	PRE-QUALIFICATION CRITERIA (PQC) for 102 KVA Transformer of MEMU/EMU Group: Traction Engineering	Ref.: 445/PQC/102KVA Rev. No.: 00 Page 01 of 01

1. Pre-qualification Criteria

1.1 The bidder should be supplier of 102 KVA Transformer for use in rolling stock application (locomotive/EMU/Metro) in India or abroad.

1.2 The bidder should be an "Approved" vendor of RDSO/CLW/Indian Railways. If not, if offer of bidder meets technical requirement, BHEL will approach and submit credentials/details furnished by bidder with their offer to customer i.e., RDSO and await its decision for a maximum of one month from the date of submission. The approval requested shall be for usage of offered 102 KVA transformer in Aux Converter of MEMU/EMU project.

1.3 If approval is not received within the above period, BHEL shall treat the offer as "Not meeting" Pre-qualification criteria and offer shall be rejected.

Extension beyond one month will not be given for whatsoever reason.

2. Documents to be submitted:

2.1 Proof of supply of offered 102 KVATransformer for rolling stock application (locomotive/EMU/Metro) in India or abroad directly or through any agency.

2.2 Clause by clause compliance to technical specification as mentioned in clause no. 3.1.

3. Reference documents:

3.1 Purchase-cum-Technical Specification No PS4452660, Rev. No. 00 for 102 KVA Transformer for Aux converter MEMU/EMU

	Rev.	**00**		**Approved by:** Santosh Kumar Sahu	
			Prepared by:	**Department:**	**Date:**
			Pradeep Kumar	Traction Engg.	12.05.2023

PURCHASE SPECIFICATION FOR 10mh DOWN CHOPPER INDUCTOR GROUP: TRACTION ENGINEERING

SPECIFICATION FOR DOWN CHOPPER INDUCTOR

REVISION HISTORY SHEET

REV. NO.	DATE	NATURE OF CHANGE	REASONS	PREPARED BY	APPROVED BY
00	16.08.2019	FIRST ISSUE		Purushottama	Shekar R
01	10.06.2023	SECOND ISSUE		S K SAHU	S B CHUDHURY

THIS DOCUMENT IS A SPECIFICATION CUM DATA SHEET. VENDOR TO GIVE CONFIRMATIONS AND DATA AS REQUIRED AND SUBMIT THE SAME TO BHEL / EDN, BANGALORE. ANY DEVIATIONS TO THIS DOCUMENT TO BE BROUGHT OUT CLEARLY BY VENDOR.

Number of Pages: 9 pages + Annexures

Note:

Reference document : 1414TW008
Material Code : TI0668123889

REVISIONS 01 10.06.2023

APPROVED BY:

(Shekar.R)

PREPARED BY:	ISSUED BY	DATE
(Purushottama Rao)	TRACTION ENGG	10-06-2023

SPECIFICATION FOR 10 mH DOWN CHOPPER INDUCTOR

Brief description:

This specification describes the requirement of a down chopper inductor used in EMU Projects. Down chopper is part of traction converter and used to feed the auxiliary converter supply. Down copper converts the high DC link on input side to a relatively low voltage suitable for auxiliary converter. Down chopper is a DC-DC converter operating at higher switching frequencies. Down chopper consists of an inductor, an IGBT based power electronic switch and capacitor as major components. Fig.1 depicts the context diagram of the down chopper. The inductor used in the down chopper is a forced air cooled type. It is ventilated by the air exhausted from the power modules hence the inlet air for the inductor is not directly drawn from atmosphere.

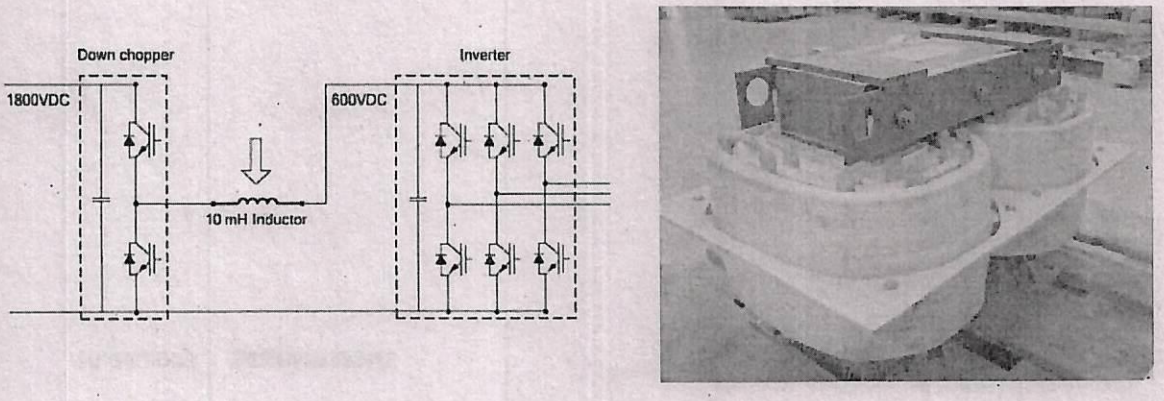


Fig.1 Context Diagram of Down Chopper

Detailed Specification

1. **Configuration and type :** Forced air cooled, Series connection of coils
2. **Nominal Inductance:** 10mH +/- 5%
3. **Current Rating:**

Nominal Current	: 187 A rms
Steady State Ripple Current	: 45 A (triangular wave)
Maximum Current	: 230 A rms
Maximum Surge Current	: 3 kA for 50 mS

4. **Voltage Ratings:**

Rated Voltage between terminals	: 1800V

5. **Switching Frequency** : 900Hz
6. **Insulation class** : 5.75 kV
7. **Temperature Class** : H
8. **Weight** : 120 Kg
9. **Applicable Standards**

Standard	Description
IEC 60076/ IS2026/IS11171	Power transformers
IEC 60077-1	Railway applications – electric equipment for rolling stock-part 1.
IEC 60310	Traction transformers and inductors
IEC 61287-1	Electronic power converters installed on rolling stock
IEC 61373	Railway applications – Rolling stock equipment –shock and vibration tests
EN61558/ IEC 61558-2-16	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V
EN50124-1,IEC1376	Railway Applications - Insulation Coordination Basic Requirements - Clearance And Creepage Distances
IEC60571/EN50155	Operating conditions

10. Ambient conditions / operating conditions

Description	Value	Unit	Notes
Max. Atmospheric Temperature	+50 (under sun)	°C	
Average annual temperature	35	°C	
Min. Atmospheric Temperature	-5	°C	
Temperature inside HT Room compartment	70-75	°C	For stationary rake
Relative humidity	< 98	%	Up to 100% during app 3 - 4 months (rainy season) per year frequent condensation can occur

Note: Atmosphere during hot weather is extremely dusty, humid and salty

10.A Fire Safety Requirement

Material should be complied with HL2 of EN45545-2 of Fire Safety Standard.

11. Material Requirements

Core:

Electrical steel should be CRGO silicon steel laminations with core loss of 0.85 W/Kg (at 1.5T and 50 Hz) or less. Supplier should specify the grade of core material at the time of technical proposal. A test certificate for the material grade along with the loss is to be submitted during testing.

Winding:

Winding material should be of aluminum strip type without exposing to atmosphere. Proper care has to be exercised to coat/electroplate the terminals.

Insulation:

Class H: All windings to be uniformly insulated. Should meet the requirement as per IS2026 /IEC 60076.

12. Type of Ventilation: Forced Air cooled with a nominal flow of 2000 m^3/hr.

13. Mechanical Dimensions:

Mechanical dimensions are to be followed in line with the drawings provided in Annexure-A. Any deviation in dimensions should be indicated to BHEL at the proposal stage. A prior approval may be necessarily obtained from BHEL for the same.

14. Submittals

14.1 Prior to Manufacturing:

a) Design information such as the winding structure, expected temperature calculations should be submitted along with the clause wise compliance to this specification. In case of any deviations, vendor shall bring to the notice of BHEL.
b) Manufacturer should submit the dimension details and drawings. BHEL will approve the drawing prior to manufacturing process.
c) Test plan with full details to be furnished. The place of the tests to be indicated against each test.
d) Manufacturer's credentials or previous supplies in railways, conformance to international quality standards and manufacturing standards such as ISO, IRIS should be submitted.
e) Major items to be incorporated in the final product along with material certificates should be provided.

14.2 After Manufacturing:

a) Two Sets of Type test reports along with the calibration reports for the test equipment in line with the set of test specified by this document against type test.
b) Two Sets of Routine test reports along with the calibration reports for the test equipment for the tests conducted internally in line with the set of test specified by this document against type test.
c) Two sets of Signed copy of witness reports for the tests witnessed by BHEL officials.

15. Testing (As per IEC 60310:2016 and IEC 60076)

a) Type tests are to be carried out on a single piece of equipment of a given design. The test shall be carried out on one unit chosen among the first batch produced. However BHEL has the right to ask the supplier to re conduct the type test in case of any performance differences observed or deviation noticed with respect to the process or performance.

b) Routine tests are carried out on all equipment of the same order.
List of tests to be performed on the Inductor:

Note: In case of limitation in test facility in carrying out any of the below tests, the tests can be carried out at NABL accredited laboratories as per the standard and the report in original should be submitted to BHEL.

15.1 Visual Checks (Type and Routine Test):

15.1.1 Dimensional Check:
(i) All dimensions are to be in line with the drawings as per Annexure-A
(ii) All terminal markings, PE connections are to be checked.
(iii) The finishing of the product should be verified as per standard industrial practice.

15.1.2 Rating Plate: Rating plate should contain the below information
- Manufacturer's name
- Manufacturer's type designation or number
- Manufacturer's serial number
- Date and place of manufacturing
- Connection diagram
- rated inductance, voltage and frequency
- Rated current (r.m.s. value)
- Identification of cooling method
- Total mass.

Acceptance Criteria:
All dimensions are in line with the drawings. All markings are proper and legitimate. The finishing of the product is uniform and contain no scratchy marks. Rating plate contains all the necessary details.

15.2 Check on Weight (Type Test):

The product should be weighed as per standard industrial practice.
Acceptance Criteria:
The weight of the product should be <= 120 Kg +/- 10%

15.3 Measurement of Winding Resistances (Type and Routine Test):

The resistance of the inductor winding and the temperature at which the measurement has been carried out of the windings shall be recorded. Direct current shall be used for the measurement. In all resistance measurements, care shall be taken that the effects of self-induction are minimized. Resistance of the windings shall be corrected to 115 Deg.
Acceptance Criteria:
The resistance measured should be <= 120mΩ + 10% (@ 115 deg C)

15.4 Determination of losses (Type Test):

This test may be carried out with power frequency (50Hz) voltage at a current close to the service condition current. In this case, the power frequency rms current should be calculated as equivalent current of 187 A DC and 45A triangular waveform which comes to be 188.34 A

Acceptance criteria:

The total losses measured should be <= 3200W +10%

15.5 Measurement of Inductance (Type and Routine Test):

AC Inductance measurement can be done for routine test by applying rated current 187A at 50 Hz.

For the type test, the inductor shall be fed by an a.c source (single phase) at rated frequency; impedance or inductance curves shall be plotted as a function of the current over the whole range of utilization of the inductor (from 100A to 330A in steps of 40A). The measurement shall be performed quickly so that the temperature-rise does not cause significant error. Saturation curve should be plotted for the inductor.

For type test, the inductor shall be subjected to incremental inductance test in the current range up to 300A. The relevant inductance to measure is the incremental inductance derived from a record of the terminal voltage when a specified pulsating current is passing through the inductor. The incremental inductance vs. the current may be plotted over the current range of 0-300A.

Acceptance criteria:

Measured inductance is within 10mH +/-5% up to rated current
Inductance at 250A >= 8.5 mH
Inductance at 320A >= 5 mH

15.6 Temperature Rise Test (Type Test):

The temperature rise shall be carried out at rated current. The rated current can be injected by short circuit method. The ultimate temperature-rise is reached when the temperature-rise becomes constant; this is considered to have been achieved when the temperature-rise does not vary by more than 2 K per hour in the windings and the magnetic core(s). The temperature measurement should be done by two methods namely direct method (using thermocouples or resistive thermometer, infrared camera etc.) and indirect method (measurement from resistance, voltage, current etc.). When the average temperature of a winding is determined from the variation of the D.C. resistance, it shall be extrapolated at the instant of shutdown. The points of temperature measurements should be agreed mutually before the test. During the test, the inductor is to be placed in a chamber specified in Annexure -C and 75% of the nominal flow is to be maintained.
The test is assumed to be passed provided the max hot spot temperature measured is less than that of class H as per IEC 60310:2016.

Note: Temperature rise test shall be conducted on one inductor for every 100 numbers of inductors produced.

Acceptance criteria:

The maximum hot spot temperature < 205 Deg.c (AS per standard) – 20 Deg.c

15.7 Insulation Resistance Test (Type and Routine Test):

The insulation resistance shall be measured by a meg-ohmmeter applying at least 1 000 V D.C. between windings and between winding and the earth. This test should be conducted before and after HV Test.

Acceptance criteria:

Insulation Resistance measured > =100Mohm

15.8 Dielectric Tests

15.8.1 Separate Source Voltage Withstand Test (Type and Routine Test):

The separate source voltage test shall be made by using a separate source, supplying an alternative single-phase voltage, which shall be applied in turn between each of the windings to be tested and all terminals of the remaining windings, connected together to earth. The test voltage would be 5.75 kV applied for a duration of 60 Sec.

Acceptance criteria:

The test is successful if voltage and current remain stable during the test. The current drawn during the test may be recorded. The current drawn during the test < 10mA

15.8.2 Wet Dielectric Test (Investigative Type Test):

Since the inductor is intended to use in Mumbai Locals/sub urban services which is prone to flood and moist environments, this test is aimed to know the behavior and life time of the inductor when it is subjected to those harsh conditions. This test is done on the inductor with temperature of various parts reached to their stable values (as per temperature rise test) to create the thermal shock. Temperature rise can be created by increasing the current flowing through it until it reaches the temperature levels as recorded in temp rise tests. After the temp rise, the inductor is disconnected and submerged (within 15 min from the disconnection) in the water tank filled with tap water for 30 min. The inductor is removed from the tank and allowed to tilt in any direction to remove the excess water for1 min. No wiping or forced drying is allowed. The IR test stated above to be recon ducted. If IR is good enough, 80% of HV to be applied for 60 Sec.

Acceptance criteria:

The test is successful if the HV is passed and the current is stable during HV. No flashing discharges to be observed during HV. The current drawn during HV may be noted down.

Note: *Failure of this test should not call for rejection of the material.*

In case of failure of this test, the IR reading for every half an hour should be noted down. When sufficient IR is achieved, the HV may be applied and the readings to be attached in a report. In such a case, vendor is required to submit the cause of failure and improve the design to pass the test subsequently. The test is required to repeat after the subsequent design change.

15.8.3 Voltage between Terminals withstand Test (Type and Routine Test):

The main purpose of this test is to check insulation between turns and between tappings, especially for windings repeatedly subjected to steep front voltage waveforms. The test shall be conducted by capacitor discharge method or the impulse method as per IEC 60310. The voltage levels should be selected accordingly.

Acceptance criteria:

The reference waveforms should be captured before the test on one piece of inductor. Reference waveform should be a damped sine wave and should not any irregularities in the waveform such as breaks. The test is passed if the deviation in the waveform wrt reference waveform is not more than 10%.

15.8.4 Partial Discharge Test (Type Test):

The purpose of this test is to evaluate the ability of the insulation system to perform over lifetime. The principle is to perform partial discharge measurements to verify that the transformer/inductor will operate safely under normal conditions. Before stating the test, the background noise should be measured. The partial discharge may be carried out in cold condition. Refer ANNEXURE-B for the test duration and voltage levels.

Acceptance Criteria:

The maximum discharge observed should be < 70pC

15.9 Short circuit withstand capability Test (Type Test):

The inductor together with all equipment and accessories shall be designed and constructed to withstand without damage the thermal and dynamic effects of external short circuits. The short circuit current for this inductor is 3kA

Acceptance Criteria:

I. No visual abnormalities after the test
II. All the routine tests, including dielectric tests at 80 % of the prescribed test value shall be repeated and passed.
III. No traces of internal electrical discharge are found.

15.10 Shock and Vibration Test (Type Test):

Simulated Long Life, Functional Random vibration and Shock tests are to be done as per IEC 61373 at NABL accredited laboratory and the result should be submitted. The shock and vibration values applied should be as per Category 1 class B. The test specimen may or may not be energized during the test. Tests as per clause 15.3, 15.4, 15.5 and 15.7 are applicable before and after the test. These test results should be submitted along with the shock and vibration reports.

15.10 Noise Measurement:

Measured noise at 1m distance should NOT be more than 60DB.

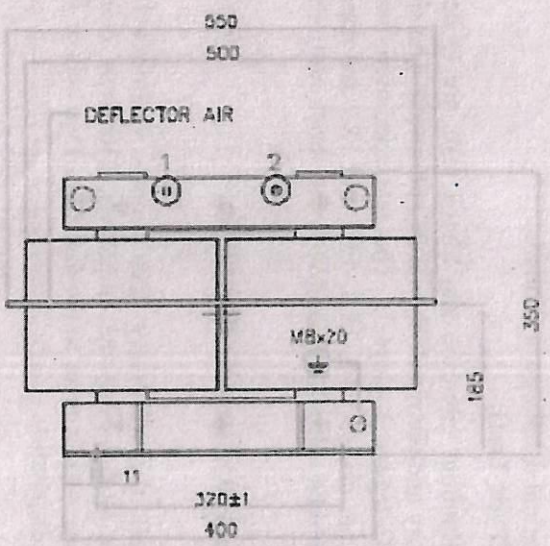
16 Dispatch:

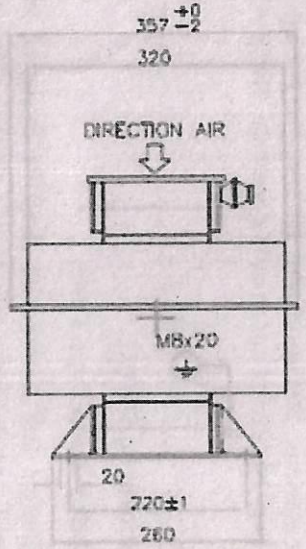
Vendor is required to submit all the necessary test reports (witnessed by M/s BHEL representatives or internal) before dispatching the materials. Dispatch clearance should be obtained from the concerned purchase officer prior to the dispatch. Two sets of full documentation should be submitted along with the dispatch.

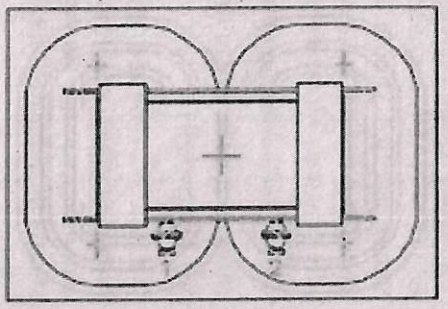
Note: In case of nonperformance of the equipment during type test or field trails, vendor is responsible for design changes and re testing.

Annexure-A

EXIT Inductor :-
(1–2) = BARS AL 20x4 + Insulator MAFELEC H35N 8 M25F



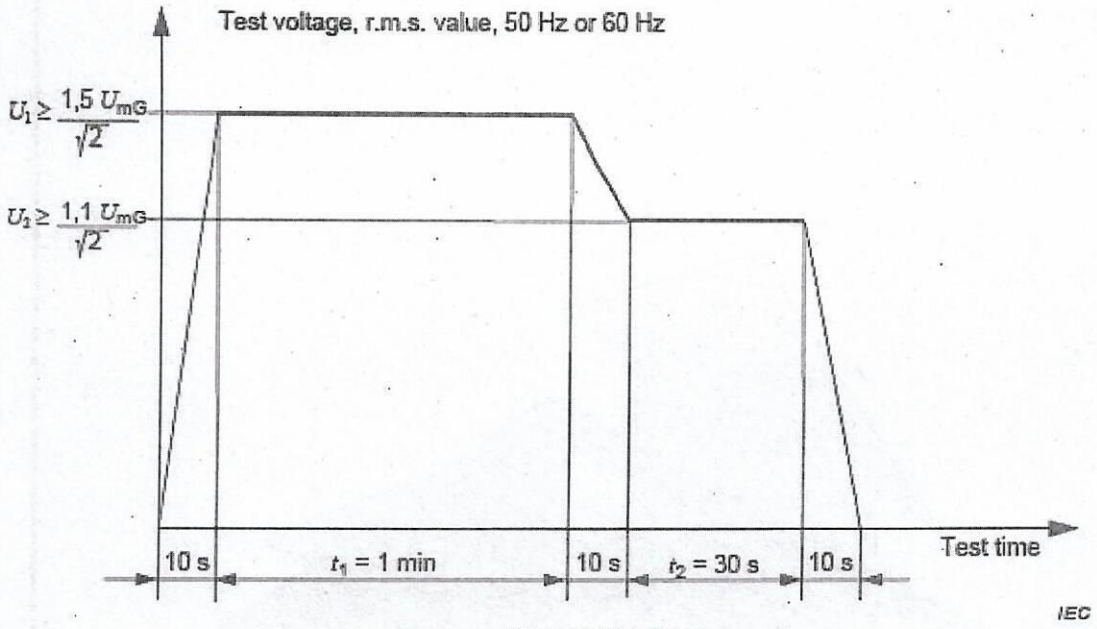




REF: 325.212/04.8057
Type Inductor : R2–52K4–DF
Lnom(mH) : 10±5%
Ieff.(A) : 187
Isat.(A) : 230

Weight (Kg) : <120

Annexure-B
Partial Discharge Test

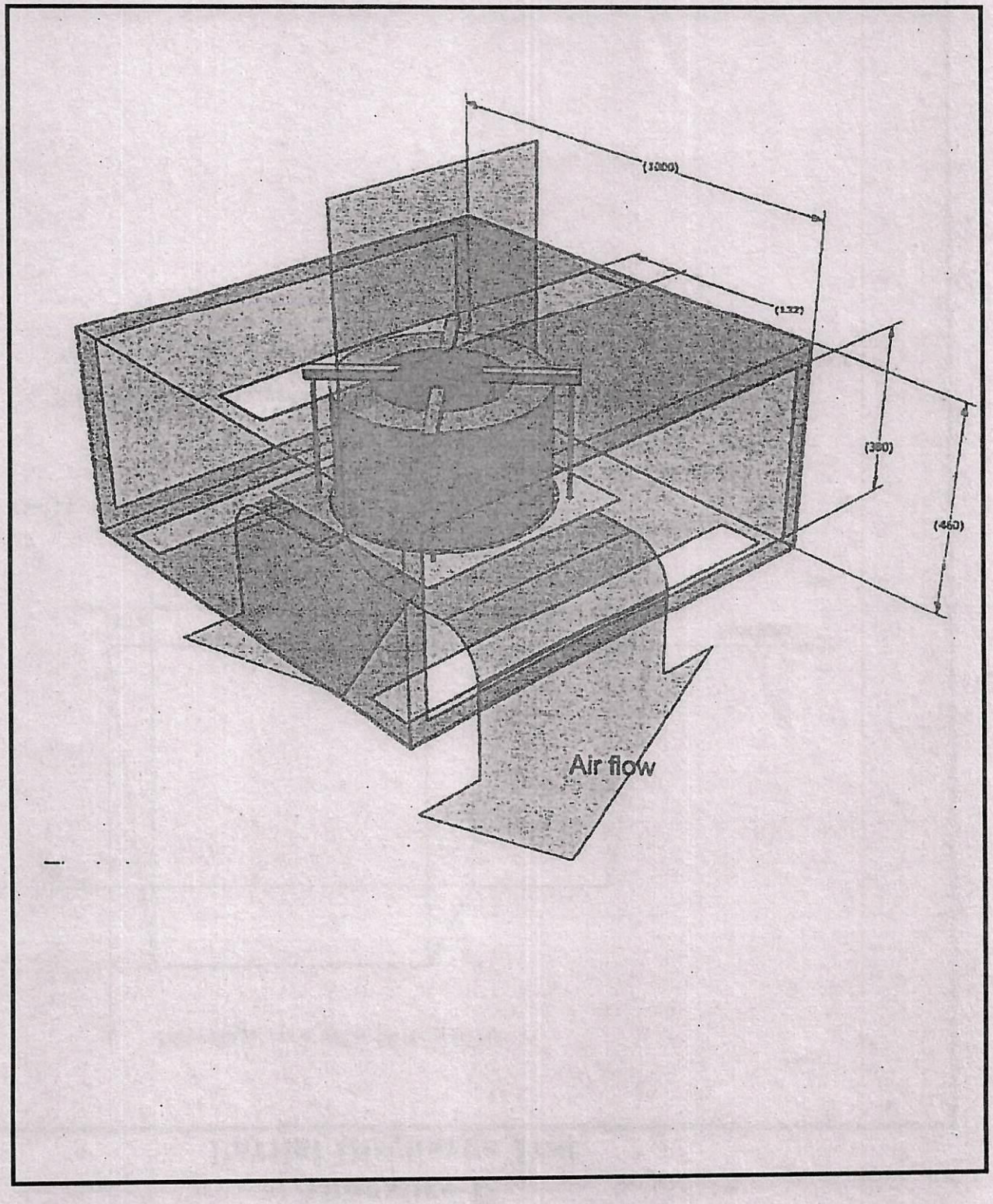


Excerpt from IEC 60310:2016

UmG to be considered as 2000V

Note: Partial Discharges to be noted down throughout the test duration.

Annexure-C
TEST BOX FOR TEMPERATURE RISE TEST



SPECIFICATION FOR 100Hz FILTER INDUCTOR

REVISION HISTORY SHEET

REV. NO.	DATE	NATURE OF CHANGE	REASONS	PREPARED BY	APPROVED BY
00	11.09.2019	FIRST ISSUE		Purushottama	Shekar R

THIS DOCUMENT IS A SPECIFICATION CUM DATA SHEET. VENDOR TO GIVE CONFIRMATIONS AND DATA AS REQUIRED AND SUBMIT THE SAME TO BHEL / EDN, BANGALORE. ANY DEVIATIONS TO THIS DOCUMENT TO BE BROUGHT OUT CLEARLY BY VENDOR.

Number of Pages: 9 pages + Annexures

Note:

Reference document : 1414TW008
Material Code : TI0668123671

REVISIONS 00 DT: 11.09.2019

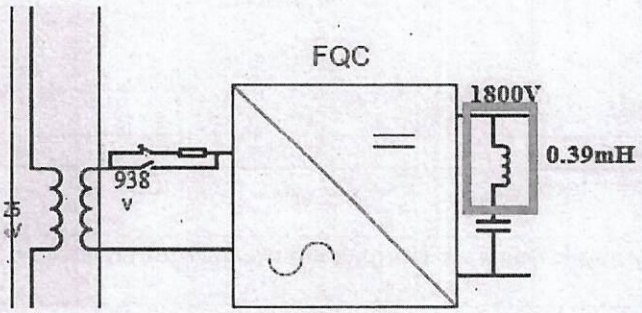
APPROVED BY:
(Shekar.R)

PREPARED BY:	ISSUED BY	DATE
(Purushottama Rao)	TRACTION ENGG	11-09-2019

SPECIFICATION FOR 100 Hz DOWN CHOPPER INDUCTOR

Brief description:

This specification describes the requirement of a 100 Hz filter inductor used in EMU Projects. 100 Hz filter is a tuned filter which is a part of traction converter and used to reduce the second harmonic ripple voltage generated above the DC Link voltage by the single phase front end Rectifiers.



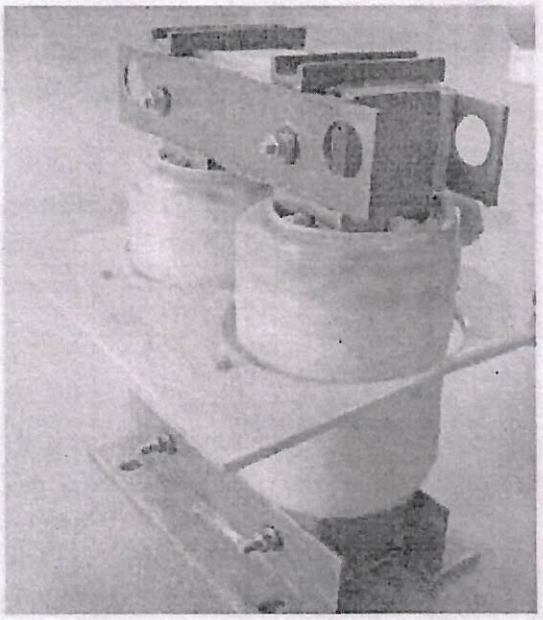


Fig.1 Context Diagram of 100 Hz Filter Inductor

Detailed Specification

1. **Configuration and type :** Forced air cooled, Parallel connection of coils
2. **Nominal Inductance:** 0.39mH +/- 2%
3. **Current Rating:**

Nominal Current	: 312 A rms
Maximum Current	: 535 A rms
Maximum Surge Current	: 25 kA

4. **Voltage Ratings:**

Rated Voltage between terminals	: 1800V

5. **Insulation class** : 5.75 kV
6. **Temperature Class** : H
7. **Weight** : 45 Kg
8. **Applicable Standards**

Standard	Description
IEC 60076/ IS2026/IS11171	Power transformers
IEC 60077-1	Railway applications – electric equipment for rolling stock-part 1.
IEC 60310	Traction transformers and inductors
IEC 61287-1	Electronic power converters installed on rolling stock
IEC 61373	Railway applications – Rolling stock equipment –shock and vibration tests
EN61558/ IEC 61558-2-16	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V
EN50124-1,IEC1376	Railway Applications - Insulation Coordination Basic Requirements - Clearance And Creepage Distances
IEC60571/EN50155	Operating conditions

10. Ambient conditions / operating conditions

Description	Value	Unit	Notes
Max. Atmospheric Temperature	+50 (under sun)	°C	
Average annual temperature	35	°C	
Min. Atmospheric Temperature	-5	°C	
Temperature inside HT Room compartment	70-75	°C	For stationary rake
Relative humidity	< 98	%	Up to 100% during app 3 - 4 months (rainy season) per year frequent condensation can occur

Note: Atmosphere during hot weather is extremely dusty, humid and salty

10.A Fire Safety requirement

Material should be complied with HL2 of EN45545-2 of Fire Safety Standard.

11. Material Requirements

Core:

Electrical steel should be CRGO silicon steel laminations with core loss of 0.85 W/Kg (at 1.5T and 50 Hz) or less. Supplier should specify the grade of core material at the time of technical proposal. A test certificate for the material grade along with the loss is to be submitted during testing.

Winding:

Winding material should be of electrolytic Grade Copper Litz wire type (suitable up to 2 kHz) without exposing to atmosphere. Proper care has to be exercised to coat/electroplate the terminals. The size of the Litz wire and the resistance value to be mentioned during the proposal stage.

Insulation:

Class H: All windings to be uniformly insulated. Should meet the requirement as per IS2026 /IEC 60076.

12. Type of Ventilation: Forced Air cooled with a nominal flow of 2000 m^3/hr.

13. Mechanical Dimensions:

Mechanical dimensions are to be followed in line with the drawings provided in Annexure-A. Any deviation in dimensions should be indicated to BHEL at the proposal stage. A prior approval may be necessarily obtained from BHEL for the same.

14. Submittals

14.1 Prior to Manufacturing:

a) Design information such as the winding structure, expected temperature calculations should be submitted along with the clause wise compliance to this specification. In case of any deviations, vendor shall bring to the notice of BHEL.
b) Manufacturer should submit the dimension details and drawings. BHEL will approve the drawing prior to manufacturing process.
c) Test plan with full details to be furnished. The place where the tests are conducted to be indicated against each test.
d) Manufacturer's credentials or previous supplies to railways, conformance to international quality standards and manufacturing standards such as ISO, IRIS should be submitted in hard copies.
e) Major items to be incorporated in the final product along with material certificates should be provided.

14.2 After Manufacturing:

a) Two Sets of Type test reports along with the calibration reports for the test equipment in line with the set of test specified by this document against type test.
b) Two Sets of Routine test reports along with the calibration reports for the test equipment for the tests conducted internally in line with the set of test specified by this document against type test.
c) Two sets of Signed copy of witness reports for the tests witnessed by BHEL officials.

15. Testing (As per IEC 60310:2016 and IEC 60076)

a) Type tests are to be carried out on a single piece of equipment of a given design. The test shall be carried out on one unit chosen among the first batch produced. However BHEL has the right to ask the supplier to re conduct the type test in case of any performance differences observed or deviation noticed with respect to the process or performance.

b) Routine tests are carried out on all equipment of the same order.
List of tests to be performed on the Inductor:

Note: In case of limitation in test facility in carrying out any of the below tests, the tests can be carried out at NABL accredited laboratories as per the standard and the report in original should be submitted to BHEL.

15.1 Visual Checks (Type and Routine Test):

15.1.1 Dimensional Check:

(i) All dimensions are to be in line with the drawings as per Annexure-A
(ii) All terminal markings, PE connections are to be checked.
(iii) The finishing of the product should be verified as per standard industrial practice.

15.1.2 Rating Plate: Rating plate should contain the below information

– Manufacturer's name
– Manufacturer's type designation or number
– Manufacturer's serial number
– Date and place of manufacturing
– Connection diagram
– rated inductance, voltage and frequency
– Rated current (r.m.s. value)
– Identification of cooling method
– Total mass.

Acceptance Criteria:

All dimensions are in line with the drawings. All markings are proper and legitimate. The finishing of the product is uniform and contain no scratchy marks. Rating plate contains all the necessary details.

15.2 Check on Weight (Type Test):

The product should be weighed as per standard industrial practice.

Acceptance Criteria:

The weight of the product should be <= 45 Kg +/- 10%

15.3 Measurement of Winding Resistances (Type and Routine Test):

The resistance of the inductor winding and the temperature at which the measurement has been carried out of the windings shall be recorded. Direct current shall be used for the measurement. In all resistance measurements, care shall be taken that the effects of self-induction are minimized. Resistance of the windings shall be corrected to 115 Deg.

Acceptance Criteria:

The resistance measured should be <= 5mΩ + 10% (@ 115 deg C)

15.4 Determination of losses (Type Test):

This test may be carried out with power frequency (50Hz) voltage at a current close to the service condition current.

Acceptance criteria:

The total losses measured (corrected to@115 Deg) should be <= 380W +10%

15.5 Measurement of Inductance (Type and Routine Test):

AC Inductance measurement can be done for routine test by applying rated current 312A at 50 Hz.

For the routine test, the inductor shall be fed by an a.c source (single phase) at rated frequency; impedance or inductance curves shall be plotted as a function of the current over the whole range of utilization of the inductor (from 100A to 540A in steps of 40A). The measurement shall be performed quickly so that the temperature-rise does not cause significant error. Saturation curve should be plotted for the inductor.

For type test, the inductor shall be subjected to incremental inductance test in the current range up to 540A. The relevant inductance to measure is the incremental inductance derived from a record of the terminal voltage when a specified pulsating current is passing through the inductor. The incremental inductance vs. the current may be plotted over the current range of 0-540A.

Acceptance criteria:

Measured inductance is within 0.39mH +/-2% up to rated current

15.6 Temperature Rise Test (Type Test):

The temperature rise shall be carried out at rated current. The rated current can be injected by short circuit method. The ultimate temperature-rise is reached when the temperature-rise becomes constant; this is considered to have been achieved when the temperature-rise does not vary by more than 2 K per hour in the windings and the magnetic core(s). The temperature measurement should be done by two methods namely direct method (using thermocouples or resistive thermometer, infrared camera etc.) and indirect method (measurement from resistance, voltage, current etc.). When the average temperature of a winding is determined from the variation of the D.C. resistance, it shall be extrapolated at the instant of shutdown. The points of temperature measurements should be agreed mutually before the test. During the test, the inductor is to be placed in a chamber specified in Annexure -C and 75% of the nominal flow is to be maintained.
The test is assumed to be passed provided the max hot spot temperature measured is less than that of class H as per IEC 60310:2016 minus 20 Deg.

Note: Temperature rise test shall be conducted on one inductor for every 100 numbers of inductors produced.

Acceptance criteria:

The maximum hot spot temperature < 205 Deg.c (AS per standard) – 20 Deg.c

15.7 Insulation Resistance Test (Routine Test):

The insulation resistance shall be measured by a meg-ohmmeter applying at least 1 000 V D.C. between windings and between winding and the earth. This test should be conducted before and after HV Test.

Acceptance criteria:

Insulation Resistance measured > =100Mohm

Dielectric Tests

15.8.1 Separate Source Voltage Withstand Test (Type and Routine Test):

The separate source voltage test shall be made by using a separate source, supplying an alternative single-phase voltage, which shall be applied in turn between each of the windings to be tested and all terminals of the remaining windings, connected together to earth. The test voltage would be 5.75 kV applied for a duration of 60 Sec.

Acceptance criteria:

The test is successful if voltage and current remain stable during the test. The current drawn during the test may be recorded. The current drawn during the test <10mA

15.8.2 Voltage between Terminals withstand Test (Type and Routine Test):

The main purpose of this test is to check insulation between turns and between tappings, especially for windings repeatedly subjected to steep front voltage waveforms. The test shall be conducted by capacitor discharge method or the impulse method as per IEC 60310. The voltage levels should be selected accordingly.

Acceptance criteria:

The reference waveforms should be captured before the test on one piece of inductor. Reference waveform should be a damped sine wave and should not any irregularities in the waveform such as breaks. The test is passed if the deviation in the waveform wrt reference waveform is not more than 10%.

15.8.3 Wet Dielectric Test (Investigative Type Test):

Since the inductor is intended to use in Mumbai Locals/sub urban services which is prone to flood and moist environments, this test is aimed to know the behavior and life time of the inductor when it is subjected to those harsh conditions. This test is done on the inductor with temperature of various parts reached to their stable values (as per temperature rise test) to create the thermal shock. Temperature rise can be created by increasing the current flowing through it until it reaches the temperature levels as recorded in temp rise tests. After the temp rise, the inductor is disconnected and submerged (within 15 min from the disconnection) in the water tank filled with tap water for 30 min. The inductor is removed from the tank and allowed to tilt in any direction to remove the excess water for1 min. No wiping or forced drying is allowed. The IR test stated above to be recon ducted. If IR is good enough, 80% of HV to be applied for 60 Sec.

Acceptance criteria:

The test is successful if the HV is passed and the current is stable during HV. No flashing discharges to be observed during HV. The current drawn during HV may be noted down.

Note: Failure of this test should not call for rejection of the material.

In case of failure of this test, the IR reading for every half an hour should be noted down. When sufficient IR is achieved, the HV may be applied and the readings to be attached in a report. In such a case, vendor is required to submit the cause of failure and improve the design to pass the test subsequently. The test is required to repeat after the subsequent design change.

15.8.4 Partial Discharge Test (Type Test):

The purpose of this test is to evaluate the ability of the insulation system to perform over lifetime. The principle is to perform partial discharge measurements to verify that the transformer/inductor will operate safely under normal conditions. Before stating the test, the background noise should be measured. The partial discharge may be carried out in cold condition. Refer ANNEXURE-B for the test duration and voltage levels.

Acceptance Criteria:

The maximum discharge observed should be < 70pC

15.9 Short circuit withstand capability Test (Type Test):

The inductor together with all equipment and accessories shall be designed and constructed to withstand without damage the thermal and dynamic effects of external short circuits. The short circuit current for this inductor is 25kA

Acceptance Criteria:

I. No visual abnormalities after the test
II. All the routine tests, including dielectric tests at 80 % of the prescribed test value shall be repeated and passed.
III. No traces of internal electrical discharge are found.

15.10 Shock and Vibration Test (Type Test):

Simulated Long Life, Functional Random vibration and Shock tests are to be done as per IEC 61373 at NABL accredited laboratory and the result should be submitted. The shock and vibration values applied should be as per Category 1 class B. The test specimen may or may not be energized during the test. Tests as per clause 15.3, 15.4, 15.5 and 15.7 are applicable before and after the test. These test results should be submitted along with the shock and vibration reports.

15.11 Noise Measurement (Type Test):

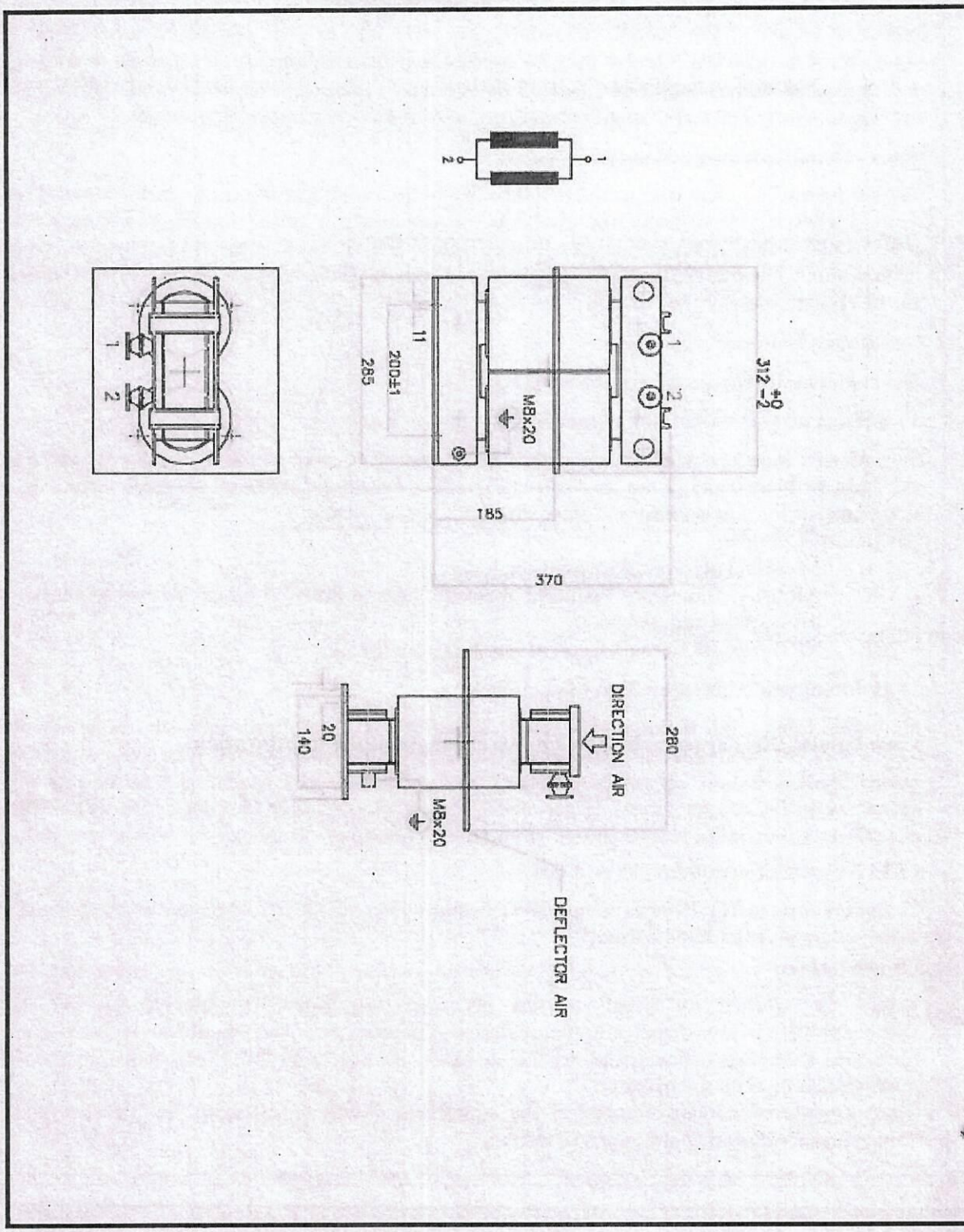
Measured noise at 1m distance should NOT be more than 60DB. Measurement to be conducted on inductor carrying the rated current.

16 Dispatch:

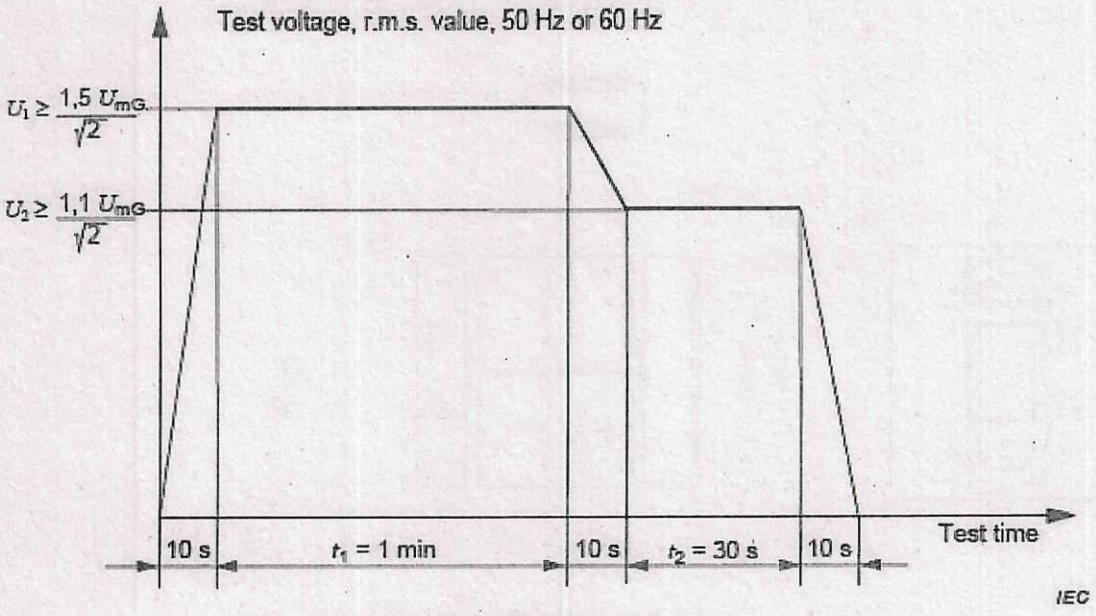
Vendor is required to submit all the necessary test reports (witnessed by M/s BHEL representatives) before dispatching the materials. Dispatch clearance should be obtained from the concerned purchase officer prior to the dispatch. Two sets of full documentation should be submitted along with the dispatch.

Note: In case of nonperformance of the equipment during type test or field trails, vendor is responsible for design changes and re testing.

Annexure-A


1
2
1
2
11
200±1
285
M8x20
312 +0 -2
185
370
20
140
M8x20
DIRECTION AIR
280
DEFLECTOR AIR

Annexure-B
Partial Discharge Test



Excerpt from IEC 60310:2016

UmG to be considered as 2000V

Note: Partial Discharges to be noted down throughout the test duration.

Annexure-C
TEST BOX FOR TEMPERATURE RISE TEST