Document Reference: OFS-OSP-136-R1

Functional Specification

OSP Auxiliary Electrical Systems Specification

Revision History						
Revision	**Date**	**Description**	**Originator**	**Reviewer**	**Checker**	**Approver**
R0	30-05-2022	First Issue, for industry feedback	EirGrid (Leon Notkevich)	Vitali Garon James Staunton Daniele Giustini	Neil Cowap	Richard Blanchfield Aidan Corcoran
R1	07/10/2022	Issued for use after industry feedback	Vitali Garon	James Staunton Leon Notkevich	Neil Cowap	Louise O'Flanagan

1 ABBREVIATIONS

Abbreviation	Definition
AC	Alternating current
ACB	Air circuit breaker
DC	Direct current
IED	Intelligent Electronic Device
LED	Light emitting diode
LV	Low Voltage (under 1 kV)
MCB	Miniature circuit breaker
MCCB	Moulded case circuit breaker
OSP	Offshore substation platform
MCT	Multi-cable transit (system)
PPE	Personal protective equipment
RCD	Residual current detection (device)
SCADA	Supervisory control and data acquisition
SCS	Substation Control System
SLD	Single line diagram
UPS	Uninterruptible power supply (system)

2 SCOPE

This Functional Specification is applicable for use in offshore wind transmission assets delivered by the Customer as Contestable Works, to be owned and operated by EirGrid.

The following specification outlines the functional requirements for the auxiliary electrical systems associated with the Offshore Substation Platform (OSP).

This document is a supporting specification to OFS-OSP-130 OSP General Specification and shall be read in conjunction with that document and all associated EirGrid specifications.

In addition to the above, 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 any party (Offshore Wind Developers, Independent Power Producers, or other developers) responsible for the design and build of assets for connection to the Irish transmission system.

EirGrid's aim is for this specification to be functional, with stated preferences in certain areas to allow for some level of commonality and economies of scale across assets to reduce the operational costs associated with these assets.

3 GOVERNING STANDARDS

3.1 RECOGNIZED INDUSTRIAL AND OFFSHORE STANDARDS

The auxiliary power system shall be designed according to the following standards.

Except where otherwise stated in the functional specification, materials shall be designed, manufactured, tested and installed according to relevant IEC/EN standards. Where applicable, the Irish adaptation of the standard (IS EN version), including any national normative aspects, shall apply. Where no IEC Standard has been issued to cover a particular subject then an EN, International or British Standard shall be applied. The latest edition and amendments shall apply in all cases.

Individual sub-systems and components shall, in addition, comply with applicable international and national codes, standards and specifications. The customer shall satisfy themselves that the latest / ruling edition of each standard is adhered to.

Table 3-1 Offshore Specific Standards

Document Number	Document Title
DNVGL-ST-0145	Standard – Offshore Substations (amended in Sep 2021)
DNVGL-OS-D201	Offshore Standard – Electrical Installations
DNVGL-OS-J201	Offshore Standard – Offshore Substations for Wind Farms

Table 3-2 International and National Codes, Standards and Specifications

Document Number	Document Title
IEC 60092-301	Electrical installations on ships – generators and motors
IEC 60331	Tests for electric cables under fire conditions
IEC 60332	Tests for electric and optical fibre cables under fire conditions
IEC 60364	Electrical installations for buildings
IEC 60529	Degrees of protection offered by enclosures
IEC 60598	Luminaires
IEC 61439	LV Switchgear and controlgear assemblies
IEC 61892	Mobile and fixed offshore units – electrical installations
IEC 62040	Uninterruptible Power Systems
ISO 8528	Reciprocating internal combustion engine driven alternating current generating sets
IS-10101 2020	National Rules for electrical installations

In case of a conflict between requirements of this specification and standards, the requirements of the specification will take precedence.

4 GENERAL

The system topology shall be developed to offer sufficient robustness to cater for normal operation and abnormalities (like emergency or islanded conditions) to be expected during the life of the OSP.

There shall be a logical segregation of loads essential for safety or operability, emergencies and the continued monitoring and control of the plant, even in the event of loss of the main grid supply. The following key principles shall be observed:

- No single point of failure in the OSP's auxiliary power system shall lead to an outage or malfunction in the primary power system or any unsafe situation. Main auxiliary power supplies shall be at least 2 x 100% redundant supplied from separate sources
- All essential and emergency systems, required for the continuous monitoring, protection and control, of the windfarm and OSP shall be provided with battery backed AC or DC UPS power supplies and an emergency power source.
- All trips, and abnormalities shall be alarmed through SCADA to operators.

As part of the design basis, Customer shall make appropriate allowances for the following:

- Margins to allow for uncertainty in total system peak load and transient conditions.
- 20% spare for future increases in load. Additional spaces, spare switchboard and distribution panel feeders and capacity shall be provided accordingly.

The above allowances are subject to EirGrid review. Full electrical load lists with

classification of normal, essential and emergency loads shall be submitted to EirGrid for review.

Auxiliary power supplies shall satisfy the requirements of section 5.5 Auxiliary power system of the DNVGL-ST-0145 standard.

It is allowable that Customer small power consumers and auxiliary consumers are fed from common auxiliary power systems (including normal, UPS and emergency systems).

5 Main Power Supplies

- The main sources of power supply for auxiliary power system shall be at least 2 x 100% redundant and can be as follows: Main power system from primary grid (through auxiliary power transformer(s)).
- Generator set(s).
- Alternative connection from another OSP; or
- Another stable source of power

The substation auxiliary power system shall be, as per DNV-ST-0145, section 5.5.2 and 5.5.3.

If two main LV switchboards are used they shall be interconnected to enhance redundancy of the power supplies.

If one main LV switchboard is provided, it shall have normally open bus-tie circuit breaker.

Incoming supplies shall be interlocked with an automatic and manual changeover facility. Auto changeover logic and interlocking philosophy shall be developed by the Customer for EirGrid review. In case of loss of one supply, the automatic changeover shall occur to restore the supplies to affected loads. Automatic changeover shall be break-before-make to ensure safe transfer. Manual changeover is required for maintenance and operational purposes. If both sources are in synchronism, manual changeover can include momentary paralleling.

The following standard voltage levels shall be used on the OSP:

- AC: 400V three-phase / 230V single-phase (IEC standard levels).
- DC: 220V.

Systems requiring a different DC voltage level (e.g. 24V or 48V) shall derive their supply from an appropriate AC:DC or DC:DC convertor.

6 Emergency Power Supply

Emergency power supplies shall be provided. They shall be independent from main auxiliary power supplies.

Emergency power supplies shall satisfy the requirements of section 5.5.3 Emergency power supply of auxiliary power system of the DNVGL-ST-0145 standard.

6.1 Emergency Generators

Emergency generators shall satisfy the requirements of the DNVGL-ST-0145 standard.

Emergency diesel generator shall automatically start and automatically provide power to all emergency and essential consumers in case all main auxiliary power sources are not

available.

Diesel tank capacity shall be sufficient for supply of all emergency and essential loads (during a loss of main power) for minimum 7 days at full . Customer shall dimension the diesel generator(s) and their associated fuel tank(s) based on the site characteristics.

The diesel generators shall be provided with packaged control systems and local LCD type displays. The generator shall be skid-mounted, secured with damping attachments that limit the transmission of vibration to the platform structure. The machine compartments shall include ducting to ambient for intake air and exhaust gases. Such ducting shall be designed to prevent ingress of rain- or seawater and be provided with screens to prevent insect infestation or bird nesting.

The generators shall be fully enclosed during normal standby and operation periods, with hatches / doors provided for routine maintenance. Consideration shall be given to locating the generators in a manner which limits the potential impact of exhaust fumes, particulates (soot) and noise on adjacent equipment or personnel working nearby.

The generators shall be configured for periodic testing, including remotely from SCADA, SCS. To this end, the generators shall be delivered with automatic synchronisers.

6.1.1 TEMPORARY GENERATOR

The OSP and auxiliary power system shall be designed so that a temporary generator can be installed and connected to the power system to provide power for commissioning or major maintenance campaigns or in case of black substation scenario.

Refer to section 5.3.1.5 Black substation condition of the DNVGL-ST-0145 standard

6.1.2 SUPPLY OF WIND TURBINES

It is not expected that the electrical power demanded for offshore wind turbines during an islanded condition is to be supplied by the OSP generators. Customer shall engage with EirGrid if this option is to be explored as part of the wind farm's O&M strategy.

6.2 UPS AND BATTERIES

6.2.1 400/230V AC UNINTERRUPTIBLE POWER SUPPLIES (UPS)

400/230V AC UPS system shall be supplied for OSP LV AC essential and emergency loads, critical auxiliary, SCADA and telecommunication loads. The UPS backed consumer (load) list to be reviewed by EirGrid but, as minimum, shall comply with DNV-ST-0145 requirements.

The UPS shall be fully redundant (2x100%).. Incoming supplies to redundant UPS units shall be from different sources (can be different switchboards or separate sections).

Redundant UPS system shall include the items listed below.

- Two fully rated rectifiers / inverters
- Two battery banks (one per rectifier / inverter). Each battery bank shall be fully rated with 50% back-up time.
- Two fully rated bypass circuits
- Two bypass-manual switch
- At least one AC distribution board

Two static bypass switchesComplete LV AC UPS will be designed with 20% spare capacity in addition to OSP essential and emergency loads. Solid state conversion /

inversion systems shall be provided with appropriate overcurrent and overvoltage protection.

If forced cooling is used, it shall be 2 x 100% redundant. Input and output terminals shall be concealed to prevent inadvertent contact with live conductors. Such protection may take the form of bespoke plugs with recessed connectors or guards (barriers).

All 400/230V AC UPS loads (essential and emergency consumers) shall be fed in a way that ensures continuity of power supplies in case of failure of one of two UPS panels. No single point of failure shall lead to a loss or any interruption of supply to any UPS consumer.

Watchdog and other status contacts shall be provided. UPS Status, indications and any abnormalities, trips, alarms of AC UPS system shall be transferred to SCADA and visible to operators.

As minimum, the following shall be alarmed (not a full alarm list):

- Incoming AC supply failure.
- Low battery voltage.
- AC output overload.
- Equipment overtemperature.
- Synchronization loss.
- Shutdown imminent.
- Battery system fault.
- Inverter failure.
- Bypass AC source failure.
- Battery disconnects or fused disconnecting switch in open position.

6.2.2 BATTERY CHARGERS

Similar to LV AC UPS, 220V DC battery charger / rectifier system (sometimes called DC UPS) shall be fully redundant with 2 x 100% charger systems.

220V DC system shall also include distribution board(s) and batteries. Batteries can be arranged either as one battery of 100% or 2 x 50% battery banks depending on chosen system configuration.

20% spare capacity for future shall be provided throughout 220V DC system.

Control and protection system loads, switchgear critical auxiliaries shall be fed from 220V DC system.

All 220V DC loads (consumers) shall be fed in a way that ensures continuity of power supplies in case of failure of one of two DC Chargers. No single point of failure shall lead to a loss or any interruption of supply to any 220V DC consumer.

Status, indications and any abnormalities, trips, alarms of 220V DC system shall be transferred to SCADA and visible to operators.
Earth fault detection shall be provided.

The chargers shall meet or exceed the following requirements.

- AC input = 400 V, three phase, 50 Hz
- DC output = 220 V DC
- Power factor at rated load shall be a minimum of 0.75 for three-phase units.
- Maximum ripple = 2% of nominal output voltage (30 mV rms) when connected to battery.
- AC input protection = circuit breaker.

- DC output protection = circuit breaker, magnetic only or fuses.
- Output current limited to load current plus charging current.
- Efficiency = 90% minimum at rated load.
- Fully filtered output.
- Individual float-and-equalize adjustments.
- Battery chargers capable of operating in parallel, sharing the load, or individually.
- Battery chargers shall be capable of supply rated load without battery bank connected.

6.2.3 BATTERIES

Batteries shall act as the transitional source of power and provide back-up in case of failure of emergency source following main auxiliary supply failure. Separate battery banks shall be provided for LV AC UPS and DC Battery Charger systems. Battery capacity shall be sufficient to supply, as a minimum, the services listed in table 5.2 in DNV-ST-0145 and any other connected loads for at least 4 hours.

Certain auxiliary consumers (like navigation lights or other consumers) may require power supplies for longer than battery back-up time. Arrangements shall be made to comply with all relevant regulations, standards (including DNV-ST-0145) and provide dedicated power supplies to such loads to cater for the case when emergency power source fails or not available. Dedicated longer back-up time battery systems shall be considered for such systems. Alternative arrangements can also be submitted to EirGrid for review.

Battery sizing calculations shall be done for minimum expected temperature in the battery room and include allowance for future lifetime degradation and 20% future spare capacity. Design contingency margin may also need to be applied.

Batteries shall be modular, with the possibility of increasing the number of modules to increase the endurance (ampere-hour rating) of the equipment. Use of VRLA (valve regulated lead acid) batteries is preferred.

End of discharge voltage shall be 80% of nominal voltage or higher.

All 220V DC loads shall be operational at the lowest and highest battery bank voltage variations.

Battery faults, abnormalities, alarms shall be transferred to SCADA and visible to operators

7 SWITCHBOARDS

7.1 MAIN DISTRIBUTION BOARDS, SWITCHBOARDS

The main distribution boards shall be metalclad cabinets containing the main power busbars and a number of compartments for the application of circuit-specific switch- and controlgear. The switchboards shall be compliant to all relevant IEC standards and be type tested.

The minimum IP protection shall be IP41 for indoor, clean, environment-controlled areas and IP56 for outdoors.

With a circuit breaker withdrawn from its service position, barriers / shutters shall automatically operate to prevent contact with the live apparatus.

Circuit breakers shall be provided with settable protection, comprising multiple stages of overcurrent and earth fault protection. Further, a shunt shall be included for incorporation

of external trip signals. Circuit breakers shall be equipped with circuits facilitating remote operation.

The incoming feeders shall be completed with ACB (air circuit breakers) and protection relays (IEDs).

The switchboards shall provide protection against arc-faults according to relevant IEC standard. Facilities for the safe venting of arc products and gases away from personnel shall also be provided.

Main switchboards shall be appropriately compartmentalized, in particular that personnel installing or attending to cable connections in a particular compartment are unable to contact live apparatus in adjacent compartments, or the busbars themselves – forms 4A or 4B separation. Type Form 3B separation is only possible if specifically accepted by EirGrid. The covers of compartments containing live conductors shall be bolted into place using multiple socket head cap bolts (“Allen head”).

A screen printed (or equivalent) mimic diagram shall be superimposed on the front panels of the switchboards, enabling inspection and maintenance personnel to easily familiarize themselves with the internal structure of the board, i.e. location of busbars and circuits, without having to open any compartments.

Switchboard nameplates shall be marked as per EN 61439-1.

All busbars shall include voltmeters and/or indications that shall enable personnel to readily determine whether or not a particular section is live.

Circuit breaker statuses, busbar voltages, main incomer current indications, any alarms or abnormalities shall be sent to SCADA, Substation Control System.

If provided with side or rear covers allowing access during construction or maintenance, these shall be recessed and affixed with countersunk screws. The front panel shall be provided with a lockable latch that does not require a special tool to operate.

7.2 SUBSIDIARY DISTRIBUTION BOARDS

All distribution boards shall comply with relevant IEC standards and be type tested.

The minimum IP protection shall be IP41 for indoor, clean, environment-controlled areas and IP56 for outdoors.

Each board shall be a metalclad cabinet of standard design and dimensions. The hinged front panel (door) shall, when closed, prevent contact with live apparatus within. An internal chassis shall serve as the mounting surface for all outward facing equipment. The busbars, neutral and earth bars, and all internal cabling and wiring shall be installed behind the chassis.

Only low mass components (indicating LEDs, voltmeters, ammeters and the like) shall be mounted on the front door. All heavy components shall be mounted on the internal chassis, with a cut out provided in the front panel for operation from external if required.

Equipment mounted on the chassis, notably MCBs, MCCBs and switches, shall feature recessed terminals aimed at minimizing the possibility of inadvertent contact.

Internal equipment installed to the rear of the chassis shall be provided with clear acrylic screens to prevent contact with live conductors / apparatus.

Each cabinet shall include a removable gland plate, pre-drilled for the maximum number of circuits that may be accommodated in the board. Holes shall be provided with dome

plugs which shall be removed when a cable is to be installed. Gland plates shall be treated to protect against corrosion but shall not otherwise be coated / painted.

If provided with side or rear covers allowing access during construction or maintenance, these shall be recessed and affixed with countersunk screws. The front panel shall be provided with a lockable latch that does not require a special tool to operate.

Incoming circuit MCCBs shall be able to be tagged and locked out using industry-standard, multi-user hasps. Each distribution board shall be provided with clips for the tagging and lockout of outgoing circuit MCBs.

Outgoing circuits shall be protected by MCBs rated according to the maximum load to be supplied, and characteristics graded to any downstream protective devices. Only the phase conductors shall be switched, with neutral leads connected directly to the neutral bar.

Each MCB shall incorporate a thermal (inverse time, for moderate overloads) and magnetic (fast acting, for bolted faults) element. Where so required, it shall be permitted to "slug" the magnetic element to provide an intermediate protection stage.

Feeder circuits supplying compartment lighting and socket outlets shall be fed via earth leakage protection using the residual current principle, with a maximum trip threshold of 30mA. It shall be permissible to combine the MCB and RCD in one unit.

Distribution boards shall include a schedule of incoming power source and outgoing circuits for easy identification of all feeders.

Any trips, including outgoing MCB shall be alarmed to SCADA, SCS system for the attention of operators. Grouping of individual alarms into Common Fault alarm is allowed. The requirement includes all LV AC and DC distribution boards.

8 LV Cabling

Low voltage cables shall follow the requirements of DNV-ST-0145. Colour coding shall be according to the latest EU / IEC standards.

MCT (mult-cable transit systems) or suitably rated cable glands can be used for cable terminations.

9 Lighting and Small Power

Lighting, sockets and other miscellaneous equipment shall follow the requirements of DNV-ST-0145 and DNV-OS-D201.

All lighting shall be LED types. Other types of lighting can be used only if specifically accepted by EirGrid.

Sockets shall be provided for the provision of electrical power to appliances, portable tools and test apparatus throughout the platform.

In habitation / rest areas, relay and control / communications rooms and workshops, sockets shall be single-phase and neutral, with an integral earth terminal of BS1363 type. 70% of the sockets shall be of a UK plug type G and the remaining 30% of EU socket (Shuko) type. All sockets shall be rated for minimum 16 A.

In workshops, equipment rooms in which heavy duty tools and equipment may be used, and on open decks and gangways where portable machinery may be required, industrial type single phase, three phase and welding type power outlets / receptacles shall be

provided. Quantity, locations and types of sockets shall be reviewed by EirGrid.

10 Lightning Protection and Earthing

Lightning protection and earthing shall be designed and implemented according to DNV-ST-0145 and therein referenced standards.

Detailed earthing and lightning protection studies shall be carried out by Customer and made available for EirGrid review.

The earth grid shall be designed to minimise current flow through the OSP structure, whether induced or impinged.

In main switchboards, distribution boards, the earth and neutral bars may be galvanically equivalent, in turn directly connected to the supply star point (TN-C earthing).

In subsidiary distribution boards, earth and neutral bars shall be distinct, with earth bars bonded to the OSP earth grid directly (TN-C-S earthing). The Protective Earth (PE) terminal / stud of any device within the cubicle / board shall be connected to the earth bar.

In power consumer cabinets the neutral terminals of all components shall be connected to the neutral lead of the supply cable, and the chassis earth points (PE) shall be connected to the OSP earth grid. (TN-S earthing).

All distribution board and consumer cabinets shall be connected to the OSP earth grid by means of tinned, braided copper strapping or insulated wire (if colour-coded, then green and yellow).

Earth and neutral bars within distribution boards and protection / control cabinets shall be copper, of cross section of minimum 50mm^2, pre-drilled, and tinned.

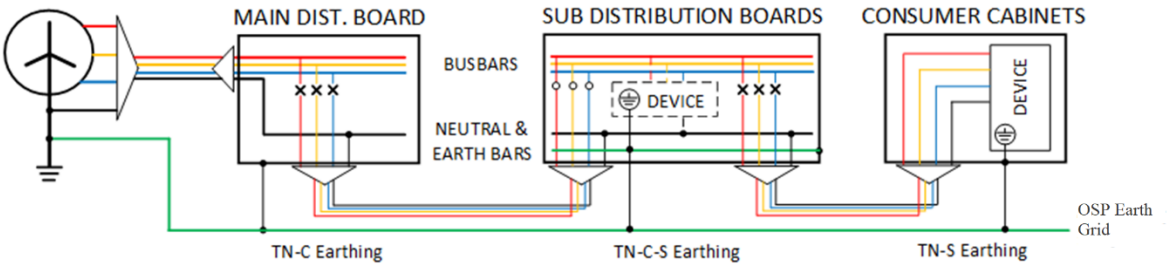

Figure 1 – Earthing Concept

11 Operational Requirements

11.1 Variations of Supply Voltage

Customer is to adhere to the requirements in I.S. 10101:2020, which gives a comprehensive set of requirements for the requirements for design and electrical installations at voltages of 1000 Volt AC and below.

11.2 Phasing

The standard rotation aboard the OSP shall be counterclockwise, (R-S-T).

Upon first livening of any point of supply, the phase rotation shall be checked using an approved instrument, prior to connection of any consumer loads.

The paralleling of two asynchronous sources, e.g. principal auxiliary supply and an emergency generator without a synchroniser, is expressly prohibited. Operational procedures and interlocking shall be provided to prevent such eventualities.

12 Labelling and Marking

All cables shall be labelled at both ends, using tags of durable materials, affixed with metal fasteners.

All cabinets shall be labelled with the assigned apparatus code and description. Such labels shall be (near-) permanently affixed to the equipment, i.e. by rivets, screws or in ticket rail. The use of double-sided tape shall not be permitted.

All circuits, apparatus and components within and on the outside of panels, boards and cabinets shall be uniquely labelled. As a minimum, the description of the item shall be provided, with additional coding advantageous, space permitting. The descriptions shall correspond with the accompanying drawings.

For rows of MCBs it is recommended to provide a ticket rail of equal length, into which individual or grouped circuit labels may be slotted. Unallocated circuits shall be provided with SPARE labels.

All internal wiring of cabinets and systems shall be marked with durable labels / marking. Markings shall be in accordance with IEC standards. The wiring identification method shall make it clear “From” (other end) and “To” (this end) of the wires and shall be agreed with EirGrid. For packaged equipment manufacturer standard wire identification may be accepted.

13 Documentation

The following documents (but not limited to) shall be provided by the Customer:

- SLDs for the auxiliary electrical systems
- Layouts, general arrangement of control rooms and switchboard rooms
- General earthing, grounding, and lightning protection plans
- Load balance calculations, including any diversity factors applied under normal
- no-break (UPS) and short-break power supply operational modes
- Power protection coordination plan considered the power protection philosophy
- the short circuit fault levels and the power supply operational modes
- Earthing study
- Short circuit fault level calculations
- Cause-effect analysis for operational conditions of all platform systems
- Electrical load lists
- Equipment datasheets
- Wiring diagrams
- Bill of Materials
- Plan of main cable ways for cables incl. size of MCTs
- Illumination plan for all rooms an outside areas (normal and emergency)
- Installation, operation and maintenance manuals