

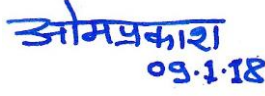


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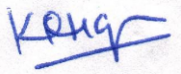

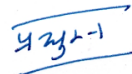
Technical Specification
for
Development of Re-generative Braking
Feature in WAG7 Electric Locomotives

Specification No: RDSO/2018/EL/SPEC/0133, Rev. '0'
Issued on: 09.01.2018

Approved by	Signature
Sr. EDSE	 09.1.18

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ELECTRICAL DIRECTORATE
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MANAKNAGAR, LUCKNOW - 226011

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REVISION HISTORY

S.N.	Date of Revision	Page No.	Revision	Reasons for Revision
1.	-	All	'0'	First issue
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4.				

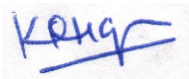

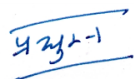
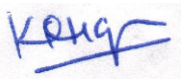

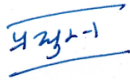
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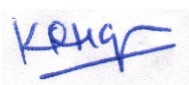
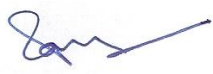
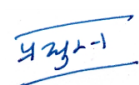
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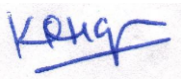

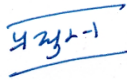
ABBREVIATIONS

The following abbreviations are used in this Specification:

Abbreviation	Full Name
AAR	Association of American Railroad
AC	Alternating Current
AF	Audio Frequency
ASIC	Application Specific Integrated Circuit
ATP	Automatic Train Protection
BS	British Standards
DC	Direct Current
EMC	Electro-magnetic Compatibility
EMI	Electro-magnetic Interference
EN	Euro Norm (European Standard)
HT	High Tension (Voltage) (according to Indian Electricity Rules)
IC	Integrated Circuit
IEC	International Electro technical Commission
IEEE	Institution of Electrical and Electronic Engineers
IGBT	Insulated Gate Bipolar Transistor
IR	Indian Railways
IRS	Indian Railway Standards
IS	Indian Standard
ISO	International Standards Organization
Kmph	Kilometers per hour

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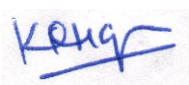
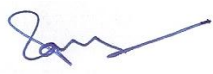
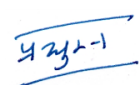
Abbreviation	Full Name
MCB	Miniature Circuit Breaker
MMD	Maximum Moving Dimension
OHE	Over Head Equipment
PCB	Printed Circuit Board
RAMS	Reliability, Availability, Maintainability and Safety
RDSO	Research Designs & Standards Organisation
SI	Systeme Internationale
UHF	Ultra High Frequency
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
VHF	Very High Frequency
VCU	Vehicle Control Unit
VCD	Vigilance Control Device

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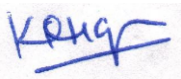

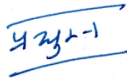
DEFINITIONS

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

Term	Definition
Agreement	shall mean the Procurement cum Maintenance Agreement for Regenerative Braking System;
BG	shall mean 1676 mm Broad Gauge used in IR;
Co-Co	shall mean one unit of the Locomotive consisting of two bogies, with each bogie having three wheels with three independent traction motors and the traction motor drive coupled to each wheel;
C&M 1 volume 1	shall mean Civil and Mechanical Engineering Report Number 1 Volume 1, issued by RDSO;
Indian Railways Schedule Of Dimensions	shall mean Indian Railways Schedule of Dimensions for broad gauge, revision 2004 (or latest);
IP	shall mean degree of protection provided by enclosures according to IEC 60529;
Man Machine Interface (MMI)	shall mean the interface between the system or equipment and the human interfacing with that equipment;
WiMax	shall mean the telecommunication technology, based on the IEEE 802.16 standard that provides wireless data, from point-to-point links to full mobile cellular type access; and

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Term	Definition
CLW	shall mean Chittaranjan Locomotive Works, Chittaranjan (West Bengal) – 713331.
Tenderer'/'Vendor'	Shall mean the firm/company submitting the offers for the supply of re-generative braking application in WAG7 electric locomotives conforming to this specification.
Purchaser	Shall mean the President of the Republic of India as represented by the Railway Organization entering into the contract.
Vendor	Shall mean any firm or company with whom the order for supply of regenerative braking system has been placed or intended to be placed.
Sub-Vendor	Shall mean any person, firm or company from whom Vendor may obtain any material, sub-assemblies assemblies used for the manufacture of regenerative braking system.
Inspecting Officer	Shall mean person, firm or department nominated by the purchaser to inspect the locomotive on his behalf or the representative of the Inspecting Officer so nominated.
Others	Any capitalized term used herein not specifically defined shall have the meaning ascribed to such term in the Agreement.

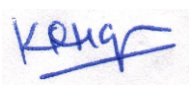
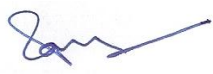
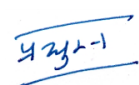
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CHAPTER 1

General Description, Operating and Environmental Conditions

1.1 Introduction

- 1.1.1 Existing WAG7 locomotives are as per RDSO specification number RDSO/EL/2007/EL/Spec/0049(Rev.2).
- 1.1.2 Presently, dynamic braking is provided in WAG7 locomotives. It is proposed to provide re-regenerative braking feature in place of dynamic braking in WAG7 locomotives with minimal changes.
- 1.1.3 The Vendor shall get himself acquainted with the technical parameters of the present 5000 HP WAG7 locomotive to understand the necessary modification that needs to be done in the existing propulsion equipment for providing re-regenerative braking in place of dynamic braking. Vendor may collect necessary and required data, Specification & Drawings of existing WAG7 locomotives from Railways.
- 1.1.4 The purpose of this specification is to develop re-regenerative braking feature as well as provide re-regenerative braking in existing WAG7 electric locomotives manufactured at CLW/BHEL.
- 1.1.5 RDSO shall approve the detailed scheme of re-regenerative braking feature and design of power converters & its associated assemblies required for re-regenerative braking provision in WAG7 locomotives. Type testing will be witnessed by RDSO.
- 1.1.6 The vendor shall provide all the items required for the proper functioning of the re-regenerative braking in WAG7 locomotive in accordance with the best current international practices, whether included in this specification or otherwise.
- 1.1.7 This specification defines the system and performance requirements for the re-regenerative braking in existing 5000HP WAG7 locomotive. It also specifies the existing power supply system, leading parameters of locomotive and tentative re-regenerative braking effort for WAG7 locomotive.

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1.1.8 The environmental and service conditions, performance requirements and technical requirements are specified in these Specifications and Standards.

1.1.9 The design and manufacture of the regenerative braking system equipment shall be based on the requirements set out in these Specifications and Standards and in accordance with Good Industry Practice.

1.1.10 The Vendor shall demonstrate, to the satisfaction of the IR, that the sub-systems proposed to be used in the Locomotives are based on proven technology and design. For the avoidance of doubt, the IR may require the Vendor to conduct such tests and trials as may be necessary to establish the reliability and efficiency of such technology and designs in accordance with the Good Industry Practice.

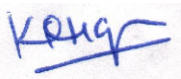

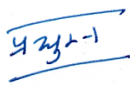
1.1.11 Due consideration shall be given at design stage to ambient conditions of dust, moisture, high temperature and vibrations prevalent in India, as specified in the clause 1.5 in this Specification.

1.2 SCOPE

This specification covers the design, manufacture, installation, testing commissioning & field trial of Re-regenerative braking feature developed in existing 5000 HP, 25 KV, 50 Hz tap changer control WAG7 electric locomotives.

Development and retro-fitment of Regenerative Braking feature in existing WAG7 locomotive shall consist of following processes/equipment/components.

- (i) Re-layout of items/sub-items as per requirement of regeneration system
- (ii) System design activities for braking effort V/s speed, armature current V/s speed, field current V/s speed, generated voltage V/s speed, power back feed V/s speed
- (iii) Design, development & testing of IGBT based traction converters, IGBT based chopper and other equipments

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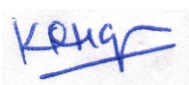
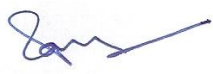
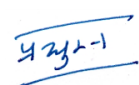
- (iv) Removal of existing DBR & MVRF. Released items are to be returned back to Indian Railways.
- (v) Changes in BA panels, AC2 panels, controller interface etc. as per requirement during retro-fitting of regenerative braking
- (vi) Supply of cable accessories, piping, structure assembly and hardware etc. required for installation of re-generative system.
- (vii) Provision for metering the re-generated energy along with braking effort.
- (viii) Locomotive will be given to Vendor by Indian Railway for carrying out retro-fitting of equipment/assemblies for regenerative braking after successful completion of type tests on equipment to be supplied by them.
- (ix) Vendor shall get time lines for retro fitting approved by RDSO.
- (x) Retro-fitting will be carried out either at Vendor's premise or at Railway facilities. This is to be clearly indicated by the Vendor.
- (xi) Retro-fitting of equipment for regenerative braking in WAG7 locomotive and its testing
- (xii) Field trials

1.3 References to various standards

1.3.1 The standards applicable and relevant to the complete Locomotive and to the various sub-systems and systems shall be:

- (i) IEC publications;
- (ii) EN ;
- (iii) UIC;
- (iv) AAR
- (v) IEEE;
- (vi) BS;
- (vii) IS; and
- (viii) Any other standards referred to in this Specification.

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

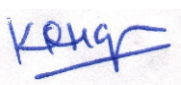

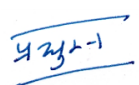
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- (i) Standards mentioned in Specifications and Standards set forth herein;
- (ii) EN /IEC/UIC/AAR; and
- (iii) IS.

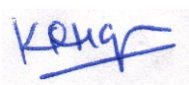
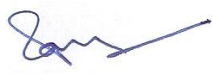
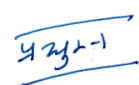
For avoidance of any doubt, in case of any conflict between the requirements of these standards, the stipulations of these Specification and Standards shall have precedence.

1.3.2 The design of the re-generative braking equipment/any other additional equipment, system and sub-systems thereof shall comply with the following standards. Deviations from these specifications as specified herein and as may be mutually agreed to subsequently between the manufacturers and RDSO will only be towards improving reliability and increasing safety margins.

- 1. Electric traction – rolling stock – test methods for electric and thermal /electric rolling stock on completion of construction and before entry into service : IEC 61133
- 2. Specific rules concerning the electronic control part of converters : IEC-60571
- 3. Railway application – rolling stock – Part 1: combined testing of inverter fed alternative current motors and their control system : IEC 61377-1
- 4. Electric railway equipment-train communication network : IEC 61375-1
- 5. Railway applications – electromagnetic compatibility – Part 3-2: rolling stock – Apparatus : EN 50121-3-2/
IEC 62236-3-2
- 6. Railway applications – electromagnetic compatibility – Part 2: emission of the whole railway system to the outside world : EN 50121-2/
IEC 62236-2

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7. Railway applications – compatibility between rolling stock and train detection system : EN 50238
8. Relays, Contactors and switches : IS 3231, IEC 60337, 60947
9. Cables : IEC 60228, IS 10810
10. Lightning arrestor : IEC 60099-4, IS 3070 pt III
11. Railway applications – rolling stock equipment – shock and vibration test : IEC 61373
12. Programming languages for PLC : IEC 61131
13. Railway applications – electric equipment for rolling stock : IEC 60077
14. Power converter installed on board rolling stock – Part 1: Characteristics and test methods : IEC 61287-1
15. Power converter installed on board rolling stock– Part 2: Additional technical information : IEC 61287-2
16. Railway application – rolling stock protective provisions against electrical hazards : IEC 61991
17. Auxiliary machines : IEC 60034
18. Power factor correction : IEC 60871
19. Control cubicle : IEC 60068
20. Degree of protection provided by enclosures : IEC 60529

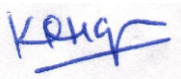

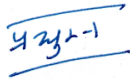
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- 21. Rules for installation of cabling : EN 50343
- 22. AAR approved couplers and coupler yokes : M-211
- 23. Railway applications, welding of railway vehicles and components. EN15085
- 24. Air brakes : RDSO's specification No. 02-ABR-02
- 25. Schedule of Dimension for broad gauge : IR Schedule Of Dimension for Broad Gauge, revision 2004 (or latest)
- 26. Reliability of electronic component : IEC 61709
- 27. RAMS : EN 50126/ IEC 62278
- 28. Railway applications- Rolling stock- protective actions against electrical hazards : EN 5013
- 29. EMC & EMI : IEC 61000 series

1.3.3 The latest version of the aforesaid standards, which have been published at least 60 (sixty) days before the last date of bid submission shall be considered applicable.

1.3.4 Alternative Standards

The requirements listed in these Specifications and Standards are the minimum. The Vendor may adopt alternative internationally recognized codes, standards and specifications if it can demonstrate to the Government that such alternative is superior or more pertinent to the Locomotive than the standards specified in these Specifications and

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Standards. The Vendor shall seek the prior approval of the Government for any alternate standards proposed to be used.

1.4 Power Supply System

1.4.1 Power supply system for 25 KV 50 Hz AC traction

- | | | |
|-------------|------------------------------|--|
| i) | General | The power supply system adopted is 25 KV 50 Hz AC (the nominal voltage and frequency of the system). The design calculations and guaranteed performance shall be based on 22.5 KV. |
| ii) | Variation in supply voltage: | 19 KV to 27.5 KV
Occasional maximum – 31 KV
Instantaneous minimum – 17.5 KV |
| iii) | Variation in frequency: | ±8% (46.0 to 54.0 Hz) |
| iv) | Stagger of the contact wire: | ± 200 mm on straight track.

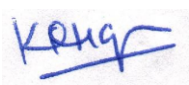
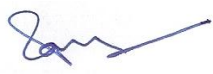
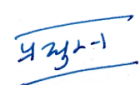
Up to 300 mm on curves |

1.4.2 OHE Parameters

Normal contact wire height in mid span	Normal OHE	High rise OHE
		5.5 m from rail level
Max. contact wire height	5.8 m from rail level	7.57 m from rail level
Min. contact wire height	4.58 m from rail level	7.37 m from rail level
Neutral Sections	After every 25 to 50 Kms	

1.4.3 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

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(ii) Short neutral sections of approx. 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.

There shall be power interruptions at neutral sections varying from 12 seconds to 30 seconds.

1.4.4 Pantograph bounce Up to 45 ms (limit of zero pressure contact).

Note: The occasional maximum and occasional minimum voltage may persist for 30 minutes.

1.5. Climatic and Environmental Conditions

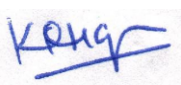

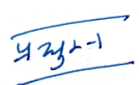
- i)** Maximum temperature (atmospheric)
 - Under sun - 75°C
 - In shed - 55°C
 - Temperature inside locomotive may reach 55°C.
 - Minimum temperature - 10°C

- ii)** Humidity 100% saturation during rainy season

- iii)** Reference site conditions
 - Ambient temperature 50°C
 - Temperature inside loco 55°C

 - Altitude 1776 m above sea level

- iv)** Rain fall Very heavy in certain areas (an annual rainfall of 11,872 mm (467.4 inch)). The locomotive shall be designed to permit its running at 10 km/h in flood water level of 102 mm above rail level. Since the locomotive shall be required to work at a restricted speed of 10 km/h on a flood water level of 102 mm. in areas

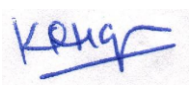
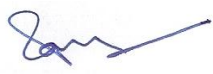
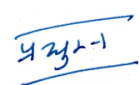
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- experiencing heavy rains during monsoon, special care should be taken during manufacture to allow satisfactory running of the locomotive under the above condition.
- v) Solar radiation 1 kw/ m²
 - vi) Wind speed High wind speed in certain areas with wind pressure reaching 150 kg/ m²
 - vii) Atmosphere during hot weather Extremely dusty and desert terrain in certain areas.
 - viii) Coastal area Locomotive and equipment shall be designed to work in coastal areas in humid and salt laden atmosphere with maximum pH value of 8.5, sulphate of 7 mg per litre, maximum concentration of chlorine 6 mg per litre and maximum conductivity of 130 micro siemens/cm.
 - ix) Vibration The equipment sub-system and their mounting arrangement shall be designed to withstand satisfactorily vibrations and shocks encountered in service as specified in relevant IEC publication unless otherwise prescribed.

The environmental conditions specified above are for the general guidance of the manufacturer/Vendor. Further specific information, if any required, shall be ascertained from RDSO.

1.6 Signal and Telecommunication Installations:

1.6.1 The tracks over which the Locos will run may be equipped with 83-1/3 Hz track circuits as well as track circuits at higher frequencies. Similarly, other devices like axle counters, block instruments, point machines, etc., may also be employed. On the communication network, control circuits, tele-printer circuits, as well as VHF/UHF and micro-wave circuits are employed.

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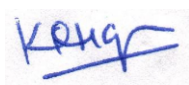

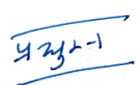
1.6.2 The harmonic currents injected in the overhead supply system (as also the track return current) can introduce voltage/current harmonics on power supply and can interfere with signal and telecom circuits. The design of the power electronics and control electronics provided on the propulsion system shall be such as not to cause levels of interference exceeding the levels specified below at any point for stages of operation of 100% down to 50 %, working in a train:

	Interference Current	Limit
1.0	Psophometric current	10.0 A
2.0	DC component	4.7 A
3.0	Second Harmonic component (100 Hz) and 83.33 Hz component	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

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

1.6.3 The Vendor 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. Test results shall be provided in a Type Test report.

1.6.4 If the interference limits for track circuits and axle counters as per EN 50238 are more onerous than those stated in Clause 1.7.2 of this Specification. These limits as per EN 50238 shall be applied subject to provisions made in Clause 1.3.4 of this specification.

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1.7 Other Important Requirements

1.7.1 Submission of design details: The details of the design will be submitted to RDSO in the course of the design process. These will be examined in consultation with the Vendor for approval. The most essential criteria to be met are as below:

1.7.2 The equipment shall be equipped with technology incorporating IGBTs and microprocessor control that has been working satisfactory in Railway Traction Application. The details of such applications will be provided. The system design, sub-system design and the equipment design will meet the overall requirement of performance.

1.7.3 Subject to the above, the equipment will represent proven latest technology specially adopted for application. However, the Vendor needs to submit the manufacturing details of mechanical items during design evaluation stage.

1.8 Reliability, Availability, Maintainability and Safety (RAMS) for regenerative braking feature to be installed in locomotive

1.8.1 General

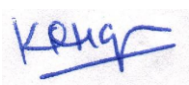
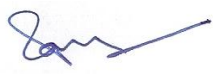
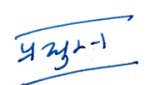
The Vendor shall design the equipment required for provision of regenerative feature in WAG7 Locomotive to ensure Guaranteed Reliability, Availability and high degree of Safety in order to provide a dependable service. The optimization of the system with respect to Reliability, Availability, Maintainability and Safety shall form an integral element of these Specifications and Standards.

The plan for Reliability, Availability, Maintainability and Safety shall conform to EN 50126/ IEC 62278. Reliability of electronic components shall conform to IEC 61709.

1.8.2 There shall be an efficient means of operation of the Locomotive after all failures in accordance with Good Industry Practice.

1.8.3 Components critical for safety shall fail into safe operating mode in case of malfunctioning. The system safety plan shall identify and list safety critical components and this list shall be updated periodically.

1.8.4 The Vendor shall establish and operate a detailed Reliability, Availability, Maintainability and Safety (RAMS) Assessment system in support of the

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design, manufacture and subsequent testing, commissioning, operation and maintenance of the equipmentsupplied and commissioned by them.

1.8.5 Safety Assessment shall be carried out and shall include the following principles:

- (i) Degraded modes and emergency operations shall be considered as well as normal operations;
- (ii) Safety risk assessment shall utilize more than one methodology to assess risks; and
- (iii) Safety risk assessment shall include the consideration of dependent failures, in particular the traction power, braking and control systems.

1.9 Quality of Materials, Manufacturing Processes and Workmanship:

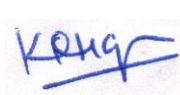

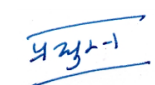
1.9.1 All materials used in the manufacturing of the additional equipment required for provision of re-generative braking in WAG7 locomotive shall not give rise to health hazards for crew and staff. The materials shall also be suitable for standard repair operations such as those currently used by the Government (e.g. welding, cutting etc.) without the need for staff to be protected by other than standard means. Materials used for additional equipment required for provision of re-generative braking shall be appropriate for achieving the Design Life of the Locomotive.

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

1.10 INFRINGEMENT OF PATENT RIGHTS :

IR shall not be responsible for infringement of patent rights arising due to similarity in design, manufacturing process, use of similar components in the design and development of the regenerative braking in WAG7 Locomotive and any other factor not mentioned herein which may cause such a dispute. The entire responsibility to settle any such disputes/matters lies with the vendor.

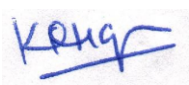
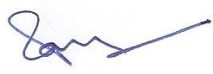
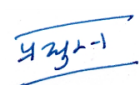
1.11 All the provisions contained in RDSOs ISO procedures laid down its Document No. QOD-7.1-11 dated 05.12.2017 or latest version (titled "Vendor Changes in approved status") and subsequent versions/ amendments thereof, shall be binding and applicable on the successful vendor/ vendors in the contracts floated by Railways to maintain quality of products supplied to Railways.

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1.12 DOCUMENTATION:

Following documents shall be submitted by the Vendor:

- i. System design concept
- ii. Schematic Circuit diagram
- iii. Functional Description
- iv. Clause by clause compliance
- v. Credentials with details of supply made of such/similar items
- vi. Salient features and advantages of the offered design/system
- vii. Details of technical support and training offered.
- viii. List of special tools, jigs and fixtures needed for assembly, testing/validation, commissioning, maintenance and repair along-with full technical specifications and probable Vendors.
- ix. Logistics proposed for warranty support.
- x. Declaration for long-term support by the Vendor.
- xi. Guaranteed values of efficiency of devices/sub-assemblies and assemblies
- xii. Expected efficiency with respect to vehicle load/speed along-with calculations
- xiii. Technical details of the devices proposed to be used.
- xiv. Cooling system design description and cooling fluid data.
- xv. Schedule maintenance activities with periodicity.
- xvi. IRIS/ISO 9001 certification.
- xvii. Communication protocol and software structure description along with compatibility with the locomotive control system.
- xviii. Mechanical interface diagram and compliance to existing equipment.
- xix. Calculation and simulation results of system behavior, including interference to the S&T track circuits and equipment.
- xx. Data sheets for devices and other equipment proposed along with detailed description of supply proposed.

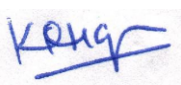

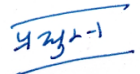
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- xxi. Calculation to withstand short circuit current under fault conditions.
- xxii. Details of short time rating of the Integrated/individual Converter
- xxiii. Technical documentation explaining the complete scheme, characteristics, diagnostics, protection and control etc.
- xxiv. Detailed drawings of each system/sub-system with interface details.
- xxv. Design calculations for selection of devices, cooling systems and various subsystems, establishing the adequacy of the components selected.
- xxvi. Complete BOM / technical specification of components with source of supply.
- xxvii. Mechanical drawings, mounting arrangement, weight, details of mounting accessories.
- xxviii. Procedure for parameter alteration, software downloading, diagnostic uploading, analysis etc.
- xxix. Maintenance, Trouble shooting and repair manual in soft form & hard copy.
- xxx. All calculations evaluated on the basis of software simulations shall be supported by sample calculations.
- xxxi. 3D models of all the additional cubicles, compatible to NX platform.
- xxxii. Recommended list of spares with cost for 3-years comprehensive maintenance after warranty along-with full drawing/design and details of OEM.

1.13 The Vendor’s responsibility shall be extended to the following:

The design, development, testing, supply and installation of the re-generative equipment is vendor’s responsibility. Additionally, vendor shall also provide detailed installation instruction for re-generative braking system for Railways for reference & record. For this purpose, the Vendor shall also depute his representative during installation and commissioning of the equipment, supplied against the specification. The Vendor shall arrange to carry out detailed test & performance proving, jointly with Railways. The Vendor shall also quote for special tools, testing jigs, and instruments, which may be required for troubleshooting and maintenance of the equipment supplied. The design shall be developed as per requirement given in the specification.

The Vendor shall wholly and completely be responsible for the performance of the complete equipment.

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CHAPTER 2

PERFORMANCE REQUIREMENTS

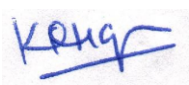
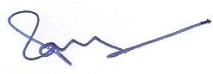
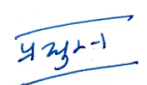
2.1 Performance of Existing WAG7 Locomotive:

With line voltage of 22.5 KV AC and half-worn wheels and axle load of 20.5 t, the WAG7 locomotive is capable of the following performance:

- | | | |
|-------------|----------------------------|---|
| i) | Starting Tractive Effort | Starting tractive effort under dry rail condition should be in the region of around 44.0 t. |
| ii) | Continuous Tractive Effort | 30.8 t |
| iii) | Continuous rated speed | 44 km/h |
| iv) | Continuous rated power | 3675 kw (5000 HP) at rail |
| v) | Dynamic braking effort | Around 20 t over the speed range of 25 to 50 km/h. The speed range should be wider depending on the design. |
| vi) | Maximum service speed | 100 km/h |
| vii) | Mechanical arrangement | Should be such that it should be possible to test the loco at a speed of 110 km/h. |

2.2 Load Haulage Performance:

2.2.1 The WAG7 locomotive is capable to start the load on gradient and attain the following balancing speeds indicated in the Table, under all weather conditions and conforms to the loco performance curve indicated in **Annexure II & III.**

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Load haulage performance of 5000 HP tap changer loco

SNo	Load	Grade	No. of locos	Balancing speed(km/h) Gear ratio 16:65
i)	4830 t (Box N)	Level	1	86.0
ii)	- do -	1 in 300	1	55.0
iii)	- do -	1 in 200	2	72.0
iv)	- do -	1 in 80	3	54.0
v)	- do -	1 in 70	3	48.0
vi)	3300 t (BCN)	1 in 150	1	47.0
vii)	- do -	1 in 100	2	64.0
viii)	- do -	1 in 60	3	59.0

2.2.2 For load haulage it may be required to use two or more locomotives in multiple unit operation. Provision is made so that a maximum of 4 locomotives can be operated as couple unit.

2.3 Train and Locomotive Resistance Data

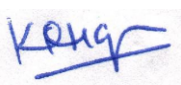

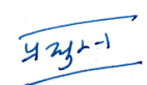
The train resistance and the locomotive resistance data as followed by IR is as follows:

i) Train resistance (excluding locomotive)

- a) Mean starting resistance on level tangent track (including acceleration reserve)
- 5.0 kg/tonne for BOX Wagons
 - 4.5 kg/tonne for BOXN Wagons in Yards
 - 4.0 kg/tonne for BOXN Wagons on Main Line

- b) Mean running resistance on level tangent track
- $R_t = 0.87 + 0.0103V + 0.000056V^2$ kg/tonne (for BOX Wagon)
 - $R_t = 0.6438797 + 0.01047213V + 0.00007323V^2$ kg/tonne (for BOXN wagon)

where 'R_t' is the resistance in kg per metric

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tonne of freight train & 'V' is the speed in km/h

ii) Loco Resistance

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

b) Running resistance on level tangent track $R_l = 2.2424 + 0.00349 V + 0.000407 V^2$ kg/tonne
 where 'R_l' is the resistance in kg/tonne of locomotive and 'V' is the speed in km/h.

(The compensation to be allowed for curve resistance is to be taken as 0.4 kg/tonne per degree of curvature)

2.4 Important Locomotive Parameters of WAG7 locomotive

i) Axle load and weight of the locomotive The locomotive shall consist of 6 axles. The axle load of the locomotive shall be limited to 20.5 t with tolerance of ± 2%. The total weight of the locomotive, of the bare bogie frame and of the ballast weight if any, shall be indicated by the Vendor. The total weight of the locomotive shall not be outside the range of 123 t ± 1%.

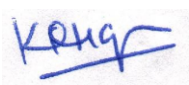
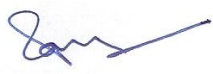
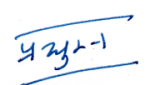
ii) Maximum permissible speed and test speed The locomotive shall be suitable for a test speed of 110 km/h and a maximum service speed of 100 km/h with half worn wheels for main line on BG minimum track standards as described in chapter 2 para 2.1.

iii) Buffing load The loco shall be designed to withstand a static buffing load of 400 t.

iv) Lateral force The lateral forces shall be limited to 4.0 t per axle at the max test speed of 110 km/h.

v) Dynamic augment Dynamic augmentation should be below 50%.

vi) Un sprung mass per axle Un sprung mass per axle shall be limited to 4.3 t.

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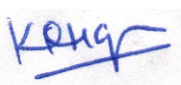

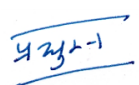
2.5 Brake System

The locomotive is provided with IRAB9 type air brake system of RDSO approved design. The L- type composite brake blocks are provided.

2.6 Performance Requirements of the Re-generative System

With line voltage of 22.5 KV AC and half-worn wheels and axle load of 20.5 t, the WAG7 locomotive shall be capable of the following performance:

- 2.6.1 Regenerative braking: Regenerative braking effort shall be available over full speed range of the locomotive. Regenerative braking effort shall be 25% of gross weight over the speed range of 10 kmph to 35 kmph & approximately 20% of gross weight at 50 kmph without slipping, and as limited by maximum regenerative power for higher speeds.
- 2.6.2 Maximum Power regenerated through re-generative braking shall be equal to or more than 2430 KW the maximum power which was dissipated during application of dynamic braking in existing WAG7 locomotive($6 * I^2 R = 6 * 900^2 * 0.5 = 2430 \text{ KW}$).
- 2.6.3 The manufacturer shall furnish the necessary design details, data, calculations and drawings of items to be used in locomotive for providing re-generative braking for evaluation and approval of RDSO.
- 2.6.4 The efficiency of converter including magnetics shall be at least 92%.
- 2.6.5 Converter shall be designed according to Traction motor continuous and short time ratings.

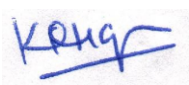
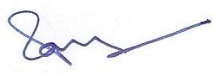
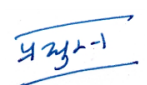
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CHAPTER 3

Technical Requirement of Regenerative Braking Equipment

3.1 General

- 3.1.1 Development of Regenerative Braking feature in existing WAG7 locomotives shall generally meet the requirement as detailed at Clause 2.6 and shall consists of provision of IGBT based converters, IGBT based chopper and other associated equipments. Supply of cable accessories, piping, structure assembly and other items required for retro fitment shall be supplied by vendor. Assemblies/components and various other parts etc. used in for retro-fitment of these items for regenerative braking application in WAG7 locomotives should conform to relevant BIS, IEC, or international specifications, wherever such specifications are available and applicable.
- 3.1.2 The equipment associated with re-generative braking shall be equipped with technology incorporating IGBTs and microprocessor control that has been working satisfactorily in Railway Traction application. The details of such applications and will be provided. The system design, sub-system design and the equipment design will be such as to meet the overall requirement of performance.
- 3.1.3 Subject to the above, the re-generative braking associated equipment/assemblies/sub-assemblies will represent proven latest technology specially adopted for application.
- 3.1.4 Adequate margin will be built in the design, particularly to take care of the high ambient temperatures, dusty condition, high humidity, etc. prevailing in India.
- 3.1.5 Efficiency of equipment and reduced energy consumption, high power factor, reduced interference to signaling and telecommunication circuits will be important considerations, but next only to reliability.
- 3.1.6 The Vendor shall design the equipment required for providing re-generative braking in WAG7 locomotive to ensure guaranteed

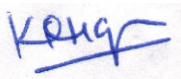

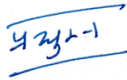
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reliability, availability and high degree of safety in order to provide a dependable service. The plan for Reliability, Availability, Maintainability and Safety shall conform to EN 50126/IEC 62278. Reliability of electronic components shall conform to IEC: 61709.

- 3.1.7 Submission of design details: The details of the design will be submitted to RDSO in the course of the design process. These will be examined in consultation with the Vendor for approval.

3.2 IGBT based converters, IGBT based chopper

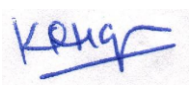
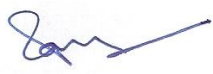
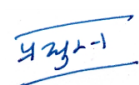
- 3.2.1 The power converter shall be completely IGBT based, The voltage rating of IGBT shall be higher than the surge voltage across IGBT terminals through main transformer windings, and shall be so chosen that at least 25% margin is available after taking into consideration the DC link voltage and voltage jump on account of inductances and capacitances in the circuit. Water cooling or forced air cooling shall be adopted for power converter IGBT based system. The current rating of power devices shall be such that the junction temperature has a minimum thermal margin of 10 degree Celsius, at maximum loading conditions under the specified ambient temperature, with respect to maximum permissible junction temperature of power devices declared by the manufacturer. 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 10°C (degree Celsius) shall be kept with respect to maximum permissible junction temperature of power devices declared by the manufacturer.
- 3.2.2 The protection scheme of the converters, chopper system shall prevent any damage to these systems in the event of short circuit current flowing under fault conditions, in accordance with Good Industry Practice. The system shall also be designed to withstand extreme disturbances like short-circuit / open circuit at all points of input / output interfaces with Locomotive, with minimized effects/damages. This shall be Type Tested according to the relevant provisions of the IEC 61287/any other relevant standard.

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- 3.2.3 Adequate protections not limited to following shall be provided in the system:
- Over current;
 - line or DC link over voltage and under voltage;
 - over temperature;
 - traction motor over load, over temperature and over speed;
 - earth fault; and
 - failure of line/pre-charging contactors(s) to open when commanded.
- 3.2.4 During the earth fault or fault in the traction motor, protection scheme of the power converter shall prevent any damage to the chopper/converter.

3.3 Electronics

- 3.3.1 The general provisions of this paragraph shall be applicable to all electronics used, including for converters, chopper system. The electronics used on the Locomotive shall conform to IEC-60571. However, due to higher ambient temperature specified, it shall be suitable for working for short time (at least 15 minutes) at high temperatures as expected to be encountered in Locomotive standing under sun. There shall be no requirement of pre-cooling of the electronics on Locomotive standing in sun for long duration. The electronic control equipment shall be protected against unavoidable EMI / EMC in the machine compartment.
- 3.3.2 The electronics shall be designed to be sealed from the remaining part of the machine room so as to ensure that there is no dust ingress whatsoever in to the electronics. The electronics shall be designed with adequate margin so that there are no failures on thermal account.
- 3.3.3 The electronic cards and couplers / connectors shall be polarized or suitably designed to ensure that insertion in wrong position is not possible.
- 3.3.4 Capacitors shall be suitably rated, keeping in view the high ambient temperature specified, vibrations of electric rolling stock and electrical surges expected during operation. High failure rates of

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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. The Expected life of the cards, and electronics in general shall be at least 18 years under actual working conditions.

3.3.5 The cooling arrangement of the electronics of the system shall be designed so that it can perform at the temperatures inside the locomotive machine room as given in clause 1.5.

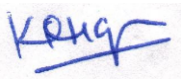

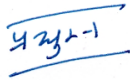
3.3.6 The electronics of the converters, and chopper system shall preferably not be placed near to the roof to avoid the effect of solar gain. The electronics shall preferably be placed in a separate compartment away from the converters.

3.4 Insulation, Cable & wiring

3.4.1 Insulation, Cables & Wiring requirement shall be met as per Clause No. 4.2.23 of RDSO spec No. RDSO/EL/2007/EL/Spec/0049 (Rev.2).

3.4.2 **Any other equipment/sub-equipment required during retro-fitment of regenerative braking**

Requirement of equipment/sub-equipment, piping, structure assembly, changes in BA panels, AC2 panels, controller interface, hardware etc. during retro-fitment of regenerative braking shall be met as per RDSO spec No. RDSO/EL/2007/EL/Spec/0049(Rev.2) and from RDSO/CLW/Railways approved sources.

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CHAPTER 4

General Conditions, Inspection, Test & Trials and other Requirements

4.1 General Conditions

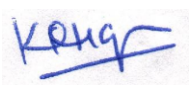
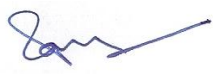
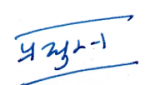
4.1.1 General design features of re-generative braking

- (i) The equipment to be used for re-generative braking shall incorporate features to yield high availability for traffic use, low maintenance requirements, easy maintainability, high reliability in operation and high efficiency.
- (ii) The Vendor will provide the items required for proper functioning of the re-generative braking in WAG7 locomotives in accordance with current international practices.
- (iii) The specification has been prepared for the general guidance of the Vendor to prepare the key design for the proposed re-generative braking in WAG7 locomotives. Any deviation from specification, intended to improve the performance, utility and efficiency of the locomotive as a whole or part thereof may be proposed for consideration. All such proposals will, however, be accompanied with complete technical details and justification for proposed deviation.

4.1.2 **Approval of design:** The design of the equipment & sub-equipment for regenerative braking and retro-fitment in WAG7 locomotives shall be developed based on the requirements given in this specification and sound engineering practices. The design shall be developed in SI units only.

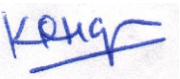

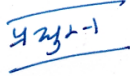
4.1.3 The entire design of equipment/sub-equipment being supplied by contactor to achieve the functionalities mentioned in the specification shall be carried out by the Vendor and submitted to RDSO along with required technical data and calculations for necessary approval. The Vendor shall be responsible for achieving the desired performance parameters of the locomotive for the equipment supplied by him. The manufacturing shall commence after the approval of design by RDSO.

4.1.4 The Vendor shall submit all necessary data, designs, calculations, drawings and specifications referred in their drawings or design

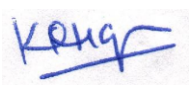
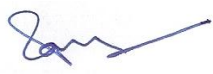
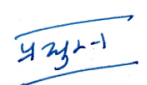
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documents in English language as required by IR for examination and shall provide explanation and clarification of the documents for which approval is sought. After the final design is approved, the Vendor shall furnish complete set of specifications and standards as mentioned in the approved drawings & documents and shall also submit the list of equivalent Indian Standards, wherever applicable. Vendor shall submit complete design details, block diagrams, functional description of all sub-systems, schematic drawings, loading calculations, circuits, component rating, wiring diagrams, ventilation design, device rating & data sheets of front end converter, booster converter and step down chopper, control and the major equipment, loading of electronic equipment /components calculated under the ambient conditions as specified, etc. The aspects covered above are not exhaustive and the Vendor shall commit to supply.

- 4.1.5 Vendor shall enclose details of their system design, weight particulars and its disposition covering all items, basic software specification, electronics, communication protocols, display systems, and any other aspect / equipment which is within the scope of supply of the Vendor. The Vendor shall also submit in their offer the simulated values of the maximum interference currents in the power supply.
- 4.1.6 The Vendor shall submit the complete material / technical specification and sources of the components during design approval. The specification shall specifically be indicated on relevant drawings / documents.
- 4.1.7 The Vendor shall furnish details of its Quality Assurance and Quality Control at the design approval stage. The quality checks to be made at various stages of manufacture, final assembly and commissioning with tolerance would be indicated. The system would also cover the quality assurance for bought out items.
- 4.1.8 Approval of design means the approval of general design features. Notwithstanding approval from IR the Vendor shall be wholly and completely responsible for the satisfactory performance of the equipment.

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- 4.1.9 The Vendor shall be responsible for carrying out improvements and modifications at his own expense on all the equipment supplied, provided such modifications/improvements are decided to be necessary for meeting the requirements of reliability, performance, safety etc. jointly between Vendor and Purchaser.
- 4.1.10 For the purpose of technical decisions on improvements/modifications etc. on equipment, the final authority from the Purchaser's side shall be IR. However, the decision on obsolescence management of component/module/assembly etc. shall be mutually agreed by IR and Vendor.
- 4.1.11 The design will be made based on the requirements given in this specification and sound, proven and reliable engineering practices. The entire key design will be submitted with technical data and calculations to RDSO for approval.
- 4.1.12 The Vendor will submit a program indicating the expected dates on which drawings will be submitted for approval to RDSO to assist RDSO to plan resources for this approval.
- 4.1.13 The Vendor's engineer will deliver the drawings to RDSO and will provide explanation and clarification of the drawings for which approval is sought.
- 4.1.14 Deviations proposed by the Vendor in the interest of reliability and better performance will be examined by RDSO in close consultation and association with the manufacturer so as to arrive at the final locomotive design.
- 4.1.15 All necessary data, designs, calculations and drawings required by RDSO for examination of the manufacturer's proposals will be furnished by the Vendor. The design data calculations and drawings required by RDSO for approval of the design.
- 4.1.16 The Vendor will, in addition to furnishing information required by RDSO, also liaise with Indian Railways for any exposure of Indian Railways to current state of the art technology abroad so as to assess the relative merits/demerits of different designs offered and to arrive at mutually final designs. Information on experience on the equipment offered on different user railway systems will also be required by the Indian

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Railways for an appropriate assessment. The manufacturer/Vendor will give appropriate assistance in this regard also.

4.2 Inspection, test and trials:

4.2.1 The individual installed equipment, systems and subsystems, as may be necessary, shall be type and routine tested in accordance with relevant IEC, BS and RDSO publications as per details given in clause 1.3.2 according to the test program to be drawn up by the Vendor in consultation with RDSO. If equipment of the same make and type not undergone changes affecting performance has already been type tested according to clause 1.3.2, under reference site conditions given in clause 1.5 and equivalent operating conditions, reports will be submitted to RDSO. In such case type tests may be exempted. However all major equipment shall be type tested.

All equipment shall be routine tested according to the relevant IEC publications.

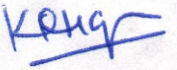

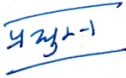
Required type tests of electrical and mechanical equipment shall be carried out by the Vendor at his own responsibility and costs and in the presence of and to the satisfaction of the Inspecting officials of RDSO. The type test shall be carried out at the manufacturing premises of the Vendor where all the facility required for type test shall made available by the Vendor.

4.3 Equipment/Systems/Subsystems testing:

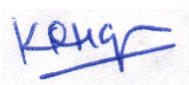
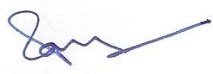
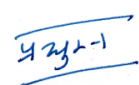
4.3.1 The equipment, systems and subsystems will be type/routine tested accordingly to this Specification and Standards.

4.3.2 Witness of tests: Some of these tests may be required to be witnessed by RDSO.

4.3.3 Raw material/Component testing: IR may also in addition, require test results on raw materials and components of critical nature, so as to ensure that they meet the performance and reliability stipulations. This may extend to components/equipment/raw materials not manufactured in the Vendor's Works, but purchased by him.

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- 4.3.4 Furnishing of test results: The Vendor shall be expected to furnish results of necessary tests and inspections carried out internally and in the presence of the Inspecting Officials.
- 4.4 **Re-generative Braking Test:** The locomotive shall be subjected to re-generative braking test conducted by IR on IR track conditions mainly to satisfy the Railways regarding operational performance & capability of re-generative braking.
- 4.5 The efficacy of braking effort shall be tested during trials by running the locomotive with suitable load. Trial scheme will be mutually finalized between Indian Railways and the vendor.
- 4.6 Tests to determine the levels of interference with the traction power supply and Signal and Telecommunication equipment and facilities to prove that these are within acceptable limits (ref. clause 1.6).
- 4.7 **Service Trials:** The WAG7 locomotive provided with re-generative braking shall also be evaluated during operation under actual load conditions. These shall be termed as "Service Trials". Apart from checking on repeatability of the operational performance under different conditions of track, OHE, signaling systems, etc. as well as under different conditions of wear and tear on the locomotive itself, these tests will also be used to throw light on the maintainability, accessibility, reliability and such other aspects which have been mentioned in this specification.
- 4.8 **Training of IR personnel:**
Vendor shall arrange necessary training of IR personnel as following:
(i) Training on design/maintenance at firm premises.
(ii) Training on operation at the Electric Loco Sheds/Lobbies.
- 4.9 **Documentation:** The Vendor will furnish as made drawings and tracings, manual of instructions for operation and maintenance of equipment used additionally for re-generative braking, trouble-shooting instructions and such other technical information as may be required for the maintenance and operation of these equipment in locomotives in India.
- 4.10 **Technical support:** The Vendor will ensure the availability of technical support in the service trials and during the period of guaranty and AMC. The terms and conditions regarding these aspects will also be incorporated in the contract.

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CHAPTER – 5
VENDOR'S AND RAILWAY'S RESPONSIBILITIES

5.1 Vendor's detailed scope of work:

5.1.1 Method of Development

General flow of development of regenerative braking feature in existing WAG7 electric locomotives shall be as under:

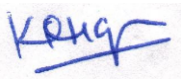

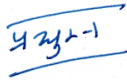
- i) Vendor shall submit the detailed scheme for provision of regenerative braking in WAG7 indicating the works that will be carried out by the vendor and Railway. Timelines shall also be indicated.
- ii) Detailed design document submission & approval
- iii) Submission and approval of type test protocol
- iv) Type tests of equipment
- v) Installation & commissioning
- vi) Service Trial

5.1.2 The Vendor shall design, manufacture and supply the equipment for regenerative braking in WAG7 locomotive and shall ensure that the locomotive meets the performance requirements as mentioned in the specification.

5.1.3 Integration & testing/validation of additional equipment of re-generative braking in WAG7 locomotive shall be under Vendor's scope of work. Vendor shall also associate themselves during the field trial of first locomotive.

5.1.4 Vendor should submit all the design details covering additional items, their mounting, any modification/shifting of equipment, integration details, wiring diagram etc. in hard and soft copy to IR.

5.1.5 **Performance Curves:** The preliminary notch-wise Regenerative Braking Effort Vs Speed at standard as well as site conditions shall be submitted along with the offer.

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5.1.6 **Efficiency:** The Vendors shall indicate efficiency for the different additional/modified components/equipment/systems supplied by them against the specification.

5.2 Railway's Scope of Work:

5.2.1 Locomotive will be given to Vendor by Indian Railway for carrying out retro-fitment of equipment/assemblies for regenerative braking after successful completion of type tests on equipment to be supplied by them.

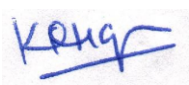
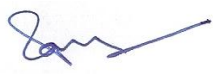
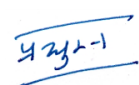
5.2.2 Retro-fitment will be carried out either at Vendor's premises or at Railway facilities. This is to be clearly indicated by the Vendor.

5.2.3 Railway will provide electricity, water, overhead crane etc. free of cost for the retro-fitment work of re-generative braking, if proposed in Railway Premises.

5.3 Scope of Work/Supplies:

In general, the differentiation of scope of work of Vendor& Purchaser shall be done on following lines as given below:-

Item No.	Item description	Responsibility of Design or Specification	Responsibility of Manufacturing or Procurement
1.	Provision of IGBT based converters/choppers and associated equipment for re-generative braking in WAG7 locomotive	Vendor	Vendor
2.	Changes in BA panels, AC2 panels, controller interface etc. as per requirement of regenerative braking	Vendor	Vendor
3.	Supply of cables, accessories, piping, structure assembly and hardware etc.	Vendor	Vendor
4.	Shifting of equipments for provision of re-generative braking feature in WAG7 locomotive	Vendor	Vendor
5.	Any other equipment, if required for re-generative braking can be decided during detailed design stage	Vendor	Vendor

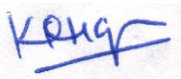

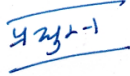
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Annexure I**DETAILS OF MAIN SIGNAL & TELECOMMUNICATION EQUIPMENTS
USED ON 25 KV AC ELECTRIFIED SECTIONS OF INDIAN RAILWAYS****A. Track Circuiting Installation:**

	Types	Working frequency	Remarks
1.	AC 83-1/3 Hz track circuit	83-1/3 Hz	AC vane type of relays are used. Two supplies at 83-1/3 Hz at 90° out of phase required for local and control supplies are transmitted from central location in the section using lead and aluminium sheathed cables. Both single and double rail type of track circuits are used.
2.	H.F. jointless track circuits	20 kHz 40 kHz	
3.	A.F. track circuits	1700 ± 50 Hz 2300 ± 50 Hz	2000 ± 50 Hz 2600 ± 50 Hz
4.	High voltage impulse track circuits		Similar to Jeuomont impulse track circuits.
5.	Long jointless track circuit	2580 Hz 2820 Hz	
6.	DC track circuit (single rail)	D.C.	9 Ohm. AC immunized relays tested for minimum 50 Hz immunity of 50 volts are used.

B. Electrical & Block Signalling Equipment:

	Types	Working frequency	Remarks
1.	Block instrument	(i) Carrier, 2000,	Block circuit in RE area are provided

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(a) Daido single line tokenless block instruments

2500 Hz Mod. Frequency 65 & 85 Hz

(ii) Carrier, 1800, 2700 Hz Mod. Frequency 65 & 85 Hz

on PE insulated quada in lead sheathed or aluminium sheathed main telecommunication cables. Intrinsic screening factors of lead sheathed cables at 50 Hz + 800 Hz are 0.4 in range 50 V – 450 V/km and 0.06 in range 0 – 10 V/km respectively. The screening factors for cables are 0.1 and 0.016 at 50 Hz and 800 Hz respectively in the range of 50 to 450 V/km field strength.

2. Point machines

(a) Point operation

DC, 24 V
DC, 110 V
Single phase AC
50 Hz, 220 V
three phase AC
50 Hz, 380 V

(b) Point detection

DC, 12 V
DC, 24 V
DC, 60 V

3. Signal

(a) Control

DC, 12 V
DC, 24 V
DC, 60 V

(b) Signal lighting

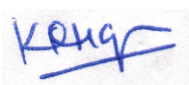
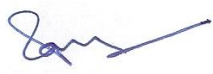
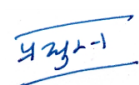
110 V AC stepped down to 12 V AC for signal lamp.

(c) Route indicator lighting

110 V, AC

(d) Shunt signal lighting

110 v, AC

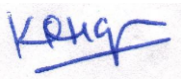

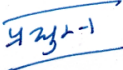
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4. Retarder operation and control (a) 50 Hz AC
(b) DC
(c) Doppler radar speed check at 10.7 GHz.
5. Axle counter 3.7 kHz, 5 kHz, 10 kHz, 17 kHz
6. AWS 1 kHz, 2 kHz, 4 kHz.

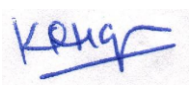
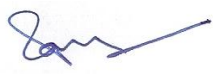
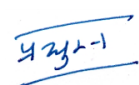
C. **Telecommunication Cabling Installations:**

Types	Working frequency	Remarks
1. Control circuit	(a) Speech – VF band (b) Signalling – 50 Hz, interrupted at 3½ cycles per sec.	
2. VF telegraphy	150 Hz, 1620 Hz	
3. Teleprinter	150 Hz, 1620 Hz	
4. Trunk circuit	Speech VF band and signaling – 17 Hz, 50 Hz, 150 Hz	
5. Gate control	Speech VF band and signaling – 17 Hz	
6. Block bell and train wire	150 Hz	
7. Carrier circuits	1+3 stackable carrier equipment 3.9 Hz to 11 kHz	Speech communication plus data transmission.

D. **Radio Communications:**

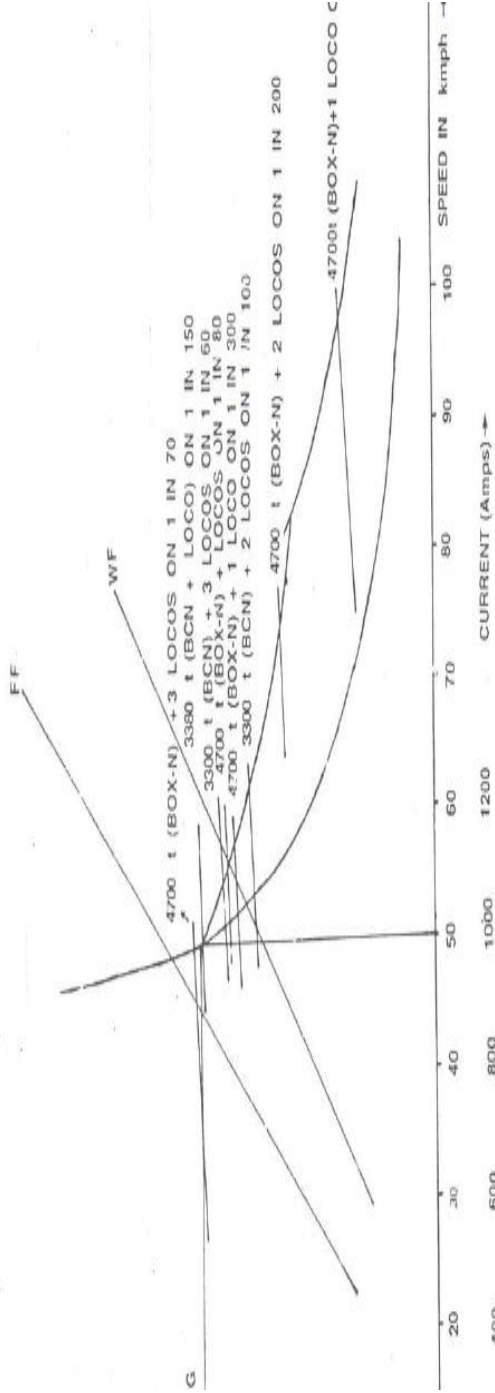
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Types	Working frequency	Remarks
1. HF communications	2-16 MHz (SSB and DSB working)	For speech communication and data transmission.
2. VHF links	68-87 MHz 146-163 MHz	
3. UHF	437-445 mhz 462-170 MHz	
4. Microwave	7124-7425 MHz	
E. <u>Miscellaneous:</u>		
Types	Working frequency	Remarks
1. Clock network	Square wave pulses 1 in 5 sec	
2. PA equipment	VF band	
3. CCTV	3 MHz	

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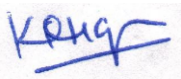

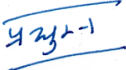
Annexure-II

TRACTION MOTOR - TYP
 No. OF MOTORS - 6
 CONT. RATING - 75
 GEAR RATIO - 18.1
 WHEEL DIA - 1052
 WEIGHT OF LOCO - 1231
 LINE VOLTAGE - 22.5

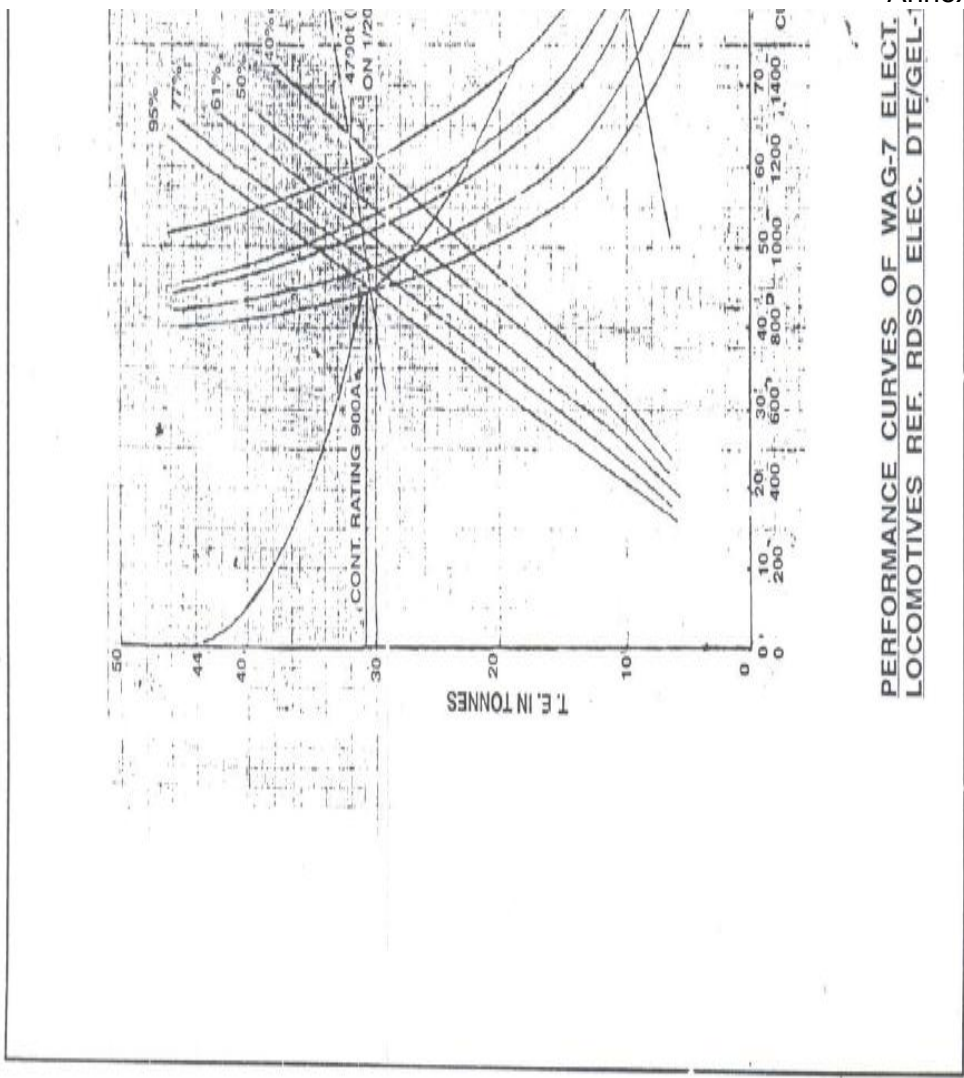


PERFORMANCE CURVE (GEAR 1)
 GENERAL DESCRIPT
 THE LOCOMOTIVE (ELE
 WAG
 7

3-7 ELECT.
 : : DTE/GEL-1032

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Annexure-III



PERFORMANCE CURVES OF WAG-7 ELECT. LOCOMOTIVES REF. RDSO ELEC. DTE/GEL-

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