TRANSNET
freight rail

A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT

SPECIFICATION

WAVE-FILTER INDUCTORS FOR 3kV DC TRACTION SUBSTATIONS

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TABLE OF CONTENT

1.0 SCOPE

1.1 This specification covers Transnet Freight Rail's requirements for the supply of wave-filter; air cored inductor coils for 3kV DC traction substation.

1.2 The inductor coils shall be mounted indoors and form part of the resonant shunt circuit designed to attenuate the magnitude of the 6^{th}, 12^{th}, 18^{th} and the 24^{th} harmonic frequencies.

2.0 STANDARDS AND PUBLICATIONS

Unless otherwise specified all materials used and equipment developed and supplied shall comply with the current edition of the relevant IEC, SANS and Transnet Freight Rail's publications where applicable.

2.1 INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60310: 2016:	Railway applications - Traction transformers and inductors on board rolling stock.

2.2 SOUTH AFRICAN NATIONAL STANDARDS

SANS 1019:	Standard voltages, currents and insulation levels for electricity supply.

2.3 TRANSNET FREIGHT RAIL'S PUBLICATIONS

CEE 0224: 2002	Drawings catalogues instruction manuals and spares list for electrical equipment supplied under contract.
CEE TCK 004:	Wave filter cell layout.
BBB3483:	Wave-Filter Harmonic Coil Carrier assembly for 3kV DC substation.
BBB3484:	Wave-Filter Harmonic Coil Carrier components for 3kV DC substation.
BBB3486:	Inductance Coils for resonant shunt circuits for 3kV DC substation.
BBB3487:	Harmonic Filter Coil winding details (as wound) for 3kV DC substation.
BBD5994:	Technical Documentation Management Policy.

3.0 TENDERING PROCEDURE

3.1 The tenderer shall indicate compliance with the specification. This shall take the form of a separate document listing all the clause numbers of the specification with an individual clause by clause statement of compliance or non-compliance in English.

3.2 The tenderer shall motivate a statement of non-compliance.

3.2.1 The tenderer shall submit descriptive literature consisting of detailed technical specifications, general construction details and principal dimensions, together with clear illustrations of the equipment offered.

3.3 The tenderer shall complete and submit the technical data sheet in appendix B.

3.4 Failure to comply with clauses 3.1, 3.2, 3.3 and 3.4 could preclude a tender from consideration

4.0 SERVICE CONDITIONS

4.1 ATMOSPHERIC CONDITIONS

4.1.1	Altitude:	0 to 1800m above sea level.
4.1.2	Ambient Temperature:	-10°C to +55°C.
4.1.3	Relative Humidity:	10% to 90% .
4.1.4	Lightning Conditions:	20 ground flashes per square kilometre per annum.

4.1.5 Pollution : Heavily salt laden or polluted with smoke from industrial sources.

4.2 MECHANICAL SERVICE CONDITIONS

4.2.1 The 3kV DC traction substations are situated next to railway lines and the equipment will therefore be subjected to vibration. The design must take appropriate counter measures to ensure reliability of equipment that is sensitive to vibration.

4.3 ELECTRICAL SERVICE CONDITIONS

4.3.1 The nominal no-load DC voltage of a traction substation output varies between 3150 V and 3900 V.

4.3.2 The maximum voltage under no-load conditions can increase up to 4000 V due to a combination of the traction transformer tap settings and Eskom's supply voltage or regenerative braking.

4.4 THE WAVE-FILTER CIRCUIT

4.4.1 The wave-filter circuit is connected across the output of the 3kV rectifier. In each 3kV DC substation, the wave-filter equipment is located in an enclosure isolated from the rest of the substation equipment.

4.4.2 Wave-filter combinations are used according to the configuration type of rectifier in the substation. The six pulse type rectifier substations are normally equipped with 300Hz, 600Hz, 900Hz and 1200Hz filters to reduce the effect of the 6^{th}, 12^{th}, 18^{th} and 24^{th} harmonics frequencies respectively.

4.4.3 Substations with 12-pulse rectification are normally tuned for the 12^{th} and 24^{th} harmonics frequencies.

4.4.4 The wave-filter circuit is a RLC-circuit consisting of resistors and inductor coils with corresponding capacitor banks.

4.4.5 Drawing BBB3486 contains a table with the calculated and required standard values for the inductor coils and corresponding capacitor banks.

4.4.6 A 100-Ampere fuse and a resistor are connected in series with the resonant circuit for protection against the increase of harmonic current according to drawing CEE TCK 004.

4.4.7 The wave-filter circuit on substations with external wave-filter rooms, has a link switch for mechanical discharging the circuit capacitors.

4.4.8 The busbar insulator provides insulation between the positive busbar and the substation walls.

4.4.9 The discharge resistor is included for safety precautions to prevent the rapid collapse of flux when the circuit is opened.

5.0 TECHNICAL REQUIREMENTS

5.1 GENERAL

5.1.1 The inductors shall be air cored and specifically manufactured for high-voltage 3kV-DC applications.

5.1.2 The inductors shall be mounted on a wooden frame and the capacitors on the floor unless otherwise specified.

5.1.3 The inductors shall be manufactured according to the constructional and dimensional values in the drawings BBB3483, BBB3484 and the tables in drawings BBB3486 or BBB3487, in order to fit into newly manufactured or existing wooden frames.

5.1.4 Each inductor consists of two coils. The successful tenderer shall supply the coils in accordance to the requirement indicated in schedule of requirements appendix A.

5.2 **INDUCTOR VALUE IN MILLI HENRY (MH)**

5.2.1 The required mutual inductance values are given in drawing number BBB3486 and the alternative values are listed in BBB3487. The required mH values shall be obtained with the inductors installed on the wooden frame and placed at a distance "D" apart.

5.2.2 Drawing BBB3487 shows the required minimum and maximum mutual inductance values of the coils at the minimum and maximum spacing "D".

5.3 **VOLTAGE RATING**

5.3.1 The table in drawing BBB3486 lists the harmonic voltage operating requirements with respect to each harmonic LC-circuit parameters. The continuous, 1-minute and the 30-minute voltage ratings are also provided.

5.3.2 The inductors shall be manufactured to withstand continuous DC voltages between 3150 V and 4000V under no-load or regenerative braking conditions.

5.4 **CURRENT RATING**

5.4.1 The current operating requirements for the continuous, 1-minute and 30-minute ratings are given in the table contained in drawing BBB3486 with respect to each harmonic circuit.

5.5 **WIRE REQUIREMENTS**

5.5.1 The details for the particular wire required are described in the table contained in drawing BBB3486.

5.5.2 The wire shall be made of aluminium material.

5.5.3 The wire shall be fabric or cotton covered and no joints will be acceptable in the wire.

5.6 **BOBBIN / COIL CARRIER REQUIREMENTS**

5.6.1 The bobbin shall be made of Phenolic paper grades "Tufnol" or fibreglass reinforced polyester material.

5.6.2 The successful tenderer shall refer to drawing BBB3483 and BBB3486 for the design and dimensions of the bobbin.

5.7 **WINDING DETAILS**

5.7.1 The details regarding the required wounding, direction, connection, bounding, length, turns and layers of each winding are shown in BBB3486.

5.7.2 The mutual inductance shall be achieved by differentially coupling the two windings.

5.7.3 The distance "D" shown in the table contained in drawing BBB3486 shall be adjustable to achieve the desired mutual inductance.

5.7.4 The number of layers depends on the type of harmonic filter; the coils are designed for e.g. 6^{th}, 12^{th} harmonic frequencies, etc. The details for the number of layers and turns are shown in BBB3486.

5.8. **LIFE EXPECTANCY OF THE INDUCTOR**

5.8.1 The coils shall have a rated life expectancy of not less than 20 years (175 000 working hours).

6.0 CABLES AND CONNECTIONS

6.1 Tails at least 500 mm long shall be supplied for connection of the inductor coils to the rest of the wave-filter circuit. The tails shall be insulated and fitted with 16-mm lugs securely crimped to the tails.

7.0 RATING PLATE

7.1 A non-corrosive metal plate shall be fixed to each inductor giving the following information:

- Manufacture's Name
- Manufacture's Serial Number
- Type of Inductor

- Rated Current (Mean DC current)
- Value of Inductance in Millie Henry
- Rated DC Voltage
- Total Mass

7.2 The nameplate shall be visible in the position of normal service and installation.

7.3 The value of the associated capacitor to be clearly stencilled on both coils.

8.0 TESTS REQUIREMENTS

8.1 The inductors shall be subjected to the test requirements set in specification IEC 60310.

8.2 Type test and routine test certificates shall be supplied for each inductor offered.

8.3 In addition to the requirements of appendix B, the tenderer shall supply the following as per requirement in IEC 60310 specification: The rated values and service conditions i.e. current, voltage, frequency, duration, duty cycle, ventilation, etc.

9.0 QUALITY ASSURANCE

9.1 Transnet Freight Rail reserves the right to carry out inspection and witness any tests on the equipment at the works of the supplier/ manufacture.

9.2 Arrangements will be made timeously for such inspections to be carried out before the delivery of the equipment.

10.0 GUARANTEE AND DEFECTS

10.1 The tenderer shall guarantee the satisfactory operation of the equipment supplied by him and accept liability for maker's defects, which may appear in design, materials and workmanship.

10.2 The guarantee period for the equipment shall expire after a period of 12 months commencing on the date of installation and commissioning of the equipment or the date the equipment is handed over to Transnet Freight Rail whichever is the later.

11.0 PACKAGING AND TRANSPORT

11.1 The tenderer shall ensure that the equipment be packed in such a manner that it will be adequately protected against mechanical damage and ingress of moisture during handling and transportation.

11.2 The tenderer shall provide transport for the delivery of the equipment to the site where required.

12.0 APPENDIX A

SCHEDULE OF REQUIREMENTS

(To be filled in by Transnet Freight Rail's Maintenance Depot)

1. INDUCTORS

1.1 The following table shall be filled in with reference to the table contained in drawing BBB3486.

Harmonic	Inductor Required (mH)	Quantity Required
6^{th}	2.814	
12^{th}	1.173	
18^{th}	1.564	
24^{th}	1.759	

2. MAINTENANCE DEPOT

2.1 Depot Name: _____

2.2 Depot Address: _____

13.0 APPENDIX B

TECHNICAL DATA SHEET

(To be filled in by Tenderer)

- Inductor Tolerance (mH) at operational frequencies: _____
- Max Nominal Inductance at operational frequencies: _____
- Number of Turns (N): _____
- Rated Peak Current in Amperes (I): _____
- Rated DC Current in Amperes (I_N): _____
- Overall Mass of the Inductor (kg):_____
- Overall Dimensions of the Inductor (mm): _____
- Max Ambient Temperature in °C (T_a):_____
- Max Surface Temperature in °C (T_s): _____
- Maximum Permissible Operational Temperature in °C: _____
- Maximum Permissible AC Current in Amperes: _____
- Maximum Permissible AC Voltage in Volts: _____
- Maximum Energy Stored in Inductor at rated peak current (I): _____

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