

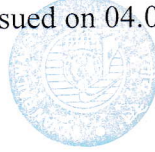


सत्यमेव जयते

भारत सरकार
रेल मंत्रालयGovernment of India
Ministry of Railways

**Functional Requirement Specification (FRS)
Of
4-Quadrant Converter (4-QC)
For
Conventional Electric Locomotives converted from diesel (ALCO)
Locomotives**

FRS No. RDSO/2019/EL/FRS/0027 (Rev. '0')
Issued on 04.09.2019



Approved by	Signature
PEDSE	 04/9/19

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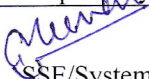


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Status of Revision

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1.	-	All	0	First Issue.
2.				
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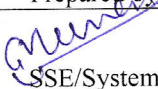
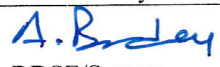
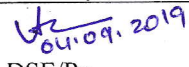


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1. Introduction

Meeting for “Development of Four Quadrant Control Converter for WAG7 Electric Locomotives” was held at RDSO, Lucknow on 15.03.2019 & MOM was circulated vide letter no. EL/3.2.19/RB/4QC dated 03.05.2019 wherein firms were requested to explore the possibility of development of four quadrant converter for WAG7 locomotive which can work in motoring as well as regenerative braking mode. If such converter is developed, it will eliminate the requirement of GR, SMGR, RSI, MVSI, BA panel & SL blocks etc. The space thus freed with elimination of said equipments, can be utilised to accommodate increased size of converters. During the meeting, firms proposed various variant & designs of 4-QC including the requirement of new design transformer compatible with proposed 4-QC. However, Member (Traction) vide Item no.1 of Inspection Note bearing no. 2016/Elect (G)/145/02 dated 17.05.2019 directed RDSO to develop specification of propulsion equipments for conversion of Diesel ALCO loco to Electric loco with regenerating capability features with four quadrant converter, chopper, harmonic filter, reactor and main transformer (without RSI, Tap changer & SL). Further, during meeting at Railway Board on 10th May 2019 regarding conversion of Diesel locomotives to Electric locomotives, it was decided that RDSO should develop specification for conversion of Diesel ALCO locomotive to Electric Loco with regenerating capability features(without RSI, Tap changer, SL,DBR etc) with four quadrant converter ,chopper, harmonic filter, reactor, new type of master controller and main transformer.

With aforesaid proceedings, this FRS has been prepared for the development of 4-QC.


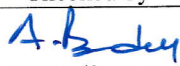
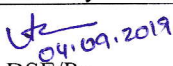
2. Objective & Scope of the FRS

This document lists the functional requirement of 4-QC to be used in Conventional Electric locos converted from ALCO diesel locos. This document has been prepared with an aim of defining the requirements for development of 4 Quadrant Converter which shall eliminate the requirement of Tap changer, RSI & SL blocks, DBR etc. which will not only address the maintenance issues of aforesaid equipments but will also provide linear control of traction motors to a great extent.

This document is a beginning for further development of equipment specification, inspection and test schedules required for use of 4-QC on electric locos of IR.

3. Environment Conditions

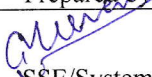
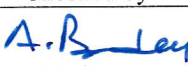
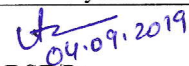
Atmospheric temperature	Maximum temperature of metallic surface under the Sun: 75 degree Celsius and in shade: 55 degree Celsius Minimum temperature: - 10 degree Celsius (Also snow fall in certain areas during winter season)
Humidity	100% saturation during rainy season
Reference site conditions	i) Ambient temperature: -10 °C to 55 °C ii) Humidity: 100% iii) Altitude: 1776 m above mean sea level
Rain fall	Very heavy in certain areas.

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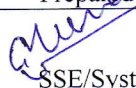

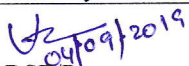
Atmospheric conditions	Extremely dusty and desert terrain in certain areas. The dust concentration in air may reach a high value of 1.6 mg/m^3 . In many iron ore and coal mine areas, the dust concentration is very high affecting the filter and air ventilation system.
Coastal area	Humid and salt laden atmosphere with maximum pH value of 8.5, Sulphate of 7 mg per liter, maximum concentration of chlorine 6 mg per liters and maximum conductivity of 130 micro Siemens /cm.
Wind speed	High wind speed in certain areas, with wind pressure reaching 150 kg/m^2 .
Electromagnetic pollution	High degree of electromagnetic pollution is anticipated in locomotive machine room/HT & LT compartment, where the equipment shall be mounted. Necessary precaution shall be taken in this regard. The system shall be interference free from the communication system between the Guard-Driver-Control and Public address system. The system should be tested as per IEC 61000 for Electro Magnetic Compatibility.
Vibration	The system shall be designed to withstand the vibrations and shock encountered in service satisfactorily as specified in IEC 1287 and 60571 publications for the electronic equipments used on Rail Vehicle and relevant IECs as applicable to other equipment.

4. Technical Details of existing Locomotive & its traction motor for development of 4-QC

SN	Parameter	Value
i.	Weight of twin WAGC3 loco	2x123t=246t 123 t is the weight of single WAGC3 loco
ii.	Axle load	20.5ton
iii.	Adhesion	35%
iv.	Starting Tractive Effort(kg)	Twin WAGC3=86000 Single WAGC3=43000
v.	Continuous tractive effort(kg)	Twin WAGC3=52800 Single WAGC3=26400
vi.	Maximum Speed(kmph)	115
vii.	Horse Power	Twin WAGC3=10000HP Single WAGC3=5000HP
viii.	Gear Ratio	18:74

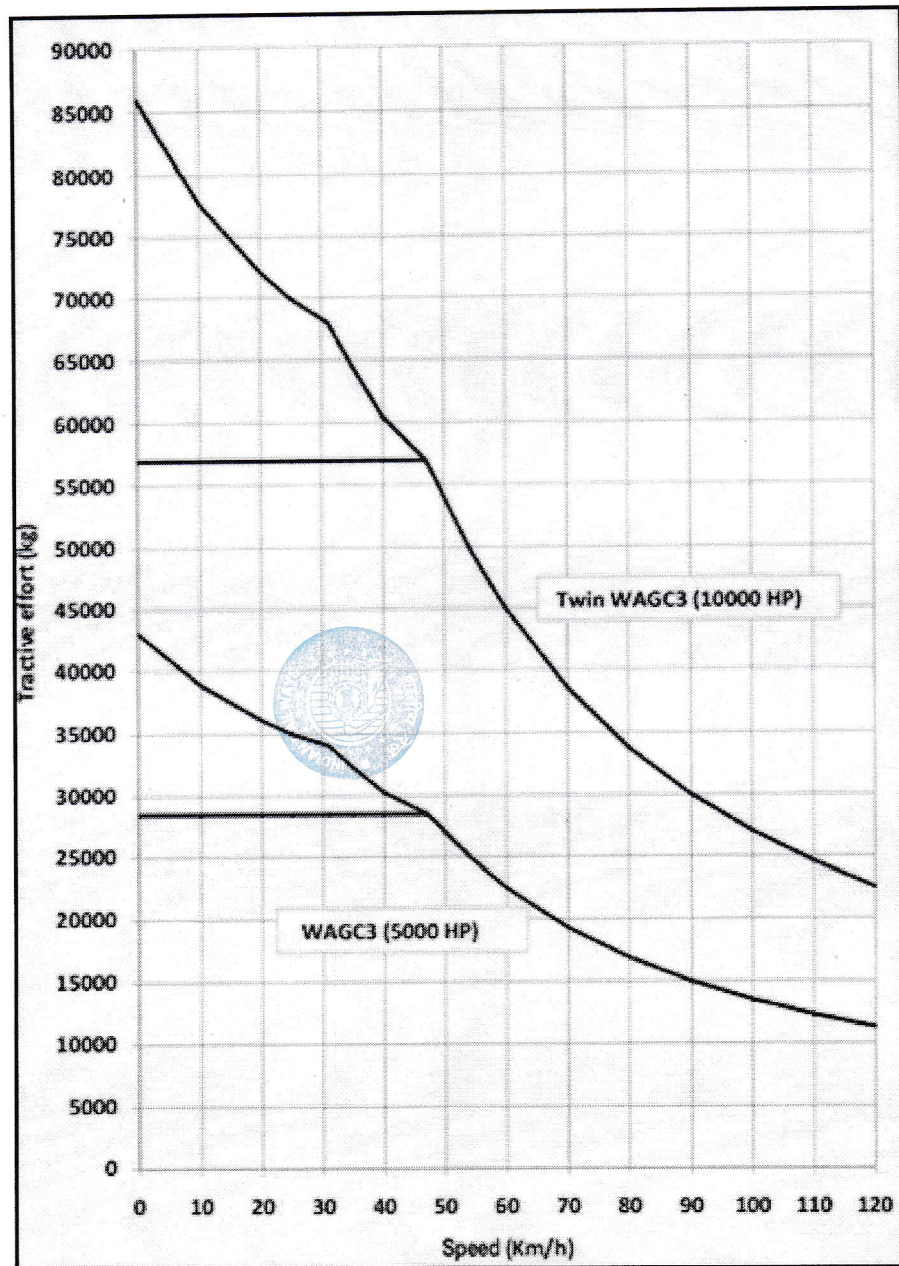
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ix.	No. of Transformer	For Twin WAGC3=2 For Single WAGC3=1
x.	Type of Traction Motor	TM4907BZ(BHEL)
xi.	Rating of traction motor(continuous)	750V,900A,600kW(800hp)
xii.	No of traction motor	6 per loco i.e. 12 nos
xiii.	Short time rating of Traction Motor	<ul style="list-style-type: none"> • 50minutes:1070A • 12minutes:1100A • 6minutes:1250A • 4minutes:1467A • 2 minutes:1550A
xiv.	Main transformer	<ul style="list-style-type: none"> • Phase : Single • Cooling: OFAF • Primary Voltage: 25 kV (nominal), 17.5 kV (min.), 30 kV (max.) • Secondary no load voltage: 2x1000V at highest tap (32) at 17.5kV Catenary voltage. • Primary input: 5670kVA • Secondary output:5400kVA • Auxiliary Circuit:270kVA
xv.	Silicon Rectifier(RSI)	<ul style="list-style-type: none"> • No. of cubicles per loco: 2 • Rated Current: 3300A • Maximum Starting current:4050A • No load rated input voltage at 17.5kV Catenary:1000V ac • No load rated output voltage at 17.5kV Catenary: 900Vdc

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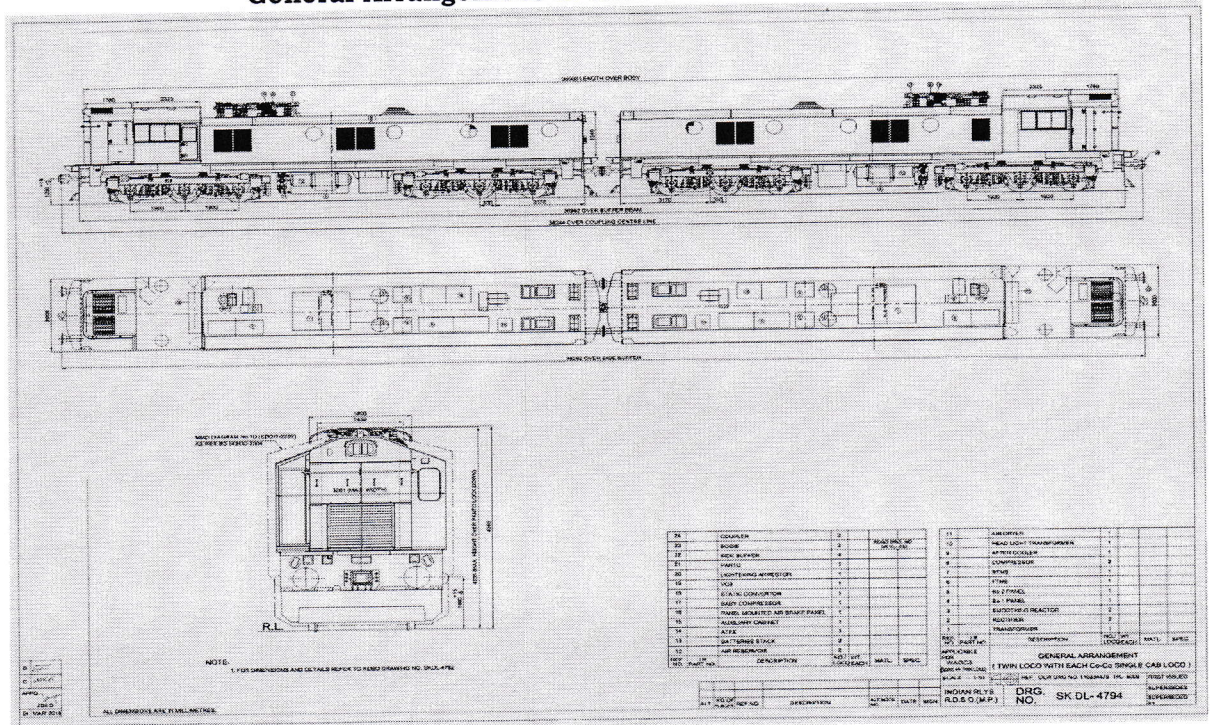
Speed Vs Tractive Effort Curve of Single & Twin WAGC3 locomotive

1. Starting Tractive Effort: 43000kg(WAGC3),86000kg(2 WAGC3)
2. Gear Ratio: 18:74



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General Arrangement of twin WAGC3 loco



5. Functional requirements

- 5.1 The Converter shall work in both directions i.e. in motoring mode & in regenerative mode.
- 5.2 The Auxiliary converter may be integral part of converter. Alternatively, auxiliary winding may be proposed on transformer for independent Auxiliary converter. Some of the regenerated energy can be directly consumed in the auxiliaries. The output of Auxiliary converter shall be 3-phase 415V.
- 5.3 There shall not be any adverse effect on motoring performance after provision of 4-QC which means the locomotive should give same or better motoring performance after provision of 4-QC.
- 5.4 There shall not be any adverse effect on the performance curves of motor/loco.
- 5.5 The overall weight of locomotive shall not be changed & axle load of loco shall remain same as before provision of 4-QC, new design transformer & other accessories i.e. the overall weight of loco shall be 123t \pm 1% and axle load shall be 20.5t \pm 2%.
- 5.6 Firms may design the converter for 3S-2P combination of traction motors. However, alternatively, converter may be designed for 6P combination of traction motors. RDSO has no reservation in any combination of traction motors & in turn the designs for converter.
- 5.7 Cooling system & design of transformer shall be decided by OEMs.
- 5.8 Regenerative braking effort shall be available over full speed range of the locomotive

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without skidding.

5.9 Converter shall be designed according to Traction motor continuous and short time ratings.

5.10 Testing of transformer & converter or any other equipment which is part of the system shall be done as per relevant standards.

6. Scope of Supply

- (i) 4-Quadrant Traction Converter
- (ii) Auxiliary Converter
- (iii) Transformer
- (iv) VCU as per the requirement
- (v) DDU
- (vi) Master Controller
- (vii) Control cabling
- (viii) All other accessories/equipments needed for conversion as specified in this FRS.

7. Documentation

7.1 The manufacturer shall furnish the necessary design details, calculations, drawings, functional description, protection scheme, cooling system details for transformer & converter, weight balancing calculations & FEA etc to RDSO/PUs for approval.

7.2 BOM (Bill of material), data sheets for components/devices & other equipment proposed for use in the design of transformer & converter.

7.3 Mounting arrangement drawing and weight.

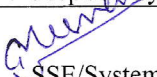
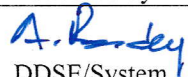
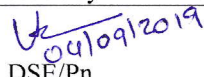
7.4 Details of equipment prototype type test i.e. Transformer test, Converter Test & any other associated equipment

7.5 Test protocol with procedure duly indicating the standards to be followed.

8. Infringement to Patent rights

Indian Railways 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 4 -Quadrant converter & transformer and any other factor not mentioned herein which may cause such dispute. The entire responsibility to settle any such disputes/matters lies with the vendor.

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