Appendix 2-3 – EirGrid Specification (Typical Trench Bedding Details)

Document Reference: CDS-GFS-00-001-R0

110 kV, 220 kV and 400 kV Underground Cable Functional Specification

General Requirements

Revision History					
Revision	**Date**	**Description**	**Originator**	**Checker**	**Approver**
R0	12.03.2020	First Issue – Supersedes CDS-HFS-00-001-R1 as Functional Specification is Now Applicable to All Voltage Levels and Updated as per Due diligence Tracker. Sections modified: 2, 6, 7, 8, 14, 16, 17.1, 19, 20, 21	Daniele Giustini	Due-diligence process and Conor Farrell	Brendan Murray

Contents

1 Scope

This specification forms part of a suite of documents that describes EirGrid's requirements for underground cables.

This specification outlines the general requirements for the design and construction of 110 kV, 220 kV and 400 kV underground cable systems which will be connected to the 110 kV, 220 kV and 400 kV transmission system operated by EirGrid.

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.)

1.1 Scope of Works

The "works" consist of cable design, manufacture, installation, civil works, pre-commissioning tests and maintenance under guarantee of the proposed cable system complete with the joints, terminations, fibre and accessories necessary for the satisfactory and reliable operation of the circuit including provision and storage of spares prior to handover date to EirGrid and the TAO.

Commissioning of the cable system and final connection to the transmission system will be arranged by EirGrid.

2 General

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.

In undertaking the project, the Customer shall at all times be aware of and comply with the applicable Health & Safety legislation, Approved Codes of Practise and Industry Standards and all subsequent modifications or amendments in relation to same.

Where appropriate, the underground power cable components and all associated ancillary materials shall carry the CE Mark in accordance with Direction 93/465/EEC.

The project shall comply with this specification, unless any deviation 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 in EirGrid's Derogation Process XDS-GGD-00-001. Early engagement pre-construction with EirGrid is required for any proposed deviations.

As stated in the EirGrid Connection Agreement or Committed Project Parameters all cable routes shall be agreed with EirGrid prior to Planning Application. 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 should 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 Register of materials and a letter declaring the proposed cable system and related spares is in compliance with the EU Reach Directive.

2.1 Minimum Clearances

The spacing of the cable / ducts shall be, at a minimum, in accordance with the requirements in standard drawings and shall comply with Table 1.

Further detailed requirements are outlined in the EirGrid Cable Civil Works Functional Specification CDS-HFS-03-001.

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]
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

Table 1: Minimum Clearances for HV Cable Ducts

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

The Customer shall also note that where the minimum standard clearance 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.

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

3 Spares

3.1 Engagement Process

The Customer shall consult EirGrid at an early stage to determine the requirements for cables spares.

Cable Spares are required where non–standard cable and cable accessories are proposed. EirGrid will determine, in conjunction with TAO, the requirement for spares based on the Customers submission.

Upon submission of the Customer cable design and cable accessories and in advance of ordering any equipment, the customer shall receive written confirmation from EirGrid if the proposed cable and cable accessories (joints and terminations) are compatible with EirGrid's standard range of stock and spares.

3.2 Spare Requirements

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

These spares shall be made available at energisation stage to be transferred to the TAO.

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 as a result of a lack of availability of spare parts.

Where the cable system is non-standard in terms of EirGrid's current range of 110 kV, 220 kV and 400 kV cable accessories, the Customer shall supply the following spares at a minimum.

Item	Quantity
Cable	Equivalent to one phase of the longest section
Joints	6
Terminations	6 (for each type used on the project)

Table 2 – Cable Spares Requirements

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.

3.3 Spares Storage and Packaging

The cable spares and accessories shall be stored indoor in a secure, accessible and weatherproof building.

The spare cable shall be supplied on a long-life galvanised steel drum which shall be covered with suitable material to provide physical protection for the cables during shipment and during storage and handling operations.

The ends of the cable shall be durably sealed before shipment with heat shrink protective covers to prevent ingress of moisture and shall be firmly and properly secured to the drum.

The direction for rolling shall be indicated by an arrow. This is the opposite direction to that of cable pay off.

Spare parts which are liable to deterioration by atmospheric pollution, humidity or ingress of foreign matter shall be totally sealed in polythene bags, suitable for storage.

Spare parts which are subject to deterioration due to condensation shall be protected by packs of silica gel or other approved desiccants.

Packages shall be crated in robust waterproof wooden packing cases. Large items shall be crated separately and shall be securely clamped against movements.

Each packing case shall be clearly labelled, with the label providing the following information:

- Spare part name
- Eirgrid Material Code
- Project number and title
- Description of serial number of contents
- Expiry date of all chemical components and time limited inert components
- Lifting and storage / stacking instructions
- If multiple cases pertain to an individual joint or termination then the relationship must be clearly labelled eg box 2 of 3

The expiry date should be at least five years and shall at a minimum exceed the warranty requirements of the cable system from TAO handover date.

If the case contains fragile parts it should be clearly indicated on the label and on the crate.

The Customer is responsible for replacement of any degradable material provided with spares, e.g. filling compound, and any costs associated with their ongoing replacement once they expire, until the ownership of the asset constructed contestably is passed to the TAO.

All costs associated with the above spares shall be at the expense of the Customer.

One full set of special jointing tools shall be provided to EirGrid where non-standard accessories are used.

4 Training

If the cable system is non-standard in terms of EirGrid's current range of cable and accessories, then the Customer shall provide training for EirGrid nominated staff.

The Customer shall submit a training plan which shall describe in detail how the Customer proposes to train EirGrid nominated staff.

This plan shall be provided at least 8 weeks before the training course and at least 4 weeks before the commissioning of the plant.

The course shall cover cable jointing for any new cable and accessory designs.

Training instructors shall be knowledgeable and experienced in the manufacture, erection, installation, testing and maintenance of the cable system and shall have good communications skills in the English language.

The training shall be provided on site during the construction period or at the manufacturer's factory as appropriate. All costs associated with the above training shall be at the expense of the Customer.

5 Service Experience

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 particular cable system proposed is new but the workforce working remains substantially the same as in the preceding manufacturing facility, then the combined experience time will be taken into consideration by EirGrid.

c) Service Experience

Service experience shall be minimum **five years** experience associated with installation of over 1000 km for the relevant voltage level of the cable in at least three EU utilities.

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.

6 Quality Assurance Plan

The Customer shall submit a detailed Quality Plan (as per the latest revision of the EirGrid Safe by Design Methodology XDS-SDM-00-001) prior to the design phase of the project. The Customer shall maintain and submit all quality certification documents relating to the products and systems supplied for the cable system.

The Customer Quality Plan shall demonstrate, to the satisfaction of EirGrid, that the control measures adopted at the design and construction stage will result in successful commissioning and long-term performance of the built circuit.

Each manufacturer and contractor shall have a Quality Assurance System conforming to ISO 9001:2000. The Customer shall ensure that the same requirements are applied to products, systems and services supplied by sub-contractors and suppliers.

The routine tests and inspections for supplied materials and processes shall be specified in the Customer's Quality Plan.

The Customer shall submit a detailed statement of the quality system as applied to design, materials, manufacture, installation, installation supervision and testing, supported with samples of documentation used for quality assurance certification.

The Quality Plan shall address, but not limited to, the elements in the following list:

- Competence of Civil and Electrical Designer, Contractor, Pre-Commissioner. This shall detail the experience and qualification of engineers / contractors and proven track record;
- Details of Quality Assurance Certification;
- Material selection, sampling, handling, testing on site and testing off site;
- Site work Audit and Control Plan (further information in section 13.1);
- Document submittal schedule;
- Legal transactions concerning property transfer and cable route over third party lands;

The Customer shall identify the person responsible for quality assurance, who will engage with EirGrid on material and installation quality.

All test equipment used for testing and recording test results shall be calibrated for accuracy at regular intervals and shall display the date of next calibration and that of last calibration.

All materials and workmanship shall be of a suitable type and quality to ensure that the cable system as a whole will operate satisfactorily in accordance with EirGrid Specifications.

Acceptance by EirGrid of the design of the cable system and its components shall not relieve the Customer of their obligation to supply and install the cable system to a suitable quality capable of meeting the requirements of the EirGrid functional specification and service requirements.

7 Design

This Quality assurance requirements outlined in the EirGrid "General Specification XDS – GFS-00-001" apply to the cable system and shall be met by the customer.

The Customer should be aware that an EirGrid internal stage gate review process is in place to ensure that projects are designed and constructed in accordance with the required specifications and standards.

Further guidance can be found in EirGrid document "Getting Connected, Delivery Phase of Contestable Projects" and EirGrid General Requirements Functional Specification XDS-GFS-00-001 which is provided at project kick off or by request to info@eirgrid.com.

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

- Performance to the required underground power cable system requirements including continuous current rating and short circuit rating as per the circuit parameters communicated by EirGrid;
- 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 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.

EirGrid will inform the Customer if a Distributed Temperature Sensing (DTS) system is required for the specific project. DTS system requirements are specified in the Cable Material Functional Specification CDS-HFS-02-001.

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

- Route selection and survey prior to Planning Permission application;
- Route risk assessment;
- Material selection;
- Detail Design.

7.1 Design log

Any omissions, issues and/or non-compliances identified by EirGrid Client Engineers during the design review and construction phase will be logged in Design Review and Construction Monitoring comments logs. All comments raised during the design phase shall be rectified in advance of construction commencing.

The Customer shall use the latest comments log template which will be included in the contestable works package.

All such items shall be addressed and rectified by the Customer in revised designs submission and / or remedied at site. In any event all issues shall be closed before handover of the assets.

Further detail on the Customers Quality Assurance requirements can be found in the EirGrid General Requirements Functional Specification XDS-GFS-00-001.

8 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 are not satisfied with any supplier, then that supplier will not supply any material for the project.

9 Inspections during Manufacture

The Customer shall submit a test programme to EirGrid and shall give at least three 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. In the event that EirGrid are not satisfied with any material / equipment production, then remedial actions shall be proposed by the Customer. Any consequent delay due to the provisions of this clause shall be the sole responsibility of the Customer.

10 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 and acceptance prior to the shipment of material / equipment from the manufacturing plant. 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 60840 and fibre testing in accordance with IEC 60793.

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.

11 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 and acceptance prior to shipment from the manufacturing plant. 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.

12 Installation

The Customer shall submit all installation methods for the cable and fibre system to EirGrid 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.

12.1 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 metres 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.

13 Reinstatement Finishes

The requirements for the reinstatement of trenches, 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 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. These confirmations shall be summarised in a document log and submitted as an appendix. This shall be submitted to EirGrid before the ownership of the circuit is transferred to the Transmission Asset Owner.

14 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 accepted by EirGrid.

15 Inspections by EirGrid

During the construction of the project, onsite inspections may be carried out by authorised EirGrid Client Engineers or their agents to ensure compliance with statutory provisions and agreed engineering design and / or specifications.

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

The Customer shall ensure that the EirGrid Client Engineers and their agents have unrestricted access to the project as required to carry out this role.

EirGrid reserve the right to request Trial Holes or Slit Trenches to be carried out by the Customer on the as installed underground cable or ducting section to audit the construction works, the number of each will be dependent on the installation itself.

Trial holes shall only be required in exceptional circumstances if the customer proceed to construction ahead of EirGrid's knowledge, design non-compliances or quality issues are identified during construction.

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.

16 Pre-Commissioning

Prior to hand over of the cable to EirGrid for commissioning, the Customer shall carry out pre-commissioning tests in accordance with the provisions of EirGrid Cable Installation Functional requirements (CDS-HFS-04-001).

Such tests shall be carried out by the Customer.

When all pre-commissioning tests have been satisfactorily completed, the Customer shall certify and declare the works are ready for EirGrid commissioning.

The following documents shall be handed over to EirGrid before commissioning starts:

- Material certificates and signed cable pre-commissioning test results sheets;
- Pre-commissioning documents including photographic evidence of compliance;
- As-builts of Cable route.

The Customer shall provide competent test personnel, instrumentation and test rigs together with all auxiliary personnel, electric power and other services necessary for the completion of the tests.

16.1 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 and it must take place when the cable is not terminated.

In the case of Gas Insulated Switchgear the cable termination should not be installed in final position prior to testing, rather they should be left supported and protected to facilitate connection to test equipment and GIS insulated dead end canisters. Once testing is finished they can then be installed into GIS cable chambers.

In case of Air Insulated Switchgear (AIS) Cable Sealing Ends the following two scenarios must be considered:

- AIS terminations within station compound can be installed in final position but any connecting conductors or busbar connecting the terminations to overhead lines or equipment should be disconnected.
- CSE on line / cable interface mast, the cable must remain at ground level and not be raised to the mast platform in order not be considered part of the Network to allow for the PD test;

The Customer shall submit the PD test procedure for EirGrid review during the design stage.

The test shall be performed in accordance with IEC 60840 or IEC 62067 and witnessed by EirGrid and / or nominated representatives.

The Customer shall provide a report to EirGrid outlining the PD test records.

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), **on line** 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 off line elevated voltage test with PD monitoring for a period of 1 hour as per relevant IEC Standards.

17 Commissioning

The Customer shall provide a certificate to EirGrid detailing all checks carried out and a statement of full compliance of the system with approved drawings and Specifications.

Commissioning of the cable circuit and associated fibre cable will be arranged by EirGrid.

EirGrid may carry out further inspections as deemed necessary. Any such inspections do not absolve the Customer from full responsibility for ensuring the satisfactory completion of the works.

17.1 Commissioning equipment requirements

The Customer is required to provide the equipment for cross bonding checks during commissioning.

The Customer shall provide all required test equipment (portable generator, load bank and leads) to verify operation of the Sheath Voltage Limiters (SVLs) and for the cross-bonding scheme tests.

The Customer shall engage with EirGrid for details of the specific test equipment requirements.

The Customer shall provide commissioning assistance to support EirGrid to enable any immediate remedial works as necessary.

17.2 Cable Parameter Tests:

The Customer shall carry out the following electrical tests in accordance with the relevant IEC Specifications and provide results to EirGrid.

- Zero, positive and negative sequence impedance tests to verify actual as laid values ;
- As laid electrical resistance of the cable

A proposed measurement procedure shall be submitted to EirGrid for review.

18 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 depths of the duct installed shall be recorded as per Section 7 of CDS-HFS-00-001 Functional Specification. 3rd party service levels and details shall be added to the As Built drawings including GPS co-ordinates of the actual crossing locations.

The Customer shall provide a full as-built record of the installed ducts to EirGrid for review before hand over of the ducts, cable and cable accessories assets.

All ducts shall be clearly labelled power or comms including ownership of duct.

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

19 Warranty

The entire cable system asset constructed by the Customer and transferred to TAO shall be fit for purpose as intended and free from defects for a period of 24 months from the Handover Agreement effective date.

All civil works related to the cable system asset constructed by the Customer and transferred to TAO shall be free from defects for a period of 5 years from the Handover Agreement effective date.

The entire cable system asset constructed by the Customer and transferred to TAO shall be free from corrosion for a minimum period of 5 years from the Handover Agreement effective date.

In the event of any defect occurring during the above periods, the Customer shall deliver all components necessary to correct the fault, together with any necessary instructions and specialist assistance, with the cost to be borne by the Customer.

The warranty periods referred to above shall be extended by the same periods as the respective original warranty and to commence from the date of rectification of the default should any defect arise within the original warranty period.

20 Information and Drawings

The project safety file shall be submitted to TAO on completion of the project in accordance with the Construction Regulations and XDS-SDM-00-001 EirGrid Safe By Design Methodology.

20.1 General Information Required

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

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	
Statement of each company'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	

20.2 Detailed Information Required

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

Detailed route drawings including all of the following:

Detailed Information Required	Check
Proposed cable route before planning permission submission, cable plans and long 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	

Consents including all of the following:

Consents Information	Check
Easements / wayleaves 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	

Civil Works including all of the following:

Civil Works	Check
Detailed programme for Civil Works	
Cable trench cross-section drawings	
Future access Civil Works details and drawings	
Joint bay construction drawings	
Joint bay arrangement drawings	
Communication C2 chambers construction 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)	
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	

Material including the following

Material Information	Check
Cable cross section drawing	
Cable technical schedule (as per format provided)	
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)	

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	
Duct proving records	
Cable pulling tension records	
Steelwork erection proposals	
HV Cable Installation Record sheet	

Electrical Information as follows:

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	
Magnetic field calculations and compliance report with ICNIRP Guidelines	

Testing including the following:

Testing Information	**Check**
Prequalification test results	
Manufacturing test programme	
Type test results	
Acceptance test results	
Programme of cable delivery	
Ducting	
Duct and joint bays surround materials	

After laying sheath test results	
Fibre optic test results (OTDR etc.)	
Steelwork test results	
Records of all tests as per IEC standards	

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	

References, Warranties, Other

References, Warranties, Other Information	**Check**
Certificate of warranty as per this Specification	
Service experience list of projects	
Service experience list for material manufacturer	
Service experience list for material installers	
Updated manufacturers training certificate for jointers and installers cable system and accessories	
Training plan for EirGrid nominated staff	
Curriculum Vitaes of jointer training instructors	
Details of storage facilities to be provided for spares	
Details of shelf life of spares items	

Document Reference: CDS-HFS-01-001-R2

110 kV Underground Cable Functional Specification

Route Selection, Design and As Built Records

Revision History					
Revision	**Date**	**Description**	**Originator**	**Checker**	**Approver**
R0	07/02/2012	First Issue – Supersedes CDS-WTS-01-001-R0	ESBI – see page 2	-	Christy Kelleher / Paul Moran
R1	12/01/2017	Updated as per Due diligence Tracker	Daniele Giustini	-	Paul Moran / Kieran French
R2	12/03/2020	Updated as per Due diligence Tracker. Sections modified: 2, 3, 4, 5, 6, 7, 8, 8.6, 8.8.	Daniele Giustini	Due-diligence process and Conor Farrell	Brendan Murray

Contents

1 Scope

This specification describes the requirements for route selection and as-built records for 110 kV underground cables which will be connected to the 110 kV transmission system operated by EirGrid.

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, C2 chambers and link boxes.)

2 General

The Customer shall submit all Planning Permission designs and cable routes in compliance with the requirements of this specification for EirGrid review and acceptance in advance of submitting to the local authority.

High Voltage cable installation across third party lands is undesirable and only considered in exceptional circumstances.

High Voltage cable installation across peat lands is not acceptable and should only be considered if no other option exists. In case of peat lands additional extensive engineering design and documentation will be required by EirGrid before the Customer proposal can be evaluated, please refer to section 6 for further information.

The Customer shall submit all Construction designs and cable routes in compliance with the requirements of this specification for EirGrid review and acceptance in advance of any civil works or installation works proceeding.

The Customer should be mindful that reviews of non –standard (third party 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 and ESBN. 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 shall be conducted by the Customer in advance to determine the suitability of the route. Results of the site investigations shall be issued as part of the Customers design submission for EirGrid review.

Where the gradient of the route exceed 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.

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 and along any areas the cable route that is not located within the public road.

Direct burial of the cable is not permitted in any circumstance with the exception of the approx final five metres cable run for connection to AIS cable sealing ends.

Fibre optic cable direct burial is not permitted in any circumstance. All communications ducting should terminate in either a C2 Communications Chamber; block ducting within the station compound or within the station building itself.

The Customer shall gain 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/acceptance shall have the same specification detailed in Construction and As-Built Design section below.

2.1 Statutory Wayleave

A wayleave and / or an easement may be required by EirGrid. The Customer is responsible for arranging such agreements where the cable is proposed to cross private property.

Any costs associated with the transfer of the wayleave / easement to EirGrid's designated contact will be borne by the Customer.

3 Policy on Underground Cable Routes Through Third Party Lands

EirGrid's policy in relation to the routing of underground cables is that they shall be routed through public roads or public lands.

This approach provides security and protects the integrity of the cable by:

- Limiting the risk of accidental damage
- Prohibiting future development on the route
- Providing access for inspection, maintenance and fault repair as required.

However, with the increased use of underground cable on the network, particularly at 110 kV, situations may arise where it may become necessary to traverse third party lands.

High Voltage cable installation across third party lands is undesirable and only considered in exceptional circumstances. Should a potential requirement for such an installation be proposed, EirGrid shall be consulted at the earliest opportunity.

HV cable route options through third party lands shall only be considered if all other options have been exhausted (to the satisfaction of EirGrid).

If it is absolutely necessary and no other reasonably practical options exists, the Customer may propose routing cables on private land, subject to design review and all necessary wayleaves/easements being obtained and subject to prior EirGrid acceptance.

The Customer shall bear the cost of the transfer of these easements to EirGrid's designate.

In these situations the following provisions will apply:

- Prior written approval from EirGrid must be obtained
- A deed of grant of wayleave in respect of the cable route to ESB must be provided. (min width 4m for 110 kV circuits)
- Proper delineation of the easement area and identification of the cable route must be provided on the marked-up folio
- Durable robust route markers must 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 1700mm
    - Width 92mm
    - Weight 3.5kg

For route markers appearance and label please see appendix A.

- No development may take place. Trees should be planted far enough from the easement area so that roots will not encroach into the easement.
- 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. Such access road to be designed and constructed for heavy plant (5t axel loading) movement along the length of the route.
- Joint bays, link boxes and C2 Communication Chambers to be located on public roadways and public property as a standard even if cable route traverses private properties.

The Customer shall submit details of all consents required / agreed along the full route. The Customer shall also provide general arrangement, long sections and cross sectional drawings along the full route.

3.1 Cable Route Crossings

A full survey shall be carried out, including trial holes 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 300mm must be maintained between the EirGrid ducts (power or comms) and all other services.

Where other Utilities require greater clearance (i.e. for high pressure gas pipes it is 600mm) the Customer shall ensure these are adhered to.

3.2 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 cable, the design shall take due account of cable de-rating due to mutual heating of the cables through HV cable analysis. The mutual coupling effect of other cables and pipelines must also be taken into account.

Where 110 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 as per IEC 60287.

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 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 must be kept away from access points e.g. driveways, entrances etc.
- Adequate room must be provided in front of and behind each joint bay, link boxes and C2 chambers location to accommodate cable drums, vehicle used for maintenance and pulling equipment.
- All proposed joint bays locations must be proven 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 will be constrained and will require that minor sections are of substantially equal length.
- C2 communications chamber and link boxes to be installed at each joint bay. Additional C2 communications chamber will be required if route design exceed the maximum allowable pulling forces and tensions for the installation of fibre cable
- Splicing of fibre optic cable will take place in specific C2 chambers as determined at detailed design stage.

Joint bays should be positioned so as to avoid unnecessary road closures and traffic management during installation and maintenance. Associated communications chambers and link boxes shall be installed off the carriageway where practical. Link boxes and C2 communication chambers positions shall be accepted by EirGrid during the design phase.

The Customer's designer shall consider the maintenance requirements and operators access for opening jointing containers when designing the location of the C2 chambers / link box.

5 Horizontal Direct Drilling

5.1 Trenchless Technology

Should it be necessary to cross obstacles such as bridges, railways, water courses etc. with the cable duct(s), and all infeasible, then the method of installing the cable duct(s) by trenchless technology may proposed for EirGrid review.

Long lengths of ducting outside such areas installed using trenchless technology are not accepted.

The Customer shall submit a design proposal for EirGrid to review.

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

The following is the size of duct to be used for directional drilling for 110kV power ducting:

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

Communication ducts shall be 125mm OD SDR 11 in trenchless installation.

Transition couplers shall be used to join SDR 11 ducts with standard SDR 21 and 17.6 ducts, for additional duct details please see specification CDS-HFS-03-001.

In exceptional circumstances, a transition pit may be used at both ends of the trenchless technology installation to join trenchless ducts with standard ducts. The transition pit requirements are outlined in standard drawing XDC-CBL-STND-H-013.

6 HV Cable Trench Installation through Peatland

Overhead Lines are the preferred transmission infrastructure to be used through peatland (for both blanket and/or raised bogs).

Cable Trenches crossing through peatland shall be avoided if at all possible.

Any routes identified through peatland must be reviewed and accepted by EirGrid on a case by case basis. Should a potential requirement for such an installation be proposed, EirGrid should be consulted at the earliest available opportunity.

If all other HV cable route options have been exhausted (to the satisfaction of EirGrid) then a design may be considered by EirGrid through peatland. Such design shall be reviewed and accepted by EirGrid before the Customer can submit the planning permission.

The Customer shall submit a detailed feasibility study of the options and their proposal for installation of a short section of the HV cable route in peatland.

The feasibility study shall advise why the other route options are not being progressed and also provide case studies of where a similar peat land cable design has been installed successfully.

For all underground cables constructed in peat, regardless of location (e.g. within or beneath a road or otherwise), the Customer shall include the following in the feasibility:

- A desktop study of the route including a review of all existing geotechnical information, outlining all constraints and geotechnical risks
- An outline of all site investigation 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 risk are to be controlled and/or mitigated
- A feasibility design for the cable route 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 towers 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

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.
- 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 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 the service road.

It should be noted that as with any non-standard design, EirGrid should receive early notification pre-construction that a non-standard design is being proposed and a formal derogation submitted.

It should also be noted that the process for seeking acceptance of a non–standard design is more onerous and timely as more stakeholders are involved in the review. Also the design may require additional warranties to mitigate risk if deemed necessary.

Cable drawings included in XDC-CBL-STND-H-007 shall be used for guidance only in determining the construction design.

7 Design Submission

The Design shall be submitted for EirGrid review and acceptance. A period of 15 working days shall be allowed for EirGrid review of any design submission from date of receipt of each submission to date of notification of comments or no comments.

In programming design submission the Customer should allow for the possibility that re-submissions may be necessary before EirGrid will be in the position to accept the design. No site works should start before design is accepted. . The number of re-submissions will be inversely proportional to the quality level of the design submissions.

Design submission schedule shall be submitted and agreed with EirGrid at project kick off meeting.

Each design submission to EirGrid shall be sequentially numbered and dated.

Each submission shall be accompanied by a transmittal sheet which lists the documents comprising the submission. If the submission includes revisions of documents previously submitted the transmittal sheet shall include a reference to the original submission number.

8 Construction and As-Built Design

8.1 Background Mapping

Ordnance survey strip mapping in national grid co-ordinates is required along the proposed cable route. The route design and As Built 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.

8.2 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 out below by this specification.

Up to date Vector Ordinance Survey Strip mapping in national Grid co-ordinates 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. The drawings shall be sufficiently detailed to enable construction to proceed without the need for other supporting drawings / documents or interpretations. All Drawings and supporting documentations shall be checked and approved by the Designer 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 3rd party service crossings 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 recommend that increased quality assurance photograph evidence is recorded for instances when the design or ducts deviate from the standard trefoil formation to be included in the as-built drawing package.

8.3 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 Smartline / 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.

8.4 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 sample attached.

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.

8.5 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. The sample as-laid record has some examples of tie-in dimensions.

8.6 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 cross section 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 accepted by EirGrid before construction starts.

8.7 Existing Utility Services

All existing services exposed by the trench excavation or in the vicinity 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 standard drawing XDC-CBL-STND-H-009.

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.

8.8 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.

8.9 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 sample drawing number XDC-CBL-STND-H-009.

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:

Object	Level/ Layer	Colour	Style
ESB 110 kV Cable	2/ESB	5/Magenta	4/DashDot
ESB 220 kV Cable	2/ESB	1/Blue	6/DashDotDot
ESB 400 kV Cable	2/ESB	1/Blue	6/DashDotDot
ESB 38 kV Cable	2/ESB	3/Red	2/Dash
ESB MV/LV	6/Utilities	3/Red	0/Continuous
ESB Fibre Cable	2/ESB	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

Table 1 - Plotting Styles

8.10 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.

The Customer shall ensure final As Built drawings are issued to ESB Central Site office before the cable commissioning starts.

9 Appendix A - Route Marker post

Document Reference: CDS-HFS-02-001-R3

110 kV Underground Cable Functional Specification Cable Materials

Revision History					
Revision	**Date**	**Description**	**Originator**	**Checker**	**Approver**
R0	07/02/2012	First Issue – Supersedes CDS-WTS-02-001-R1	ESBI – see page 2	-	Christy Kelleher / Paul Moran
R1	20/01/2015	Section 2 – Highest voltage for equipment (rms), U_m , amended from 128kV to 123kV	Kieran French	-	Paul Moran
R2	12/01/2017	Updated as per Due diligence Tracker	Daniele Giustini	-	Paul Moran / Kieran French
R3	12/03/2020	Updated as per Due diligence Tracker. Sections modified: 2, 3, 4, 5, 8.	Daniele Giustini	Due-diligence process and Conor Farrell	Brendan Murray

Contents

1 Scope

This specification forms part of a suite of documents that describes the requirements for cable materials for 110 kV underground cable systems which will be connected to the 110 kV transmission system operated by EirGrid.

It covers the design, manufacture, testing and delivery to Ireland of 110 kV (nominal voltage) underground cable materials, together with all accessories needed for their proper and reliable operation.

2 Functional Requirements

2.1 Network Parameters

The cables and accessories shall be rated in accordance with the “Network Parameters” table contained in the EirGrid General Requirements specification XDS-GFS-00-001.

The neutral of the system 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 / SLD.

The minimum rating requirement of the cable is dependent on the Customer connection and will be advised by EirGrid.

2.2 Service Conditions

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

The climate in Ireland is moderate and extreme temperatures are very rare.

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 General Requirements specification XDS-GFS-00-001.

3 Standards

All materials shall comply with and be manufactured and tested according to 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 110 kV cables and associated fibre optic cables, where required, shall be manufactured, installed and tested in accordance with:

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 oversheaths which have a special protective function and are applied by extrusion
IEC 60287	Electric cables – Calculation of the current rating
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 60840	Power Cables with extruded insulation and their accessories for rated voltages up to 150 kV (Um = 170 kV) – Test methods and requirements
IEC 61238	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 61914	Cable Cleats for Electrical Installations
IEC 62271 – 1	High-voltage switchgear and controlgear – Part 1: Common specifications
IEC 62271 – 209	High-voltage switchgear and controlgear – Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable-terminations
HD 632.2 2008	Power cable with extruded insulation and their accessories for rated voltage above 36kV (U_m=42kV) – Test methods and requirements.
ENA-ER-C55/5	Insulated Sheath Power Cable Systems
IEC 60794-1-1	Optic Fibre Cables – Part 1 Generic Specification – General
IEC 60794-1-2	Optic Fibre Cables – Part 1-2: Generic Specification – Basic optical cable test procedures
ITU-T G.652D	Characteristics of Single Mode Optical Fibre Cable
ITU-T G.655E	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable

EN 187105	Single Mode Optical Cable (Duct/Direct Buried Installation)
XDS-GFS-17	EirGrid Specification: Galvanised fabricated steelwork
XDS-GFS-18	EirGrid Specification: Hot dip galvanising of iron and steel other than wire
IEC 60794-1-1	Optic Fibre Cables – Part 1 Generic Specification – General
IEC 60794-1-2	Optic Fibre Cables – Part 1-2: Generic Specification – Basic optical cable test procedures
ITU-T G.652D	Characteristics of Single Mode Optical Fibre Cable
ITU-T G.655E	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
BS EN 7912-2	Power cables with XLPE insulation and metallic sheath, and their accessories, for rated voltages from 66 kV (Um=72.5 kV) to 132kV (Um=145kV). Requirements and test methods

In any conflict exists between the standards quoted and this specification, this specification shall take precedence.

4 Equipment Design

4.1 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 waterblocked with conductor semi-conducting layer, superclean 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.

4.1.1 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 60840 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.

4.1.2 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.

4.1.3 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 a vital Health and Safety issue 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.

4.1.4 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 0.7mm.

4.1.5 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.

4.1.6 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 60840 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.

4.1.7 Cable Metallic Sheath

The metal sheath shall be either copper or aluminium wire screen with foil laminate or welded aluminium.

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 2.1 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.

EirGrid will advise the Customer of any project specific requirements for the conductor and metal sheath.

4.1.8 Polyethylene Outer Sheath

The outer sheath shall be of HDPE grade and shall have a minimum thickness dimensions in accordance with IEC 60840 plus 1mm. The colour of the sheath shall be black. The shore D hardness 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 5 kV for one minute over the cable lifetime on a fully ducted system.

The outer surface of the HDPE/MDPE outer sheath shall have an extruded or coated graphite 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.

4.1.9 Cable Identification

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

- ELECTRIC CABLE
- 110000 Volts
- 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 10mm. The gap between the end of one set of embossed characters and the beginning of another shall not be greater than 150mm.

Identical dimensions as described for embossing shall apply via 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.

4.2 Joints

Joints shall be designed and tested in accordance with IEC 60840.

Prefabricated joint designs are required. Joints shall be fitted with a casing or surround which shall be completely watertight to the standard of the cable itself.

The connector shall be suitable for jointing by compression or a shearbolt system.

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 annual voltage testing of the cable outer sheath.

4.3 Terminations

Terminations shall be designed and tested in accordance with IEC 60840.

All terminations shall be fluid free type.

The particular requirements for each type are as follows:

4.3.1 Gas Insulated Metal Enclosed Switchgear Terminations

Proven plug and socket switchgear termination designs are required.

Where these terminations are used, they should be provided with insulating glands capable of withstanding the 10 kV DC commissioning test and annual 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.

4.3.2 Outdoor Terminations

Outdoor terminations shall be dry type with polymeric insulator.

The termination design shall take in account the severity of the pollution level that applies to the locality. 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 heavy pollution level 43.3mm / kV. In certain cases a higher RUSCD value for very heavy pollution level 53.7mm / kV may be required where requested by EirGrid. 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.

Stand-off insulators will be required capable of withstanding the 10 kV DC commissioning test and annual outer sheath test.

Corrosion failure or UV or overall weathering degradation of the polymeric insulator material shall be addressed using a 5000 hours multiple stress test e.g. IEC 62217 annex B, EDF salt fog test or other suitable test.

4.3.3 Customer transformer terminations

Connection to the Customer transformer can only be done via air insulated termination and overhead conductor to the air insulated transformer bushings.

4.4 Distributed Temperature System

A distributed temperature sensing system (DTS) may be required by EirGrid and communicated at early project stage.

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

The detailed functionality of the DTS system is to be discussed and agreed with EirGrid. This will require at least No.2 additional fibres in the cable with 200% redundancy to be provided within the one phase of the cable (for example at the metallic screen layer of the power cable) to enable accurate conductor temperature measurements to be determined. A multimode, double ended configured DTS system would be required for increased accuracy.

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.

The DTS systems shall have the capability of providing Real Time Current Ratings, the ability to generate alarms, maps and provide RTTR within the box or as a server based option, all of which can be linked in with the SCADA system.

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.

4.4.1 Fibre Optic Cable

4.4.1.1 Optical Fibre

The optical fibres shall be single mode fibres and conform to the requirements of IEC 61300.

4.4.1.2 Fibre Technology Design

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

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

4.4.1.3 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 acceptance.

4.5 Current Ratings

The current ratings shall be calculated 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 of native soil and backfill 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

- 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

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 and acceptance.

An internationally accredited software shall be used to perform the rating calculations.

4.6 Overload Rating

The overload ratings for the durations requested in the cable technical schedule shall be provided. The conductor temperatures reached during these overloads shall be stated.

The maximum allowable continuous conductor temperature shall be 90°C.

The maximum allowable one second short-circuit conductor temperature shall be 250 °C.

5 Sheath Bonding / Earthing and Phasing

The sheath bonding arrangement should be taken into account when establishing the current rating of the cable according to 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 150V for 110kV cable.

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 an SVL should be installed with the prior agreement of EirGrid.

Where the cable sheath shall be directly earthed, the Customer shall employ three phase direct earthing link boxes. The Customer shall also install sheath interruption link boxes at every joint bay.

The Customer shall install link boxes at both terminations.

Where the cable sheath shall be single point bonded (mid / end point bonded), the Customer shall use a combination of a single point bonded earthing link box (with sheath voltage limiters) and direct earthing link boxes. Depending on the cable system design solution the Customer may be required to install an earth continuity conductor for single point bonding in accordance with the standard outlined in Engineering Recommendation ENA-ER-C.55/5 published by the UK Electricity Association with an LV copper conductor having minimum size of 240mm^2. The length of cable circuit where single point bonding may be used is limited by the sheath standing voltage. The Cable bonding diagram shall be submitted to EirGrid for review/acceptance.

The earth continuity conductor shall be installed in a dedicated HDPE duct, separate from the Telecoms ducts as per standard drawing XDC-CBL-STND-H-008. The ECC conductor cannot pass through the C2 chambers at the joint bays but shall be connected directly to the link boxes.

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

6 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 screenwires to the main conductor at the back of the pulling eye.

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

7 Manufacturing Process

7.1 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 CDS-GFS-00-001 General Requirements functional specification.

7.2 Handling of Manufacturing Process Deviations

Deviations from these criteria or any occurrence of manufacturing process deviation shall be immediately notified to EirGrid. In the event that remedial action, repair or reworking may be appropriate, such action shall only proceed with the prior approval of EirGrid. Any product which has been repaired, reworked or has been the subject of remedial actions without prior approval may be liable to rejection notwithstanding the results of any tests prescribed by this Specification. Any consequent delay due to the provisions of this Clause shall be the sole responsibility of the Customer and shall not relieve the Customer of their obligations regarding adherence to the works programme.

8 Tests

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

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

8.1 Routine Tests

For routine tests refer to CDS-GFS-00-001 General Requirements functional specification.

Routine test reports shall be provided to EirGrid for acceptance before the cable, fibre and accessories are delivered to site.

EirGrid may send a representative to the factory during the manufacturing of any or all of the cable lengths involved. The Supplier should arrange to notify the Purchaser in good time regarding the manufacturing programme for the cables.

8.2 Sample Tests

Sample tests will be carried out on the cable in accordance with IEC 60840 and CDS-GFS-00-001 General Requirements functional specification.

In addition to the test specified in IEC 60840 the cable's water blocking ability shall be tested by applying a 1 meter head of water over an 11 day period; no water shall issue from the 3 meter cable sample at room temperature as specified in BS EN2912-2. This test shall be undertaken as a sample test, once per production run or as agreed between EirGrid and the Customer.

A test shall be undertaken to ensure that the surface conductivity of the outer sheath graphite or extruded semiconductive layer is less than or equal to 16 kΩ / 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 acceptance before the cable and accessories are delivered to site.

8.3 Type Tests

Type tests shall be carried out in accordance with IEC 60840 and CDS-GFS-00-001 General Requirements functional specification.

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 acceptance for the cable and associated accessories. Where type tests have not been undertaken for this material or the material tested is not the same of what is proposed to be installed then EirGrid will decide on whether additional type testing is required or not.

8.4 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 60840, IEC 60229 and CDS-GFS-00-001 General Requirements functional specification. The results of this shall be submitted to EirGrid.

9 Fibre Optic Cable

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 12 optical cores (= 48 fibres). 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, meter marking.

10 Fibre Optic Cable Installation

10.1 Installation

All Fibre Optic cable installation must be in accordance with the manufacturer’s specifications and recommendations.

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

Table 1 - Fibre Installation

*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 the relevant specification.

[Eirgrid may require testing of fibres post installation to confirm maintained compliance with designed specifications]

10.2 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 prior to installation

Document Reference: CDS-HFS-03-001-R2

110 kV Underground Cable Functional Specification

Civil Works

Revision History					
Revision	**Date**	**Description**	**Originator**	**Checker**	**Approver**
R0	07/02/2012	First Issue – Supersedes CDS-WTS-03-001-R0	ESBI – see page 2	-	Christy Kelleher / Paul Moran
R1	12/01/2017	Updated as per Due diligence Tracker	Daniele Giustini	-	Paul Moran / Kieran French
R2	12/03/2020	Updated as per Due diligence Tracker: Sections modified: 2, 3, 4, 6.	Daniele Giustini	ESB due-diligence process and Conor Farrell	Brendan Murray

Contents

1 Scope

This specification describes the requirements for civil works for 110 kV underground cables which will be connected to the 110 kV transmission system operated by EirGrid.

The Customer shall install a fully ducted solution for the cable civil works/installation.

2 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 outlined in Appendix A of this specification.

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 and Table 1.

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).

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

Table 1: Minimum Clearances for HV Cable Ducts

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 to Appendix A standard drawings:

- Approved Yellow marker warning tape,
- Approved Red cable protection tape,

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

- 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 according to EirGrid specification CDS-HFS-01-001.

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

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

3 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 these EU electricity utilities of at least 1,000,000 metres.
- As an alternative to such experience within the EU, similar experience with Japanese, South Korean, Australian or US/Canadian utilities would be considered.
- At least 5 years production in the particular factory proposed is required, although if the particular plant in the proposed factory is relocated existing plant using substantially the same workforce the combined time of both plant and factory would be considered.

3.1.1 Duct Service Conditions

The following service conditions apply to ducted underground cable installation:

Service Condition	Requirement
Soil Temperature Range	-5 ^{o}C to 20 ^{o}C
Continuous Heat Generation within duct	up to 30 Watt/m run.
Temperature Range	0 ^{o}C to 70 ^{o}C (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

Table 2: Duct Service Conditions

4 Duct Requirements

4.1 Reporting Requirements

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

The weekly reports shall be submitted no later than 5:00pm on Monday for the previous week works.

The detailed weekly report shall include the following information:

1. Map of the entire route showing the sections being worked on for that period.
2. Map showing the section from joint bay to joint bay being worked on that week.
    a. This map shall highlight the completed works the previous week and the works scheduled the week at the time of writing.
3. The map in item 2 should also show the location of all service/culvert crossings and they should be appropriately sequentially numbered.
4. A brief summary table.
5. Photographic evidence of the work completed displaying the following:
    - All photos must 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 must cover the entirety of the ducting works and shall be taken at suitable intervals (10 meters approximately). GPS co-ordinates should be provided for each photo. Photos shall be geotagged.
    - The photos must 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 power ducts are installed (prior to backfilling with CBGM B) and again prior to backfilling the communications ducts layer. The photos should display all the elements necessary to confirm that the quality of ducting installation is of a high standard i.e. clean trenches, spacer templates, correct depths of CBGM B, 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 i.e. stone/piped culverts, a series of photos must show the extent of the works carried out.
6. A summary of the quality testing complete for the week which may include compaction tests, delivery dockets, cube tests which clearly specify type of concrete used etc.

7. Surveyed levels of the monitoring stations along the deep peat/top hat design sections (where required).
8. Cube tests results can be issued when are available.

4.2 Materials

Material for duct bed and surround and trench backfill for standard formation shall be CBGM Category B (Cement Bound Granular Material Category B), 15N/mm^2.To obtain this value a minimum of 7 days curing is required in accordance with Series 1000 of the NRA "Specification of Road Works". The material should conform to the thermal resistivity requirement of this specification. Proof of conformance to the thermal resistivity requirement of this Specification following 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 of this specification may also be requested by EirGrid at any stage during construction.

Proof of conformance to the thermal resistivity requirement of this Specification for thermal sand used in Joint Bay and approx. five meters direct buried section before Cable Sealing Ends is also required.

Concrete for road reinstatement shall be grade C40/N20 with minimum cement content 350 kg/m^3 in accordance with Series 1000 of the NRA "Specification for Road Works".

Concrete used in the trench for 3rd party service crossings and bridge crossings shall be grade C25/30, wet type, in accordance with Series 1000 of the NRA "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 is 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 NRA "Specification for Road Works".

4.3 Duct Specification

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

All ducts and fittings shall be designed to satisfactorily withstand the service conditions for a period of 40 years minimum.

4.3.1 Duct Testing Requirements

Testing of duct products shall be required to ensure that the ducting shall perform satisfactorily over the expected service life on EirGrid system and the service conditions given above.

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 reistance shall be greater than 750 N at 5% when measured in accordance with IEC 61386-24.

Type or Sample Tests to perform to other equivalent National or International Specifications or standards may be submitted with the 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.

4.3.2 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 bended they shall not deform or suffer 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. Ducts manufacturer should produce instructions for welding and these needs to be reviewed for acceptance by EirGrid and strictly adhered to during construction activity.

4.3.3 Ducts Packaging design

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

4.3.4 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 frictions with cable surface.

HV cables used in the Irish transmission system shall be 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 failure of expensive power cable, for this reason high smoothness of the duct inner surface and low friction coefficient is very important.

4.3.5 Ovality and Diameter Tolerances

The ovality of coilable and non-coilable ducts shall not exceed the dimensions shown in the following Table 3: 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

Table 3: Ovality and Diameter Tolerances

4.3.6 Duct colour and lengths.

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

All ducts shall have a standard length of 6m, 9m or 12m. Coils can be used for Horizontal Directional Drill.

4.3.7 Duct Marking

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

- “DANGER ELECTRICITY CABLES”;
- 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 meter at every meter.

Maximum gap between two adjoining legends shall be less than 150mm.

Height of legend to be not less than 20mm and the legend should be write in three lines at 120° apart.

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

The insertion depth shall be marked at the end of each duct.

For ducts to be installed in Horizontal Directional Drilling 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.

4.3.8 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:

- Very expensive cable damage.
- Necessity for additional unplanned cable joints.

Coupler design shall:

- Allow manual alignment and assembly for duct length 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 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 in 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 160 mm and 200 mm SDR21 PE ducting, it is essential that the coupler is able to withstand the bending forces required to bend a 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 /160 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 sizes
- 160 mm for 160 mm, 200 mm, and 225 mm ducts

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

4.3.9 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 the same 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 couplings, these transition couplers will 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 4: Ducting Sizing 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.

Duct Type 1 (HDD)	Duct Type 2 (Standard Trench)
225 mm SDR 11 HDPE	200 SDR 21 HDPE
180 mm SDR 11 HDPE	160 mm SDR 21 HDPE
140 mm SDR11 HDPE	125 mm SDR 17.6 HDPE

Table 4: Ducting Sizing

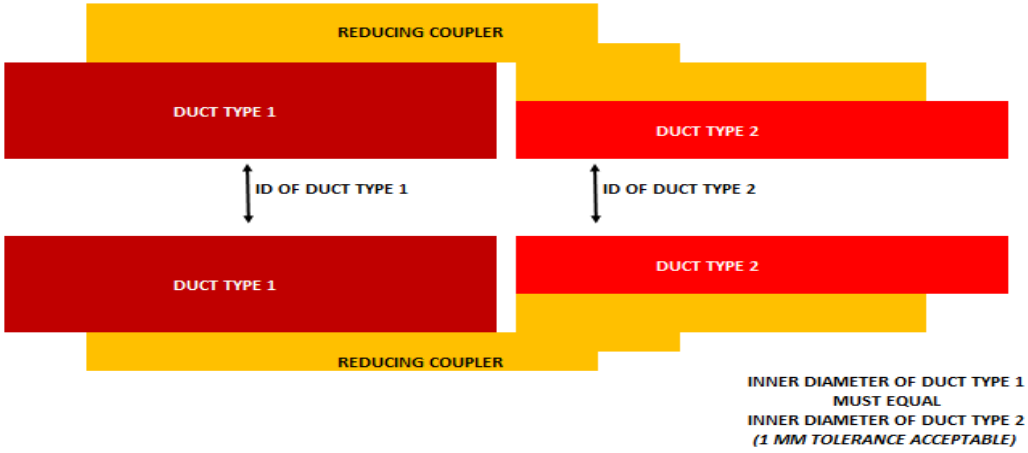

Figure 1

Inner diameter of Duct Type 1 must equal the inner diameter of Duct Type 2 to within a 1mm tolerable difference only.

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. Insertion depth will be dependent on the design of the reducing coupler but shall be of equal length on both sides, must match with the standard insertion depth as marked on the associated ducts and will ensure that both duct types are 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 water tight and secure connection to the duct.

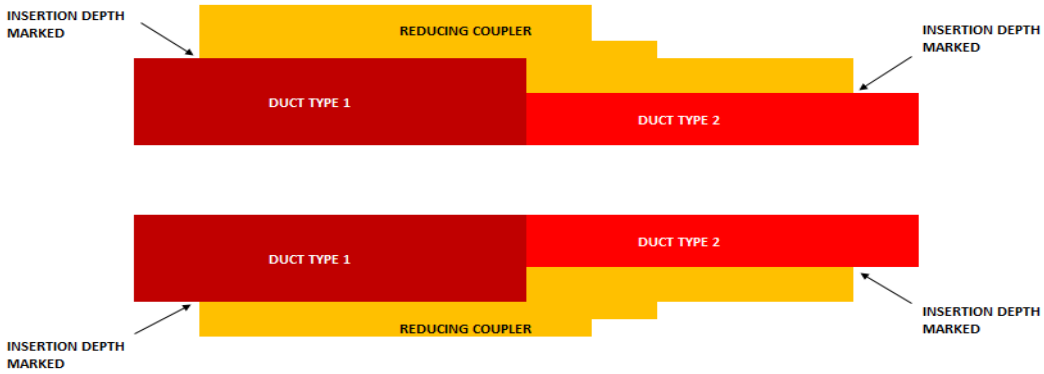

Figure 2

An alternative is to use transition Chambers.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. For transition chamber standard drawing refer to Appendix A.

Communication ducts do not require transition couplers or chambers. the 125mm OD SDR11 can 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 indipendantly. Finally the communication ducts can be proved C2 chamber to C2 chamber at either side of the HDD section with a 90mm mandrel.

4.3.10 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.

Immediately on delivery of ducts, the Customer shall check that they comply with the specification, in particular in respect of wall thickness, internal and external diameter along full length, 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 used shall be such to avoid distortions of the ducts and the integrity of the ducts shall be maintained throughout their site storage and transport. The bales of ducts should not be stacked over two bales in height.

Duct bales shall be held in position by an appropriate 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 designed out.

Indelible waterproof labels to be placed on each bale of ducting stating ‘‘Approved for ESB Networks / EirGrid use’’ and A4 laminated installation labels 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 including excessive and/or inferior wall thickness:
- Duct ovality;
- Duct damage and distortion
- Duct caps are installed:
- Correct packaging on delivery storage;

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

4.4 Duct Installation

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

Ducts may be cut provided that they are suitably held, supported in a safe manner and protected during the process. All ends shall be cut square to the longitudinal axis of the area and treated to ensure a smooth finish.

Ducts shall be spaced strictly in accordance with the drawings outlined in the appendices of this specification. Where this is not possible due to spatial constraints 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 so that there is not bending or stress on the coupler. Pre-formed short-radius bends are not permitted, unless agreed with Customer's Designer and cable manufacturer.

For HV ducts, the radius shall not be less than 6 m. In order to avoid damage when bending ducts, no heat shall be applied to the ducts when joining ducts together via couplers. The Customer shall ensure that collars joining ducts 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 should not be removed until the duct is in the trench. Once installed the ducts 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: Any 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 result in cable failure.

4.4.1 Use of Templates

Timber templates shall be used for duct installation. The template shall have the correct dimension to achieve the required duct formation as per accepted design. Multiple templates will be required for several types of formations as part of the circuit accepted 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 ducts spacers shall be used. Spacers to be made of the same type of concrete being used in the trench and left in situ after pouring.

4.4.2 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.

Ropes when spliced must be spliced in approved manner

4.4.3 Tying of Ducts

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

4.4.4 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 standard design outlined in Appendix A of this specification.

In any case the minimum shallow trench depth is 450mm from ground level to top of the HV power duct. Please refer to Appendix A of this specification for.

4.4.4.1 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 outlined in in Appendix A of this specification for bridge crossing or service crossings installations. 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 in Appendix A of this specification.

4.4.5 Surface Cable Plate Markers

Surface cable metallic plate 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.

4.4.6 Trench Layout

The trench layout shall be as per relevant EirGrid standard drawings in the appendices of this functional specification.

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 gradients 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 drawings in the appendix of this specification.

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 this requirement shall be included in the design review submission for EirGrid acceptance.

4.4.7 Joining of Ducts

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

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

4.4.8 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 and cleaned out to minimise possibility of abrading cable during pulling. No internal burrs or sharp edges are allowed as a result of end cutting operations.

The Duct plain ends shall be chamfered before 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 duct manufacturer.

4.4.9 Dirt ingress into the Ducts

Dirt ingress into the ducts shall be prevented as any dirt or pebbles trapped in the ducts may lead to cable failure. This is to prevent dirt or other sharp objects pressing between the duct and the cable resulting in deep scores and gashes on the cable outer sheath which may 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 installed duct ends and retained in place all times. These bungs shall be fitted with an internal D-ring to facilitate the tying of draw rope.
- Trenches, joint bays etc. shall kept free of water so as to prevent any risk of the cable and other materials to be laid in the trenches joint bays etc. being detrimentally affected.

5 Joint Bays and Communication Chambers

5.1 General requirements

All reinstatement of the cable trench shall be in accordance with the manufacturer's specification, the requirements of the local authority and as per the detailed design in advance of the works.

Installation of joint bays and communication chambers shall be in accordance with standard drawings included as appendices to this document.

5.2 Joint Bays

Joint bays location shall be chosen with suitable terrain and access to facilitate 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 drawings in Appendix A of this specification.

5.3 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 chambers location shall be chosen with suitable terrain and access to facilitate the operation of fibre cable pulling equipment, fibre cable splicing, fibre cable maintenance, fault finding activities and future operation of the installation.

The construction and reinstatement of communication chambers shall comply with the drawings in the appendix of this specification.

5.4 Link Box Chambers

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

Link box chambers location shall be chosen with suitable terrain and access to facilitate 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 and reinstatement of link box chambers shall comply with the drawings in the appendix of this specification.

5.5 Lubrication Points

Lubrication points may be required to ensure cable installation can be pulled without exceeding the manufacturer's maximum permissible cable pulling forces of the proposed cable.

Lubrication points shall be installed in cable route in close proximity to area of high bends concentration.

Optimised position 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 with suitable terrain and access to facilitate the operation at any phase of the development and future operation of the installation.

6 Construction Supervision

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. Duct installation and cable pulling weekly report shall be prepared and submitted to EirGrid weekly during the works as per Duct Installation section of this Functional Specificaiton.

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

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

7 Appendix A

Drawing No.	Drawing Title
XDC-CBL-STND-H-001	Standard - 3rd Party Crossing (125mm Above)
XDC-CBL-STND-H-002	Standard - 3rd Party Crossing (160mm Above)
XDC-CBL-STND-H-003	Standard - 3rd Party Crossing (125mm Below)
XDC-CBL-STND-H-004	Standard - 3rd Party Crossing (160mm Below)
XDC-CBL-STND-H-005	Standard - Riverbed Crossing
XDC-CBL-STND-H-006	Standard - Bridge Crossing
XDC-CBL-STND-H-007	Standard - Trench Through Peat
XDC-CBL-STND-H-008	Standard – Trench Cross Section
XDC-CBL-STND-H-009	Standard – As-built Cable Route
XDC-CBL-STND-H-010	Standard – C2 Chamber
XDC-CBL-STND-H-011	Standard – Link Box Chamber
XDC-CBL-STND-H-012	Standard – Pre-cast Joint Bay
XDC-CBL-STND-H-013	Standard – Transition Chamber

Document Reference: CDS-HFS-04-001-R2

110 kV Underground Cable Functional Specification

Cable Installations and Pre-Commissioning

Revision History					
Revision	**Date**	**Description**	**Originator**	**Checker**	**Approver**
R0	07/02/2012	First Issue – Supersedes CDS-WTS-04-001-R0	ESBI – see page 2	-	Christy Kelleher / Paul Moran
R1	12/01/2017	Updated as per Due diligence Tracker	Daniele Giustini	-	Paul Moran / Kieran French
R2	12/03/2020	Updated as per Due diligence Tracker. Sections modified: 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 17, Appendix A.	Daniele Giustini	Due-diligence process and Conor Farrell	Brendan Murray

Contents

1 Scope

This specification covers the installation requirements of 110 kV underground cables and associated fibre cabling (where applicable) which will be connected to the 110 kV transmission system 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 and jointing accessories are stored in a secure location.

The Customer shall familiarise themselves with the requirements of the EirGrid 110 kV Underground Cable Standards prior to undertaking any design and installation work.

2 Cable System Configuration

The arrangements of the cables, their relative position to each other, their surroundings and all methods of installation over the whole route length shall be in accordance with the cable system design previously submitted to and accepted by EirGrid.

3 Prevention of Water Ingress

During the installation (between duct proving and ends of commissioning) the Customer shall maintain open trenches, joint bays, cable basements etc. free of water so 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.

4 Cable Handling

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

4.1 Transportation

Cable shall be delivered to site on steel drums on a drum trailer or on a truck trailer.

4.2 Loading / Unloading

To avoid serious injury to personnel and damage to cable drums, an appropriately sized axle shall be used for lifting along with a spreader bar to prevent the lifting gear damaging the drum and crushing the cable. Appropriately rated proprietary lifting hooks that fit into and lock onto the axle hole may be used in place of a steel axle. All lifting equipment shall be rated to lift the gross weight of the drums, with an appropriate factor of safety.

4.3 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.

5 Cable Pre Pulling Requirements

The Customer shall submit to EirGrid for acceptance the following documents before pulling activities can commence:

- Detailed program for cable installation four week prior to start 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.

6 Cable Pre Pulling Checks

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

All cable drums shall be checked by rotating the drum and visually observing 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 Customers plan to remedy the damage.

This inspection shall take place for all cable drums 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 at a later stage when cable is installed along the ducted route.

A 10 kV DC test shall be under taken to assess the conductive properties as outlined in section 12.

7 Cable Installation

No cables 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 cable installation before civil works for the entire route is complete. The risk assessment shall and control measure shall ensure the cable is adequately protected during works.

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

7.1 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 deemed acceptable to EirGrid prior to the cable being pulled.

Ample notice (>4 weeks) shall be provided to EirGrid to 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 1 below. A sponge can be used to remove the water from the duct section prior to proving.

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
160	145	HDPE, SDR 21	135 mm	155mm	165mm
180	147	HDPE, for directional drilling duct (SDR 11)	135mm	155mm	165mm
200	181	HDPE, SDR 21	170 mm	187mm	197mm
225	183	HDPE, for directional drilling duct (SDR 11)	170 mm	187mm	197mm

Table 1

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 file output facility.

The printout should measure speed and tension every 3m and the pdf output file shall record speed and tension every meter. 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 certification shall be provided to EirGrid before any cleaning and proving activity takes place.

The duct cleaning/proving report (see appendices) 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 supervisor who has witnessed the tests. Fully completed reports and print outs for each section of ducting, for every duct, shall be submitted to EirGrid for review and acceptance 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 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 instruments.

Following the duct proving process, approved 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 1 - Set up for Swivel, Brush, Mandrel and Sponge for Duct Proving and Cleaning

7.1.1 Duct Cleaning Issues Encountered

The proving of the ducts will be deemed as 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 exceed 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,
- A camera can 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.

7.2 Cable Pulling

7.2.1 Side Wall Force Calculations

Cable pulling shall not take place until such a 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 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 up so the pulling force will not result in side wall force cable limit being exceeded.

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

7.2.2 Ducts Pre - Lubrication during Installation

Cable lubricant is required during the cable pulling activity to reduce cable-duct friction.

For cable installations in ducts, the ducts shall be pre-lubricated using an approved 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 calculation referred to in the cable pulling and laying section above.

7.2.3 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.

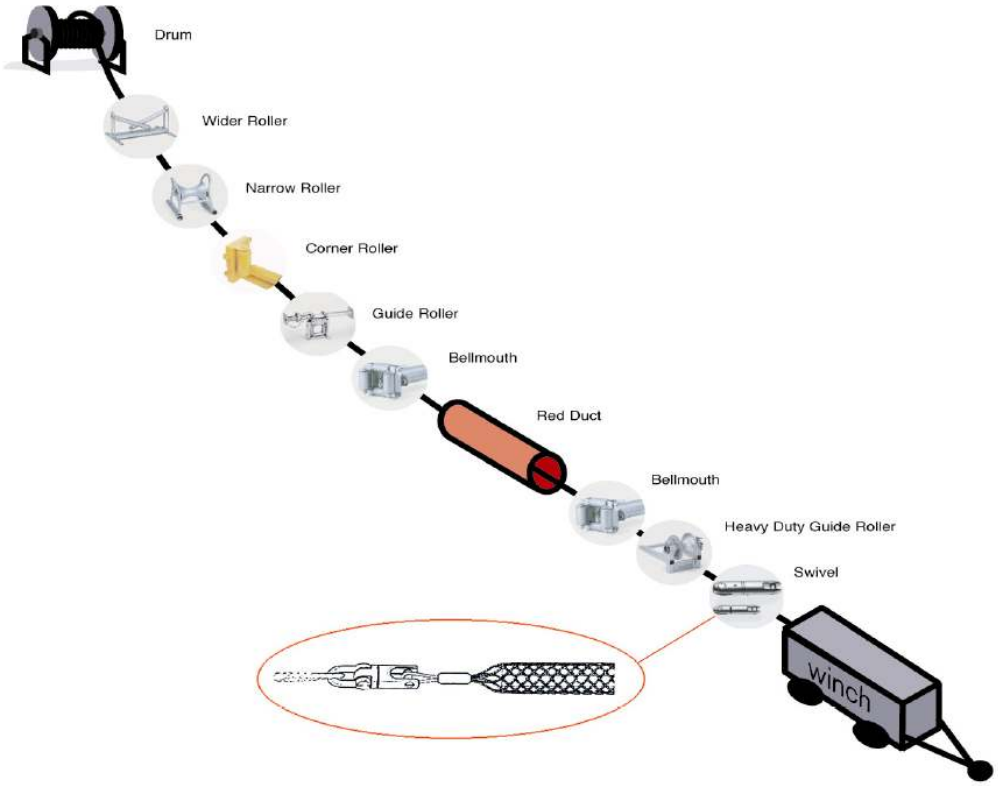

Figure 2 - Set up for Cable Pulling

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, acceptance and written agreement by EirGrid prior to any work commencing on site.

8 Joint Bays and Terminations

All cable joints and terminations 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 accessories manufacturer.

8.1 Sealing of cable ducts

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

9 Cables in Basements and Entry to Switchroom

This cable basement layout shall be submitted as part of the detailed design EirGrid for 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 factored for disconnecting and reconnecting of the cable over its life time and also for the installation of future adjacent cables.

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

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

10 Precautions after Laying

Care shall be taken during cable installation to ensure that no damage occurs to cables and / or accessories which are laid and exposed, but not protected.

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 cable, fibre and / or accessories during installation is the responsibility of the Customer. The Customer is responsible for all accrued costs which are 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.

11 Repairs to Cable Outer Sheath Layer

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

12 Pre-Commissioning

Cable pre-commissioning is the responsibility of the customer.

All cables shall be electrically tested immediately **after each pull is complete**.

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 following list of tests shall be carried out on two occasions: 1) following cable pulling and 2) after cable jointing on each cable section.

1. Measure Insulation resistance, phase to screen and phase to phase resistances;
2. Check continuity of all phase and screen conductors;
3. Check phasing of conductors;
4. Check phase clearances and phase to earth clearances;
5. Sheath test cables (10kV calibrated Insulation resistance test kit shall be used for this purpose).
6. Perform Partial discharge test @1.7Uo at 50 Hz or 0.1Hz. Results shall be within limits set by the cable manufacturer and have to be accepted by EirGrid.
7. Visual inspection of link boxes connection to ensure the accepted cable bonding diagram is adhered to.
8. Test the joint bays earth grids to ensure compliance with XDC-CBL-STND-H-012 dwg.

These 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 pre-commissioning report shall be submitted to EirGrid for acceptance at the end of the pre-commissioning phase.

If the sheath test results do not meet values in Table 2, then jointing works of further sections of the cable circuit shall not commence. Should the results not meet the values in Table 2, the cable shall be repaired or replaced and 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 as in Table 2.

All test information shall be recorded 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 under taken 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 (in appendix) and all results shall exceed the values stated in the table 2:

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	1	10	4	2.5
0.5	1	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

Table 2: 10 kV DC test minimum values

13 Fibre Optic Cable Installation

13.1 Installation

All Fibre Optic cable installation shall be in accordance with table 3 and this specification.

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

Table 3

*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. The imprint of plates will not be considered as damage.

13.2 Splicing

Splicing shall carried out by ESB Telecoms representatives 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.

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.

OTDR testing:

All 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.

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.

14 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.

Installed fibre must meet the performance requirements as set out in the relevant specification

15 Installation details required for each Cable Section

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

16 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.

17 Management of Water on Site

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

18 Appendix A – 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: _____

Phase	R	S	T
Drum No.			
Length (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 Mult. 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. Pulling Tension Record

Maximum Pulling Tension Recorded in kN	R	
	S	
	T	
	Fibre	

14. 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				

15. Meteorological Data

Max. Temp _____ °C

Weather _____

Humidity _____ %

Remarks_____

_____

_____

_____

_____

Signed _____

Date _____

19 Appendix B – 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 runbber 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 sugddenly 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.

Contractor

Name: _____

Signature: _____ Date: _____

Customer Representative

Name: _____

Signature: _____ Date: _____

Document Reference: CDS-HTS-01-001-R2

110kV Underground Cable

Technical Schedules

Revision History				
Revision	**Date**	**Description**	**Originator**	**Approver**
R0	07/02/2012	First Issue – Supersedes CDS-WTC-01-001-R1	ESBI – see page 2	Christy Kelleher / Paul Moran
R1	24/06/2015	Document Reference corrected to CDS-HTS-01-001	Kieran French	Paul Moran
R2	12/01/2017	Updated as per Due diligence Tracker	Daniele Giustini	Kieran French / Paul Moran

SCHEDULE A

Physical Characteristics of 110 kV Crosslinked Polyethylene Cable

Note: All dimensions to be filled in where applicable.

Item	Query	Required	Offered
1	Conductor:		
	(a) Material	Cu/Al	
	(b) Type e.g. round, etc.		
	(c) Design e.g. stranded, etc.		
	(d) Nominal diameter (mm)		
	(e) Cross-sectional area (mm^2)		
	(f) Method of water blocking		
2	Inner Semi-conducting Layer:		
	(a) Material	Semiconductive compound	
	(b) Nominal thickness (mm)		
	(c) Minimum thickness (mm)		
3	Insulation:		
	(a) Material	XLPE	
	(b) Nominal thickness (mm)		
	(c) Minimum thickness (mm)	≤10%	
	(d) Diameter over insulation = Ovality of cable Core (mm)	< 0.7	
4	Outer Semi-conducting Layer:		
	(a) Material	Semiconductive compound	
	(b) Nominal thickness (mm)		
	(c) Minimum thickness (mm)		
5	Nominal diameter over core screen (mm)		

SCHEDULE A
(continued)

Physical Characteristics of
110 kV Crosslinked Polyethylene Cable

Item	Query	Required	Offered
6	Radial thickness of insulation including semi-conducting layers		
	(a) Nominal (mm)		
	(b) Minimum (mm)		
7	Bedding Layer/Water Barrier		
	(a) Material		
	(b) Thickness (mm)		
	(c) OD of bedding layer (mm)		
	(d) Method of electrical connection between 4 and 8		
	(e) Method of water blocking		
8	Sheath:		
	(a) Material		
	(b) Type, corrugated or smooth	Lead/Cu/Al	
	(c) Nominal thickness (mm)		
	(d) Mean diameter (mm)		
	(e) Cross-sectional area (mm^2)		
	(f) Diameter over crest of corrugations (mm)		
	(g) OD of sheath if not corrugated (mm)		
9	Outer Sheath:		
	(a) Material		
	(b) Density (kg/m^3)		
	(c) Nominal thickness (mm)		
	(d) Minimum thickness (mm)		

SCHEDULE A
(continued)

Physical Characteristics of
110 kV Crosslinked Polyethylene Cable

Item	Query	Required	Offered
10	Nominal diameter of completed cable (mm)		
11	Weight of finished cable (kg/m)		
12	(a) Normal length per drum (m) (b) Maximum length per drum (m)		
13	(a) Normal gross weight of loaded drum (kg) (b) Max gross weight of loaded drum (kg)		
14	Max. drum dimensions width/height (m/m)		
15	Minimum radius of bend around which cable can be pulled (a) Laid direct (m) (b) In ducts (m) (c) Cable placed in position with former (m) (d) Cable placed in position without former (m)		
16	Permissible pulling force allowed on conductors during installation (kN)		
17	Maximum permissible sidewall forces (kN)		

SCHEDULE B

Electrical Characteristics of 110 kV Crosslinked Polyethylene Cable

Item	Query	Required	Offered
1	Maximum AC/DC resistance of conductor at 20°C Ω/km		
2	Maximum AC resistance of conductor at 90°C Ω/km		
3	Minimum insulation resistance MΩ/km		
4	Maximum phase inductance mH/km		
5	Maximum phase capacitance μF/km		
6	Maximum charging current per phase A	140	
7	Zero phase sequence impedance for 3-phase cable ($R_0 + jX_0$) Ω/km		
8	Maximum permissible continuous temperature of conductor/sheath °C/°C		
9	Maximum permissible continuous current rating when installed as per this specification; Laid in ducts surrounded by material: A 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 Winter Concrete Thermal Resistivity = 0.85 K.m/W Spring Concrete Thermal Resistivity = 1.0 K.m/W Summer Concrete Thermal Resistivity = 1.0 K.m/W Autumn Concrete Thermal Resistivity = 1.0 K.m/W		

SCHEDULE B
(continued)

Electrical Characteristics of
110 kV Crosslinked Polyethylene Cable

Item	Query		Required	Offered
10	Single phase maximum AC/DC sheath resistance at 20°C	Ω/km		
11	Losses:			
	(a) Conductor loss per phase at current in item 9(a)	W/m		
	(b) Dielectric losses per phase at Uo	W/m		
	(c) Sheath loss per phase at current in item 9(a)	W/m		
	(d) Total losses per phase	W/m		
12	Maximum/expected dielectric loss angle at Uo and a conductor temperature of:			
	20°C	%		
	40°C	%		
	60°C	%		
	Maximum operating temperature +5°C	%		
13	Maximum/expected dielectric loss at 20°C and:			
	0.5 Uo	%		
	1.0 Uo	%		
	1.5 Uo	%		
	2.0 Uo	%		
14	Thermal resistance between conductor and metallic sheath	Km/W		

SCHEDULE B
(continued)

Electrical Characteristics of
110 kV Crosslinked Polyethylene Cable

Item	Query		Required	Offered
15	Thermal resistivity of:			
	(a) Insulation and semi-conducting layers	Km/W		
	(b) Anti-corrosion serving	Km/W		
16	Design 1.2/50 μs impulse stress for 1050kV at conductor/core screen	kV/mm		
17	Design Switching Impulse stress for 1050kV at conductor/core screen	kV/mm		
18	Design AC stress for Uo at conductor/core screen	kV/mm		
19	Average design AC stress across insulation	kV/mm		
20	Minimum 50% flashover voltage of sealing end for a 1.2/50μs wave (nominal), positive/negative	kV		
21	Surface conductivity of outer sheath graphite / extruded semiconductive layer at ambient temperature	(ohm/linear m)	$\leq 3k\Omega/m$	
22	Surface leakage distance of termination insulator (outdoor)	mm		

SCHEDULE B
(continued)

Electrical Characteristics of
110 kV Crosslinked Polyethylene Cable

Item	Query	Required	Offered
23	Relative permittivity of dielectric		
24	Single phase withstand current for the following clearance times		
	0.1s A		
	0.2s A		
	0.5s A		
	1.0s A		
	3.0s A		
25	Permissible 1 second short time withstand current, corresponding conductor temperature kA/°C		

SCHEDULE B
(continued)

Electrical Characteristics of
110 kV Crosslinked Polyethylene Cable

Item	Query	Reply
26	Permissible steady overload and conductor temperature for 0.5/1/2/4 hours after prior continuous loading of: 50% of current in Item 9(a) 75% of current in Item 9(a) 90% of current in Item 9(a) 50% of current in Item 9(b) 75% of current in Item 9(b) 90% of current in Item 9(b)	0.5 1 2 4
27	(a) Is the cable design fully in accordance with the Specification? (b) If not, list all deviations.	
28	(a) Does the specific factory proposed for production of the cable system meet **all** of the Service Requirements set out in Section 6 pages 5/6 of the General Requirements Specification CDS-HFS-00-001-? (b) Are details of such Service Experience under subsections 6(a), 6(b and 6(c) provided in a separate submittal, to demonstrate full compliance with Section 6 to the Client?	