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400 kV & 220 kV Shunt Reactors

Functional Specification

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R0	10/06/2022	First Issue	Vitali Garon	Daniele Giustini, Niall McMahon	Leon Notkevich, Neil Cowap	Aidan Corcoran, Richard Blanchfield
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Table of Contents

1 SCOPE

This Functional Specification is applicable for use in offshore wind transmission links delivered by the Customer as Contestable Works, to be owned and operated by EirGrid. The following specification outlines the requirements for the design, procurement, construction/assembly, and commissioning of 220 kV and 400 kV Shunt Reactors for use in Onshore Compensation Compounds (OCC) and Offshore Substations Platforms (OSP)

This specification should be read in association with the project specific contestable works pack and project documentation and all other relevant functional specifications as issued by EirGrid.

For the purpose of this specification the term Customer shall refer to Offshore Wind Power Developers, Independent Power Producers responsible for the design and build of assets to be handed over to EirGrid.

The Customer shall submit a completed set of the appropriate Technical Schedules for EirGrid review. Note that most parameters of the Technical Schedule shall be completed during the design by Customer in consultation with EirGrid.

- OTS-SSS-415 Technical Schedules for 220 kV Shunt Reactors

In addition to the requirements of this specification, the reactors shall comply with:

- EirGrid Functional Specification OFS-SSS-400 “Onshore Compensation Compound General Requirements”, OFS-GEN-005 “Network Engineering Studies ” and other applicable EirGrid standards and requirements.

  Project specific requirements including the project functional specification, project protection specification and single line diagram.

2 ABBREVIATIONS

Table 1 Abbreviations

AIS	Air Insulated Switchgear
AISI	American Iron and Steel Institute
AN	Air Natural
BSP	British Standard Pipe
CLP	Classifying, labelling, packaging regulation
CMS	Condition Monitoring System
CPR	EU Construction products regulation
CT	Current Transformer
DGA	Dissolved Gas Analysis
EN	European standard
GIS	Gas Insulated Switchgear
HV	High voltage
I.S.	Irish Standard
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission

ISO	International Organization for Standardization
MCB	Miniature Circuit Breaker
NDT	Non-Destructive Testing
ONAN	Oil Natural Air Natural
PCB	Polychlorinated Biphenyl
PVC	Polyvinyl Chloride
REACH	Registration, Evaluation, Authorization and Restriction of chemicals
RIP	Resin Impregnated Paper
RIS	Resin Impregnated Synthetic
ROHS	Restriction Of Hazardous Substances directive
RUSCD	Reference unified specific creepage distance
SHR	Shunt Reactor
SI	Statutory Instrument
TAO	Transmission Asset Owner
VT	Voltage Transformer
WEEE	Waste electrical and electronic equipment

3 HEALTH AND SAFETY

The Customer shall ensure that a satisfactory safety risk assessment has been completed in accordance with the EirGrid Safe by Design methodology - XDS-SDM-00-001.

General Health and Safety requirements are outlined in OFS-SSS-400 “Onshore Compensation Compound General Requirements”.

All works are subject to health and safety legislation outline in section 4.1.

Refer to section 8 for requirements relating to materials which may be classified as hazardous.

The design shall ensure safety of personnel during the operation, decommissioning, and simplicity of maintenance.

The design shall:

a) Ensure safe maintenance operations. All parts of the reactor to which access is required or provided shall be capable of being earthed when disconnected from the system.

b) Determine the number and location of earthing devices in accordance with the equipment layout, so that the safety of personnel is fully guaranteed during operation and maintenance of the equipment.

c) Provide adequate safety screens for all moving parts.

d) Ensure safety of personnel and restriction of material damage in the event of internal fault.

All position indicators, marshalling cabinets, terminal boxes, etc. shall be accessible from ground level with the exception of tank-top devices.

- Tank projections shall not constitute climbing aids.

- Asbestos shall not be used in any part of the reactors.
- The PCB content of insulating oil shall be less than 1 ppm.

4 LEGISLATION CODES AND STANDARDS

4.1 LEGISLATION

Equipment offered shall be compliant with the provisions of the latest applicable versions of all relevant Irish legislation and directives of the European Union.

These include the following or latest versions/ amendments as appropriate:

GIS equipment shall carry the CE Mark in accordance with Directive 768/2008/EC and the EU Construction Products Regulation (No. 305/2011 – CPR), adequate documentation to demonstrate full compliance should be obtained by the Customer and issued to EirGrid. This documentation will have to be included in the Safety File. A non-exhaustive list of the relevant legislation is below

Item	Description/Title
SI No. 132	Safety signs regulations 1995 (implements EEC Directive 92/58)
SI No. 291	Safety, Health and Welfare at Work (Construction) Regulations
SI No. 299	Safety, Health and Welfare at Work (General Application) Regulations 2007
SI No. 445	Safety, Health and Welfare at Work (General Application) (Amendment) Reg. 2012
Reg (EC) No 1907/2006	Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
Reg (EC) No 1272/2008	Classification, Labelling and Packaging of Substances and Mixtures (CLP)
Reg (EU) No 517/2014	Fluorinated greenhouse gases and repealing regulation (EC) No 842/2006
Reg (EU) 2015/2068	Format of labels for products and equipment containing fluorinated greenhouse gases
Reg (EU) 2015/2065	Format for notification of the training and certification programmes of the Member States
Reg EU 2015/2066	Minimum requirements and the conditions for mutual recognition for the certification of natural persons carrying out installation, servicing, maintenance, repair or decommissioning of electrical switchgear containing fluorinated greenhouse gases or recovery of fluorinated

Item	Description/Title
	greenhouse gases from stationary electrical switchgear
Directive 2014/30/EU	Harmonisation of the laws of the Member States relating to electromagnetic compatibility
Directive 2013/35/EU	Minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)
Directive 2011/65/EU	Restriction of the use of certain hazardous substances in electrical and electronic equipment (ROHS)
Directive 2012/19/EU	Waste Electrical and Electronic Equipment (WEEE)
Directive 2014/30/EU	Harmonisation of the laws of the Member States relating to electromagnetic compatibility
ECE/TRANS/275	Vol. I and II ("ADR 2019") European Agreement Concerning the International Carriage of Dangerous Goods by Road
ICNIRP	International Commission on Non-Ionizing Radiation Protection (ICNIRP)
ISO14001	Environmental Management System

4.2 EirGrid Specifications and Drawings

In addition to compliance with this standard, equipment offered shall be compliant with the provisions of the latest applicable versions of related EirGrid specifications.

In case of conflict with international or national standards EirGrid specifications and drawings specify take precedence.

4.3 National International and Other Applicable Standards

Except where otherwise stated in the functional specification, materials shall be designed, manufactured, tested, and installed according to relevant IEC and/or EN standards.

Where available, the Irish adaptation of European standards (IS EN version), including any national normative aspects shall be applied.

Where no IEC standard or EN standard has been issued to cover a particular subject then an international or British Standard shall be applied. The latest edition and amendments shall apply in all cases.

The equipment shall comply with the latest editions of the international standards, codes and normative references indicated below, and the latest editions of the standards that they reference.

In case of conflict with international or national standards, EirGrid specifications shall take precedence.

A non-exhaustive list of the applicable standards is below

Item	Description/Title
IS 10101	National Wiring rules for electrical installations
ET103	National rules for electrical installations – Power installations exceeding 1 kV AC
ASTM D 2247	Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
ASTM D 2794	Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D 3359	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM D 3363	Standard Test Method for Film Hardness by Pencil Test
ASTM D 3455	Standard test methods for compatibility of construction material with electrical insulating oil of petroleum origin
ASTM D 4752	Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub
BS EN ISO 25817	Arc-welded joints in steel
IEC 60076	Power Transformers all parts
IEC 60137	Insulated bushings for alternating voltages above 1000 V
IEC 60214-1	Tap-changers Part 1: Performance requirements and test methods
IEC 60214-2	Tap-changers Part 2: Application guide
IEC 60227	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750 V
IEC 60296	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
IEC 60507	Artificial Pollution Tests on High-Voltage Insulators to be used on A.C. Systems
IEC 60529	Degrees of Protection provided by Enclosures (IP Code)
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-Filled electrical equipment - Sampling of gases and of oil for analysis of free and dissolved gases
IEC 60599	Mineral Oil-Impregnated Electrical Equipment in Service – Guide to the Interpretation of Dissolved and Free Gases Analysis

Item	Description/Title
IEC 60599 AMD 1	Amendment 1 Mineral Oil-Impregnated Electrical Equipment in Service – Guide to the Interpretation of Dissolved and Free Gases Analysis
IEC 60641-2	Pressboard and Press paper for electrical purposes, method of tests
IEC 60688	Electrical measuring transducers for converting A.C. and D.C. electrical quantities to analogue or digital signals
IEC 61672	Electroacoustics - Sound Level Meters.
IEC 61850	Communication Networks and Systems in Substations
IEC 62271-1	Common specifications for high-voltage switchgear and controlgear standards
IEC 62271-209	High-voltage switchgear and controlgear Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable terminations – Edition 1.0.
IEC 62474	Material declaration for products of and for the electrotechnical industry
IEC 62535	Insulating liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil.
IEC Guide 113	Materials Declaration Questionnaires - Basic Guidelines - Edition 1.0
IEC TR 60616	Terminal and Tapping Markings for Power Transformers
IEC TR 60815	Guide for the Selection of Insulators in Respect of Polluted Conditions
IEC TR 62271-301	High-voltage switchgear and controlgear Part 301: Dimensional standardisation of high-voltage terminals
IEC TS 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC TS 61639	Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above-First Edition
ISO 12944	Corrosion Protection of Steel Structures by protective paint systems
ISO 2409	Paints and varnishes. Cross-cut test
ISO 2813	Paints and varnishes. Measurement of specular gloss of non-metallic paint films at 20 °, 60 ° and 85 °

Item	Description/Title
ISO 4892-3	Plastics. Methods of exposure to laboratory light sources. Fluorescent UV lamps
ISO 7724	Methods of test for paints. Determination of colour and colour difference: calculation
ISO 9001	Quality Management Systems
ISO 9227	Corrosion tests in artificial atmospheres. Salt spray tests
Doble TOPS	Transformer Oil Purchase Specification.

5 SERVICE CONDITIONS

All equipment shall be designed and constructed to endure service and environmental conditions appropriate to their location and in accordance with the service conditions described in OFS-SSS-400 “Onshore Compensation Compound General Requirements”.

Reactors will be installed less than 1,000 m above sea-level.

Reactors shall be suitable for outdoor operation.

The humid salty atmosphere in Ireland is particularly severe on non-galvanised ferrous parts and on aluminium and its alloys. The Shunt Reactors will likely be installed in proximity of the seashore or offshore and therefore the RUSCD required is for very heavy pollution level: 53.7 mm/kV.

6 SERVICE EXPERIENCE

The Supplier(s) shall satisfy each of the following requirements:

(a) At least 10 years’ experience in the production of reactors at the relevant voltage or higher.

(b) Satisfactory[1] service experience in the EU at each voltage for which equipment is offered, as an alternative to such experience within the EU, similar experience with UK, Swiss, Japanese, Australian, South Korean, or US /Canadian utilities would be considered.

(c) Installation of the product range for at least 5 years in at least three utilities within the EU or alternatives as outlined in point (b).

(d) For 400 kV equipment - at least ten (10) units of similar type and rating (or higher) in service.

(e) For 220 kV equipment - at least thirty (30) units of similar type and rating (or higher) in service.

(f) At least 5 years production in the particular proposed manufacturing plant is required, although if the proposed plant has been relocated and is using substantially the same

[1] Satisfactory service experience requires that there have been no major failures that subsequently resulted in the removal from service of all reactors of the same type or construction from service in the utility.

workforce the combined time of both plants would be considered.

The products being offered to EirGrid must be manufactured in the same plant which produced the products which are cited as meeting the service requirements outlined above.

7 Network Parameters

The equipment shall be suitable for installation on the Transmission system. The design parameters are specified in OFS-SSS-400 “Onshore Compensation Compound General Requirements”.

Refer to project documentation including the project protection specification and single line diagram for details of relevant primary currents and voltages.

The Customer shall submit fully completed and signed set of technical schedules to facilitate an EirGrid review in advance of equipment order. A minimum of two weeks required, but longer additional time is preferred.

8 Environmental Design and Hazardous Substances

The Customer shall comply with all current applicable latest Irish and European environmental legislation. Refer also to section 4.1 and the Health and Safety section of OFS-SSS-400 “Onshore Compensation Compound General Requirements”.

This includes compliance in relation to:

- Declaration of materials
- Declaration of Hazardous Substances
- Safety Data Sheets and Packing Waste
- Disposal of Material Found to be Hazardous

9 Quality Assurance

9.1 General

General quality assurance requirements for all projects are outlined in OFS-SSS-400 “Onshore Compensation Compound General Requirements”.

The Customer shall ensure the shunt reactor is manufactured in accordance with the requirements of this specification.

Any deviations to the Functional Specifications shall be outlined for EirGrid review.

Where deviations are proposed in the design the Customer shall submit a formal Derogation Request outlining an explanation of why the non-compliance is expected and any additional information to support the request for EirGrid to consider. Further information is outlined in EirGrid’s Derogation Process (OFS-GEN-24 - Guidance for Derogation Requests).

9.2 Material Workmanship

All materials and workmanship shall be of a suitable type and quality to ensure that the equipment will operate satisfactorily in accordance with the specification.

9.3 QUALITY ASSURANCE SYSTEM

Equipment Manufacturers shall have ISO 9001 registration and maintain a documented quality control and quality assurance system which shall be in accordance with ISO 9001 or an equivalent international standard.

Details of particular quality requirements must also be observed, such as:

- Maintenance of a risk register.
- Recording of non-conformances and follow-up corrective action.
- Evidence of continuous improvement and reviewing of targets and objectives.
- Procedures and work instructions to facilitate quality production.
- Statistical records of Quality Control Tests:

  Sample copies of completed statistical records on tests and quality control checks within the factory should be provided, in order to provide confirmation of Quality Control Procedures.

  Details of the inspection tests and procedures for incoming raw material should be provided. Where the Customer relies on Quality Control testing being performed by the Supplier, details shall be provided of the tests carried out by the Supplier and the confirmatory control tests by the Customer. Copies of the actual record sheets being used are required.

- Auditing:

  In the event of quality problems which are likely to cause an impact on equipment being supplied, the Customer must inform EirGrid. In the case of faulty equipment being returned by Customer, the Supplier must provide a preliminary report. This report shall be shared with EirGrid for review.

  EirGrid reserves the right to conduct an audit to ensure compliance.

- Changes in Product details:

  As per the initial submission documentation, the Customer undertakes that the product(s) will be manufactured as specified and agreed and that there will be no change to the product or manufacturing process during the life of the Customer's contract without prior notification to EirGrid. In addition, the supplier undertakes to notify EirGrid in advance of any proposed changes to the installation/maintenance procedures of the product(s) on this contract.

9.4 SUB-SUPPLIERS

The Supplier shall fully declare all sub-suppliers of material associated with or used in the final product. This declaration shall include Sub-Suppliers' names and countries of origin.

Customers shall ensure that suppliers have in place a management system either certified to ISO 9001 latest edition and 14001, or demonstrably complying with the principles of these standards. Delivery

Packaging, delivery, and storage shall be in accordance with best practice and Manufacturer's recommendations.

10 Maintenance

10.1 General

The Customer shall advise about the Manufacturer recommended maintenance interval and scope for the shunt reactor.

10.2 Special Tools

The Customer shall list any special tools required for maintenance of the equipment in the schedule of Special Tools (part of Technical Schedules). All such tools shall be provided with clear instruction in English as to their function and operation.

10.3 Spare Parts

The Customer, in consultation with their OEM's, shall list all recommended spare parts.

All recommended spare parts shall be provided with associated drawings and instructions.

Refer to OFS-GEN-009 for more details.

10.4 Maintenance Instructions

The Customer shall provide a complete set of maintenance instructions. The instructions shall be complete, in English and contain all associated instructions and drawings pertaining to the continuing maintenance of the equipment throughout its lifecycle.

11 Compliance With Specifications

11.1 Deviations from Specification

The Customer shall list all deviations from the requirements of this Specification in the schedule of deviations within the Technical Schedules.

Where deviations are proposed in the design the Customer shall also submit a formal Derogation Request outlining an explanation of why the non-compliance is expected and any additional information to support the request for EirGrid to consider. Further information is outlined in EirGrid's Derogation Process Guidance document OFS-GEN-24.

12 Type And Duty

Shunt reactors are required to provide reactive compensation by absorbing reactive power and will be expected to operate in both a predominately cable and overhead line network.

The reactors described in this specification will be shunt connected to the 400 kV or 220 kV export cables connecting the OCC to the OSP.

All reactors shall be capable of off-load variation of reactance via off-load tap changers. Depending on project requirements, on load tap changers can also be considered if agreed by EirGrid.

The reactors will typically be installed directly on a feeder circuit (connection to the OSP). The requirement for a separate circuit breaker, other than the feeder circuit breaker, will be determined on a project specific basis.

Shunt reactors may also be connected to a busbar via a circuit breaker subject to

satisfactory CB switching studies for shunt reactor and export cable.

Refer to project specific documentation for confirmation of the required connection arrangement.

Oil immersed reactors shall be naturally cooled (ONAN) three phases stars connected with an earthed neutral.

Air core reactors shall be single phase units

12.1 Reactive Power And Voltage

The rated voltages and maximum continuous operating voltages shall be as follows:

Table 2 Rated and Maximum Voltages

System Voltage	Rated Voltage	Max System Voltage
400 kV	400/√3 kV	420/√3 kV
220 kV	220/√3 kV	245/√3 kV

The rated power at rated voltage and 50 Hz shall be as calculated by the Customer and in line with the Customer project strategy for WF and export cable reactive compensation.

The number of taps and variation in reactance as a function of tap position shall be calculated by the Customer and in line with the Customer project strategy for WF and export cable reactive compensation.

The Customer shall advise on harmonic current rating and the positive and zero sequence inductance per phase of the reactor.

For oil filled reactors - under these service conditions, the temperature rise of the top oil during continuous operation at maximum operation voltage, shall not exceed 60°C, and the temperature rise of the windings shall not exceed 65 °C. The Customer shall advise the calculated hot spot temperature.

For air core reactors - under these service conditions, the temperature limits for the windings shall not exceed those specified in IEC 60076-11. The Customer shall advise the calculated hot spot temperature.

The magnetisation curve for the reactor shall also be provided to EirGrid for review.

12.2 Rated Insulation Levels

Reactors shall be rated for insulation levels as stipulated in OFS-SSS-400 “Onshore Compensation Compound General Requirements”.

12.3 Voltage/Current Characteristics

A curve showing the voltage/current characteristics shall be submitted to EirGrid for design review. In order to avoid harmonic current generation under system overvoltage conditions, the reactor shall have constant linear impedance up to 1.5 times the nominal voltage (i.e., 220 kV or 400 kV). Furthermore, the impedance should be accurately balanced between

the three phases.

The characteristics will be accepted as linear provided that the impedance (voltage divided by current) at the specified upper limit of linearity is within +/- 5 % of the value at rated voltage as per clause 7.9.3 of IEC 60076-6.

12.4 OVER FLUXING

The reactors may be subjected in service to long duration 50 Hz overvoltage's and short duration high frequency overvoltage's. They shall withstand the following over fluxing requirements without exceeding the permissible temperature rises in section 12.1.

- Continuous 110 % of rated volts/Hz
- 1 minute 125 % of rated volts/Hz
- 10 seconds 140 % of rated volts/Hz

This shall be in addition to a margin for the deviation of applied voltage/frequency to rated voltage /frequency of 5 % (IEC60076-1, Clause 5.4).

The over-excitation curve for the reactor showing volts/Hz versus time shall be submitted to EirGrid for review and shall show details in the range of 100 % to 150 % Excitation and 0 to 100 minutes.

The over-excitation capability shall be confirmed as part of the temperature rise test.

12.5 SWITCHING OVER VOLTAGES

The Customer shall provide calculations to EirGrid of the magnitude of the in-rush current on switch-in and calculation of the transient recovery voltage appearing across the contacts of the Circuit Breaker on switch-out. The Customer shall use these values in the selection of an appropriate circuit breaker to connect the reactor and feeder circuit or just reactor (depending on the selected configuration) into the OCC busbar.

The Customer shall confirm the mechanical and electrical withstand of the internal insulation accordingly and shall consider if a controlled switching (i.e., where point on wave switching is used to control opening of the associated circuit breaker) is required or not. Depending on the requirement it shall be adequately considered for the purpose of the calculations.

12.6 CURRENT WITHSTAND

Reactors shall be rated for continuous currents corresponding to the application of maximum system voltage, as described in Table 2, irrespective of tap position.

Any series connected circuit elements shall meet the short circuit withstand capability as stipulated in OFS-SSS-400 "Onshore Compensation Compound General Requirements".

12.7 ZERO PHASE SEQUENCE IMPEDANCE

For three phase reactors, the ratio between zero sequence and positive sequence reactance's shall be as close as possible to unity.

Acceptable X_0/X_+ ratios are in the 0.9 to 1 range.

Customers shall state, in the Technical Schedules, the zero phase sequence impedances of the three-phase reactor.

12.8 VIBRATION AND INDUCED CURRENTS

Special attention shall be given in the design and manufacture to minimising active part and tank vibrations.

In the case of air core reactors, the Manufacturer (on behalf of the Customer) shall advise all necessary safety and construction measures to eliminate the effect of induced currents causing voltage potential rise in adjacent structures and steelwork. The Customer shall advise EirGrid on the measures being considered in the project

12.9 LOSSES

As the reactor will be in constant operation, the total loss in the reactor shall be kept to a minimum. Lifetime optimisation of CAPEX and OPEX shall be considered, losses should comply with (EU) No 548/2014

The Customer shall state the losses in accordance with IEC 60076-6 at rated current, frequency and reference ambient temperature.

The Customer shall state the X/R ratio of the reactor.

12.10 ADJUSTMENT OF INDUCTIVE REACTANCE

The project application may require the ability to vary the reactance of shunt reactors off load.

The reactance at each required operating point will be specified in the project technical schedule.

An off-load or on-load tap changer shall be provided for oil type reactors and shall meet the requirements of IEC relevant standards.

A convenient and secure means shall be provided of adjusting the reactance.

The required position of links or handles to adjust the reactance shall be clearly documented.

12.11 NOISE

The Shunt Reactor shall comply with chapter 1 of Part 5 of the Safety, Health and Welfare at Work (General Application) Regulations 2007 S.I. No. 299 of 2007 as amended from 12 November 2007 by the Safety, Health and Welfare at Work (General Application) (Amended) Regulations 2007 (S.I. No. 732 of 2007) which sets down the minimum requirements for the protection of workers from the health risks associated with noise in the workplace.

The noise levels of reactors shall be stated by the Customer and shall be measured in accordance with EN 60076-10 at 100% Ur.

The A-weighted normal level shall not exceed 70 dBA[2] at 2 m away from the principal radiating surface.

[2] Reactor noise level shall be reduced further, and/or noise mitigation measures shall be provided as required to meet planning requirements. Refer to OFS-SSS-400 for further requirements.

13 Clearances From Live Parts

Clearances from live parts shall be as specified in the latest version of OFS-SSS-400 “Onshore Compensation Compound General Requirements” functional specification.

The minimum design clearances in air as per OFS-SSS-400 “Onshore Compensation Compound General Requirements” are as follows:

Table 3 Clearances from Live Parts

Voltage kV	Ph-Earth mm	Ph-Ph mm
220	2400	2700
400	4100	4750

14 Oil Filled Reactors

14.1 Radiators

The radiators shall be attached to the tank but shall be detachable from it for transport and maintenance. Shut-off valves shall be provided for this purpose. These valves shall clearly indicate the open and closed positions. Air-bleed and oil drain valves shall be provided on each radiator. A pocket to accommodate a temperature measuring device shall be provided in a return connection.

14.2 Marshalling Cabinet

A reactor marshalling box shall be provided, for the marshalling of all wiring to the reactor and housing of all associated control equipment and instrumentation including the functions and devices described in section 14.5.

It shall be mounted on the reactor using suitable anti-vibration mountings.

The base of the box shall be 600 mm above the base of the reactor to allow for bund walls and the maximum height of the top of the box shall be 2 m above ground level to allow viewing of all temperature dials without opening the door.

The door of the marshalling box shall incorporate a strengthened glass or polycarbonate window to allow external viewing of dial thermometers.

The marshalling box shall have an ingress protection of IP54 or greater in accordance with EN 60529.

All cables shall enter the enclosure vertically from below and shall be appropriately glanded at their point of entry.

The marshalling box shall be equipped with the following:

a) A separate removable gland plate to take a minimum of eight 25 mm diameter holes for external cabling.

b) A hinged door fitted with retainers to allow fixing in the open position and suitable for locking with a padlock.

c) A 230 V, 50 Hz anti-condensation space heater which shall be controlled by

means of a humidistat and a cut-out thermostat with an adjustable operating range, to prevent overheating.

The live parts of heaters shall be enclosed with a minimum ingress protection of IP2X.

d) Outdoor industrial 16 A 230 V socket mounted on panel exterior.

e) A fixed internal lamp controlled by a door switch.

f) Terminals with a minimum of 10 % spare.

g) A drawing, fixed to the inside of the door, on robust material, indicating the connections within the box.

h) A minimum ingress protection of IP2X for any shafts or moving parts.

i) Earthing facilities

Internal earth bars shall be provided as described in OFS-SSS-402 and shall be equipotentiality bonded to internal metallic parts by copper conductors of at least 6 mm^2.

Overall earthing and bonding towards external metallic parts shall be provided by bonding to the tank structure.

j) External label on front door. Refer to drawings OFD-SSS-511for details.

k) Labelling of internal equipment, terminals, terminal blocks etc. as appropriate.

14.3 TERMINAL BLOCKS

All interface terminals for connection of cables shall be screw/screw type. All terminals must be individually numbered; each block of terminals must be identified. Each section of terminals must have end plates and end brackets and must have an identification label to identify the terminal block.

All terminals shall be in accordance with OFS-SSS-402. Current transformer terminals shall allow for shorting and isolation of current transformer circuits. Refer to OFS-SSS-402 for further details.

14.4 INTERNAL WIRING

The internal wiring shall conform to IEC 60227 and with OFS-SSS-402.

The units shall be delivered with all items of equipment fully wired.

All wiring shall be methodically arranged and shall follow an orderly and tidy pattern, grouped in a logical manner according to circuits involved, and shall be adequately supported and protected from mechanical damage. Wiring shall be arranged so that access to terminals or other apparatus is not impeded.

All connections to equipment and to terminals shall be tight and shall be made off with suitable crimp type connections. Wire looms shall be neat and shall not impede access to terminals of equipment. Connections to devices must not be under strain. Where wiring is connected to moveable equipment, such as equipment on hinged panels or doors, the conductor shall be multi-strand flexible. Wiring runs shall be so arranged as to minimise pick-up of interference or spurious transients. Not more than two wires shall be connected

to any one side of a terminal.

Internal wiring shall be connected to the equipment side of the terminal blocks except where looping is required on the external cable connection side of the terminal block to provide short-circuiting facilities for current transformer secondary circuits.

Detailed layouts of the marshalling cabinets shall be provided including all terminals, location of devices, size of trunking, etc.

Where current transformers are required, it shall be possible to bridge-out i.e. short-circuit the current transformer secondary circuits at each of the relevant file terminal blocks.

All conductors shall be stranded copper.

Conductor sizes and colours shall be in accordance with OFS-SSS-402.

14.5 CONTROL EQUIPMENT

The following control, instrumentation, and related items to provide a complete working system shall be provided:

a) A dial thermometer to indicate the temperature of the reactor top oil. This thermometer shall be fitted with:

- Four independently adjustable volt free contacts, one connected to give an alarm, one to trip the associated circuit breakers and two spares.

  Multiplication of contacts by use of auxiliary relays is unacceptable.
- Devices other than mercury switches are preferred as the latter are ‘level’ sensitive.
- A maximum temperature pointer, which shall be re-settable by hand from ground level.
- Mechanical protection shall be provided to protect the dial from accidental strike and damage.

The dial shall be mounted so that it may easily be read by a person standing at ground level through a window in the door of the control cabinet.

The dial thermometer shall be scaled to at least 120 °C.

b) A dial thermometer of the same manufacture and mounted in the same manner as (a), but which indicates winding hot spot temperature of the HV winding using a thermal image technique. It shall be fitted with:

- A test facility for the thermal image technique.
- A set of independently adjustable volt free contacts, one connected to give an alarm, one to trip associated circuit breakers and two spares. Multiplication of contacts by use of auxiliary relays is unacceptable.
- A maximum temperature pointer which shall be re-settable by hand from ground level.
- Mechanical protection shall be provided to protect the dial from accidental strike and damage.

The dial thermometer shall be scaled to at least 150 °C.

A corresponding, thermal imaging Current Transformer with a minimum burden and accuracy to complement item (a) above shall also be provided. The CT circuit shall include a shorting/ test link in the terminals.

c) A transducer for remote indication of winding temperature. These may be supplied as part of (b) or separately provided.

d) A minimum of 2 fibre optic temperature sensors per winding shall be provided for real-time winding temperature monitoring.

A test facility for the fibre optic temperature sensors shall be provided by means of an additional fibre optic probe for connection to test equipment.

e) Two adjustable thermostats in the main tank top oil shall be provided. These thermostats will be used to provide an additional trip and alarm facility. The setting range shall be from 70 °C to 120 °C. The trip and alarm contacts will be volt free. Multiplication of contacts by use of auxiliary relays is unacceptable.

f) All ancillary equipment must meet the service experience requirements of section 6. All thermometers shall be remote indicating type with external probes for measurement of the oil temperature. Direct mount type shall be avoided where possible due to the environmental conditions. Where temperature probes, thermostats and thermocouples are mounted on the top of the tank they shall be protected by an additional cover or shield designed and fitted by the reactor Customer to provide protection from rain, snow, and ultraviolet sunlight radiation.

14.6 AUXILIARY POWER SUPPLIES

The control and protection equipment shall be operated by the following auxiliary electrical power supplies.

a) 230 V -15% +10 % for small power requirements.

b) 220V DC (-15 % +10 %) for trip circuits.

c) 220V DC (-15 % +10 %) for alarm and signalling circuits.

All auxiliary supply circuits shall be protected by MCBs each of which shall be provided with a normally closed auxiliary contact to indicate MCB tripped/open.

All contacts shall be wired to terminals within the marshalling cabinet for connection with the station DC signal supply. All signals and alarms shall be dependant only on the relevant DC source voltage, i.e. contactors or auxiliary relays providing DC signals and alarms shall not be driven by an AC source.

14.7 PARTIAL DISCHARGE

The partial discharge levels for the reactor shall not exceed the values permitted by the relevant IEC Publications.

Evidence shall be submitted by the Customer showing that the equipment has passed the partial discharge test requirements of IEC 60076-3 for reactors and IEC 60137 for bushings.

Two additional valves of minimum size 50 mm BSP (DN 50 (minimum) or DN 80) shall be

provided in the same position as, but on the opposite tank wall to, the oil filtration connections. Valves shall be routed direct into the reactor tank without right angles or 'S' bends to allow the insertion of partial discharge sensors for triangulation of any internal discharge activity.

14.8 TANK AND ACCESSORIES

14.8.1 GENERAL

The tank shall be of welded steel plate with sufficient strength and rigidity to withstand application of full vacuum and all forces acting during transport, lifting / skidding as well as in service including pressures due to fault conditions. Its construction shall be such that air pockets do not form inside the tank. All welding shall conform with BS EN ISO 25817 to a quality level for weld imperfections of 'Stringent' level symbol 'B'. Tank construction and welds shall be NDT tested and relevant certificates must be produced.

The tank cover shall be bolted and welded and shall be designed to effectively shed water. The seal between the main tank and the cover shall be flat gasket type. 'O' Ring type gaskets requiring raised channels or raised flanges are not acceptable as they can draw in water by means of capillary action during the heating/cooling cycle. The design shall be such that it does not present a hazard to personnel working on top of the reactor, i.e. risk of falling shall be minimised.

All joints at manholes, handholes and bushing openings shall be bolted and shall be provided with suitable gaskets and flanges. It is preferred that for dismountable mechanical connections, the "O" ring type of flange seal shall be used. Gasket arrangements shall be designed to prevent over-compression of the gaskets and ingress of moisture between the flanges.

The accessories shall be vandal-proof as far as possible to protect against the possibility of a major oil spillage due to vandalism. Oil level indicators of the glass tube type shall not be used, inspection windows shall have easily removable metal covers to protect the glass, e.g., on Buchholz and gas pressure relays.

Anti-vibration mountings for the marshalling cabinet, dial thermometers, etc. shall be rated for continuous exposure to sun, rain, frost, snow, and oil.

The undercarriage shall be as follows:

- The main tank will be skidded into position and mounted on anti-vibration supports to reduce vibration transmission to the foundation. A skid base shall be provided to allow the reactor to slide along axis on to the foundation.
- Anti-vibration material and appropriate supports shall be included.

The reactor shall be such that it can be installed approximately 150 mm above the top of its foundation so that inspection/painting of the base is possible. The arrangement for location of the reactor on the foundation shall be included in the overall dimensioned drawing to be submitted with the design review to EirGrid and in the final dimensioned drawings.

Where wooden anti vibration or mounting materials (synthetic) are proposed, these are to be reviewed by EirGrid.

14.8.2 CONSERVATOR TANK

A conservator tank shall be provided on each reactor. The capacity shall be such as to accommodate the change in oil volume over the range of ambient temperatures specified under section 5.

It shall have an oil level gauge located in an IP65 rated marshalling cabinet. This oil level gauge shall be mechanically protected by a suitable metallic or polycarbonate shield. The gauge shall be graduated for temperatures of –10 °C, 0 °C, +15 °C and +30 °C. The conservator shall be fitted with a float switch with low oil level signal contact.

A fixed pipe shall be brought to ground level and terminated with a valve to enable topping up in the event of oil loss without the need to switch the reactor out of service.

Where the conservator tank is mounted on or fixed to the main tank the design of the required support structure and its fixing to the main tank shall be such that the main tank will not be adversely affected by any additional mechanical loading or stress produced by the oil filled conservator tank and support structure under worst case outdoor environmental conditions as specified in OFS-SSS-400 “Onshore Compensation Compound General Requirements”. Design calculations shall be provided to prove the support structure design is adequate.

14.8.3 BREATHERS

The conservator shall be fitted with a maintenance free powered gel regeneration breather. Any proposed gels shall be EU REACH compliant. Desiccant type breathers are not acceptable. The breathers shall be located so that visual inspection can be performed at ground level. No valve shall be fitted between a breather and its tank compartment.

The maintenance free regeneration breathers shall be provided with suitable control equipment housed in an IP64 compartment if separate to the reactor marshalling cabinet. This compartment shall be located so that it is accessible from ground level. Voltage free contacts shall be provided for remote signalling of a fault or failure of the device. Multiplication of contacts by use of auxiliary relays is unacceptable.

Breathers shall be fitted with mechanical protection to prevent damage from accidental strike.

14.8.4 OIL FILTRATION

The reactor shall be designed and equipped for vacuum filling and oil treatment on site. It shall be fitted with outlets and gate valves for the connection of oil and vacuum connections of an oil conditioning unit.

A minimum of two 50 mm connections shall be provided on the main tank for the purposes of oil filtration. One connection will be positioned near a bottom corner on a longer side of the tank and the other near the top corner diagonally opposite. Each of the valves/connections shall have a 50 mm BSP female threaded connector to interface with the male connector from the oil conditioning plant and shall be fitted with a male plug. Flanged valves may be supplied provided they have cover plates fitted with a suitable 50 mm BSP female threaded boss and plug.

Two additional valves of minimum size 50 mm BSP (DN 50 (minimum) or DN 80) shall be

provided in the same position as, but on the opposite tank wall to, the oil filtration connections. Valves shall be routed direct into the reactor tank without right angles or 'S' bends to allow the insertion of partial discharge sensors for triangulation of any internal discharge activity.

One 100 mm connection shall be brought from the top of the conservator tank for connection to the vacuum equipment. Its valve shall have a NW 100 flange to interface with the connector from the oil connecting plant and shall be fitted with a cover plate.

Care shall be taken when positioning the oil conditioning points to ensure a good flow of all the oil through the reactor, e.g., in the case of the main tank, one point shall be located high on the tank at one end and the other low down on the tank at the diagonally opposite end. The connection for the vacuum control switch shall be such as to facilitate efficient drawing of a vacuum, e.g., to the highest point of the conservator accessible from the ground.

The arrangement of the oil conditioning connections and the interface details shall be submitted to EirGrid for review.

14.8.5 VACUUM WITHSTAND

The main tank, conservator, radiators, and cable boxes shall all be capable of withstanding as close to full vacuum as is achievable, e.g., down to 1 kPa or better.

It is anticipated that the vacuum withstand capability of the assembled reactor shall be proven as part of the evacuation procedure during first filling of the reactor with oil. Before admitting oil into the tank, the rate of pressure rise over a short period shall be measured and the reactor leak rate (Litres/s) shall be estimated.

14.8.6 PRESSURE RELIEF DEVICE

A pressure relief device which is set to open on excess pressure and to reseal automatically without damage or endangering personnel, shall be fitted to the main tank. The exact pressure at which the pressure relief device is set to operate will be stated by the manufacture. The pressure relief device will be fitted with volt free signal and trip contacts. Multiplication of contacts by use of auxiliary relays is unacceptable.

A blow-out of oil shall be directed safely away from the reactor by means of a pipe downwards into the bund. However, any ejected oil must remain within the oil tight reactor bund in which the reactor will be installed. Details of the reactor bund and containment shall be finalised during the design review.

Where a testing facility is included in the pressure relief device access to the testing device shall be possible without dismantling surrounding equipment.

14.8.7 OIL SAMPLING DEVICES

Oil sampling devices shall be fitted for taking oil samples from the top and bottom of the tank.

Sampling points shall be accessible to a person standing at ground level.

14.8.8 OIL VALVES

All oil valves shall be provided with means of securing them in the open and closed positions with padlocks. They shall clearly indicate whether they are in their open or closed positions and shall be fitted with appropriate blanking plates.

The type of valves being used shall be listed in the Technical Schedule, except on radiators where butterfly valves shall be used.

All oil valves (other than radiator butterfly valves) shall be made of brass.

14.8.9 GAS-IN OIL MONITOR

The reactor shall be supplied with an on-line continuous gas-in oil incipient fault monitor e.g., Kelvatek/ Camlin TOTUS types or similar.

The monitor shall be capable of carrying out the following functions:

- oil sampling
- Dissolved Gas Analysis (DGA) of all eight IEEE/IEC gases
- Diagnostics/Interpretation of insulating oil gas content. Preferably Doernenburg or Rogers Ratio method
- Diagnostics/Interpretation of paper insulation ageing and lifetime.
- Indication of oil moisture content

An inlet and outlet flange shall be provided on the reactor to provide an oil circuit to the gas monitor unit. These valves shall be located at points of good convective oil flow, remote from the tap changer and easily accessible.

The final location shall be reviewed by EirGrid prior to order.

The flange bringing oil to the DGA unit is typically located around two thirds above the base of the reactor and the flange returning oil to the reactor is typically located around one third above the base of the reactor. These valves shall be at least 0.5 m apart.

A brass 38 mm gate valve or similar standard valve shall be provided for isolating purposes between the tank and the monitor.

Remote access for monitoring and controls shall be compatible with the SCADA, see OFS-GEN-015 specification for further details.

The Gas-In Oil Monitoring shall be integrated with the Condition Monitoring System (CMS)

Setup and commissioning of the monitor on site shall be performed by the Manufacturer of the gas in oil monitor, as part of the on-site assembly service.

14.8.10 OIL PIPING

Non-metallic pipes for oil are not acceptable.

14.8.11 THERMOSTAT POCKETS

In addition to the thermometers specified in section 14.5, two spare thermostat pockets for measuring top oil temperature shall be provided.

14.8.12 LIFTING LUGS

Lifting lugs shall be provided for supporting the core and windings and for supporting the complete reactor. The lifting lugs shall be capable of supporting the reactor when filled with oil, including safety factors to consider lifting dynamics.

14.8.13 PADLOCKING

Provision for padlocking shall be provided and a hole, approximately 7 mm diameter, shall be available for accepting padlocks with a shackle diameter of 30 mm, shackle length of 23 mm and 6.3 mm diameter cross-section.

14.8.14 JACKING PADS

Four jacking pads shall be provided near the corners of the reactor and approximately 500 mm above the lowest part of the tank. These pads shall be designed to take the complete weight of the reactor filled with oil.

14.8.15 HAULING EYES

Hauling eyes shall be provided on all sides of the reactor.

14.8.16 EARTHING

Earthing facilities shall be provided to meet the earthing requirements as given in OFS-SSS-407.

Typical arrangements for earthing of transformer tanks are illustrated in OFD-SSS-513 “General Arrangement Earthing Practice” and this should be used for shunt reactor tanks.

Earthing terminals shall be provided close to each corner of the tank to facilitate earthing of the reactor using copper lugs each having 14 mm holes for fixing bolts.

Earthing straps shall be provided from the main reactor tank to all simultaneously accessible metallic parts including the tank cover, and across all flanged joints to ensure that all metallic parts are at equipotential[3].

14.8.17 CORE EARTHING

The reactor shall be fitted with a covered box with IP65 environmental protection level, containing appropriately rated bushings to permit earthing of the core by a connection which is removable for testing. The core earthing bushing shall be rated for a minimum of 5 kV.

14.8.18 INSPECTION PLATES

An inspection plate, at least 600 x 750 mm, shall be located in the tank roof to permit the removal of paper insulation samples from HV and LV leads. Inspection plate gaskets should not be glued in place.

14.8.19 GUARD RAIL / FALL ARREST SYSTEM

To facilitate assembly, commissioning, inspection and periodic maintenance testing, persons shall be required to access the tank cover and all devices located on the top of the reactor throughout its service lifetime. A ladder with a fall prevention cage shall be fitted to

[3] These additional copper bonds are not shown in OFD-SSS-513.

the side of the reactor as a permanent fixture to facilitate this. The ladder steps shall be designed and constructed with non-slip material on each rung. This ladder shall be lockable with a steel cover to prevent access to the top of the reactor during service. Where the ladder approaches the level of the cover a handrail shall protrude upwards a minimum of 1 metre beyond the level of the tank cover. Where electrical clearances permit, a fall protective gate shall be put in place at point of ascent/descent (of similar quality/safety to that of barrier system). The fall protective gate shall have a self-closing mechanism in place and clearly identified by yellow colour.

On the top cover of the transformer the Customer shall provide a barrier or guard rail system with permanent fixing brackets or sockets to erect the rail around the edge of the cover when required. The barrier shall be certified to minimum of Class A fall prevention standard per EN 13374. The guard rail shall be at least 950 mm high with an intermediate guard rail at approximately 470 mm high. A toe board of approximately 150 mm height shall also be part of the barrier/guard rail system to prevent tools or materials falling from the edge. The guard rail shall ensure that no gaps of greater 250 mm are present around the perimeter of the main tank cover when it is erected. The permanent fixing brackets or sockets shall be designed, and load tested with appropriate test certification to EN 13374. The barrier or rail shall not impede access to the top bushing for test purposes or to the lower capacitive tap test point which requires accessed for conditional assessment tests.

Safe assembly of the barrier system shall be ensured by provision of anchor points to connect 150 kg capacity fall arrest lanyards. An anchor post shall be provided within 1 m distance of the ladder/handrail point on the top cover. This may be a permanent fixture, if electrical clearances permit, otherwise a baseplate shall be provided for the installation of a portable anchor post.

This shall be a DURAHOIST™ TOTEM anchorage post or similar as proposed by the Customer. Additional anchor posts shall be provided on the top cover at suitable locations to allow personnel to install each anchor post while still attached to the previous post via a fall arrest lanyard. All permanent anchor points shall be certified to an EN standard and clearly identifiable.

Personnel shall be able to safely assemble the barrier at all edges while anchored to a post located at a distance suitable for the lanyard length. The Customer shall demonstrate by provision of a dimensioned drawing the location of all proposed anchor posts and locations that can be safely accessed while anchored to each post. The Customer shall advise the recommended length of the fall arrest or fall restraint lanyard to be used and this shall be incorporated in the design and submitted to EirGrid for review. A single length lanyard shall be used for the complete reactor therefore no point requiring to be accessed shall be located beyond the reach of an anchor post with the single length lanyard proposed. The Customer shall ensure the system provided also includes all associated necessary specific attachments and articles/materials in which to correctly use the system, for example runner connectors, latching pins or applicable karabiners.

Alternative working at height safety systems such as a permanent perimeter system, ‘Latchway’, or horizontal safety lifeline mounted on the cover of the reactor may be proposed as an alternative by the Customer. These shall ideally be positioned above or level with the user. In the event of such system being proposed the Customer shall

demonstrate, by provision of a suitable dimensioned drawing, that it is possible to reach all edges of the cover to assemble the barrier without detaching the fall arrest lanyard. Oil pipework, cable trays and other obstacles shall be appropriately positioned to avoid conflict with the lanyard attached to the safety lifeline when personnel are moving along the top of the reactor.

A risk assessment and safe working procedure for the use of the working at height system and barriers shall be provided by the Customer in their submission and demonstrated through the provision of the dimensioned drawing outlined above. This will be reviewed by EirGrid.

Were other associated equipment, plant/machinery/articles etc. is required to facilitate the safe installation of the temporary systems this shall be clearly identified in the risk assessments and safe system of work (work procedures). The Customer shall also outline the inspection/testing requirements and frequency for the barriers/guardrail, anchors, fall arrest equipment and all other components of the system.

14.9 PROTECTION

14.9.1 BUCHHOLZ RELAY

A double float and vane Buchholz relay shall be provided in the pipe connection from the main tank to the oil conservator tank. This relay shall be such that a slow release of gas closes an alarm circuit while a sudden pressure rise results in the operation of an alarm and trip circuit. It shall be fitted with a minimum of two trip and one alarm volt free contacts. Multiplication of contacts by use of auxiliary relays is unacceptable.

A gate-valve shall be fitted in the pipe between the conservator tank and the Buchholz relay associated with the main tank. Design shall ensure that when the gate-valve is in the closed position, expansion of oil due to heating does not create a risk of over-pressure which may weaken or damage the main tank.

The Buchholz relay shall be stable in operation so that it does not operate for faults external to the reactor.

14.9.2 GAS SAMPLING DEVICE

The gas release connection from the Buchholz relay shall be brought down to a gas sampling device which shall be accessible to a person standing at ground level. The sampling device shall be labelled "Test".

A test connection from the Buchholz relay shall be brought to the gas sampling device, if suitable, or may be terminated beside it.

The gas sampling device shall have the following facilities:

a) Gas connection from the Buchholz relay through an isolating valve on the gas sampling device.

b) Coupling in the pipe connections to enable the device to be removed from the reactor.

c) Gas sampling valve at the top, with outlet approximately 3 mm diameter to make rubber tube connection. The outlet shall have a captive screwed cap.

d) Oil drain valve at the bottom with blanking plug.

e) The oil level in the device shall be visible from the front.

f) Isolating valves in both the gas sampling and test connections. These valves shall be accessible to a person standing at ground level.

14.9.3 CURRENT TRANSFORMERS

The CT shall comply with OFS-SSS-424.

The CT ratio will be calculated by the customer. The CT secondary circuits shall be wired to the Marshalling Cabinet.

Location, type and characteristics of the CTs shall be determined based project specific requirements. Current transformers can be installed in the turrets of the bushings on the reactor.

Refer to OFS-GEN-016 specification for Protection, Control, Metering requirements of EirGrid.

14.10 TERMINALS

14.10.1 TYPE

Each phase on the HV side shall be brought out from its winding to either

a) An external bushing for AIS conductor connection, or

b) A single-phase cable end box for cable connection.

Each phase on the LV side shall be terminated through external bushings to allow for star connection of the three LV phases externally and connection to earth on site.

14.10.2 OUTDOOR BUSHINGS

The bushings shall be Resin Impregnated Paper (RIP) or Resin Impregnated Synthetic (RIS) condenser type bushings with silicone rubber external insulation. They shall comply in general with IEC Publication 60137.

Each bushing shall be fitted with a test tap for the measurement of the capacitance (C_1 and C_2) and Tan Delta of the bushing. The insulation quality shall be such that the % Tan Delta of the tap does not exceed 0.5 %.

The minimum value of cantilever withstand load for 220 kV and 400 kV bushings shall be 2.5 kN regardless of current rating as per EN 60137 – heavy load level II

The minimum design clearances in air shall be as stated in section 13

Lower minimum external clearances in air will be accepted for the bushings if, as part of the reactor assembly, they successfully pass the tests which prove the insulation withstand requirements of the reactor. However, the bushings shall be arranged to facilitate conductor connections complying with the above clearances.

The Reference Unified Specific Creepage Distance (RUSCD) for the phase to earth insulators shall be 53.7 mm/kV_{L-L}. in accordance with EN 62271-1 and EN TS 60815 requirements for very heavy pollution level.

The RUSCD shall be corrected for insulator diameter using the method given in IEC TS 60815-3.

The Customer shall also state the profile factors (as defined in IEC TS 60815-3) for the proposed insulator design in the Technical Schedules.

The terminals, which shall comply with IEC TR 62271-301, shall be of flat aluminium with hole/holes 14 mm diameter at 50 mm centres. Stud type terminals may be accepted. The size of terminal shall be sufficient for the current rating.

The bushings shall be identified in accordance with IEC TR 60616 as follows:

An observer facing the HV side of the reactor shall read, from left to right

HV Bushings	1U	1V	1W
LV Bushings	1N(u)	1N(v)	1N(w)

Terminal markings shall be clearly and permanently shown on the cover plate and on the side walls of the main tank below each bushing location. They shall be visible from ground level.

14.10.3 CABLE BOXES

If applicable, a drawing of each box shall be provided by the Customer to define the interface and describe the division of responsibility between the suppliers of reactor and cable, i.e., for supply of fixings, gaskets, etc.

The housing shall be arranged for vertical entry of the cables from the bottom. The height of the take-off position above ground level should be at least 3 m so as to permit convenient connection / disconnection of cables.

The assignment of responsibilities in the area of reactor / cable interface shall be generally in accordance with IEC 62271-209. If a corona shield is required, then it is in the reactor Manufacturer's supply.

14.11 REACTOR OIL

The insulating oil shall be new, unused mineral oil and free from potentially corrosive sulphur in accordance with IEC 62535.

The Customer shall advise if reactors are to be transported to site without oil or with just the active part covered in oil. If the reactor is to be transported without oil the manufacturer shall advise on precautions to be taken to protect the active part against humidity and advise on the maximum permissible period that the reactor may be left without oil covering the active part.

The Customer shall ensure that at all stages in the manufacture, test, and installation of the reactor the reactor and insulating oil shall be free of all contaminants including cross-contamination by other insulating fluids.

The oil in all reactors shall be tested and certified 'no detectable Silicon'.

14.12 MARKINGS

14.12.1 GENERAL

All signs, labels, rating plates, information plates, diagram plates and instructions shall be clear, indelible, corrosion proof, in English and clearly visible to a person standing at ground level.

Rating and information plates shall be made from grade A4 stainless steel as per ISO 3506-1 (AISI 316).

Labels and safety signs shall be provided in accordance with OFD-SSS-511 drawing for Standard Signage".

The CE Mark shall be included in accordance with directive 93/465/EEC where appropriate[4].

The Customer shall submit drawings of all labels and plates for EirGrid review. The exact position of all plates will be agreed during the design review.

14.12.2 RATING PLATE

A rating plate in accordance with IEC 60076 shall be securely attached to each reactor. This shall include the additional information in Clause 7.7 of IEC 60076-6.

This plate, or another of similar construction, shall also include the following information:

- Connection diagram of all instrument transformers
- For all current transformers installed inside the reactor, the location, ratio(s), accuracy class and rated output (VA rating) of the current transformer.

14.12.3 LOCATION OF OIL VALVES AND AIR RELEASE COCKS

A plate showing the locations and normal positions of all oil valves and air release cocks or plugs shall be provided. This plate shall incorporate a warning to operators to refer to the Maintenance Instructions before applying vacuum treatment to the tank.

14.12.4 GAS POINTS

Labels shall be attached to all gas release, gas sampling and Buchholz test points stating the name of the associated oil compartment.

14.12.5 DIRECTION OF ROTATION

The direction of rotation of operating handles, valves etc. shall be clearly marked in red arrows and text on or beside each item.

14.12.6 CONTROL AND AUXILIARY EQUIPMENT

All control and auxiliary equipment in the marshalling cabinet shall be clearly labelled.

[4] see also section 4.1 .

14.12.7 BUSHINGS

The name-plate shall, in addition to the information required by IEC 60137, include the measured values of capacitance (C1 and C2) and dielectric dissipation factor between high voltage terminal and test tap and between test tap and earth, stating the test voltage applied.

15 AIR CORED REACTORS

15.1 GENERAL

Air core reactors shall be mounted on support insulators. Each phase of the reactor will be separately supported. The complete 3 phase air core reactor and auxiliary MV equipment shall be enclosed by a suitable fencing arrangement in order to prevent accidental contact or breach of safety clearances. No gates should be installed along the fence and to get access to the reactor compound a section of the fence shall be removed by means of removing bolts and fencing panels. Minimum distance of Reactors and auxiliary MV equipment from the compound fencing shall be calculated and assessed by the Designer and Reactor manufacturer.

Air core reactors shall be naturally cooled (AN).

The Customer shall advise all necessary safety and construction measures to eliminate the effect of induced currents causing voltage potential rise in adjacent structures, reactor compound earth grid and steelwork and any other precautions required regarding installation of the reactor.

The minimum design clearances in air shall be as stated in section 13.

15.2 INSULATORS

Air core reactors shall be supplied with suitable support insulators to meet minimum clearances as detailed above. The insulators shall be composite type support insulators.

The Reference Unified Specific Creepage Distance (RUSCD) for the phase to earth insulators shall be 53.7 mm/kV_{L-L}. in accordance with EN 62271-1 and EN TS 60815 requirements for very heavy pollution level.

The RUSCD shall be corrected for insulator diameter using the method given in IEC TS 60815-3.

The Manufacturer shall also state the profile factors (as defined in IEC TS 60815-3) for the proposed insulator design in the Technical Schedules.

The rated static and dynamic terminal loads for these insulators shall be such that they will support the reactor for the lifetime of the reactor under the service conditions outlined in OFS-SSS-400 “Onshore Compensation Compound General Requirements”.

15.3 TERMINALS

The terminals, which shall comply with IEC TR 62271-301, shall be of flat aluminium with hole/holes 14 mm diameter at 50 mm centres. The size of terminal shall be sufficient for the current rating at the voltage involved.

Typical static and dynamic terminal loads are below, but the customer needs to verify with

calculation that they will withstand the applicable forces

- Static cantilever load 4 kN
- Dynamic load 5.6 kN

15.4 MAGNETIC FIELD

The Customer shall supply drawings/documents with a plot indicating the magnetic field strength in the vicinity of the reactors and in the surrounding area of the reactor compound.

The Customer shall supply guidance concerning the magnetic clearance around the reactors. The maximum magnetic field strength should be in accordance with the latest version of the ICNIRP guidelines.

15.5 LIFTING EYES / SLING POINTS

Each phase reactor module will be provided with suitable and clearly marked lifting eyes or slinging points to allow for craning in storage and during assembly.

15.6 EARTHING

Earthing facilities shall be provided to meet the earthing requirements as given in OFS-SSS-407.

Metallic structures at ground level, such as insulator bases, shall be provided with an earth stud of minimum size M14.

Special consideration is required when designing the earthing of reactors due to induced voltages and circulating currents.

15.7 MARKINGS

15.7.1 GENERAL

All signs, labels, rating plates, information plates, diagram plates and instructions shall be clear, indelible, corrosion proof, in English and clearly visible to a person standing at ground level.

Rating and information plates shall be made from grade A4 stainless steel as per ISO 3506-1 (AISI 316).

Labels and safety signs shall be provided in accordance with XDN-LAB-STND-001 “Station Design Standard 110/ 220/ 400 kV Station Signage”

The Customer shall submit drawings of all labels and plates for EirGrid review. The exact position of all plates will be agreed during the design review.

15.7.2 RATING PLATE

A rating plate in accordance with IEC 60076 shall be fitted. This shall include the additional information in Clause 7.7 of IEC 60076-6.

This plate, or another of similar construction, shall also include the following information:

- Connection diagram of all instrument transformers
- For all current transformers installed inside the reactor, the location, ratio(s),

accuracy class and rated output (VA rating) of the current transformer.

An additional set of rating plates for all equipment installed withing the compound should be fixed on the reactor compound fence in proximity of the reactor kiosk

16 Painting And Corrosion Protection

Corrosion of both ferrous metals, aluminium and aluminium alloys is a particular problem in Ireland.

Experience has shown that because of high humidity, extreme precautions are necessary, to prevent the aggressive ingress of moisture between flange plates, around gaskets and O-rings, at insulator/flange interfaces, etc. All necessary precautions shall be taken to prevent this. Tactile 506 type grease or equivalent should be used if required. This level of attention shall also be paid to all devices bought from sub-suppliers.

The Customer shall clearly state the corrosion protection applied to all aluminium or aluminium alloy parts. This corrosion protection shall be suitable for the site environmental conditions.

Any aluminium or aluminium alloy exposed to the environmental conditions shall be of a suitable grade for the environment. The Customer shall ensure that all exposed points in their equipment at which aluminium or aluminium-alloy parts are in contact with or in close proximity to other metals are protected to exclude air and moisture.

The Customer shall confirm that all paint systems employed for corrosion protection of steel parts meet or exceed the requirements of ISO 12944-5 (Corrosion Protection of Steel Structures), to provide high durability (minimum of 15 years) coating with category C5-M corrosion protection, suited to environments with high condensation, pollution, and salinity as per ISO 12944-2.

Minimum requirements for the painting and corrosion protection systems for Hot Dip Galvanised Steel are as follows:

- Hot dip galvanising of steel shall be fully compliant with the requirements of EirGrid's specification OFS-SSS-420 Hot-dip galvanising of iron and steel articles other than wire".
- Paint system for hot-dip-galvanised steel surfaces shall meet or exceed the requirements of Paint System A7.13 of ISO 12944-5, to provide high durability (minimum of 15 years) coating with category C5-M corrosion protection, suited to environments with high condensation, pollution, and salinity as per ISO 12944-2.

The process for painting hot-dip galvanised steel is detailed below:

Table 4 - Table Process for Painting Hot-Dip Galvanised Steel

PROCESS	MATERIALS	MINIMUM REQUIREMENTS
Clean	Appropriate solvents or other cleaning agents	A grease / oil free substrate
Sweep blast	Aluminium oxide or another inert abrasive medium	A light texture on the zinc layer with no more than 3 % of the zinc removed by the process

PROCESS	MATERIALS	MINIMUM REQUIREMENTS
Priming	As per Paint System A7.13 of ISO 12944-5	As per Paint System A7.13 of ISO 12944-5
Undercoating	As per Paint System A7.13 of ISO 12944-5	As per Paint System A7.13 of ISO 12944-5
Finish coating	As per Paint System A7.13 of ISO 12944-5	As per Paint System A7.13 of ISO 12944-5

The minimum requirements acceptable to EirGrid for individual items are as follows:

a) Hot-Rolled Steel, Mechanism Boxes, Marshalling Cabinets, Fasteners larger than 12 mm Diameter and pipes:

   i. Hot dip galvanising, in accordance with EirGrid Specification; and

   ii. Painting system as per painting and corrosion protection for Hot Dip Galvanised Steel stated above.

b) Smaller Fasteners, Cable Clips and any nonferrous material or stainless steel of suitable grade for the environmental conditions stated in EirGrid OFS-SSS-400 Onshore Compensation Compound General Requirements specification.

c) As a minimum all exposed non-stainless ferrous parts, including supporting steel work for Reactors, kiosks, nuts, and bolts, shall be hot-dip-galvanised to comply with EirGrid specification, OFS-SSS-420.

Corrosion of both ferrous metals and of aluminium and aluminium alloys is a particular problem in Ireland.

Experience has proven that extreme precautions are necessary (because of the high humidity) to prevent the aggressive ingress of moisture between flange plates, around gaskets and O-rings and at insulator/flange interfaces. For oil Reactors flat gasket seals are required on the tank lid and other large oil/air interfaces to prevent water ingress through capillary action.

16.1 MINIMUM REQUIREMENTS

The following are the minimum requirements of the painting and corrosion protection systems for Hot Dip Galvanised Steel and for Thermally Sprayed Zinc Coated Steel:

16.1.1 HOT DIP GALVANISED STEEL

Hot dip galvanising of steel shall be fully compliant with the requirements of OFS-SSS-420.

16.1.2 THERMALLY SPRAYED ZINC COATED STEEL

The minimum thickness of the zinc coat shall be 150 µm.

The paint system for thermally sprayed metal surfaces shall meet or exceed the requirements of Paint System A8.02 of ISO 12944-5 (Corrosion Protection of Steel Structures), to provide high durability (above 15 years) coating with category C5-VH corrosion protection, suited to environments with high condensation, pollution, and salinity as per ISO 12944-2.

The process for thermally sprayed zinc coating and application of the required painting system shall be as detailed below:

Table 5 - Painting process for zinc coated steel

PROCESS	MATERIALS	MINIMUM REQUIREMENTS
Metal spraying to EN 22063	Zinc	150 µm
Sealer coating	As per Paint System A8.02 of ISO 12944-5	As per Paint System A8.02 of ISO 12944-5
Undercoating	As per Paint System A8.02 of ISO 12944-5	As per Paint System ISO 12944-5
Finish coating	As per Paint System A8.02 of ISO 12944-5	As per Paint System A8.02 of ISO 12944-5

The minimum requirements acceptable to EirGrid for individual items shall be as follows:

a) Hot-Rolled Steel:

   i. Grit blasting to SIS 05 59 00 or to BS 7079 to achieve a second quality 50-micron finish.

   ii. As per 'Thermally Sprayed Zinc Coated Steel'.

b) Conservator Tank:

   i. Hot-dip galvanising, in accordance with OFS-SSS-420.

   ii. As per 'Hot Dip Galvanised Steel'

c) Radiators, Mechanism Boxes, Marshalling Cabinets, Fasteners larger than 1 2mm Diameter and pipes:

   i. Hot-dip galvanising, in accordance with OFS-SSS-420.

   ii. As per 'Hot Dip Galvanised Steel'

d) Smaller Fasteners, Cable Clips:

   Non-ferrous materials or stainless steel to be used otherwise use of appropriately plated components to be used.

e) Inside of Tank:

   Painting of the inside of the tank, oil pipes etc., with an oil resisting coating.

f) Roof/Cover of Tank:

   In addition to the requirements of point (a) above the roof/cover of the tank shall be painted with non-slip paint, i.e., apply nonslip aggregate to an application of undercoat.

g) Nuts and Bolts:

   All nuts, bolts and washers shall be stainless steel with grade A4 as per ISO 3506-1 (AISI 316) or better. Where they are in contact with aluminium, they shall be galvanised type and shall have grease applied to help prevent galvanic corrosion. All nuts, bolts and/or washers shall all be manufactured in one factory.

All external surfaces shall be primed and finished in grey colour RAL 7033.

All necessary precautions shall be taken to prevent the aggressive ingress of moisture

between flange plates, around gaskets and O-rings, at insulator/flange interfaces, etc. Tactile 506 type grease or equivalent shall be used if required. This shall apply to all devices provided by sub-suppliers e.g., thermostats, Buchholz relay.

The Customer shall protect all exposed points in their equipment at which aluminium or aluminium-alloy parts are in contact with or in close proximity to other metals and shall ensure that air and moisture are excluded from such situations.

If there are aluminium or aluminium alloy parts used such parts shall be anodised with painted or equivalent finish.

16.2 TESTING OF THE PAINTING AND CORROSION PROTECTION SYSTEM

The painting and corrosion protection system shall be type tested as per ISO 12944-6.

In addition, the following type and routine tests shall be carried out where they are not covered by ISO 12944-6:

a) The required tests of appearance on the painting and corrosion protection system for hot dip galvanised steel and thermally sprayed zinc coated steel are detailed below and shall be carried out as part of type and routine tests:

Table 6 - Tests of Painting and Corrosion Protection System Appearance

TEST METHOD	GLOSS	COLOUR	GENERAL APPEARANCE
ISO 2813	80 $^{+/-}$ 10 Units @ 60 ^{o}		
ISO 7724		∆E CIELAB of not more than 1.5 under D65 light source from the master chip agreed with EirGrid.	
Viewed in clear north light with the unaided eye at a distance of 2m.			The coating shall be of smooth uniform appearance, with no inclusions, voids, or other blemishes, which mar the surface.

The required type and routine tests of performance characteristics on the painting and corrosion protection system for hot dip galvanised steel and thermally sprayed zinc coated steel are detailed below:

Table 7 - Painting and Corrosion Type Tests and Routine Tests

TYPE TESTS				
TEST	**METHOD**	**REQUIREMENTS**		
480 HOUR SALT SPRAY	ISO 9227	MAXIMUM ADHESION LOSS AT SCRIBE	BLISTERING REMOTE FROM SCRIBE	OTHER DEFECTS
		2 mm	None	None
480 HOUR HUMIDITY	ASTM D 2247	BLISTERING	COLOUR CHANGE	OTHER DEFECTS

TYPE TESTS				
TEST	**METHOD**	**REQUIREMENTS**		
		None	None	None
SOLVENT RESISTANCE RUB TEST	ASTM D 4752	CORROSION	BLISTERING	OTHER DEFECTS
		None	None	None
1,000 HOURS UVA ARTIFICIAL WEATHERING	ISO 4892-3	MAXIMUM COLOUR CHANGE	MAXIMUM LOSS OF GLOSS @ 60 ^{0}	OTHER DEFECTS.
		ΔE = < 2.6	< 25 %	None
ROUTINE TESTS				
TEST	**METHOD**	**REQUIREMENTS**		
Initial adhesion. Cross Hatch Test	ISO 2409 ASTM D 3359	MINIMUM RATING		
		0		
Hardness Test	ASTM D 3363	MINIMUM RATING		
		0		
DIRECT IMPACT	ASTM D 2794	FAILURE AT 56 INCH / LB		
		None		

These test pieces shall have minimum dimensions 100 mm x 100 mm.

16.2.1 ADDITIONAL SILICONE COATING

Experience has shown that a number of air core reactors have failed due to breakdown of the external coatings or the paint system on the reactor windings. Therefore, an additional coating of silicone is to be applied on the external surface of air core reactors to limit dirt and grit sticking to the surfaces and prevent paint system deterioration due to UV light.

17 TESTS

17.1 GENERAL

Tests shall be carried out in accordance with the appropriate IEC publications and OEM recommendations, unless stated otherwise. Customer shall submit ITPs (inspection and test plans) and testing / commissioning procedures to EirGrid for review.

Type tests shall be performed on one of each type to be delivered. Type tests are not required if the Customer provides type test reports for the specific equipment, provided the type tests are fully applicable to the specific equipment.

All equipment must be subjected to and pass the specified type tests at an accredited testing laboratory in accordance with the relevant IEC Publication, and the test certificates or reports obtained shall be submitted to EirGrid for review.

As EirGrid may wish to witness type, routine, and special tests, or visit the factory during the manufacture of the Reactor.

All functional testing shall be executed and recorded on the Plant and Materials installed during the commissioning, under normal and possible fault conditions.

Type and routine test results shall be furnished for bushings, Buchholz relays and other ancillary equipment. EirGrid may require that some of these tests be repeated if they do not meet the requirements of this specification and relevant national and international standards.

17.2 REACTOR TESTING

Inspection and test requirements consist of testing at works (type and routine tests), factory acceptance tests (FAT) for main components and sub-systems, commissioning tests, performance verification and acceptance tests, as well as extended performance acceptance tests. The Customer shall develop and submit the Test Plans to EirGrid for review and comments, the FAT report following successful completion of the FAT and all test reports following completions of all commissioning tests, in accordance with the requirements of this specification.

The Customer shall provide the following for EirGrid Review:

1. A Master Test Plan
2. Specific Test Plans (FAT, type, routine),
3. Site Acceptance Test Plan,
4. Commissioning Test Plan and Procedures,
5. Performance Verification and Acceptance Test Plan

17.3 TESTING RESPONSIBILITIES

The Customer shall perform all testing including the performance verification and acceptance tests. All tests that require connection of the Reactor to EirGrid's system may be witnessed by EirGrid. Energised system testing shall be kept to a minimum.

The Customer shall provide commissioning and specific Shunt Reactor energisation

procedures as part of the Commissioning Test Plan to EirGrid for review.

The Customer shall provide all necessary labour and test equipment / material to perform all tests and inspections that are the Customer's responsibility.

17.4 INSPECTION AND TEST PLAN (ITP)

The Inspection and Test Plan shall be in accordance with OEM recommendations, these EirGrid's Requirements and shall cover all aspects of testing and inspections. The preliminary and detailed ITP shall be submitted to EirGrid and shall include a schedule of all pre-commissioning and commissioning tests. All plant and material forming part of the Shunt Reactor system shall be included in the ITP.

Test procedures shall be developed and submitted to EirGrid for review.

The Customer shall provide Declaration of Fitness for the Shunt Reactor that have been commissioned.

17.5 GENERAL TEST REQUIREMENTS

All equipment must be subjected to and pass the specified routine tests in the factory of manufacture before delivered to site.

All equipment must be subjected to and pass the specified type tests at an accredited testing station in accordance with the relevant IEC Publication, and the test certificates or reports obtained shall be submitted for review. Separate type tests may not be required on items of equipment that are of the same design, insulation class and comparable rating. Existing type test reports may be accepted if the equipment tested was identical to the equipment offered, the equipment is to be under the same or less stresses than the equipment already tested, and the relevant equipment standards have not changed. A comprehensive report describing the past tests and how they can be applied to the new equipment shall be provided.

17.6 TYPE TESTS

General requirements for type tests are specified in OFS-SSS-400 "Onshore Compensation Compound General Requirements".

All the type tests prescribed in the relevant IEC Publication shall have been made on Shunt Reactor components. These tests shall have been carried out at a recognised testing stations (including by manufacturers).

All reactors offered shall have been fully type-tested in accordance with the tests listed in the relevant IEC Publications and the results shall demonstrate, in relevant respects, the capability to meet the requirements of this specification.

Certificates/Reports containing full details of type tests shall be issued to EirGrid for review.

Full details of any modifications (no matter how minor) which have been made to the Shunt Reactor since the full set of type test was carried out shall be submitted together with the reports on the tests which were carried out to prove the modification.

EirGrid reserve the right to request further testing to be carried out. All proposals are subject to this condition. Such testing may be witnessed by EirGrid.

The equipment available for type tests shall be identical in all respects to that to be supplied to EirGrid.

In the event of a type test failure, EirGrid will not be charged for any additional type tests.

The following shall be regarded as type tests:

a) Temperature rise test. The test shall be made in accordance with IEC 60076-2 for oil type reactors and IEC 60076-11 for dry type reactors

b) Measurement of vibration for liquid immersed reactors

c) Measurement of acoustic sound level

d) Dielectric tests as per IEC 60076 standard

e) Verification of IP rating capability on all enclosures

f) Type tests for the painting and corrosion protection system in section 16.2

Tests which are not applicable to the reactor construction type can be omitted.

17.7 TESTS ON ALL REACTORS

The following tests shall be performed on each reactor

Test results and measurements shall be included in the routine test report.

In general, tests shall be performed in the order listed in IEC 60076-1.

Routine Tests

(a) Measurement of winding resistance

(b) Measurement of reactance

(c) Measurement of loss at ambient temperature. The procedure for loss measurement shall be in accordance with IEC 60076-6 for the type of reactor.

(d) Routine dielectric tests - as per Table 1 of IEC 60076-3

(e) Measurement of insulation resistance and/or capacitance and dissipation factor of the winding insulation to earth for liquid-immersed reactors.

Capacitance and % power factor shall be measured between the high voltage terminal and test tap with 10 kV applied, and between test tap and earth with 1 kV applied.

(f) Leak testing with pressure for liquid-immersed reactors (tightness test).

(g) Check of the ratio and polarity of built-in current transformers.

(h) Check of core and frame insulation for liquid immersed reactors with core or frame insulation.

(i) Measurement of DC insulation resistance between each winding to earth and between windings.

(j) Measurement of dissolved gasses in dielectric liquid from each separate oil compartment (for liquid immersed reactors). This test shall be conducted before and after routine testing of the reactor. Samples of oil shall be taken from the reactor and analysed for dissolved gases using the procedures specified in

IEC 60567 and IEC 60599.

Results of the analysis of gases dissolved in the oil shall be immediately submitted to EirGrid.

Special tests

(k) Measurement of zero sequence impedance of three phase reactors.

(l) Measurement of mutual reactance of three phase reactors.

(m) Measurement of harmonics of the current.

(n) Determination of linearity of reactance.

(o) Measurement of magnetic characteristics for gapped-core reactors and magnetically-shielded air-core reactors.

(p) Dielectric special tests – as per Table 1 of IEC 60076-3

(q) Vacuum deflection test on liquid immersed reactors.

(r) Pressure deflection test on liquid immersed reactors.

(s) Measurement of frequency response analysis using the sweep frequency method. Test method to be agreed in advance with EirGrid.

(t) Check of galvanising and painting including routine tests for painting and corrosion protection system as outlined in section 16.2 .

(u) Mechanical test of assessment of tank for suitability for transport.

Non-IEC Tests/ Checks

(v) Actual creepage distance over external insulation on a representative sample of all H.V. equipment prior to despatch from works.

(w) Testing of the integrity of all welds via NDT leakage current or other equivalent methods.

(x) Check of non-retention of water on the tank cover.

17.8 TESTS AFTER ERECTION

The customer shall test the complete Shunt Reactor after full erection as per IEC and OEM recommended tests.

These tests shall include Partial Discharge measurements.

If the Shunt Reactor is connected by cable, then site HV tests may be required depending on the scale of the site assembly.

The test plans and procedures to be carried out after erection shall be reviewed by EirGrid. EirGrid may also witness the tests.

18 MAINTENANCE

18.1 MAINTENANCE LAYOUT

The plant shall be arranged to give safe personnel access to maintenance staff when the plant is not energised. The layout shall be designed to minimise the impact of maintenance on the availability of the Shunt Reactor.

The general layout of the plant shall be such as to permit replacement or maintenance of any sub-components of the plant. The layout shall also allow for the provision of vehicular access for maintenance purposes if required.

The general layout of the plant shall be such as to permit replacement of any complete Shunt Reactor components by crane or other suitable lifting machinery. Access arrangements shall be subject to review by EirGrid.

The exact location and layout of the Shunt Reactor on site will be agreed with EirGrid considering the physical constraints of the site and the system constraints in de-commissioning any existing equipment.

To ensure safety of personnel during maintenance:

- All parts of main circuits to which access is required shall be capable of being earthed.

Provision shall be made for carrying out primary injection tests on all current transformers.

Provision shall be made to allow component testing according to the maintenance procedure.

18.2 SPECIAL TOOLS AND EQUIPMENT

The Customer shall provide a list of any special tools or equipment required for the erection and subsequent maintenance of the Shunt Reactor system. This schedule shall include any hoists, jigs, gauges, templates, meters, etc.

18.3 SPARE PARTS

The Customer, in consultation with their OEM's, shall list all recommended spare parts.

All recommended spare parts shall be provided with associated drawings and instructions.

Refer to OFS-GEN-009 for more details.

18.4 MAINTENANCE INSTRUCTIONS

The Customer shall provide a complete set of maintenance instructions (O&M). The instructions shall be complete, in English and contain all associated instructions and drawings pertaining to the continuing maintenance of the equipment throughout its lifecycle.

19 COMPLIANCE WITH SPECIFICATION

All deviations from the requirements of this specification shall be listed in the “Deviations Schedule” included in the Technical Schedule.

Should EirGrid determine that the offer does not comply with this specification or any part of it, EirGrid reserve the right to reject the proposal.

20 DOCUMENTATION

All documents and communication shall be in English.

20.1 TO BE SUBMITTED FOR ASSESSMENT

- Fully completed copy of the SCHEDULES attached to this Specification including Deviations from Specification, quoting relevant section numbers of this specification.
- Fully detailed Type Test Certificates/Reports.
- Full technical particulars, detailed electrical connection diagram including internal wiring, detailed physical drawings, technical literature, photographs, catalogues, technical pamphlets, reference list, recommended spare parts, etc..
- Details of corrosion protection and associated type test details.
- Details of factory routine, type, and special tests to which all units will be subjected to..
- Storage, Installation and Maintenance instructions.
- Any other data or information necessary to fully describe the Shunt Reactor system.
- Reference list for equipment similar to the proposed Shunt Reactor including details of quantities already in service, location and contact person.
- Service experience to date including defects history.
- A short description of the Quality Control philosophy including sampling techniques, statistical parameters etc. plus tests carried out on raw materials employed.
- Factory production experience of Reactors in general and specific Reactor proposed under this specification.
- Service Experience as required in this specification.

20.2 TO BE SUBMITTED WITH FEED AND DETAILED DESIGN

The extent of detail design documents for submission to EirGrid for review shall be agreed in the beginning of FEED and detailed design stage. To achieve that MDR (master document register) and SDR (supplier document register) shall be submitted to EirGrid to establish which documents will be reviewed by EirGrid.

20.3 TO BE SUBMITTED PRIOR TO DELIVERY

Prior to delivery of equipment, as minimum, the following documents shall be submitted to EirGrid:

a) Completed Finalised Technical Schedules with guaranteed rated values and characteristics

b) Final fully detailed drawings of the equipment to be supplied including physical dimensions including all details necessary for the design of foundations, support fixings, high voltage connections, equipment layout, details of secondary terminal arrangements and provision for control cables.

c) Detailed storage, installation, operation, and maintenance instructions.

d) Final Factory Test reports comprising:

Summary sheet with list of all tests

Detailed results and measurements for all tests performed - including routine testing, factory acceptance testing, type tests and special tests.

Calibration certificates for all test equipment used

Quality documentation for the equipment – including incoming quality checks etc.

Type and special test certificates

Serial numbers of tested equipment

20.4 DESIGN DOCUMENTS AND DRAWINGS

Primary and secondary design documents and drawings to be submitted during project detail design stage shall include:

- Outline dimensioned drawings of complete equipment.
    - arrangement complete with fittings
    - arrangement for transport and shipping
    - Schematic diagrams of the complete Shunt Reactor showing enclosures and components including CT wiring and terminations
    - A three-dimensional model in REVIT or equivalent of the physical layout of the Shunt Reactor and all its components.
- Data sheets and FAT reports for complete equipment and for all individual components including weight of all units.
- Single line diagrams, wiring diagrams, schematics, bill of materials.
- Recommendation for installation, operation, and maintenance, including list of tools and equipment required e.g., test equipment.
- Control and monitoring system documentation;
- Earthing arrangements
- Insulation co-ordination report.

- At the handover time, all technical documents (e.g., Navisworks / AutoCAD 3D models of equipment, drawings, instruction manuals, etc.) shall also be provided in electronic format and drawings shall be delivered via Internet e-mail in one of the following formats:
    - Microstation.dgn – compatible with latest version MicroStation (if available)
    - ACAD-dwg – latest release
    - Misc.dxf – compatible with latest version MicroStation

20.5 TEST PROGRAMME

The Customer shall submit a proposed inspection and test programmes (ITP) and test procedures to EirGrid for review prior to commencement of the tests. This applies to factory, fabrication yards, site tests.

20.6 TECHNICAL RECORDS

Technical records shall include:

- Guaranteed rated values and characteristics i.e., the Project Specific Technical Schedules that accompany the submission, modified where necessary.
- Detailed physical and electrical drawings.
- Drawings showing dimensions, positioning, and fixing arrangements of the core, windings, leads, oil directing devices, shields and other main features which could distort or move during internal faults. A description of materials used in the core, windings, insulation, shielding, lead supports, winding formers and conductor spacers shall be provided together with a photograph of the active parts before they are tanked.
- Detailed installation, operation, and maintenance instructions.
- Certificates relating to the insulating material.
- Summary of type tests, routine tests, and special tests, with copies of the Test Certificates.
- Full details of all auxiliary equipment including FAT reports.

21 TRAINING

The Customer shall submit a training plan which shall describe in detail how the Customer proposes to train EirGrid staff for operation of future EirGrid assets.

Training requirements will be detailed further in OFS-GEN-009 - Operation and Maintenance General Specification.