OFS-CAB-101-R2

220 kV and 400 kV Underground Cable Functional Specification

Revision History						
Revision	**Date**	**Description**	**Originator**	**Reviewer**	**Checker**	**Approver**
R0	14-6-2022	First Issue	Daniele Giustini	James Staunton	Neil Cowap Leon Notkevich	Aidan Corcoran, Richard Blanchfield
R1	17/10/2022	Issued for use after industry feedback	Daniele Giustini	James Staunton	Neil Cowap Leon Notkevich	Louise O'Flanagan
R2	21/12/2022	Issued for use after industry feedback	Daniele Giustini	James Staunton	Neil Cowap Leon Notkevich	Louise O'Flanagan

1 LEGISLATION, CODES AND STANDARDS

All materials shall comply with and be manufactured and tested in accordance with the current edition of the standards of the International Electrotechnical Commission in so far as they are applicable. Where no IEC standard has been issued to cover a particular subject, then a recognised national standard shall be applied.

The cables and associated fibre optic cables, where required, shall be manufactured, installed and tested in accordance with the following latest versions/ amendments at time of issue of this specification as appropriate:

Number	Title
ISO 9001:2000	Quality Management Systems
IEC 60050	International Electrotechnical Vocabulary
IEC 60060	HV Test Techniques
IEC 60071	Insulation co-ordination
IEC 60228	Conductors of Insulated cables
IEC 60229	Tests on cable over-sheaths which have a special protective function and are applied by extrusion
IEC 60287	Electric cables – Calculation of the current rating (Calculation methods for steady state current ratings and losses)
IEC 60332	Tests on electric and optical fibre cables under fire conditions
IEC 60793	Optical fibres guidelines
IEC 60794-1-1	Optic Fibre Cables – Part 1 General Specification: General
IEC 60794-1-2	Optic Fibre Cables – Part 1-2: Generic Specification – Basic optical fibre test procedures
IEC 60811	Common test methods for insulating and sheathing materials of electric cables
IEC 60815	Selection and dimensioning of high-voltage insulators for use in polluted conditions
IEC 60853	Calculation of cyclic and emergency current rating of cables
IEC 60870-5-101	Transmission protocols – Companion standard for basic tele-control tasks
IEC 60870-5-104	Network access for IEC 60870-5-101 using standard transport profiles
IEC 60874-14	Connectors for optical fibres and cables
IEC 60949	Calculation of thermally permissible short-circuit currents, considering non- adiabatic heating effects
IEC-61000	Electromagnetic compatibility (EMC) Testing and measurement techniques
IEC 61238-1	Compression and mechanical connectors for power cable.
IEC 61300	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 1: General and guidance.
IEC 61386-24	Conduit systems for cable management - Part 24: Particular requirements - Conduit systems buried underground
IEC 61443	Short-circuit temperature limits of electric cables with rated voltages above 30 kV (Um = 36 kV)
IEC 61757-2-2	Fibre Optic Sensors – Part 2-2: Temperature Measurement – Distributed Sensing.
IEC 61914	Cable Cleats for Electrical Installations
IEC 61936-1	Power installations exceeding 1 kV a.c. - Part 1: Common rules

Number	Title
IEC 62067	Power Cables with extruded insulation and their accessories for rated voltages above 150 kV (Um = 170 kV) up to 500 kV (Um =550 kV) Test methods and requirements
IEC 62134	Fibre optic interconnecting devices and passive components- fibre optic closure
IEC 62217	5000-hour multi-stress test and a tracking wheel test are described in IEC/TR 62730 (2012).
IEC 62271 – 1	High-voltage switchgear and control gear – Part 1: Common specifications
IEC 62271 – 209	High-voltage switchgear and control gear – 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
HD 632.2 2008	Power cable with extruded insulation and their accessories for rated voltage above 36kV (Um=42kV) – Test methods and requirements.
ENA-ER-C55/5	Insulated Sheath Power Cable Systems
ITU-T G.652D	Characteristics of Single Mode Optical Fibre Cable
CIGRE TB-272	Technical Brochure No. 272 – Large cross sections and composite screens design
CIGRE TB-303	Technical Brochure No. 303 – Revision of Qualification Procedures for HV and EHV AC Extruded Underground Cable Systems
CIGRE TB-283	Technical Brochure No. 283 - Special bonding of high voltage power cables
CIGRE TB-797	Technical Brochure No. 797 - Sheath bonding systems of AC transmission cables - design, testing, and maintenance
CIGRE TB-880	Power cable rating examples for calculation tool verification
BS50299:2002	Oil-immersed cable connection assemblies for transformers and reactors having highest voltage for equipment Um from 72.5 kV to 550 kV
ISO 8501	Corrosion Protection of Steel Structures by Painting
ISO 9001	Quality management systems — Requirements
ISO 14001	Environmental management systems — Requirements with guidance for use
ISO 14005	Environmental management systems — Guidelines for a flexible approach to phased implementation
IS EN 10210	Plastics - Methods for the preparation of samples for biodegradation testing of plastic materials
EN 61386-21	Conduit systems for cable management Part 21: Particular requirements – Rigid conduit systems
RFC 4180	Common Format and MIME Type for Comma-Separated Values (CSV) Files
OFS-SSS-419	EirGrid Specification: Galvanised fabricated steelwork
OFS-SSS-420	EirGrid Specification: Hot dip galvanising of iron and steel other than wire
	The Computer for DTS system and test equipment supplied under this specification shall be compliant with the latest versions of the following Standards.
ISO 27001:2014	Information Security Management
TII Specification	Road Pavements – Concrete Materials (CC-SPW-01000)

Number	Title
for Road Works Series 1000	
TII Specification for Road Works Series 1700	Structural Concrete (CC-SPW-01700).

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

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 requirements for the design, manufacture, installation, civil works, commissioning tests of the proposed cable system complete with the joints, terminations, fibre and accessories..

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 familiarise themselves with the requirements of this Specification prior to undertaking any design, material procurement, installation and commissioning.
For the purpose of this specification the term ‘cable system’ encompasses all equipment necessary to provide the required HV electrical connection (e.g. the HV cables, LV cables, fibre optic cable, ducting, joint bays, terminations, C2 chambers and link boxes.)

2.1 GENERAL REQUIREMENTS

Section 3 outlines the general requirements for the design and construction of 220 kV and 400 kV underground cable systems which will connect the Onshore Compensation Compound (OCC) to the Transition Joint Bay (TJB) where the land cable will be jointed to the submarine cable for the connection of the OCC to the Offshore Substation Platform (OSP). This cable system will be owned and operated by EirGrid.

2.2 ROUTE SELECTION, DESIGN AND AS BUILT RECORDS

Section 4 outlines the requirements for route selection, design and as-built records for 220 kV and 400 kV underground cables which will connect the Onshore Compensation

Compound (OCC) to the Transition Joint Bay (TJB) where the land cable with be jointed to the submarine cable for the connection of the OCC to the OSP. This cable system will be owned and Operated by EirGrid.

2.3 Cable Materials

Section 5 covers the design, manufacture, testing and delivery to Ireland of 220 kV and 400 kV (nominal voltage) underground cable materials, together with all accessories needed for their proper and reliable operation of the cable system which will connect the Onshore Compensation Compound (OCC) to the Transition Joint Bay (TJB) where the land cable with be jointed to the submarine cable for the connection of the OCC to the OSP. This cable system will be owned and Operated by EirGrid.

2.4 Cable Civil Works

Section 6 describes the requirements for civil works for 220 kV and 400 kV underground cables system which will connect the Onshore Compensation Compound (OCC) to the Transition Joint Bay (TJB) where the land cable with be jointed to the submarine cable for the connection of the OCC to the Offshore Substation (OSP). This cable system will be owned and Operated by EirGrid.

2.5 Cable Installation

Section 7 covers the installation requirements of 220 kV and 400 kV underground cables and associated fibre cabling) which will connect the Onshore Compensation Compound (OCC) to the Transition Joint Bay (TJB) where the land cable with be jointed to the submarine cable for the connection of the OCC to the Offshore Substation (OSP). This cable system will be owned and Operated by EirGrid.

The cables and accessories shall be installed and handled in accordance with the instructions of the cable manufacturer and EirGrid standards.
The installation and handling of the cables and accessories shall be undertaken at all times by sufficient numbers of capable and experienced staff, suitably trained and supervised. An EirGrid representative may be on site during all works.

The Customer shall be responsible for the supply of all necessary plant, equipment and tools to ensure that the work is carried out to the required standard and in accordance with the agreed project programme.

The Customer shall ensure that cable, materials and jointing accessories are stored in a secure location.

3 General Requirements

3.1 Network Parameters

The cables and accessories shall be suitable for installation on the Irish Transmission system. The design parameters are specified in EirGrid's functional specification OFS-SSS-400, Onshore Compensation Compound General Requirements.

The System Neutral shall be effectively earthed as per IEC 60071-1.

The cables and accessories shall be designed for operation on the system specified and to comply with the requirements laid down in this specification.

The cable system shall be designed to operate for nominal and short circuit level as specified in the project specific specification document / Single Line Diagram.

The minimum rating requirement of the cable is dependent on the Customer connection agreement see section 4.6

3.2 SERVICE CONDITIONS

The site climatological conditions shall be taken into consideration when designing the cable system.

The cable system shall be capable of operating satisfactorily at the service conditions as specified in the “Service Conditions” section of the latest revision of the EirGrid Onshore Compensation Compound General Requirements OFS-SSS-400.
Network parameters are defined in the OFS-GEN-005 Network Engineering Studies Specification.

For all underground cable systems, the design and construction elements shall be in accordance with applicable Irish and EU Health and Safety Regulations and Approved Codes of Practice.

Where appropriate, the underground power cable components and all associated ancillary materials shall carry the CE Mark in accordance with Directive 93/465/EEC.
The cable and its installation shall comply with this specification, unless any deviation/derogation which has been specifically requested by the Customer is accepted in writing by EirGrid.

Where deviations from the functional specifications are proposed in the design, the Customer shall submit a formal Derogation Request providing a detailed explanation of why the non-compliance is expected and any additional information to support the request for EirGrid to consider and review on a case-by-case basis. Further information is outlined OFS-GEN-024 Guidance for Derogation Requests. Early engagement pre-construction with EirGrid is required for any proposed deviations.

As stated in the EirGrid Connection Agreement all cable routes shall be agreed with EirGrid prior to submission of planning consent. Cables shall not be routed through any area likely to flood (areas classified in 1 in 100 year fluvial and pluvial events). Catchment Flood Risk Assessment and Management (CFRAM) mapping shall be consulted in this regard.

Equipment and facilities not specifically mentioned here or in this specification, but which are clearly necessary for the construction, satisfactory operation, safety, security and reliability of the underground cable system are also understood to be included in the scope. EirGrid will not accept any cable system materials which breach the EU Reach Directive. All cable system components which contain chemical compounds shall be declared in the hazardous materials and safety datasheets.

The Customer shall provide a Register of materials and a letter declaring that the proposed cable system and related spares follow the EU Reach Directive.

3.3 DESIGN LIFE

EirGrid expect that correctly designed and installed ducted underground power cable circuits will operate satisfactorily for at least 40 years. The customer shall issue a certificate of conformity for the 40-year asset life requirement as part of the technical schedule submission.

3.4 INFORMATION AND DRAWINGS

The project safety file shall be submitted to EirGrid on completion of the project in

accordance with the Construction Regulations and XDS-SDM-00-001 EirGrid Safe by Design Methodology.

3.5 Detailed Information Required

The full cable system design pack shall be made available to EirGrid for review, the following documents is a non-exhaustive list of document EirGrid expect to be produced and issued for review. Cable design program submission has to be agreed with EirGrid:

Detailed Information Required	Check
Proposed cable route before planning permission submission, cable plans and cross section drawings	
Location of all existing services, type, size and depth of installation along the route	
Proposed trench arrangement where cable crosses other services	
Dedicated crossing design for every 3rd party service crossing, bridge, road, river	
Detailed cross and long sections through bridges which clearly illustrate separation from other services, depth of burial of cable ducts and also how ducts enter / exit bridge abutments / deck	
Detailed design including cross sections, long sections, plans where cable routes traverses water crossings	
Cable rating calculation, EMF calculation and Sheath Voltage calculation	
Proposed joint bay locations (including distances between joint bays)	
Proposed link box chamber locations	
Proposed C2 communication chamber locations	
Future access points / routes for maintenance and repairs	
Cable pulling force calculation	

4 Route Selection, Design and as Built

4.1 General

The design produced by the Customer shall comply with EirGrid functional requirements and shall make adequate provision for:

- Performance to the required underground power cable system requirements including continuous and/or dynamic current rating and short circuit rating
- Safety of operation and maintenance personnel
- Safety of members of the public

- Reliability and continuity in service
- Ease of inspection and maintenance
- Ease and clarity of operation
- Avoidance of spurious alarms
- Ability to withstand the service conditions specified
- Freedom from undue vibration and noise
- Precautions to minimise fire risk

EirGrid require a Distributed Temperature Sensing (DTS) system to be included in the Cable system. DTS system requirements are specified in section 5 of this Specification.

The proposed cable design shall be submitted to EirGrid at the following project stages:

- Route selection and survey prior to submission of planning application.
- Route risk assessment prior to submission of planning application
- Material selection at detailed design stage
- Detail design
- Results of the site investigations at detailed design stage

Any omissions, issues and/or non-compliances identified by EirGrid Client Engineers during the FEED, Detailed Design Review and Construction phase will be logged in Design Review and Construction Monitoring Comments logs.

The Customer shall submit all FEED, Construction designs and proposed cable routes in compliance with the requirements of this specification for EirGrid review.

High Voltage cable installation across third party lands is to be avoided where possible.

High Voltage cable installation across peat lands is undesirable and only permitted in exceptional circumstances. In such cases additional and extensive engineering design and documentation will be required by EirGrid before the Customer's proposal can be evaluated, refer to section 0 for further information.
The Customer should be mindful that reviews of non-standard (i.e. third-party lands and peatland) routes is resource intensive as significant time may be spent in reviews, further research and meetings between teams which involves various staff across EirGrid. The customer shall factor this time in their overall programme and decision making for non-standard designs as this may impact the projects critical path.

The Customer shall provide a detailed cable route map, to a suitable scale, to EirGrid for review. All relevant landscape features, buildings, kerb-lines and other services shall be marked.

The cable route shall avoid changes of line and direction as much as possible. Any changes in direction shall not exceed a radius greater than the minimum installation radius for the cable proposed by the Customer cable manufacturer.

The route of the cable shall follow solid stable ground on flat or gently graded slopes not subject to erosion. Site investigations including trial holes and slit trenches shall be conducted by the Customer in advance to determine the suitability of the route.

Where the gradient of the route exceeds 1 in 6 metres or cannot avoid unstable ground, special measures shall be designed and implemented to achieve satisfactory long-term duct and cable performance.

In order to facilitate access for installation and maintenance, the cable route as standard shall follow public roadways, footpaths or green areas under the control of the relevant Local Authority.

Permanent Service roads shall be installed along the cable route providing suitable and safe access for maintenance and cable pulling vehicles at all joint bay locations that are not located within the public road.

Direct burial of the cable is not permitted in any circumstance with the exception of the approximately five metres final cable run for connection to AIS cable sealing ends and/or Line Cable Interface Masts.

In circumstances where the cable is to be terminated on, for example, a Line Cable Interface Mast or on air insulated cable sealing ends and the cable will be in-situ before the permanent support structure is erected, or for operational reasons the cable is not terminated, the Customer shall design and install suitable temporary mechanical protection for the exposed and vulnerable cable ends. The design of the temporary works shall be submitted for EirGrid's review. The cable shall also be protected against water ingress and the temporary design shall be submitted to EirGrid for review. Once the final structure is ready the cable will be re-directed to the Mast/Sealing end for its final termination.

Direct burial of fibre optic is not permitted in any circumstance. All communications ducting shall terminate in a C2 Communications Chamber except in the case of entry to a block formed surface duct within the station compound or on entry into station building.

The Customer shall obtain agreement for the proposed route from the relevant Local Authority and all other relevant stakeholders e.g. Transport Infrastructure Ireland, Department of Environment, Heritage & Local Government etc. Formal permission shall be obtained from the relevant authorities for any proposed crossing of railways, navigable rivers, waterways, canals, harbours and docks. Construction cable design details issued to EirGrid for review shall have the same specification detailed in Section 4.12 of this Specification.

4.2 MINIMUM CLEARANCES

The spacing of the cable / ducts shall comply with the requirements in the relevant EirGrid standard drawings and with the minimum dimensions stated in Table 1: Minimum Clearances for HV Cable Ducts.

Table 1 Minimum Clearances for HV Cable Ducts

Item	Description	Clearance (mm)
1	Minimum vertical cover to communication or ECC ducts	750[1]
2	Minimum vertical cover to HV power ducts	950[1]
3	Minimum clearances to 3rd party services (in any direction)	300[2]

[1]This dimension is applicable to standard cross sections (trefoil or flat formations).

Item	Description	Clearance (mm)
4	Minimum clearances to High Pressure / explosive 3rd party services	600[2]
5	Shallow crossing minimum vertical cover to HV power ducts	450[3]
6	Minimum horizontal spacing between any duct not in trefoil formation in the duct bank	75

Prior written agreement is required from the relevant road authorities for any proposal that includes shallow crossings. The Purple Book specifies a minimum vertical depth of 600 mm in lightly trafficked road carriageways and 750mm for heavy trafficked roads.

The Customer shall also note that where the minimum standard "vertical cover" requirements cannot be achieved e.g. bridge crossings, then an alternate route shall be taken, or Horizontal Directional Drilling shall be investigated as an option.

4.3 ROUTE SELECTION FOR UNDERGROUND CABLES

Underground cables shall, as a standard, be routed within the reserve of public roads.
If it is absolutely necessary and no other reasonably practical options exists, the Customer may propose routing cables on private land, the design have to be submitted to EirGrid for review.

Where a Customer proposes to route a high voltage cable through private land that is owned by a third party then, in such circumstances, the Customer will be required to undertake a detailed feasibility study that describes all of the options considered and explains to EirGrid why the routing of the cable off public road cannot be avoided and how maintenance on EirGrid's asset can be achieved.

EirGrid shall be consulted at the earliest opportunity and prior to the submission of any planning application. EirGrid acceptance for such deviation will be via derogation process (refer to OFS-GEN-024).
The routing of HV cables through third party lands shall only be considered if all other options have been exhausted (to the satisfaction of EirGrid functional requirements).

A cable in 3rd party lands is considered a non-standard design, refer to drawing OFD-SSS-531

The Customer will be required to obtain all of the necessary easements / agreements with private landowners for cable routes traversing third party lands.

All such rights must be acquired by way of Deed. Where a final route has not yet been established, draft agreements must be provided. Alternatively the Customer may opt to serve section 53 wayleave notices, instead of acquiring deeds by agreement with third parties once they have obtained CRU consent. In this instance the Customer shall transfer all rights acquired under these notices to EirGrid.
Minimum wayleave width for 220kV cables single circuit is 4m (centred on centre phase),

[2] Unless additional clearance is specified and agreed by 3rd party service asset owner.

[3] Reduced cover of 450mm may be considered where highly congested areas, bridge crossings are met or the alternative solution is a very deep crossing where ratings may not be achieved. This is subject to prior written agreement with EirGrid.

for 220kV double circuits the width will be 4m plus the distance required from circuit #1 centre phase to circuit #2 centre phase needed to achieve the circuits minimum rating, in any case it cannot be less than 8m.

In these situations, the following provisions shall apply:

- Review completed by EirGrid
- Durable robust route markers shall be provided at agreed positions (line of sight, at bends location and property boundaries) along the route. Route Markers to have the following dimensions:
    - Height 1700 mm
    - Width 92 mm
    - Weight 3.5 kg

Suitable unrestricted right of way access, both to the route from the nearest public road and along the route, for the purposes of inspection, maintenance and repair shall be marked on the folio. Access track with a durable and low maintenance hard stand surface to Joint Bays installed in 3rd party lands to be designed and constructed for heavy plant (5t axle loading) movement for the requested cable lifetime. The width of the access track shall be sufficient for the safe moving of machineries required to perform the construction, maintenance, fault finding and repairs of the served cable system section.

Joint bays, link boxes and C2 Communication Chambers should be located on public roadways and public property as far as is possible, even in locations where the cable route traverses' private land. If Joint Bay is located in 3rd party lands a concrete, low maintenance requirement, hard stand is to be constructed on either side of the joint bay, along the short sides, with a length of 6 meters each and be able to withstand the load of the cable drum plus the pulling trailer.

The Customer shall also provide general arrangement, long sections drawings and cross-sectional drawings along the full route, prior to lodging any planning application for the proposed development.

4.4 EASEMENT AGREEMENTS

When a Customer proposes to route a section of cable on or off public roads then it shall be the Customer's responsibility to obtain the consent of those affected stakeholders. The Customer shall produce an easement for the cable route drawing showing access points to every easement section of the cable route for EirGrid review.

A full survey shall be carried out, including trial holes, slit trenches and bore holes as required before design is finalised to identify all major obstacles, such as major road crossings, rivers or railways and other services.

This survey shall inform the designer on establishing a detailed cable route and installation plans.

All efforts shall be made to minimise conflict with other services, and to facilitate the ease of installation and maintenance. Where the cable crosses other services, this should be clearly identified in the Customer's designs including GPS coordinates.

The Customer shall submit a cross section of the cable route identifying all locations where the cable crosses other services. A minimum standard clearance of 300 mm must be

maintained between the EirGrid ducts (power or communications) and all other services. Where other Utilities require greater clearance (such as in the case of high-pressure gas pipes where it is 600 mm) the Customer shall ensure that these are adhered to.

4.5 CABLE DE-RATING CONSIDERATIONS

Where more than one circuit / two cables per phase is being installed or where one cable is installed adjacent to an existing HV or MV cable, the design shall take due account of cable de-rating due to mutual heating of the cables through cable analysis. The mutual coupling effect of other cables and pipelines must also be considered.

Where 220 kV or 400 kV underground cables cross lower voltage cables, they shall be routed under the lower voltage cables for safety reasons. If it is necessary to bury the cable at greater depth at any point, then the Customer shall take account of this in the rating of the cable.

The Customer shall take note of the presence of existing HV & MV underground circuits. The Customers design shall model the impact of neighbouring underground circuits in terms of the new cables rating and the impact on the existing cables ratings.

Where it is proposed to cross (over or under) or run in parallel with an existing circuit, the cable system must be designed to ensure that no de-rating of existing circuits occurs as a result of the proposed cable.

Where this scenario arises, the Customer will be required to demonstrate via detailed cable rating calculations that mitigations have been taken to limit potential de-rating of existing underground circuits.

This may include but is not limited to the use of bentonite, the use of a larger cable, the use of Horizontal Directional Drilling to increase thermal separation and thermal independence.

4.6 CURRENT RATINGS

The current ratings shall be calculated in accordance with the current edition of IEC 60287 and IEC 60853 parts 2 and 3 latest editions with the actual conditions and the actual environmental conditions in project specifications.

The recommendations of Cigré TB 610, Cigré TB 640, Cigré TB 272, and Cigré TB 880 shall be considered in the current rating calculations.

Below requirements and limitations of the current rating calculation shall be met:
Accredited simulation tools shall be applied in cable current rating calculation, in case of self-developed calculation methods, methodology description and verification shall be provided by the Customer.

Cable current rating estimation shall cover all the valid installation scenarios in the selected cable route, such as, but not limited to buried in seabed, cable crossing and parallel installations, ambient air, in trenches and troughs and HDD ducts, etc.

For dynamic rating calculation, the Customer may base this on project specific parameters, such as the wind farm load profile, burial depths and environmental conditions as per the project specific design basis. The load profile shall consider cable pre-conditioning as well as the maximum foreseeable load duration The dynamic rating calculation shall consider the entire lifetime of the assets and take due account of potential foreseeable changes due to environmental conditions and climate change.

In both steady state and dynamic rating, maximum conductor temperature shall not exceed the max designed cable conductor temperature defined in IEC 60287-1-1.

Consideration of thermal mutual impacts with adjacent or crossing services is required.

Any additional regulations related to project specifications shall be respected.

For Steady state calculations, if chosen by the designer as method for cable dimensioning, these have to be done in accordance with the current edition of IEC 60287.

The following parameters shall be assumed for each season, the ground temperatures to be considered during the year are:

- Winter Ground Temperature; 10°C for months December to February inclusive
- Spring Ground Temperature; 15°C for months March to April inclusive
- Summer Ground Temperature; 20°C for months May to September inclusive
- Autumn Ground Temperature; 15°C for months October to November inclusive

Thermal resistivity (TR) of native soil should be considered as follows:

- Winter Soil Thermal Resistivity = 1.0 K.m/W
- Spring Soil Thermal Resistivity = 1.2 K.m/W
- Summer Soil Thermal Resistivity = 1.2 K.m/W
- Autumn Soil Thermal Resistivity = 1.2 K.m/W

Alternatively the Customer can use “site measured values of ” Thermal resistivity for native soil surrounding the cable trench to calculate the expected cable rating. A Thermal Resistivity investigation campaign is required to define these values.
Native Soil samples shall be tested in accordance with ASTM D5334-08, at 10% moisture content. Samples interval is to be agreed with EirGrid following production, by the Customer, of a geophysical report for the cable route describing the depth and extent of different type of soil stratum.

Thermal resistivity of backfill should be considered as follows:

- Winter Concrete (CBGM B) Thermal Resistivity = 0.85 K.m/W
- Spring Concrete (CBGM B) Thermal Resistivity = 1.0 K.m/W
- Summer Concrete (CBGM B) Thermal Resistivity = 1.0 K.m/W
- Autumn Concrete (CBGM B) Thermal Resistivity = 1.0 K.m/W

Alternatively the Customer can use site measured values of Thermal resistivity for back fill surrounding the cable ducts to calculate the expected cable rating. For concrete mix TR test requirements please refer to section 6.5.

The current rating shall be calculated based on the depth, separation distances and type of soil proposed in the appropriate trench cross section. Details of all assumptions shall be provided to EirGrid for review.

4.7 OPTIMIZATION OF CABLE SIZING

Life cycle costs for the cable system shall be considered in the selection of cross section.

Optimization of the cable sizing shall take due account of the CAPEX costs as well as the OPEX costs as per the following section.

4.7.1 OPEX CALCULATION

The Euro/Mwh value, with due consideration of inflation to be used to calculate the electrical losses element of the OPEX cost of the HV cable. This Euro/Mwh value shall be advised by EirGrid.

$$kWh\ per\ year = \frac{3 * \left[(I_{pmd})^2 * R\right] * LLF * H}{10^3}$$

Equation 1 kWh Per Year

Where
$kWh = Kilowatt\ Hours$
$I_{pmd} = Peak\ Annual\ Single\ Phase\ current$
$R = total\ Resisitance\ of\ Circuit = R_{perkm} * km$
$LLF = Loss\ Load\ Factor\ See\ Below$
$H = number\ of\ hours\ per\ year = 8{,}766$

$$LLF = \frac{P_{Lavg}}{P_{LPeak}}$$

Where:-

$$P_{Lavg} = \frac{\sum_{n=1}^{T}(In^2 * R)}{T}$$

$$P_{Lpeak} = (I_{Peak})^2 * R$$

Equation 2 LLF Calculation

Where:
$P_{Lavg} = Average\ Powerloss\ in\ kw\ over\ a\ time\ period\ (1\ Year)$
$P_{LPeak} = Peak\ loss\ in\ kw\ during\ that\ time\ period\ (1\ Year)$
$H = number\ of\ measrements\ take\ i.e\ 1\ per\ hour\ over\ 24\ hours\ H\ number\ = 24$
$In = Load\ in\ amps\ at\ H\ number\ n$
$I_{Peak} = Loading\ at\ maximium\ demand\ or\ Peak\ loading\ in\ A$
$n = H\ Number$
R= Resistance
$T = Total\ H\ in\ Period$

4.8 SHEATH BONDING / EARTHING AND PHASING

The sheath bonding arrangement should be considered when establishing the current rating of the cable in accordance with IEC 60287.

The sheath bonding and earthing scheme, including bonding leads shall be in accordance with Engineering Recommendation ENA-ER-C.55/5 published by the UK Electricity Association.

The sheath voltage shall not exceed 150 V for 220 kV and 400 kV cable systems.

If the sheath voltage limit cannot be achieved the joint bays should be relocated to mitigate

the issue or alternatively an intermediate vault equipped with Sheath Voltage Limiters (SVLs)shall be installed.

Special bonding shall be employed throughout the HV cable network to mitigate risks associated with circulating currents in HV cable screens.

The Customer shall install link boxes at both terminations.

The acceptable cable bonding systems are single point and cross bonding. Solid bonding systems are not accepted due to rating, safety and security issues.

The Earth Continuity Conductor (ECC) shall be installed in a dedicated HDPE duct, separate from the Telecoms ducts as per EirGrid standard drawing.

The ECC conductor shall not pass through the C2 chambers at the joint bays but shall be connected directly to a centralised earthing bar in the link box chamber, and not connected directly to the link box.

Depending on the cable system design solution cross bonding of the cable sheath shall be used along routes which have two or more joint bays. This may be used in combination with the single point bonded sheath earthing method outlined above.

The following non-exhaustive list of items is required from the Customer for EirGrid review:

- Full sheath bonding / earthing scheme including phasing
- Sheath standing voltage calculations for the cable route
- Bonding lead cross section drawing and technical schedule
- Distances between joint bays (where applicable)
- Earth continuity conductor cross section drawing, technical schedule and trench arrangement
- Link Box Drawings and general arrangement (including distances from joint)
- C2 communication chamber drawings and general arrangement
- Sheath Voltage Limiter technical schedule

4.9 JOINT BAYS, LINK BOXES & C2 COMMUNICATION CHAMBERS

The following criteria shall apply to the selection of joint bays, link boxes and C2 Communication Chambers:

- Joint bays, link boxes and C2 chambers shall be kept away from access points e.g. driveways, vehicle entrances etc.
- Adequate room must be provided in front of and behind each joint bay, link boxes and C2 chamber locations to accommodate cable drums, vehicle used for maintenance and pulling equipment.
- All proposed joint bays locations shall be surveyed by trial holes and in areas of poor ground conditions the use of bore holes may be necessary.
- The selection of joint bay, link boxes and C2 chambers should take account of the maximum calculated pulling forces and tensions

- Where cross-bonding of the cable sheath is employed, joint bay positions shall be constrained and shall require that minor sections are of substantially equal length.
- C2 communications chamber and link boxes shall be installed at each joint bay. Additional C2 communications chamber will be required if the cable route is such that the maximum allowable pulling forces and tensions for the installation of the fibre cable would otherwise be exceeded.
- Splicing of fibre optic cable shall take place in specific C2 chambers as determined at detailed design stage.
- The link box chamber shall be positioned on the same side of the joint bays for the entire route of the cable.
- Where cable cores are transposed on the cable route, the location for transpositions shall be on the approach to the joint bay and on the same side of each joint bay for the entire route of the cable.

Joint bays shall be positioned so as to minimise road closures and traffic management during installation and maintenance. Associated communications chambers and link boxes shall be installed off the carriageway where practical. The location of link boxes and C2 communication chamber shall be agreed with EirGrid during the design phase.

4.10 TRENCHLESS TECHNOLOGY

Trenchless Technology, such as Horizontal Directional Drilling, should only be used in circumstances such as:

- Crossing watercourse
- Crossing railways
- Crossing motorways
- Congested road crossings

where standard design is not feasible. The Customer will be required to undertake a detailed feasibility study that describes all of the options considered and clarifies why the Trenchless Technology has been selected. Trenchless installation shall be considered in the Customer cable rating calculation and report.

Any licences or agreements required to carry out this work shall be obtained by the Customer and a copy forwarded to EirGrid.

Cable ducts with the following dimensions shall be used for directional drilling installations[4]:

- 140 / 180 / 225 mm HDPE with a minimum SDR 11

Communication or ECC ducts shall be 125mm OD SDR 11 in trenchless installation.
If 250mm OD SDR 21 ducts are used transition pits are required in trenchless installation to interface SDR 21 and SDR 11 ducts.

Transition couplers shall be used to join SDR 11 ducts with standard SDR 21 and SDR17.6 ducts, for additional duct details please see section 7.4 of this Specification.

A transition pit may also be used at both ends of the trenchless technology installation to

[4] Subject to duct filling factors according to industry standard

join trenchless ducts with standard ducts. The transition pit requirements are outlined in EirGrid standard drawings.

4.11 HV CABLE TRENCH INSTALLATION THROUGH PEATLAND

For environmental and engineering reasons the routing of underground cables through peatland shall be avoided if at all possible. Overhead lines are the preferred transmission infrastructure to be used for traversing peatland (both blanket and/or raised bogs). If a Customer is intending to propose the routing of an underground cable through peatland EirGrid shall be consulted at the earliest available opportunity and well in advance of the submission of any planning application. The Customer will be required to undertake a detailed feasibility study that describes all the options considered and clarifies to EirGrid's why the routing of the cable through the peatland cannot be avoided.

For all proposals that include the installation of underground cables in peat, regardless of location (even beneath a public or private roadway) the Customer shall provide the following for EirGrid's review:

- A desktop study of the route including a review of all existing geotechnical information, outlining all constraints and geotechnical risks
- An outline of any site investigations carried out along the route
- A peat stability risk assessment/peat landslide hazard risk assessment shall be completed that shall consider the risk of peat slides in blanket bog and bog bursts in raised bog.
- In association with the peat stability risk assessment/peat landslide hazard risk assessment a Materials Management Plan shall also be submitted for review by EirGrid
- A preliminary peat stability mitigation plan shall also be submitted with the peat stability risk assessment/peat landslide hazard risk assessment outlining how all design, construction and operations risks are to be controlled and/or mitigated
- A feasibility design for the cable trench.

The Customer shall include the following in the design submission:

- An outline of any site investigations carried out and the associated findings
- A detailed peat stability mitigation plan shall also be submitted with the peat stability risk assessment/peat landslide hazard risk assessment outlining how all design, construction and operations risk are to be controlled and/or mitigated
- A demonstration that settlement or differential settlement of the cable shall not occur to the extent to which the cable's function or durability could be compromised over the design life.
- Demonstrations that lateral movement due to downhill creep of peat shall not occur.
- Clear outline of any planned site investigation or ground condition verification during the works
- An outline of the construction supervision during the works
- Flooding risk shall be assessed.

Line / Cable interface tower locations shall be assessed in a similar manner. However, this shall include access and egress routes to the locations.

If roads in peatland are proposed to be constructed as “floating roads”, the Customer should consider in the design that these are prone to gradual differential settlement leading in time to an undulating surface. Where the cable route is proposed to be constructed in a “floating road”, the Customer shall assess whether it will be necessary to replace the floating road with a road founded on mineral soil in order to avoid future settlements or peat instability.

The peat stability risk assessment/peat landslide hazard risk assessment shall be carried out by an experienced geotechnical engineer (min. 10 years’ experience, Chartered Geotechnical Engineer). The assessment shall be carried out in accordance with all current legislative requirements and guidelines and at a minimum the Scottish Government Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments shall be followed.

Specific requirements on the design of any cable route through peatland are listed below:

- A minimum 3 m paved and gated service road designed for heavy traffic will be installed to provide safe access for inspection, maintenance and fault repair along the entire cable route through peatland. The specific road witdh depends on the proposed cable system, equipment and machinery required to perform construction, operation, fault finding, second cable pulling and decommissioning activities.
- All materials used must comply with the Transport Infrastructure Ireland (TII) Specification for Road Works and all relevant Irish and European Standards. British Standards may also be used where appropriate and where no equivalent Irish or European Standard is applicable. A maintenance plan listing responsible parties for maintaining the HV cable, trench, road and gates shall be submitted.
- A drainage design for the route must be included with the submission. The drainage design must ensure the continued integrity of the road surface, but it must be demonstrated that the peatland will not be adversely affected by pollution, by siltation or by changes to the hydrological conditions.
- The service road which accompanies the HV cable route should be suitably designed (i.e. if the road is to be used by heavy vehicles or machinery this should be reflected in the structural design for the road).
- Peat must be completely excavated to either competent mineral soil or bedrock at the joint bay locations.
- Joint bays and communication chambers are to be located adjacent to the service road. A suitable hard stand area shall be constructed at either end of the Joint Bay providing suitable and safe access for maintenance and cable pulling vehicles at all joint bay locations that are not located within the public road.

It should be noted that as with any non-standard design, EirGrid should receive early notification that a non-standard design is being proposed and a formal derogation submitted.
It should also be noted that the process for seeking derogation from standard requirements is more onerous and timelier as more stakeholders are involved in the review. Also, the design may require additional warranties to mitigate risk if deemed necessary.

The design of an installation in peat will be bespoke and site specific. The arrangement shown in EirGrid Standard Drawings Standard - Trench Through Peat (included in the list of drawings in Appendix A) is to be used for guidance only in determining the construction design.

4.12 As-Built Records

Prior to backfilling the trench above the red marker strip covering the telecoms ducts, and prior to covering the joint bays, C2 chambers and link boxes the Customer shall record, and document installed locations (including GPS co-ordinates) and levels.

The burial depths of the installed duct shall be recorded as per Section 4.12 and of this Specification. The levels, locations (including GPS co-ordinates) and details of third-party services encountered and crossed shall be included in the As Built drawings. The Customer shall provide a complete as-built record of the installation to EirGrid for review as soon as the trenching and ducting works are completed.

The Customer shall provide the Operations & Maintenance package for the entire cable system to EirGrid. This package shall contain all relevant information for the HV cable, ducts, the fibre optic cable, link boxes, C2 chambers, joint bays, cable sealing ends and any other cable accessories.

4.13 Background Mapping

Ordnance survey strip mapping in ITM co-ordinate system is required along the proposed cable route. The route design and As Built records shall then be overlaid on this OSI mapping. If OSI background mapping is not available or of limited information a topographical survey should be carried out and plotted at a scale of 1:2500 or larger depending on the site in question but not smaller than 1:5000.

4.14 Recording As-Built Record Information

The Customer may use the survey instrumentation of their choice to record the as built record; the chosen method must be capable of recording the information within the tolerances set in this specification.

Up to date Vector Ordinance Survey Strip mapping in ITM co-ordinate system shall be used for the entire route to produce As Built records.

The survey shall record points along the top of the centre cable/duct when the cable is installed in trefoil formation and the top of the central power duct when installed in flat formation. A surface ground level shall be recorded adjacent to this point. It is necessary for the surveyor to record hard detail along the route of the cable. A typical example of the hard detail would be kerbs, buildings, footpaths, manholes, fences, bottom of banks etc. This hard detail will be coloured black with a line thickness 0 and shall be suitably annotated. Drawings relating to vaults (chambers, transition pits and link boxes) and joint bay positions shall be presented in scale 1:25. Drawings relating to plans and elevations of non-standard duct cross sections shall be presented in scale 1:100 with vertical and longitudinal cross views.

All drawings shall be on international A3 size unless otherwise agreed.

Drawings shall be complete in all respects, accurate numerically and geometrically correct. All Drawings and supporting documentations shall have concluded the QA cycle of the Designer Company and to be checked and approved by the Customer before submission to EirGrid for review.

The required electronic format is “.dwg”, “.dgn”, “.pdf” and “.dxf”.

Grid co-ordinates shall be shown from the centre point of all joint bays, C2 Communication Chambers, transition pits, Cable Sheath Link Chambers, Phase Sectionalising Kiosks, 3rd party service crossings etc.

The location of all crossing of 3rd party services shall be identified on the drawings using GPS co-ordinates.

Geotag photographs shall be taken along the full length of the route during construction activity.

It is recommended that increased quality assurance photographic evidence is recorded in case where the design or ducts deviate from the standard formation to be included in the as-built drawing package.

4.15 Horizontal Accuracy

The cable/ducts shall be surveyed and plotted on the background mapping to an accuracy of +/- 50 mm in the horizontal plane (Easting and Northing). The same accuracy is required for the surveying of all joint bays, transition pits, C2 chambers, fibre joint locations, 3rd party service crossings etc.

The cable shall be represented on the plot by one continuous Smart line / Polyline from joint bay to joint bay. All bends along the cable route shall be reflected accurately as they exist on the ground. This shall be in the form of a continuous curve. The use of tangent lines is not suitable for recording such information.

The minimum number of points necessary to survey a radius bend is three. More points shall be surveyed where necessary.

Points shall be surveyed at 10 m intervals or as necessary to record accurately the true position of the power ducts in the ground.

4.16 Vertical Accuracy

The cable/ducts shall be surveyed and plotted on the background mapping to an accuracy of +/- 20 mm in the vertical plane. All reduced levels shall be orthometric heights to OSI datum, mean sea level at Malin Head. All reduced levels shall be annotated on the as-laid record as per the EirGrid Standard as Built drawing.

Points shall be recorded at a maximum of 10 m separation, where the trench installation is as per the standard trench cross section. For standard trench cross section please refer to standard drawings.

Where the trench depth deviates from the standard trench cross section, i.e. deeper or shallower than standard depth, points shall be recorded as often as is necessary to achieve the tolerance as specified above.

4.17 Tie-In Dimensions

Tie-in dimensions shall also be clearly marked on the plot. These shall be at 40 - 50 m centres along the cable route or closer as required. Please refer to the EirGrid Standard as Built drawing.

4.18 Cross Section and Long Section Information

Dedicated cross sections and Long Sections, for each crossing point, are required where the vertical alignment of the cable/ducts deviates from the standard design depth to avoid an obstruction. Typical example of such obstacles would be cables, bridges, culverts, watercourses, transmission gas mains or drainage pipes. The trench section`s shall include details of these.

Cross sections and Long Sections are also required if the formation of the cable / ducts deviates in any way from the standard trench cross section in the specification. These drawings shall be prepared to a standard acceptable to EirGrid and in line with the Customer Quality Plan.

4.19 Existing Utility Services

All existing services exposed by the trench excavation or in the vicinity (within 3m from the edge of the trench) must be recorded and plotted on the drawings. The location including GPS co-ordinates and depth of these services shall be recorded to the same tolerances as those outlined for recording the location of the cable / duct.

The drawings shall also be annotated with information detailing the type and size of the service e.g. Water main 125 mm. Refer to the EirGrid Standard as Built drawing.

Where there is a change in the detailed design as a result of conflicts uncovered (presence of third-party services, restricted depth, width available) during trench excavation, the revised design for the affected section shall be submitted to EirGrid for review before duct installation proceeds on this section of the route.

4.20 Additional requirements

The cable route shall have a continuous chainage reference from end to end shown clearly at 20m interval on the route drawings.

Cable route plan drawing shall include insert photographs showing a red line representing the location of the proposed cable route.

4.21 Plotting

The recorded information shall be plotted on the background mapping provided. The final as-built record shall be produced to the same quality as the EirGrid Standard as Built drawing.

Text shall be 2 mm high when plotted at a scale of 1:500. The text shall also appear horizontal to the sheet and should not obstruct any line work. To achieve this, annotation arrows with a line thickness of ‘0’ may be used. All surveyed detail should be plotted with the attributes in the following

Table 2 Plotting Styles

Object	Level/ Layer	Colour	Style
ESB/EG 110 kV Cable	2	5/Magenta	4/DashDot
ESB/EG 220 kV Cable	2	1/Blue	6/DashDotDot
ESB/EG 400 kV Cable	2	1/Blue	6/DashDotDot
ESB 38 kV Cable	2	3/Red	2/Dash

Object	Level/ Layer	Colour	Style
ESB MV/LV	6/Utilities	3/Red	0/Continuous
ESB Fibre Cable	2	2/Green	2/DashDot
Drainage Foul	6/Utilities	20/Yellow	0/Continuous
Drainage Surface	6/Utilities	20/Yellow	0/Continuous
Gas	6/Utilities	7/Light Blue	0/Continuous
Telecoms	6/Utilities	2/Green	0/Continuous
Water	6/Utilities	1/Blue	0/Continuous
Other	6/Utilities	6/Brown	0/Continuous

4.22 SCHEDULE FOR PRODUCTION OF AS-BUILT RECORDS

The Customer shall submit accurate surveyed electronic drawings in AutoCAD and pdf version to EirGrid and shall outline their detailed programme for submission to EirGrid.

5 CABLE MATERIALS

5.1 SERVICE EXPERIENCE

5.1.1 SERVICE EXPERIENCE FOR HV CABLE AND ACCESSORIES

The Customer shall submit a reference list of dates, quantities, and clients for each cable and accessory type being offered.

a) General Manufacturing experience

The cable system types (cable, joints, terminations, link boxes etc.) being offered shall have a minimum of a five years proven service record. A list shall be provided outlining the projects and clients the manufacture has supplied in the last five years.

b) Specific Manufacturing experience at manufacturing facility proposal

At least five years production experience in the particular cable manufacturing facility proposed by the Customer is required. However, if the proposed cable system manufacturing facility is new but the workforce remains substantially the same as in the preceding manufacturing facility, then the combined period of experience will be taken into consideration by EirGrid.

c) Service Experience

- Installation of the product in at least three EU or EEA utilities
- At 220 kV, a service experience of the product range of at least 5 years duration and at least 500 km in these EU or EEA utilities.
- At 400 kV, a service experience of the product range of at least 5 years duration for the supply of 362 kV and above and at least 250 km in these EU or EEA utilities.

As an alternative to such service experience within the EU/EEA, similar experience with Japanese, Australian, US/Canadian or South Korean or UK utilities will be considered.

The Customer shall ensure the jointers / installers proposed for the project, shall have a minimum of a five years' proven service record and updated training certificate from the

manufacturers of the cable system and accessories proposed for the project.

5.1.2 Scope and Experience for Fibre Optic Preforms

The Contractor shall meet the following requirements:

5.1.3 General Manufacturing Experience of Optical Fibre Preforms

At least 10 years of experience in the production of Optical Fibre Preforms for subsequent drawing into single mode optical fibre conforming to ITU-T Specification G.652.D.

5.1.4 Specific Manufacturing Experience of Optical Fibre Preforms at Manufacturing Facility Proposed for this Project

At least 5 years of production experience at the particular preform manufacturing facility proposed by the Contractor for production of the Preform is required.

In the case where a particular plant proposed is a relocated existing plant and the workforce remains substantially the same as in the preceding manufacturing facility, then the combined period of experience of both manufacturing facilities will be taken into consideration by EirGrid.

5.1.5 Scope and Experience of Single Mode Fibre

The Contractor shall meet the following requirements:

5.1.6 General Manufacturing Experience of Single Mode Fibre

At least 10 years of experience in the production of Single Mode Fibre.

5.2 Specific Manufacturing Experience of Single Mode Fibre

At least 5 years of production experience at the particular cable manufacturing facility proposed by the Contractor for the production, drawing and spooling of Single Mode Fibre to ITU-T Specification G.652.D is required.

In the case where a particular plant proposed is a relocated existing plant and, but the workforce remains substantially the same as in the preceding manufacturing facility, then the combined period of experience of both manufacturing facilities will be taken into consideration by EirGrid.

5.2.1 Service Experience for Single Mode Fibre

This shall be minimum 5 years of service experience associated with supply of Single Mode ITU-T G.652.D fibre and accessories in at least three EU/EEA Countries.

As an alternative to such service experience within the EU/EEA, similar experience with Japanese, Australian, US/Canadian or South Korean or UK will be considered.

5.2.2 Scope and Experience for (DTS)

The Contractor shall comply with each of the requirements set out below except that point (c) may be considered by EirGrid as alternatives to b(i) and/or b(ii):

a) The DTS system manufacturer shall have at least 5 years' experience in the design, manufacture and installation of DTS systems applicable to the cables industry covering both land and submarine installations pertaining to HV cables

b) Continuous satisfactory service experience of at least 12 months for the product on offer:

i. Installation of the product in at least three EU/EEA countries.

And

ii. with a service experience of at least 5 years duration in these EU/EEA countries.

c) As an alternative to such experience of (b i) and (b ii) above within the EU/EEA, similar experience with Swiss, UK, Japanese, Australian, South Korean or US/Canadian utilities will be considered.

d) At least 5 years production of the product in the particular plant proposed is required, although if the particular plant proposed is relocated and continues using substantially the same workforce the combined production experience of both plants will be considered.

e) The product proposed as following this specification shall be manufactured in the same plants which produced the products cited as meeting the service experience requirements outlined in section (b) or (d) above.

The Customer shall ensure that the DTS system manufacturer retain a workforce suitable for the manufacture of the product. The Customer shall on request supply the details of levels of qualification attained by key employees involved in delivering of the project, minimum expected qualifications include Master level education in the relevant field and/or 5 years' experience.

5.3 SPARES

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.

5.3.1 INSURANCE SPARE REQUIREMENTS

If following consultation with EirGrid cable spares are required, the Customer shall purchase and store the cable spares as outlined below.

These spares shall be made available at asset transfer to EirGrid.

EirGrid shall have full access to the building in which the spare components are housed and will not accept responsibility for costs incurred as a result of any extended outage resulting from a lack of availability of spare parts.

Where the cable system is non-standard in terms of EirGrid's current range of 220 kV and 400 kV cable accessories, the Customer shall supply the following spares at a minimum.

Table 3 Cable Spares Requirements

Item	Quantity
Cable	Equivalent length to one phase of the longest section (For Each cable type used)
Joints	6
Terminations	6 (For Each cable type used)

Please note, the spares requirements referred to above are based on a single circuit, single cable per phase arrangement, based on circuits employing more than two joint bays. Very short or very long cable routes requirements may differ.

5.4 TRAINING

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

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

5.5 EQUIPMENT DESIGN

5.5.1 CABLE

The cable shall be single core triple extruded dry cured cross-linked polyethylene insulated design.

The conductor shall be standard compacted aluminium or copper conductor sizes which are longitudinally water-blocked with conductor semi-conducting layer, super-clean XLPE insulation with a firmly bonded outer semi-conducting layer, bedding tapes, longitudinal water blocking layers, an HDPE outer sheath overall, with an extruded or graphite coated outer conductive layer.

5.5.2 CONDUCTOR

Stranded conductor shall be a fully longitudinally watertight design with all of the individual strands fully water blocked, so that if water enters the cable from any cable end, then water movement is effectively stopped. The water blocking design shall be tested to IEC 62067 and BS 7912(2002) standards.

The conductor water blocking material shall be a proven material with regard to long-term water blocking ability and with regard to compatibility with the extruded cable layers.

Any special treatment required for water-block material during jointing of the conductor, including its removal, shall be highlighted by the Customer for agreement with EirGrid.

Solid aluminium conductor may be accepted subject to EirGrid approval of a related derogation requested by the Customer.

All cable conductors shall meet all IEC 60228 requirements, except for:

- 220 kV 2,500 mm² enamelled cables, the Conductor Resistance AC90 Value shall not exceed 9.9x10-3 Ω/km, and
- 220 kV 2,500 mm² Aluminium cables, the Conductor Resistance AC90 Value shall not exceed 1.2x10-3 Ω/km.

For all cables, all accessory designs and cable conductor water blocking designs, shall work in tandem to provide for the conductor to be connected using shear bolts type connectors which do NOT require the removal of water blocking material or enamelled or oxidising material from individual conductor strands. The cable conductor and accessory design combination shall be proven by long term testing to prevent overheating at the accessory locations.

5.5.3 CONDUCTOR SCREEN

The extruded layer shall be continuous and shall cover the surface of the conductor

completely. The conductor screen average thickness and minimum thickness shall be stated in the Technical Schedules.

5.5.4 XLPE INSULATION

The dielectric layers over the conductor shall be applied by a single pass dry type triple extrusion process.

Cross-linking shall be achieved using a dry-curing method.

All cable cores shall be thoroughly degassed prior to application of HDPE cable sheathing. This is an important Health and Safety requirement for EirGrid as the build-up of methane and other gaseous extrusion by products in the fully ducted system could cause explosions and fires both during and after cable installation work.

The insulation layer shall be concentric with the conductor. The insulation ovality shall be a maximum 10%. This shall apply to all cable voltages covered by this Specification.

Cables with stresses greater than 8 kV/mm at the conductor and 4 kV/mm at the outer surface shall require a prequalification test per IEC 62067.

5.5.5 INSULATION SEMICONDUCTING LAYER

The outer semi-conducting layer shall be extruded non-strippable type. It shall be continuous, be uniformly bonded to the insulation and shall cover the surface of the core completely.

The ovality (maximum diameter – minimum diameter) shall not exceed 0.9 mm for 220 kV and 400 kV cables.

5.5.6 SCREEN-OUTER SHEATH SEPARATING LAYER AND SCREEN-CABLE CORE SEPARATING/BEDDING LAYERS

These layers, when used as part of the cable design shall be fully compatible with the cable insulation, semiconducting material and sheath and not suffer any changes, when subjected to highest permissible short circuit stress, which would adversely affect the performance of the cable.

5.5.7 LONGITUDINAL WATER BARRIER IN THE SCREEN AREA

An effective barrier to longitudinal water movement in the screen area shall be provided. This shall be designed to meet the test requirements set out in IEC 62067 as appropriate. In addition, the Test specified in BS7912 (2012) shall be undertaken, on an agreed sample basis, as part of the test on the main conductor longitudinal water barrier test as detailed earlier above.

5.5.8 CABLE METALLIC SHEATH

The metallic sheath shall be either copper or aluminium wire screen with foil laminate or continuously welded aluminium. The wires shall be distributed evenly over the circumference of the underlying cable. The average calculated distance between separate wires shall not be greater than 4 mm. The distance between two neighbouring wire elements shall at no point be greater than 8 mm.

The aluminium foil sheath shall be water impervious over the longitudinal water-blocking tapes in the screen area. This shall be in accordance with IEC 62067 standards.
It shall have an outer sheath of high-density polyethylene with graphite or extruded outer

conductive layer to facilitate DC testing of the outer sheath.

The metallic sheath, in conjunction with any supplementary copper or aluminium screen wires shall be capable of carrying the full short circuit fault current specified in section 4.2 and continuous sheath temperatures of 80°C, throughout the forty-year minimum lifetime of the cable. Type test shall include the short circuit test report for the sheath including details of the temperature measurements of the adjoining semi conducting layer and cable insulation.

5.5.9 Polyethylene Outer Sheath

The outer sheath shall be of HDPE grade and shall have a minimum thickness dimensions in accordance with IEC 62067 plus 1mm. The colour of the sheath shall be black. The hardness on the 'Shore D Hardness' scale shall be between 55 and 61.

For all single core cables, it shall be capable of withstanding a DC voltage test of 10 kV for five minutes after installation and an annual DC test of 10 kV for one minute over the cable lifetime on a fully ducted system.

The outer surface of the HDPE outer sheath shall have a graphite or extruded outer conductive layer. The surface resistivity of the outer sheath shall be less than 16 kΩ/m length of cable, at ambient temperature, to enable an accurate and effective detection and location of faults or damages in the cable outer sheath layer.

If the outer conductive layer is of the extruded type, the friction coefficient, when dry, shall be as low as possible relative to the friction coefficient applicable to standard HDPE outer sheath material.

5.5.10 Cable Identification

The extruded protective sheath of the cable shall be embossed, or laser indented with marking on each side, at 180 degrees, showing the following information:

- EIRGRID ELECTRIC CABLE
- 220000 Volts / 400000 Volts, as appropriate
- Manufacturer's name
- Cable type (XLPE)
- Year of manufacture
- Batch number
- Conductor size and material
- Anti-corrosion serving material type

The embossed letters/figures shall be raised and consist of upright block characters with a minimum height of 10 mm. The gap between the end of one set of embossed characters and the beginning of another shall not be greater than 150 mm.

The same dimensions specified for embossing shall apply to indentation of the cable sheath.

In addition, the cable outer sheath shall be sequentially marked in metres in a clearly visible colour. Each cable length should be marked from zero up to the specified drum length.

5.5.11 JOINTS

Joints shall be designed and tested in accordance with IEC 62067 and they shall be of prefabricated type.

Joints shall be fitted with a casing or surround which shall be completely watertight to the same standard as that of the cable itself. Joint Bay and all accessories water blocking designs, shall work in tandem with cable water blocking design to provide for the conductor to be connected using shear bolts type connectors which do NOT require the removal of water blocking material or enamelled or oxidising material from individual conductor strands. The cable conductor and accessory design combination shall be proven by long term testing to prevent overheating at the accessory locations.

The joints shall be suitable for direct burial in joint bays with Thermal sand backfill for the service and installation conditions.

The connector shall be suitable for jointing a shear bolt system.

Joint and box support designs shall be designed to prevent water ingress in the event of relative movement of the cable and joint components to each other after backfilling of joint bays.

All connection systems shall be of proven design and shall be tested to IEC 61238 or equivalent long-term test regime. Each joint shall be supplied complete with a suitable compound filled glass fibre box or other suitable protection to protect the joint casing from corrosion and also to withstand sheath standing and surge voltages, as well as the maintenance routine voltage testing of the cable outer sheath. Compound free joints at all voltage levels are preferred. Where compound is proposed for use at joints, those compounds shall conform to all REACH requirements.

In most instances, EirGrid only require DTS on the middle phase of the flat circuit and the FO will be transposed at each joint bay. This will mean that joints shall joint between FO cables and non-FO cables, as well as FO cable to FO cables.

For fibre optic joints requirements, covering cables with embedded DTS, see section 6.4.

5.5.12 TERMINATIONS

Terminations shall be designed and tested in accordance with IEC 62067.
All terminations shall be dry type.
The particular requirements for each type are as follows:

- Gas Insulated Metal Enclosed Switchgear Terminations

All terminations used for terminating at GIS switchgear shall by dry type terminations.
Proven plug and socket switchgear termination designs are required.

These terminations should be provided with insulating glands capable of withstanding the 10 kV DC commissioning test and routine maintenance outer sheath test. The Customer should ensure that the cable accessory manufacturer co-ordinates with the supplier of the Gas Insulated Metal Enclosed Switchgear equipment. This is to ensure that the limits of supply are clearly identified as per IEC 62271-209 and that entry and mounting details for the cable termination equipment is agreed.

- Outdoor Terminations

Outdoor terminations shall be dry type with polymeric insulators.
The termination design shall consider the severity of the pollution level that applies to the

installation site. The Reference Unified Specific Creepage Distance (RUSCD) for the phase to earth insulators shall be in accordance with IEC 62271-1 and IEC 60815 for rated voltage and for very heavy pollution level (53.7mm / kV). No arcing horns are required.

Outdoor terminations shall be fitted with a copper or tinned aluminium stalk of adequate cross-section for the cable rating and polymeric insulators which shall not crack or shatter explosively during fault conditions.

This cylindrical copper stalk shall be connected to the cable conductor using a proven shear bolt type connector tested to IEC 61238-1 or equivalent.

Stand-off insulators shall be required capable of withstanding the 10 kV DC commissioning test and routine maintenance outer sheath test.

The ability of the polymeric insulator material to withstand corrosion, UV light degradation or overall weathering degradation shall be demonstrated using a 5000 hour multiple stress test e.g. IEC 62217 annex B, EDF salt fog test or other suitable test.

5.6 DTS Fibre Optic Cable

5.6.1 Fibre Optic Cable

Two installation types apply to this Specification, those fibres integrated into the HV Cable design, and those used to transpose the fibre at jointing locations. This Specification applies to both installation types and where ‘fibre’ is mentioned throughout this section, the Customer shall consider this to refer to both the embedded fibre and the transposition fibre at jointing locations, unless stated otherwise.
The optical fibres shall be single mode, the cores shall be contained in thixotropic gel in loose tube attanged in multiple elements. Sufficient number of cores shall be included in the fiber cable for DTS and DAS purpose to enable sufficient and accurate conductor temperature measurements. Number of cores requirement shall consider at least 2 additional fibres in the cable with 100 % redundancy within the cable. The DTS fiber cable is embedded in the power cable and separate from the fiber cable used for communication purpose.

5.6.2 Fibre Specification

All fibre cores shall meet ITU-T G.652D specification. The Customer shall provide certification showing compliance with the specification for all fibre cables proposed for the project.

5.6.3 Fibre Containment

The fibre containment tube shall be continuous welded stainless-steel tubing, water-blocking shall be provided in the containment design. Water blocking material shall be a proven material with regard to long-term water blocking ability and with regard to compatibility with the extruded cable layers. Water-blocking shall be tested, on an agreed Sample basis, using the test detailed in BS 7912 (2012) standard.

The Customer shall ensure that fibres are packed in the tube to allow for the prescribed bending radius of the HV Cable. The ratio of HV cable length to effective fibre length shall be specified in the design, the method of overlay of the stainless-steel tube shall also be specified in the cable design.

5.6.4 Identification of fibres

Individual fibre cores shall be identified in accordance with Bellcore Standard EIA/TIA-598, UV colours shall not be permitted.

Where more than one containment tube is employed, the containment tubes shall be clearly marked using the ring-mark method with markings no less than 1 metre apart along the entire length of the tube. The Customer shall provide a diagram showing the arrangement and identification of multiple tubes in the cable construction.

5.6.5 Splicing and Terminating Enclosures

The Customer shall provide all fibre jointing enclosures and associated hardware and consumables required to complete and contain the fibre splicing at all HV joint locations and at the cable terminations ends. These components shall support the requirements set out in ITU-T Recommendation L.400 and be suitable for the intended HV joint environment.

5.6.6 Splicing and Terminating Instructions

The Customer shall provide fully dimensioned drawings and detailed instructions describing the mounting of fibre joint enclosures, integration of fibres, dressing in raceways and sealing of entry ports.

5.6.7 Transposition Linking Cables

For fibre transpositions, the cable shall be fully non-dielectric, test certification shall be submitted to EirGrid as evidence that this requirement is satisfied prior to installation. The Customer shall provide further instructions and dimensioning as required. The Customer shall provide the necessary transposition linking cable suitable for the installation environment and containing fibre cores of the same number, colour codes and specification as that which is integrated into the HV cable.

5.6.8 Fibre Splicing Prerequisites

Designs for placement of enclosures, stripping/dressing of cable, fibre handling, splicing and slack storage must consider that fibre Splicing shall be by fusion arc machine only.
At each HV cable joint there shall be an excess length of at least 3.0 to 3.5 m of HV cable made available, in order to complete fibre jointing operation per design.

In addition, the Customer shall provide detailed instructions and dimensioned drawings for cutting, stripping and re-dressing HV cable lengths for successful extraction of the fibre containment tubes.

5.6.9 Tools, Equipment and Spares

1000 m of the specific fibre supplied with each installation shall be provided on a spool to EirGrid at the expense of the Customer. This fibre shall be retained by EirGrid for future DTS calibration and testing purposes.

Specialised / Bespoke tools shall be supplied where required for precision cutting, profiling, forming or adjusting any transport tube containing the fibres. The tool shall be calibrated to the dimensions of the tube to be cut and a sufficient quantity of tools shall be supplied to allow for attrition of the wearing surfaces over the installation project.

5.6.10 Design Lifetime

The expected lifetime of the fibre shall be 40 years based on the service and operating and system conditions outlined in this specification.

The design for the completed fibre connectivity shall in all aspects allow for any expected fibre creep whilst preventing the ingress of moisture, dirt or contaminants.
The Customer shall warrant that the fibre and all associated items, their collective designs and installation instructions supplied shall provide an operational lifetime of the fibre equal

to or greater than the design lifetime of the HV cable system it supports.

5.6.11 DRUM TESTING

The Customer shall provide a means for the optical testing of all of the fibre cores without opening the drum or stripping the HV cable end.

A ruggedized flexible fibre cable tail shall be provided from one end of the HV cable fibres and extended via a port in the cable drum to provide a minimum of 3 metres of fibre for testing. Provision shall be made for adequate protection of the fibre tail during drum transport and storage.

DTS fibre cores shall be optically tested for manufacturing defects and transportation damage to the fibre cores at the point of final delivery for installation in Ireland.

Each fibre core on the drum shall be examined at 1550 nm to determine full continuity over the drum length without defect. The drum battens shall not be removed; testing shall be via the exposed tail end. The results shall be certified and stored in removable electronic media in a unique folder name format:

[PROJECTNAME] [DRUMIDENTIFIERCODE] [TESTLOCATION] [DDMMYY] [TESTERNAME] [ORGANISATION]

Discrepancies shall be verified and immediately notified to EirGrid.

The Customer shall provide the calibration report to EirGrid, detailing the refractive index of the installed fibre.

The optical fibres embedded in the HV cable and those used at joints shall be from the same preform, they shall also be single mode and conform to the requirements of ITU-T, recommendation G.652D, Table 4/G.652. D.

Fibre cores shall be contained in thixotropic gel in loose tubes arranged as 4 elements containing 12 optical cores (= 48 fibres). Containment tubes shall be clearly marked using the ring-mark method with markings no less than 1 metre apart along the entire length of the tube. The Customer shall provide a diagram showing the arrangement and identification of multiple tubes in the cable construction. Fibre cores and loose tubes to conform to colour code EIA/TIA-598. UV colour coding is not permitted. The tube arrangement may include fillers where required for mechanical stability. The fibre cable shall be designed and constructed for conventional installation in underground ducting and feature the following properties:

- All Dielectric construction
- UV proof black HDPE outer jacket
- 2no. ripcords
- Glass layer rodent protection
- Water blocking layer
- Central strength member
- Sheath Marking to include: “Optical Cable”, Manufacturer and product identification, manufacturing date, metre marking.

All components used for fibre splicing at HV joint locations shall support the requirements set out in ITU-T Recommendation L.400 and be suitable for the intended HV Joint environment. Fibre Technology Design

Full details of mounted fibre fittings / fixtures / splice enclosures / joint boxes proposed shall be provided by the Customer to EirGrid for review.

All enclosures, boxes accessories and any other ancillary items related to the fibre element will conform to the IEC 61300 suite of standards.

5.6.12 Fibre Optic Equipment

Only correctly calibrated and modern equipment shall be used in splicing. Reports and test results will be required and should be maintained and made available in soft and hard copy. The tools used for optical span line testing are the Optical Time Domain Reflectometer (OTDR) and the Optical Loss Test Set.

The Customer shall provide a list of fibre optic equipment and tools in advance of installation.

The software specification for the OTDR shall be provided by the Customer to EirGrid for review.

5.6.13 Route installation considerations

Fibre cable route sections are to be planned carefully such that:

- Installation does not conflict with manufacturer's specifications or recommendations.
- Jointing/splicing locations shall be selected from the point of view of safe future maintainability and must be agreed with EirGrid.

5.7 Distributed Temperature System

A Distributed Temperature and Strain Sensing system (DTS) is required by EirGrid for the entire cable system (land cable plus submarine cable).

The DTS System shall monitor the Temperature and Strain on a single mode fibre optic cable which has been embedded in one phase the High Voltage (HV) land power cable and in the three-phase submarine cable. Separate fibre optic cables / systems for temperature and strain monitoring can be proposed by the Customer.

The system includes the DTS equipment (the measurement instrument and the server if applicable) and all the ancillary equipment (for data analysis, mapping and storage).
The DTS shall be designed to have the following capabilities:

- Provide Temperature and Strain information at discrete locations along the cable route, particularly where special engineering has been implemented by the use of HDD or installation through water courses, it shall be possible to segregate into zones to facilitate interrogation of specific parts of the cable route to within 1 m accuracy.
- Provide both temperature and strain measurement values for the same time intervals.
- Use the temperature and strain measurements with the circuit parameters provided via EirGrid's SCADA system to provide Real Time Current Ratings to the end user

through the use of a GUI.

- Generate alarms at set temperature/rating settings and a ‘unit fail alarm.
- Use the temperature and strain measurements GIS data from the circuit as-laid records to provide Real Time Thermal Ratings (RTTR).

5.7.1 DTS TECHNICAL REQUIREMENTS

The measurement instrument and any associated ancillary equipment required for the full functionality of the DTS shall be installed in a standard cabinet within the Onshore Compensation Compound control room. A human machine interface (HMI) shall be installed within the same enclosure. The HMI shall allow full local control of the unit, connection of other Human Machine Interface (HMI) devices, e.g. keyboard/mouse, shall be facilitated by USB connection.

Spatial resolution shall be in the range 0.5 m – 20 m.

Sampling Interval shall be 0.1 m or as determined by the Spatial resolution.

Laser class type shall be 1 or 1M.

Laser wavelength shall be 1550 nm.

The measurement instrument shall be capable of operating in an environment of 0 °C to +40 °C.
The measurement instrument shall be capable of being powered by a 100-240VAC supply and shall not exceed a demand of 650VA.

All components used in the DTS measurement instrument shall be compliant with the requirements of IEC61000. The utilisation of “black box” components/modular elements shall not be accepted.

The DTS measurement instrument along with the information processing function shall be capable of working without compromising the accuracy and resolution specification in substation environments where switching transients and RF interference are present. The supplied equipment shall meet the basic EMC requirements for radiated interference as well as mains-borne interference. Power and control cables shall be shielded to reduce induced over-voltages when used at site.

The system will be a Brillouin based system capable of operating in both BOTDR and/or BOTDA configurations.

A minimum of two independent measurement channels are to be provided with the ability to expand the system up to 16 independent measurement channels for both BOTDA and BOTDR.

The detailed functionality of the DTS system is to be discussed and agreed with EirGrid. This will require at least two additional fibres in the cable with 200% redundancy to be provided within the one phase (for land cable) of the cable (for example at the metallic screen layer of the power cable) to enable accurate conductor temperature measurements to be determined. A single mode double ended configured DTS system might be required for increased accuracy.

The Customer shall provide a model showing the expected sheath temperature in relation to the core temperature, over time, given environment and load variables.

Latency/hysteresis in the propagation of heat to the sheath shall be included in the model. DTS units will be employed in a loop or single ended configuration. The unit should have the ability to be multichannel and the capability to operate in both radial and ring format from a common location such that multiple circuits can be monitored.

5.7.2 DTS Measurement Requirements

Optical Budget for BOTDR shall be 18dB, and for BOTDA shall be 36dB. The use of external attenuators to regulate output power shall not be accepted.

Maximum Acquisition time to complete scan shall be 10 minutes.

The guaranteed accuracy from the measurement instrument shall be minimum 2σ temperature repeatability of 2 ºC at 65 km for a measurement time of 10 minutes and Spatial Resolution of 5 m, without repeater.

The DTS System shall have the facility to compensate for high insertion losses.
The DTS System shall be capable of taking 50,000 measurement points.

5.7.3 DTS Real Time Thermal Rating Requirements

The DTS systems shall have the capability of providing Real Time Current Ratings, the ability to generate alarms, maps and provide RTTR, all of which can be linked in with the SCADA system. All events, alarms and recorded values presented shall be timestamped with reference to the time synchronisation technology (GPS Clock) used by EirGrid's SCADA system.
It is envisaged that the RTTR output shall provide measured values, calculated temperature values and predicted temperature models with respect to predicted overload capability.

This information shall be used to facilitate the validation of the design by EirGrid, the cable thermal designs and to identify any hot spots, GIS capability shall be built into the RTTR to allow the accurate identification of the hotspots. The system shall also have the capability to enable EirGrid to predict and plan future allowable safe cable current rating based on current loading and immediate past cable loading history, thereby ensuring that cables are operated in a safe and reliable manner.

The RTTR output shall use the measured temperature values and the circuit load information provided by SCADA to calculate the real time thermal rating of each zone on the circuit.

This information will be used by the DTS system along with operational limit information provided by EirGrid, to predict operational capacity on the circuit.

The following non-exhaustive list of RTTR analysis shall be reportable by the DTS system:

- Calculated maximum permanent circuit load
- Overload capability for 1-36 hours
- Calculated conductor temperature

5.7.4 DTS Geographical Requirements

The DTS System shall use the circuit as-laid records to locate the position of the temperature and strain measurements at configurable discrete positions along the cable route, and thus provide the end user with Real Time Thermal Rating (RTTR) information relating to specific locations on the cable route length.

"Hot spots" are particular areas on a cable route where the thermal conditions of the cable are under stress. For example, where special engineering has been implemented or where HV cable circuits come into close proximity with each other. Hot spot and pinch point analysis shall be recorded and presented to the user via the GUI.

5.7.5 Proprietary Software/Licensing

Propriety mapping of geographical information shall not be accepted, additional licensing requirements to present geographical information shall also be rejected.

5.7.6 DTS Navigation Requirements

Trouble areas, alarms, hotspots shall be colour coded for quick and unambiguous identification "at a glance". Zones, sections and structures shall be clearly identifiable on the GIS view.

All alarms on an asset identified on the GIS shall have the option to drill down for detailed information on the event/alarm, asset detail etc. Detail shall include all measured values, the reason for the alert, circuit/zone/point identification, longitude/latitude, time date and duration of event, ability to reset or edit set point values and other as applicable.

Alarms on the asset shall be dynamically coloured on the GIS representation for ease of identification by the user. It shall be possible to export alarms and identifiable events in the format specified in this Specification, to allow comprehensive analysis to take place. It should be possible to export multiple measurements preceding and following the event.

It shall be possible to configure all zones as temperature and/or strain measurements, a combination of both shall also be possible on a single circuit. Differentiation between each zone shall be clearly evident. Temperature or strain shall be referenced as absolute value or a relative measurement when compared to a baseline value specified by EirGrid.

It shall be possible to zoom and move the GIS representation along the monitored asset in its totality.

Selection of alarms, structures and areas of special engineering shall have the option to "got" or "auto zoom to" via context menu selection or other method.

5.7.7 DTS Graphical User Interface (GUI) Requirements

5.7.7.1 User Access for Control, configuration and interrogation

The GUI shall allow user access per user levels, for the purposes of setup, configuration and interrogation of gathered data and alarms.

The GUI shall also allow full local control of the unit, connection of other Human Machine Interface (HMI) devices, i.e. keyboard/mouse, shall be facilitated by USB connection.

All operational software components shall allow for the configuration of different levels of users, in designated groups, of the system, this shall include but not necessarily be confined to the following groups.

- Basic Level User

  User shall have the ability to view only, no configuration or export of data allowable, user shall be able to view sections, zones, alarms, historical and statistical data.

- Advanced Level User

  User group shall have ability to perform all operations of previous user group levels

and also to setup and configure measurement sensors and circuits, user shall also have the ability to acknowledge alarms, import, export, start/stop measurements. This level shall be for trained operators only. It shall be permitted that this level shall have the ability to add other users but only up the advanced user level.

- Administrator Level User

  All previous user group abilities plus the ability to configure unit outputs, create/add/delete alarms, audit other users' actions, ability to assign users to user group levels and set/reset passwords.

User access shall be controlled by username and password and the system as supplied shall come with one default user per group preconfigured.

User access shall be controlled by username and password and the system as supplied shall come with one default user per group preconfigured. Administrator Users shall have the ability to set/reset User passwords.

5.7.8 Temperature and/or Strain

It shall be possible to identify critical zones on a Circuit for temperature and/or strain measurements, a combination of both shall also be possible on a single Circuit. Temperature or strain shall be referenced as absolute value or a relative measurement when compared to a configurable baseline value.

5.7.9 DTS Communications & OS Requirements

The unit shall provide for a number of communications channels.

Temperature and Strain based alarms and limits shall be configurable in the unit. Alarms shall be generated when limits are approached/breached as prescribed by EirGrid. Limits shall be circuit specific. Alarms shall be communicable over SCADA protocols.

System failure alarms shall be provided via Single Pole Double Throw (SPDT) volt free contacts locally on the unit.

Alarm notification through standard communications protocols shall be available, alarms, alarm types and trigger conditions shall be configurable by EirGrid.

The unit shall be fully compliant with standard communications protocols to allow bi-directional data transfer from the unit to the SCADA system, this shall include one or more of the following capabilities.

- MODBUS
- IEC 60870-5-101
- IEC 60870-5-104
- TCP/IP

The product shall be capable of importing operational variables relating to the circuit; voltage, load, active power, reactive power and any other information deemed necessary from the EirGrid SCADA system.

The operating system shall be based on one or more of the following:

- UNIX-like or Linux based systems incorporating GUI for DTS System configuration and setup.

- Windows 10 or later based system incorporating GUI for DTS System configuration and setup.
- Windows Server 2019 for data analysis, RTTR and GIS representation as appropriate.

All Operating Systems (OS) shall have Mainstream Supplier support with respect to security and update packages to the end of 2025 at a minimum.

Supplied OS shall be compatible with all common file formats, e.g. FAT, ext2/3/4, ISO 9660 and others.

Propriety OS shall not be accepted.

Any OS utilised shall employ suitable intrusion prevention measures/software, firewalls, anti-virus and/or other.

5.7.10 DTS Operational Safety

The ability to terminate a measurement at any time shall be facilitated by the inclusion of a "Master/Laser Off" key switch mounted in a prominent position on the front of the DTS measurement instrument. This key switch shall be clearly labelled. If this switch is invoked during normal operation an 'operation interrupted locally' alarm shall be generated.

Three keys shall be provided for this key switch for each measurement instrument. Keys shall be interoperable from unit to unit, i.e. each pair of keys shall be unique to each unit. Keys shall be numbered uniquely for the purposes of identification and in the event of loss for replacement.

Connection to the measurement channel shall be via E2000/APC connections.

5.7.11 DTS Alarm Requirements

Temperature and Strain based alarms, alarm types, limits and trigger conditions shall be configurable in the system. Alarms shall be generated when limits prescribed are approached and breached. Limits shall be Circuit specific.

Interrogation of all alarms shall be required for any circuit identified on the GIS for the purpose of providing detailed information relating to the condition of the circuit prior to the alarm event. Detailed information includes all measured values, the reason for the alert, circuit/zone/point identification, longitude/latitude, time date and duration of event, ability to reset or edit set point values and other as applicable.

It shall be possible to export data in the format specified in Section 6.5.11 of this Specification, to allow comprehensive analysis to take place. It shall be possible to export multiple measurements preceding and following the alarm event.

Measurement instrument failure alarms shall be provided via Single Pole Double Throw (SPDT) volt free contacts locally on the unit.

The following is a non-exhaustive list of the alarms to be provided by the DTS System.

- Approaching Configured Limit on Circuit.
- Configured Limit has been Breached.
- Fibre Break Alarm.

- Measurement Instrument Failure Alarm.
- DTS System Failure Alarm.
- Operation Interrupted Manually Alarm.

5.7.12 DTS SECURITY REQUIREMENTS

Access control for remote monitoring, patching or software updates shall be controlled by the end user.

Remote access by the end user to the unit shall be via TCP/IP standard protocols. Access shall be via 2-way authentication or one-time token and in line with the most recent access and security protocols employed by the end user on its network.

At no time shall access be available to the manufacturer to the DTS measurement instrument without the prior consent of the end user.

Security and access protocols as implemented by the end user shall be made available where applicable.

5.7.13 DTS DATA OUTPUT REQUIREMENTS

Propriety file formats for data processing shall not be acceptable.

Alarms, events and any notification on breach of monitored or configured limits shall be notifiable to nominated operators.

Notification shall be via email, SMS, Push Notifications, STDP or other suitable means of communication.

Notification of events or alarms through common SCADA communications protocols shall be possible.

It shall be possible to retrieve historical data for any given point, zone, section or other measured structure on the asset directly from the GIS system, this data shall be exportable in a readable format for analysis.

The Product shall provide all three of the following types of file outputs:

- Hierarchical Data Format 5

Hierarchical Data Format 5 (HDF5) is a data model, library, and file format for storing and managing data. It supports an unlimited variety of datatypes and is designed for flexible and efficient Input/output (I/O) and for high volume and complex data. HDF5 is portable and is extensible, allowing applications to evolve in their use of HDF5. The HDF5 suite includes tools and applications for managing, manipulating, viewing, and analysing data in the HDF5 format.

- Comma Separated Values

Comma Separated Values (CSV) is a simple format for representing a rectangular array (matrix) of numeric and textual values.

While there are various specifications and implementations for the CSV format there is no formal specification in existence, this allows for a wide variety of interpretation of the format. For the purposes of this specification the CSV file outputs shall be in the format as specified in the RFC 4180 standard.

RFC 4180 specifies that:

- Each record is located on a separate line, delimited by a line break
- The last record in the files may or may not have an ending line break
- There shall be an optional header line appearing as the first line of the file with the same format as normal record lines. This header shall contain names corresponding to the fields in the file and should contain the same number of fields as the records in the rest of the file.
- Within the header and each record, there shall be one or more fields, separated by commas. Each line should contain the same number of fields throughout the file. Spaces are considered part of a field and should not be ignored. The last field in the record must not be followed by a comma.
- Each field may or may not be enclosed in double quotes. If fields are not enclosed with double quotes, then double quotes shall not appear inside the fields.
- Fields containing line breaks, double quotes and commas should be enclosed in double quotes. If double quotes are used to enclose fields, then a double quote appearing inside a field shall be escaped by preceding it with another double quote
- Text or File Format

A Text File refers to a file that is structured as a sequence of lines of electronic text. The proposed text file format shall be clearly outlined, additional metadata shall or shall not be incorporated to assist in analysis of the text file content.

Text file content shall be plain text, ASCII character set or Unicode UTF-8 only shall be utilised in the generation of the text file. Binary file format shall not be accepted.

5.7.14 DTS DATA STORAGE REQUIREMENTS

Solid State Hard Disk Drives shall be utilised for the storage of data. It shall be possible to retrieve historical data for any given circuit or pre-programmed section/zone on any particular circuit directly from the DTS system. Date ranges shall be selectable for export of data in this manner. The extent of stored historical data, i.e. the number and type of measured values, shall be a user configurable value.

All data shall be stored for a period of 12 months, after which it shall be archived by EirGrid as a daily average value unless it is alarm specific. Alarm data shall be archived along with a daily average measured value for temperature on the circuit and its zones.

Failure of the DTS measurement instrument shall not result in loss of stored data.

Data recorded from measurements shall be exportable to an external RAID array for long term storage of data via TCP/IP/FTP.

5.7.15 DTS TRAINING REQUIREMENTS

Training shall be provided for EirGrid’s staff for each User Level identified in Section 6.5.6.1 of this Specification. All personnel to be trained shall be assumed to be beginner level for the purpose of producing the training syllabus. Training shall include configurations, implementation of the GIS, use of the GUI for the purpose intended, interrogation of the system, alarm set point configuration, RTTR interpretation, and all other functions of the

system as Specified in this Specification.

Certification shall be provided for attendees of the training course.

Referto OFS-GEN-009 for afuther details

5.7.16 DTS Spare Parts Requirements

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.

5.7.17 DTS Lifetime Requirements

Embedded PC, optical components, power supplies, DAC's and other hardware utilised in the measurement units will have a Mean Time to Failure (MTTF) of 70,000 hours continuous operation based on service and operational conditions as outlined with an overall service lifetime of 25 years.

If an optical switch is used the MTTF shall be greater than 10 million switch cycles.
A semiconductor Laser will be utilised in the instrument with a projected operational lifetime of greater than 25 years.

It is preferable that Solid State Hard Disk Drives are utilised where possible.
A full and complete list of consumable and user replaceable spare parts will be provided including all technical details, minimum recommended quantities and supplier details.

5.7.18 DTS Design Submission Requirements

The Customer shall provide a DTS System Report in the design submission for EirGrid review.
The report shall describe the proposed system, including:

- Technical documentation stating DTS system power supply requirements, accuracy in temperature, spatial resolution, maximum allowable fibre attenuation at operating frequencies, measuring intervals, for various fibre ranges, etc.
- Descriptions and interface requirements with the terminal station SCADA systems.
- Descriptions of output protocols to SCADA for eventual display of real-time temperature profiles and zone alarm data to remote System Operators.
- Descriptions of methods to be used by remote specialists from the vendor to modify DTS system settings, oversee functionality and retrieve historical data.

In addition, the following documentation shall be provided to EirGrid:

- Schematic overview of the system.
- Test reports (including Factory Acceptance Test & Site Acceptance Test SAT).
- Material list/Spare parts.
- Electrical drawings.
- Lay-out drawings, including As-Built Drawings.
- User manuals (English).
- System failure warnings.

- Maintenance prescriptions and schedules.

5.7.19 DTS TESTING REQUIREMENTS

The customer or the selected manufacturer shall have the use of a dedicated testing facility where temperature and strain simulations can be performed on test samples for the purposes of model formulation.

The Customer shall provide a fibre calibration service (determination of refractive index), the minimum Fibre length for refractive index testing shall be specified by the manufacturer to EirGrid.
DTS units shall have been designed, tested and perform in accordance with IEC 61757-2-2.

As appropriate EirGrid shall be entitled to attend factory acceptance testing of completed or near completed units.

The following list provides a summary of tests that shall be completed at the manufacturer's facility prior to unit acceptance:

- Temperature Accuracy test.
- Temperature Resolution test.
- Temperature Stability test.
- Step Response of the DTS system.
- Long term Temperature Stability test.
- Functional Testing and Final Inspection.
- Spatial Resolution Testing.

Additionally, the following test results shall be made available to EirGrid on request:

- Environmental Testing (temperature stability and optical budget variation with varying instrument ambient conditions).
- EMC testing of complete unit and individual components.
- CE conformance certification.

Any programme of testing or calibration shall be agreed in advance between the manufacturer and EirGrid, a period of 4 weeks' notice is required to permit availability of EirGrid staff.

The test or calibration programs and dates shall be mutually agreed between the manufacturer and EirGrid.

Mechanical and environmental testing shall be in accordance with IEC-60794-1-2.

5.7.20 DTS FIBRE SPLICING

This section describes the requirements for splicing, testing and commissioning of DTS fibres in HV cable systems.

Depending on the cable design, there may be several fibres in one or more tubes. DTS fibre cores shall be handled and spliced with the utmost care as re-work has the potential of being extremely costly.

Documents included in Appendix E are supplementary to this Specification and should be read for informative purposes to assist the Customer with understanding the requirements of this Specification fully.

5.7.21 TRAINING AND QUALIFICATIONS

Splicing shall only be undertaken by appropriately qualified personnel having the following requisite skills and training:

- HV Cable Manufacturer fibre specific training.
- Minimum of one-year experience of external Single Mode fibre network jointing in Telecoms/Power/ Rail Transport industries with relevant industry training.

Testing personnel shall hold the following requisite skills and training:

- CFCE or equivalent industry certification for Testing and Commissioning of Single Mode Fibre Systems. Testing and commissioning shall be carried out and certified by a person or subcontractor other than the installation and splicing technician or subcontractor.
- Minimum of three years' experience in Telecoms/Power/Rail Transport with relevant industry training.

5.7.22 TOOLS AND EQUIPMENT

Tools and equipment shall be certified and suitable for the intended task.
Specialised / Bespoke tools shall be used where specified or otherwise deemed appropriate.

Splicing shall be by fusion arc machine and associated precision cleaver. Mechanical splicing shall not be acceptable.

Where specialist equipment such as splicing machines, OTDRs and test/recording equipment is operated on battery power, spare batteries shall be charged and available.
All equipment shall have a valid calibration status.

5.7.23 SITE CONDITIONS

DTS fibre splicing shall only take place in dry, low humidity conditions. Moisture ingress in the joint will reduce operating lifetime and may be detrimental to the in-service performance of the fibres. Suitable measures shall be taken to keep moisture (condensation, rain etc.) out of the splicing area during set-up preparations and splicing.

5.7.24 TRANSPOSITIONING OF DTS FIBRE

Where the High Voltage Cable is transposed along the cable route, for instance cable routes laid in flat formation, the DTS is required to monitor the temperature of the fibre optic cable on the middle phase. This means the DTS fibre must be transposed to the middle phase at each jointing location along the route.

The cable accessory manufacturer shall furnish the splicing contractor with detailed instructions on the method for transposing the fibre. A risk assessment and method statement shall be produced by the Customer and furnished to the EirGrid 2 weeks prior to works beginning on site.

5.7.25 Preparation and Splicing of DTS Fibres

All fibre related operations and activity shall be strictly in accordance with manufacturer's specific instructions.

Stripping, prepping and splicing of fibres, mounting of protectors and storage of fibre loops in raceways and placement and fixing of joint enclosures shall be strictly in accordance with manufacturer's approved documented procedures, instructions and drawings.

Splicing shall be by fusion arc machine and associated precision cleaver with regard to ITU-T Recommendation L.400.

Mechanical splicing is not acceptable.
All fibre cores in the cable shall be spliced through end to end except where otherwise specified by a Transposition or Breakout Joint Configuration Instruction.
No fibre core shall be left 'Stumped' in any joint except where otherwise specified by a Breakout Joint Configuration Instruction.

'Dis'/open circuit cores or Faulty/Out of Limits splicing shall not be acceptable. Random/Cross core splicing shall not be acceptable. Microbends shall not be acceptable. Splicing Losses shall comply with the limits set out in 'Acceptable Results' below.

5.7.26 Testing

All cores shall be tested at 1310 nm and 1550 nm in both directions, A>B and B>A.
Fibre testing shall be by OTDR and 1 km launch lead.

ILM measurements shall also be made where the completed link includes connectors. Inspection & Cleaning shall be undertaken in compliance with latest edition of IEC-61300-3-35.

5.7.27 Drum Testing

DTS fibre cores shall be optically tested for manufacturing faults/transportation damage to the fibre cores at the point of delivery/collection from Supplier.

Each fibre core on the drum shall be examined at 1550 nm to determine full continuity over the drum length. Testing shall be via the exposed tail end. The results shall be tabulated using the test sheets provided in Appendix E, signed by the Engineer.

These results shall be included in the safety file pack and issued to EirGrid for review. The file shall be saved in a folder with the following name format:

[PROJECTNAME][DRUMIDENTIIERCODE][TESTLOCATION][DDMMYY][TESTERNAME][ORGANISATION]

Discrepancies shall be verified and immediately notified to EirGrid.

5.7.28 In-Construction Testing

A-B and B-A tests from remote bare ends shall be performed to verify integrity of splicing per joint bay. Results shall be stored in removable, write protected electronic media in the

format given below and make a separately stored back-up copy.

All splices shall be measured in both directions, i.e. A-B and B-A at both 1310 nm and 1550 nm and shall be verified following completion and sealing of the joint closure and prior to completion of works at the joint bay. Any re-splicing or re-dressing shall be undertaken immediately and shall be re-tested in situ. This testing shall be repeated following backfilling of the joint bay.

The In-Construction Fibre Test Reports shall be filled as shown in Appendix E of this Specification. Reports shall be submitted to EirGrid and shall be store on site during jointing activity for inspections on site.

5.7.29 Testing of completed link

All fibres in the completed link shall be tested and certified between the designated project responsibility demarcations (Terminal joints, tails, connectors or ODF).

Losses shall be better than 0.30 dB Average per Splice. Average shall be calculated as:
(Actual Measurement Loss A to B) + (Actual Measurement Loss B to A) ÷ 2
Individual directional splice losses of between 0.15 dB and 0.3 dB may be permissible where the calculated average does not exceed 0.3 dB however this shall be subject to derogation only in specific circumstances following notification to, and investigation by EirGrid.

Microbends are not acceptable.

The total link loss per core shall be determined as follows:

Link Loss (dB) = fibre loss + splice loss + connector loss (where connectors are included in the project).

Maximum fibre link attenuation shall not exceed 0.37 dB/km at 1310 nm and 0.22 dB/km at 1550 nm. If these values are not achieved, then the Customer shall propose remedial action, up to and including excavation at joint bays and re-working of the fibre optic splicing. The proposed remedial action shall be submitted for the EirGrid review prior to any remedial action being carried out. Remedial shall be at the Customer's expense.

Where applicable, maximum individual bidirectional connector loss shall not exceed 0.5 dB.

5.7.30 Recording

Submitted Test Results shall be recorded in Belcore format .sor file type,

[Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
A comprehensive Test Report showing Calculated Averages at both 1310 nm and 1550 nm for each fibre core shall be presented as follows for EirGrid review:

[Origin_id][End_id][Cable_id][Fibre_number][Lambda][Direction][Report]

Origin and End designations shall be the relevant joint bay numbers or cable ends.

5.7.31 Photo Recording and Records

A digital photo record of each fibre joint module and raceway sub-assemblies clearly demonstrating compliance with manufacturer's instructions shall be made and stored in removable electronic media in a unique folder name format:

[PROJECTNAME][JOINTBAYNo.][EnclosureSERIALNUMBER][DDMMYY][OPERATORNAME][ORGANISATION]

Sample of these photos shall also be included in the weekly report and the DTS photo book shall also be included in safety file pack.

Test results and records shall be submitted in the format specified in Appendix E to this Specification to EirGrid for review.

Two full copies of the results shall be submitted and stored in separate, removable, non-volatile write/wipe-protected media. One copy shall be retained by the Customer, the other is to be certified and submitted to EirGrid for analysis prior to Commissioning of the DTS fibre system.

5.7.32 Quality Control and Acceptance for Service

All cores shall be spliced through to give full end to end connectivity within the limits specified herein. Any non-compliance shall be corrected to specification prior to energisation of the link.

5.8 Communication Fibre Optic Cable

Communication Fibre cable requirements described in this document do not account for Customer communication needs between the OSP and the Customer control room/control centre in the OCC or elsewhere. The Customer should calculate and design the additional number of pairs needed for their own communication requirements and consider these in addition to the number of optical cores required for the EirGrid systems.
The optical fibres shall be single mode and conform to the requirements of ITU-T, recommendation G.652, Table 4/G.652.D. Fibre cores shall be contained in thixotropic gel in loose tubes arranged as 4 elements containing, at minimum, 12 optical cores (= 48 fibres); the Customer shall ensure the number of opital cores in the communication fibre cable match the EirGrid requirements. Fibre cores and loose tubes to conform to colour code EIA598-A. UV colour coding is not permitted. The tube arrangement may include fillers where required for mechanical stability. The fibre cable shall be designed and constructed for conventional installation in underground ducting and feature the following properties:

- All Dielectric construction.
- UV proof black HDPE outer jacket.
- 2no. ripcords.
- Glass layer rodent protection.
- Water blocking layer.
- Central strength member
- Sheath Marking to include: “Optical Cable”, Manufacturer and product identification, manufacturing date, metre marking.

5.9 Pulling Eye

A pulling eye shall be fitted to the leading end of the cable. This shall be designed and installed so that the pulling forces during installation are transferred to the conductor. The pulling eye shall be completely watertight, with a full metal seal. The pulling eye shall be capable of remaining watertight during cable pulling. The diameter of this pulling eye shall be as small as possible over the diameter of the cable to facilitate pulling into ducts.

The pulling eye arrangement shall be a design which facilitates sheath testing of the cable, without having to remove the heat shrink sealing, whilst on onsite on the drum.

This shall be achieved by connecting the metallic sheath or screen wires to the main conductor at the back of the pulling eye.

The Customer shall provide details of the pulling eye to EirGrid for review.

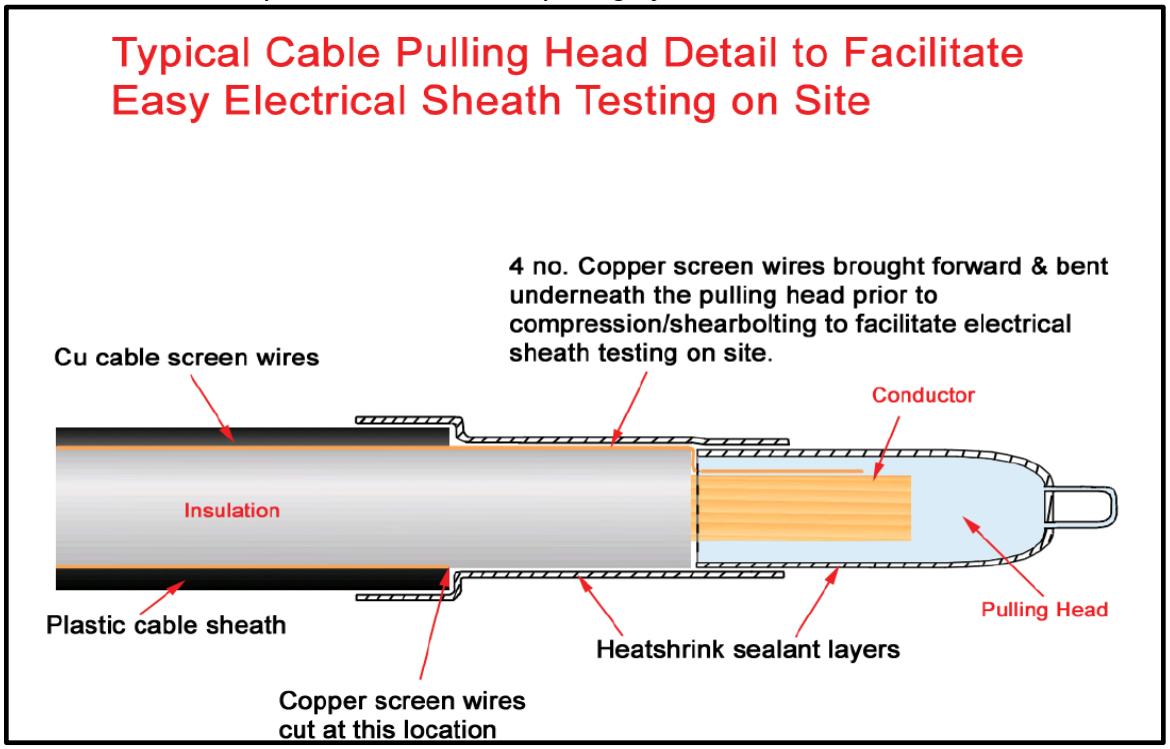

Figure 1 Typical Cable Pulling Head

5.10 Manufacturing Process

5.10.1 General

The process of product manufacture shall at all times ensure that sufficient and adequate quality checks are carried out to determine compliance of design and component material with established criteria.

For Manufacturer service experience requirements please refer to section 6.1 of this Specification.

5.10.2 Handling of Manufacturing Process Deviations

Deviations from these criteria or any occurrence of manufacturing process deviation shall be notified to EirGrid.
Any repair joints due to incidents during manufacturing and load-out shall be investigated and the root cause analysis report shall be provided to EirGrid for review. Depending on the cause of the incident and the probability of reoccurring of the issue the cable may need to be replaced.

5.10.3 Prequalification Inspections

EirGrid shall retain the right to carry out prequalification inspections on all of the Customer's proposed material suppliers. In the event that EirGrid is not satisfied with any supplier, then that supplier will not supply any material for the project.

5.10.4 INSPECTIONS DURING MANUFACTURE

The Customer shall submit a test programme to EirGrid and shall give at least four weeks' notice of scheduled routine and sample tests.

EirGrid shall retain the right to carry out inspections during manufacture on all of the Customer's proposed material / equipment suppliers.

5.11 TESTS

5.11.1 TYPE TESTING

The Customer shall submit a programme to EirGrid showing dates of all Type testing. EirGrid will retain the right to witness all type tests.

The Customer shall submit the results of all type tests to EirGrid for review. The type tests submitted must be those pertaining to the cable, fibre and accessories to be installed.

All materials shall be tested to confirm the suitability of the supplier's design. All type testing shall be in accordance with IEC 62067 and fibre testing in accordance with IEC 60794 and IEC 61300.

Type Tests on the fibre optic element shall be carried out in accordance with ITU G.252 and IEC 61300.

The Customer is responsible for all costs associated with type testing. In the event of material not meeting the specified requirements, the Customer shall be responsible for all costs associated with redesign and material replacement including those incurred by EirGrid.

5.11.2 ACCEPTANCE TEST AND INSPECTION

The Customer shall submit a programme to EirGrid showing dates for acceptance testing. EirGrid shall retain the right to witness acceptance tests and on all proposed material / equipment deliveries.

The Customer shall submit the results of all acceptance tests (i.e. Routine, Sample Type and Special Tests if applicable) to EirGrid for review. Acceptance tests and inspections shall be carried out before delivery of any material / equipment from the manufacturing plant. The Customer is responsible for all costs associated with acceptance tests and inspection.

In the event of material / equipment not meeting the specified requirements, the Customer shall be responsible for all costs associated with material replacement, including all associated costs incurred by EirGrid.

Records of all tests carried out as requested in this Specification shall be submitted to EirGrid for review.

All routine, sample and type tests prescribed by this Specification shall be carried out at the expense of the Customer and to the satisfaction of EirGrid functional requirements, who may elect to have representatives present at any of the tests specified, at a time and date to be mutually agreed.

5.11.3 ROUTINE TESTS

Routine tests will be carried out on the cable in accordance with IEC 62067.

All fibre elements in the cable shall be OTDR tested with no exceptions and shall be witness

tested. Further, a provision for OTDR testing shall be available on the drum, i.e. the same as the sheath testing point. This shall be required for confirmation testing once it has arrived on site, pre-pulling.

Routine test reports shall be provided to EirGrid for review.

EirGrid may send a representative to the factory during the manufacturing of any or all of the cable lengths involved.

5.11.4 Sample Tests

Sample tests will be carried out on the cable in accordance with IEC 62067.

In addition to the test specified in IEC 62067 the cable's water blocking ability shall be tested by applying a 1 metre head of water over an 11-day period; no water shall issue from the 4 metre cable sample at room temperature as specified in BS EN7912-2. This test shall be undertaken as a sample test, once per production run or as agreed between EirGrid and the Customer.

Sample Tests on the fibre optic element shall be carried out in accordance with ITU G.252 and IEC 61300.

A test shall be undertaken to ensure that the surface conductivity of the outer sheath graphite or extruded semi conductive layer is less than or equal to 16 ohm / metre at ambient temperature. This test shall be undertaken on the first and last drum of each production run. Sample test reports have to be provided to EirGrid for review.

5.11.5 Type Tests

Type tests shall be carried out in accordance with IEC 62067.

For the electrical tests, the cable length shall be fitted with one of each type of accessory, joint, or sealing end to be supplied. Type test certificates shall be provided to EirGrid for review for the cable and associated accessories. Where type tests have not been undertaken for this material or the material tested is not the same as what is proposed to be installed then EirGrid will decide on whether additional type testing is required or not.

5.11.6 Requirement for Pre-Qualification Tests

Pre-qualification certs shall be submitted to EirGrid for acceptance. Where documentation is not readily available, all pre-qualification tests shall be carried out in accordance with IEC 62067 and CIGRE Technical Brochure 303 and witnessed by the EirGrid's representative.

6 Cable civil Works

6.1 General

All trenching, ducting, cable installation and backfilling works will be carried out in accordance with the latest Safety, Health and Welfare at Work Acts for Construction and General applications. The required trench and duct layout shall be as per the required detailed cross sections shown in the relevant drawing listed in Appendix A of this specification. Installation works should not contravene manufacturer recommendations, in case of conflicts with EirGrid requirements the Customer shall engage with EirGrid to discuss the topic, EirGrid will provide clear directions.

All roads will be permanently reinstated to the specification of the relevant authority.
The trench shall be as level as possible in both directions.

The Customer shall submit cross section details of where the trenching works cross other services.

The spacing of the cable / ducts shall be at a minimum, in accordance with the requirements of the drawings in Appendix A of this specification.

For safety, constructability, maintenance, and de-rating reasons the new cable duct routes shall be designed / installed as far as is practical away from existing services (3rd parties services and HV/MV/LV cables).

When changing the grade of the trench to accommodate crossing other services, the grade change shall be as shallow as possible and not more than 1:6.

The following material shall be used in accordance with Appendix A standard drawings:

- Approved EirGrid Yellow marker warning tape,
- Approved EirGrid Red cable protection tape,
- Approved steel plates with red protection tape attached,
- A393 steel mesh,
- Duct ties every 3m when duct formation is trefoil,
- Approved marker posts where cable is in private land in accordance with Appendix B of this Specification.

Details are to be agreed with EirGrid in advance of installation.

EirGrid personnel are available to provide a trenching and ducting workshop to the Customer before the start of the civil works upon request.

6.2 INSTALLATION RECORDS

For duct and joint bay installation works the Customer shall take good quality photographs of the trench and installed duct work materials at 10 metre intervals along the cable route with data logged with GPS coordinates.

At all third-party service crossings, bridge crossings, couplers, joint bays and special features of the underground power cable route, additional photographs of special or non-standard construction shall be taken demonstrating compliance with the EirGrid functional design and specifications. These photographs shall be organised in a systematic manner (sequentially numbered) identifying the location using GPS co-ordinates that the photograph was taken and uploaded weekly on a dedicated folder on the EirGrid project extranet site.

These quality assurance records are vital during the construction works in order for the Customer to demonstrate compliance with the design and the EirGrid functional specification.

6.3 DUCT MANUFACTURER SERVICE EXPERIENCE

The duct manufacturer shall have:

- At least 10 years' experience in the production of the range of the ducts and fittings specified i.e. the "product'',

- Service experience:
  - Installation of the product in at least one EU electricity utility
  - With a service experience of the product range of at least 5 years duration in three EU electricity utilities of at least 1,000,000 metres.
- As an alternative to such experience within the EU, similar experience with UK, Japanese, South Korean, Australian, or US/Canadian utilities would be considered.

At least 5 years production in the proposed factory is required. However, in the case where a particular proposed factory is a relocated existing factory and the workforce remains substantially the same as in the preceding manufacturing facility, then the combined period of experience of both manufacturing facilities will be taken into consideration by EirGrid.

6.4 DUCT SERVICE CONDITIONS

The following service conditions apply to ducted underground cable installation:

Table 4 Duct Service Conditions

Service Condition	Requirement
Soil Temperature Range	-5 ºC to 20 ºC
Continuous Heat Generation within duct	up to 30 Watt/m run.
Temperature Range	0 ºC to 70 ºC (within duct)
Soil pH range	1 – 11 (Acidic Bog – Limestone Rock)
Ground water table level	Up to 0.5 m above duct level (worst case scenario) under normal conditions. under normal conditions.
UV Light Exposure	During handling & storage up to 1 year

6.5 MATERIALS

Material for duct bed and surround and trench backfill for standard formation shall be CBGM B (CL 822) Compacted to CL.813.10 and Table 8/4 of T.I.I. Specification for Roadworks (15 N/mm² after 7 days). The material should conform to the thermal resistivity requirement of this specification. Proof of conformance to the thermal resistivity requirement of this Specification in accordance with ASTM D5334-08, (namely 1.0 K.m/Watt) at 0% moisture content, is required during duct installation.

Proof of conformance to the thermal resistivity requirement shall be provided for at least every 500T of concrete mix installed, or as requested by EirGrid.

Concrete for road reinstatement shall be grade C32/40 with minimum cement content 350 of kg/m3 in accordance with Series 1000 of the TII “Specification for Road Works”.

Concrete used in the trench for third party service crossings and bridge crossings shall be grade C25/30, wet type, in accordance with Series 1000 of the TII “Specification for Road Works”.

Pea gravel and foam concrete shall not be used for duct surround material.

Concrete for joint bay, link boxes and communication chambers are specified in the relevant standard drawing in Appendix A.

Formed finishes to Joint Bays shall be to class F2 and unformed finishes shall be to class U1 in accordance with Clause 1700 of Series 1000 of the TII “Specification for Road Works”.

6.6 SAND

Thermal Sand is used to backfill around HV cables and joints, usually in the following locations: HV cable joint bays, transition chambers and on approach to Cable Sealing Ends. EirGrid maintains a list of pre-approved suppliers across Ireland. New suppliers are added regularly upon completion and passing of the tests set out below.

The thermal sand shall meet the requirements set out herein and in ENA Technical Specification 97-1 (latest Revision) section 6.1 (if there is any discrepancy between the two specifications then this Functional Specification shall take precedence).
There are 3 main criteria for the thermal sand.

- It shall have no sharp stones or flints as these may damage the cable sheath during compaction.
- At least 95% shall pass a 4 mm sieve and 100% shall pass an 8 mm sieve.
- The fully dried sample @ 0% moisture shall have a maximum thermal resistivity of 2.7 K.m/W. This test must be completed by the thermal needle probe method as outlined in ASTM D5334. The thermal resistivity @ 2% moisture shall also be recorded.

The Customer shall, before material is delivered to site, select random samples of the sand that is proposed to be used (the sample shall fall within the above grading, and subject them to testing for thermal resistivity, particle distribution and dry relative density all at his own cost and submit the following information to the EirGrid for review prior to commencement of the Works:

- The source or sources of the material
- Certificates of Compliance with the specified grading limits
- Thermal resistivity test results demonstrating the ability of the material to meet the above criteria

After a suitable thermal sand source has been reviewed it is important that the quality of the sand delivered to site from that source is consistent with the sample that has been provided for review. Proof of conformance to the thermal resistivity requirement specified herein of the thermal sand used in Joint Bays and used in the approximately five metre direct buried section before Cable Sealing Ends may also be requested by EirGrid at any stage during construction.

6.7 REPORTING REQUIREMENTS

All works shall be continuously supervised by a competent person acting on behalf of the Customer and detailed weekly reports shall be submitted to EirGrid containing photographic evidence and matching GPS co-ordinates of where work is taking place throughout the duration of the works.

The weekly reports shall be submitted no later than 5:00pm on first working day of the week for the previous week’s work.

The detailed weekly report shall include the following information:

- Map of the entire route showing the sections being worked on for that period.
- Map showing the section from joint bay to joint bay being worked on that week. This map shall highlight the completed works the previous week and the works scheduled for the coming week at the time of writing and shall show the location of all service/culvert crossings and they shall be shown appropriately sequentially numbered.
- A brief summary table.

Photographic evidence of the work completed during the week under review, displaying the following:

- All photos shall be taken in sequence in the direction of work from joint bay to joint bay so that the installation process can be clearly seen.
- The sequence of photos shall cover the entirety of the ducting works and shall be taken at suitable intervals (10 metres approximately). GPS co-ordinates should be provided for each photo. Photos shall be geotagged.

The photos shall show the various sequences of work so that each stage of the installation process can be seen. Predominantly but not exclusively the photos shall be taken after the trefoil/flat power ducts are installed (prior to backfilling with CBGM B) and again prior to backfilling the layer of communications ducts. The photos shall display all the elements necessary to confirm that the quality of the ducting installation is of a high standard, this includes but is not limited to showing clean trenches, proper spacer templates, correct depths of CBGM B, the compaction equipment being used, correct positioning of ducting and marker tapes, clearances etc.

Photos at service/culvert crossings shall be referenced to that crossing number and display all the necessary information to confirm that the installation meets the required clearances and design. Photos of service crossings (under/over) shall clearly display that the minimum clearances are being achieved (using a measuring tape) and the extent of additional protection measures where required.

Where services are replaced such as stone/piped culverts, a series of photos shall show the extent of the works carried out at those locations.
A summary of the quality testing completed for the week which may include compaction tests, delivery dockets, cube tests which clearly specify type of concrete used etc.

Surveyed levels of the monitoring stations along the deep peat/top hat design sections (where applicable).

6.8 DUCT REQUIREMENTS

6.8.1 DUCT SPECIFICATION

All ducts and couplers shall be supplied by the Customer. All ducts shall satisfy the criteria specified in this section.

All ducts and fittings shall be designed to satisfactorily withstand the service conditions specified in Table 5 for a period of at least 40 years.

All ducts shall be clearly labelled as being used for electricity or communications cables including ownership of the installation.

6.8.2 Duct Testing Requirements

Testing of duct products shall be required to demonstrate that the ducting is capable of performing satisfactorily over the expected service life and under the specified service conditions.

All duct products shall pass the programme of impact tests and deformation tests as set out below:

- 200 Joule of impact energy measured when the duct temperature is 15–20-degree C.
- The impact test hammer head dimensions shall be as stated in IEC 61386-24.:
- Deformation resistance shall be greater than 750 N at 5% when measured in accordance with IEC 61386-24.

Type or Sample Tests in accordance with other equivalent National or International Specifications or standards may be acceptable with the prior agreement of EirGrid. Certification shall be required to show that the ducting has passed Type and Sample Tests in the Specifications outlined above and conforms to the Test requirements set out in this Specification.

EirGrid shall have the right to inspect work, which is the subject of this Specification at any stage of manufacture and may reject any material which is found to be defective or in any way not in conformity with this Specification. The Customer shall afford all reasonable facilities for such access and inspection. The Customer shall bear the cost of all sample tests.

The Customer shall supply without charge all tools, gauges and other equipment which shall be required for testing the material in accordance with the Specification and shall prepare and supply without charge all test pieces and samples associated with the tests required by this Specification.

6.8.3 Bendability and Weldability of Ducts

Ducts shall have good bendability characteristic so the need for preformed bends is reduced as much as is possible and they will be easy to work in confined trench situations.

When ducts are bent, they shall not deform or kink for an excessive ovalisation, the mandrel shall pass through the ducts even when they are bent.

Ducts of SDR11, used for particular applications, shall be fully weldable. The ducts manufacturer should produce instructions for welding, and these shall be submitted to EirGrid for review and they shall be strictly adhered to during construction activity.

6.8.4 Ducts Packaging design

Normal handling and transport impact loads shall be considered in duct packaging design.

6.8.5 Frictions of Duct wall

When pulling in heavy power cables the achievement of the lowest possible frictional drag between the cable surface and the internal duct wall is fundamentals shall be less than 0.2. This will reduce cable tensile and sidewall forces reducing the number of cable joints in the cable circuit.

The internal surface of the duct shall be designed to minimise the static and kinetic friction with the cable surface.

HV cables used in the Irish transmission system shall have polymeric outer plastic PVC, LDPE, LLDPE, MDPE or HDPE sheaths of 1.8 – 3 mm thickness. The sheaths can be damaged by abrasive contact with rough surfaces and this could lead to subsequent failure of the power cable, for this reason a high level of smoothness of the duct inner surface with a low friction coefficient is very important.

6.8.6 Ovality and Diameter Tolerances

The ovality, that is the deviation from perfect circularity, of coilable and non-coilable ducts shall comply with the limits specified in the table below

Table 5 Ovality and Diameter Tolerances

Nominal Diameter	Diameter Tolerance		Maximum Ovality
mm	Positive mm	Negative mm	mm
≤ 160	1.0	1.0	2.0
> 160	1.5	1.5	3.0

6.8.7 Duct colour and lengths

All ducts shall be coloured red in accordance with IS 370. The red colour designation is BS 5252:04-E-53 – BS 5252:04-E-56. A minimum of 0.3 mm thickness of the red coloured material is required throughout the length of the duct in the case of triple layer extrusion.

All ducts shall have a standard length of 6 m, 9 m, or 12 m. Longer coilable lengths can be used in the case of Horizontal Directional Drill installation.

6.8.8 Duct Marking

HDPE ducts shall be indelibly and clearly marked in white or black with the legend:

- “DANGER ELECTRICITY CABLES”
- EirGrid High Voltage cable
- Batch No
- Manufacturers Name and Date of manufacture
- Impact test, i.e. “200 J”
- Duct Diameter
- Duct SDR value, i.e. “SDR 21”

Coils used for Horizontal Directional Drilling shall be consecutively marked on the metre at every metre.

Maximum gap between two adjoining legends shall be less than 150mm.
The height of the text font shall not be less than 20 mm and the legend shall be written in three lines at 120° apart.

To ensure that the end of the ducts is pushed fully into position at coupler positions a visible circumferential mark coloured black is required at the plain end of the duct to indicate the correct duct penetration distance.

For ducts to be installed in Horizontal Directional Drilling installations the black, visible, circumferential line shall identify the final installation position within the reducing couplers. The black line shall be indelible and shall be resistant to UV light degradation.

6.8.9 DUCT COUPLER

Ducts and their associated couplers shall be designed as an integral system.

Coupling systems shall provide a smooth junction between adjoining duct lengths. Coupler designs which result in distortion of adjoining duct lengths; edge protrusions or inadequate centralising of adjoining duct lengths shall not be accepted owing to the risk of:

- Cable damage.
- Necessity for additional unplanned cable joints.

The coupler design shall:

- Allow manual alignment and assembly for duct lengths of up to 12 m in confined trench bottom conditions without recourse to specialist tools, by installation staff.
- Prevent duct-coupler loosening due to vibration during backfilling operation.
- Prevent ingress of water even where ducts may be buried up to 3 m below water level.
- Prevent ingress of water/slit/grit where ducts are bending away from the coupler, at a bend angle of up to 4°
- Eliminate the possibility of grit or other sharp particles ensconcing themselves into any wells or crevices at the centralising stop of PE couplers, particularly during brushing and duct cleaning operations.
- Withstand the bending forces experienced during normal duct laying operations e.g. assembly and coupling of ducts at ground level and dropping into the trench as the excavated trench section moves along.

For 125 SDR 17.6 and 200 mm SDR21 PE ducting, the coupler shall withstand the bending forces required to bend the HDPE duct section to a radius of 6 m.

All couplers shall be tested for their capability to withstand these bending forces by clamping them in position and subjecting them to the bending forces involved using a length of 125 mm / 200 mm HDPE ducting as appropriate.

The minimum dimension between centre of coupler and midpoint of gasket seal for such couplers shall be:

- 130 mm for 125 mm duct size
- 160 mm for 200 mm duct size

A durable indelible label shall be affixed to each coupler with the inscription in large legible print “Always lubricate coupler with approved compound”.

6.8.10 POLYETHYLENE REDUCING COUPLERS

Ducts of SDR11 are used in Horizontal Directional Drills (HDD). HDD designs are bespoke designs where ducts of SDR11 may be installed in separate bores or multiple ducts may be installed in a single bore. Regardless of the HDD arrangement, every HDD is expected to

eventually transition to a standard trench arrangement.

Preferred method for transition is to use transition couplers. These transition couplers shall match the internal diameter of the two duct types to each other without the need for any transition chambers.

Since the safety/security of the power cable is of the utmost importance in all duct installations, the inner diameter (ID) of the two duct types shall be flush together so that no sharp edges will be present inside the transition coupler. The ID of Duct Type 1 (on the HDD side of the coupler) shall match the ID of the corresponding Duct Type 2 (on the Trench side of the coupler) to within 1 mm.

The duct sizes to be matched together are shown in Table 7 as Duct Type 1 and Duct Type 2. The SDR11 value may be altered slightly to accommodate this requirement. Adjusting SDR21 or SDR17.6 ducting is not permitted, outside the normal thickness range for SDR21 or SDR17.6.

Table 6 Matching Duct Sizes

Duct Type 1 (HDD)	Duct Type 2 (Standard Trench)
225 mm SDR 11 HDPE	200 SDR 21 HDPE
140 mm SDR11 HDPE	125 mm SDR 17.6 HDPE

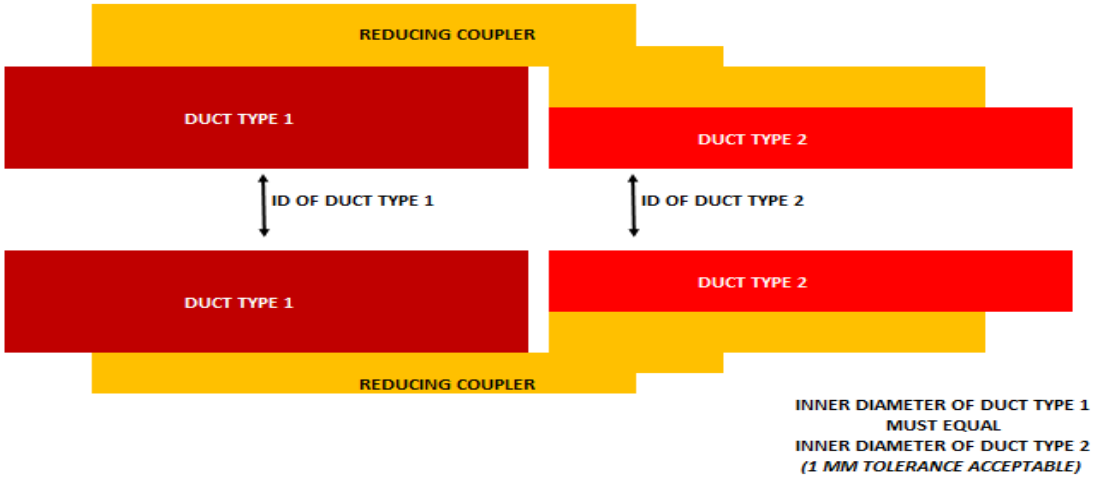

Figure 2 Reducing Coupler Configuration I

The inner diameter of Duct Type 1 must be the same as the inner diameter of Duct Type 2 to within a tolerance of 1mm.

Where Duct Type 1 and Duct Type 2 meet inside the reducing coupler, it is important that the centre stop position is kept free from dirt, silt or any other debris that may fall into the crack during duct cleaning/proving or cable pulling. In order to do this, both Duct Type 1 and Duct Type 2 should be marked for insertion depth so that no gap occurs. The insertion depth will be dependent on the design of the reducing coupler but shall be of equal length on both sides and must match the standard insertion depth as marked on the associated ducts The reducing coupler shall be designed such that the two duct types can be inserted flush together, reducing the gap to zero. The ring seal on both ends of these reducing couplers should be the same as is used on the standard straight duct couplers, providing a watertight and secure connection to the duct.

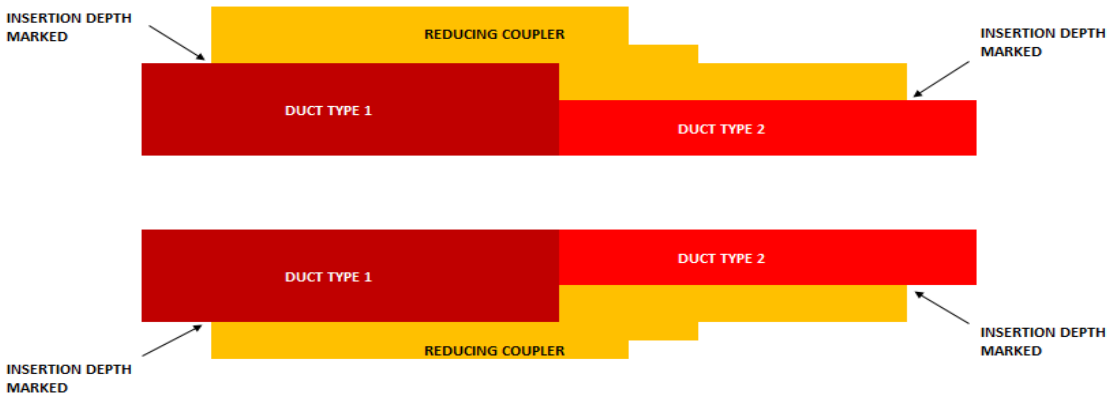

Figure 3 Reducing Coupler Configuration II

Transition Chambers can be used as an alternative to reducing couplers. Three SDR11 ducts would normally enter the Transition Chamber on one side and three standard ducts would normally be positioned on the opposite side of the chamber, to allow for the Trench arrangement. See standard transition chamber drawing in Appendix A.

Communication / ECC ducts do not strictly require transition couplers or chambers. The 125mm OD SDR11 could be coupled directly to 125mm OD SDR17.6 by chamfering the internal surfaces of the SDR11 duct (4mm chamfer over 15mm distance). Prior to connecting the communication HDD ducts (SDR11, 90mm diameter mandrel) to the standard communication ducts (SDR17.6, 105mm diameter mandrel) each section shall be proved independently. The communication ducts can be proved from C2 chamber to C2 chamber at either side of the HDD section with a 90mm mandrel.

6.8.11 DUCT HANDLING AND STORAGE

Great care shall be taken while handling ducts to avoid damage. Ducts shall be delivered with caps in place and shall remain in place until installation of the duct to prevent ingress of dirt.

On delivery of ducts to site, the Customer shall check that they comply with the specification, in respect of wall thickness, internal and external diameter along full length and straightness etc.

The ducts shall not be stored in places where they are likely to be in contact with surface water or other foreign matter which could make its way into the ducts. The method of stacking for storage shall be such as to avoid distortions of the ducts. The integrity of the ducts shall be maintained throughout their site storage and transport. The bales of ducts shall not be stacked more than two bales in height.

Duct bales shall be held in position by an appropriately designed system of timber battens and straps.

This design shall ensure ducts are not deformed during handling and transportation. Collapsed bales are a safety hazard; this hazard must be avoided in the design.

Indelible waterproof labels are to be placed on each bale of ducting stating ‘‘Approved for EirGrid use’’ and laminated installation labels (in size A4) are to be fixed to each bale of ducting.

The Customer quality assurance management system shall include detailed inspection of delivered ducts and accessories. Each delivery of ducts shall be inspected to ensure compliance with this specification to verify the following:

- Correct labelling;
- Correct dimensions of wall thickness;
- Duct ovality.
- Duct damage and distortion.
- Duct caps are installed;
- Correct packaging.

Ducts which have become discoloured or deformed shall be marked as defective and not suitable for installation. They shall be discarded and not installed under any circumstances.

6.8.12 Duct Installation

Each duct, coupler and joint shall be carefully examined for structural integrity and cleanliness immediately before and after installation.

Ducts shall be spaced in accordance with the drawings listed in Appendix A. Compliance with these drawings may not always be possible due to spatial constraints and in such cases, clarification should be sought from EirGrid prior to any ducts being installed.
Ducts shall be laid evenly to minimise gradient changes where possible.

If a change in direction is required, bends shall be formed by evenly bending the ducts only and the couplers shall be braced as to avoid bending or placing stress on the coupler. Pre-formed short-radius bends are not permitted, unless agreed with EirGrid and cable manufacturer.
For HV ducts, the bending radius shall not be less than 6 m. In order to avoid damage, no heat shall be applied to the ducts when joining and/or bending ducts together via couplers. The Customer shall ensure that couplers are staggered to ensure that pressure is not placed on a single point across 3 phases.

The diameter of the cable ducts shall be the same throughout the cable route. Transition from one duct size to another which may create a “lip” which could damage the cable sheath on initial installation of the cable or over the lifetime of the cable due to thermal effects / movement of the cable on the “lip” is not acceptable.

Every effort shall be made to prevent dirt ingress into the ducts. Duct caps shall not be removed until the duct is laid in the trench. Once installed any exposed ends shall be capped with waterproof caps at the end of each day’s work and at each joint bay.

Where the ducts enter into the joint bay (i.e. joint bay interface), appropriate waterproof sealing shall be applied.

Proprietary expanding duct bungs shall be installed at the end of each duct laying section.
Note: Dirt or pebbles trapped in the ducts can cause significant damage to the cables if not removed. During cable pulling, dirt or other sharp objects can be pressed between the duct and the cable resulting in deep scores and gashes on the cable sheath which can later result in cable failure.

6.8.13 Use of Templates

Timber templates shall be used for duct installation. The template shall have the correct dimensions to achieve the required duct formation as per the construction design. Multiple templates will be required for the several types of formations as part of the cable construction design.

Duct installation templates shall be used every 3m or less to ensure the required spacing between ducts is achieved.

When dry or wet concrete surround is used concrete duct spacers shall be used. The spacers shall be made of the same type of concrete the is being used in the trench. They shall be left in situ after pouring.

6.8.14 Draw Ropes

A 12mm polypropylene draw rope shall be supplied by the Customer and installed in all ducts to facilitate pulling in the cable.

The draw rope shall be fixed to the rear of the proprietary duct bung.

6.8.15 Tying of Ducts

Ducts that are to be placed in trefoil formation shall be tied evenly at 3 m centres with an appropriate strap.

6.8.16 Shallow Depth Installation

Where the standard formations, trefoil or flat, trench layout and burial depth cannot be achieved due to the type of terrain or presence of other services (bridge crossings etc) the design shall be in accordance with the relevant standard design listed in Appendix A of this specification.

It is EirGrid preference to cross a 3rd party service with the HV cable trench passing below the existing service. If this solution will impose an unsustainable de-rating of the circuit the option to cross passing above the existing service will be considered by EirGrid.
In any case the minimum shallow trench depth is 450mm from ground level to top of the HV power duct.

6.8.17 Cable Protection - Steel Plates

Galvanised Steel plates having the following dimensions: 750mm long x 200mm wide x 6mm thick with red marker strip fixed to top surface shall be used as shown in the standard drawing for bridge crossing or service crossings installations, refer to Appendix A for drawing reference. The plates shall be installed with 10mm gaps to avoid issues related to possible circulating currents.

A393 steel mesh may be required in addition to steel plates as outlined in the relevant standard drawing.

6.8.18 Surface Cable Plate Markers

Surface cable metallic plate markers with the following dimensions: 300mm long x 150mm wide with four screw-hole and bolts shall be used on footpaths, fences, bridges, walkways as outlined in Appendix A of this specification. They shall be fitted to solid durable surfaces and shall be fitted flush with their surround.

6.8.19 Trench Layout

The trench layout shall be as per relevant EirGrid standard drawings listed in Appendix A.
The specification relating to the relevant Local Authorities shall be followed for the excavation and reinstatement of the ducted cable trenches.

Where a change in the gradient of the trench is required to accommodate other service

crossings or special installations the change shall be as minimal as possible.

Where a change in direction of the trench is required to avoid obstruction, the bends shall be formed by evenly bending the ducts themselves only and the couplers shall be braced so that there is no bending or stress on the couplers. Heating of the ducts is not allowed when the bending action is performed. The spacing of the ducts shall be in accordance with the relevant drawings listed in the Appendix A.

Natural bending in the ducts shall be as wide and gradual as possible.

The duct route shall be designed and constructed to ensure that the cable manufacturer's maximum tensile and sidewall pressure pulling forces shall not be exceeded on the cable when pulled in the ducts. The detailed design calculation to confirm compliance with this requirement shall be included in the design submission for EirGrid review.

6.8.20 JOINING OF DUCTS

When joining ducts using couplers an adequate quantity and quality of lubricant shall be applied to the coupler for ease of fitting.

Ducts shall be tapped home until the black mark on the duct is reached. The duct shall only be tapped into place with a smooth timber or plastic plank to avoid damages. Couplers shall be staggered by a coupler length as appropriate.

6.9 CUTTING OF DUCTS

Where duct cutting is required, they shall be suitably held, supported, and protected during the cutting process.

Ducts ends shall be square to the duct axis. No internal burrs or sharp edges are permitted. Any swarf or debris created by the cutting and smoothing process shall be cleaned out to minimise possibility of abrading cable during pulling.

The Duct plain ends shall be chamfered before being coupled together; all duct ends shall have the outside surface chamfered down to a maximum 30% of the wall thickness. The minimum length of the chamfer shall be 10mm to allow easy insertion into other duct lengths or couplers.

Ducts cutting on site shall be done as per instructions issued by the duct manufacturer.

6.9.1 DIRT INGRESS INTO THE DUCTS

Dirt ingress into the ducts shall be prevented as any dirt or pebbles trapped in the ducts during the cable pulling process may result in deep scores and gashes on the cable's outer sheath which may subsequently result in cable failure. It is not acceptable to allow dirt ingress into the ducts and attempt to remove it later by cleaning the ducts with brushes.
The ingress of dirt into the ducts shall be prevented by the following measures:

- On delivery from the supplier, the ducts shall be fitted with transport end caps. These shall remain in place during duct storage to prevent dirt entering on the duct bales.
- When the ducts are installed, rubber bungs shall be immediately fitted to exposed ends and retained in place for as long as is practicable. These bungs shall be fitted with an internal D-ring to facilitate the tying of the draw rope.
- Trenches, joint bays etc. shall kept free of standing water.

6.10 JOINT BAYS AND COMMUNICATION CHAMBERS

6.10.1 GENERAL REQUIREMENTS

Reinstatement of the cable trench shall be in accordance with the EirGrid requirements, the requirements of the local authority and as per the detailed design that was accepted in advance of the works.

Installation of joint bays and communication chambers shall be in accordance with the relevant standard drawing listed in Appendix A.

Joint bays, communication chambers, link box chambers and any other structures shall be pre-cast concrete.

6.10.2 JOINT BAYS

Joint bay locations shall be chosen where the terrain and access are suitable for facilitating the operation of cable pulling equipment, cable jointing, cable maintenance, fault finding activities and future operation of the installation.

A hard-core surface shall be provided at either end of the joint bay to facilitate access and operation of heavy vehicles required to perform activities listed above.

The construction, final backfill, and pre-cabling backfill, and reinstatement shall comply with the relevant drawings listed in Appendix A of this specification.

Every Joint Bay shall have an earthing system with a resistance ≤ 10 ohm. A typical earth system design is included in the appendix A, but the designer shall consider the type of soil and its resistivity when preparing the construction design. The Joint Bay earth system shall be tested to ensure the earth resistance value is below the max allowed. Step and touch voltages in the area surrounding every joint bay shall be within the limits set up in the Earthing and lighting functional specification in accordance with relevant standards.

The HV cables shall be clamped in position in the joint bays using a suitable cable clamping support bracket.
Cable duct seals capable of withstanding 2 bar pressure, shall be fitted after jointing and termination.

6.10.3 COMMUNICATION CHAMBER

C2 Chambers shall be installed at all joint bays along the cable route.
Communication chambers shall be provided to meet the requirements of standard telecommunication cable drum lengths or as required to limit fibre cable pulling forces.

Communication chamber locations shall be chosen where the terrain and access are suitable for facilitating the operation of fibre cable pulling equipment, fibre cable splicing, fibre cable maintenance, fault finding activities and future operation of the installation.

The construction of the communication chambers shall comply with the relevant drawings listed in the Appendix A of this specification.

6.10.4 LINK BOX CHAMBERS

Link box chambers shall be provided to meet the requirements of the cable sheath earthing and connection design.

Link box chamber locations shall be chosen where the terrain and access are suitable for facilitating the operation of cable sheath earthing and connection, maintenance, fault finding

activities and future operation of the installation.

The link box chamber shall be in close proximity to the Joint Bay so that the bonding leads connected to the joints will be no longer than 10m.

The construction of the link box chambers shall comply with the relevant drawings in the Appendix A of this specification.

6.10.5 LUBRICATION POINTS

Lubrication points may be required to ensure that the cable can be pulled into the ducts without exceeding the manufacturer's maximum permissible cable pulling forces.

Lubrication points shall be installed along the cable route particularly in areas where there are high concentrations of bends.

Optimised positions shall be chosen e.g. on the crest of steep incline to maximise lubricant dispersion on the route. Lubrication points shall be properly sealed to prevent the ingress of dirt.

Lubrication point locations shall be chosen where the terrain and access are suitable for facilitating the operation at any phase of the development and future operation of the installation.

6.11 CONSTRUCTION SUPERVISION

6.11.1 INSTALLATION

The Customer shall submit to EirGrid method statements for the installation of the cable and fibre system for review before any installation work commences on site.

The information shall be provided in sufficient time to allow a full review by EirGrid.

All cable and fibre installation work shall be carried out in accordance with the manufacturer's approved installation methods.

The Customer shall advise EirGrid well in advance of commencement of any installation work so that a representative may be made available to witness the works.

For additional details on installation requirements see applicable installation specifications and standard drawings which form part of the overall suite of documents.

6.11.2 Reinstatement Finishes

The Customer shall agree with the relevant local authority, public body or private landowner as applicable and in advance of the works commencing the requirements for the reinstatement of trenches and the reinstatement of excavations around, manholes and joint bays shall be agreed in advance by the Customer with the local authority, relevant public body or private landowner. The agreed reinstatement details shall be in line with agreements made with planning/ local authorities and/or private landowners and is to be submitted to EirGrid before the works are carried out.

The Customer shall obtain a statement of confirmation from the relevant party that the reinstatement has been completed to their satisfaction. This shall be submitted to EirGrid before the ownership of the circuit is transferred.

The Customer shall advise EirGrid of the programme of cable civil works so that EirGrid can witness installation works. The Customer shall ensure adequate Quality Assurance is performed on site. Weekly reports of duct installation and cable pulling weekly report shall be prepared and submitted to EirGrid during the course of the works.

Report templates to be used by the Customer for weekly installation reports will be provided by EirGrid on request.

All and any excavations and duct installation work may be supervised by an EirGrid representative.

7 Cable Installation

7.1 Cable System Configuration

The arrangements of the cables, their relative position to each other, their surroundings and all methods of installation over the entire route length shall be in accordance with a cable construction system design that is submitted for review to EirGrid in advance of the commencement of the works.

7.2 Prevention of Water Ingress

During the installation (between duct proving and ends of commissioning) the Customer shall maintain trenches left open, joint bays, cable basements etc. free of standing water so as to prevent any risk of the cables and other materials being damaged.

The Customer shall submit all water management proposals to ensure the cable system does not experience any water ingress during construction works (transportation, storage, installation, jointing/termination, and commissioning) and during the cable system lifetime.

7.3 Cable Handling

Care and attention are required in this regard as any mishandling of cable drums may lead to damage of cable or injury to workers or members of the public. Appropriate and safe practices of transportation, loading, unloading and storage on site shall be used at all times.

7.3.1 Transportation

The HV cable shall be delivered to site on steel drums on a drum trailer or on a truck trailer.

7.3.2 STORAGE

All cable ends shall be sealed to stop the ingress of water and future deterioration of the cable. Cable drums shall be stored on hard even surfaces to prevent the flanges from sinking into the ground thereby causing adverse effects to the cable as a result of the drum weight resting on the cable.

Joints, terminations, and link boxes should be stored indoors, in a dry environment until they are required for installation on site.

7.4 CABLE PRE-PULLING REQUIREMENTS

The Customer shall submit to EirGrid for review the following documents before pulling activities:

- Detailed program for cable installation four weeks prior to the start of cable pulling, jointing and termination to allow EirGrid representative to witness site activities.
- Up to date detailed pulling calculation based on as laid route four weeks prior to start cable pulling.
- Design Risk Assessment and Method Statement for cable installation works two weeks prior to start cable pulling.

7.4.1 CABLE PRE-PULLING CHECKS

Prior to cable pulling, the outer coils on the drum of cable that is to be installed shall be visually inspected for any mechanical damage / perforations.

All cable drums shall be checked by rotating the drum and visually inspected for any bumps / perforations or any other signs of damage.

EirGrid shall be advised if any mechanical damage is found. If mechanical damage is identified a detailed proposal shall be submitted to EirGrid outlining the extent of the damage and Customer’s plan to remedy the damage.

All cable shall be inspected in this manner before the cable is pulled. This will reduce the incidence of sheath faults which can be very costly, and time consuming to locate and rectify after the cable is installed.

A 10 kV DC test shall be undertaken to assess the conductive properties as outlined in section 7.9.2.

7.5 INSTALLATION IN COMPLIANCE WITH DESIGN

The Customer shall declare, in writing, to EirGrid that the construction of the works has been completed in accordance with the Design that was reviewed by EirGrid.

7.5.1 INSPECTIONS BY EIRGRID

During the construction of the project, onsite inspections may be carried out by EirGrid’s Client Engineer or agent to check compliance with statutory provisions and the agreed engineering design and / or specifications.

The construction shall be following the design drawings produced / approved by the Customer and reviewed by EirGrid. The design drawings shall be comprehensive and detailed and shall be present for inspection at all times on site.

EirGrid reserves the right to request trial holes or slit trenches be excavated by the Customer on the route of the installed underground cable or ducting section to audit the construction works if there is a doubt as to the quality of the installation in question.

These excavations shall only be required in exceptional circumstances and where the customer proceeded with the construction works without EirGrid's knowledge or without providing EirGrid with sufficient advance notice to allow EirGrid to arrange for an inspector to attend site.

In the event of a non-compliant installation being exposed by the trial holes or slit trenches, any additional investigation work, as deemed necessary by EirGrid shall be facilitated by the Customer.

No cables, joints, terminations, link boxes or fibre shall be installed until the detailed design and EirGrid review process is complete.

A detailed plan and risk assessment shall be submitted if the Customer wishes to commence with cable installation before the civil works for the entire route is complete. The risk assessment and associated control measures shall ensure the cable is adequately protected during works.

The Customer shall propose a cable installation plan for review by EirGrid.

7.6 CABLE INSTALLATION

7.6.1 DUCT CLEANING AND PROVING

Each duct shall be cleaned and proven prior to pulling the cable.

Duct cleaning and proving works shall be completed, and the duct cleaning/proving report submitted for EirGrid review prior to the cable being pulled.

Appropriate notice (>4 weeks) shall be provided to allow EirGrid witness this activity.

The ducts shall be thoroughly cleaned internally to ensure no foreign matter including water remains inside. The ducts shall be cleaned and proved using a clean, stiff brush, mandrel and sponge with diameter as outlined in Table 7 below. A sponge can be used to remove the water from the duct section prior to proving.

Table 7 Duct, mandrel, brush and sponge dimensions

Duct dimensions			Minimum mandrel diameter	Minimum brush diameter	Minimum sponge diameter
OD (mm)	ID (mm)	Duct Type			
125	103	HDPE, SDR 11	90mm	110mm	120mm
125	111	HDPE, SDR 17.6	105 mm	120mm	130mm
140	113	HDPE, for directional drilling duct (SDR 11)	105 mm	120mm	130mm

Duct dimensions			Minimum mandrel diameter	Minimum brush diameter	Minimum sponge diameter
OD (mm)	ID (mm)	Duct Type			
200	181	HDPE, SDR 21	170 mm	187mm	197mm
225	183	HDPE, for directional drilling duct (SDR 11)	170 mm	187mm	197mm
250	221	HDPE, SDR 21	210 mm	230 mm	240mm

The cleaning and proving of the ducts shall be carried out under supervision by the Customer's Representative. Cleaning and proving shall be carried out using a winch which has a calibrated dynamometer and printout and pdf/cvs file output facility.

The printout should measure speed and tension every 3 m and the pdf/cvs output file shall record speed and tension every metre. Max speed for duct proving shall be set to 25 m/min. The dynamometer shall be calibrated annually and certified by an independent calibration tester.

The calibration certificate shall be provided to EirGrid before any cleaning and proving activity takes place.

The duct cleaning/proving report (see template in Appendix D) shall be completed and submitted to EirGrid for all ducts.

The report shall be signed by the Contractor and counter-signed by the Customer's Representative who will have witnessed the tests. Fully completed reports and print outs for each section of ducting and for every duct, shall be submitted to EirGrid for review before cables can be installed.

A minimum of one pass in the cable pulling direction of a suitably sized mandrel, brush and cleaning sponge shall be made to prove the cleanliness of the duct.

If a spike in the pulling force record occurs or dirt is found a second or additional passes will be required.

During the duct cleaning and proving task a sonde transmitter can be connected close to the mandrel or brush to help locate a blockage quickly and accurately. The sonde should be for specific use with a C.A.T. or other precise cable location instrument.

Following the duct proving process, rubber bungs with internal securing eye shall be fitted to prevent ingress of water, sand, or other debris. The ducts shall then be left roped and the ropes secured to the internal securing eye in preparation for cable pulling.

Figure 4 Set up for Swivel, Brush, Mandrel and Sponge for Duct Proving and Cleaning

7.6.2 Duct Cleaning Issues Encountered

The proving of the ducts will be deemed to have failed if:

- The pulling tension exceeds 1 tonne (10 kN).
- Mandrel is stuck;
- Mandrel is moving with sudden bursts even if the pulling tension is less than maximum specified.
- Rope shoots suddenly up the duct.
- Ducts do not maintain the same formation as at the start of the pull.
- If the speed exceeds 25 m/min.

Should the duct testing and proving fail?

- The Customer shall clean and prove the ducting in the opposite direction to the previous proving direction; and
- A camera shall be placed down the duct to check the internal integrity of the duct.

If the above steps do not meet the pass criteria, then the Customer shall carry out repair works to rectify the fault.

The repair works shall be carried out following the production of a method statement and risk assessment.

Following the repair of the duct or ducts, the Customer shall also retest all the ducts within the circuit section of the repaired duct even if these ducts had been successfully tested and proved prior to the repair works being done.

If repairs are being carried out to a duct or circuit located within 500 mm of an existing bank of ducts, then EirGrid may request the testing of these ducts. The repair and retesting costs shall be borne by the Customer.

7.7 Cable Pulling

7.7.1 Side Wall Force Calculations

Cable pulling shall not take place until such time that a calculation demonstrating the pulling and sidewall forces for each cable pulling section based on the as laid duct installation has been issued to EirGrid for review and any and all concerns/comments have been addressed.
When bends are present in a duct run, the typical arrangement (subject to design confirming same) is to position the cable drum at the end closest to where most of the bends lay and the winch shall be positioned at the end furthest from the bends.

This method reduces:

- The tensile and side wall forces on the cable.
- The likelihood of the winch rope sawing through or burning through the ducts at bend positions.
- The pulling forces and wear and tear on the winch and the winch rope.

The winch tensile force limit must be set so that the pulling force will not result in the maximum permitted side wall force being exceeded.

All cables shall be sealed against water ingress and protected and adequately supported after cable pulling.

7.7.2 Ducts Pre - Lubrication during Installation

Cable lubricant is required during the cable pulling activity to reduce friction between the cable and the inner wall of the duct.

The ducts shall be pre-lubricated using a cable lubricant to facilitate cable pulling. Lubrication pits will be used where appropriate to ensure adequate lubrication.

Following the cleaning and proving of the entire duct run and immediately prior to cable pulling, all power ducts shall be pre-lubricated during the operation of pulling back of the winch rope from the winch end. The lubricant (recommended quantity 10 litres per 100m of duct or as recommended by the cable manufacturer) shall be placed in the duct at the winch end and a suitably robust sponge securely attached to the winch rope to spread the lubricant uniformly over the entire length of the duct.

A lubrication schedule shall be submitted to EirGrid for review in association with the pulling plan and in accordance with the calculation referred to in the cable pulling and laying section above.

7.7.3 Cable Installation Equipment

The following equipment shall be used for the installation of cable into ducting:

- Bell mouth installed on the duct for entry and exit positions
- Rollers to support cable entering and exiting ducts
- The following as specified by the cable manufacturer
    - Cable pulling stocking
    - Cable pulling eye
- Swivel with torque relief winch with force measurement facility, pdf file output and print out facility
- Mandrel
- Brush
- Sponge

Cable rollers shall be used at duct entry and exit positions to guide the cable from the drum into the duct and to prevent abrasion / ripping of the cable via contact with the trench bottom and sides and also to prevent the cable picking up debris before entry into the duct.

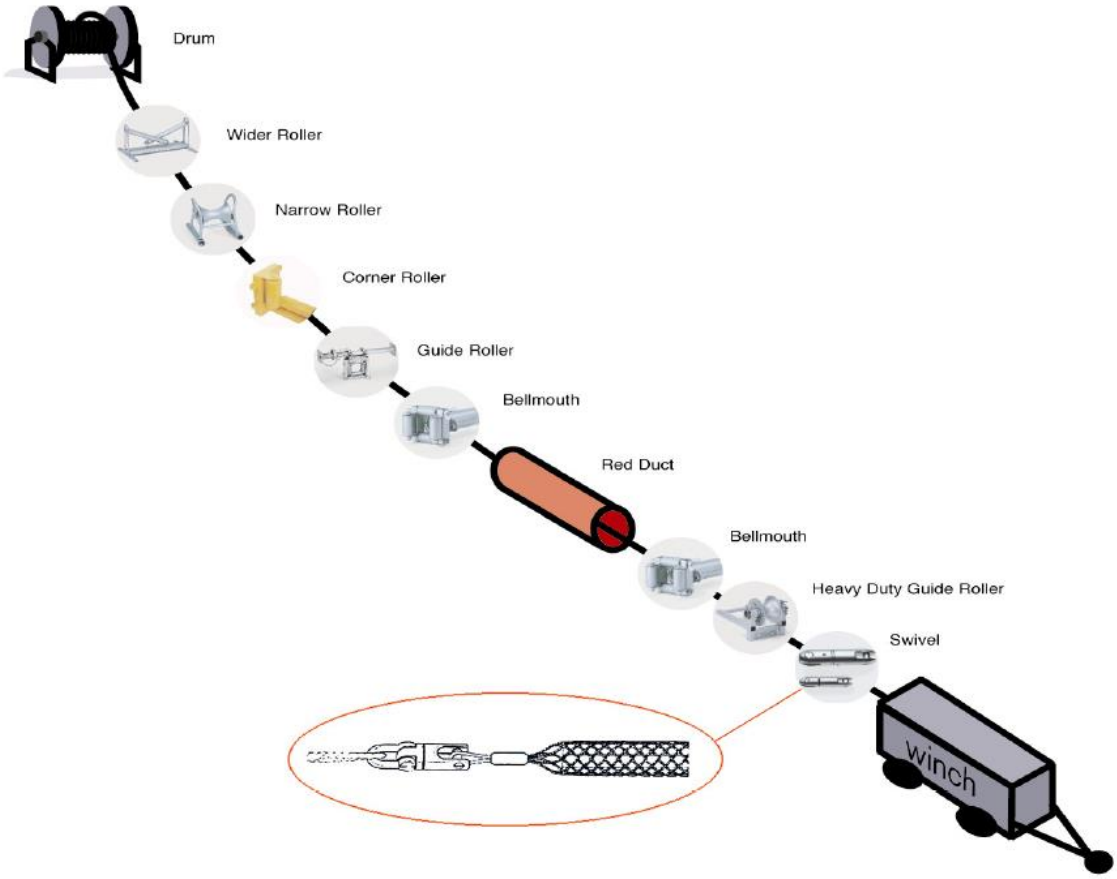

Figure 5 Set up for Cable Pulling

At the point of cable entry into the pipe or duct, a bell mouth shall be provided to ensure no damage to cable during entry. Where cables leave duct mouths to enter a cable trench, trough, draw pit, basement, etc. a permanent support of concrete, steelwork, clamps or cement and sand filled bags as appropriate shall be used to reduce the possibility of damage, or movement of the cables. Where site conditions necessitate additional protection, a permanent concrete canopy shall be incorporated over the duct mouths.

For cable pulling a calibrated winch with pulling force print out and pdf file output facility shall be used. Where cable rollers are required, the Customer shall provide calculation to demonstrate compliance with max side wall forces as recommended by the cable manufacturer.

Any deviation from the installation plan must be submitted for review by EirGrid prior to any work commencing on site.

7.8 JOINT, TERMINATIONS AND LINK BOXES

All cable joints, terminations and link boxes shall be installed in accordance with the material manufacturer's specifications and recommendations.

Cable jointing shall be carried out by trained and experienced cable jointers certified by the accessory's manufacturer.

All HV cables shall be clamped at all joint bays on the cable route.

7.9 SEALING OF CABLE DUCTS

Cable ducts shall be sealed after completion of the cable joint. Details of the proposed sealing method shall be submitted to EirGrid for review.

7.10 LABELLING

Labels should be fixed at terminations to indicate the bay name and the phase designation for each cable.

Labels should be fixed to the internal walls of the link box chamber indicating the joint bay number and the direction of the cable route at each end of the chamber. Phase designations should also be labelled on each phase in the link box.

7.11 CABLES IN BASEMENTS AND ENTRY TO SWITCHROOM

The cable basement layout shall be submitted to EirGrid as part of the detailed design review.

Where cables are installed on the floor of cable tunnels or basements, they shall be clamped firmly to the floor at regular intervals not exceeding 1.5m or as recommended by the cable manufacturer.

Where cables are to be installed in basements and are to cross over existing circuits then the circuit being installed shall be supported and clamped on a cable bridge of galvanised steel adequately earthed.

Adequate clear space and cable slack allowance shall be provided for disconnecting and reconnecting of the cable over its lifetime and also for the installation of future adjacent cables.

All optical fibre cables, on entry to buildings shall be installed on cable trays/ladders to meet the final transition joint location. This location shall be agreed with EirGrid at detailed design phase.

Where cables pass through internal floors or walls or within ducts in a substation building, the openings shall be sealed against water ingress following cable installation by use of a fire-retardant sealant assembly approved by the cable manufacturer.

7.12 PRECAUTIONS AFTER LAYING

Due care shall be taken during cable installation to ensure that no damage occurs to cables and / or accessories which are laid and temporarily exposed.

Joint bays, link boxes and C2 chambers should be kept free from water and protection provided to prevent intentional or accidental damage to the cable.

Any damage to the HV cable, fibre optic cable and / or accessories during installation is the responsibility of the Customer. The Customer is responsible for all costs arising as a result of damage during installation.

The Customer shall ensure that, immediately following cable pulling, caps, suitable heat shrinks and tapes are used to prevent ingress of moisture.

7.12.1 Repairs to Cable Outer Sheath Layer

If the installation process causes any damage to the cable's outer sheath layer this shall be notified to EirGrid immediately. Following which, where possible, the Customer shall undertake the appropriate repairs as agreed with EirGrid and the cable manufacturer,

7.12.2 Tests on Individual Lengths after Laying

A 10 kV DC Test for 1 minute between cable sheath and earth shall be carried out by the Customer after installation and before and after jointing in accordance with IEC 62067, and IEC 60229. The results shall be recorded and submitted to EirGrid.

7.12.3 Cable Parameter Tests and Commissioning:

The Customer shall carry out the following electrical tests immediately after each section is pulled (JB to JB):

- Measure Insulation resistance, phase to screen and phase to phase resistances
- Cable sheath test (10kV calibrated Insulation resistance test kit shall be used for this purpose)
- Check phasing of conductors
- Check continuity of all phase and screen conductors

All cables shall be tested again prior to and following any jointing activity to ensure that sheath faults are prevented.

Terminations shall not be connected to switchgear during tests.

The Customer shall carry out the following electrical tests during commissioning in accordance with the relevant IEC Specifications and provide results to EirGrid. The following list of tests shall be carried out once the cable is fully pulled and jointed:

- Measure Insulation resistance, phase to screen and phase to phase resistances
- Zero, positive and negative sequence impedance tests to verify actual as laid values
- Check continuity of all phase and screen conductors
- Check phasing of conductors
- Check phase clearances and phase to earth clearances
- Cable sheath test (10kV calibrated Insulation resistance test kit shall be used for this purpose)
- Perform Partial discharge test at 1.7 Uo at 50 Hz or 0.1 Hz. Results shall be within limits set by the cable manufacturer and have to be reviewed by EirGrid
- Visual inspection of the connections in all link boxes to ensure compliance with the final cable bonding diagram
- Test the joint bays earth grids to ensure compliance with EirGrid standard drawing

Commissioning tests may be witnessed by EirGrid. As a result, adequate notice (> 4 weeks) of these tests should be provided to EirGrid to facilitate the witnessing of these tests.

A specific and detailed risk assessment and method statement shall be provided to EirGrid for review before these tests take place.

A commissioning report shall be submitted to EirGrid for review at the end of the commissioning phase.

If the sheath test results do not meet values stated in Table 8, then jointing works of further sections of the cable circuit shall not commence. Should the results not meet the values in Table 8 the cable that failed the test shall either be repaired or replaced and then retested. After each section of cable is jointed to an adjoining section the electrical tests are to be repeated to verify compliance with test values stated in Table 8.

All test information shall be recorded and included in the 'As-Built' documentation.
All cables shall be sealed / capped after cable testing.

A 10 kV DC test, as per IEC 60229 shall be undertaken to assess the conductive properties of the outer jacket. The test results including leakage current / insulation resistance shall be recorded in the HV Cable installation record sheet (see template in Appendix C) and all results shall exceed the values stated in Table 8 and Table 9

Table 8 10 kV DC test minimum values

HV Cable Test Length (km)	Screen to earth		Core to Earth	
	Minimum Values (Values recorded shall exceed these)		Minimum Values (Values recorded shall exceed these)	
Test Length (km)	Resistance (Mega Ohms)	Leakage Current (Micro Amps)	Resistance (Mega Ohms)	Leakage Current (Micro Amps)
0.25	1000	10	4	2.5
0.5	1000	10	3	3.3
0.5-1	500	20	2000	5
2	500	20	2000	5
3	340	29	1332	7.5
4	260	38	1000	10
5	200	50	800	12.5
6	166	61	666	15
7	142	70	572	17.4
8	124	80	500	20
9	110	90	444	22
10	100	100	400	25
11	90	110	364	27.4
12	82	121	334	30
13	76	131	308	32
14	72	140	286	35
15	66	150	266	37
16	62	161	250	40
17	58	172	236	42
18	54	185	222	45
19	52	193	210	46
20	50	200	200	50
30	33	333	132	83
40	25	400	100	100

7.12.4 HIGH VOLTAGE AC TEST AND PD MONITORING REQUIREMENTS

The Customer shall complete High voltage testing with Partial Discharge (PD) monitoring of the installed cable system as part of the cable commissioning.

Special arrangements may be required to allow for this testing in consideration of the cable length and its joint to the submarine cable. If it is not possible to test the entire cable connecting the OCC to the OSP the Customer shall propose an alternative method. The Transition Joint Bay connecting the land cable to the submarine cable shall be included in the PD test and therefore cannot be used to connect the portable generator or to earth the cable during the test.

In those cases where the cable is to be terminated in Gas Insulated Switchgear, the cable termination should not be installed in final position prior to testing, rather it should be left supported and protected to facilitate connection to test equipment and GIS insulated dead end canisters. Once testing is finished it can then be installed into the GIS cable sealing end. Depending on the station building design it may not be possible to install the test trailer/kit within the cable room. In this case the test may have to be performed at the last Joint Bay location. For this reason, additional cable slack could be required for the installation of the temporary GIS termination. The Customer should discuss this with EirGrid before the cable is pulled to the last joint bay. Any additional material required to perform the HV PD test is at the expenses of the customer.

In case of Cable Sealing Ends (CSE) with air insulated bushings the following two scenarios must be considered:

- If located within the station compound the cable can be installed in final position but any connecting conductors to overhead line or substation equipment should not be connected.
- If located on a line / cable interface mast, the cable end must remain at ground level and not be raised to the mast platform in order not to be considered part of the Network. In this case a temporary CSE may be required to perform the test.

The Customer shall submit the PD test procedure for EirGrid's review during the design stage before finalising the contract with the HV PD testing contractor.

The test shall be performed in accordance with IEC 62067 and witnessed by EirGrid and / or nominated representatives.

The Customer shall provide a report to EirGrid outlining the PD test results, these shall be included in the cable commissioning pack handed over to EirGrid before energisation.
The Customer shall discuss details with EirGrid prior to any cable termination.

- In the case of short cable lengths (less than 1km with no Joint Bays), online PD monitoring during the soak test is acceptable and will be performed by EirGrid.
- Cable circuits in excess of this length (1km or with Joint Bays) shall be tested using offline elevated voltage test with PD monitoring for a period of 1 hour as per relevant IEC Standards.

7.12.5 TESTING OF FIBRE OPTIC CABLE

Routine Tests on the fibre optic element shall be carried out in accordance with ITU G.252 and IEC 61300.

All fibre elements in cable shall be OTDR tested with no exceptions and shall be witnessed. Further, a provision for OTDR testing shall be available on the drum, i.e. the same as the sheath testing point. This shall be required for confirmation testing once it has arrived on site, pre-pulling.

7.13 COMMUNICATION FIBRE OPTIC CABLE INSTALLATION

7.13.1 INSTALLATION

All Fibre Optic cable installation shall be in accordance with Table 9 and this specification and with the manufacturer's specifications and recommendations.

Table 9 Fibre Installation Requirements

Tensile Performance	Parameter	Requirement	Value
EN 187105-5.5.4	Long term load	No attenuation increase*	Load: 1000 N
		No fibre strain	
IEC 60794-1-2-E1A and E2A	Short term load, during installation	No changes in attenuation before versus after load	Load: 2700 N
		Max fibre strain 0.33%	
Crush Performance			
EN 187105-5.5.3	Long term load	No attenuation increase*	Load (Plate / Plate): 500 N
IEC 60794-1-2-E3	Short term load	No changes in attenuation before versus after load	Load (Plate / Plate): 2000 N
		No damage**	
Bending Performance			
EN 187105-5.5.1	Handling fixed installed	No attenuation increase*	Bend radius: 10 x D
IEC 60794-1-2-E11	During installation (under load)	No changes in attenuation before versus after load	Bend radius: 20 x D
			D is cable diameter
Temperatures			
	Operation	No attenuation increase*	-40 to +70°C
EN 187105-5.6.1	Installation		-15 to +60°C
IEC 60794-1-2-F1	Storage/Shipping		-40 to +70°C

*No changes in attenuation means that any changes in measurement value, either positive or negative within the uncertainty measurement shall be ignored. The total uncertainty of measurement shall be less than or equal to 0.05 dB.

**Mechanical damage – when examined visually without magnification, there shall be no evidence of damage to the sheath.

If the installation causes any defect that impairs the performance (optical or otherwise) of the fibre cable these shall be notified to EirGrid immediately. Following this the Customer shall undertake the appropriate repairs as agreed with EirGrid.

Installed fibre must meet the performance requirements as set out in this specification. EirGrid may require testing of fibres post installation to confirm maintained compliance with

designed specifications.

Fibre cable route sections are to be planned carefully such that:

- Installation does not conflict with manufacturer's specifications or recommendations
- Jointing/splicing locations shall be selected from the point of view of safe future maintainability and must be agreed with EirGrid prior to installation

7.13.2 SPLICING

Splicing shall be carried out by the Customer. It can be performed by fusion of the fibre optic cables in specifically constructed splice canisters. This will be direct splicing between two or more single mode fibre optic cables.

Splicing shall be by fusion arc machine and associated precision cleaver. Mechanical splicing shall not be acceptable.

The maximum Wavelength Splice Attenuation requirements (per km) shall be as follows:

- 1310 nm 0.06 dBm
- 1550 nm 0.06 dBm
- 1625 nm 0.06 dBm

The Customer shall measure each splice loss after each splice is made, but before the splice case is closed by the OTDR. The Customer shall test all fibres for attenuation and provide a record of each fibre loss at both wavelengths (1310 and 1550 nm), in both directions.

After the installation of the fibre cable is complete and all splices are made and tested, the Customer shall perform the cable completion test. This consists of measuring the loss of each fibre path in both directions between fibre optic connectors in the patch panel.

7.13.3 OTDR TESTING

All test traces will be provided in hard and soft copy. This testing will be conducted at 1310 nm, 1550 nm and 1625 nm wavelengths. OTDR testing will be conducted on a bi-directional basis for each fibre in each span at the appropriate wavelengths for the fibre described above.

7.13.4 POWER TESTING

This end-to-end loss measurement is to be conducted for each fibre in the span and from both directions using an industry-accepted laser source and power meter. The bidirectional average will be used to determine the end-to-end loss of the span at each appropriate wavelength.

This test will be conducted at 1310 nm, 1550 nm and 1625 nm.
This power testing will ensure fibre continuity and the absence of crossed fibres in the span.

7.13.5 DAMAGE TO FIBRE CABLE

If the installation causes any defect that impairs the performance (optical or otherwise) of the fibre cable these shall be notified to EirGrid immediately. Following this the Customer shall undertake the appropriate repairs as agreed with EirGrid.

7.13.6 INSTALLATION DETAILS REQUIRED FOR EACH CABLE SECTION

The HV cable installation record sheet and duct proving record sheet (see templates in Appendix C and D of this specification) must be fully completed by the Customer and supplied to EirGrid.

7.14 WASTE MATERIALS

The Customer shall submit Safety Data Sheets for all hazardous substances used in the cable system. They shall be classified in accordance with European Community SI No. 402/1980 (Safety Signs at places of Work Regulation 1980). This also refers to packing waste that can have associated biological issues such as transmission of disease or introduction of unwanted flora and fauna.

The Customer is required to dispose of any waste in a manner which does not harm the environment and corresponds with the guidelines above.

7.15 MANAGEMENT OF WATER ON SITE

All site water must be managed in accordance with the planning permission requirements and relevant authority's water management regulations and guidelines.

APPENDIX A – STANDARD DRAWINGS

Table 10 General Drawing List

Drawing No.	Drawing Title
OFD-SSS-521	Standard – As-built Cable Route
OFD-SSS-522	Standard – C2 Chamber
OFD-SSS-523	Standard – Link Box Chamber
OFD-SSS-524	Standard – Transition Chamber
OFD-SSS-525	HV cable earthing practice joint bays
OFD-SSS-526	JB clamp bracket

Table 11 220 kV Drawing List

Drawing No.	Drawing Title
OFD-SSS-527	Standard - 3rd Party Crossing (300 mm above)
OFD-SSS-528	Standard - 3rd Party Crossing (300 mm Below)
OFD-SSS-529	Standard - Riverbed Crossing
OFD-SSS-530	Standard - Bridge Crossing
OFD-SSS-531	Standard - Trench Through Peat
OFD-SSS-532	Standard – Trench Cross Section
OFD-SSS-533	Standard – Pre-cast Joint Bay 8 x 2.6 m (220 kV)

APPENDIX B – ROUTE MARKER POST

APPENDIX C - CABLE INSTALLATION RECORD SHEET

HV CABLE INSTALLATION RECORD SHEET

CIRCUIT DETAILS

1. Circuit Name:
2. Section Number: _____ From: _____ To: _____

CABLE DETAILS

3. Cable Manufacturer: _____
4. Cable Description: _____
5. Drum Details: _____
6. Fibre Cable Manufacturer: _____
7. Fibre Cable Description: _____
8. Fibre Drum Details: _____

	R	S	T
o.			
(m)			

9. Total Installed Length (R+S+T) = _____ (metres)
10. Total Fibre length Installed = _____ (metres)

CABLE DESIGN

11. Cable Pulling Calculation. Route Section:

Straight Length (m)	Bend Angle (degree)	Curve Radius (m)	Curve Length (m)	Tension Increased Along Straight (kg)	Bend Tension Multy. Factor (cable)	Forward Cable Tension (kg)	Forward Sidewall Load (kg)	Reverse Cable Tension (kg)	Reverse Sidewall Load (kg)

CABLE INSTALLATION DETAILS

12. Installation Method

Duct: _____ Nose Pull: _____
Open Trench: _____ Bond Pull: _____

13. Confirm printout record is attached

Confirm dynameter printout is attached	Check

14. Pulling Tension Record

Maximum Pulling Tension Recorded in kN	R	
	S	
	T	
	Fibre	

15. Installation Data

Phase	R	S	T	Fibre
Date Installed				
Direction Installed				
DC Sheath Test Date pre-installation				
DC Sheath Test Result pre-installation				
DC Sheath Test Date post-installation				
DC Sheath Test Result post-installation				

16. Meteorological Data

Max. Temp _____ °C
Weather _____
Humidity _____ %

Remarks_____
_____
_____
_____
_____

Signed _____
Date _____

APPENDIX D- DUCTING CLEANING/PROVING RECORD SHEET

DUCT CLEANING/PROVING RECORD SHEET

CIRCUIT DETAILS

1. Circuit Name: _____
2. Section: From: _____ To: _____
3. Section length: _____

DUCT DETAILS

Duct ID	Diameters (mm)			
	Duct inner	Sponge	Brush	Mandrel
1				
2				
3				
4				
5				
6				

DUCT FORMATION & ID SKETCH

Typical	At the start of the pull	At the end of the pull

PROVING DETAILS

Duct ID	Duct designation	Max pulling tension (kN)	Comments
1			
2			
3			
4			
5			
6			

4. Winch serial number: _____
5. Winch calibration date: _____
6. Direction of proving: From: _____ To: _____
7. Have the ducts been cleaned and proved successfully? Yes/No
8. Have the ducts maintained the correct formation? Yes/No
9. Have rubber bungs been fitted after proving & cleaning? Yes/No

Note: The proving of the ducts shall be deemed to have failed if any of the following occur:

1. Pulling tension exceeds 10kN.
2. Mandrel moves with sudden bursts (even if the pulling tension is not exceeded).
3. Mandrel becomes stuck.
4. Rope shoots suddenly up the duct.
5. Ducts do not maintain the same formation as at the start of the pull.

6. Pulling speed exceeds 25 m/min.

Confirm dynameter printout is attached	Check

Contractor
Name: _____

Signature: _____ Date: _____

Customer Representative
Name: _____

Signature: _____ Date: _____

APPENDIX E - DTS FIBRE DOCUMENT

EIRGRID GROUP

Requirements for splicing of DTS fibres in HV cable systems

INSTALLATION	Comment
Fibre Jointer	Fibre jointer must be trained and experienced in single mode FO splicing and installation practices. Documentation required.
	Details of fibre jointers to be submitted upon completion of installation.
	Fibre Jointer must complete, sign and date Fibre Install Document
TESTS	**Comment**
OTDR 1310nm wavelength with 1Km launch lead	
A>B	Each core to be tested; required format is Belcore with .sor file name extension. [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
B>A	Each core to be tested; required format is Belcore with .sor file name extension. [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
Bi-directional	Each core to be tested; required format is Belcore with .sor file name extension. [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
Report	Report on each core; PDF format, name extension [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction][Report]
OTDR 1550nm wavelength with 1Km launch lead	
A>B	Each core to be tested; required format is Belcore with .sor file name extension. [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
B>A	Each core to be tested; required format is Belcore with .sor file name extension. [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
Bi-directional	Each core to be tested; required format is Belcore with .sor file name extension. [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
Report	Report on each core; PDF format, name extension [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction][Report]
Light source and power meter bi directional	Each core to be tested; dB values required. As per Fibre Test Documentation.
Test Engineer	Test engineer must be trained and experienced in fibre characterisation. Documentation required.
	Details of test engineer to be submitted upon completion of installation. Test engineer must be independent from fibre jointers.
	Test Engineer must complete, sign and date Fibre Commission Document
RECORDS	**Comment**
	Photos of each installation. Each photo labelled appropriately. Photo should clearly show joint enclosure, excess fibre and splice storage
Splicing	**Comment**
Fusion splice machine	Precision cleave tool must be used
OTDR	Must be within its calibration date
Inspection & Cleaning IEC-61300-3-35 Standard June 1st 2010	For full potential of low loss, it must be ensured that there is no contamination prior to connecting
Link loss (dB) = Cable loss + Connectors loss + Splices loss	Not to exceed minimums stated below
Maximum fibre link attenuation	
1310nm wavelengths	0.37dB/km
1550nm wavelength	0.22dB/km
Maximum fusion splice losses	
Bi-direction per splice	0.15dB (if above, reasonable explanation must be submitted)
	Above 0.3dB not acceptable
Maximum Connector losses	Bi-directional per connector
	0.5dB
Microbends	Microbends are unnaceptable

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DTS Fibre Commission Document

HV Cable		Connector Inspection (where applicable)	
Nominal length Km		Initial Condition (Good/Bad)	
Operating Voltage		Connector Cleaned?	
Phase		Final Condition (OK/Rejected)	

Insertion Loss Measurements	1310nm	1550nm
Reference power levels at A end (dBM)		
Reference power levels at B end (dBM)		
Measured insertion loss B to A (dB)		
Measured insertion loss A to B (dB)		

Insertion Loss Measurements required for each core

Equipment Details	Light Source	Power Meter
Manufacturer		
Model Number		
Serial Number		
Calibration Date		

OTDR Trace File
1310nm [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]
1550nm [Origin_id][End_id]-[Cable_id][Fibre_number][Lambda][Direction]

OTDR Equipment	
Manufacturer and Model number	
Serial Number	
Calibration Date	
Launch lead identification	

Comments:

Test Engineers Details	
Name	
Company	
Test Date	
Signed	
Date	

APPENDIX F - COMMUNICATION FIBRE INSTALL DOCUMENT

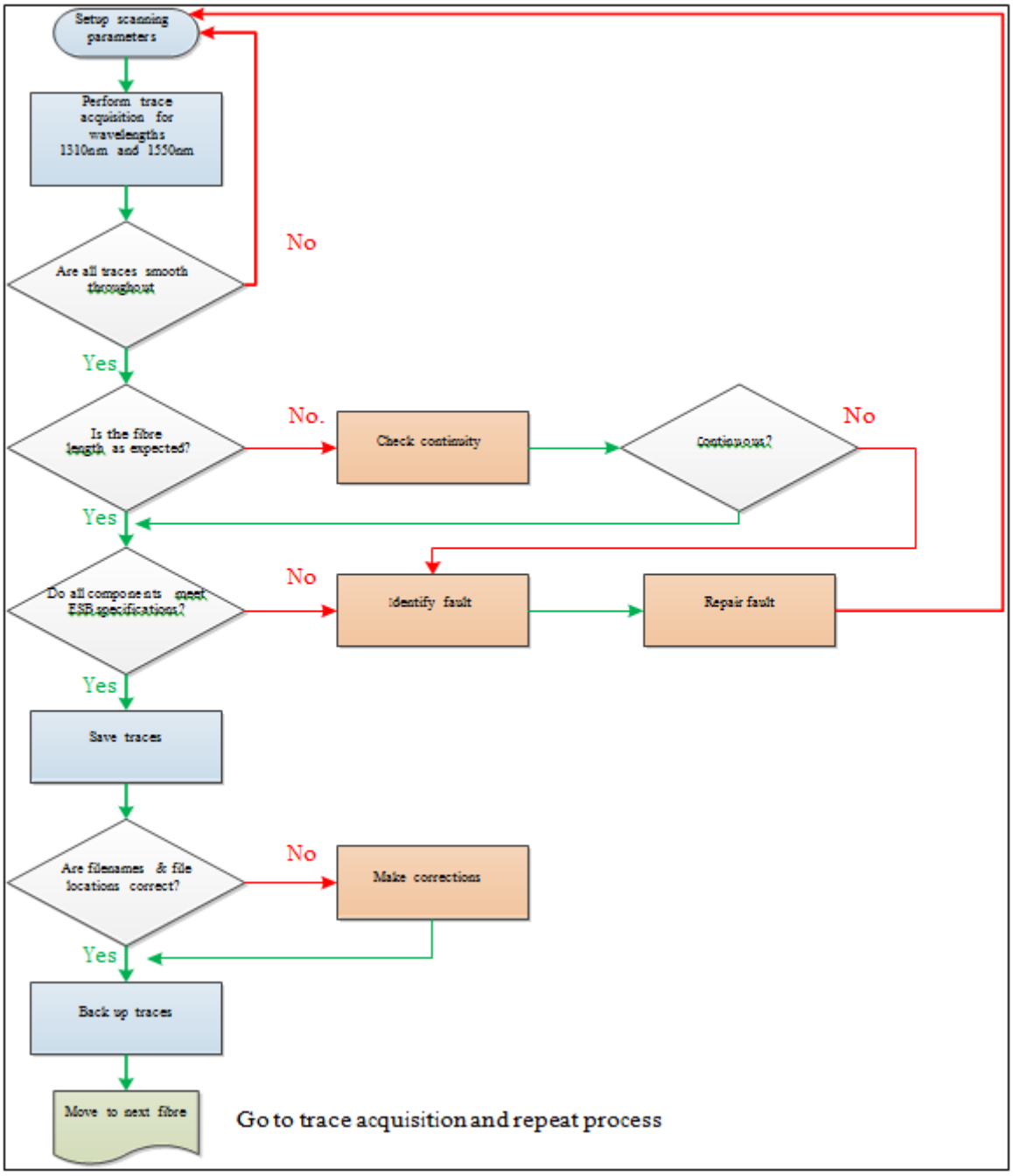
EIRGRID GROUP

Fibre Install Document			
Fusion Splicer Details		**Precision Cleaver Tool**	
Manufacturer		Manufacturer	
Model Number		Model Number	
Serial Number			
Calibration Date			

Description	**Confirmed**
All fusion splices as per requirements	☐
Fibre management in all joints as per instructions	☐
No microbends present	☐
All FO joints dressed and closed per instructions	☐
All FO joint closures and lead-ins affixed per instructions	☐
Photos of completed FO joints	☐
Comments:	

Fibre Jointer No.1		**Fibre Jointer No.2**	
Name		Name	
Company		Company	
Install Date		Install Date	
Signed		Signed	
Date		Date	

Guide to the basic process of assessing the OTDR trace



APPENDIX G - INFORMATION FROM CABLE (FOR CUSTOMER USE ONLY)

Table 12 General Information Required

General Information Required	Check
Outline Works programme for each section of the Works.	
Organisation chart for the project.	
Certification letter of compliance with the specification and any deviations proposed from the specification documents	
Copy of all contractor/sub-contractor's quality control / assurance policies and procedures	
ISO 9001:2000 series certification for each manufacturer / erector	
Certificate of compliance with the disposal of waste material	

Detailed Information Required

The following documents shall be submitted by the Customer in accordance with a programme agreed with EirGrid:

Table 13 Detailed Information Required

Detailed Information Required	Check
Proposed cable route (FEED design) before planning permission submission, cable plans and cross section drawings	
Location of all existing services, type, size, and depth of installation along the route	
Proposed trench arrangement where cable crosses other services	
Dedicated crossing design for every 3rd party service crossing, bridge, road, river	
Detailed cross and long sections through bridges which clearly illustrate separation from other services, depth of burial of cable ducts and also how ducts enter / exit bridge abutments / deck	
Detailed design including cross sections, long sections, plans where cable routes traverses water crossings	
Proposed joint bay locations (including distances between joint bays)	
Proposed link box chamber locations	
Proposed C2 communication chamber locations	
Future access points / routes for maintenance and repairs	

Table 14 Consents including all of the following

Consents Information	Check
Easements details and drawings	
Local authority and other agreements	
Agreements with TII / CIE and any other infrastructure providers	
Statutory Constraints e.g. SAC, NHA	
Work Restrictions	

Table 15 Civil Works including all of the following

Civil Works	Check
Detailed programme for Civil Works	
Future access Civil Works details and drawings	
Joint bay permanent access track for JB located in private fields	
Joint bay temporary access track for construction for JB located in private fields	
Joint bay construction drawings	
Joint bay reinstatement drawings	
Communication C2 chambers construction drawings	
Link Box design drawings	
Link Box arrangement drawings (including distance from joint)	
Details of proposals to prevent water ingress into joint bays	
Details of proposed ducting and supplier	
Details of proposed thermal sand and supplier (if used)	
Details of proposed concrete mix and schedule of test reports to be submitted during construction to confirm TR value	
Proposed support mechanism for joints in joint bays	
Method statement for civil works	
Programme for submission of as-laid records	
Certificate of As-built records agreement	

Table 16 Material including the following

Material Information	Check
Cable technical schedule (as per format provided)	
Cable cross section drawing	
Final cable order lengths	
Cable pulling tension calculations	
Joint drawings (for each type)	
Joint technical schedules	
Termination drawings (for each type)	
Termination technical schedules	
Link box design drawings	
Bonding lead cross section drawing and technical schedule	
Sheath voltage limiter technical schedule	
Earth continuity conductor cross section drawing, technical schedule, and trench arrangement	
Cable clamp drawings, arrangement, and schedules	
Steelwork drawings	
Steelwork loading calculations	
Steelwork galvanisation proposal	

Proposed cable pulling eye / stocking	
Proposed cable lubricant for duct installation (where used)	
Fibre optic cable and accessories details	
Fibre optic cable and accessories details (when required)	
DTS technical schedule and schematic (when required)	

Table 17 Information for the Installation

Installation Information	Check
Programme of Installation	
Method statement for duct installation / cable pulling	
Details of arrangements to prevent water ingress into cable / joints	
Jointing instructions for joints / terminations	
Jointing certificates and QA forms	
Duct proving records (electronic file and paper print outs)	
Cable pulling tension records (electronic file and paper print outs)	
Steelwork erection proposals	
HV Cable Installation Record sheet	

Table 18 Information for the Installation

Installation Information	Check
Cable technical schedules	
Bonding / Earthing schematic drawing including phasing	
Sheath standing voltage calculations for the cable route	
Distances between joint bays (where applicable)	
Joint bay earth system drawing (where applicable)	
Cable rating calculations in accordance with IEC standards (dynamic and / or static)	
Magnetic field calculations and compliance report with ICNIRP Guidelines	

Table 19 Testing Including the following

Installation Information	Check
Cable technical schedules	
Bonding / Earthing schematic drawing including phasing	
Sheath standing voltage calculations for the cable route	
Distances between joint bays (where applicable)	
Joint bay earth system drawing (where applicable)	
Cable rating calculations in accordance with IEC standards (dynamic and / or static)	
Magnetic field calculations and compliance report with ICNIRP Guidelines	

Table 20 Safety Information including the following

Testing Information	Check
Safety organisation chart	
Safety file	

Evidence of appointment of Project Supervisor Design Process (PSDP) and Project Supervisor Construction Stage (PSCS)	
Signed certificate / letter stating full compliance with all Irish Construction and Safety regulations and including all risk assessments for the cable system proposed	

A. Appendix G – Abbreviation List

List of Abbreviation is given in table below.

AC	Alternating current
CSA	Cross Section Area
CT	Current Transformer
DAS	Distributed Acoustic Sensing
DC	Direct current
DTS	Distributed Temperature Sensing
EPR	Ethylene Propylene Rubber
FAT	Factory Acceptance Test
FO	Fibre Optic
GIS	Gas Insulated Switchgear
ITP	Inspection and Test Planning
LWP	Longitudinal Water Penetration
OTDR	Optical Time Domain Reflectometer
PD	Partial Discharge
PQ	Pre-qualification
RTTR	Real Time Thermal Rating
RWP	Radial Water Penetration
SAT	Site Acceptance Test
SC	Short Circuit
SCADA	Supervisory Control and Data Acquisition
TJB	Transition Joint Bay
TDR	Time Domain Reflectometry
UV	Ultraviolet
VIV	Vortex-induced Vibration
VLF	Very Low Frequency
XLPE	Cross Linked Polyethylene