

3.4.2 The outline dimensions of the Locomotives shall also meet the requirements of Clause 2.5 of this Specification and Standard .

3.5 Traction Performance

3.5.1 Across the range of 21.5 kV to 27.5 kV line voltage and with half worn wheels, the Locomotives shall be capable of the following performance.

	Parameter	**Requirement**
(i)	Starting tractive effort under dry rail condition up to speed not less than 10 Km/h	Not less than 510 kN
(ii)	Continuous rated speed (constant power)	Not more than 50 Km/h
(iii)	Max. design speed	110 Km/h – with fully worn wheels
(iv)	Max. operating speed	100 Km/h – with fully worn wheels
(v)	Continuous rated power at rail	Not less than 4.5 MW at all speeds from continuous rated speed to maximum design speed

Table 5 – Locomotive Performance

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3.5.2 There shall be no significant reduction in the starting tractive effort from that stated in Table 5 of this Specification and Standard across the voltage range specified in Clause 2.6 of this Specification and Standard.

3.5.3 The efficiency of the traction converter (line side converter and drive side inverter) shall not be less than 97% under full load and at the continuous rated speed. Similarly the efficiency of the auxiliary shall not be less than 96% under full load. In each case the efficiency shall be computed from parameters measured at conditions corresponding to full load and governed by IEC 61287-1 for traction converter and auxiliary converter.

3.5.4 In inching mode, at a constant speed settable by the driver in steps of 0.1 Km/h, in the range of 0.5 to 1.5 Km/h, it shall be possible for the WAG9D Locomotive to haul loads up to 7500 tonnes on a gradient of 1 in 1000 or flatter.

3.5.5 In shunting mode at speeds up to 15 Km/h it shall be possible for the Locomotive to haul loads up to 7500 tonnes on a gradient of 1 in 1000 or flatter.

3.6 Braking Performance

3.6.1 The performance of the regenerative brake of the Locomotive shall satisfy the following requirements

Parameter	**Requirement**
Regenerative Brake Force	Not less than 260 kN over the speed range of 10 Km/h to 62 Km/h without sliding, and as close as possible to 260 kN at higher speeds

Table 6 - Braking Performance

3.7 Jerk Rate

3.7.1 The starting tractive effort of the Locomotive shall be applied gradually without producing jerks in the train being hauled by the Locomotive.

3.7.2 For the existing WAG9 locomotive the rate of change of tractive effort is limited to 20 kN/second. This level of control shall be applied to the Locomotive and it shall be maintained throughout the tractive effort curve.

3.7.3 For the existing WAG9 Locomotive the rate of change of breaking effort is limited to 100 kN/second. This level of control shall be applied to the Locomotive and it shall be maintained throughout the braking effort curve.

3.8 Noise

3.8.1 The Locomotives shall satisfy the following requirements:

(a) Stationary Locomotive

The noise level inside the cab shall not exceed 70 dB(A) with all auxiliary equipment including cab air conditioner operating at its greatest noise output. The noise level shall be measured in the cab along the centre line between 1200 mm and 1600 mm above the floor

and at a distance of 600 mm from the front of the cab. The measurement shall be conducted in accordance with ISO 3381.

(b) Moving Locomotive

The noise level inside the cab, when the Locomotive is running at the maximum speed shall not exceed 80 dB(A) with all auxiliary equipment including the cab air conditioner operating. The noise level shall be measured in the cab along the centre line between 1200 mm and 1600 mm above the floor and at a distance over 600 mm from the front of the cab. The measurement shall be done according to ISO 3381.

3.8.2 All noise levels listed above in Clause 3.8.1 are in decibels referred to 20 micro pascals, as measured with "A" weighting network of standard Type 1 sound level meter with time weighting "F".

3.9 Weight and other leading parameters of the Locomotive

3.9.1 The Locomotive shall satisfy the following criteria.

Parameter	**Requirement**
Bogie configuration	Co-Co
Axle load	22 tonnes ± 2%
Number of axles	6
Locomotive weight (fully equipped and operational)	132 tonnes ± 1%*
Centre of gravity of the locomotive shell with all the mounted equipment installed (Products and CLW Components)	As per the Existing WAG9 Locomotive (including ballast). Note: the centre of gravity calculations report IB18-06.3 and drawing IB031-00318 for the Existing WAG9 Locomotive (without the ballast) are referenced in Annex 1 of this Specification and Standard.
Buffing load	The Locomotive shall be designed to withstand static buffing load of 400 tonnes at the buffers
Lateral forces	The lateral force measured at axle box level shall be <= 4.0 tonnes
Dynamic augment	Dynamic augmentation in vertical direction of load shall be <= 50%
Type of coupler	AAR "E" type coupler head and with AAR "F" type shank and AAR "F" type yoke
Height above rail level of centre buffer coupler (with new wheels)	1090 +15/-5 mm

Parameter	Requirement
Bogie configuration	Co-Co
Minimum clearance of all items except wheel from rail level in fully loaded condition and with fully worn wheels	102 mm
Wheel diameter	1092 mm (in new condition) 1016 mm (in fully worn condition)
Schedule of dimensions	The Locomotive shall confirm to Indian Railways Schedule of Dimensions for Broad Gauge, revision, 2004 with latest addendum and corrigendum slips.
Ride Index	Shall not be greater than 4

Table 7 - Locomotive Mass

*Note: The weight of the existing WAG9 locomotive without ballast is 123 tonnes. The Locomotive shall be provided with additional ballast of 9 tonnes out of scheme of ballast of 12 tonnes in accordance with the drawings referenced in Annex 1 of this Specification and Standard.

3.10 Duty Cycle

3.10.1 Other than when required for scheduled maintenance the Locomotive shall be available for operational service 24 hours per day, 365 days per year.

3.10.2 Each Locomotive shall be capable of travelling 200,000 km in service annually without any detrimental effect on the performance of the Locomotive.

3.10.3 At times the Locomotive working in adverse terrain shall be required to negotiate longer periods at lower speeds. The typical duty cycle encountered in operation is outlined below and the Products shall be capable of operating under these conditions.

Speed (in km/h)	0-10	10-30	30-60	60-80	80-100
% of total running time of Locomotive	5 %	10 %	20 %	50 %	15 %

Table 8 - Typical Product Duty Cycle

3.11 Design Life

The Locomotive shall be required to operate in service for a minimum of 35 years and shall have a design life of 35 years.

3.12 Reliability

3.12.1 The Propulsion Equipments shall be designed to achieve a high level of reliability, particularly under the extreme environmental conditions experienced in India.

3.12.2 No single-point failure of the Propulsion Equipments shall cause the complete failure of the Locomotives and the number of single point failures which would result in a loss of more than 1/6th (one sixth) of the traction power shall be minimised. The Company shall identify and advise the Government of any single-point failures that shall cause a loss of power of 1/6th (one sixth) or greater of the traction power as part of the Design Package.

3.12.3 In the event of breakdown of any Propulsion Equipments (or basic unit of equipment) it shall be possible to continue to haul the train with the least reduction possible in its services, operating within restricted but permissible conditions.

3.12.4 Where the system design of the Propulsion Equipments incorporates component redundancy as the method of reducing the consequences of a single point failure, such redundancy shall not allow hidden faults to remain undetected.

3.12.5 In the event of the Propulsion Equipments failures and the traction motor failure described below the following performance levels shall be maintained:

(a) breakdown of the drive side converter of any traction converter or electrical failure of any traction motor:

the traction power of the Locomotive shall only be reduced by 1/6th (one sixth);

(b) breakdown of the line side converter of any traction converter:

the traction power of the Locomotive shall only be reduced by 1/4th (one fourth);

(c) breakdown of an auxiliary converter:

redundancy in the auxiliary converter(s) shall be provided so that in the event of a failure, the traction capacity of the Locomotive is not degraded;

(d) the control electronics (VCU) shall include redundancy so that a failure shall not affect the traction, braking and safety related control operations;

(e) failure of drive controller unit or power supply of the drive controller unit or gate unit or gate unit power supply of a drive side converter of any traction converter:

the traction power of the Locomotive shall only be reduced by 1/6th (one sixth);

(f) failure of drive controller unit or power supply of the drive controller unit or gate unit or gate unit power supply of line side converter of any traction converter:

the traction power of the Locomotive shall be reduced only by 1/4th (one fourth); and

(g) failure of one speed sensor:

the operation of the Locomotive shall not be degraded and all traction motors shall remain operational.

3.13 Maintenance targets (exchange times/overhaul periodicities)

The design and construction of the Propulsion Equipments shall satisfy the maintenance requirements of existing WAG9 locomotive.

3.14 Fire Performance

3.14.1 The Propulsion Equipments shall be designed and constructed in accordance with BS6853 Category II or an alternative internationally recognised standard.

3.14.2 A reliable fire detection and alarm system shall be provided. The fire detection system shall be located in the machine room and shall be suitably interfaced with the vehicle control unit to notify the driver of an incident.

3.15 Safety

3.15.1 The Propulsion Equipments shall enable the Locomotives to operate safely over the operating routes identified in Clause 2.4 of this Specification and Standard.

3.15.2 The design and construction of the Propulsion Equipments shall not introduce uncontrolled risk to the Government or any other third parties.

3.15.3 Any of the Propulsion Equipments which are critical for safety shall fail to a safe operating mode.

CHAPTER-4

TECHNICAL REQUIREMENTS

4.

4.1 Introduction

4.1.1 The specific technical requirements which the Locomotive shall satisfy are detailed in Clauses 4.2 to 4.37 of this Specification and Standard.

4.1.2 Clause 4.2 contains general requirements to be applied to the Locomotive.

4.1.3 Clause 4.3 contains details of the modes of operation for the Locomotive.

4.1.4 Clause 4.4 contains details of how the Locomotive shall function.

4.1.5 Clauses 4.5 to 4.36 contain specific requirements for specific equipments.

4.1.6 The specific requirements for any equipment, described in this Chapter-4, shall be over and above to the requirements described in the specification of the equipment referenced in Annex-1. In case of conflicting requirements, the requirements of this Specification and Standard shall prevail.

4.2 General Requirements

4.2.1 The Locomotive shall be Manufactured similar to being manufactured by CLW except for Propulsion Equipments. The manufacturer shall be required to manufacture according to the design being followed by CLW. The specifications for all major components which shall be followed by the Company for the manufacturing/procurement of the equipments are listed in Annex 1. However, if any equipment specification is not found in consonance of the overall per-formance parameters of the Locomotive or if any other modifications are to be suggested by the Company for improving the Locomotive performance, the Company shall approach RDSO for consideration and approval of the same. No change in specification of any equipment should be done without prior approval of RDSO.

4.2.2 Adequate margin shall be built into the design of all the Propulsion Equipments, to address the effects of high ambient temperatures, fine dust conditions and the high humidity prevailing in India as detailed in Chapter-2 of this Specification and Standard.

4.2.3 The Propulsion Equipments, including their mounting arrangements, shall be designed to satisfactorily withstand the vibrations and shocks likely to be encountered in service. The Company shall note the accelerations stated in Clause 2.17 of this Specification and Standard, measure the vibrations and shocks experienced by the existing WAG9 locomotives in service and apply these loadcases, with suitable safety factors, to the design of the Propulsion Equipments.

4.2.4 The under slung equipment, such as the transformer shall be sufficiently robust to withstand impact with ballast and other small objects which may normally be encountered while the Locomotive is in service.

4.2.5 The electronics used shall conform to IEC 60571, although the higher ambient temperatures experienced in India as stated in Clause 2.9 of this Specification and Standard shall be taken into consideration. The electronics shall not be designed for a temperature class below class Tx of IEC 60571.

4.2.6 All the electronics shall be positioned in the Locomotive in such a fashion that they are not subjected to high running temperatures during operation. This shall be achieved by the location of the electronics or the provision of suitable cooling during operation or a combination of both.

4.2.7 The Propulsion Equipments shall be suitably rated to enable a Locomotive which has been inactive and exposed to the maximum ambient conditions (based on the worst case combination of temperature and solar gain as stated in Clauses 2.9 and 2.15 of this Specification and Standard) to be able to start up and operate without any requirement for pre-cooling of the electronics.

4.2.8 The Company shall limit the current drawn by the Locomotive such that there shall be no adverse effect on the pantograph or the OHE whilst the Locomotive is at standstill.

4.2.9 The protection, alarm and indication circuits shall normally have self-correcting features, which shall prevent the tripping of the Locomotive or a significant reduction in tractive effort. If driver's intervention is practicable, sufficient time/advance indication shall be made available to the driver, to the extent possible, to enable corrective action.

4.2.10 The voltage rating of all IGBT equipment shall have at least a +25% margin available after taking into consideration the DC link voltage and voltage jump on account of inductance and capacitances in the circuit. The current rating of the IGBT equipment shall be such that the junction temperature has the minimum thermal margin of 10ºC (degrees Celsius) in the maximum electrical load conditions and the worst case ambient conditions as defined in Clause 2.9 of this Specification and Standard.

4.2.11 The design calculations of worst case temperature rise of equipment shall be made after taking into account 25% choking of filters and heat sink/radiator fins. A safety margin of at least 10ºC shall be kept with respect to maximum permissible junction temperature of power devices declared by the manufacturer.

4.2.12 The design of the Propulsion Equipments shall allow in-situ cleaning of any filters with the required maintenance tools.

4.2.13 All relevant SMIs, MSs and TCs of RDSO shall be referred and complied by the Company while manufacturing the Locomotive. The latest lists of SMIs, MSs and TCs are available at RDSO's official website www.rdso.indianrailways.gov.in. All modifications of CLW shall also be incorporated in the Locomotive.

4.3 Modes of Operation (Normal and Degraded)

4.3.1 Unless stated otherwise in this Specification and Standard the Locomotive shall operate (in normal and degraded conditions) in the same manner as the existing WAG9 locomotive as described in the current operational manual provided in Annex 2.

4.3.2 The Company shall investigate the operation and functionality of the existing WAG9 locomotive and develop the full functionality of the Propulsion Equipments to provide a similar level of operation.

4.3.3 For the avoidance of doubt, in addition to meeting the requirements of Clauses 4.3.1 and 4.3.2 of this Schedule it shall be possible for the Locomotives to operate as a single locomotive in the following modes:

(a) Inching Mode - the Locomotive shall be able to operate at a constant speed settable by the driver in steps of 0.1 Km/h, in the range from 0.5 to 1.5 Km/h. It shall be possible to change from inching mode to normal mode and vice versa by the driver depending upon his requirement;

(b) Constant Speed Control (CSC) - the Locomotive shall be able to operate at a pre-set speed selected by the driver. The selection of speed shall be possible by pressing a switch. However, the system shall be inherently fail safe and shall immediately come out of the pre-set speed mode to normal mode on actuation of the master/ brake controller, reduction of brake pipe pressure, activation of the direct brake or as required from safety considerations;

(c) Shunting Mode – the Locomotive shall be able to shunt the wagons to create the train formation. This operation shall be the same as that which is undertaken by the existing WAG9 locomotive shall be in accordance with Clause 3.5.5 of this Specification and Standard.

4.3.4 It shall be possible to operate a Locomotive in multiple with other Locomotives of the same type i.e. it shall be possible to operate a Locomotive with other Locomotives. It shall be possible to operate a maximum of 2 (two) Locomotives in multiple operation.

4.3.5 When operating in multiple the control of the coupled Locomotives shall be achieved from the active cab of the leading Locomotive. Provision shall also be made to enable the driver in the active cab to monitor the important parameters of the other Locomotives as well as to identify important faults in all Locomotives.

4.3.6 Provision shall be made in the control circuitry of the Locomotive, to limit the starting tractive effort to predefined values when required during multiple operation with other Locomotives. The two predefined value settings shall be 300 kN and 353 kN per Locomotive.

4.3.7 For the avoidance of doubt, in addition to meeting the requirements of Clauses 4.3.1 and 4.3.2 of this Specification and Standard it shall be possible for the Locomotives to operate with other Locomotives in the following modes:

(a) trailing mode – the Locomotive shall be able to operate the trailing Locomotive's traction power from the leading Locomotive's cab, in the event of total failure of the traction power on the lead locomotive;

(b) banking mode – the Locomotive is mechanically and pneumatically coupled to the rear of a train and the lead locomotive shall control all the train brakes; although in emergencies the rear Locomotive driver can activate the emergency brake; and

(c) towing mode – following a failure of a Locomotive which is prevented from operating under its own power, it shall be possible to haul a Locomotive as part of a train configuration.

4.4 Functionality of the Locomotive

4.4.1 Unless stated otherwise in this Specification and Standard the functionality of the Locomotives shall provide the same operational functionality in normal and degraded conditions, driver controls and interfaces as the existing WAG9 locomotive as described in the current operational manual provided in Annex 2.

4.4.2 The following Clauses of this Clause 4.4 of this Specification and Standard provide an overview of the required functionality of the Locomotive. The Company shall investigate the operation and functionality of the existing WAG9 locomotive and develop the full functionality of the Propulsion Equipments to provide the same level of operation.

4.4.3 Driving controls and interlocks – the driving controls shall mimic those of the existing WAG9 locomotive. The system shall have interlocks to prevent tractive effort if the:

(a) emergency stop button is active;

(b) parking brake remains applied for speed more than 5 km/h;

(c) pneumatic (direct) locomotive brake is applied for speed more than 10 km/h;

(d) automatic brake is applied for speed more than 10 km/h;

(e) main reservoir is below 5.6 Kg/cm^2;

(f) brake pipe pressure is below 4.7 kg/cm^2;

(g) isolation cock brake pipe control system is isolated;

(h) fire detection system activated; or the

(i) emergency exhaust isolating cock is open.

4.4.4 Traction interlocks – the activation of the traction interlock shall reduce the tractive/braking effort to zero and stop the pulsing of the traction converter. An indicator shall alert the driver to the loss of tractive/braking effort. The following shall activate a traction interlock:

(a) vigilance system activation;

(b) emergency stop button activation;

(c) pressure switch emergency brake;

(d) battery voltage too low;

(e) 110% over speed;

(f) failure of electronic brake control;

(g) electric brake failure; and

(h) any traction converter failure modes, including angle transmitter disturbance and protective actions where the design process undertaken by the Company identifies that a traction interlock is necessary.

4.4.5 The traction interlock shall be released as soon as the reason for the traction interlock disappears and the driver moves the master controller to the neutral position. This interlock shall be manually released and shall never be an automatic operation.

4.4.6 Sanding control – this shall be by automatic and manual operation. The manual operation shall be by a foot switch. The automatic operation shall be controlled by the wheel slip/slide control system. Only the leading axles of each bogie shall deliver sand to the wheel rail interface dependent on direction of travel. The sand discharge rate shall optimise adhesion whilst not impeding detection through the track circuits.

4.4.7 Vigilance – the vigilance system requires the driver to operate, as a minimum, either the vigilance foot pedal, the sanding foot pedal, the master controller or the push button provided on the assistant driver's side, within a 60 second period. Any of these actions shall reset the timer. Failure to reset the timer within the 60 second period shall trigger an alarm. The alarm is to be cancelled by the vigilance foot pedal within 16±4 seconds. Failure to cancel the alarm shall activate the emergency brake which shall only be resettable after 32±2 seconds. The vigilance control device shall be Procured and provided in the Locomotive in accordance with specification referenced in Annex 1.

4.4.8 Pantograph control – a mechanical interlock system to ensure that a pantograph cannot be raised until all the HV systems are secured and un-earthed shall be installed. The Locomotive pantograph shall be raised by a selection switch which has three modes and a raise and lower switch which are described below:

(a) position "Auto" - automatically selects the pantograph at the opposite end of the locomotive to the activated cab;

(b) position "I" - selects the pantograph at the cab 1 end to be raised irrespective of which cab is active; and

(c) position "II" - selects the pantograph at the cab 2 end to be raised irrespective of which cab is active.

The selected pantograph shall be raised by the use of an "up" switch. If there is insufficient air pressure to raise the pantograph an auxiliary pantograph compressor shall be automatically activated. The pantograph shall not raise until the auxiliary compressor has de-activated;

The pantograph shall be lowered by the use of a "down" switch. The switch shall open the VCB first, if closed, when activated.

4.4.9 Compressor Control – the compressors shall be operated in three different modes which are described below:

(i) operating mode "Off" - with the switch active in this position both compressors shall be inactive.

(ii) operating mode "Auto" - with the switch active in this position the compressors shall supply the pneumatic system automatically cutting out once the pressure reaches 10 kg/cm2. The compressor shall automatically reactivate if the main reservoir pressure reduces below 8 kg/cm2. The compressors shall operate alternately to ensure that the duty is balanced for both compressors.

(iii) operating mode "Man" - with the switch active in this position both compressors shall be active as long as the main circuit breaker is closed. It should be noted that the compressor cut-out switch shall not operate in this position.

4.4.10 Emergency stop button – there shall be an emergency stop button located on the driver's desk that shall open the VCB, lower the pantograph and apply the emergency brake. The system shall be designed such that the control system shall not reset until the Locomotive has come to rest. The button shall be sited such that it is within the reach of the driver but shall not be susceptible to accidental or inadvertent operation.

4.4.11 Emergency Brake Activation – the emergency brake shall be activated by the following:

(a) vigilance equipment exceeding time limits;

(b) emergency stop button activation;

(c) 110% of maximum speed being exceeded;

(d) moving the automatic brake controller to the EMERGENCY position;

(e) activation of the emergency brake cock on the assistant driver's side; and

(f) failure of the electronic brake control.

4.4.12 Parking brake control – the parking brake shall be applied and released by the use of a single latch illuminated pushbutton. The parking brake shall be interlocked with the traction equipment to prevent the driver taking traction with the parking brake applied. The drive shall not be able to apply the parking brake if the Locomotive speed is greater than 5 Km/h.

4.4.13 Control of lighting - the control of the Locomotive lighting shall be similar to that of the existing WAG9 locomotive. The cab lighting shall be controlled by the driver and all the gauges and meters shall be self illuminated. The machine room lighting shall be such that all initial fault finding can be undertaken without additional lighting.

4.4.14 Head lights – the head lights shall have twin beams that are controlled by the driver.

4.4.15 Marker lights – there shall be two sets of marker lights, one white and one red that are controlled by the driver.

4.4.16 Flasher light – in the event of the train parting the flasher light shall be automatically activated and any tractive effort on the Locomotive shall be disabled until acknowledged by the driver. Similarly, in the event of alarm chain pulling the flasher light shall be automatically activated until acknowledged by the driver. The flasher light shall have the ability to be activated manually by the driver by operating a switch provided on the flasher light unit.

4.5 General Layout

4.5.1 Unless stated otherwise in this Specification and Standard or required in order to satisfy the requirements of this Specification and Standard the layout of the Propulsion Equipments shall be generally consistent as the existing WAG9 locomotive as described in the current operational manual provided in Annex 2.

4.5.2 The locomotive shell shall be Manufactured to meet the overall dimensions defined in CLW drawing number 1209-03.301-002. The design shall ensure that a walkway with an envelope of at least 1.83 m height and 600 mm width

is available along the length of the Locomotive from one cab to the other cab. There shall be a space envelop of 640 mm x 1500 mm x 575 mm (WxHxD) available in the machine room for the provision of a Train Protection and Warning System (TPWS) in the future by the Government.

4.5.3 The fitment of the Propulsion Equipments and other equipments shall be positioned such that the weight is evenly distributed and maintains the centre of gravity of the existing WAG9 locomotive and axle load tolerances as detailed in Clause 3.9 of this Specification and Standard.

4.6 Vehicle Structure

4.6.1 The locomotive shell for the Locomotive shall be Manufactured or Procured as per CLW specification number CLW/MS/3/152. The latest versions of the drawings referenced in CLW/MS/3/152 shall be applied and are referenced in Annex 1. In order to achieve the Locomotive weight defined in Clause 3.9.1 of this Specification and Standard the Company is not required to apply all of the ballast defined in CLW/MS/3/152. Any changes that may be required for the installation of the new equipments (such as additional/alternative opening required for cooling, modification in existing ducting arrangement) shall be based on the design and construction standards applied to the existing design.

4.6.2 The CLW specification number CLW/MS/3/152 is referenced in Annex 1.

4.6.3 The design of the Propulsion Equipments shall promote preservation of asset value. The design shall protect against corrosion through the use of materials and coatings as appropriate. The design of the structure shall ensure that no water traps exist. Dissimilar metal corrosion shall be prevented and anti-corrosion paint shall also be applied.

4.6.4 In selecting materials of insulation, the moist tropical weather conditions prevailing in India shall be considered and suitable action taken.

4.6.5 The machine room and cab shall be protected against dust and water in accordance with IP54 with all doors and windows in closed conditions. The Propulsion Equipments inside the machine room and cab shall be suitably protected against dust and water ingress to ensure their reliable operation and performance throughout the Design Life of the Locomotive.

4.6.6 If the cooling air for the Propulsion Equipments is drawn from outside the Locomotive it shall pass through filters located in the side wall or the roof of the locomotive such that there is no ingress of water from these locations particularly during the rainy season. The existing locations of the air filter shall preferably be retained.

4.6.7 Any air discharge / purge shall be from the bottom of the Locomotive and shall be diffused / deflected such that dust/dirt from the track bed does not get sucked in to the Locomotives.

4.6.8 The machine room shall be pressurized and the filters shall be designed to prevent any dust ingress in the machine room.

4.6.9 If the machine room air is drawn from outside of the Locomotive the filter assembly shall be designed having the following two stage filters:

(a) first stage of cyclonic/inertial filter; and

(b) second stage of mesh filter. A suitable dust scavenger system shall also be provided to separate out dust. The details of filtering shall be part of Design Package.

4.6.10 If the machine room air is recirculated it is not necessary to install a two stage filter but suitable filters shall be provided in order to satisfy the requirements of Clause 4.6.5 of this Specification and Standard.

4.6.11 If external air is used to cool the equipments then the pressure and flow of air within the Locomotive shall be so regulated as to provide adequate cooling to the equipments inside the compartments, paying particular attention to the cooling of the electronic equipment as detailed in Clause 4.19.2 of this Specification and Standard. The design shall also ensure that no water ingress takes place from any filter, duct or opening.

4.6.12 The cow catcher assembly shall be Manufactured or Procured; and provided in accordance with the specification referenced in Annex 1.

4.7 Painting and Marking

4.7.1 The painting of the Locomotive shall be done in accordance with the specification referenced in Annex 1.

4.7.2 The design of the Propulsion Equipments shall protect against corrosion through the use of materials and coatings, as appropriate. Any paint system used shall be durable and resistant to damage, and shall ensure that the life of the coating is at least 6 (six) years before a re-paint is necessary.

4.7.3 Subject to re-painting the exterior of the locomotive shell at 6 (six) yearly intervals and the interior of the locomotive shell at 6 (six) yearly intervals and any attention provided during maintenance to attend to any damage to the paint system caused by accidental impacts, the paint system shall protect the substrate from corrosion over the Design Life of the Locomotive. The paint system shall be capable of withstanding the effects of any detergents used in cleaning, which are commercially available in India, and the use of Government washing machines.

4.7.4 The paint system and colours shall take into consideration the solar radiation as detailed in Clause 2.15 of this Specification and Standard. The Company shall select a paint scheme /type that shall minimise any temperature rise in the machine room due to solar gain.

4.7.5 The transformer tank, radiators and associate equipment shall be protected with pollution/oil resistant and dust repellent epoxy paint. Other equipment shall be suitably painted and a uniform colour shall be chosen.

4.7.6 The paint finish shall be of a high quality of detail and finish. The surface finish, paint thickness and gloss shall be consistent throughout the Locomotive.

4.7.7 Lettering and labelling shall be applied to the exterior and interior of the Products to inform staff of matters such as positions of equipment, safety warnings etc. Lettering and labels shall be durable.

4.7.8 Safety warning labels and notices shall comply with the requirements of international rail standards.

4.8 Couplers and Buffers

4.8.1 Draw gear and coupler – these shall be compatible with that of the existing WAG9 locomotive and shall be Procured in accordance with the specifications referenced in Annex 1.

4.8.2 Side buffer - these products shall be compatible with that of the existing WAG9 locomotive. The side buffers shall be Procured in accordance with the specifications for the existing WAG9 locomotive, which are referenced in Annex 1.

4.8.3 Multiple unit coupling – the electrical coupling of the Locomotives in multiple formation shall have a UIC coupler. To provide redundancy two couplers shall be fitted. The pin connections shall match that of the existing WAG9 locomotive. The coupling shall be Procured in accordance with the specification for the existing WAG9 Locomotive, which is referenced in Annex 1.

4.8.4 Pneumatic coupling – the pneumatic hoses shall be compatible with that of the existing WAG9 Locomotive. The coupling shall be Procured in accordance with the specifications for the existing WAG9 locomotive, which is referenced in Annex 1.

4.9 Bogies, Suspension, Brake Rigging and Traction Transmission Sytem

The Locomotive bogie frame shall be Manufactured or Procured and; the suspension system, brake rigging and traction transmission system shall be Procured in accordance with drawings/specification referenced in Annex 1. The centre pivot elastic ring shall also be Procured in accordance with drawings/specification referenced in Annex 1.

4.10 Wheel, Axle and Axle box

The Locomotive wheel sets shall be Manufactured or Procured in accordance with drawings/specification referenced in Annex 1, but rough axle and wheel disc shall necessarily be Procured in accordance with drawings/specification referenced in Annex 1. The axle boxes shall be Procured in accordance with drawings/specification referenced in Annex 1.

4.11 Pantograph and HV Roof Mounted Equipment

4.11.1 The pantograph equipment and the high voltage roof mounted equipment including the vacuum circuit breaker, earthing switch, high voltage roof bushing, current transformer, primary voltage transformer, surge arrestor, roof line fitting, insulators and horns shall be Procured and provided in accordance with the specifications referenced in Annex 1.

4.11.2 The power drawn by the pantograph of the Locomotive from OHE shall be at a power factor of 0.98 (or better) for power demands above 2MW across the OHE voltage range from 19 kV to 27.5 kV, subject to the interference levels as specified in Clause 2.7 of this Specification and Standard.

4.11.3 Pantograph bouncing as detailed in Clause 2.6 of this Specification and Standard shall not adversely affect the performance of Propulsion Equipments.

4.11.4 Primary voltage transformer for measuring OHE voltage, primary current transformer for measuring current taken from OHE and two metal oxide gapless surge arrestor (one before VCB and one after VCB) shall be Procured and provided in accordance with the specifications referenced in Annex 1.

4.11.5 Vacuum circuit breaker shall be Procured and provided in accordance with the specifications referenced in Annex 1.

4.11.6 Harmonic filter resistance shall be Procured and provided in accordance with the specifications referenced in Annex 1.

4.11.7 High voltage roof bars and insulator shall be Procured and provided in accordance with the specifications referenced in Annex 1.

4.12 Transformer

The transformer shall be Manufactured or Procured in accordance with specification referenced in Annex 1.

4.13 High Voltage Cable Assembly

The high voltage cable assembly shall be Procured in accordance with specification referenced in Annex 1.

4.14 Traction Converter

The traction converter shall be Procured in accordance with specification referenced in Annex 1. Certain required features of the traction converter are detailed in the following clauses.

4.14.1 The traction converter to be provided by the Company shall be completely IGBT based.

4.14.2 The traction converter system shall be capable of withstanding the maximum short circuit current under fault conditions of the traction motor detailed in Clause 4.15 of this Specification and Standard. The converter system shall also be designed to withstand extreme disturbances such as short-circuit / open circuit at all points of input / output interfaces with the Locomotive, with minimised effects / damages. This shall be type tested according to the relevant provisions of IEC 61287.

4.14.3 During an earth fault or a phase-to-phase fault in the traction motor, the protection scheme of the converter shall prevent any damage to the converter.

4.14.4 The traction converter shall provide the following special features to maximise the performance and reliability of the Locomotive and to minimise the possibility of a Locomotive being stalled in the section:

(a) there shall be an independent drive converter per axle;

(b) suitable redundancy in the vital PCBs, particularly connected with safety, so that in the event of their failure the likelihood of the Locomotive becoming inoperative or its performance being degraded is minimised; and

(c) only dry type capacitors (having self healing property) shall be used for DC link / harmonic filter / resonant circuits.

4.14.5 The traction converter output shall be controlled such that the torque pulsations and traction motor heating caused by current ripple shall be minimised. It is the Company's responsibility to make sure that the output quality of the traction converter is entirely suitable for the traction motors as detailed in Clause 4.155 of this Specification and Standard. The traction

converter shall generate a 3-phase output having switching frequencies and pulse pattern which are equal to or better than the existing GTO system.

4.14.6 The cooling of the traction converter shall be defined by the Company ensuring that the converter is able to maintain its constant output under all environmental conditions.

4.14.7 The source code and compiler of all software of traction converter shall be supplied to the Government by the Company.

4.15 Traction Motors

4.15.1 The existing three phase traction motors 6FRA 6068 of the existing WAG9 locomotive shall be retained. The traction motor shall be Procured in accordance with the specifications referenced in Annex 1.

4.15.2 The specification for the motors is summarised in **Table** below.

SN	Characteristics	Unit	6FRA 6068
1	**Continuous Rating**		
.1	Shaft output	KW	850
.2	Nominal Voltage	V	2180
.3	Current	A	270
.4	Speed	RPM	1283
.5	Torque	Nm	6330
.6	Frequency	Hz	65
.7	Power Factor	-	0.88
2	**One Hour Rating**		
.1	Shaft output	KW	850
.2	Nominal Voltage	V	2089
.3	Current	A	290
.4	Speed	RPM	1135
.5	Torque	Nm	7140
.6	Frequency	Hz	57.5
.7	Power Factor	-	0.86
3.	**Short Time Overload Rating:**		
.1	Shaft output	kW	850
.2	Nominal Voltage	V	1660

.3	Current	A	370
.4	Speed	RPM	892
.5	Torque	Nm	9100
.6	Frequency	Hz	45.7
.7	Power Factor	-	0.86
4.	**Maximum service Speed**	**RPM**	**2584**
5.	**Maximum design Speed**	**RPM**	**2842**
6.	**Temperature Sensor**	**2 PT 100 resistance elements installed in stator tooth.**	
7.	**Speed Sensor**	**Weigand transmitter system with transmitter ring for 120 pulses per rotor revolution.**	

Table 8 - Characteristics of Traction Motor

4.15.3 Traction motor suspension unit, pinion and main gear shall be Procured and provided in accordance with the specifications referenced in Annex 1

4.16 Speed sensor of traction motor

Active speed sensors of 120 pulses per revolution shall be Procured and provided. The speed sensor shall be housed in the existing housing of the traction motor end cover. Any change in the end cover cap, if required, shall be specified by the Company as part of the Design Package and the modified cap shall be supplied by the Company along with the speed sensor.

4.17 Auxiliary Power Equipment

4.17.1 A suitable auxiliary system shall be provided by the Company. This shall consist of, but not limited to, auxiliary converters, auxiliary machines (blower-motors, oil / water pumps, air-conditioner), the battery charger and associated protection systems.

4.17.2 The auxiliary system shall be galvanically isolated from the traction power system and the DC control system.

4.17.3 The auxiliary system design shall ensure that there is no surge / spike in the output voltage between phase-to-phase and with respect to earth. The common mode output voltage (with respect to earth) shall be as low as possible.

4.18 Auxiliary Converter

The auxiliary converter shall be Procured in accordance with specification referenced in Annex 1. Certain required features of the auxiliary converter are detailed in the following clauses.

4.18.1 The inverter side of the auxiliary converter shall be IGBT based and the rectifier side shall be thyristor/IGBT based. The auxiliary converter shall be

forced air-cooled or water cooled. The control shall be microprocessor / micro-controller based with diagnostic features. Protection from overload/short circuit, single phasing and any other protection considered necessary for reliable functioning shall be provided. The output of the auxiliary converter shall be sinusoidal.

4.18.2 The auxiliary converter for the Locomotives shall be the same in all respects.

4.18.3 Two / three auxiliary converters, identical in all respects, and a battery-charging unit shall be provided in each Locomotive. The design and rating of the auxiliary converters and load distribution shall be such that in case one auxiliary converter fails, the remaining converter shall take the entire auxiliary load and the Locomotive shall remain functionally operable. The changeover arrangement shall be automatic.

4.18.4 Rating of the auxiliary converters to be offered shall be decided after considering the connected loads, the requirement for redundancy as described in Clause 3.12.5 of this Specification and Standard and an additional margin of 10 kVA per converter for possible future increases in the load.

4.18.5 The battery charging unit shall be a part of the auxiliary converters and shall supply the control voltage at 110 V DC (nominal). It shall be capable of charging the 199 AH Nickel-Cadmium battery with suitable closed loop charging characteristics and provide separate monitoring of battery voltage / current. The specification of the battery is referenced in Annex 1.

4.18.6 Apart from the locomotive control circuit and battery, the locomotive head light, flasher light, marker lights and auxiliary compressor shall also be connected to the 110V DC circuit. The Company shall investigate the functionality of the Existing WAG9 Locomotive and Existing WAP7 Locomotive and ensure that the same functions/systems are powered by the 110V DC circuit.

4.18.7 The power quality of the 415V three phase sine wave AC under all working conditions shall be as detailed below in Table 9:

Output Voltage	415V ± 5%
Output Frequency	50Hz ± 3%
Short time current overload rating	125% for 20 sec.
Total harmonic distortion (THD)	Less than 10% in output voltage
Voltage unbalance	Less than 1 %

Table 9 - Auxiliary Converter Output

4.18.8 In addition to the above, galvanically isolated supplies of 230 V AC and 110 V AC single phase, of 1 kVA each, shall be made available in both cabs to enable the powering of small equipment.

4.18.9 The source code and compiler of all software of auxiliary converter shall be supplied to the Government by the Company.

4.19 Cooling Systems

4.19.1 The Locomotive shall be able to start up at the maximum temperature which may be reached inside the Locomotive (after standing inoperative in the sun

for a prolonged duration) without any requirement for the pre-cooling any electronic equipment.

4.19.2 The cooling arrangement of the electronics of the traction converter, auxiliary converter and the VCU shall be designed so that the temperature adjacent to the electronic cards remain below 45 ºC (degrees Celsius) while the Locomotive is operating. The cooling of electronics may be combined with cab air conditioning to achieve this, if required.

4.19.3 The electronics of the traction converter, auxiliary converter and the VCU shall preferably not be placed near to the roof to avoid the effect of solar gain. The electronics shall preferably be placed in a separate compartment away from the converters.

4.19.4 The cooling of the traction motors, heat exchangers, radiators and air circulation within the machine room shall be by the use of air blast cooled by means of a motor driven blower set (blowers). The requirements of the blowers are:

(a) machine room blower - in the design of the existing WAG9 locomotives the machine room blowers (2 x 2.6 kW each) for cooling the central electronics, traction converter electronics and the auxiliary converters (electronics as well as power electronics) are connected to single phase AC supply. This arrangement shall be dispensed with and the machine room blowers (of adequate capacity) shall for simplicity and reliability be supplied from the three phase supply. This cooling shall meet the requirements of Clause 4.19.2 of this Specification and Standard. The details of machine room cooling concept shall be part of Design Package;

(b) traction converter and transformer radiator blower - the cooling of the main transformer and traction converter is presently achieved by the use of common oil cooler radiators (aluminium alloy heat exchanger modules) but with different oil circuits in the existing WAG9 locomotives. There are two cooling units, one for each bogie in the existing locomotives. The existing radiator and the existing blower shall be Procured and used; and

(c) traction motor blower - these shall be Procured and provided in accordance with the specification referenced in Annex 1.

4.19.5 In order to reduce energy consumption as well as to increase equipment life, multiple level ventilation control shall be adopted, which shall vary the output of all the blowers according to the cooling needs. The auxiliary converter output and control system shall be designed accordingly. As part of the design submissions the Company can propose alternate simple control functions in order to reduce energy consumption as well as to increase equipment life.

4.19.6 The temperature rise limits for a machine room blower shall be reduced compared to the IEC limits to allow for the higher ambient temperature specified in this Specification and Standard. The maximum temperature rise shall not be more than 80 ºC (degrees Celsius). An insulation system of class 180 ºC (degrees Celsius) or higher shall be adopted.

4.19.7 The machine room blowers and associated motors shall satisfy the following requirements:

(a) vacuum pressure impregnation of the stator winding shall be performed using solventless varnish having a thermal index reflecting the operating environment and rated, as a minimum above 200 ºC (degrees Celsius);

(b) for motors higher than 15 kW, flange bearing housing units shall be used. The bearing design shall be such that no greasing and no intermediate attention shall be required for at least 18 months; and

(c) L-10 life of bearings when calculated according to ISO Recommendation R-281 shall not be less than 35000 working hours.

4.19.8 The cooling arrangement together with the radiators, blowers, coolant and cooling circuit with pumps shall be of a rugged construction to withstand vibrations and shock. The sealing of the cooling system shall be such as to prevent spillage/leakage of the coolant.

4.20 Control Equipment

The control equipment consists of SB1, SB2, HB1, HB2 and FB cubicles. The SB, HB and FB cubicles shall be Manufactured or Procured and provided in accordance with the specification referenced in Annex 1.

4.21 Electronic Equipment

4.21.1 The electronics of the traction converter, auxiliary converter and the VCU shall preferably be designed to be sealed from the remaining part of the machine room and shall be protected against dust in accordance with IP65.

4.21.2 Use of application specific integrated circuits (ASICs) shall, preferably, be avoided. Circuit boards shall use general purpose ICs wherever possible.

4.21.3 The electronic cards shall be mechanically coded to ensure that the insertion of a card into an incorrect slot is not possible.

4.21.4 Capacitors shall be suitably rated, keeping in view the high ambient temperature specified, the vibrations of the electric rolling stock and the electrical surges expected during operation. High failure rates of electrolytic capacitors mounted on PCBs of electronic cards are expected due to high operating temperature / voltage / current vis-à-vis designed operating temperature / voltage / current. Dry type of capacitors shall preferably be used.

4.21.5 The expected life of the cards and electronics in general shall be at least 18 (eighteen) years under actual working conditions.

4.21.6 Features of the electronic systems:

(a) the diagnostic computer in the Locomotive shall be able to differentiate between fault in rest of the Locomotive and fault in the electronic equipment; and

(b) should the fault be found on electronic equipment, the diagnostic computer shall enable fault finding to be carried out at module level.

4.22 Instruments and Gauges

OHE line voltage, battery voltage, tractive/braking efforts, energy consumed / regenerated, pressures in the main reservoir pipe, brake actuators, brake pipe and feed pipe and indication of air flow in the brake pipe and any other indication considered important /

relevant for the driver shall be Procured and provided on both the driver's consoles similar to existing WAG9 locomotives. The specifications of these items are referenced in Annex 1.

4.23 Master controller

The master controller shall be Procured and provided in accordance with the specifications referenced in Annex 1.

4.24 Driver's Display

4.24.1 Colour graphics display units for the driver shall be provided on the driver's desk in each cab. These shall display important information relevant to the driver, such as operational aspects, the status of the main systems and fault status / messages.

4.24.2 The display shall be menu driven. The interface with the driver shall be key based and shall be very simple considering the average level of proficiency of drivers in handling electronic devices. The menu design shall be similar to Existing WAG9 Locomotive and Existing WAP7 Locomotive.

4.24.3 The Company shall describe the level of information to be provided on the drivers display and the proposed format as part of the Design Package.

4.24.4 The display shall be designed to provide full guidance and assistance to the driver about action to be taken in the case of a fault on the Locomotives. The interface shall be user friendly and there shall normally not be any need for a separate trouble shooting directory for the driver's use.

4.24.5 The selection of the display medium shall take into account high ambient temperature and light, due to direct sunlight on the driver's desk. A backlit arrangement shall be provided for all time visibility.

4.24.6 The display system shall be protected against dust and moisture to an IP rating of IP 65.

4.24.7 The display system along with its controls shall be suitably robust.

4.24.8 The faults and other displays on the driver's display shall remain identical with the existing WAG9 locomotive.

4.25 Wiring and cabling

4.25.1 The power and control cables shall be Procured and provided in accordance with specifications referenced in Annex 1.

4.25.2 The fibre optic cables shall be Procured and provided in accordance with specifications referenced in Annex 1.

4.26 Vehicle Control

Control and communication shall be based on open control architecture and compliant to IEC 61375 "Train Communication Network" protocol. VCU (hardware) shall Procured and provided in accordance with the specification referenced in Annex 1. The software for VCU shall be provided by CLW. Alternatively following clauses shall apply for vehicle control:

4.26.1 Control and communication shall be based on open control architecture and compliant to IEC 61375 "Train Communication Network" protocol or any other equivalent, internationally published protocol. The programmable devices shall be programmed using language compliant to IEC 61131.

4.26.2 The majority of the control and monitoring functions shall preferably be implemented by software so as to reduce hardware and cables. The safety integrity level for this software and the associated electronics shall be allocated and assessed in accordance with EN 50126 and the associated international standards.

4.26.3 The control system shall integrate the task of fault diagnostics and display in addition to vehicle control. It should be capable of real time monitoring of the status of all the vital equipment continuously and the occurrence of faults. It shall also take appropriate protective action and shut down the equipment wherever necessary. Features of self-check, calibration and plausibility checks shall be incorporated in the design.

4.26.4 Unless stated otherwise in this Specification and Standard the VCU shall provide a similar functionality as the system installed in the existing WAG9 locomotive as described in the current operational manual as set out in Annex 2.

4.26.5 The VCU shall interface (including hard wiring) with the brake system. Presently the E-70 brake system supplied by D&M / Faively Transport and the CCB brake system supplied by Knorr Bremse are used on existing WAG9 locomotive. Provision shall also be made to interface with the brake system through multiplexed pairs of wires using an RS-485 protocol. The interface hardware and software shall be designed accordingly.

4.26.6 The adhesion control system shall be optimised for maximum utilisation of adhesion factor and shall be capable of generating the required starting tractive effort as detailed in Clause 3.5.1 of this Specification and Standard under dry rail conditions. The wheel slip detection and correction system shall be an integral part of the vehicle control system and shall capture any excessive acceleration, differential speeds between axles, over speed and any other parameter considered necessary to maximise adhesion and minimise wheel slipping / skidding

4.26.7 The VCU shall control the automatic flasher operation (in case of train parting and ACP) and the vigilance functionality.

4.26.8 The energy metering (energy consumption and energy regeneration) function shall be integrated into the control software and shall provide an accuracy of 5%.

4.26.9 The VCU shall have a diagnostics computer, with non-volatile memory, to store all relevant diagnostic data. When a fault occurs which may affect operation, the VCU shall record all fault information including equipment parameters, background data, time stamp and GPS data. All data shall be captured and stored to facilitate thorough and accurate fault analysis. There shall be a facility to capture post trigger and pre-trigger background information. The diagnostic computer shall specify diagnostic of fault up to card level. The diagnostic system shall be able to identify and log all faults on the Locomotive caused by incorrect operation by the driver and such data shall be stored in the diagnostic computer for a period of not less than 100 days. Application software shall be provided to facilitate the fault diagnosis and the analysis of equipment failures. The steps required to complete the investigation shall be displayed on the VCU display in simple language along with background information. The application software shall be compatible for working on commercially available operating systems.

4.26.10 The vehicle control unit (VCU) shall also provide on-line, context sensitive trouble-shooting assistance to the driver in case of any fault, through the driver's display. The fault display to the driver shall be accompanied by the standard trouble shooting instructions in simple English language.

4.26.11 For diagnostic purposes (including downloads) it shall be possible to access all the processors within a Locomotive and other Locomotives in a train formation over a wired train bus using a standard laptop connected to one of the ports provided on the VCU rack. The wired train bus shall satisfy the requirements of IEC 61375 or any other equivalent internationally published protocol. The required interfaces shall be built into the VCU so that standard laptops, with commercially available operating systems, can be used without any special interface. A suitable software tool shall also be provided in the laptops. Using this tool, it shall be possible to reset the diagnostic memory for further recording and undertake detailed analysis off line.

4.26.12 It shall be possible for the Government to execute parametric changes (within permissible ranges) in the vehicle control software, if so required in the future, in order to improve the operation of the Locomotive. It shall be possible to configure these parameters through a laptop and a menu-driven, easy to use, application software shall be provided for this purpose. Password protection shall be provided to safeguard against misuse. As a minimum, the parameters to be changed shall be the current and voltage sensor settings, horse power, temperature sensor setting, pressure sensor setting, maximum speed of the Locomotive, wheel diameter, main reservoir pressure setting for loading and unloading of compressor, vigilance control timer settings and maximum tractive effort. It shall be preferable for the Government to have the ability to change further parameters and the Company shall provide details of these as part of the Concept Design Package.

4.26.13 The existing fault screen of the driver (fault messages displayed on driver display) shall remain same as in existing WAG9 locomotive with the adoption of IGBT traction converter except for following new messages needed due to individual axle control:

- Motor 1 – Bogie 1 isolated – reduced traction/braking
- Motor 2 – Bogie 1 isolated – reduced traction/braking
- Motor 3 – Bogie 1 isolated – reduced traction/braking
- Line converter 1 – Bogie 1 isolated – reduced traction/braking
- Line converter 2 – Bogie 1 isolated – reduced traction/braking
- Motor 1 – Bogie 2 isolated – reduced traction/braking
- Motor 2 – Bogie 2 isolated – reduced traction/braking
- Motor 3 – Bogie 2 isolated – reduced traction/braking
- Line converter 1 – Bogie 2 isolated – reduced traction/braking
- Line converter 2 – Bogie 2 isolated – reduced traction/braking

4.26.14 The source code and compiler of all software of vehicle control shall be supplied to the Government by the Company.

4.27 Brakes and Air System

4.27.1 The traction converter shall have regenerative braking capabilities from the maximum speed to 0 km/h without wheel slip. In the event of a regenerative brake failure the pneumatic brake shall safely bring the Locomotive to rest. The regenerative braking system shall interface with the pneumatic braking system detailed in Clauses 4.27.2 to 4.27.5 of this Specification and Standard.

4.27.2 The brake system shall be Procured and provided in accordance with specification referenced in Annex 1.

4.27.3 The Company shall ensure that the interface between the installed electrical cabling is compatible with the existing system and the control functionality is identical to that of the existing WAG9 locomotive.

4.27.4 Pneumatic pipe work including reservoirs, hose pipes and fixing arrangements in accordance with CLW specification number CLW/MS/3/153 shall be Procured and provided in the Locomotives. The Company shall ensure that the pipe work interfaces with the pneumatic brake system of which the specification is referenced in Annex 1.

4.27.5 The Company shall ensure that all the open pipe work is protected during manufacture to prevent the ingress of debris into the pneumatic system. An air tightness check shall be undertaken on each of the pipe runs before the installation of the equipment is undertaken.

4.27.6 Under slung, resiliently mounted with the under frame, compressors shall be Procured and provided in accordance with specification referenced in Annex 1. The compressor shall be adequately protected with safety slings in accordance with RDSO modification sheet. Auxiliary compressor shall be Procured and provided in accordance with specification referenced in Annex 1.

4.27.7 The air delivered to the pneumatic system shall be clean and dry free from water vapour, oil and particles. A heatless regenerative type air dryer shall be Procured and provided between the air compressor and the main reservoir so as to provide dry compressed air to the Locomotive brake system in accordance with specification referenced in Annex 1. The air dryer shall be preceded by automatic drain valve and oil separator, which collects and discharges bulk of the moisture and oil present in the compressed air, before it enters the air dryer.

4.27.8 Pneumatic sanding gear shall be Procured and provided for the leading axles of each bogie in accordance with specification referenced in Annex 1. It shall be operative in either direction of travel. Automatic sanding arrangement during wheel slipping by means of wheel slip detection system shall be provided. The sanding shall be direction selective. The Company shall install a suitable regime for the interaction between sanding and active wheel slip adhesion control system so that wheel slip adhesion control system shall not be prohibited from working.

4.27.9 The sand boxes shall be easily accessible for filling from outside. Each sand box shall have a capacity of 50 kgs (+/- 10%) capacity.

4.27.10 The sanding gear shall be capable of functioning properly in the tropical humid climate which increases the propensity of sand remaining moist. The sand ejection mechanism shall be designed such that it does not get choked due to moist sand and the design shall also consider provision of a suitable heating arrangement inside sand box.

4.28 Horns

Dual tone pneumatic horns, in accordance with specification referenced in Annex 1, shall be Procured and provided facing outwards at each end of the Locomotive. The two horns shall have different tones but shall be in harmony with each other when blown together. Push buttons placed next to each other shall be provided on the driver side as well as on the assistant driver side for the operation of either one or both the horns at any time by the driver or assistant driver.

4.29 Lighting

The lighting equipment (head light, corridor lights, marker lights, flasher lights, gauges and instrument lamps to illuminate the dials etc.) shall be Procured and provided in accordance with specification referenced in Annex 1.

4.30 Speed cum Energy Indication and Recording Equipment

The speed cum energy and indication and recording equipment shall be Procured and provided in accordance with specification referenced in Annex 1.

4.31 Drivers Cab

4.31.1 A cab shall be provided at each end of the Locomotive with provision for adequate forward visibility in accordance with drawings mentioned in CLW's specification of shell (CLW/MS/3/152). The cab shall be insulated against noise, vibration and heat and the ingress of water and dust in accordance with Clause 4.6.5 of this Specification and Standard. Driving cabs shall be adequately reinforced and connected with the main under frame at the cab ends.

4.31.2 An air conditioning and heating system shall be provided in each cab, including cooling, heating and ventilation. The air conditioning and heating system shall Procured and provided in accordance with specification referenced in Annex 1.

4.31.3 Two crew fans shall be Procured and provided, one each for the driver and assistant driver in accordance with specification referenced in Annex 1.

4.31.4 The fixed front glass panel(s) of the cab windscreen, the glasses on the doors and side windows of the cab and the fixed glass panels of the equipment compartment shall be Procured and provide in accordance with specification referenced in Annex 1.

4.31.5 A hinged grill for prevention of damage to the front glass panel of the windscreen shall be provided.

4.31.6 The windscreen wipers with washers shall be Procured and provided on the windscreen in accordance with specification referenced in Annex 1.

4.31.7 Rolling blind(s) and sun visors shall be provided on the windscreens. The details of sun visor shall be part of Design Package.

4.31.8 The windscreen glass shall be plastic laminated and shall be Procured in accordance with specification referenced in Annex 1.

4.31.9 The layout of the driving cab and the driving position shall be similar to existing WAG9 locomotive. The relative positions of cab equipments shall be similar to those available on the existing WAG9locomotive. Panel A, B, C and D shall be Manufactured or Procured and provided in driver cab in accordance with specification referenced in Annex 1.

4.31.10 A drivers' seat and a second seat for the assistant driver shall be provided in each cab. The seats shall be Procured in accordance with specification referenced in Annex 1.

4.31.11 Access to the cab shall be from either side of the cab by means of inward opening doors . The door leading to machine room from the cab shall open into the machine room. The doors shall be Manufactured or Procured in accordance with specification referenced in Annex 1.

4.31.12 The cab access doors shall be provided with a lock and key.

4.31.13 In addition to above, each driver's cab shall be provided with the following:

(a) Two cabinets in the rear and a locker for a toolbox;

(b) one fire extinguisher, Procured in accordance with specification referenced in Annex 1, in addition to the one for the machine room;

(c) one LED based rechargeable torch with socket and charger;

(d) vigilance system, Procured in accordance with specification referenced in Annex 1, for monitoring alertness of the locomotive crew;

(e) suitable trays with clamps for the working time table, caution orders, walkie-talkie etc.; and

(f) suitable LED based lighting in cab. There shall also be provision that during running of the Locomotive only the drivers' desk, time table and

caution order area shall be illuminated so as not to reduce the visibility of driver.

The details of item (a), (c), (e) and (f) shall be part of Design Package.

4.31.14 Provision shall be made to enable the Government to implement a Train Protection and Warning System (TPWS) at a future date. A space of 360 mm x 450 mm x 150 mm (HxWxL) shall be provided for the future fitment of the Driver Machine Interface (DMI).

4.32 Safety Systems

4.32.1 Standard protective systems shall be provided for protection of the electrical equipments against abnormal currents, excessive voltages, etc., with indicating facilities, so as to ensure safe and correct operations. All equipments shall be adequately earthed, insulated, screened or enclosed and provided with essential interlocks and keys as may be appropriate to ensure the protection of the equipments and safety of those concerned with its operation and maintenance.

4.32.2 A sensitive and reliable protection arrangement against an earth fault shall be provided in each circuit group.

4.32.3 All electrical circuits shall be fully insulated from the locomotive shell on both the positive and negative sides and the super-structure shall not be used as a part of any earth return circuit.

4.33 Fire prevention measure

4.33.1 The Propulsion Equipments shall incorporate all reasonability practicable measures to prevent fires and shall be such that should any fire take place, the effect shall be minimized. Materials which are not fire-retardant shall not be used.

4.33.2 The Locomotives shall be provided with a manually-operated two position earthing switch. The operation of the switch shall enable earthing of the power circuit of the Locomotive and allow attention to the HT equipments by releasing interlocked keys from a box fitted to the earthing switch. The earthing switch shall be Procured in accordance with specification referenced in Annex 1.

4.33.3 The Locomotive shall be provided with one fire extinguisher of 22.5 kg, Procured in accordance with specification referenced in Annex 1, for protection of machine room equipments from fire. The 22.5 kg fire extinguisher shall be connected to fire extinguisher pipe line. These fire extinguishers shall be manually operable by the driver.

4.33.4 The Locomotive shall be provided with a fire extinguisher pipe line to match the equipment layout within the machine room. This shall in accordance with specification referenced in Annex 1.

4.34 Fire detection and alarm system

Fire detection and alarm system in accordance with specification referenced in Annex 1, shall be Procured and provided. The fire detection system shall detect fires in the machine room and shall be suitably interfaced with the vehicle control unit to notify the driver.

4.35 Battery and Battery Box

The battery box shall be Manufactured or Procured and provided in accordance with specifications referenced in Annex 1. The battery shall be Procured and provided in accordance with specifications referenced in Annex 1.

4.36 Other Equipments

Other equipments as referenced in Annex 1 shall be Procured and provided in accordance with specifications referenced in Annex 1. There may be some other equipments, which are not mentioned in Annex 1, shall be referred in Category Book of CLW

CHAPTER 5

TESTS & TRIALS

5.1 Tests

5.1.1 The Government shall conduct, or cause to be conducted, adequate trial runs of Locomotives to determine their compliance with this Specifications and Standard.

5.1.2 Tests to be conducted on the first Locomotive or its sub-systems, as the case may be, (the "**Type Tests**") and routine tests to be carried out on all Locomotives and sub-systems (the "**Routine Tests**") have been specified in this Chapter 5.

5.1.3 The Company shall provide the results of all Tests to the Government for review and comments, if any.

5.2 Agency for conducting Tests

All Tests set forth in this Chapter 5 shall be conducted by the Company or such other agency or person as it may specify in consultation with the Government.

5.3 Type Tests on the Prototype Locomotive

5.4.1 All Type Tests specified in IEC 61133, including the optional tests, shall be conducted at the manufacturer's plant for first Locomotive. Some dynamic tests can be done on the Government's track.

5.4.2 The first Locomotive shall be subjected to the Tests specified below in this paragraph 5.4.2, by the Government, on the Government's railway line, to determine the conformity thereof with this Specifications and Standard:

(a) Rating and performance trials

Rating and performance trials shall include the following:

(i) Dynamometer car test to ascertain starting and rolling resistance of the Prototype Locomotive and to prove "tractive effort-speed" and "regenerative braking effort/speed" characteristics;

(ii) adhesion test to prove adhesion capability; and

(iii) emergency braking distance trials.

The above measurements shall be recorded in accordance with RDSO report no. MT-316, published in October 2001 and MT-93, published in July 1997.

(b) Temperature measurement of electronics

Temperature measurement shall be carried out by suitable equipment, in working condition of the Locomotive, to demonstrate the temperature rise, above ambient, of the components of electronic equipment.

(c) Compatibility tests with signal and telecommunications installations

Compatibility tests with signal and telecommunications installations shall be carried out to determine the levels of interference with the traction power supply and the

signal and telecommunication equipments and to prove that these are within acceptable limits in accordance with this Specifications and Standard.

5.4 Type Tests on Prototype Sub-systems

5.5.1 The individual sub-systems Manufactured by the Company, for the first time, shall be type tested in accordance with relevant IECs or RDSO's or CLW's specifications for various sub-systems.

5.5.2 Dry heat test

Dry heat test, as specified in IEC 60571, shall be conducted for testing power and control electronic equipments at 80 degree celcius.

5.5.3 Test on combined test bed

The propulsion equipment shall be tested on the combined test bed at the manufacturer's works as specified in IEC 61377. Tests shall be conducted at all the specified loads including the full load and special loading conditions with reference to the maximum wheel diameter difference. The Tests shall also measure the system efficiency and system response in case of failure of control signals.

5.5.4 Efficiency Test

The efficiency of the power converter (line side converter and drive side inverter) and auxiliary converter shall be measured at full load. Efficiency at full load means, efficiency computed from parameters measured at conditions corresponding to full load and governed by IEC 61287-1 for power and auxiliary converter.

5.5.5 Government, on its own discretion, may waive some of the tests in case of sub-system, where the Company can establish to the satisfaction of the Government that such tests have already been carried out earlier and where sub-system has been proven in prolonged service.

5.5 Service Trials

The first Locomotive shall be evaluated by the Government during operation for the first 50,000 Kms. (the "**Service Trials**"). Service Trials shall include load haulage tests on different sections with different gradients at different speeds to evaluate the hauling performance of the first Locomotive in compliance with the Specifications and Standard. Defects and deficiencies, if any, shall be notified to the Company for rectification with retrospective effect in all Locomotives produced so far.

5.6 **Routine Tests on Locomotives**

All the static routine tests specified for a Locomotive in IEC 61133 shall be conducted at the Company's premises. The following dynamic routine tests specified for a Locomotive in IEC 61133 shall be conducted on Government's track:

Sub-clause	Test	Remarks
9.2.2	Traction performance (tractive effort/speed characteristics)	Declaration of conformity shall be given
9.4.2	Braking tests	Only brake feel test at

		maximum speed shall be done while working without any load.
9.7	Speed regulating system tests	
9.9.1	Safety of running	

5.7 Routine Tests on Sub-systems

2.1 The individual sub-systems of the Locomotives shall be tested in accordance with relevant IECs or RDSO's or CLW's specifications for various sub-systems.

2.2 The Company shall furnish copies of the work test certificates (WTC) of all routine tests of the sub-systems of the Locomotive.

Annex 1

Specifications/drawings for the system/subsystem/equipment of the Locomotive

Serial No.	Equipment	Specification	Description	Drawings
1.	Loco diagram of WAG9/WAP7 Locomotive			1209-03.301-002
2.	Locomotive Shell Specification WAP7 & WAG9	CLW/MS/3/152	Shell assembly	IB 031-00273
3.			Roof hatch assembly	IB 101-00124
4.			C. B. Coupler	SKDL 3430
5.			Loco Side Buffer	SKDL 4561, MP-0.41.00.03
6.			Spring pocket ballast	IB021-00953, IB022-00550, 00553, 00554, 00555 and 00556
7.			Side wall ballast	IB031-00340
8.			Pneumatic pipe layout	CLW/MS/3/153
9.			Painting specification	M&C/PCN/100/2006 of RDSO
10.	Vehicle mass and centre of gravity calculations	Report number IB18-06.3	Centre of gravity	IB031-00318

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11.	Welding Procedure Specification	Document number A0326-0001 to A0326-0030 and A0713-0001 to A0713-004		
12.	Static Locomotive gauge drawing			RDSO Drg No. SKEL-3917
13.	Bogie arrangement			IB011-00065, IB011-00192_1, IB011-00192_2, IB011-00192_3, IB011-00192_4, IB011-00194_1, IB011-00194_2
14.	Suspension Springs	CLW/MS/3/008		Primary Spring: IB011-00843, Secondary Spring: IB011-00842.
15.	Dampers	CLW/MS/10/005		
16.	Traction rod			1209-01.113-001
17.	Centre pivot housing			1209-01.113-002
18.	Centre pivot elastic ring	RDSO/2007/EL/SPEC/0053		
19.	Cattle guards	CLW/MS/3/107		1209-02.140-032
20.	Brake rigging of WAG9 locomotive	CLW/MS/3/007		
21.	Axle			1209.01.311.054
22.	Wheel disc			1209.01.111.003 Alt.4. For WAP7profile C.S.L.3040 thick.
23.	Wheel set			1209.01.111.003 Alt.2.

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24.	Pantograph	RDSO/2008/EL/SPEC/00 66		
25.	VCB	CLW/ES/C/47		
26.	Earthing Switch	CLW/ES/3/0010		
27.	Primary voltage transformer	CLW/ES/3/0009		
28.	Primary current transformer	CLW/ES/3/0010		
29.	Surge arrestor	CLW/ES/3/0016		
30.	Roof bars	CLW/ES/3/0063		
31.	Roof line insulators	CLW/ES/3/0051		
32.	Harmonic filter resistance	CLW/ES/3/0015		
33.	High Voltage Roof Bushing	CLW/ES/3/0052/B		
34.	High voltage cable bushing	CLW/ES/3/0052		
35.	Main Transformer	CLW/ES/3/0456		
36.	IGBT based traction converter	CLW/ES/3/IGBT/0486		
37.	Traction Motor	CLW/ES/3/0005		CLW/ES/3/0005

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38.	TM suspension unit	CLW/MS/3/201		
39.	TM pinion	ELRS/SPEC/GP/0038		
40.	Main gear	ELRS/SPEC/GP/0038		
41.	Traction Motor temperature sensor	3EHM311882		
42.	IGBT based auxiliary converter	CLW/ES/3/IGBT/0485		
43.	Traction motor blower	CLW/ES/3/0019		
44.	Filter assembly for traction motor blower	CLW/MS/3/012		
45.	Traction motor scavenger blower	CLW/ES/3/0021		
46.	Instruments (meters) in cab	CLW/ES/3/0190		
47.	Gauges in cab	CLW/ES/3/0190		
48.	Master controller	CLW/ES/3/0031		
49.	Harnessed power cables	CLW/ES/3/0196		
50.	Harnessed control cables	CLW/ES/3/0196		
51.	Fibre optic cables	CLW/ES/3/0141		

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52.	SB1 and SB2 cubicle	CLW/ES/3/0194, CLW/ES/3/0195, CLW/MS/3/098		
53.	HB1 and HB2 cubicle	CLW/ES/3/0191, CLW/ES/3/0192, CLW/MS/3/047		
54.	FB cubicle	CLW/ES/3/0193, CLW/MS/3/046		
55.	VCU	CLW/ES/3/0011		
56.	Brake System	CLW/MS/3/001		
57.	Main Compressor	CLW/ES/3/0100		
58.	Auxiliary Compressor	CLW/ES/C-4		
59.	Air Dryer	MP-0.01.00.06, REV.0.003		
60.	Sanding gears			1209-01.138-031 & 1209-01.138-032
61.	Air Horns	Included in CLW/MS/3/001		
62.	Head lights	CLW/ES/3/0114/A		
63.	Marker lights	ELRS/SPEC/PR/0022		
64.	Flasher lights	ELRS/SPEC/LFL/0017		
65.	Corridor lights	CLW/ES/3/0041		
66.	Speedo meter	CLW/ES/3/0028		

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67.	Vigilance System	Included in CLW/MS/3/001		
68.	Cab air conditioner	RDSO/2007/EL/SPEC/0055(Rev.0) Nov'07 with amend.1		
69.	Crew fan	CLW/ES/3/0110		
70.	Look out glass	CLW/MS/3/027		
71.	Side window glass	CLW/MS/3/027		
72.	Driver seat	CLW/MS/3/021		
73.	Cab door and machine room door	CLW/MS/3/013		
74.	Wiper assembly	CLW/MS/3/050		
75.	Panel A, B, C & D of cab	CLW/ES/3/0239, CLW/ES/3/0240, CLW/ES/3/0241		
76.	Fire detection unit	CLW/ES/3/0057		
77.	FDU pipe line	CLW/ES/3/0254		
78.	Fire Extinguishers	CLW/MS/3/016 & CLW/MS/3/108		
79.	Battery Boxes	CLW/MS/3/037 Alt 4		
80.	Batteries	CLW/ES/3/0030		
81.	UIC Coupling	1494 0537 762		

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82.	Switches	CLW/ES/3/0032, CLW/ES/3/0068, CLW/ES/3/0074, CLW/ES/3/0075, CLW/ES/3/0079, CLW/ES/3/0108, CLW/ES/3/0203		

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Annex 2

WAG9 Operating Manual

In accordance with Document number 3EHW411172

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Annex 3

List of Designs and Drawings

1. **SPECIFIC REQUIREMENTS**

1.1 Within the Design Package the Company shall provide copies of the following specific requirements.

1.1.1 Power and auxiliary converter: make and type, number of cubicles per loco, kVA rating calculation of auxiliary converter based on load and redundancy requirement, thermal characteristics of IGBTs, arrangement of devices, margin in current, voltage and junction temperature, cooling system, air/water flow rates and arrangement of filtered air, noise level, configuration with detail calculation of branch wise current providing adequacy of the devices used, rating of each IGBT, thermal margin with calculations, overall dimensions and weight, type and rating of the capacitor for DC link as well as resonance circuit, if provided, protection scheme of power converter and the designed power loss in the converter.

1.1.2 Vehicle control unit and diagnostic system: make and type of microprocessor, complete functional description, list of faults to be displayed in driving cab and stored in permanent memory, procedure for down loading the list and format of faults from memory, protection schemes of all equipments, control scheme for converter, DC link, inverter, traction motor, braking etc.

1.1.3 Smoothing Reactor / Filters: make and type, number and rating of the coils, inductance and ripple characteristics up to 1.5 times the rated current, ratings of the conductor, insulation system used, losses, temperature rise limit, cooling system, dielectric test voltages, overall dimensions and weight of the equipment.

1.1.4 Traction Motor Speed Sensor: make and type pulse generating ring and sensors, electrical diagram, power consumption and output pattern of the sensor.

1.1.5 Machine Room Blower: make and type, nominal voltage, starting current and torque, torque speed characteristics at relevant voltages, continuous rating, speed, power factor and slip of the motor, type of enclosure, details of cooling fan, air gap, rating of windings and insulation, conductor size, current density, type of conductor insulation, type of impregnation, rating of lead wire, terminals and terminals block, details of rotor end rings and bars with current density, details of bearing giving sizes, clearances, tolerances, dimensions, L-10 life calculation of the bearings and weight of machines, tests conducted to ascertain the reliability of windings/motors. Power consumption of rated capacity, dimensions and weight of the blower.

1.1.6 Event recorder: functional description and diagnostic system of the equipment.

1.1.7 Driver's display: the details of interface with other systems and functional description of the equipment.

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1.1.8 Machine Room Filter: details of primary (inertial/cyclonic) and secondary filter along with maintenance procedures and pressure drop calculations.

1.2 The Company shall provide the following details of the design of the Propulsion Equipments and the Locomotive:

1.2.1 weights and centre gravity of major Products with weight unbalance calculations;

1.2.2 adhesion calculation;

1.2.3 system performance calculations;.

1.2.4 cooling system calculations;

1.2.5 tractive and braking effort vs speed curves showing balancing speed;

1.2.6 detailed step-wise calculations for equipment ratings and performance requirement, excluding proprietary know how of the Company;

1.2.7 curves of efficiency, power factor, frequency, slip as a function of speed;

1.2.8 calculations for life of bearings used in auxiliary machines;

1.2.9 harmonic calculations;

1.2.10 reliability predictions of each equipment at ambient temperatures of 50 ºC (degrees Celsius) under normal operation;

1.2.11 variation in traction power beyond 21.5 kV – 27.5 kV;

1.2.12 variation of auxiliary power, if any, in the specified occasional maximum to minimum voltage range and method of reduction / limitation of hotel load and auxiliary power;

1.2.13 the value of maximum starting tractive effort that shall be developed under dry rail conditions and also under all weather conditions; the formulae for linking adhesion characteristics with the operating speed; and the achievable running adhesion characteristics;

1.2.14 redundancy concepts;

1.2.15 reliability calculations indicating mean time between failures (MTBF) for different sub-systems; and

1.2.16 marking scheme including details of paints and colour scheme, letter size etc.

1.3 The Company shall provide the following Drawings:

1.3.1 general layout of all equipments in the locomotive body including driving cab layout, driver's desk layout, driver's visibility diagram, locomotive lifting arrangement, location of jacking pads and bogie retention arrangement;

1.3.2 full set of pneumatic and schematic drawings for the Locomotive;

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1.3.3 schematic diagram of power, regenerative braking, control and auxiliary circuits including multiple operation;

1.3.4 arrangement for wheel slip detection and correction system;

1.3.5 transformer and power converter cooling arrangement;

1.3.6 mounting details of major equipment;

1.3.7 machine room filters; and

1.3.8 modified cap of speed sensor housing in traction motor end cover, if any.

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