Приложение 3

AIR CORE REACTORS
FED-MCD

INSTRUCTION MANUAL

M002 R1

GRID | ALSTOM

Summary

WARNING

REACTOR AND ITS ACCESSORIES, INCLUDING SUPPORT STRUCTURE, SHALL BE CONSIDERED AS LIVE PARTS AFTER THE ENERGIZATION.

ANY PERSON INVOLVED WITH TRANSPORT, INSTALLATION, OPERATION AND MAINTENANCE OF THE AIR-CORE REACTORS SHALL READ THIS INSTRUCTION MANUAL PRIOR TO HANDLE THE EQUIPMENT.

1.0 – Technical Information

1.1 – Introduction

ALSTOM has more than 50 years of experience in developing and manufacturing air-core reactors for various market segments around the world, including power generation, transmission and distribution, industrial facilities, OEMs and electrical test laboratories.

ALSTOM provides a wide range of cost-effective solutions in various air-core reactor applications, such as short-circuit current limitation, neutral grounding, reactive shunt compensation, damping of inrush and discharge current of capacitors banks, harmonic filtering, and static Var compensation.

The ratings and dimensions of air-core reactors depend on their application. This information is detailed and presented in the outline drawings and further technical documents provided for each order. However, this instruction manual applies to all reactor applications supplied by ALSTOM.

ALSTOM's air-core reactors are custom designed, manufactured and tested according to the main national and international standards, such as:

- ABNT NBR 5119 – Reatores para sistemas de potência (Brazil)
- IEC 60076-6 – Reactors
- ANSI IEEE Std C57.16 – Standard requirements, terminology, and test code for dry type air core series-connect reactors
- ANSI IEEE Std C57.21 – Standard requirements, terminology, and test code for shunt reactors rated over 500 kVar
- ANSI IEEE Std 32 – Standard requirements, terminology, and test procedure for neutral grounding devices

1.2 – Reactor's Technology: FED and MCD.

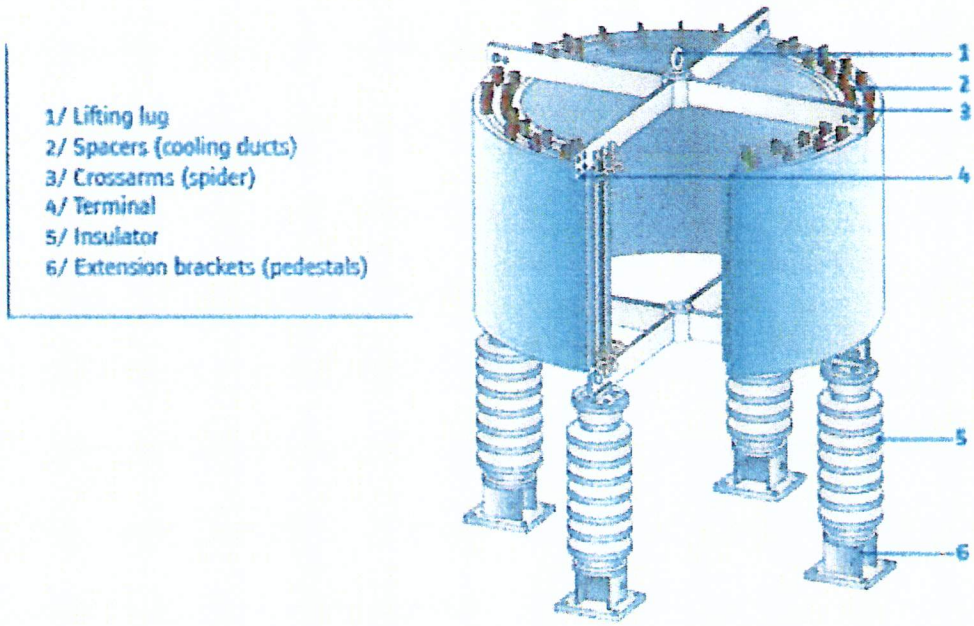
This instruction manual applies to FED and MCD reactors only.

- FED – Fiberglass Encapsulated Design
- MCD – Multi-Wire Cable Design

The winding of FED and MCD reactors consists of various conductors (wires for FED and cables for MCD), double-insulated with polyester or Teonex® film, connected in parallel. The conductors are mechanically immobilized and encapsulated by epoxy impregnated fiberglass filaments forming cylinders. Depending on the reactor ratings, one or more

of these cylinders are connected in parallel between aluminum or copper spiders. The individual cylinders are separated by fiberglass spacers forming cooling ducts.

The picture 1 illustrates the FED and MCD reactors.



Picture 1 – Air Core Reactor construction

2.0 – Transportation, Receiving, Unpacking and Storage

2.1 – Transportation

Reactors are packed in crates suitable to inland, sea or air freight, which are properly treated to meet the main international statements.

Normally, each packing contains a single coil and the insulators and aluminum pedestals may be packed in the same crate. However, depending on the size and weight of the coils, two or three units may be packed together.

Remarks:

a) In case of visible damages in the reactor or in its packing due to transportation, ALSTOM and Insurance Company must be immediately contacted.

b) It is not recommended to stack reactor's crates for transportation or storage, unless otherwise authorized by ALSTOM.

2.2 – Receiving

The instructions and procedures for receiving of the reactors are described below:

1) Check the content of the package and evaluate if it is in accordance to the Invoice and Packing list;

2) Verify the pack conditions in the act of receiving, if possible, with de reactor still in the truck;

3) In case of damage in the package, the receiver must follow the instructions below:

a) Inform the truck driver about the damages and look for the causes or any incidents during the transport;

b) Register in the Waybill the following information: package number and/or equipment serial number and description of the damages founded;

c) Take pictures of all damages founded, identifying the package number and/or reactor serial number;

d) In case of customer responsibility for the transport, contact your insurance company;

e) Communicate ALSTOM immediately and keep the packages likewise they were received for inspection and review by ALSTOM and/or Insurance Company;

f) Wait for ALSTOM instructions about how to proceed with the damaged load and open the packs only after ALSTOM's permission.

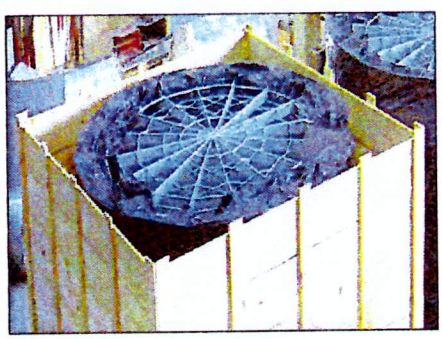
2.3 – Unpacking

Before starting the unpacking process, please read the chapter 3.0 for lifting procedures.

The instructions and procedures for unpacking the reactor are described below.

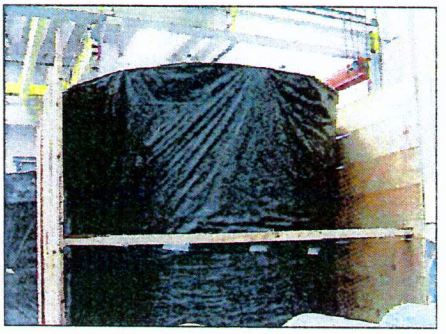
1) Remove the metallic/plastic tapes and/or plates from external sides of the crates.

2) Remove carefully the top of the crate.

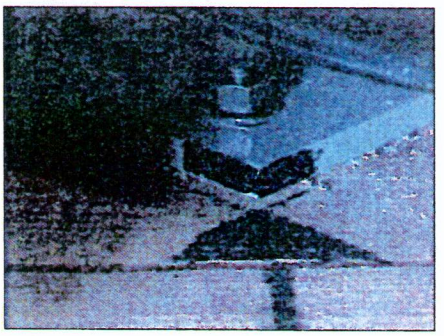


3) Remove the ropes and wood bars which fix the coil to the crate.

4) Remove the side panels and wood bars.



5) Unscrew the bolts that fix the reactor to the crate.



In case of damage in one or more reactors after the unpacking, the following actions should be taken:

1) Take pictures of all damages founded, identifying them with the reactor's serial number.
2) Communicate ALSTOM immediately and wait for instructions of how to proceed with the damaged reactor.

2.4 – Storage

The storage of the reactor can be done in its own package when stored in a covered place with appropriate environmental conditions.

For storage in uncovered place, after 2 months, remove the reactor from the wood package.

Note: It is not recommended to pile the boxes for transport and storage, unless ALSTOM has given previous permission.

Picture 2 – Storage of reactors in wood boxes.

3.0 – Lifting

3.1 – Lifting Procedure

The lifting of the crates has to be done by hoists, cranes, forklifts or crane trucks. However, unpacked reactors can only be lifted by cranes, hoists or crane trucks.

For large reactors, the crates can be lifted by the lifting lugs installed on the top crossarm of the reactors. In this case, you will find openings on the top of the crates to access the lifting lugs.

After you removed the package, the lifting and handling of the reactors must follow the following procedures:

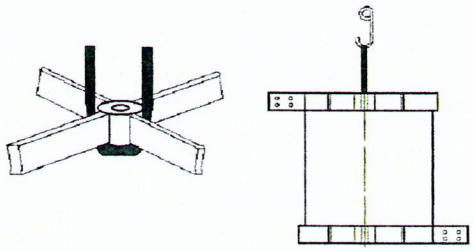
Note 1: Depending on the dimensions and weight of the reactor, the lifting must be done by one or more uniformly distributed points on the top crossarm. If necessary, the lifting lugs, which can be removable or not, will be provided with the reactor (see picture 5).

Note 2: The reactor's dimensions and total weight are informed on the dimensional drawings and identification nameplates.

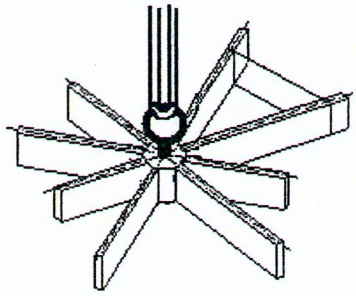
1) The reactor's lifting shall be done by wire ropes, textile slings or chains of sufficient load capability, according to the reactor's total weight.
2) For reactors without lifting lugs, the lifting shall be done by the center of the top crossarm (see picture 3).
3) For reactors with one or more lifting lugs, the lifting or moving shall be always done using all available lifting lugs.
4) Before energizing the reactor, remove the lifting lugs (if they are removable).

ATTENTION:

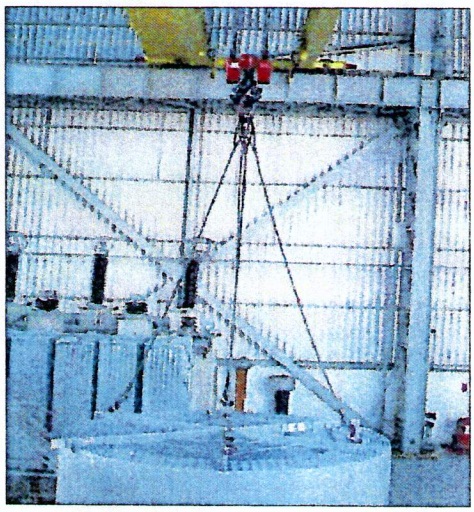
- **The lifting shall be done individually, with one reactor at a time. Never lift assembled double or three-phase reactors.**
- **Never lift reactors by the fiberglass ties/bars between the arms, corona rings and/or top hat, if they are included in the supply.**
- **Big reactors' packages have openings on the top, in order to permit access to the reactor's lifting lugs.**

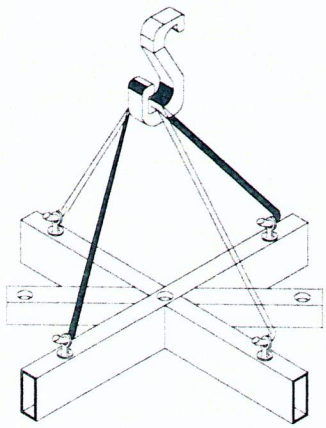


Picture 3 – Lifting of the reactor by the center of the crossarm.



Picture 4 – Lifting of the reactor by a lifting lug located in the center of the crossarm.





Picture 5 – Lifting of reactor by lifting lugs located on the crossarms.

3.2 – Lifting Of Horizontal Packed Reactors

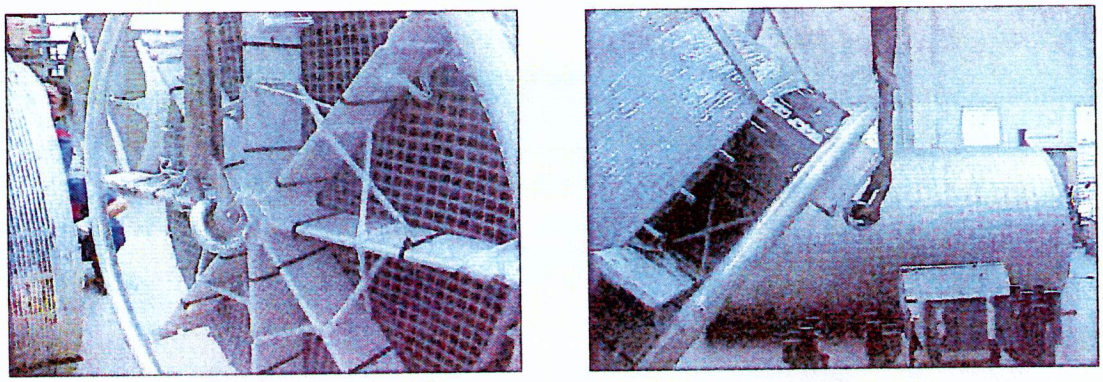
In general, specific manual will be attached to the crate for horizontal packed reactors, otherwise follow the instructions below.

When the reactor is horizontal packed, the lifting shall be done by the lifting lugs provided with the reactor, normally installed in the center of the crossarms and/or aluminum pedestal.

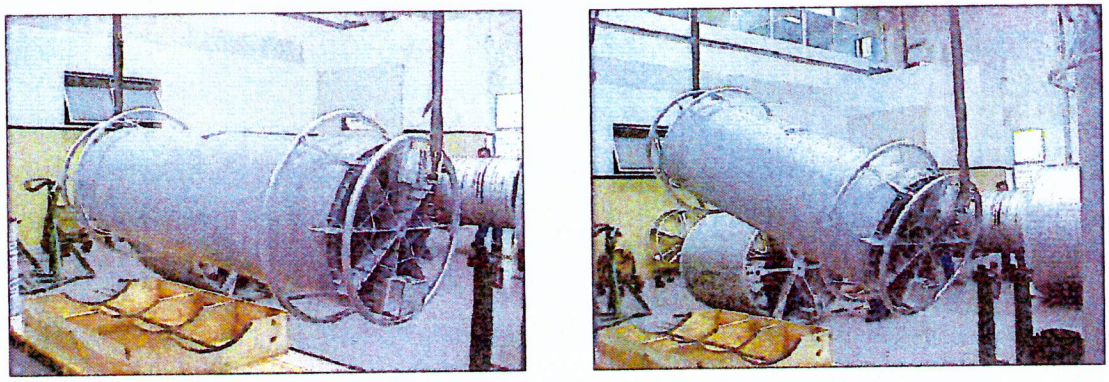
ATTENTION:

- **Place one lifting sling for each lifting lug (top and bottom). The reactor can be supplied with 4 lifting lugs on the top. But, please choose the top lifting lug that corresponds to the bottom lifting lug (same orientation);**
- **Slowly lift both sides of the reactor at the same time;**

- **Slowly turn the reactor to the vertical position;**
- **The reactor is not to be placed on the ground in the vertical position without sufficient clearance from ground level. Wooden blocks placed under the mounting feet can be used to achieve the distance;**
- **With the reactor in the vertical position, remove the bottom lifting lug.**
- **Take care to avoid touching the corona rings with the lifting ropes or textile slings during the lifting.**
- **Always use wood blocks or metallic supports in order to protect the corona rings during the handling process.**



Picture 6 – Reactor with top central lifting lug and base pedestal.



Picture 7 – Slowly lift both sides of the reactor at the same time.

4.0 – Assembly

The responsible for the reactor's assembly shall have in hands the dimensional drawings and manuals provided by ALSTOM, which have all information necessary about the right positioning of terminals, insulators and pedestals.

Notes:

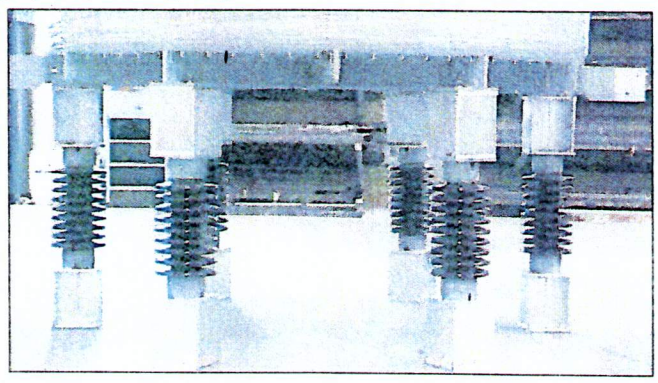
a) For special mountings, in which cases these procedures do not apply, ALSTOM must be consulted in order to provide instructions and the appropriate accessories.
b) The assembly of the reactors, foundation civil works and anchor bolts are not provided by ALSTOM, unless an agreement/supply is approved during the tendering phase and confirmed in the purchase order.
c) In some cases, aluminum plates/blocks can be provided in order to help to level the reactor and insulators.

ATTENTION: Take care to avoid small metallic parts (bolts, nuts, washers) or tools to fall into the cooling ducts between the cylinders (see picture 1).

4.1 – Single-phase Reactors

The assembly of single-phase reactors shall be done as described by the following procedures:

1) Position the coil provided with its support insulators and possible aluminum pedestals at the place foreseen. Mark the position of the fixing holes on the floor. Remove the coil. Drill the holes and fit suitable anchor bolts (not supplied);
2) Bolt the base pedestals to the foundation base with appropriate anchor bolts (not supplied) without fully tightening;
3) Bolt the insulators to the pedestals (base and top if they are included) without fully tightening;
4) With the base insulators and the aluminum pedestals mounted on the concrete base then mount the reactor on the base insulators tightening the bolts, taking care that terminals are in the right position);
5) If the axial loose distance exceeds 1mm, or for levelling the coils, insert thin metal plates between the insulators and the adjacent metal parts (reactor's mounting pads or pedestals);
6) Verify the reactor's alignment to provide uniform distribution of mechanical efforts on the bottom insulators;
7) Remove the lifting lugs (if they are supplied).

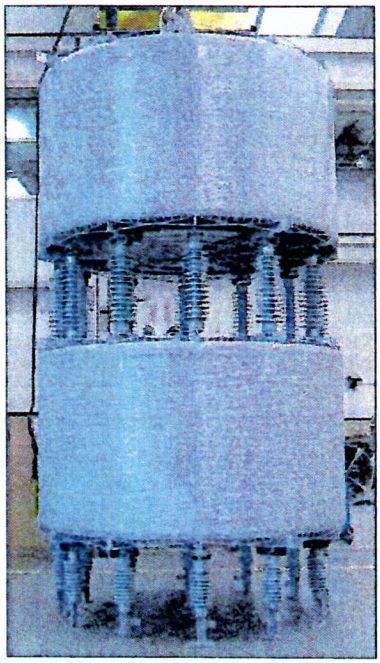


Picture 8 – Single-phase reactor's assembly.

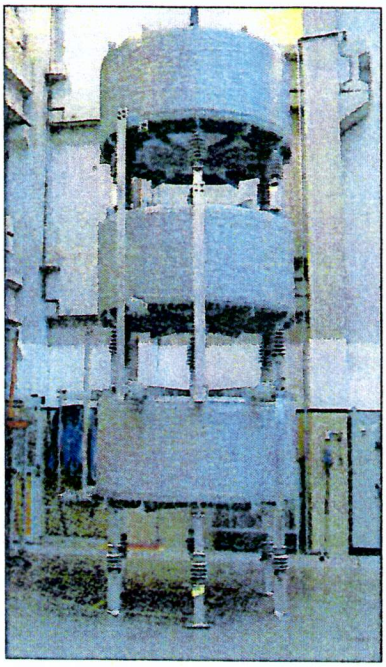
4.2 – Double or Three-phase Reactors

The assembly of stacked reactors (double or three-phase reactors) shall be done as described by the following procedures:

1) Position the "bottom" coil provided with its support insulators and possible aluminum pedestals at the place foreseen. Mark the position of the fixing holes on the floor. Remove the coil. Drill the holes and fit suitable anchor bolts (not supplied);
2) Bolt the base pedestals to the foundation base with appropriate anchor bolts (not supplied) without fully tightening;
3) Bolt the insulators to the pedestals (base and top if they are included) without fully tightening;
4) With the base insulators and the aluminum pedestals mounted on the concrete base then mount the "bottom" coil on the base insulators tightening the bolts, taking care that terminals are in the right position);
5) If the axial loose distance exceeds 1mm, or for leveling the coils, insert thin metal plates between the insulators and the adjacent metal parts (reactor's mounting pads or pedestals);
6) Verify the reactor's alignment to provide uniform distribution of mechanical efforts on the bottom insulators;
7) Remove the lifting lugs from the "bottom" coil (if they are supplied).
8) Place the "middle" coil on top of the "bottom" coil equipped with its insulators and pedestals (if supplied) by loosening the screws and making sure that the position of the terminals is in accordance with the dimensional drawings or align the relative orientation arrows of the modules (see picture 11);
9) Fasten the "middle" coil to the "bottom" coil using the screws and washers supplied with the reactors. Tighten the screws located at the base and the head of the insulators and pedestals (if supplied);
10) If the axial loose distance exceeds 1mm, or for levelling the coils, insert thin metal plates between the insulators and the adjacent metal parts (reactor's mounting pads or pedestals);
11) Verify the reactor's alignment to provide uniform distribution of mechanical efforts on the bottom insulators;
12) Remove the lifting lugs from the "middle" coil (if they are supplied);
13) For Three-Phase reactors, place the "top" coil on top of the "middle" coil equipped with its insulators and proceed as described in the steps 8 to 12.

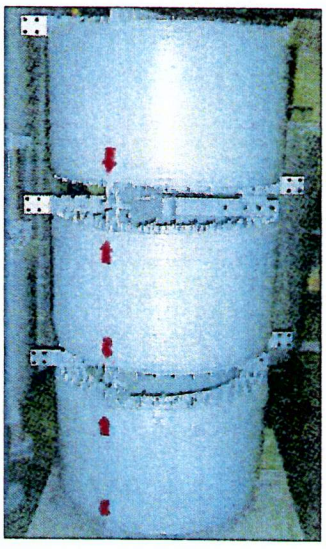


Picture 9 – Double reactor assembly.



Picture 10 – Three-phase reactor assembly.

ATTENTION: The arrows on the reactors show the relative position of the coils (top, middle and bottom), which has to be respected and maintained during the assembly. These marks are result of previous assembly in the factory in order to verify the reactors' alignment and leveling. In the assembly, the arrows shall be aligned as shown in the picture 11.



Picture 11 – Orientation arrows on the coils.

4.3 – Reactors with Fiberglass Pedestals

The responsible for the assembly of fiberglass pedestals must follow the steps described below:

1) Position the fiberglass pedestal with its aluminum pedestals (if supplied) at the place foreseen. Mark the position of the fixing holes on the floor. Remove the pedestal Drill the holes and fit suitable anchor bolts (not supplied);
2) Bolt the pedestals to the foundation base with appropriate anchor bolts (not supplied) without fully tightening;
3) Bolt the insulators to the pedestals without fully tightening;
4) With the base insulators and the pedestals mounted on the concrete base then mount the reactor on the base insulators tightening the bolts, taking care that terminals are in the right position);
5) If the axial loose distance exceeds 1mm, or for levelling the coils, insert thin metal plates between the insulators and the adjacent metal parts (reactor's mounting pads or pedestals);
6) Verify the reactor's alignment to provide uniform distribution of mechanical efforts on the bottom insulators;
7) Remove the lifting lugs from the reactors and fiberglass pedestals (if they are supplied).

ATTENTION: The arrows on the reactors and fiberglass pedestals show the relative position of the coils, which has to be respected and maintained during the assembly. These marks are result of previous assembly in the factory in order to verify the reactors' alignment and leveling. In the assembly, the arrows shall be aligned. Please also check the serial numbers of each fiberglass pedestal that corresponds to the respective reactor.

Picture 12 – Assembly with fiberglass structures (pedestals).

4.4 – Reactors with Top Hat

When the reactors are supplied with top hats (fiberglass covers), the responsible for the assembly shall follow instructions that will be provided in specific manual, which will be sent with the reactor.

ATTENTION: As a general rule, it is not allowed walk or lie directly on the top hat. The access to the reactor lifting lugs must be done by elevation platform or similar structure.

4.5 – Reactors with Bus Bars

When reactors are supplied with bus bars, in case the reactor dimensional drawing does not have all information needed for the assembly, the responsible should follow the instructions that will be provided in the specific manual, which will be sent with the reactor.

4.6 – Bolt Tightening Torque

The table hereafter gives the recommended tightening torque according to the bolt diameter and the type of connection:

Torque of bolts (daN*m):

Diameter of the bolts	Electrical Connections	Insulators and Pedestals	Other Connections
M10	3.0 – 4.0	-	2.0 – 3.0
M12	4.5 – 5.0	4.5 – 5.5	3.0 – 4.0
M16	7.0 – 8.0	12.0 – 14.0	4.0 – 5.0
M20	10.0 – 12.0	16.0 – 18.0	5.0 – 6.0

Torque of bolts (ft*lbs):

Diameter of the bolts	Electrical Connections	Insulators and Pedestals	Other Connections
3/8"	22 – 29.5	-	15 – 22
1/2"	33 – 37	33 – 40.5	22 – 29.5
5/8"	52 – 59	88.5 – 103	29.5 – 37
3/4"	74 – 88.5	118 – 133	37 – 44

5.0 – Installation Issues

5.1 – Electrical Connections

The instructions and procedures for electrical connections of the reactor are described below.

1) The incoming and outcoming conductors shall be connected to line terminals of the reactors by mean of a connector, taking into account its current carrying capability, material and recommended tightening torques.

2) Normally, there is no polarity in air-core reactors. Both terminals of the coil can be connected to the line/source side or to the substation/load side of the reactor. But it is recommended to use the same connection criteria for all adjacent reactors.

3) Check the compatibility between terminal and conductor material to avoid galvanic corrosion. Do not place in direct contact an aluminum plate with a copper plate in order to avoid a fast corrosion of the aluminum contact.

4) If needed, ALSTOM can supply tin-plated adapters or bronze terminals to establish proper electrical connections.

5) The tightening torque of the screws is indicated by the supplier of the screws or in the tables of the chapter 4.6.

6) For long storage time or if the reactor is stored in adverse weather conditions which cause oxidation of the contact surfaces, these ones must be cleaned with a fine steel brush (wire diameter 0.3 mm) or a fine sandpaper (of roughness 150 grainsize) and afterwards protected using a neutral contact grease (type Contactal, Penetrox or equivalent). The surfaces should be totally covered with grease to protect the aluminum surfaces against corrosion.

Remark: The corrosion may increase the contact resistance and thus, produce an abnormal heating at the contact points.

5.2 – Magnetic Clearances

ATTENTION: The magnetic clearances to be considered for each phase/coil are indicated on the dimensional drawings.

The magnetic field of the reactor may induce eddy currents in metallic parts installed in its vicinity, such as ground grid, concrete rebar, fences and elevating structures. To avoid excessive heating due to induced currents, the installation of the reactor shall respect the recommended magnetic clearances by ALSTOM.

The magnetic clearances comprise two different regions around the reactor:

- MC1: region for installation of metallic parts not forming closed loops
- MC2: region for installation of metallic parts forming closed loops

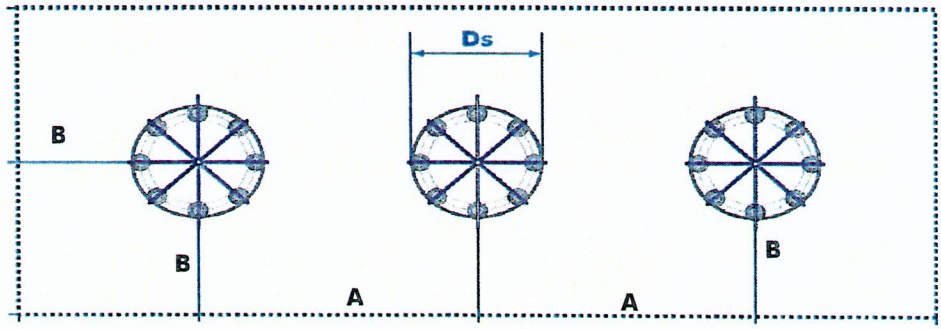
The instructions for magnetic clearances are described below.

1) Within MC1 region, it is not recommended the installation of any metallic parts (even not forming closed loops)

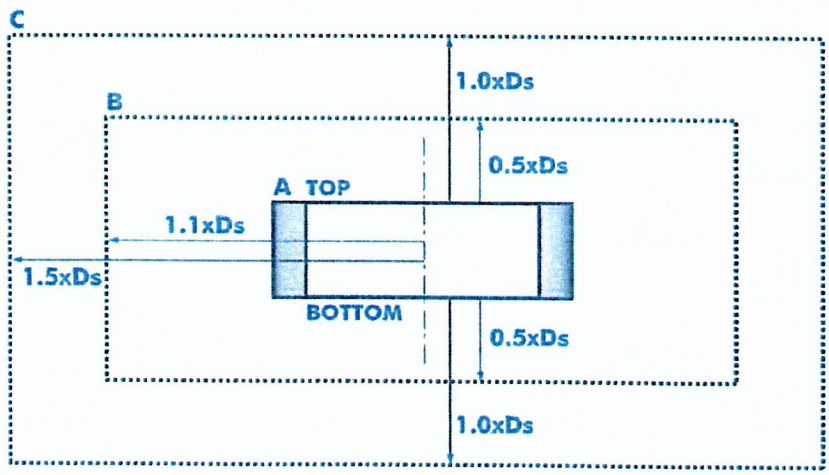
2) Between the borders of the MC1 and MC2 regions, it is allowed the installation of metallic parts not forming closed loops.

3) Externally to the MC2 region, it is allowed the installation of any metallic parts (even forming closed loops).

If this information is missing on the outline drawing it will be included in particular documents appended to this instructions book or follow the picture 13.



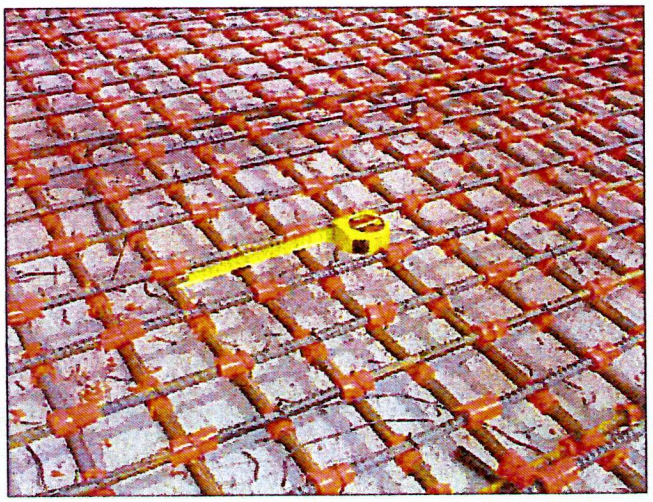
A: Minimum magnetic clearance between centerlines of adjacent reactors. Refer to outline drawing.
B (MC1): Minimum magnetic distance between centerlines and metallic parts not forming closed lops. Refer to outline drawings.



A: Reactor outer surface
Ds: reactor outer diameter
Keep metallic parts not forming closed loops outside B (MC1)
Keep metallic parts forming closed loops outside C (MC2)

Picture 13 – Recommended magnetic clearances.

Depending on the distance between reactor and foundation, the ground grid shall be insulated to avoid closed loops, as illustrated in the picture 14.



Picture 14 – Magnetic insulation of the ground grid

5.3 – Electrical distances

The minimum clearances distances between the coil and the neighboring pieces must be in accordance with the normalized distances for the voltage level of the equipment.

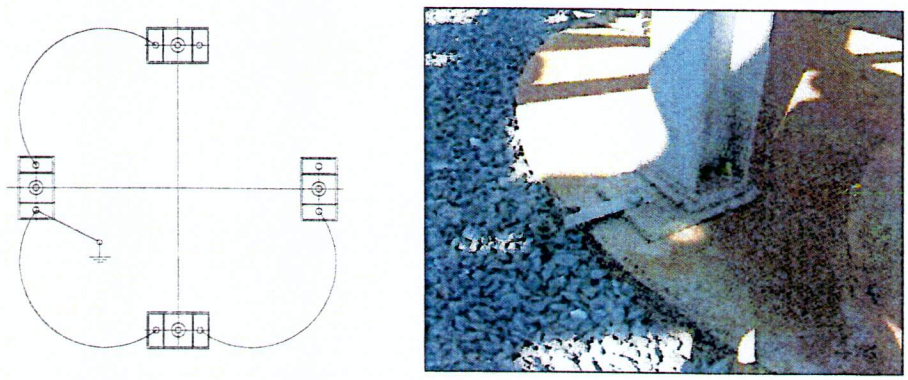
5.4 – Earthing of Aluminum Pedestals and Metallic Structures

The metallic parts of the support structure that are "floating" must be earthed according to the following instructions:

1) Earth one of the reactor pedestals, Use the assembly screws or grounding connectors to connect the pedestal with the substation ground grid (Be careful to the compatibility of the different materials);
2) Connect the other pedestals to the earthed pedestal, leaving at least two pedestals disconnected to each other in order to avoid the formation of closed loops (see picture 15);
3) Alternatively, each pedestal can be earthed individually, connecting them to the substation ground grid or by one or more earthing copper bars, in case of inexistence of ground grid;
4) The earthing connectors shall be specified by taking into account the pedestals materials and earthing conductors, in order to avoid aluminum galvanic corrosion;
5) When requested, ALSTOM can provide the earthing connectors, generally made of bronze.

Notes:

a) For reactors provided with the fiberglass pedestals, the structure earthing must be done in only one of mounting pads or base aluminum pedestals (if supplied), seeing that all metallic parts of the fiberglass pedestal are connected to each other;
b) For installations without ground grid: The quantity of copper bars depends on the earthing resistance of the installation place. The bars dimensioning and supply are not responsibility of ALSTOM.



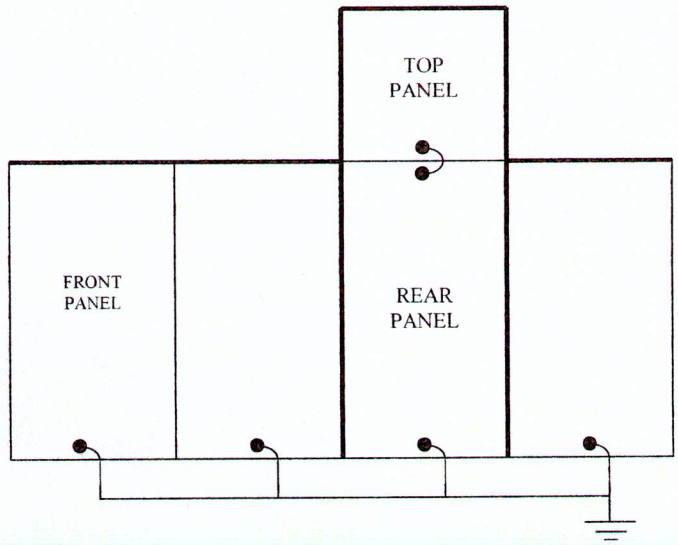
Picture 15 – Earthing of base pedestals.

5.5 – Reactors Installed in Metallic Enclosures (Cubicles)

Reactors installed in indoor rooms or metallic enclosures must follow the procedures described below:

1) Air entrances (louvers) must be considered at the top and bottom parts of the frontal and lateral enclosure panels to allow the flow through the reactor for its self-cooling by natural air convection;
2) The minimum internal dimensions of the enclosure must respect the dimensions indicated in the reactor dimensional drawing and/or specific technical documentation;
3) In order to avoid closed loops through the four sides, you must insulate the rear panel from the side and top panels by opening the closed loops and all panels must be grounded. The insulation does not need to be thicker than 1/8", but the through going bolts between the rear panel and side panels, and between the top panel and side/front panels must be insulated by means of insulating bushings and washers. See sketch in the picture 16 about grounding and insulating. The thicker lines indicate the insulated boltings.

Note: If you install the reactor in an enclosure with closed loops, you get higher losses and the enclosure may heat up. The declared losses in the reactor drawing do not include inducted losses in the enclosure.



Picture 16 – Magnetic insulation of enclosure panels.

5.6 – Commissioning

The responsible for commissioning of the reactors shall follow the instructions below before the energization of the equipment:

1) Check the reactor electric connections (recommended tightening torque);
2) Check the reactor mechanic connections: base pedestals, insulators, top hat, etc;
3) Check the earthing connections;
4) Clean the cooling ducts of the main coil with non-metallic bars and air pressure (Check that the cooling ducts are not obstructed by objects which could prevent the cooling of the equipment);
5) Check the reactor's fiberglass ties between the arms;
6) Check the welded connections on the arms of the reactor;
7) Check the reactor external surface and the painting. Touching up may be necessary according to the recommended procedures in this manual.

Note: Commissioning electrical tests are not applicable to air-core reactors. However, if power sources and measuring equipment are available at field, it is recommended to perform the following tests:

- Measurement of dc resistance
- Measurement of inductance / impedance at power frequency
- Measurement of inductance / impedance at tuning frequency

The measured figures at field shall be compared with those values presented in the routine test reports. Depending on the power source type and accuracy of the measuring equipment, the results may deviate slightly from the factory values.

6.0 – Painting

ATTENTION: The type of painting and color are indicated on the reactor dimensional drawing.

1) The reactor is sandblasted to guarantee best adherence of the paint. Initially, the reactor is painted with a base coat of isocyanate shop-primer (10 to 25 microns thick), with minimum interval for repainting reactor is 6 hours at minimum ambient temperature of 25°C and maximum 80% humidity.
2) After curing, a finishing coat of polyurethane paint with minimum coat thickness of 75 to 125 μm is applied. The total curing process takes at least 04 days at minimum ambient temperature of 25°C and maximum 80% humidity.
3) The total thickness of all coats (dry) is not less than 90 μm;

The finishing coat used to protect the surfaces is a two-component polyurethane painting:
Base: SUMATANE HB PART A;
Hardener: SUMATANE HB PART B;
Supplier: SHERWIN WILLIAMS.

Notes:

a) As a standard, ALSTOM adopts the finishing painting with aliphatic polyurethane paint. For polluted environments or when specified by the customer, the reactor can be painted with silicone-based paint (RTV).

- RTV Silicone High Voltage Insulator Coating Si-COAT 570.
- Color: See dimensional drawings.

b) Painting procedures and non-standard colors must be clearly specified during the tendering process and purchase order.

6.1 – Painting touch up

If the reactors require touching up, remove all debris from the required areas and apply 1 coat of polyurethane finish as follows:

1) Delimitate the area which will be retouched with adhesive tape;
2) Remove the panting of the delimitated area using sand paper of roughness degree 100 or with a wirebrush to eliminate any roughness;
3) Clean the area with non acid paint stripper or alcohol, and let it dry;
4) Coat the surface with finishing paint specified in the chapter 6 and color specified on the dimensional drawings, using a paint brush or spray airgun;

5) Cover the painted surface with plastic (or similar material) with the purpose to protect it from the sun or rain for a period of 24 hours, to assure the paint drying process;

Note: The drying times mentioned above consider minimum ambient temperature of 20°C. For lower temperatures, the drying time must be longer.

If the reactor has a silicone-based paint (RTV) coat:

1) Remove the RTV coat using plastic brush to eliminate any roughness, taking care not to remove the base paint coat of the reactor surface;
2) Clean the area with alcohol and let it dry;
3) Using a paint brush, coat the surface with RTV paint specified by ALSTOM;
4) Cover the painted surface with plastic (or similar material) with the purpose to protect it from the sun or rain for a period of 72 hours, to assure the paint drying process;

Note: RTV is a silicon base paint. After you open the can, its cure starts. So, once you open the RTV can, try to use it at once (same day) because the RTV will not be good for use after that. It is recommended to retouch the reactor in an indoor environment.

7.0 – Maintenance

ATTENTION: The maintenance recommended in this manual must be done with non-energized reactor and duly earthed.

Normally, the air-core reactors need little maintenance. The maintenance periods depends on the storage conditions before the start-up, installation conditions (outdoor or indoor) and environmental conditions.

An annual inspection of the reactors is recommended as a standard procedure or after unusual atmospheric events. Although, for high polluted areas, depending on the amount of pollution, this inspection is to be carried out on a more frequent basis.

The maintenance procedures are relatively simple and are indicated as follows:

1) Visual inspection of reactor and support structure;
   a. Check that the cooling ducts are not obstructed by objects which could prevent the cooling of the equipment. If necessary, clean the cooling ducts wit non-metallic bars (e. g., fiberglass) or air pressure.
   b. Check the fiberglass ties between crossarms;
   c. Check the welded connections of the conductors on the crossarms;
2) Check the reactor external surface and painting. In case of paint deterioration, follow the procedures of the chapter 6.1.

3) In polluted and aggressive environments, the reactors must be washed with high-pressure water for cleaning the external reactor surface, insulators and pedestals;

4) Check the tightening of the connections. If necessary, tight the bolts in accordance to the recommendable torque table.

a. Line terminals
b. Earthing terminals
c. Insulators
d. Aluminum pedestals and mounting pads.

5) If power sources and measure equipment are available at field, it is recommended to measure the DC resistance and/or inductance with nominal frequency (or tuning frequency, in case of filter reactors). The measured values can be compared with those values presented in the routine test reports or during the commissioning. Depending on the power source type and accuracy of the measuring equipment, the results may deviate slightly from the factory values.

8.0 – Environmental Effects and disposal

Before disposing of a product, always familiarize yourself with the local disposal regulations for all the components and materials you are going to dispose of.

The reactors are composed by materials that are not considered dangerous to the environment. For future disposal of the product, in order to minimize the environmental impacts, the following procedures have to be followed:

1) Packaging

- Wooden packaging can be reused or burnt to gain energy except for preservative treated wood, which must be recycled or disposed of according to the local regulations.
- Plastic film (PE) can be recycled or burnt to gain energy.
- Possible steel parts can be recycled.

2) Main Coil and pedestals

- Fiberglass spacers, fiberglass bird barriers and other fiberglass pieces must be taken to a reprocessing plant or industrial waste landfill.
- Metal parts can be recycled.

3) Insulators

- Insulators must be taken to a reprocessing plant or industrial waste landfill.
- Metal parts can be recycled.

CONTACT – TECHNICAL ASSISTANCE

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ДЕКЛАРАЦИЯ

С настоящото декларираме, че при токоограничаващи реактори тип XLTR няма метални арматура, само алуминиеми скоби за осигуряване на магнитните отстояния. Поради тази причина няма метални повърхности, които да бъдат обработвани с антикорозионни покрития.

13.07.2017

С уважение:

Димитър Ивонев - Управител
Грид Солюшънс клон България

Item : 01

Our Ref.: BX17439-R0

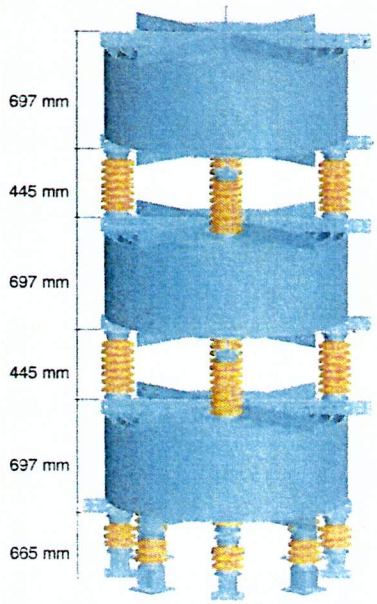
Your Ref.:

Current limiting Reactor

2 three-phase reactor set(s) , Type XTLR 0.463mH / 2000 A

Rated Inductance	0.463 **mH**	**Insulation Level (BIL) Between Terminals**	60	**kVp**
Tolerance	- 0 / + 10 **%**	**Short-Time Current / Duration**	20 / 2	**kA / s**
Rated Impedance	0.145 **Ω**	**Offset Peak Current**	55	**kAp**
System Voltage / Frequency	6.3 kV / 50 Hz	**Total Losses per phase @ 75ºC / Rated Current**	10	**kW**
Rated Current	2000 **A**			
Design Current	2000 **A**			
Rated Power per phase	580 **kvar**			
Cooling	A.N.	**Maximum Operating Altitude**	1000	**masl**
Installation	Outdoor	**Maximum Ambient Temperature**	40	**ºC**
Insulation Class	F (155ºC)	**Wind Speed**	122.4	**km/h**
Mounting Arrangement	Three-phase stacked coils	**Seismic Acceleration**	0.23	
Weight per coil	577 **kg**	**Applicable Standard**	IEC-60076-6	
Weight with insulators and pedestals	2056 **kg**			

Reactor dimensions



Extra Information

Reactor Color - RAL 7035
Conductor Material - Aluminum
Total Height (Ht) = 3682 mm
Coil Diameter (Ds) = 1550 mm
Mounting Diameter (Df) = 1400 mm
Minimum Distance Between Centerlines (De)= 2635 mm

Notes

1 - Outline drawing for quotation only.
2 - Terminal dimensions are indicative and can be changed.
3 - Location of terminals can be oriented to suit customer's requirements.
4 - Aluminum brackets may be located both superior or inferior part of insulators.
5 - Dimensions in [mm].

SUPPORT SYSTEM

Insulators	Included
Base Insulator (quantity x type)	8 x TR225
BIL of Base Insulator	110 kVp
Creepage Distance of Base Insulator	394 mm
Inter-Phase/Coil Insulator (quantity x type)	4 x TR225
BIL of Inter-Phase/Coil Insulator	110 kVp
Creepage Distance of Inter-Phase/Coil Insulator	394 mm

Packing Dimensions

Reactor Crates
Quantity of Reactors Crates (w/1 itens) : 6
Gross Weight of Each Reactor Crate : 739 kg
L x W x H: 170 x 170 x 90 cm

Base Insulator Crates
Quantity of Insulators Crates : 1
Gross Weight of Each Insulator Crate : 598 kg
L x W x H: 189 x 101 x 51 cm

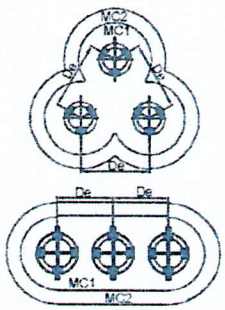
Magnetic Clearances

Axial clearance from the top/bottom spider to:
- Small metallic parts not forming closed loops (MC1)= 635 mm
- Small metallic parts forming closed loops (MC2)= 1226 mm

Radial clearance from the reactor centerline to:
- Small metallic parts not forming closed loops (MC1)= 1091 mm
- Small metallic parts forming closed loops (MC2)= 1464 mm

Stray magnetic field may induce currents in metallic parts that may cause thermal and electrodynamic effects. Required nearby structures as auxiliary equipment, electronic equipment, rebar, etc shall be located in areas where the effect will not create excessive heating. In case of specific analysis necessity, please contact us.

Installation Diagram



OFFER Nº	TECHNICAL OFFER	
BX 17 439		
Sheet 01/01		

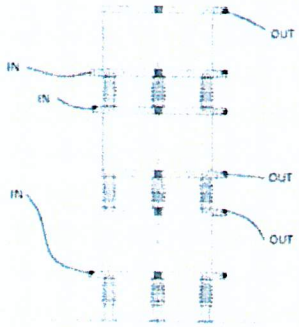
CUSTOMER	ESO
PROJECT	Hascovo of BG Transmission operator ESO
DATE	11/07/2017

Technical Specifications

[1] "ESO Reactors_EN.docx"

Scope of Supplying from GE Brazil (AIB RPC)

- Three phase air core current limiting reactors



Out of Scope of Supplying from GE Brazil (AIB RPC)

- Elevating structures
- Line Connectors
- Foundation structures and anchor bolts
- Instalation and assembly supervision.
- Fences

Technical Remarks

- Creepage distance: 25 mm/kV (43.3 mm/kVph-gr USCD)
- Paiting color: Light Grey RAL 7035
- Insulators are included (Brown color, metric threads).
- Extension brackets to provide the minimum magnetic distance between reactor's bottom and metallic parts **not** forming closed loops are included.
- Central coil of the stacked reactors have inverted terminals (see image above) in order to improve the delivery time.

- Moderate seismic requirements, by static coefficient analysis, according to IEEE 693-2005.
- Horizontal acceleration 0.23 g - Vertical acceleration 0.184 g - Damping 2%
- Static coefficient 1.0 - Safety factor 2.0
- Seismic and short-circuit events are not assumed to occur simultaneously.
- Seismic report is not included.

Routine and Type Tests

- Routine tests are included according to Clause 8 of IEC-60076-6:
  - Measurement of winding resistance
  - Measurement of losses at ambient temperature
  - Measurement of harmonic current losses
  - Measurement of inductance
  - Lightning impulse test
  - Visual inspection and dimensional checks

- Standard type and special tests, as per IEC Standard, are NOT included:
  - Wet power frequency voltage withstand test (*)
  - Dry lightning impulse voltage withstand test
  - Temperature rise test
  - Measurement of acoustic sound level
  - Short-time current withstand test

- Type and Special tests are not included and shall be purchased/quoted separately.
  - The complete set of type and special tests costs around 200 KEUR, and its execution depends on the availability and technical capability of external laboratories.
  - Some of the type tests, such as short-time current, can be replaced by reports with theoretical demonstrations or reports of similar equipment tests (if avaliable).
  - Type tests on insulators (*), in principle, might be provided by the insulator supplier.

Rev.	Date	Description
4		
3		
2		
1		
0	11/07/2017	First issue.

Item : 01

Our Ref.: BX17439-R0 — Your Ref.:

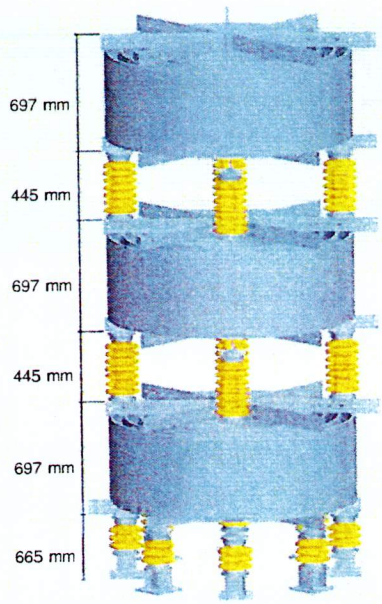
Current limiting Reactor

2 three-phase reactor set(s) , Type XTLR 0.463mH / 2000 A

Rated Inductance	0.463 **mH**
Tolerance	- 0 / + 10 **%**
Rated Impedance	0.145 **Ω**
System Voltage / Frequency	6.3 kV / 50 Hz
Rated Current	2000 **A**
Design Current	2000 **A**
Rated Power per phase	580 **kvar**
Cooling	A.N.
Installation	Outdoor
Insulation Class	F (155ºC)
Mounting Arrangement	Three-phase stacked coils
Weight per coil	577 **kg**
Weight with insulators and pedestals	2056 **kg**

Insulation Level (BIL) Between Terminals	60	**kVp**
Short-Time Current / Duration	20 / 2	**kA / s**
Offset Peak Current	55	**kAp**
Total Losses per phase @ 75ºC / Rated Current	10	**kW**
Maximum Operating Altitude	1000	**masl**
Maximum Ambient Temperature	40	**ºC**
Wind Speed	122.4	**km/h**
Seismic Acceleration	0.23	
Applicable Standard	IEC-60076-6	

Reactor dimensions



Extra Information

Reactor Color - RAL 7035
Conductor Material - Aluminum
Total Height (Ht) = 3662 mm
Coil Diameter (Ds) = 1550 mm
Mounting Diameter (Df) = 1400 mm
Minimum Distance Between Centerlines (De)= 2635 mm

Notes

1 - Outline drawing for quotation only.
2 - Terminal dimensions are indicative and can be changed.
3 - Location of terminals can be oriented to suit customer's requirements.
4 - Aluminum brackets may be located both superior or inferior part of insulators.
5 - Dimensions in [mm].

SUPPORT SYSTEM

Insulators	Included
Base Insulator (quantity x type)	8 x TR225
BIL of Base Insulator	110 kVp
Creepage Distance of Base Insulator	394 mm
Inter-Phase/Coil Insulator (quantity x type)	4 x TR225
BIL of Inter-Phase/Coil Insulator	110 kVp
Creepage Distance of Inter-Phase/Coil Insulator	394 mm

Packing Dimensions

Reactor Crates
Quantity of Reactors Crates (w/1 itens) : 6
Gross Weight of Each Reactor Crate : 739 kg
L x W x H: 170 x 170 x 90 cm

Base Insulator Crates
Quantity of Insulators Crates : 1
Gross Weight of Each Insulator Crate : 598 kg
L x W x H: 189 x 101 x 51 cm

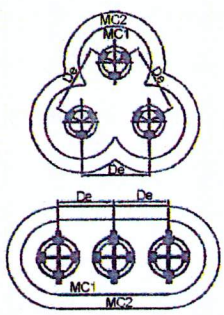
Magnetic Clearances

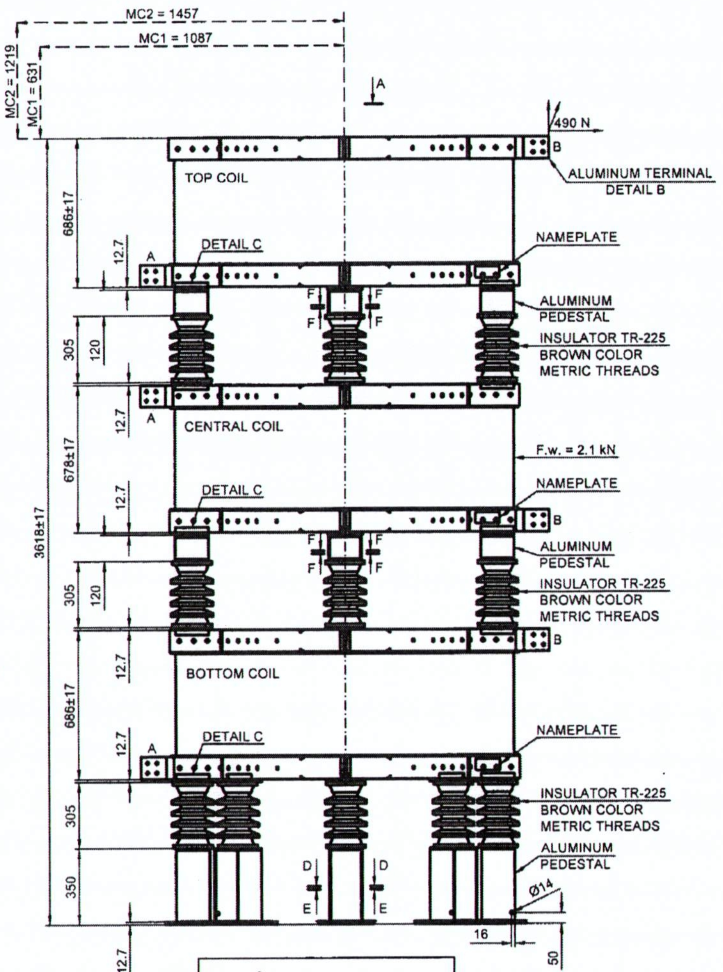
Axial clearance from the top/bottom spider to:
- Small metallic parts not forming closed loops (MC1)= 635 mm
- Small metallic parts forming closed loops (MC2)= 1226 mm

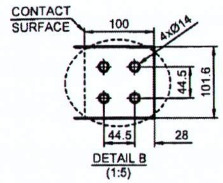
Radial clearance from the reactor centerline to:
- Small metallic parts not forming closed loops (MC1)= 1091 mm
- Small metallic parts forming closed loops (MC2)= 1464 mm

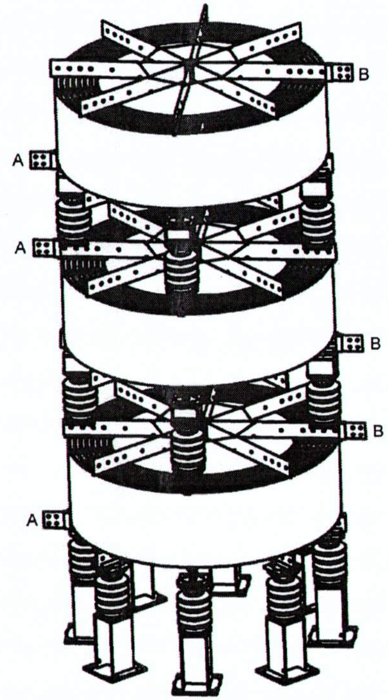
Stray magnetic field may induce currents in metallic parts that may cause thermal and electrodynamic effects. Required nearby structures as auxiliary equipment, electronic equipment, rebar, etc shall be located in areas where the effect will not create excessive heating. In case of specific analysis necessity, please contact us.

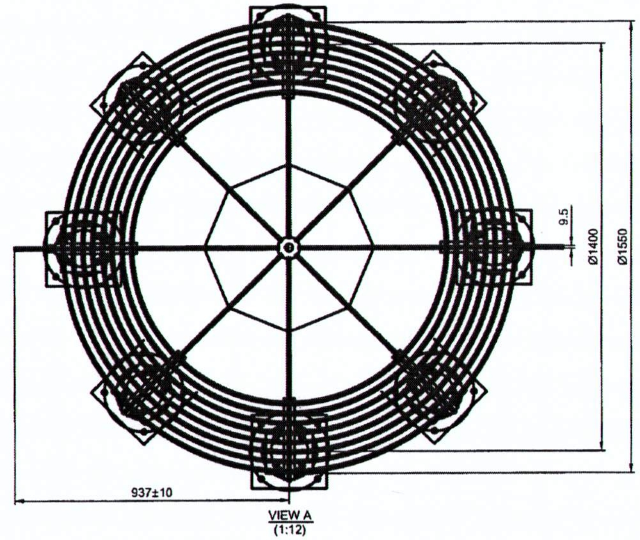
Installation Diagram











CURRENT LIMITING REACTOR

ITAJUBÁ-MG / BRASIL

Type XTLR - 0.463 mH / 2000 A   Serial nº: *

Rated Inductance	0.463 mH (-0/+10%)	System Voltage	6.3 kV
Rated Impedance	0.145 Ω	Bil Between Terminals	60 kVp
Rated Frequency	50 Hz	Short-time Current/Duration	20 kA / 2 s
Rated Current	2000 A	Offset Peak Current	55 kAp
Design Current	2000 A	Total Losses (75°C/In)	10 kW
Rated Power	582 kvar	Q-Factor/Frequency	—
Cooling	A.N.	Altitude	≤ 1000 m.a.s.l
Installation	Outdoor	Ambient Temperature	40 °C
Temp. class	F (155°C)	Standard	IEC-60076-6
Nº Phases	3	Year	2017
Weight per coil	556 kg	Instruction book nº	M002

* 2401420010001 To 2401420010002 TOP COIL
CENTRAL COIL
BOTTOM COIL

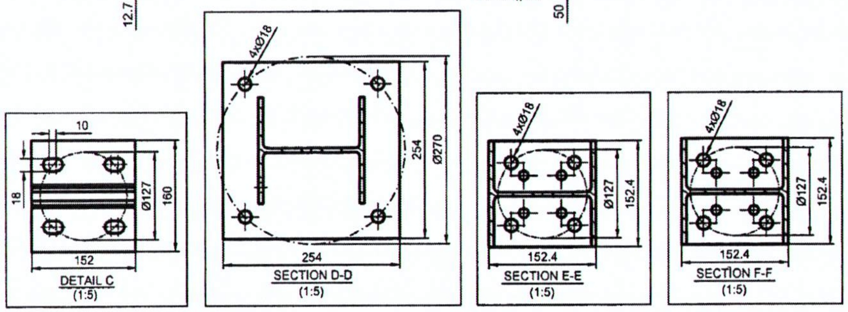
(1:1)

REACTOR CONNECTION

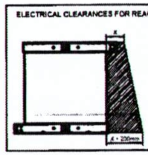
TERMINAL	COIL		
	TOP COIL	CENTRAL COIL	BOTTOM COIL
A	IN	IN	IN
B	OUT	OUT	OUT

NOTES:

- Total weight: 1994 kg.
- Stray magnetic field induces currents in metallic parts that may cause thermal and electrodynamics effects. Required nearby structures as auxiliary equipment, electronic equipment, rebar, etc shall be located in areas where the effect will not create excessive heating. If specific analysis or information is required, please contact the manufacturer.
- Moderate seismic performance level, by static coefficient analysis, according to IEEE Std 693-2005.
  -Horizontal acceleration 0.23 g -Vertical acceleration 0.184 g -Damping 2%
  -Static coefficient 1.0 -Performance factor 2.0
- Short-circuit and seismic events are assumed not to occur simultaneously.
- MC1 = Minimum magnetic clearance for small metallic parts not forming closed loops.
- MC2 = Minimum magnetic clearance for large metallic parts or metallic parts forming closed loops
- F.w. = Force of wind load at 122.4 km/h.
- Reactor color: RAL 7035.
- Nameplate, Dimensions: 63 x 130 x 0.8 m.m
  Material: Stainless steel, printings in bold.



ELECTRICAL CLEARANCES FOR REACTOR CONNECTION



BIL (kVp)	X (mm)
≤ 110	200
≤ 150	300
≤ 200	350
≤ 250	500
≤ 350	650
≤ 450	900
≤ 550	1100
≤ 650	1300
≤ 750	1500
≤ 850	1700
≤ 950	1900
≤ 1050	2100

Revision N°	Date	Drawn by	Checked by	Approved by	Modifications

Drawn by	Checked by	Approved by	Customer drawing number	Customer project reference
EMC	AFR	MRM	-	-
22-09-17	22-09-17	22-09-17		

Grid Solutions

Description: ESO REACTOR DIMENSIONS

Location Unit: AIB		Unit: mm / Format: A2	Location: -
Reference: RPC	Mass (kg): -	Scale: 1/16 / Sheet: 1	Sheet name: -
Drawing number: 2401420010-001			Revision N°: 00