Trenchless Cable Functional Specification

CDS-GFS-01-001

20/04/2026

EirGrid

The Oval, 160 Shelbourne Road, Ballsbridge, Dublin D04 FW28
Telephone: +353 1 677 1700 | www.eirgrid.ie

Revision History						
Revision	**Date**	**Description**	**Originator**	**Reviewer**	**Checker**	**Approver**
R0	20/04/2026	First Issue	Mott MacDonald	Daniele Giustini, Niall McMahon (EirGrid)	Emma Butler, Oliver Canty, John Martin (ESB)	Neil Cowap

Technical Specification Approval

Title	**Trenchless Cable Functional Specification**		
Specification revision number & date	Document No.	CDS-GFS-01-001-R0	Date: 20/04/2026
Produced by: EirGrid/EAM	Date: 20/04/2026		
EirGrid			
Department:	**Engineering & Asset Management**		
Approved:	**Approved**		
Date:	17.04.2026		
ESB Networks:			
Department:	**Network Asset - Cables**		
Accepted:	**Due Diligence - Accepted**		
Date:	17.04.2026		

Contents

1 Scope

1.1 Purpose and scope of the document

This functional specification specifies the requirements for trenchless techniques of cable installation associated with the planning, design, construction, installation, commissioning, operation, and maintenance of cable tunnels and other trenchless works. It should be noted that the primary purpose of these trenchless installations is the service of delivering an appropriately functioning cable system or systems. While this is considered an alternative to typical trenched techniques, these techniques shall only be used by exception and shall be agreed through the existing EirGrid design review process.

There are several trenchless techniques available. This specification deals with the delivery of cable systems using the following trenchless techniques:

- Horizontal Directional Drilling (non-person-entry)
- Micro-tunneling (non-Person-entry)
- Tunnel Boring Machine Tunnelling (person-entry)

This specification sets out the design parameters which any cable system Developer is expected to adhere to and key submissions to be made to EirGrid during the design and construction phase of a project. While standardisation of trenchless works design is preferable, it is accepted that each design is specific to the project requirements and location. It is important to recognise the techniques involved are specialist in nature and therefore, specialist trenchless expertise shall be obtained.

Sections 2, 3, and 4 of this specification apply to all trenchless techniques. Specific technical requirements are covered in other sections of this specification.

In this document, 'Developer' is any entity which develops assets to be connected to the transmission network.

1.2 Abbreviations

Abbreviation	Definition
ATEX	Atmosphères Explosibles (equipment for explosive atmospheres)
BTS	British Tunnelling Society
DC	Direct Current
DRA	Design Risk Assessment
DTS	Distributed Temperature Sensing
EACS	Electronic Access Control System
EN / IS EN	European Standard / Irish Standard European Norm
EPA	Environmental Protection Agency
ER	Employers' Requirements
ERIC	Eliminate, Reduce, Isolate, Control
FEED	Front End Engineering Design
GDR	Geotechnical Design Report
GBR	Geotechnical Baseline Report
GIR	Geotechnical Interpretive Report

Abbreviation	Definition
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HMI	Human Machine Interface
HSA	Health and Safety Authority
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission
IDS	Intruder Detection System
IR	Infrared
ISO	International Organisation for Standardisation
ITP	Inspection Test Plan
LS0H / LSOH	Low Smoke Zero Halogen
LV	Low Voltage
LVAC	Low Voltage Alternating Current
LPCB	Loss Prevention Certification Board
MEP	Mechanical, Electrical and Plumbing (services)
MTBM	Micro Tunnel Boring Machine
NCC / DCC	National Control Centre / Distribution Control Centre
NTP	Network Time Protocol
O&M	Operation and Maintenance
PD	Partial Discharge
PDA	Potential Damage Assessment
PLC	Programmable Logic Controller
PSCS	Project Supervisor Construction Stage
QA	Quality Assurance
QC	Quality Control
RAMS	Risk Assessment and Method Statement
SCADA	Supervisory Control and Data Acquisition
SDR	Standard Dimension Ratio
SPZ	Source Protection Zone
SVL	Sheath Voltage Limiter
TB	Technical Brochure (CIGRE)

Abbreviation	Definition
TBM	Tunnel Boring Machine
TCS	Tunnel Control System
TGDB	Technical Guidance Document B (Fire Safety)
TVCMS	Tunnel Ventilation Control & Monitoring System
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive
VSS	Video Surveillance System

2 Applicable Legislation, Codes and Standards

Equipment offered shall comply with the provisions of the latest applicable versions of all relevant Irish legislation, EU regulations and EU directives. All equipment and devices shall, where required, carry the CE mark in accordance with Directive 768/2008/EC.

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

The applicable Legislation, EirGrid Requirements, National, International and other applicable standards are included but not limited to those stated in Sections 2.1 to 2.3.

2.1 Legislation

- Safety Signs Regulations 1995
- Safety, Health and Welfare at Work Act 2005
- Safety, Health and Welfare at Work (Construction) Regulations 2013
- Safety, Health and Welfare at Work (General Application) Regulations 2007
- Safety, Health and Welfare at Work (General Application) (Amendment) 2012
- Safety, Health and Welfare at Work (Confined Spaces) Regulations 2001
- Ireland Building Regulations Part B 2024
- Technical Guidance Document B (TGDB) Fire Safety Volume 1 2024

2.2 EirGrid Requirements

CDS-GFS-00-001	110kV/220kV/400 kV Underground Cable Functional Specification
XDS-GFS-00-001	110/220/400 kV Substation General Requirements
XDS-GFS-06-001	110/220/400 kV Control, Protection and metering
XDS-GFS-08-001	Station Auxiliary Power Supplies
XDS-GFS-10-001	220V/48V/24V DC and 230/400V/110V AC Distribution Boards
XDS-GFS-11-001	Auxiliary Cables and Wiring System
XDS-GFS-12-001	Earthing and Lightning Protection
XDS-GFS-13-001	Substation Civil and Building Works
XDS-GFS-14-001	Station Electric & Mechanical Services for Transmission System Control Buildings and Compound
XDS-GFS-17-001	Galvanised Fabricated Steelwork
XDS-GFS-18-001	Station Hot Dip Galvanizing of Iron and Steel Other than Wire
XDS-GFS-20-001	Pre-commissioning Specification
XDS-GFS-38-001	Transmission Station Labelling Specification
XDS-GGD-00-001	Derogation Process
XDS-SDM-00-001	Safe by Design Methodology

2.3 National, International and Other Applicable Standards

Standard	Title
ET103	National Rules for Electrical Installations exceeding 1kV a.c. (1.5kV d.c.)
IS 10101	National Rules for Electrical Installations
ISO 9001:2000	Quality Management Systems. Requirements
IEC 60050	International Electrotechnical Vocabulary (IEV)
IEC 60332	Tests on electric and optical fibre cables under fire conditions
IEC 60754.	Test on gases evolved during combustion of materials from cables
IEC 61034	Measurement of smoke density of cables burning under defined conditions
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61914	Cable cleats for electrical installations
IEC 62061	Safety of Machinery – Functional safety of safety-related control systems
IEC 62443	Security for industrial automation and control systems
IS EN 3	Portable Fire Extinguishers
IS EN 206	Concrete. Specification, performance, production and conformity
IS EN 13670	Execution of concrete structures
IS EN 13877	Concrete pavements
IS EN 1363-1	13A plugs, socket-outlets, adaptors and connection units. Rewirable and non-rewirable
IS EN 1366-2	Fire resistance tests for service installations. Fire dampers
IS EN 5306-8	Fire extinguishing installations and equipment on premises. Selection and positioning of portable fire extinguishers. Code of practice.
IS EN 13501-3	Fire classification of construction projects and building elements. Classification using data from fire resistance tests on projects and elements used in building services installations: fire resisting ventilation ducts and fire dampers and/or power, control and communication cables.
IS EN 15650	Ventilation for buildings. Fire dampers
IS EN 50200	Method of test for resistance to fire of unprotected small cables for use in emergency circuits
EN 1991	Eurocode 1. Actions on structures
EN 1992	Eurocode 2. Design of concrete structures
EN 1997-1	Eurocode 7. Geotechnical design. Part 1: general rules
EN 1997-2	Eurocode 7. Geotechnical design. Part 2: Ground properties
EN 16191:2014	Tunnel Boring Machines – Safety Requirements
EN 22476-15	Geotechnical investigation and testing. Field testing. Measuring while drilling
EN 50110-1	Operation of electrical installations. General requirements
EN 50131	Alarm systems. Intrusion and hold-up systems

Standard	Title
IEC 60332-3	Tests on electric and optical fibre cables under fire conditions. Test for vertical flame spread of vertically mounted bunched wires or cables.
EN 60839	Alarm and electronic security systems.
EN 62676-4	Video surveillance systems for use in security applications. Part 4: application guidelines.
HSA Code of Practice for Indoor Air Quality	
HSA Code of Practice for Working in Confined Spaces	
BS 6164:2019	Health and Safety in tunnelling in the construction industry. Code of practice
IET Guidance Note 4	Protection against fire
CIGRE TB 770	Trenchless technologies
CIGRE TB 403	Cable systems in multi-purpose or shared structures
CIGRE TB 808	Short term flexibility in power systems: drivers and solutions
CIGRE TB 194	Calculation of temperatures in ventilated cable tunnels. Part 1
CIGRE TB 669	Mechanical forces in large conductor cross-section XLPE cables
CIGRE TB 889	Installation of underground HV cable systems
CIGRE Electra 143	Calculation of temperatures in ventilated cable tunnels – Part I
CIGRE Electra 144	Calculation of temperatures in ventilated cable tunnels. Appendices I to IV
ENA TS 97-1	Special backfill material for cable installations
ENA-ER-C55/5	Insulated Sheath Power Cable Systems
ENA ER 2	Guidance on Security of Substations, Cable Bridges & Cable Tunnels
British Tunnelling Society - Specification for Tunnelling	
British Tunnelling Society - Joint Code of Practice for Risk Management of Tunnel Works in the UK	
Pipejacking Association's Pipejacking design guidance for CDM duty holders	
WIS 4-32-08	Specification for the fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials
ASTM F2620	Standard practice for heat fusion joining of polyethylene pipe and fittings
ASTM F1960-11	Standard guide for use of maxi-horizontal directional drilling for placement of polyethylene pipe or conduit under obstacles, including river crossings
NEN 3650-1	Requirements for pipeline systems – Part1: General requirements
EN 1916	Concrete pipes and fittings, unreinforced, steel fibre and reinforced
EN 681-1	Elastomeric seals – Material requirements for pipe joint seals used in water and drainage applications – Part 1: Vulcanized rubber
EN 16191	Tunnel boring machines – Safety Requirements
EN 12110	Tunnelling machines. Air locks. Safety requirements.

Other Standards incorporated by reference in the EirGrid Requirements above

3 Trenchless Techniques Overview

Trenchless Technology shall only be used in circumstances where standard cable trenched design is not feasible.

The Developer will be required to produce a Trenchless Justification Report which shall detail a feasibility study that outlines all trenched options that were considered, and provides justification for the selected Trenchless Technology. Trenchless installation shall be considered in the Developer's cable rating calculation and report.

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

Non-person-entry installations are defined as trenchless installations which will not be accessible to any personnel post construction. Entry during construction shall be minimised.

Person-entry installations are defined as those which will be accessible to personnel during and post construction, with diameters large enough to allow safe access to the tunnel with the cable systems installed.

3.1 Non-Person-Entry Installation

3.1.1 Horizontal Directional Drilling (HDD)

HDD is used for varying lengths of installation for pipe size diameters up to 800mm in normal situations and to 1000mm in exceptional circumstances with favourable conditions. A minimum bore size of 250mm should be considered for single phase boring.

Directional drilling involves drilling in a shallow arc using a steerable drilling head to cross major infrastructure such as motorways, rivers, canals, railways, busy roads, and environmentally sensitive areas. A rotating steerable hollow drill is used to drill a pilot hole. The hole is then enlarged via multiple reaming passes. When the correct bore diameter has been achieved the ducts (or bundle of ducts) are pulled through to be installed. The bore depth and separation between cables required to achieve the minimum rating requirements determines the number of bores to be installed.

3.1.2 Micro-tunnelling

3.1.2.1 General

The following describe a list of some (but not exhaustive) available trenchless methods on the market for installing pipes to enable the subsequent installation of cable ducts. The developer may propose these, or other methods not explicitly covered in this document for use on projects by demonstration of feasibility and meeting the requirements of the project and this specification. The requirements will follow those of micro-tunnelling set out in Section 6 with design of the pipes/ linings to meet the reliability requirements of the Eurocodes or other standards agreed in the Basis of Design with EirGrid. Proposals for the methods and for the method of design shall be submitted to EirGrid for review and acceptance in the FEED stage prior to adoption.

To avoid induced electromagnetic fields, multiple steel pipes, where single phase cables are installed in separate pipes, shall not be permitted as lining in a micro-tunnel.

3.1.2.2 Pipejacking

Pipejacking is a technique for installing precast pipes to form a tunnel lining. Typically, the pipes (typical internal diameter 300-2400mm, commonly starting at 800mm for cable installations) are jacked from a drive shaft or pit behind a suitable shield or shielded machine. The precast pipes are installed using hydraulically powered rams which push off a jacking system within the drive shaft. The precast pipes form a string connected to the back of the tunnelling shield. As the shield advances through the ground, further pipes are added to the string at the drive shaft. Spoil from the excavated face may be removed by a variety of means including auger flight, slurry pumping and on larger person-entry constructions by skips, trucks and conveyors.

Where the pipejacking technique involves non-person-entry sized pipelines and micro-tunnel boring machines (MTBM), this is considered micro-tunnelling.

On completion of the drive length, the shield is recovered at the reception shaft leaving a complete installed product pipeline. The shield can be steered ensuring the correct line and level of the pipeline.

3.1.2.3 Auger Boring

Auger boring consists of installing a pipe using a tunnel auger, which excavates and removes the soil from the face and transports it back along its length. Typically, temporary drive and reception shafts are required to drive and receive the auger, and to house the ancillary equipment and remove the spoil from tunnelling operations.

Normally, auger boring is suited to soft ground above the water table. With auger boring, the cutting face is open and therefore face stability can be difficult to maintain especially in mixed face or predominantly granular conditions, and ground water can be difficult to control, which can lead to ground loss, ravelling, surface settlement and potentially inundation of the launch pit.

Installed pipe diameter ranges for auger boring are typically between 250mm to 1200mm, although larger are possible. The pipe material is typically steel, although alternative materials are possible. Achievable lengths are ground and ground water condition dependant, but often around 80-120m (longer in favourable ground). Straight drives, or limited curves can be achieved.

3.2 Person-Entry Installation

Larger diameter tunnels for person-entry are expected to be constructed using Tunnel Boring Machine (TBM) tunnelling. TBM tunnelling is a technique used for installing precast concrete segments which form the tunnel primary lining. TBM sizes typically range from 3-17m. Smaller diameters are possible but may not meet the requirements for operational space or construction safety. Diameter selection justification considering both construction and operational phase logistical and safety requirements shall be presented in the FEED stage.

TBM excavations can use a wide range of cutting heads, depending on ground and ground water conditions. TBMs can be used to excavate from hard rock conditions and soft soil conditions and are able to provide active face support to limit ground movement and maintain stability. The heads may be fitted with blades for soft soil, picks for hard soil/soft rock and disc cutters for hard rock.

TBM excavation methods include earth pressure balance machines (EPBMs) and slurry machines. The installation process of the precast concrete segments consists of the transportation and erection of segments. Segments are usually transported through the tunnel by cars on rails from the drive shaft to the rear end of the machine. TBMs generally advance by thrusting off previously constructed segmental lining with hydraulic rams from within the shield. The erection of segments is carried out by an erector at the rear of the machine, within the shield.

Upon completion of the drive length, the TBM, shield and back up gantries are recovered at the reception shaft leaving a complete installed lining. The TBM can be steered, ensuring the correct line and level of the tunnel alignment. Curves are readily achieved with a TBM, the radius being limited by the TBM type, diameter, ring length, and cable bending radius.

4 General Trenchless Techniques Requirements

4.1 Overview

This Section covers general requirements for all trenchless techniques considered in the project design.

In addition, technology specific requirements shall also be adhered to and are outlined in:

- Section 5 for HDD,
- Section 6 for micro-tunnelling, and
- Section 7 for person-entry tunnels.

The Developer shall, from the very outset, consider all issues associated with trenchless solutions to ensure safe construction, operation and maintenance, and efficient design delivery within the required timescales. The need for trenchless infrastructure shall be based on the criteria listed below:

- The need to avoid or minimise surface disruption
- The need to avoid sensitive sites
- Crossing of highways, rivers, canals, railways (where third-party asset owners do not allow for alternative crossing solutions to be implemented)
- Where open trench construction for cable routes or part of cable routes is not feasible

In determining the requirement for a trenchless solution for the installation of cable systems, and in its subsequent design, the Developer shall at the outset identify and understand the applicable functional requirements and governing documents that will influence the design.

Key factors associated with the physical environment of the cable shall also be considered, as they are essential to optimising electrical performance. These include ensuring:

- Adequate heat dissipation to prevent overheating and subsequent reduction in its capacity for carrying current (cable rating)
- Adequate physical protection to protect the cable from damage and to ensure it is not a potential danger to people while in service
- Adequate access, as appropriate, for maintenance crews to inspect, repair or replace it

The design shall consider the space requirements for cable installation and operation, the protection of the cables from damage, and, where required, ventilation for removal of heat and the safe access for personnel during cable installation and jointing, operation, maintenance and decommissioning.

The Developer should understand the potential methods of construction that could be utilised and whether the method of construction and any associated limitations will dictate the size of the installation. Thereafter, development of the design shall proceed according to operational criteria and requirements, and EirGrid Standards. In addition, as the design phase develops, the Developer shall consider and comply with the criteria in the reference documents listed in Section 2.

The design shall also consider guidance and current best practice principles as detailed in the reference documents listed in Section 2. This also includes the construction stage requirements listed in Sections 4.3, 5.4, 6.4, 7.4.

This shall incorporate considerations for design, construction, operation, health and safety, and risk management.

4.2 Design Stage Requirements

4.2.1 General

The Developer shall have specialist experience, training, and competence in the trenchless installation methodology chosen for the project and shall ensure consideration of a fully integrated and progressive design from the outset.

4.2.1.1 Reports required

Reports to be submitted to EirGrid for review and acceptance at the FEED, detailed design, and post construction phases of the project are listed in Table 1Table 1 below.

Table 1 Design stages reports required

Report	Section	FEED Stage	Detailed Design Stage	Construction	Post Construction
Trenchless Justification Report	4.2.1.2.1	X			
FEED Design	4.2.1.2	X			
Cable Ratings Report	7.5.3 & 4.2.1.3.2	X	X		X
Proposed list of temporary works designs	4.2.13	X	X		
Geotechnical Baseline Report	4.2.1.3.1		X (prior to commencement of detailed design)		
Basis of Design	4.2.2		X (submitted for acceptance prior to detailed design)		
Cable system electrical report	5.3.6, 6.3.6, 7.5.1		X		
Design Reports (technology specific)	4.2, 5.3, 6.3, 7.3		X		
Inspection Test Plan	4.3.1		X		
Construction Methodology Report	4.3.1, 5.4.1, 6.4.1, 7.4.1		X		
Construction weekly progress report				X	
Construction 2 weeks look ahead report				X	

Drawings to be submitted shall include at a minimum those required in CDS-GFS-00-001. The following drawings, Table 2, shall also be required.

Table 2 Design stages drawings required

Drawing	Section	FEED Stage	Detailed Design Stage	Post Construction
Route Alignment	4.2.7, 4.2.8, 4.2.1.4	X	X	X
General arrangement	-	X	X	X
Detailing and reinforcement drawings (shafts and tunnel linings if applicable)	-		X	X

4.2.1.2 FEED

At the Front-End Engineering Design (FEED) stage, the design shall initially be developed to the appropriate detail required for submission of planning permission. The FEED design shall be provided for EirGrid review and acceptance prior to submission of a planning application. The design shall address the following aspects as a minimum:

- Employers Requirements
- Route alignment design
- Vertical alignment design
- Diameter selection and compatibility with method and alignment/length
- Trenchless method selection compatible to ground conditions
- Site locations and requirements for shafts, depending on the proposed technology
- Site area, constraints and site conditions
- Site work area selection
- Site investigation needs
- Permanent works
- List of temporary works
- Assessment of risk and associated control measures

Documents required at the FEED stage are outlined in Table 3 below.

Table 3 Documents required at FEED stage

Documents to be submitted	Reference
Trenchless Justification Report	Section 4.2.1.2.1 below
Preliminary Cable Ratings Report	Section 7.5.3 below
Third-party Agreement	Section 4.2.10 below
FEED Design	Section 4.2.1.2 Above

A preliminary cable ratings report shall be submitted for review and acceptance. Calculations shall be as per the requirements laid out in CDS-GFS-00-001.

A desk study and survey of the existing site conditions, both surface and subsurface shall be carried out at FEED stage. The Developer shall prepare a scope of works for a phased geotechnical investigation for review.

Sufficient information on the ground conditions shall be available to enable justification of the selected method.

Preliminary studies on the ground movement and potential impact on third parties shall be conducted to ensure the method is feasible. Preliminary engagement with third parties shall be conducted at the FEED stage to ensure their requirements can be accommodated within the proposals submitted for planning. This may include third-party agreements or approval in principle.

The need or potential need for 24/7 working shall be assessed and accounted for in the FEED stage to ensure constraints not compatible with the method are not applied in the planning permissions.

4.2.1.2.1 Trenchless Justification Report

A trenchless justification report is required prior to submission of planning consent for EirGrid's review. This report shall demonstrate:

- The need for a trenchless installation
- Alternatives considered
- The appropriate type of trenchless installation to use and selected geometries; and
- The approach taken in the identification of the appropriate type
- Where more than one trenchless method is shown to be feasible, comparisons of the construction and operational phase cost, programme and sustainability shall be presented to inform the decision of which is preferred
- Confirmation that the cable may be removed from the installation when it reaches end of life
- Completion of a design risk assessment
- Consent agreements, if any

At all times, the chosen system design and trenchless technique shall meet the project's cable system technical requirements as advised by EirGrid.

In selection of the most appropriate trenchless technique, the following general steps shall initially be undertaken to collate and process the site-specific information listed previously:

- Ground investigation to determine the soil and groundwater conditions
- Landowner engagement
- Site survey and investigation to determine the location of existing pipelines, other services/existing structures and potential obstacles (cable and pipe detection devices, ground penetrating radar), and historical context

Where a person-entry tunnel is chosen as the preferred method, consideration shall also be given to the additional systems to be designed according to the requirements set out in Section 7.

The Developer shall consider several factors when deciding on the appropriate trenchless technique including, where applicable, but not limited to:

- Cable rating requirements
- Design life
- Size required
- Length and depth
- Availability of equipment
- Location and space constraints
- Topography and ground (soil) conditions
- Time of installation, replacement, or renovation
- Routine access and emergency access/egress
- Site conditions
- Safety
- Cost
- Risk of failure
- Availability of resources (power, water, drainage)
- Presence of other services and apparatus

- Physical obstacles (e.g. rivers, railways, buildings)
- Reinstatement requirements
- Traffic disruption (including pedestrians)
- Land use
- Disruption to third parties
- Settlement or heave
- Noise, dust, and other environmental factors

In consideration of the above list, the Developer shall produce feasible solutions with techniques that meet a number of frequently conflicting criteria:

- The need to minimise the risk of damage and impact to assets or obstacles being crossed
- The need to minimise and optimise outages on existing substations and circuits in the construction and operation of the cable system
- The need to minimise disruption to the local area, traffic, and pedestrians
- The need to minimise the risk of potential damage to other existing underground services and above ground structures
- The need to minimise any adverse impact on the environment
- The need to minimise disruption to householders

Preliminary alignment, initial settlement and indications of monitoring requirements shall also be submitted for review and acceptance as part of the trenchless justification report.

4.2.1.2.2 Desk Study

A comprehensive desk study of site conditions shall be undertaken at the FEED stage. Information obtained from publicly available sources of information can help to identify key constraints on the alignment and shall provide ready and cost-effective access to information on ground and groundwater conditions. As a minimum, the desk study, in reference to EN1997-2, shall include the following:

- General site topography
- Local geology
- Review of current and/ or historical boreholes to outline potential geotechnical risks and parameters
- Review of current and/ or historical boreholes to understand local groundwater conditions
- Review of previous land use and sources/ routes of contamination
- Review of records of mines and mineral deposits
- Review of archaeological records and historical investigations
- Outline scheme design and associated construction risks
- Inform the proposed ground investigation and requirements

Feasible horizontal alignments shall be “walked” as part of the FEED stage to identify any surface features contrary to interpretation of the available data and to more clearly set in perspective likely construction impacts. Overhead items nearby such as HV power lines shall be noted as these could have a major impact on access or site use.

Once desk study information has been appraised, the Developer shall undertake a preliminary geotechnical investigation to verify anticipated ground conditions and to identify any special ground and groundwater conditions. A second function of the preliminary geotechnical investigation is to identify any environmental concerns. The survey shall be performed in the planning phase of the project, before planning submission.

Ground investigation requirements shall be determined by a Geotechnical Advisor / Geotechnical Specialist who is familiar with the proposed alignment corridor and the range of potential construction techniques. The extent of the investigation required shall depend on known or suspected local conditions as per EN 1997-2.

4.2.1.3 Detailed Design

Detailed design submission shall be made to EirGrid after planning consent is obtained. This shall be reviewed and accepted by EirGrid prior to construction. The specific timing of submissions varies and is outlined below.

Design calculations and reports shall be provided for all permanent works in line with the requirements of this section, and that of the technology specific section where relevant. A list of temporary works shall be submitted, and where temporary works impact on permanent works or third-party assets the temporary works design shall be submitted to EirGrid for review and acceptance.

Construction documentation shall be developed that record the method and risk management systems in RAMS, monitoring plans and contingency plans.

Operation and maintenance manuals shall be provided demonstrating a safe system of work. Engagement and agreement with the TAO's operational team is required to ensure compatibility of the design.

Geotechnical reports and assessment shall be undertaken in accordance with EN 1997-1 and EN 1997-2 and be issued to EirGrid for review and acceptance.

The design shall be based on the findings of geotechnical site investigations, which shall follow the recommendations of EN 1997-2 and include:

- Desk Study: collation and analysis of all existing ground and groundwater data about the site to produce a preliminary ground model upon which to base an intrusive ground investigation,
- Ground Investigation Report: Field investigations and laboratory testing carried out in accordance with EN 1997-2 Ground Investigations and Testing, with the aim of updating the preliminary ground model and testing the ground to provide engineering parameters for each stratum encountered,
- Geotechnical Design Report: Presentation of revised ground model and interpretation, deviation and selection of design parameters in accordance with EN1997-1 and 1997-2. A separate geotechnical interpretive report (GIR) may be presented and included in the geotechnical design report

A phased ground investigation may be required as determined by the design requirements and to minimise uncertainties in the ground model. A ground investigation report and geotechnical interpretive report shall be required for each phase of investigation.

In addition to detailed site and ground investigations the following requirements must be adhered to in the final design:

- Legislation: the trenchless development shall be designed to the latest revision of the Building Regulations, where applicable
- Environmental: the design must have due consideration for the local environment and comply with the Environmental Protection Agency and Local Authority requirements
- Cable system requirements: minimum cable current rating requirements, security of operation, maintenance requirements. The design must meet the technical and safety requirements for the plant and cables to be installed. Facilities must be provided for the delivery, offloading, handling, and installation of plant and cables and for their possible future removal, additions, or alterations.
- Health and Safety: where person-entry is anticipated, the tunnel and shafts are to be considered as confined spaces during construction and operation unless demonstrated otherwise. The design shall comply with relevant Health and Safety regulations and any applicable regulations concerning confined spaces.

The following documentation, Table 4, shall be submitted to EirGrid for review and acceptance prior to construction.

Table 4 Documents required at detailed design stage

Documents to be submitted	Reference
Desk study	In compliance with EN 1997
Geotechnical Baseline Report	Section 4.2.1.3.1 below, prior to commencement of detailed design
PDA Reports Phase 1-3	As applicable, Section 4.2.12.4.3
Ground Investigation Report(s)	In compliance with EN 1997
Geotechnical Interpretive Report(s) (GIR)	In compliance with EN 1997
Geotechnical Design Report (GDR)	In compliance with EN 1997 and to include as a minimum:
	Ground conditions
	Existing assets identified and design requirements
	Feasibility assessment
	Method selection/ options assessment
	Guidance system/ installation tolerance
	Alignment and profile design
	Ground movement prediction
	Permanent works design
	Temporary works design
Cable Ratings Assessment	In compliance with CDS-GFS-00-001 and section 4.2.1.3.2 of this document
Design Drawings	In compliance with CDS-GFS-00-001 and to include:
	Route Alignment drawings in line with the requirements of CDS-GFS-00-001
	Civil works drawings in line with the requirements of CDS-GFS-00-001
Design Reports	Technology specific requirements
	Route alignment design
	Cable system electrical report
Category 3 Check Certificates	Section 4.2.4
Designer's Risk Assessment	Section 4.2.3
Designers Hazard Elimination and Management Record (DHEAMR)	Record of hazards and mitigations including those that have been eliminated. To be passed to the contractor and then owner as a record.
RAMS (incl. contingency plan)	Section 4.3.1, 5.4.1, 6.4.1, 7.4.1
Ground Movements	Section 4.2.12.4
Communications Plan	-
Operation & Maintenance Manual	In line with the requirements of XDS-GFS-00-001

4.2.1.3.1 Geotechnical Baseline Report

Prior to the commencement of detailed design, a Geotechnical Baseline Report (GBR) shall be developed and agreed between the Developer and EirGrid. This is a contract document that sets the range of ground conditions that are to be accounted for by the Developer. The GBR is used to manage the risks associated with unforeseen ground conditions during construction.

The Developer shall remain responsible for ensuring sufficient site investigation is undertaken and to develop a geotechnical design report, in accordance with EN 1997-2, to support their detailed design. Any new information received shall require re-validation of the proposed solution. The GBR shall include a design risk assessment.

The GBR shall be based on available ground investigation reports, including any ground water or underground water reports, and any additional further ground investigation carried out in advance of Contract award to confirm design considerations and assumptions. The GBR will identify the range of uncertainty associated with the level of data which is available or obtainable, and to identify relevant anticipated ground conditions and geotechnical parameters in accordance with the Joint Code of Practice for Risk Management of Tunnel Works in the UK, published by the British Tunnelling Society, or an equivalent national document approved by EirGrid, if applicable.

4.2.1.3.2 **Cable Ratings Assessment**

A detailed cable ratings and a cable system electrical report are required along with detailed monitoring system design. The cable reports shall include, at a minimum:

- Sheath voltage calculations
- EMF calculations
- Cable pulling calculations for installation and removal
- Cable mechanical design
- Sheath bonding design
- SVL design
- Joint and termination design and calculations
- Cable rating calculations

4.2.1.4 Post Construction

A monitoring plan detailing all post-construction monitoring requirements shall be provided along with a plan for settlement monitoring.

As built drawings of the specific trenchless installation along with any ancillary facilities shall be provided. As built records shall be issued as outlined in CDS-GFS-00-001 and in the technology specific sections of this specification, 5.4.3, 6.4.4, and 7.4.3.

4.2.2 Basis of Design

The Basis of Design defines the design standards, analysis methods, design approaches, assumptions, geometries, tolerances, load combinations, materials, load and material factors and other inputs for the detailed design. The document shall be sufficient to communicate in full the assumptions and design basis to be adopted and to inform an independent checker of the assumptions, along with the design drawings and specifications to undertake an independent check.

4.2.3 Risk Assessment

The developer shall identify and analyse the risks associated with alternative construction methods.

Design risk assessments (as per the latest revision of EirGrid's Safe by Design Methodology XDS-SDM-00-001) shall be prepared at each design stage and in the construction phase to take account of any realistic variation in design criteria or design values and their impact on the design and its implementation. The risk assessments must also take account of potential failure mechanisms and include mitigation, and contingency measures appropriate to the anticipated or proposed method of construction. All design risks shall be documented in the DRA. At a minimum, the DRA shall:

- Assess the potential problems and failures that could occur during installation and operation,
- Outline risks,
- Propose control measures that remove the risks in the first instance, or significantly reduce those risks if removal is not practicable, and
- Where the crossing is to be under rail, road, or similar critical infrastructure, consider specific risks to that infrastructure and design mitigation measures to significantly reduce those risks if removal is not practicable.

The objective of the preparation of design risk assessments and use of the geotechnical baseline report (GBR) is to achieve a robust design where the risk of failure or damage to the works or to a third-party from all reasonably foreseeable causes (including health and safety considerations) are satisfactorily mitigated and accepted by EirGrid.

Any documents, reports or data associated with the stages identified within this Section shall be submitted to EirGrid for review and acceptance.

The Developer's Risk Assessment and Method Statement (RAMS) shall outline the measures of control to be established to manage developer's residual risks and include any additional risks associated with the construction of the works.

4.2.4 Checking of Design Submissions

The Developer should refer to the clauses in the Connection Agreement / Infrastructure Agreement for design submission and acceptance requirements.

4.2.5 Route Design

The Developer shall use ERIC (eliminate, reduce, isolate, control) principles.

The Developer shall consider all available options for the location of shafts or pits and the trenchless installation alignment (vertical and horizontal). These will be influenced by:

- Start and end points
- Land availability and landowner agreement
- Construction requirements including green areas for emergency shafts where required
- Tunnelling/trenchless techniques
- Geology and structural geology (faults and joints etc)
- Above and below ground obstructions especially existing tunnels
- Other properties close to shaft sites
- Third parties affected by the works
- Access requirements
- Available services
- Planning constraints
- Connections from existing services
- Operational requirements including future connections
- Safety considerations
- Listed and/or sensitive buildings and bridges
- Foundations of existing buildings and structures (the potential for encountering piles shall be considered)
- Surface topography
- Available right of way
- Existing features such as railways, major highways, and canals
- Cable installation and operational inspection, maintenance, and replacement requirements
- Location of joint bays
- Commissioning and testing requirements
- Estimated electromagnetic fields and impressed voltages on nearby structures

Different trenchless techniques produce differing amounts of ground loss and subsequent settlement at the surface and subsurface. The amount of relative ground loss can be reduced using closed face tunnelling techniques, although final settlement will also be linked with the diameter and annulus treatment.

The route alignment shall be adjusted vertically or horizontally away from sensitive structures. Where this is not feasible, trenchless methods shall be selected and control measures developed that reduce the settlement impact and/or likelihood. These control measures shall be reviewed and accepted by EirGrid.

The Developer shall also consider interface requirements between the trenched and trenchless installations. Cable minimum bending radii and maximum pulling tensions, provided by the cable manufacturer, shall also be considered. Where the cables interface with a ducted system, the requirements of CDS-GFS-00-001 shall also apply at the interface.

4.2.6 Cable System Design

Circuit design shall generally be in accordance with EirGrid's specification for underground cable systems (CDS-GFS-00-001).

Other guidance documents shall be considered in the trenchless installation design, including but not limited to:

- CIGRE Technical Brochure 640 (A guide for rating calculations of insulated cables)
- CIGRE Technical Brochure 770 (Trenchless technologies).
- CIGRE Technical Brochure 714 (long-term-performance-of-soil-and-backfill-systems)
- CIGRE Technical Brochure 797 (sheath bonding systems of AC transmission cables)
- Technology specific considerations, where identified in the relevant sections of this specification

The initial cable system design, at FEED stage, for the trenchless section shall be based on any recent available desktop and borehole data for the area under consideration. The information shall be relevant to the depth at which the trenchless installation is to occur.

Cable rating calculations shall be provided, by the Developer, using an internationally accredited software package.

If lesser known, or in-house developed tools are proposed, EirGrid require the verification of sample calculations for acceptance purposes. For this purpose, CIGRE Technical Brochure 880 "Power Cables Ratings examples for calculation tool verification" will be used and relevant worked examples for comparison are to be provided by the Developer. These will be agreed with an EirGrid representative.

When ground condition information is not available or cannot be acquired in time, the following guidance values shall be used in the preparation of preliminary rating calculations.

Table 5 Ground conditions

Depth	Thermal Resistivity	Ground Temperature
5m<depth<10m	1 K·m/W	13°C
40m	1 K·m/W	14°C

Up to a depth of 5m, standard parameters per CDS-GFS-00-001 shall be used.

The following shall also be considered in preparation of the cable system design:

- Steady state conditions,
- Sheath voltages during short circuits (especially when operating with large phase separation),
- Magnetic losses for steel pipes, where proposed,
- Pipes and conduit filling,
- Soil dry-out where required,
- Mechanical and cable installation,
- Electro-magnetic interference with crossing services during short circuit events (i.e. rail control cables),
- Impressed voltages during short circuit events.

For detailed design work, the Developer shall also:

- Obtain data from trial pits and boreholes, acquired in compliance with EirGrid standards,
- Review the drill profile to account for any changes due to findings from ground data investigations,
- Refine pulling calculations to determine the feasibility of the drill,
- Update general rating calculations based on the outcomes of ground investigations.

The Developer shall also consider, during detailed design, the thermo-mechanical behaviour of the circuit during operation.

For any rigidly cleated sections, i.e. below terminations, in substation basements, in air crossing, on bridges structures, or even in joint bays, the Developer shall provide calculations to demonstrate how the forces are managed, controlled, and transferred to other sections, especially with respect to terminations and joints. Cleats shall be selected based on calculated forces generated by the cable and accessories.

For semi-rigid or flexible systems, such as in ducts along the route, the Developer shall provide an overall analysis of the forces in the system and their management.

The above calculations shall be performed in accordance with the following recommendations:

- CIGRE Technical Brochure 194
- CIGRE Technical Brochure 669
- CIGRE Technical Brochure 889

Communication ducts shall be 140mm OD SDR11 in trenchless installations.

4.2.7 Horizontal Alignment

The alignments shall be optimised to minimise distances between fixed points (shafts/pits), which will have been identified during the route design. The alignments shall include any necessary shafts or pits for tunnel construction, shafts for access and for the safe operation, maintenance and where applicable replacement of the system.

The drive lengths shall consider the pipe size, trenchless method, and geotechnical conditions as well as the construction and operational safety and potential impacts of not completing the drive. The number of bores and spacing requirements/constraints shall also be considered in conjunction with the tolerances achievable with the proposed method. The optimum alignment is one that requires the smallest number of shafts or pits without exceeding the practical drive length and pipe being used.

Consideration shall be given to avoid high risk factors such as suspected buried features including deep foundations or piling, existing tunnels or sewers, identified wells, unexploded ordinance, and archaeology which may have been identified during desk studies and searches. The location of historic and project boreholes shall also be considered.

Trenchless works, both excavation at the tunnel face and shaft sinking, could induce ground settlement or heave which could be of significance when adjacent to sensitive structures. Any structures which could be at risk from ground movement shall be identified and the effect of trenchless construction in close proximity shall be determined. Adjustment of the horizontal alignment outside of the zone of influence of these structures shall be considered in the first instance. Factors such as dewatering and any possible mixed tunnel horizon shall be anticipated and, prior to construction, structural surveys including photographic surveys undertaken on structures that could be at risk. Engagement with third parties associated with this structure shall also be undertaken.

Linear structures shall, where possible, be crossed perpendicular to their alignment and in accordance with operator/owner compliance requirements. Particular attention shall be given to railway infrastructure which is at risk of can't and twist of the tracks.

4.2.7.1 Minimum clearances for future development

For any works proposed in close proximity to an EirGrid trenchless installation an exclusion zone extending outwards from the exterior of the installation perimeter shall apply. In general, a minimum clearance distance between a trenchless installation and any works of 3m horizontally, and 6m vertically shall apply unless otherwise agreed with EirGrid.

An assessment shall be undertaken to demonstrate that there is no impact on the EirGrid trenchless installation from the proposed works. The assessment shall take into consideration the construction and operational phases cognisant of the construction method, loads, ground conditions expected and uncertainty present and full appraisal of the risks and asset owner requirements.

The output of the assessment shall determine if the minimum clearance values are sufficient or if more clearance is required. Meeting the minimum clearances does not absolve the developer of their responsibility for ensuring sufficient clearance to EirGrid trenchless installations. Where it is not possible or practicable to meet these minimums, demonstration of the adequacy of the reduced clearances shall be provided for the acceptance by EirGrid. See also section 1.1.

4.2.8 Vertical Alignment

The Developer shall determine the depth of the alignment based on the following considerations:

- Cable system design and rating requirements,
- Future operational and maintenance needs, as well as access provisions where applicable,
- Geotechnical conditions,
- Minimum clearance to buried infrastructure/utilities and historic structures, such as wells and mine workings,
- Depth sufficient to minimise the likelihood of impact to existing infrastructure and buildings due to ground movements (settlement or heave),
- Depth sufficient to minimise the likelihood of frac-out causing disruption to surface and environmental impacts,
- Guidance system selection including workable depth of the system and expected tolerance
- Future changes to the ground surface elevation.

Minimum clearance requirements from other services shall be considered to satisfy all third-party clearance requirements. EirGrid shall be consulted on minimum clearance requirements.

4.2.9 Site Conditions

4.2.9.1 Underground utilities and obstructions

Underground utilities and obstructions along or crossing the alignment shall be identified during the early project planning process. The records of all statutory undertakers likely to have apparatus in the alignment's vicinity must be obtained and studied. Utilities and obstructions within the proposed alignment may impact the success of the installation. For some obstructions, for example boulders within glacial till, it may be possible to drive through if provision is made for the obstruction in advance of the drive. Obstructions shall be defined and methods for resolution shall be addressed in the planning process. These shall be agreed with the utility owner in writing where applicable.

For the design of a new EirGrid trenchless crossing of an existing third-party asset, minimum clearance shall be designed and assessed demonstrating the following considering the geometries, loading cases and ground conditions specific to the crossing:

- Demonstrate acceptable levels of impact on the third-party asset, to the satisfaction of the asset owner, via impact assessment
- Sufficient clearance for cable performance and impact from the cables on third-party assets
- Potential impact from the third-party asset on the proposed EirGrid trenchless crossing due to imposed loading, distortion or collapse due to interaction during construction, operation, maintenance and decommissioning is sufficiently low.
- Impact from credible accidental scenarios in either asset (EirGrid or third party) which could result in failure of either asset.

Engagement with and gaining acceptance from the third party shall be the responsibility of the Developer.

4.2.9.2 Environment and Heritage

An environmental specialist shall be commissioned to provide advice and screening for conservation and heritage issues. Source Protection Zones in the vicinity of the installation shall be identified to provide advice on any necessary safety measures required. Approval from the Environmental Protection Agency and other relevant entities shall also be obtained, where required.

The Developer shall take all reasonable measures to ensure that the noise arising from site activities and operational plant and equipment shall not exceed the noise level exposure limits for general work areas as specified in the Safety, Health and Welfare at Work (General Application) Regulations 2007. Noise level exposure from the site shall also comply with any conditions of the planning permission or other local authority or Environmental Protection Agency requirements.

4.2.9.3 Easement and Rights of Way

The availability of easements, rights of way, and property ownership shall be determined during the project planning process. Early determination of unacceptable corridors may require changes in the alignment.

4.2.9.4 Planning and Consent

A planning consultant with the relevant trenchless installation expertise shall be commissioned to address planning and land matters. The installation shall comply with existing planning legislation and regulations in force at the time.

4.2.9.5 Particular constraints

Particular project constraints shall be identified and addressed early in the planning process. These may include but are not limited to:

- Limited work hours or seasonal working restrictions (e.g. holiday resorts, local festivals),
- Restricted access,
- Sensitive structures,
- Environmental restrictions,
- Noise disruptions,
- Traffic disruptions,
- Service interruptions,
- Business disruptions.

4.2.10 Third-party Crossings

To pass beneath roads, railways, canals and rivers, and beneath private lands and open spaces, trenchless methods may be considered only if a standard installation is not possible. The approval of the relevant third parties / other asset owners is required before the route is finalised and they will likely require assurance that their structures will not be affected. Consents can generally be categorised into two aspects:

- Legal Agreements: a legal agreement is required if the third-party owns the sub-soil above and/or below its asset. If not, a legal agreement may not be required. The third-party shall confirm this requirement. A legal agreement may stipulate conditions such as liabilities and periodic payments. The completion of a legal agreement often requires the prior completion of an engineering Approval-In-Principle (AIP). One legal agreement is usually required for each structure/asset.
- Approval from Third Parties: engineering approval from a third-party is required to ensure that the third-party is aware of the proposed works and its impact on their assets. In general, an Approval-In-Principle shall be sought at early stages to reduce the likelihood of objections from statutory third parties. An AIP is often required by the third-party prior to the completion of a legal agreement described above. Following the AIP, further detailed 'engineering approval' is often required. This stage of approval often requires the completion of detailed design, including assessments and surveys.

Monitoring of the third-party asset or structure and any mitigation requirements shall be listed in a third-party crossing report.

Monitoring of settlement, heave, potential damage, and any other potential impacts shall be undertaken as specified by the third-party. Irrespective of third-party requirements, EirGrid require, at a minimum, monitoring of settlement, heave where appropriate, and potential damage assessment. An instrumentation and monitoring design shall be provided to EirGrid for review and acceptance.

4.2.11 Ground Investigations

4.2.11.1 Need for Investigation

Ground investigations shall be carried out in advance of the commencement of the FEED stage and according to EN1997:1 and EN1997:2. Ground investigation factual and interpretive reports shall be issued to EirGrid for review and acceptance as per Section 4.2.

Ground and ground water conditions shall influence the selection of the preferred trenchless installation methodology.

It is particularly important to predict the properties of the ground accurately, as errors can have a serious impact on the time taken, environmental impact, and costs incurred to complete a trenchless project. Geological surveys are therefore vital and include the development of systems for the interpretation of expected geological, hydrological and seismic conditions, and the preparation of plans for site investigations.

The design of any site investigation shall be prepared or reviewed by a Geotechnical Specialist who is familiar with the proposed alignment corridor and proposed construction techniques. The ground investigation shall include an appropriate range of investigation techniques, including in-situ and laboratory testing to enable findings to be validated by cross-reference.

Reliable information on the location and features of existing underground structures, facilities and public utilities, enables determination of the most suitable location for the planned installation, the most appropriate construction methods and the precautions to be taken towards the works in the vicinity.

4.2.11.2 General

The Developer shall develop a scope of works for a phased ground investigation for review and acceptance by EirGrid. It is required, as a minimum, that boreholes shall be drilled and / or bored at all drive and reception shaft locations and at a spacing no greater than about 100m along the alignments where possible. In addition, the boreholes shall extend to a minimum of 10m below the proposed tunnel / bore/ pipeline invert. If soft, compressible soils are encountered at this depth the boreholes shall be extended until firm ground has been proven for a minimum of 2m.

Additional ground investigations, where required, shall be specified based on the complexity of the project and the nature and complexity of the ground conditions and shall be agreed with EirGrid in advance.

Boreholes placed for the site investigation of an alignment shall be placed offline so that they do not intersect the proposed alignment. Boreholes for shafts may be placed in the centre of the proposed shaft location. Where artesian conditions are found, the boreholes shall be sealed.

Investigations above and below formation level are required to identify the possible existence of the following:

- Watercourses, natural or culverted,
- Wells and boreholes including audits,
- Existing underground structures,
- Artesian aquifers,
- Perched water tables.

Special consideration shall be given to boreholes within groundwater source protection zones (SPZ). The Geotechnical contractor shall take all necessary measures, prior to undertaking the investigation work, to avoid polluting the groundwater. Approvals from relevant stakeholders shall be obtained where applicable.

Further geotechnical investigations may be required dependent upon the preliminary findings and may include trial holes to determine the nature and precise location of buried services.

4.2.11.3 Environmental Impact

The impact that a construction method has on wetlands and environmentally sensitive areas shall be considered in the evaluation and selection of construction methods and with reference to the alternatives considered. It is noted that the significance of environmental impacts and effects will be location specific and specific to the methodology proposed.

Construction through contaminated land shall be avoided as a basic principle. Only if there is no other option can it be considered. A contingency plan identifying methods for handling contaminated soils may be required as part of the contract documents in this case. For construction through contaminated lands, a risk assessment and mitigation method statement shall be prepared for review and acceptance by EirGrid.

Shafts/pits shall be located outside of the contaminated area or constructed using methods designed to minimise the migration of contaminated soil and water. Tunnelling below the level of the contaminated material, especially through impervious layers can significantly reduce or eliminate the problems associated with tunnelling operations through these areas.

4.2.12 Permanent Works

4.2.12.1 Design Life Requirements

Cable system design life shall be 40 years.

The design life requirements of the different trenchless technologies are outlined in the relevant sections.

4.2.12.2 Material selection

All materials proposed shall be selected to ensure that the required design life shall be achieved. The design shall consider durability, installation environment, reinforcement protection and corrosion protection in order to ensure that the design life requirements are satisfied.

4.2.12.3 Structural Adequacy and Loading

The lining system shall be designed so that for the duration of its intended life and assuming appropriate standards of construction and maintenance:

- It provides resistance to the intended applied loads without exceeding the capacity of the lining, including permanent deformation or causing collapse,
- It contains or dissipates internal overpressure from cable or joint failure,
- It provides resistance to the likely effects of external influences,
- It has robustness such that they will not suffer damage due to accidental events or vandalism, to an extent that would be disproportionate to the severity of the cause,
- It provides resistance to loads from any buildings or structures constructed or planned over the tunnel route or where it forms part of the foundations of any structure. Advice is to be sought from the competent and suitably qualified Structural Engineer regarding the loads associated with this type of neighbouring project,

A design report demonstrating the adequacy of the lining shall be submitted to EirGrid for review and acceptance. When calculating the structural adequacy of the lining, the following shall be considered as a minimum:

- Permanent and variable loads shall be taken into account in accordance with EN 1991,
- Dynamic factors shall be taken into account in accordance with EN 1991:2,
- All loads and load factors shall be adopted in accordance with Eurocodes.

- Structural capacity shall be established based on the Eurocodes. Where specific elements are not explicitly covered, the Developer shall demonstrate their design achieves the reliability required by Eurocode and suitable internationally recognised standards shall be stated in a basis of design document and submitted to EirGrid for review and acceptance.

4.2.12.4 Ground Movements (Settlement and Heave)

4.2.12.4.1 Settlement

Where the results of analysis indicate that settlement may be significant and potentially may result in damage or instability of structure or services, the Developer shall develop mitigation methods to prevent damage and instability. Design decisions should be reviewed (depth, diameter, etc) and where not possible to sufficiently mitigate the impact, construction techniques such as physical protection measures/supports, ground treatment and stabilisation, compensation grouting may be required.

A report outlining the above shall be submitted to EirGrid for review and acceptance.

4.2.12.4.2 Heave

Heave can occur due to applying too much pressure to the ground either via support fluids or physical thrusting of the machines/ lining. The risk of heave from pressure exerted on the ground during tunnelling shall be assessed by the developer for the proposed method and geometry. The Developer shall make sufficient calculation to demonstrate that heave and the loss of support fluid to the ground surface are acceptably low, taking into account the relevant ground / groundwater conditions, bore size, construction method & sequence, length and the design depth along the alignment.

Where heave risk (impact or likelihood) is found to be high, adequate mitigation shall be applied.

A report outlining the above shall be submitted to EirGrid for review and acceptance.

4.2.12.4.3 Potential Damage Assessment

The Developer shall use a risk-based, phased approach when undertaking assessments of the impact of ground movements on third-party assets.

Potential damage assessments (PDAs) shall be carried out for the approved alignment and construction method and submitted to EirGrid for review and acceptance. PDAs shall comprise the following:

Phase 1 Assessment:

- Determine 'greenfield' ground movement contours resulting from construction of the works using conservative assumptions, parameters and proven empirical formulae that take account of the geology and the methods of construction and the Developer's alignment as provided to EirGrid.
- Identify third-party assets potentially at risk of damage by applying limiting vertical ground movements and/or surface gradients.
- Assets exceeding the acceptable limits stated in the Contract shall be subject to a Phase 2 assessment to determine the risk of damage exceeding the acceptable limits.

Phase 2 Assessment:

- determine the impact of ground movement on third-party assets with respect to an asset's behaviour and its ability to resist movements. Moderately conservative ground movement parameters are to be used.
- Assets having a damage category less than or equal to the acceptable limit set in the Contract shall require no further assessment unless specified otherwise by EirGrid.
- A sensitivity analysis to evaluate the impact of variations in the ground movement (volume loss) parameters on assets identified as exceeding a damage category greater than the acceptable limit.
- Where a sensitivity analysis identifies that there is a risk of damage exceeding an acceptable limit or the Developer considers additional measures to reduce ground movement are not practical the asset shall be subject to a Phase 3 assessment.

Phase 3 Assessment:

- The Phase 3 assessment shall comprise a detailed analysis as follows:
  - Reassessment of the Phase 1 and 2 assumptions taking account of more detailed construction methods and sequencing based on parameters which represent the best estimate of actual impact on the works,
  - model site specific mitigation measures,
  - Undertake 3D structural analysis of the trenchless installation or structure and the construction sequence unless otherwise agreed with the client. Such analysis is typically location specific and informed by the input data,
  - take account of any additional "in tunnel measures" or excavation measures that can reduce ground movement impacts to an acceptable level,
  - allow for soil structure interaction,
  - include details of the asset including structure, foundation, survey measurements, condition survey and any intrusive survey results,
  - incorporate the results of specific "baseline" monitoring prior to construction,
  - incorporate the results of any site-specific geotechnical investigations.
- A sensitivity assessment to assess the influence of selected mitigation measures, where such mitigation is required, and parameters to ensure that the acceptable limits of the risk of damage are not exceeded,
- The risk of damage to assets shall be mitigated by best practicable means, for example, by modifying the methods or sequence of construction (e.g. in-tunnel additional support measures),
- Where the damage category exceeds Category 2 for buildings (Burland et al 1977 category of damage classification for building assessments) or acceptable levels for other assets, mitigation measures are to be designed. Additional requirements for sensitive structures shall be specified.

4.2.13 Temporary works

A list of temporary design works shall be submitted to EirGrid. Where temporary works impact the permanent design or third-party assets, the temporary works design shall be submitted to EirGrid for review and acceptance.

4.3 Construction Stage Requirements

4.3.1 Construction Methodology Report

Construction Risk Assessment and Method Statements (RAMS) and Inspection Test Plans (ITPs) are to be developed by the Developer for the proposed works. There shall be Method Statements provided for organisation and programme, communications, equipment, design and materials compliance, and the specific construction method for the trenchless installation.

4.3.1.1 Design & materials compliance:

The design and materials compliance method statement shall include at a minimum:

- Vertical and horizontal alignments,
- Details of the proposed bore/tunnel/shaft linings including outside diameter, material and supplier details,
- Temporary works and construction details of openings in shaft lining (if applicable),
- Site layout drawings to indicate the positioning of the equipment and associated installations,
- Design loads, maximum permitted loads and associated trigger points for monitoring of installation

4.3.1.2 Risk Assessment and mitigation:

An emergency and contingency plan shall be produced by the Developer in cases including but not limited to:

- loss of face pressure and/or annulus collapse; over-pressures; and frac-out.

- Methods and procedures to overcome construction hazards shall be given.
- Methods for addressing flood conditions that may affect the area, including measures for the prevention of slurry and any contaminated materials entering the surroundings during a flood event.
- Specific procedures to avoid buried utilities and contact with any overhead lines shall be given.
- Actions and measures shall be put in place to manage UXO risk, for all construction works.

4.3.2 Experience Requirements for Developer's Personnel

All the Developer's Key Personnel shall be experienced in the trenchless installation methods and underground mining processes proposed by the Developer for use in the construction of the works. The key personnel shall hold relevant industry-accepted skills accreditation.

The Developer's managerial, supervisory, and operational key personnel for the works, including any drivers/operators, shall be suitably qualified for the role.

4.3.3 Emergency Arrangements

The Developer shall develop a set of site-specific emergency procedures to cover the situations in all major project scenarios, such as shaft construction, tunnelling and fit-out. These procedures shall be incorporated in the Developer's Health and Safety Plan.

The Developer's Health and Safety Plan shall include details of emergency contact information for the Developer's confined space rescue team; this information shall also be posted on noticeboards within the site offices.

4.3.4 Ground Movement Control

Best practicable means (taking into account location conditions, technical knowledge, and financial implications) shall be applied to minimise as far as reasonably practicable the construction induced surface settlement and heave, and sub-surface movements during the trenchless installation operations. Where required and allowed, 24/7 working should be employed whilst crossing sensitive assets. Ground movement monitoring and instrumentation are to be installed to monitor the impact of construction activities and to confirm that ground movements are as predicted.

The Developer shall prepare method statements which include details of how the potential heave and settlement will be controlled and select equipment and methods of working to result in minimum ground movement during shaft and tunnel construction and operation. These shall be submitted to EirGrid for review and acceptance, noting that this does not change the Developer's responsibilities to provide the works or liability for their design.

The Developer shall develop methods and control the construction such that the impact on third-party assets is managed in accordance with the requirements from the asset owner.

The Developer shall make predictions of movements caused by the works and design and operate a system for monitoring of:

- Ground surface and sub-surface levels,
- Movement of any affected structures and utilities,
- Ground water levels.

The objectives of monitoring are to record background movements, confirm that movements during construction works are within design predictions and to allow comparison of actual movements with trigger limits. This will allow timely implementation of predetermined mitigation measures if trigger levels are approached and assistance in preventing exceedance.

The Monitoring Plan shall include participation in Review Groups (for example, Shift Review Groups (SRGs), Contract Technical Committee (CTC), and Management Action Team (MAT)) to ensure compliance with all measures and responses required.

4.3.4.1 Instrumentation and Monitoring

Instrumentation and monitoring shall be installed. The following criteria shall be taken into consideration when designing the Instrumentation and Monitoring (I&M) scheme:

- Provision of a 'baseline' for the ground movements (e.g. diurnal, seasonal variations),
- Provision of construction control,
- Verification of design parameters / assumptions,
- Measurement of performance of the lining during and after construction,
- Monitoring of environmental conditions (e.g. settlement, air quality and effects on the groundwater regime),
- Monitoring of the impact of construction activities on adjacent structures,
- Verification of the effectiveness of mitigation measures and any trigger levels set in design.
- The I&M scheme shall be submitted to EirGrid for review.

4.3.5 Protection of Third-Party Assets

The Developer shall take all practicable measures to avoid damage to all third-party assets resulting from construction works, including any de-watering activities. This shall be outlined in the DRA.

Informed by the requirements set out in Section 1.1, the Developer shall be responsible for the identification of details, dimensions, and positioning of all existing structures, plant, pipelines, and cables and shall satisfy themselves as to the exact position of existing assets which may affect or be affected by the works. The Developer is also required to confirm the presence of any new or old unknown assets prior to the start of the works and if in the zone of influence, to notify EirGrid and incorporate it in the Monitoring Plan. Mitigation measures must be presented and followed if required.

Below ground services shall be confirmed by the excavation of trial holes and / or other appropriate service identification methods where appropriate. All services and utilities that are likely to approach or cross the line of the proposed tunnels, or which are in the vicinity of the associated shafts, shall be clearly marked on site and, if appropriate, exposed to confirm the location, and protected as necessary. The Developer shall submit a site layout drawing prior to site preparation to indicate the positioning of the equipment and associated installations for review and acceptance by EirGrid.

A pre-condition survey shall be undertaken in line with the requirements of the relevant third-party. Communication and engagement with the third-party shall be undertaken by the Developer for any third-party asset at risk of damage to ensure the assets are in the same condition on completion.

Where on-site conditions differ from the Design documentation already issued, these Design documents shall be updated and re-issued for review.

4.3.6 Special Requirements in Relation to Third-party Infrastructure

The Developer shall develop the design and obtain approval from all third parties affected by the works. The Developer shall liaise with those Parties and their agents in order to obtain formal consent for the relevant section of works. Liaison shall include, but not be limited to, all correspondence necessary to answer all issues/comments raised by the third parties.

The maximum allowed movement of existing assets such as bridges or structures shall be agreed with the asset owner.

4.3.7 Ground Water Control

The construction methodology selected shall take into consideration the requirements to deal with groundwater and prevent flooding. Drive shafts/pits shall be protected from flooding from all sources.

The Developer shall obtain all necessary consents, including but not limited to any discharge, de-watering or de-pressuring activity.

Any dewatering regime is to be defined by a specialist dewatering sub-contractor. The sub-contractor shall be responsible for predicting dewatering induced ground movements and any required mitigations and control measures.

Ground water levels shall be monitored before, during, and after construction to give warning of any grout or slurry leakage to surface or watercourses. Monitoring of ground water levels shall include monitoring of available ground investigation monitoring points, if accessible.

The requirement to install a dewatering system to facilitate construction exposes existing infrastructure to increased risks and any such proposals shall be considered as part of the design development and within the potential damage assessments.

4.3.8 Noise and Vibration

The Developer is responsible for obtaining the necessary consents under the relevant Acts or Regulations from the appropriate Local Authorities by developing the noise management plan and undertaking the Contract requirements regarding noise. No work on site shall commence until these have been obtained.

Specific noise reduction methods and low noise plant will be required at all sites in close proximity of any commercial, residential and private properties or environmentally sensitive areas.

The Developer shall carry out noise and vibration monitoring in the vicinity of the *works* and other sensitive locations along the route as agreed with the Local Authority.

Care shall be taken to minimise nuisance, noise, dust, odour etc. to the public during the *Works*, especially during night and weekend operations.

Sound attenuation methods may be utilised to satisfy any noise level restrictions applied by the relevant consenting authority.

4.3.9 Procedures

The Developer shall provide full details of procedures and resources that will be employed to carry out the Works including method and sequence.

4.3.10 Site Records

The Developer shall maintain a Drive Record Sheet and/or a Shift Log that records all relevant data. The minimum required data for each method is detailed in the relevant sections.

5 HDD Specific Requirements

5.1 Overview

HDD designs are bespoke designs where ducts may be installed in separate bores or multiple ducts may be installed in a single bore. All requirements outlined in Section 4 shall apply. Additional requirements relevant to HDD installations are outlined in this section.

Cable ducts shall be provided by ESB approved suppliers. Ducts with the following dimensions have been used for directional drilling installations on the EirGrid network:

- 140 / 180 / 225 /280 mm HDPE with a minimum SDR11

5.2 Environmental Parameters

Where bore depths are between 5m and 10m below ground, the ground temperature shall be considered as 13°C for the entire year. The soil thermal resistivity shall be 1.0 K·m/W for the entire year.

For deep directional drilling, the cable circuit may cross through various soil layers, which may have different thermal properties. For this condition, the guidelines in CIGRE Technical Brochure 640 shall be followed.

5.3 Design Requirements

5.3.1 Permanent Works Design

5.3.1.1 Design Life

The expected design life of the HDD pipe/duct shall be 80 years.

5.3.1.2 Materials Selection

Cables are to be installed within ducts, these being either single ducts per bore or in bundles, depending on the outcome of the Cable Rating calculations. No voids should be in the space between the ducts and the ground. Grout material, if required, shall be selected to ensure long term ground support and stability compatible with the surrounding ground. In competent ground/rock, bentonite may be sufficient, but where ground movement is expected or requires limiting, a cementitious-bentonite grout may be necessary. Selection shall be justified in the design submissions. Steel ducts shall be avoided to reduce impacts on cable ratings.

Details of the bore and linings including outside diameter, material and supplier details shall be provided in the construction methodology report.

Cable ducts shall not be filled with bentonite to allow for the removal and replacement of cables. Cable ducts shall be designed, installed and proved prior to cable pulling as per the requirements of CDS-GFS-00-001.

Cable duct material within HDD installations shall be SDR11 HDPE. Welding of duct joints shall be carried out inspected and tested in accordance with WIS 4-32-08 or ASTM F2620 to ensure adequate pulling resistance and watertightness to the system is achieved.

5.3.1.3 Structural Adequacy and Loading

The duct shall be designed for the expected loading from the ground, ground water and imposed surcharges and/or other specific design criteria identified. Structural capacity checks and excessive deformation checks shall be undertaken based on the design loading conditions.

Suitable material factors for the pipes shall be applied in accordance with Eurocodes or compatible with the standards to which the pipes are checked.

Long term bore stability and potential future closure of the bore shall be established. If future closure / collapse of the bore cannot be ruled out, its potential impact on the long-term settlement of the surface and existing assets (and any mitigations proposed) shall be accounted for in the assessments.

Ducts are to be designed for all transport, construction and operational loading scenarios including, but not limited to:

- Ground/ ground water loading
- Grouting loads
- Live/ dynamic loads
- Buoyant/ gravity pressures of pipe on the bore walls.
- Pulling loads – axial, bending, unconstrained buckling
- Loads applied transversely to the pipe onto the soil due to the pulling process

Beneficial account may be taken for fluid inside the pipes where present.

Account should be taken for the method of installation and annulus filling/ ground stability condition in the assessment of the ground loading. Established methods of loading analysis, pulling, unconstrained buckling and design for pipes installed by HDD shall be used, for example ASTM F1960-11. The assessment shall include the deformation of the pipe due to loading, including deformations locked in during the construction process (for example the vertical load applied to the pipe while the pipe is being pulled into the ground). Beneficial effects of lateral restraint from the ground shall be ignored unless demonstrated to be ensured.

5.3.1.4 Interface with Standard Trench

Regardless of the HDD arrangement, every HDD is expected to transition to a standard trench arrangement. A transition pit may be used at both ends of the installation to join trenchless ducts with standard ducts. The transition pit requirements are outlined in standard drawing XDC-CBL-STND-H-013.

The preferred method for transition is to use transition couplers. These transition couplers shall match the internal diameter of the two duct types to each other without the need for any Transition Chambers.

The safety/security of the power cable is of the utmost importance in all duct installations, so 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), typically of SDR11 HDPE shall match the ID of the corresponding Duct Type 2 (on the trench side of the coupler) to within 1mm.

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

Table 6 Matching Duct Sizes

Duct Type 1 (HDD)	Duct Type 2 (Standard Trench)
225 mm SDR11 HDPE	200 mm SDR21 HDPE
180 mm SDR11 HDPE	160 mm SDR21 HDPE
140 m SDR11 HDPE	125 mm SDR17.6 HDPE
280 mm SDR11 HDPE	250 mm SDR21 HDPE

Figure 1

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

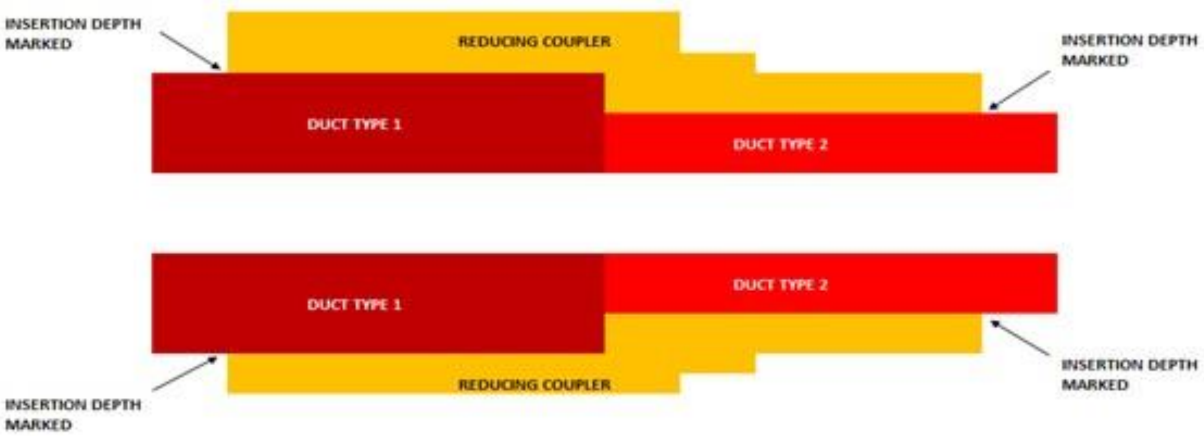

Figure 2

Transition chambers can be used as an alternative to reducing couplers. Three SDR11 ducts would normally enter the transition chamber on one side, and three standard ducts would normally be positioned on the opposite side of the chamber, to allow for the trench arrangement.

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

The mandrel and brush sizes for ducts shall be as per CDS-GFD-00-001 or Table 7 below:

Table 7 Duct, mandrel and brush dimensions

Duct Dimensions		Minimum Mandrel Diameter	Minimum Brush Diameter
Outer diameter (mm)	Inner diameter (mm)		
125 mm SDR11	103 mm	90 mm	110 mm
140 mm SDR11	113 mm	105 mm	120 mm
180 mm SDR11	147 mm	135 mm	155 mm
225 mm SDR11	183 mm	170 mm	187 mm
250 mm SDR21	226 mm	210 mm	230 mm
280 mm SDR11	229 mm	210 mm	230 mm

5.3.1.5 Third-party Crossings

Requirements for third-party crossings of HDD sections shall be as per Section 4 and CDS-GFS-00-001.

HDD installations shall not be routed under buildings and similar infrastructure, or longitudinally in-line with bridges unless this is derogated by EirGrid and agreed with stakeholders.

5.3.1.6 Heave

In addition to the Ground Movement requirements outlines in Section 4.2.12.4 the effects of fluid pressures and duct pulling in an HDD installation on potential heave shall be assessed. The analysis shall demonstrate likely mechanisms governing the response of the soils to the applied forces.

A report outlining these effects shall be submitted to EirGrid for review and acceptance.

5.3.1.7 Settlement

Settlement prediction shall use established methods for calculation, for example O'Reilly and New 1982. Account shall be made for the cumulative effect of multiple bores interaction if applicable. Parameters selected shall take due account of the method, annulus size, filling material and ground conditions. For example, references made to the volume loss of conventional tunnelling shall not be relied upon for HDD settlement prediction.

5.3.1.8 Pulling forces

Expected pulling forces on the duct shall be assessed using internationally accepted methods (for example ASTM F1960-11 or NEN 3650-1) and the duct and drilling rig verified to meet these forces with a suitable factor of safety to achieve the reliability required under the Eurocodes.

The pulling forces shall be monitored on site against agreed trigger values to ensure the pull back is behaving as expected. In the event of higher forces, pre-agreed actions for each trigger value shall be in place in the RAMS.

Methods and assessment of the handling, stacking and storing or pipes or bundles shall be made to ensure they are not damaged during these processes.

5.3.2 Electrical System Requirements

5.3.2.1 Cable System Requirements

The cable system requirements shall be in line with CDS-GFS-00-001.

5.3.2.2 Earthing Requirements

Earthing requirements for HDD installations shall be as per CDS-GFS-00-001.

5.3.3 Horizontal and Vertical Alignment

Horizontal and vertical alignments shall meet the requirements of Section 4. Directional drilling may be used on a horizontal and/or vertical curve. Design documentation and calculations shall be provided to EirGrid for review and acceptance.

Guidance system selection including workable depth of the system and expected tolerance shall be presented in the detailed design and its potential impact on the achievable horizontal and vertical alignment.

The design tolerance for the horizontal and vertical alignment shall be recorded in the design. Where the tolerance is sufficient to materially impact the analysis (additional load, reduction in cover, etc) then the sensitivity of the design to this tolerance shall be assessed and presented in the design documentation. The RAMS shall record the guidance system proposed and the achievable accuracy of the system in the context of the project to confirm it shall meet the design tolerance.

The plan alignment shall be designed with due consideration of:

- Complying with the agreed minimum clearance and interface requirements with existing assets.
- Future access requirements
- Bore spacing (if multiple bores required) being adequate for stability, influence on surface settlement and heave/frac out risk and expected tolerances.
- The location of launch and reception pits, site space availability and pipe stringing

Vertical and horizontal alignment shall be designed considering the requirements of the cables, including bending radii, pulling forces and cable ratings.

5.3.4 Launch and Receiver Pits

Pits' stability shall be assessed in the temporary works design and stability ensured via support if required. Adequate protection to personnel working around the pits to be included in the RAMS.

Launch and receiver pits may be covered to allow roads to be kept open or not excavated until needed. This shall be determined when assessing the scheme constraints and the overall programme.

5.3.5 Construction Compounds

The size of the working area and construction compounds shall be considered when designing the pit to allow a safe working area around the pit excavation.

Considerations for selecting sites shall include:

- Size of compound with sufficient space for working, storage of materials, and staff welfare facilities
- A pipe stringing area sufficient to prepare the pipe for pullback
- Construction plant operation and access to and from the site
- Existing land use availability including land ownership and planning designation and requirements of the site
- Environmental impact, in particular during construction such as noise, dust, night working, light pollution
- Previous land use
- Safety during construction and operation
- Services above ground and underground
- Security of temporary and permanent works
- Protection of the general public
- Hindering access for residents and business properties.

5.3.6 Selection of Size and Length

The HDD maximum bore size shall be determined based on the ground conditions, stability, and fluid pressures required for the proposed geometry. The selected bore size shall be suitable for the duct or bundle proposed. Coilable ducts, longer than standard ducts, may be used for HDD where smaller diameter ducts, up to 180mm, are used. These coilable ducts shall be marked consecutively every metre. Above 180mm diameter the duct shall be butt fusion welded, the welds inside the duct shall be debeaded to remove potential obstructions to the cable pull.

The installation length is typically up to 1,000m but may be longer, using special engineering, depending on ground conditions and diameters required. Suitable design reports (cable system electrical report, technology specific requirements) demonstrating the feasibility of long lengths shall be provided for review and acceptance including as a minimum:

- Duct pulling calculations
- Cable pulling calculations
- Sheath voltage calculations
- Proposal for laying out, welding and testing the pipe string
- Fluid pressure (heave, frac out) assessment
- Guidance system accuracy / tolerance

5.4 Construction Stage

5.4.1 Construction Methodology Report

Construction Risk Assessment and Method Statements (RAMS) and Inspection Test Plans (ITPs) shall be prepared by the Developer for the proposed works. The method statement for HDD shall include proposals for the guidance system and monitoring of the alignment during drilling, including demonstration that the design tolerance shall be achieved. This shall include any additional special requirements for tracking the precise location and steering of the head as required in the Project Specific Documents.

It shall also:

- Set limits (upper and lower bound) on downhole pressures (with reference to predicted downhole pressures) to control the risk of frac-out, heave, and bore instability with agreed trigger values and associated actions in the event of exceedances of those trigger values,
- Give minimum flow rates required to ensure the bore is effectively cleared,
- Provide methods for monitoring and recording drilling return volumes and down hole pressures,
- Assess that the method minimises the risk of excessive heave, in particular down hole fluid pressures,
- Set limits and trigger values for pulling forces and associated actions in the event of exceedances of those trigger values
- Provide the grouting pressures (if applied) required both to expel drilling fluid and that must not be exceeded to avoid hydraulic fracturing and buckling of the duct,
- Provide a schedule and description of procedures for duct delivery, assembly and fusion operations, pilot hole drilling, pre-reaming, reaming, testing and pull back and grouting,
- Provide pre-installation and post installation duct testing as per CDS-GFS-00-001,
- Provide the Developer’s proposed sequence of bore installation,
- Provide proposals for minimising the risk of inadvertent returns along sections of low cover,
- Provide proposals to minimise vibration during all works activities and for measuring vibration and noise during the works,
- Provide a description of the drill rig and its drilling and pullback capacity and drill rig specification

- Provide methods to fill/ballast the duct during pullback if applicable,
- Provide methods for grouting of the annular gap between excavated ground and the sleeve, including proposed materials, mix details, and performance (if applicable),
- Provide a method of spoil removal and storage and a method and location for disposal of drilling fluids,
- Provide the configuration and location of steel roller supports if applicable.
- Provide methods of visual supervision to monitor for surface frac outs in high risk areas.

The HDD specific risk assessment and construction methodology shall include a blowout/frac out contingency plan to detail the monitoring, control, and mitigation of inadvertent fluid returns that may occur along the pilot hole path. The plan shall detail a procedure to undertake if frac-out or loss of fluid pressures occurs to ensure contamination of the surrounding ground is minimised. Mitigation actions against the loss of fluid must also be addressed.

The developer shall also develop a Pilot Hole Contingency Plan to be submitted prior to the start of the works. This plan shall be reviewed, updated, and submitted to EirGrid for review and acceptance prior to mobilisation. The Pilot Hole Equipment Contingency Plan shall explain actions to be taken should the Developer's equipment fail during drilling operations. The Plan shall include description of back up equipment, materials, manpower, and other necessary resources to proceed in a timely manner.

The Developer shall provide the vertical and horizontal alignment for the proposed design solution. Tolerances shall be as per CDS-GFS-00-001.

5.4.1.1 Face / Bore Stability and Fluid Pressure

An assessment of the stability of the excavation in the temporary state shall be carried out and a report prepared for review and acceptance by EirGrid.

The developer shall calculate and document in the RAMS the proposed drilling fluid pressures along the length of the drill in accordance with the following:

- Minimum fluid pressure and composition required to ensure stability along the length of the drill, for each stage of pilot, reaming and duct pulling.
- Maximum fluid pressure profile to limit heave and frac out along the length of the drill, for each stage of pilot, reaming and duct pulling.

The contractor shall make sufficient calculation to demonstrate that heave and the risk of frac out are acceptably low, taking into account the relevant ground and groundwater conditions, bore size, construction sequence, length and the design depth along the alignment for each phase (pilot, reaming, duct pulling). The consequent impact on existing services and third-party assets shall be similarly assessed and agreed with the relevant asset owner. Based on this assessment, a design line for the proposed drilling pressures shall be established. Established internationally recognised methods for these calculations shall be used, calculating a minimum and maximum pressure with the application of suitable safety factors. Where the difference between minimum and maximum allowable pressure is less than 50kPa, specific control measures are to be specified in the RAMS to mitigate the risk.

The developer shall set pressure trigger limits along the bore to monitor against expected performance and specify actions if thresholds are exceeded, preventing over-pressure, heave, or frac-out.

The developer shall also provide estimated drilling fluid flow rates for pilot, reaming, and duct pulling stages to ensure effective bore cleaning and solids removal. Confirm site pumping, storage, and treatment capacities cover these needs plus allowances.

The developer shall evaluate groundwater conditions, inflow rate, pumping requirements, effects on ground stability, potential need for treatment, and risk of settlement from groundwater extraction.

5.4.1.2 Lubrication and Support Fluids

Drilling fluids shall be selected for the specific ground conditions expected to ensure stability of the bore, provide adequate cutting suspension and returns and minimise clogging of the bore. A specialist mud engineer shall be consulted and selections recorded in the RAMS. Requirements for the final annulus filling medium shall be developed in the design and the selected material documented in the RAMS. The filling medium shall ensure long term stability and support to the bore, minimising shrinkage. Where long term ground movement requires control (e.g. below sensitive assets) a cementitious product shall generally be specified (e.g. cement-bentonite grout) – the performance requirements shall be specified during design for the ground conditions and loading present.

A swab pass should generally be undertaken prior to duct pulling to ensure the bore is properly cleaned.

5.4.2 Experience Requirements

The HDD contractor personnel shall have a minimum of five years of experience with similar HDD projects. This includes site managers and relevant technicians. CVs of such personnel shall be submitted to EirGrid for review and acceptance prior to the commencement of construction works.

5.4.3 Site Records

Site records requirements for HDD works shall be maintained as outlined in CDS-GFS-00-001.

As built records shall be issued to ESB and EirGrid as outlined in CDS-GFS-00-001.

The following table presents the minimum required site records.

Table 8 Site records

Activity	Details to be recorded
Daily Reports	• Project. • Location. • Date. • Weather. • Works completed during shift • Equipment & tooling used. • Materials consumed. • Hazard review. • Exceptional events. • Details of and mitigation for assets to be crossed. • Trigger value exceedances and actions taken, if any.
Drilling records	• Serial number. • Drill string length (m). • Positioning (m). • Sonde depth (m). • Start time and end time. • Azimuth of drill (degrees). • Pull on drill duct (kN). • Torque (kNm). • Pump rate (l/m). • Pump pressure and/or down hole pressure (Pa). • Mud returns (%). • Exceptional events. • The European Soil Classification Symbol for all launch, inspection and reception pits. • Position and size of launch and reception pits (m).

Drilling fluid records	• Density of drilling fluid (kg/m^3). • Density of the mud returned (kg/m^3). • pH value. • Filtration loss (cm^3). • Viscosity (Pa.s). • Balance of circulation volume. • Content of sand after recycling (%). • Make up/soil description and colour/consistency description of the returns.
Safety file	• The safety file shall be generated and passed to the relevant asset owners

Surface and asset monitoring data shall also be recorded, with adequate linkage between the drilling records (drill head location, time) to enable evaluation of the information jointly.

5.4.4 Ground Movement Control

Monitoring and trigger limits shall be established and recorded as a minimum for each drill pipe length for each stage (pilot, reaming, pipe pulling) to confirm the drill is performing as expected with respect to:

- Ground movement - Settlement/ heave
- Down hole pressures
- Flow rates
- Pulling forces
- Mud return flows noted for the variation of flow.
- Variation of the drilling path compared to the design.
- Torque and thrust force.
- Record/monitoring of the consistency and make up/ colour of the returns.

The following details the minimum requirements for the ground surface and asset specific movement monitoring and control:

- HDD shall be performed in a manner that will minimize the movement of the ground (heave and settlement) in front of, above, and surrounding the boring operation; and will minimize subsidence of the surface above and in the vicinity of the boring. The ground shall be supported in a manner to prevent loss of ground and keep the perimeter and face of the bore stable at all times, including during shutdown periods. Pulling forces and down hole pressures shall be controlled to prevent heave or frac out occurring.
- Surface ground movement monitoring shall be undertaken at intervals along the bore. The monitoring shall be undertaken at a time and location frequency sufficient to identify a trend of movement and enable works to stop prior to excessive movements occurring, until the permitted activity has been completed. The location and time stamp of each monitored point shall use a common system across the project to enable correlation with other monitoring data.
- Additional monitoring points will be placed at specific assets (bridges, structures, existing services) to be agreed with the relevant asset owners.
- Near the start of the drill and prior to crossing sensitive assets, monitoring location spacing shall be reduced and monitoring frequency increased to provide assurance the drill is progressing within the design parameters. These cases shall be considered on an asset owner and case by case basis.
- For all monitoring points, baseline readings shall be established to provide a stable value from which to compare the subsequent project monitoring. The duration and frequency of the baseline monitoring shall be agreed prior to works commencing, documented in the monitoring plan and be sufficient for the proposed works. As a minimum a survey shall be performed one day prior to initiating the operation at each required monitoring location with a minimum of 3 readings taken with a maximum difference in mm.

- All survey readings shall be recorded to the nearest 1mm or better. Digital photographs of the surface/asset conditions (or other such survey methods as agreed) shall also be taken prior to and after the pipe installation.
- Monitoring shall continue post installation completion until all movement associated with the HDD have demonstrably ceased and for a minimum additional period of 1 week. Frequency of monitoring post works to be agreed with EirGrid and the asset owner, but not less than once per day for the initial period.

6 Micro-tunnelling Specific Requirements

6.1 Overview

All requirements outlined in Section 4 shall apply. Additional requirements relevant to microtunnel installations are outlined in this section. Micro tunnelling shall be undertaken in accordance with the requirements of BTS Tunnelling Specification.

Cables in the micro tunnel shall be placed in ducts and the tunnel and shafts/puts backfilled around the ducts.

6.2 Environmental Parameters

Where micro-tunnel depths are between 5m and 10m below ground, the ground temperature shall be considered as 13°C for the entire year. The soil thermal resistivity shall be 1.0 K.m/W for the entire year.

These parameters may be used for preliminary calculations for deeper installations but shall be validated by site investigations.

6.3 Design Requirements

6.3.1 Permanent Works Design

6.3.1.1 Design Life

The design life of micro-tunnels shall be 120 years, including gaskets.

6.3.1.2 Material Selection

The developer shall take into consideration the installation method and support of cables through the transition from horizontal, within the tunnel, up to shallow buried via inclined or vertical routing. Proposals shall be submitted in outline to EirGrid for review at FEED stage and fully developed solutions shall be submitted at detailed design.

The space between the lining and cable system ducts shall be filled with bentonite or a similar material to mitigate against duct movement and damage during load and fault scenarios, if required. Cable ducts shall not be filled with bentonite to allow for the removal and replacement of cables. In larger diameter micro tunnels with multiple ducts within, duct installation method and spacing shall be developed to ensure the position of the ducts are maintained and to prevent twisting of the duct groups so as to ensure cable installation is not inhibited. Spacers/ rollers or similar may be required to achieve this. Where shown to be required for durability or serviceability concerns, cement-bentonite or cement grouts to fill the space between the lining and the ducts may be used. Proposals shall be submitted to EirGrid for review and acceptance.

Cable ducts shall be designed and proved prior to cable pulling as per the requirements of CDS-GFS-00-001.

Microtunnel pipes shall meet the requirements of EN 1916 and the requirements of BTS Tunnelling Specification. Pipe joints shall be gasketed with gaskets meeting the requirements of EN 681-1 and achieve a hydrostatic water resistance of at least twice the characteristic ground water pressure. Watertightness criteria shall be equivalent to Class 3 from the BTS Tunnelling Specification.

Packers shall be used at the pipe joints to distribute stresses. Packer materials shall be selected by the Developer and accounted for during the assessment of pipejacking forces and joint rotations. Packer size/ thickness shall be compatible with the gasket for the full range of packer compression.

Where no future entry to shafts/ pits is included as part of the design, the shafts/ pits may be designed as temporary structures and backfilled with a suitable designed material that will fully support the surrounding ground. Where there is potential for future re-excavation of the shafts/ pits, the shaft/pit lining shall be designed for 120yr design life.

Details of the proposed micro-tunnel and shaft linings including outside diameter, material and supplier details shall be provided prior to construction.

Concrete jacking pipes (and other pre-cast linings) shall be inspected upon arrival at the site for defects, with inspection records for each pipe maintained. The inspection shall be repeated prior to installation. Any pipes found with defects outside an agreed limit (to be defined by the developer prior to construction) shall be quarantined and a non-conformance report (NCR) raised to enable assessment. The pipe shall be repaired or rejected based on the outcome of the NCR. The developer shall document a process for the inspection, assessment, repair, quarantining, and rejection of pre-cast elements and submit to EirGrid for review and acceptance alongside agreed limits for each defect type identified

The space between the lining and cable system ducts shall be filled with bentonite or a similar material to mitigate against duct movement and damage during load and fault scenarios. Cable ducts shall not be filled with bentonite to allow for the removal and replacement of cables.

Cable ducts shall be designed and proved prior to cable pulling as per the requirements of CDS-GFS-00-001.

6.3.1.3 Structural Adequacy and Loading

Permanent shafts and the tunnel lining shall be designed in accordance with the Eurocodes, with the pipe capacity assessed in accordance with EN 1992-1-1.

Pipes shall be designed to meet the temporary (handling, construction) and permanent loading – design load cases shall be recorded in the design documentation but shall include (but not be limited to):

- Lifting and handling
- Jacking forces including tolerances
- Lubrication pressure
- Grouting pressure
- Ground and ground water loading
- Live loading (e.g. rail, traffic)
- Internal loading (filling)

Jacking analysis shall be undertaken (or provided by the supplier) to confirm the jacking force limits for the required curve/ joint angles.

Beneficial effects of the filling bentonite on the pipe structural capacity shall not be considered in the calculations for long term loading due to potential shrinkage.

Drive length assessment shall be undertaken to estimate the expected jacking forces required for the lengths, diameter and ground conditions present. Adequate interject stations shall be installed to mitigate the risk of becoming stuck or exceeding the allowable jacking forces, where required.

6.3.1.4 Maintenance

The design shall include details regarding the operational requirements, maintenance, checks and repairs. Where no future access for inspection or maintenance is possible this shall be considered in the durability assessment of the materials used.

6.3.1.5 Ground Movements

Heave can occur during micro-tunnelling due to excessive friction build up along the pipe or excessive face pressure/ TBM jacking forces applied. Limits are to be set to control the risk of heave, and surface monitoring in place to monitor and enable adjustment during the drive.

6.3.2 Electrical System Requirements

6.3.2.1 Cable System Requirements

All cable requirements shall be as per CDS-GFS-00-001.

Cables in a micro-tunnel shall be laid in ducts. This shall enable the pulling and re-pulling of cables if required. Duct requirements, including proving, shall be as per CDS-GFS-00-001.

There shall be no cable joints within the micro-tunnel. If there is a requirement for a joint within the tunnel, it shall be in a shaft. Such a shaft shall be accessible for maintenance purposes. Any link boxes required shall be accessible from ground level without a requirement for civil works. Joints shall not be installed vertically within shafts.

Where entry and exit shafts are employed, the cable in the shaft shall generally be installed as a rigidly cleated system, and therefore provisions adopted for shafts in tunnels must be used. See Section 7.5.5.

Regardless of the system arrangement, each duct system is expected to transition to a standard trench arrangement. A transition pit may be used at both ends of the micro-tunnel to join trenchless ducts with standard ducts. The requirements for HDD systems shall apply. See Section 5.3.1.4

6.3.2.2 Earthing Requirements

Earthing requirements for micro tunnel installations shall be as per CDS-GFS-00-001.

6.3.3 Horizontal and Vertical Alignment

Minimum clearance requirements from other services shall be considered to satisfy all third-party clearance requirements. EirGrid shall be consulted on minimum clearance requirements.

Microtunnels shall have straight drives as much as possible, jacking of pipes in a curve will require special considerations with risks, impacts on friction and jacking force limits fully assessed and presented in the design where curves are required.

6.3.4 Launch and Receiver Pits/Shafts

Shafts are to be designed as either temporary or permanent structures. If temporary, they shall be fully backfilled and the surface reinstated, ensuring long term stability and suitability of the backfill material.

If permanent/ open for future access (or re-excavation is required for cable replacement), the shaft lining shall be designed in accordance with the Eurocodes, with capacities demonstrated against EN 1992-1-1. Opening designs shall ensure the stability of the opening in the temporary and permanent situations as relevant. Shaft drainage (pump out) and cover slab requirements shall follow those in Section 7.

Permanent shafts that will be backfilled shall be waterproof to Class 4 of the BTS Tunnelling Specification whilst permanent shaft not to be backfilled shall meet Class 3. Temporary and permanent shafts shall be sufficiently watertight during construction to facilitate efficient construction and prevent excessive water entering the shaft to ensure water leakage does not induce settlement or unacceptable impacts on the local ground water regime.

Shafts shall be assessed against uplift in both the temporary and permanent cases as relevant according to EN 1997.

The shaft lining and ground shall be assessed against the required jacking loads to be applied ensuring damage is prevented and no excessive deformation will occur. Adequate supports, frames and reaction walls shall be designed and used as deemed necessary by the design. Where the shaft lining is permanent, cracking induced by the jacking loads shall be checked and limited to the permanent works requirements.

6.3.5 Selection of Size

The diameter of the micro tunnel shall be selected to facilitate the installation of the ducts for the cables with the required separation between ducts as required by the cable design Pulling calculations shall be provided in the cable system electrical report to determine the feasibility of pulling HDPE ducts into the micro-tunnels. The diameter shall also be selected by assessment of the construction and the limits on drive lengths, construction access requirements, safety risks and the friction/ allowable jacking loads on the pipes for the required drive lengths. Demonstration that the construction can be achieved safely and with acceptably low risk of failure of the drive shall be documented and presented to EirGrid for review. Assessment of the impacts of a drive failure shall be included.

6.3.6 Shaft Location and Sites

Shaft locations (drive, reception, intermediate) shall be selected during the FEED stage via a site selection study, submitted to EirGrid for review and acceptance. Each site shall be demonstrated to provide adequate space for the intended use including:

- Production of site layout plans,
- Confirmation of adequacy of service connections (or alternative provision plans),
- Suitability of transport (access/egress routes) sufficient to/from the sites including for large plant such as the TBM,
- Suitability of drive lengths between sites,
- Appropriate plan and profile alignments between sites,
- Impact on third parties and environment (planning input),
- Requirements for 24/7 working (and impact on the previous bullet),
- Potential impacts from temporary or permanent access/ maintenance requirements during operation
- Feasibility of access for cable delivery and space at surface for cable installation including allowance of space and access for future cable replacement works.

For drive sites, adequate provision of space for spoil handling, storage and treatment shall be ensured to prevent delays or stops during tunnelling.

In longer drives where the likelihood of becoming stuck increases, potential sites for rescuing the drive shall be considered and provision made in the planning application for their potential emergency use.

Reception shafts or pits shall be covered to allow roads to be kept open or not excavated until needed. This shall be determined when assessing the scheme constraints and the overall programme.

6.4 Construction Stage

6.4.1 Construction Methodology Report

Construction Risk Assessment and Method Statements (RAMS) and Inspection Test Plans (ITPs) shall be developed by the Developer for the proposed works. The micro-tunnel method statement shall include (but not be limited to):

- Proposals for the guidance system and monitoring of the alignment during tunnelling, including demonstration that the design tolerances shall be achieved,
- Set upper and lower bound limits on slurry/face pressures,
- Methods for monitoring and recording slurry volumes and face/slurry pressures
- Methods for monitoring annulus pressures and injection volumes, and reconciling with the theoretical volumes
- Proposal for the number and spacing of any inter-jack stations, including reference to the monitoring of jacking load trends,
- Grouting pressure requirements,
- Methods and sequence for grouting
- Assessment that methods minimise the risk of excessive heave, in particular face and jacking pressures,

- Method and pressures for annulus lubricant,
- Method of transportation, erection, dismantling of the TBM,
- Method of spoil removal, storage, treatment and disposal
- Planning and use of any fluids in accordance with environmental constraints
- Methods for installation of ducts
- Method for recording as built information including vertical and horizontal tolerances and presentation of as built drawings
- Methods for restraining the ducts during tunnel filling (floatation of the ducts)
- Shaft construction methodology, ground water control and abstraction (if any)
- Shaft backfilling materials and method

A submission shall be included detailing the proposed diameter, length and requirements for person-entry for the tunnelling if required. Included shall be an assessment on the safety and constructability of the proposed tunnel and a demonstration of compliance with PJA PIPEJACKING design guidance for CDM duty holders document.

6.4.1.1 Face/Bore Stability and Fluid Pressure

An assessment of the stability of the excavation in the temporary state including proposed operational pressures for the ground conditions and local ground water regime shall be carried out and a report prepared for review and acceptance by EirGrid.

Face pressure assessment shall be undertaken to establish the required minimum and maximum face pressure and annulus injection pressures for the tunnelling.

Grouting of the annulus shall be undertaken to displace the annulus fluid with a cementitious material. The pressures required to achieve this shall be documents in the RAMS and the pipes assessed for this pressure. Acceptability of the grouting pressure for the ground (heave) shall be assessed and presented.

6.4.1.2 Lubrication and Support Fluids

Unless otherwise accepted by EirGrid and relevant third parties support fluid (e.g. bentonite and/or polymers) shall be used. The materials to be used shall be suitable for the prevailing ground conditions.

Face support slurry and annulus lubrication materials shall be selected based on the ground conditions and project requirements.

6.4.1.3 Deliverables

The Developer shall provide the following details:

- Location and construction details of jacking infrastructure within the shafts including backwall and headwall details and site layout drawings to indicate the positioning of the equipment and associated installations,
- Design loads, maximum permitted jacking load and associated maximum angular deflection for the jacking pipes, and maximum permitted jacking loads for shaft walls,

Materials for pipe backfilling and method of backfilling,

6.4.2 Experience Requirements

The micro-tunnel contractor personnel be suitably qualified for the role. This includes site managers and relevant technicians. CVs of such personnel shall be submitted to EirGrid for review and acceptance prior to the commencement of construction works.

6.4.3 Construction Equipment

The following information shall be provided to EirGrid:

- The proposed shaft and pipejacking rig and TBM specifications, including age, maintenance history, capabilities and previous completed projects in similar ground,

- System of alignment monitoring and steering control and activation,
- Hydraulic or other jacking system maximum capacity and method of limiting jacking capacity to that of the maximum capacity of the pipes and shaft lining.

6.4.4 Site Records

Site and as built records shall conform to the requirements of the BTS Tunnelling Specification. As a minimum the following shall be recorded and made available to EirGrid on request:

- Face pressures
- Cutter head torque and roll of the TBM/ rings
- Face support materials and additives used
- Annulus lubrication pressures
- Stops for interventions on the TBM
- Excavation volumes
- Jacking forces and distribution
- Inter-jack station use and jacking forces
- Plan and profile alignment
- Pipe no. & timing, advance rate,
- Shift time, personnel, shift reports
- Grouting pressure and volumes
- Grout production test results
- Pipe inspection records prior to installation (and associated NCR resolution if applicable)
- Duct installation pulling forces
- Tunnel filling material and volumes
- Shaft backfilling material testing reports and volumes
- Cable installation method

As built drawings shall be submitted to EirGrid.

6.4.5 Ground Movement Control

For micro-tunnelling, methods to reduce the impact on third-party assets from TBM jacking / ram pressures and TBM slurry/face pressure shall be managed by the Developer to minimise ground movements, specifically heave. Jacking/ram pressure shall not exceed the limit to be determined by the design of the pipes. Adequate face and annulus lubrication pressures shall be applied to limit convergence and ground loss and thus settlement.

6.4.6 Risk Management and Other Requirements

The Developer shall comply with the requirements of 'A Code of Practice for Risk Management of Tunnel Works'; British Tunnelling Society; 2nd Edition; May 2012

The Developer shall comply with Section 60 of Confined space regulation (S.I. No.218 of 2001) and with BS 6164:2019 'Code of Practice for Health and safety in tunnelling in the construction industry' or international equivalent.

The Developer shall refer to the HSE/Pipe Jack Association/British Tunnelling Society 'Tunnelling and Pipe Jacking: Guidance for designers' in relation to pipe diameter and associated indicative drive lengths limits or international equivalent.

The Developer shall comply with the Safety, Health and Welfare at Work (Construction) Regulations 2013 – Part 5 in the construction of the project.

The Developer shall additionally comply with EN 16191:2014 Tunnel Boring Machines – Safety Requirements and EN 12110:2014 Tunnelling machines. Air locks. Safety requirements.

7 Person-Entry Tunnel Requirements

7.1 Overview

This section covers the requirements, in addition to those provided in all sections above, for person-entry tunnels, hereinafter referred to as tunnels. These installations will contain up to two circuits and have additional design requirements for maintenance and emergency access/egress.

Such tunnel installations require the design and installation of additional systems as set out in the following sections. While a standardised tunnel design is preferred, it is understood that each project is specific. The Developer shall therefore assess each project on its merits while incorporating the requirements of this specification, and due regard to EirGrid policies, Irish and European legislation and legal requirements.

Verification and validation of compliance with the requirements contained in this section shall be demonstrated through submission of a Requirements Verification & Validation Report. The acceptance of this report by EirGrid is a prerequisite to the facility entering operational service.

The design shall consider guidance and current best practice principles as detailed in the reference documents listed in Section 2. This also includes the construction specifications such as "Specification for Tunnelling" published by The British Tunnelling Society (BTS) where applicable.

Specifications shall prevail in the following order:

- Functional Specification for Trenchless Installations (this document)
- BTS Tunnelling Specification

This shall incorporate considerations for design, construction, operation, health and safety, and risk management.

This section focusses on the construction of tunnelling using tunnel boring machines (TBM) with segmental linings. The section assumes the tunnels will be open and accessible during the operational phase of the project. Larger diameter pipejacked tunnels may also be of sufficient size for operational access. This is acceptable provided all relevant clauses from section 7 are adhered to in addition to the relevant clauses of section 6 relevant for the method. This shall be addressed in the FEED stage and agreed with EirGrid.

7.2 Environmental Parameters

The following indoor general conditions shall be met unless more onerous conditions are specified in the latest revision of EirGrid XDS-GFS-00-001.

- Maximum ambient temperature + 40 °C
- Maximum daily average ambient temperature + 30 °C
- Annual average ambient temperature + 20 °C
- Minimum ambient temperature - 5 °C Humidity 95%

The air inlet temperature at the tunnel entrance below is for guidance, with the temperatures to be agreed with EirGrid.

Winter	Summer
5°C	20°C

The tunnel air temperature, during unmanned operations, shall not exceed 50°C at any point along the route, both during steady state and all emergency/overload conditions.

The tunnel air temperature during manned operations, shall not exceed 35°C at any point along the route, both during steady state and all emergency/overload conditions.

The tunnel temperature shall be measured on the crown of the construction via the tunnel DTS system.

Ground thermal resistivity and ground /groundwater temperature, at tunnel depth, shall be measured if required. Thermal resistivity and ground temperature shall be measured using down hole geophysical tools within ground investigation boreholes or from laboratory samples testing.

The noise from the installation, particularly the fans for tunnel ventilation, shall not exceed 45 dB(A) at any time at any noise sensitive location.

7.3 Design Requirements

Use of TBM tunnelling theoretically enables drive lengths of 10’s of km. However, practical and safety considerations apply for both construction and operational phases linked also with the selected diameter. The drive lengths, selected diameter and requirement for intermediate shafts shall be considered during the FEED stage of the project and demonstration of acceptability for the construction logistics and safety, cable installation requirements and operational inspection, maintenance, and safety requirements presented.

7.3.1 Permanent Works

7.3.1.1 Design Life

Tunnels and shafts shall be designed for a minimum life of 120 years and, if accessible, include for routine maintenance and inspection as part of the design considerations.

Consideration shall be given to the design life of structures and cable systems within tunnels and shafts in relation to their criticality and the ability to maintain and replace them. Provision shall be made for the removal and replacement of all cables and plant which shall include consideration for maintaining wayleaves and access agreements throughout the life of the tunnel and shaft site.

7.3.1.2 Material Selection

7.3.1.2.1 Segmental Lining

Generally, the segmental lining shall form a single pass final lining suitable for all stages of the project. If the developer deems a secondary lining is required, the use of it and its contribution to the ground and ground water support shall be presented to EirGrid for review.

Precast concrete segments and moulds (including tolerances) shall conform to the requirement of the BTS Tunnelling Specification. Segments may be rebar reinforced, steel fibre reinforced or a combination of the two. Plain concrete segments will not generally be accepted.

The developer shall present the segment geometry to EirGrid for acceptance, including the intended segmentation, taper and ring length compatible with the design alignment and proposed TBM. Care over detailing of the joints and recesses shall be taken to ensure the design performance of the joints and accessories meets the design intent and is compatible with the demoulding of the segments.

Tunnel pre-cast concrete segments shall have gaskets to achieve a design watertightness of at least twice the characteristic ground water pressure. Design of the gasket groove shall ensure that the loading during gasket compression does not result in spalling of the concrete. Allowance for over-compression of the gasket from the design shall be explicitly accounted for and considered when selecting the gasket setting depth. Gaskets shall meet the requirements of the BTS Tunnelling Specification.

The cable brackets will be required to be fixed to the segments at regular intervals. The allowable drilling zones, or pre-installed fixing positions will be addressed in the design to ensure compatibility with the two systems including construction tolerances.

Tunnels and shafts shall meet watertight Class 3 from the BTS Tunnelling Specification. No drips directly onto the cable system shall be permitted. See also section 7.6.

The annulus between the lining and the ground shall be grouted in accordance with the BTS Tunnelling Specification.

Concrete segments shall be inspected upon arrival at the site for defects, with inspection records for each segment maintained. The inspection shall be repeated prior to installation. Any segments found with defects outside an agreed limit (to be defined by the developer prior to construction) shall be quarantined and a non-conformance report (NCR) raised to enable assessment. The segment shall be repaired or rejected based on the outcome of the NCR. The developer shall document a process for the inspection, assessment, repair, quarantining, and rejection of pre-cast elements and submit to EirGrid for review alongside agreed limits for each defect type identified (segment repair strategy).

Design crack width criteria shall be established based on EN 1992-1-1 and EN 1992-3. Segments shall be designed to be uncracked prior to delivery to the tunnel site from the manufacturing and handling/ transportation load cases. Cracks from the manufacturing and handling process shall be addressed in the segment repair strategy.

Segment accessories (bolts, dowels, packers, bicones, etc.) shall be selected and be compatible with the proposed ring erection sequence and tolerances, and be suitable for the expected loads. Packers on the tunnel segments radial (longitudinal) joints shall not be used.

7.3.1.2.2 Shafts (other than segmental shafts)

Shafts shall be designed as permanent structures and be compatible with the construction and operational stage project requirements. The method shall be selected by the developer suitable for the site, size and ground and ground water conditions present.

Durability of the shaft elements shall be in accordance with EN 1992-1-1 cognisant of the installation methods for each element. Design crack width criteria shall be established based on EN 1992-1.

Watertightness of the shaft structures shall meet watertight Class 3 from the BTS Tunnelling Specification. No drips directly onto the cable system shall be permitted. See also section 7.6. Watertightness to be achieved either via water retaining concrete (where this can be reliably constructed and crack widths adequately controlled according to EN 1992-3), or by use of waterproof membranes. Joints between elements to be sealed using hydrophilic strips and/or grouting (or other such reliable methods).

Sprayed concrete linings shall be designed in accordance the BTS Tunnel Lining Design Guide and internationally recognised good practice.

7.3.1.3 Structural Adequacy and Loading

7.3.1.3.1 Tunnel segmental lining

Design of the tunnel lining shall include all temporary, permanent and accidental load cases (ULS, SLS, ALS) the lining may be subject to. These include, but are not limited to:

- Ground and ground water
- Surcharge
- Primary and secondary grouting pressures
- Cable loading/ cable support loading (including fault loading)
- Flood
- Seismic
- Fire
- Jacking forces
- Lifting, handling, stacking and transport

Load and material factors shall follow EN 1991-1-1/EN 1997-1 and EN 1992-1-1 respectively. Full load combinations shall be developed in accordance with EN 1991-1-1.

Segment accessories shall be calculated for the temporary and permanent forces they will be subject to, and the concrete lining checked to ensure compatibility with the loads using EN 1992-4. Design shall include allowances for free travel and long term creep/ performance if relied upon in the permanent case. In the permanent case and where the accessories remain in place, both their beneficial and detrimental (overloading) effects shall be considered in the analysis with free travel allowances and upper/lower bound stiffnesses applied as appropriate.

Ground loading on the lining shall be assessed taking due consideration of the construction method, depth and likely soil-structure interaction. Design sections shall be selected to ensure the worst case loads and load combinations are considered.

Capacity shall be verified against EN 1992-1-1 with particular consideration for the longitudinal joint design for bearing and bursting.

Explicit checks for the ram loads shall be undertaken acting on the circumferential joints. The analysis shall include:

- The effects of packers on the circumferential joints
- The eccentricity tolerance of the ram pad on the segment bearing surface
- Ring roll tolerances
- Longitudinal misalignment tolerances (lack of planarity in the circumferential joints between segments in a ring)
- Other tolerances established by the developer

The developer shall account for the ring ovalisation from build tolerance explicitly in the design. The value of this ovalisation shall be stated in the basis of design and limited on the design drawings. Other tolerances including segment stepping and lipping shall be considered explicitly in the design where relevant to the design check.

Construction tolerances shall be documented and agreed in the basis of design.

7.3.1.3.2 Shaft

The developer shall select the shaft construction method suitable for the geometries and ground conditions present to ensure the method provides support and stability to the ground in all stages of construction and adequately manages the ground water flow.

Design of the shaft shall consider all stages including construction and operational stages and take due account of the construction sequence. Design of the shaft shall include all load temporary, permanent and accidental load cases (ULS, SLS, ALS) the lining may be subject to. These include, but are not limited to:

- Ground and ground water
- Surcharge (including any asymmetric loadings)
- Primary and secondary grouting pressures (if applicable)
- Ground treatment or stabilisation
- Cable loading/ cable support loading (including fault loading)
- Flood
- Seismic
- Fire
- Jacking forces (if applicable)
- Lifting, handling, stacking and transport (if applicable)

Load and material factors shall follow EN 1991-1-1/ EN 1997-1 and EN 1992-1-1 respectively. Full load combinations shall be developed in accordance with EN 1991-1-1.

Where a shaft uses a secondary lining, if it is not designed for the full external loading, then any load sharing shall be fully justified and demonstrated.

Verticality and ovalisation build tolerances shall be explicitly included in the analysis of the shaft lining where they induce unfavourable effects. The build tolerances shall be documented and agreed in the basis of design.

Openings in the shaft shall be designed for the temporary and permanent stages of the opening, considering the construction sequence to be applied. Openings shall include for any loads from the process of breaking into or out of the shaft.

Stress distribution packers on the shaft segments (if used) radial (longitudinal) joints may be used where required by the manufacturer but their beneficial effect may not be accounted for in the long term unless the specified material performance can be demonstrated to be achieved for the full design life of the structure.

The shaft shall be designed against uplift for both temporary, permanent and flood scenarios in accordance with EN 1997-1. Uplift shall take account of any potential flood event, including potential artesian conditions from flooding. The frictional resistance of the ground shall be selected taking consideration of the construction sequence, method and materials used.

For flood events, the developer shall make clear the assumption of whether the flood will result in flooding/ filling of the shaft via the headhouse and consider this in the design and selection of the load cases.

7.3.1.4 Maintenance

Shafts and tunnels shall be designed with minimal maintenance requirements other than regular inspection for condition. Due account for this shall be taken in the development of the repair strategy and repair methods/ materials selected to ensure they are compatible with the intended 120yr design life and minimal maintenance requirements.

7.3.2 Selection of Size

The tunnel diameter shall be sufficient to install multiple cable circuits and maintain access requirements, including emergency egress. The diameter shall be compatible with the requirements for construction logistics and safety considering the drive lengths, TBM and logistics proposed and project risks. The diameter shall meet the requirements of the relevant standards including BTS Tunnelling Specification and EN 16191.

7.3.3 Shaft Location and Sites

Shaft locations (drive, reception, intermediate) shall be selected during the FEED stage via a site selection study, submitted to EirGrid for review. Each site shall be demonstrated to provide adequate space for the intended use including:

- production of site layout plans,
- confirmation of adequacy of service connections (or alternative provision plans),
- suitability of transport (access/egress routes) sufficient to/from the sites including for large plant such as the TBM,
- suitability of drive lengths between sites for both construction and operational stages,
- appropriate plan and profile alignments between sites,
- impact on third parties and environment (planning input),
- requirements for 24/7 working (and impact on the previous bullet),
- potential impacts from temporary or permanent access/ maintenance requirements during operation

For drive sites, adequate provision of space for spoil handling, storage and treatment shall be ensured to prevent delays or stops during tunnelling.

7.3.4 Horizontal and Vertical Alignment

Tunnelling shall, as much as possible, have alignments in straight drives for operational reasons. TBMs can accommodate curves more readily than micro-tunnelling. The minimum allowable bend radius shall be established based on the selected TBM and segment geometry to ensure it is compatible with the proposed alignment including for any correction requirements.

Minimum clearance requirements from other services shall be considered to satisfy all third-party clearance requirements. EirGrid shall be consulted on minimum clearance requirements.

7.3.5 Tunnel Layout and Requirements

EirGrid shall advise on the tunnel layout and requirements. This shall be project and tunnel specific.

The tunnel cross-sectional layout shall account for all required equipment within the tunnel and shall ensure all clearances are satisfied including the keeping clear of a suitably sized kinematic envelope for the purposes of emergency egress. A minimum envelope (the Kinematic Envelope) of 1.5m x 2m shall be available along the entire length of the tunnel system to allow for emergency egress, maintenance and inspection.

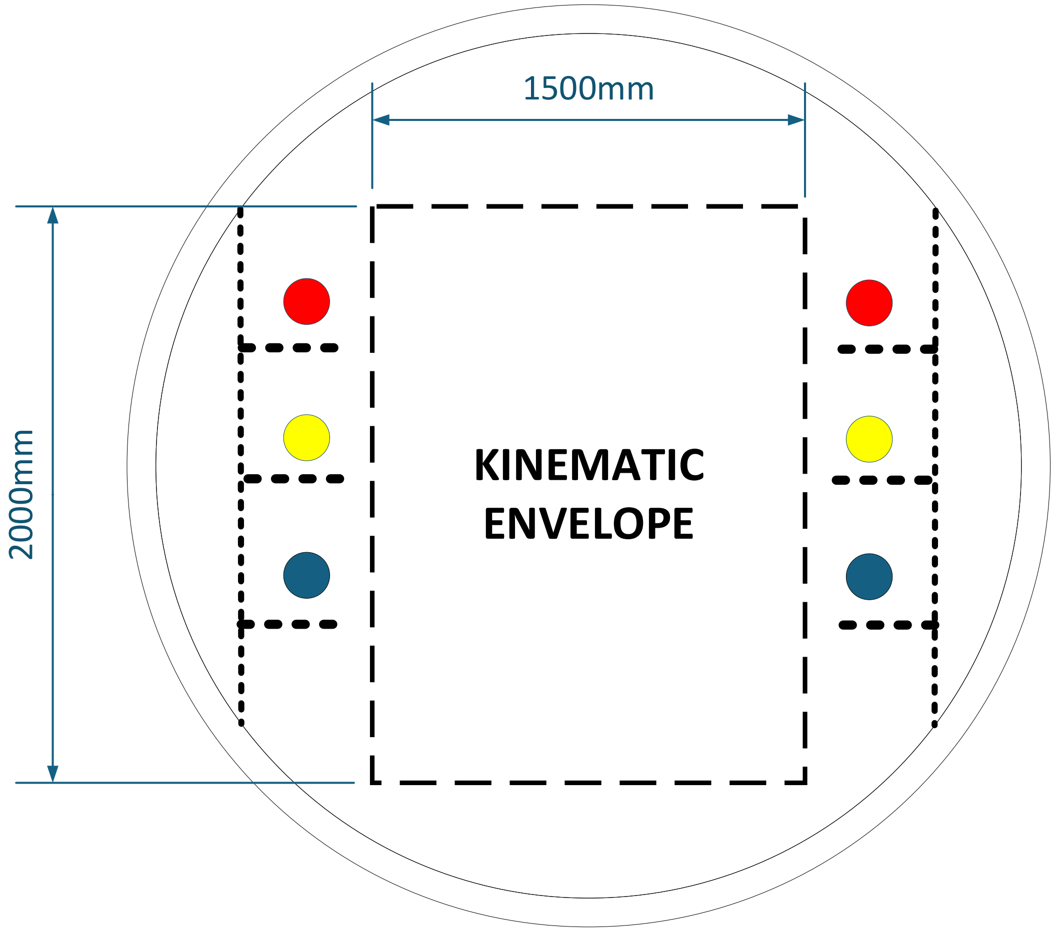

Figure 3 Kinematic envelope requirement (note: not to scale)

There shall be a minimum exclusion zone between the tunnel and any future infrastructure of 3m horizontally and 6m vertically from the extrados of the tunnel.

Two 125mm HDPE ducting shall be included in the crowns of the tunnel to facilitate DTS monitoring and protection and communications systems.

A steel I-beam shall be mounted on the tunnel crown to facilitate cable installation. This shall be considered a permanent installation to facilitate future re-pulling of cable sections as part of general system operations.

Consideration of impressed voltages on the beam shall form part of the design and mitigations shall be proposed to EirGrid for review and acceptance.

7.4 Construction Stage

7.4.1 Construction Methodology Report

The construction methodology for the person-entry tunnels shall include (but not be limited to):

- Proposals for the guidance system and monitoring of the alignment during tunnelling, including demonstration that the tolerance shall be met,
- Set upper and lower bound limits on slurry/face pressures
- Minimum flow rates required to ensure the shield is effectively cleared,
- Methods for monitoring and recording spoil volumes and face pressures,
- Assessment that the method minimises the risk of excessive heave,
- Grouting pressures required,
- Primary and secondary grouting methodology
- Method for reconciling theoretical and injected grouting volumes
- Schedule and description of procedures for segment delivery, handling, erection and grouting.
- Method of transportation, erection, dismantling of the TBM
- Method of spoil removal, storage, treatment and disposal
- Planning and use of any fluids in accordance with environmental constraints
- Method for installing the cables in the tunnel and shafts
- Shaft construction methodology, ground water control and abstraction (if any)
- Emergency evacuation and rescue procedures

7.4.1.1 Face / bore Stability and Fluid Pressures

An assessment of the stability and excavation in the temporary state shall be carried out and a report prepared for review and acceptance by EirGrid. This assessment may include:

- An assessment of proposed operational pressures for the ground conditions and local ground water regime.
- The TBM shall be capable of fully supporting the ground while the pre-cast segmental lining is installed within the rear of the TBM and grouted into the ground behind the tail skin as the machine moves forward.
- The TBM shall be capable of being pressurised to stabilise the excavation face and reduce the risk of over excavation and associated ground movements and settlement in poor ground.
- Definition of a minimum and maximum face pressure compatible with stability and prevention of heave or break out.
- Grouting pressures (primary and secondary) to be selected to ensure sufficient to fill the annulus considering ground water and face pressures whilst not exceeding the capacity of the lining or resulting in heave or breakout to the surface.

Requirements for potential maintenance and interventions in the face shall be accounted for in the design and TBM selection.

7.4.1.2 Lubrication and Support Fluids

Unless otherwise accepted by EirGrid and relevant third parties a means of active face pressure support shall be used. The materials / additives to be used shall be suitable for the prevailing ground conditions and compatible with any environmental requirements for the project.

7.4.1.3 Tunnelling equipment

The TBM shall meet the requirements of the BTS Tunnelling Specification.

7.4.1.4 Deliverables

The Developer shall provide the following details:

- Proposed TBM type and drawings
- Face support medium composition and additives
- Factory acceptance test (FAT) and site acceptance test (SAT) certificates for the TBM

7.4.2 Experience Requirements

The tunnel contractor personnel be suitably qualified for the role. This includes site managers and relevant technicians. CVs of such personnel shall be submitted to EirGrid for review and acceptance prior to the commencement of construction works.

7.4.3 Site Records

Site and as built records shall conform to the requirements of the BTS Tunnelling Specification. As a minimum, the following shall be recorded and made available to EirGrid on request:

- Face pressures
- Cutter head torque and roll of the TBM/rings
- Face support materials and additives used
- Stops for interventions on the TBM
- Maintenance records
- Excavation volumes
- Ram forces and distribution
- Plan and profile alignment
- Ring no. & timing, advance rate
- Shift time, personnel, shift reports
- Grouting pressure and volumes
- Grout production test results
- Segment inspection records prior to installation (and associated NCR resolution if applicable)
- Cable installation method

As built drawings shall be submitted to EirGrid.

7.4.4 Ground movement control

The TBM shall be designed and operated in a manner to minimise ground movements. TBM face, shield and grouting pressures/ volumes shall be maintained to limit convergence and ground loss and thus settlement. Over-pressurising the face or annulus shall also be avoided to reduce the likelihood of heave developing. The pressures and volumes shall be continuously monitored against design and theoretical limits. Where the actuals deviate, the reason shall be assessed and the impact on surface movements assessed.

7.4.5 Construction Equipment

The proposed shaft and TBM specifications, including age, maintenance history, capabilities and previous completed projects in similar ground shall be provided to EirGrid for review and acceptance.

The system of alignment monitoring and steering control and activation shall also be provided.

Mould fabrication drawings shall be produced for the segments (if not using standard products). These shall be demonstrated to meet the design intent and casting tolerances prior to the start of casting.

7.4.6 Emergency Arrangements

The Developer shall arrange for mock tunnel rescues to be undertaken throughout the project to test the planned emergency arrangements. These rescues shall be repeated as deemed necessary by the Developer, based on access and site setup changes.

7.4.7 Ground Water Control

The Developer shall ensure suitable provisions are in place to control water inflow into the shafts and tunnel during the construction. Construction shall ensure that the design tunnel grade is maintained without low points, backfalls or ponding anywhere along the alignment. The Contractor shall design in tunnel drainage provisions to maintain a dry tunnel environment.

Any dewatering activity shall be undertaken in accordance with the requirements of the BTS Tunnelling Specification.

7.4.8 Risk Management and Other Requirements

The Developer shall comply with the requirements of 'A Code of Practice for Risk Management of Tunnel Works'; British Tunnelling Society; 2nd Edition; May 2012

The Developer shall comply with Section 60 of Confined space regulation (S.I. No.218 of 2001) and with BS 6164:2019 'Code of Practice for Health and safety in tunnelling in the construction industry' or international equivalent.

The Developer shall refer to the HSE/Pipe Jack Association/British Tunnelling Society 'Tunnelling and Pipe Jacking: Guidance for designers' in relation to pipe diameter and associated indicative drive lengths limits or international equivalent.

The Developer shall comply with the Safety, Health and Welfare at Work (Construction) Regulations 2013 – Part 5 in the construction of the project.

The Developer shall additionally comply with EN 16191:2014 Tunnel Boring Machines – Safety Requirements and EN 12110:2014 Tunnelling machines. Air locks. Safety requirements.

7.5 Cable System Requirements

The following sections highlight the requirements of the cables and accessories to be used specifically in a tunnel cable system. Please also see Section 1.1.

This section shall be read in conjunction with the following documents:

Table 9 EirGrid Specifications - cable system requirements

Specification	Title
CDS-GFS-00-001-R2	110kV/220kV/400kV Underground cable specification
XDS-GFS-00-001-R4	110/220/400 kV Station General Requirements
XDS-GFS-06-001-R2	Control, Protection and Metering Specification
XDS-GFS-12-001-R4	Earthing and Lightning Protection

7.5.1 General Requirements

Cable and accessories shall be as per CDS-GFS-00-001 except where different requirements are specified in this section. A cable system electrical report shall be submitted to EirGrid for review and acceptance.

A monorail shall be used for the installation of cables. This monorail shall be left in situ for potential future use. A suitable design of the monorail shall be provided to avoid the transfer of potentials.

The bonding arrangement in the tunnel shall be chosen to minimise inspection and maintenance activities. The following solutions are accepted: single point bonded, midpoint bonded and direct cross-bonded with SVLs across the joints' insulating gaps.

There is no requirement for sheath testing after installation. A visual check will be performed along the entire route to verify sheath integrity for the section in shafts and in tunnel. To this effect, a multiple layer over-sheath with different colours is required to allow for easy identification of damage.

Cable sheaths shall be extruded metal. Cable over sheaths shall be LS0H (low smoke zero halogen) according to IEC 61034 and IEC 60754

EirGrid will require a cable specific DTS system embedded in each phase of each circuit. This will be communicated at detailed design stage. This system shall be compliant with CDS-GFS-00-001.

A maximum of two cable circuits shall be placed within a tunnel with a maximum of one cable per phase. There is no requirement for the tunnel design to make provision for future network expansion.

7.5.2 General Arrangement

Cable circuits shall be installed in the tunnel to achieve ratings, facilitate installation, maintenance, and repair. Attention must also be given to the EMF footprint along the route.

7.5.3 Cable Ratings Requirements and Calculations

The circuit(s) ratings requirements, both for normal and emergency operation are provided in the CPP or the connection agreement. These are in line with EirGrid Standards and internal policies for each voltage.

Ground properties and temperatures at installation depth shall be acquired as per Section 7.2. For any surface section of the connection, reference to CDS-GFS-00-001 shall be made.

Cable ratings calculations shall be provided for all sections (surface, shafts, and tunnel), see also Section 1.1. Cable ratings shall consider the effect of the forced ventilation and consider the discrete number of settings the ventilation system can achieve.

Cable rating calculations shall be provided, using an internationally accredited software package. CIGRE methods Electra 143 and 144 (Calculation of temperatures in ventilated cable tunnels) shall be used to estimate the circuit ratings in the tunnel, in conjunction with the indications of IEEE paper “Rating independent cable circuits in forced-ventilated cable tunnels”. Cable rating calculations shall be provided for steady state conditions and for any emergency/overload/seasonal conditions as defined by EirGrid in the project specific requirements.

Cable rating calculations shall also be provided with an ‘out of service’ ventilation system for steady state and emergency/overload conditions.

The Developer shall specify the cable ratings models used for tunnels and shafts.

Sheath standing voltages shall be determined, and SVLs chosen shall be in compliance with EirGrid’s standards and CIGRE TB 797.

7.5.4 Cable Entries and Routes

Cable entry into shafts shall consider the following:

- Cable installation methodologies,
- Water ingress
- Cable fixings and support steelwork
- Clearance from other services inside shaft

All cable entries from the surface to the shaft entry shall be sealed against water ingress, the sealing shall be removable so to facilitate cable removal, pulling and re-pulling.

Cable ratings in the tunnel shafts shall be considered separately from the tunnel considering, at a minimum, the appropriate air speeds, dimensions, and temperatures.

7.5.5 Cable Support System

The cable system steelworks are to be designed to sustain the weight of the cable (static) and additional forces associated with Short Circuit events and thermomechanical forces (dynamic). Cleats and supports are to be chosen to have the same asset life as that of the cable and accessories.

The cable support system shall consider primarily the tunnel and the shafts.

Cleats shall be selected to withstand the required thermomechanical and electromechanical (short circuit) forces of the cable system they are supporting. All cleats shall be certified to IEC 61914.

The cable support system and cleating shall be designed in accordance with the selected installation method(s) and compliant with CIGRE TB 669 and TB 194.

The Developer shall provide documentation to prove the correct management of the EMF (short circuit) and TMF (thermomechanical) forces along the route, especially at the interface between rigid and flexible sections under worst case conditions. Calculations demonstrating the ability to withstand these forces by cleats and structures shall be provided to EirGrid for review and acceptance.

7.5.6 System Earthing

The Developer shall select the earthing arrangement for the cable system in the tunnel (Section 7.5.1).

Direct cross bonding with SVL over the joint insulation gap shall be considered (per CIGRE TB 797), with no specific requirement to earth any part of the system inside the tunnel. Local bonding of structures in the tunnel can occur if calculated touch/step potential are exceeded. Earth connection points shall be available at each tunnel entrance, and in the shafts. No earthing points are required inside the tunnel.

Plexiglass shall be used to protect personnel against unintended touching of the SVLs. This plexiglass shield shall extend around and above the SVL to protect from water drops.

7.5.7 Cable Joints

The number of joints along a connection shall be minimised. Where more than one circuit is required, joints shall be staggered in relation to each other to facilitate installation and reduce risk in case of a fault, operation checks, repairs, or other activities. This staggering shall be a minimum of 50m between the end of a joint on one circuit and the start of a joint on the another.

There shall be no joints in vertical cable sections (shafts).

Cable joints and SVLs installed in tunnels shall be protected from water ingress, via suitable shielding or seals to avoid accidental contacts from inspection personnel. This is expected to be a plexiglass shielding to facilitate ease of inspection. Coffin boxes shall not be used for this purpose.

Cable joints shall have the same fire resistance and low smoke and fume emission characteristics as the cables to which they are attached.

There is no requirement for online PD monitoring of joints. Series resonant testing is required for cables where there are joints and continuous cross-bonding.

7.5.8 EMF

The Electro Magnetic Fields generated by the cable system(s) inside the tunnels and shafts shall be compliant with ICNIRP international standards in relation to working in proximity of magnetic fields.

Calculations for the ‘reference’ and ‘restriction’ levels for a typical tunnel cross section shall be provided to EirGrid for review and acceptance. These calculations shall be completed for one and two cable circuits in service.

7.5.9 Spares

Spare cables lengths shall be provided. A minimum of 100m shall be provided at each end of the tunnel. Design of the cable support system shall take the storage of these spare lengths into account.

7.6 Water Ingress and Control

7.6.1 Groundwater Ingress

The tunnel primary lining and shafts are to be substantially watertight, with no identifiable flow of water penetrating the lining. The water ingress will be accepted as compliant if at each sump the average daily water leakage rate from the tunnel or shafts draining to that sump are not to exceed 0.1 litres/m^2 of tunnel or shaft surface measured on a pro rata basis over a 24-hour period. Water ingress shall be continuously monitored.

Notwithstanding satisfactory compliance with these criteria, where there are discernible flows of water entering the tunnel or shafts at points that can be visually located, the Developer is to take necessary measures to stop such ingress. In particular, the Developer is to ensure that the cable supports remain dry and that water does not drip onto the cables, joints, link boxes or any other electrical apparatus within the tunnel and shaft.

No allowance for evaporation of water under service conditions is to be made when assessing infiltration through the complete lining.

7.6.2 Tunnel Drainage Requirements

Sumps are to be provided at appropriate shaft positions to collect any water seepage. The fall in the tunnel shall be adequate to drain water naturally to the sumps at the shafts; water ponding is not permitted along any section of the tunnel lining. Wastewater shall be discharged in accordance with the legislation requirements in force at the time and in accordance with any conditions placed by the planning authority.

The fully redundant pumping system shall be designed such that maintenance requirements are minimised. Pumps shall be provided on a duty/standby basis with duty/assist for exceptional inflows. Where possible, the system shall be designed such that maintenance can be conducted from the surface. Self-cleaning and anti-blockage features shall be incorporated where possible.

Where there is a high likelihood of a significant proportion of lime-based solids (e.g. chalk) within the tunnel water ingress, provision shall be made (for example a local tunnel drainage interceptor) to ensure it does not contaminate the separate drainage and oil containment system in the local substation.

Any water discharge licences that are required shall be obtained as part of the project and be in place prior to handover.

7.7 Headhouse and Shaft Design Requirements

7.7.1 General

All installed mechanical and electrical systems shall be located above ground to minimise the need to access equipment within the shafts. Detailed requirements for mechanical and electrical systems are provided in the sections below

For multi-shaft/headhouse tunnels, consideration shall be given to grouping equipment in 'active' headhouses' with other 'passive headhouses' minimising equipment as far as practicable.

7.7.2 Access

All shafts shall enable both access and egress. Permanent access to the shaft bottom shall be by means of open stairwell in each shaft which shall be accessed via a door within the headhouse buildings.

Shafts shall be fitted out such that a clear passage is available from shaft bottom to a ground level opening for the movement of equipment and for emergency access and evacuation of injured person, including by stretcher.

Lifting shall be via temporary equipment installed over a ground level opening.

7.7.3 Emergency Egress

Emergency egress shall be via the above mentioned lifting equipment.

The maximum distance between emergency escape points shall be determined in consultation with the emergency services, the TSO, and TAO.

7.8 Ventilation

7.8.1 Ventilation System Functional Requirements

A fully redundant forced ventilation system shall be provided for the tunnel where necessary.

The tunnel ventilation system shall be designed to provide the cooling necessary for efficient operation taking into account the maximum continuous rating for the cable, the anticipated operating regime of the circuits, thermal lag in the system and response times to equipment failure and failure modes. It must also provide a suitable and safe environment to allow maintenance and operational activities to be carried out within the tunnel. At a minimum, the ventilation system shall:

- Maintain suitable tunnel temperatures for the circuits to operate at their required ratings,
- Dilute any harmful gasses, provide fresh air and maintain a thermal environment that allows maintenance personnel to safely access the tunnel,
- In the event of a tunnel fire, be capable of moving the smoke in each direction along the tunnel. This will enable the operator to use the ventilation system to support evacuation of maintenance staff from the tunnel by moving smoke in the opposite direction to their evacuation route,
- For the purposes of cable cooling, ensure the air temperature at the downstream end of the tunnel shall not exceed 50ºC during normal operations,
- For the purposes of safe access, ensure the air temperature at the downstream end of the tunnel shall not exceed 35ºC during maintenance activities,
- Prevent smoke back-layering in either tunnel direction for the specified design fire,
- Be ATEX rated where appropriate to the equipment and the environment in which it is installed.

7.8.2 Ventilation System Design Requirements

The ventilation system shall be designed and specified such that where possible, tunnel ventilation equipment (fans, dampers, power and control panels etc.) shall be located above ground. The system shall be fully redundant with no single point of failure, e.g. fans shall be provided on a duty/standby arrangement.

Equipment shall be designed to optimise the ease of maintenance, removal, and replacement and without entry into the tunnel. It shall be possible to carry out maintenance on one fan with the other(s) in operation.

The system shall be capable of providing 100% of the design flowrate in both directions along the tunnel.

The airspeed in any publicly accessible area shall be limited to no more than 5m/s. The airspeed in the tunnel shall not exceed 11.1m/s when personnel are evacuating during an emergency.

All equipment shall achieve the required design life in the environment in which it is installed.

Any tunnel ventilation equipment which is exposed to the tunnel air shall be:

- Capable of continuous operation within an air stream at a temperature of 50ºC.
- Fire rated, and capable of extracting smoke at a temperature of 250ºC for at least 2 hours unless the fire strategy developed for the particular tunnel project has more onerous requirements

Variable speed drives (VSDs) shall be provided to limit fan starting currents, manage AC harmonics where required and to allow for control of fan speeds. VSDs shall be:

- Sourced from a reputable supplier with a proven in-service record,
- Installed in a standalone cabinet, and not as part of an LVAC panel,
- Installed to minimise fire risk.

Noise levels shall not exceed 45 dB(A) at any time during operation, at any noise sensitive location and must meet:

- Environmental requirements,
- Local government requirements,
- Health and safety requirements within the shafts, tunnels and headhouses.

Fans must operate within the stable region of their fan curve.

External louvres shall be fitted with bird mesh.

Requirements for dampers are as follows:

- Dampers shall be mechanically interlocked with fans such that a fan cannot run against a closed "fan isolation" damper
- They shall fail open so that the system shall continue to cool cables, or ventilate smoke during a tunnel fire
- Their positions are indicated locally at the damper and to the SCADA system via a sensor located at the furthest blade from the actuator

7.9 Lighting and LV Power

The provisions of XDS-GFS-14-001 apply to the Station Electric & Mechanical Services except where superseded by provisions in this section.

7.9.1 General LV Electrical

The main power supply shall be taken from the substation LVAC board. At non-substation locations, or where substation supplies are unavailable or unsuitable, a supply shall be procured from the local Distribution System Operator (DSO).

Distribution boards are to be sited at each headhouse and shall conform to the provisions of XDS-GFS-09-001 and XDS-GFS-10-001 and shall be designed to be appropriate for the environment in which they are installed.

7.9.2 Lighting

LV lighting is to be provided in the headhouse and shafts. Provision of lighting in the tunnel shall be subject to project specific risk assessment in relation to access, egress, and maintenance requirements and subject to agreement with EirGrid.

Lighting shall be positioned such that it does not require specialised access equipment or tools to maintain.

Lighting switches shall have neon indicators to allow for location within the dark. Lighting shall be controlled at the top and bottom of the shaft.

The main door entrance shall have an external LED luminaire with PIR and shall operate as the door is approached.

Lighting for general access down the shaft and at works areas at the shaft base shall be provided by LED luminaires.

7.9.3 Emergency Lighting

Emergency lighting shall be provided to facilitate escape from tunnel shafts and operate for a minimum of one hour. Increased battery autonomy may be required by the fire strategy.

The provisions of XDS-GFS-14-001 apply to the Station Electric & Mechanical Services.

7.9.4 Small Power

Each Headhouse shall contain standard 13Amp 3-pin plug double sockets conveniently located in each room and appropriately IP rated for the environment of each room. The minimum number of sockets required are as follows:

- Tunnel Control Room: 4 (double sockets)
- All other rooms: 1 (double sockets)

LV sub-main distribution cables shall be XLPE/SWA/LSOH, suitably sized to meet the maximum demand, fault rating, volt drop, and relevant de-rating factors. Cables for fire alarm, smoke damper, and mechanical control panels shall be fire enhanced cables.

The provisions of XDS-GFS-11-001 and XDS-GFS-14-001 apply to the Station Electric & Mechanical Services except where superseded by provision in this section above.

7.9.5 UPS

UPS systems shall be provided where required to provide power to the following

- PLC system
- DTS system

The UPS batteries shall be sized to maintain a continuous supply to the inverter for at least 24 hours during a normal input supply outage, with the UPS operating at rated load.

The UPS shall have the facility to interface with the SCADA system through volt free contacts.

7.9.6 Back-Up Power

Back-up power shall be provided to headhouses.

At headhouses using the existing substation LVAC supplies, its back-up power facilities shall be utilised provided sufficient capacity is available. If not available, the LV system will require expansion. If there are two or more LV systems required, these shall be fully independent.

A generator shall be required to be available to power the headhouse LVAC board as backup.

7.10 Communications and Control Systems

The Communications and Control Systems shall consist of, but not be limited to:

- Tunnel Control System (TCS)
- Tunnel Ventilation Control and Monitoring System (TVCMS)
- Distributed Temperature Sensing (DTS)
- Tunnel Voice Communications System
- Security Systems

The TCS shall provide real-time automated control and monitoring of tunnel operations, with reliable performance and remote control and monitoring capabilities from the Substation Control System (SCS) at the NCC and/or DCC, as appropriate and agreed with EirGrid. If the tunnel system shall interface with an RTU station, the appropriate solution shall be confirmed with EirGrid.

The Tunnel Voice Communications System shall provide reliable voice communication throughout the tunnel, with continuous connectivity for operational and emergency response teams.

The Tunnel Temperature Monitoring system shall provide real time temperature monitoring of the tunnel.

The DTS shall provide real-time temperature monitoring of cable overheating and fire hazards, supporting proactive maintenance and improved safety.

The Security Systems shall safeguard the tunnel systems, maintenance personnel, and headhouse assets.

7.10.1 Tunnel Control System (TCS)

The design of the TCS shall utilise a Supervisory Control and Data Acquisition (SCADA) system for control and monitoring of MEP operations. It shall interface with the following MEP systems, but not be limited to:

- Tunnel Ventilation System – control and alarm monitoring
- Sump Pumps & Drainage – control and alarm monitoring
- Alarm monitoring for both the tunnel temperature monitoring and the cable DTS
- Fire System – alarm monitoring
- Power System – alarm monitoring
- Site Security System – alarm monitoring
- Building HVAC – alarm monitoring

The TCS shall have a design life of at least 20 years.

The TCS shall consist of servers, Programmable Logic Controllers (PLCs), Human Machine Interfaces (HMIs), and network switches for system connectivity and shall meet the requirements of the EirGrid SCS specification.

The server shall be installed in the active headhouses and shall be time synchronised using Network Time Protocol (NTP) to ensure accurate timestamps for data logs, alarms, and events. Server in active headhouses shall be configured in a hot-standby redundant arrangement so that any failure shall be backed up by another server in a separate headhouse.

The TCS shall be powered from the UPS with a minimum of 24 hours of backup capacity. The TCS shall be compatible with, and interfaced to, the existing system for the purposes of alarm transmission.

The HMI shall provide mimic graphics displaying the status of MEP systems using dynamic single-line diagrams and shall include historical trends, alarms, and event displays. It shall be password protected, and all user logins shall be recorded.

Graphical User Interface (GUI) symbols and colour codes shall match SCS SCADA standards where practicable and shall be clear and simple to support operator use. Graphics shall be agreed in advance with EirGrid through the use of mock-ups.

A cyber security risk assessment shall be undertaken in accordance with IEC 62443. The TSO will advise on the security level requirement. The TCS PLCs shall be required to be Safety Integrity Level (SIL) rated as defined in IEC 61508 and IEC 62061. They shall be designed such that faulty hardware can be easily replaced.

The TCS shall be designed for modular scalability, providing a minimum of 25% spare I/O capacity. PLC and HMI software shall allow expansion via additional I/O modules. Network switches shall provide a minimum of 25% spare physical ports for future provision.

To ensure efficient tunnel operation and support increased cable loading, a DTS system and a Tunnel Ventilation Control and Monitoring System (TVCMS) shall be installed to manage airflow and temperature within the tunnel. The DTS for the cables shall interface with the TCS to adjust TVCMS rates and volume of airflow where required.

The TCS design shall consider future operation and maintenance. The DTS and TVCMS system shall be developed by a specialist in accordance with these requirements. Full operating manuals, access authorisation, protocols, and training shall be provided at handover.

7.10.2 Tunnel Ventilation Control and Monitoring System (TVCMS)

The TVCMS shall maintain temperature conditions throughout the ventilated areas of the tunnel.

The ventilation plant control panel shall be divided into control and power sections. It shall interface with the TCS for automatic ventilation sequencing and alarm monitoring.

The TVCMS shall operate automatically, with a locally operated override. Remote manual control shall be disabled during local control.

There shall be two fibre ducts installed at the tunnel crown for tunnel temperature measurement and monitoring. Its primary purpose shall be to provide distributed temperature signals to the TCS for ventilation control. Its secondary purpose shall be to detect absolute temperature thresholds and rate-of-rise conditions. It shall not be considered a life-safety fire detection system.

The system shall utilise sensing fibre installed along the tunnel soffit and manufactured in accordance with IEC 60794-3-10. The design life shall be 20 years.

The system shall, but not be limited to:

- monitor tunnel temperature along the tunnel soffit fibre optic cable,
- raise an alarm if:
    - Temperature exceeds 50°C.
    - Rate-of-rise exceeds 7°C/min (for indication only, not for life-safety fire detection),
- detect temperature variations with ±1°C accuracy, 1m resolution, and ≤10s response,
- record temperature every 30mins at 250m intervals for retention; real-time reporting shall remain active,
- communicate alarms via the TCS to the NCC and/or DCC with accurate timestamps,
- trigger audible and visual alarms at each headhouse and shaft,
- be powered from the UPS with minimum 24-hour backup.

Signals and alarms shall be available locally and remotely. As a minimum, ambient temperature and cable hotspot readings shall be continuously available locally and remotely.

7.10.3 Distributed Temperature Sensing (DTS)

The DTS for the cables shall provide real-time monitoring of cable overheating and potential fire conditions and shall meet all the requirements of CDS-GFS-00-001.

7.10.4 Tunnel Voice Communication System

The system shall include a radio base station at each headhouse, four mobile handsets with push-to-talk functionality, a 50m radius antenna, and leaky feeder cables from shaft to tunnel. Redundancy shall be provided to ensure resilience and maintain communication in the event of base station or cable failure and shall avoid single-point failure degradation.

Handsets shall be allocated as follows:

- 1 advanced handset with display and man-down alarm monitoring
- 2 handsets for maintenance personnel
- 1 handset for emergency services

The Fire & Rescue Service is expected to request a dedicated radio channel; requirements shall be agreed as part of the Fire Risk Assessment and Fire Plan.

Leaky feeder cable shall be installed along shafts and tunnel crown to provide 100% coverage. DC isolation blocks shall be installed at 500m intervals, subject to impressed voltage study validation.

The radio system shall be UPS-backed for a minimum of one hour. Base stations shall provide two independent voice channels and call recording and shall be time synchronised with the TCS via NTP.

7.10.5 Security System

Security systems shall be provided at all headhouses and shall include:

- Video Surveillance System (VSS)
- Electronic Access Control System (EACS)
- Intruder Detection System (IDS)

The systems shall provide 24/7 surveillance and threat detection and shall comply with CPNI Protection Level BASE and EN 60839 Grade 3.

Security alarms shall be interfaced to the TCS, indicating:

- Site location
- Triggering system
- Timestamp of event

Systems shall have a minimum of 24-hour UPS backup. Security cabinets shall be lockable and monitored by TCS. All security measures shall be agreed with EirGrid.

7.10.5.1 Video Surveillance System

PoE PTZ cameras shall be installed at headhouse corners to provide full perimeter coverage and general compound monitoring. Cameras shall meet EN 62676-4 and perform under all lighting and weather conditions.

Footage shall record continuously at ≥15 fps, increasing to full frame rate on motion or door activation. The NVR shall store 30 days of data plus 10% spare. Cameras shall be mounted ≥2.5m high.

7.10.5.2 Electronic Access Control

The EACS shall be installed on main entrance doors in accordance with EN 50131. Each door shall include:

- Card + PIN reader (entry)
- Card-only reader (exit)
- Break-glass emergency release, wired in-series with lock power

All EACS components shall comply with CPNI BASE and EN 60839 Grade 3. Other doors shall be egress only with panic bars. The EACS shall interface with TCS for status and alarms.

7.10.5.3 Intruder Detection System

The IDS shall detect unauthorised entry to compound, building and tunnel. Devices shall include radar sensors, PIR detectors, door contacts, and sounder/beacon. Radar shall provide perimeter intrusion detection. Alarm reporting shall occur within one second.

Personnel shall disarm the system on entry and re-arm on exit. The IDS shall comply with CPNI BASE and EN 60839 Grade 3 and interface with the TCS.

7.11 Fire Design

The fire design shall be agreed with EirGrid or as specified in the project specific requirements. At a minimum the design shall satisfy the requirements of this section. Demonstration of this shall be through a Technical Note to be submitted to EirGrid for review and acceptance.

7.11.1 Fire Risk Assessment

A Fire Risk Assessment shall be carried out for the tunnel and shafts and shall as a minimum:

- Be developed and signed by a competent and responsible person with not less than 10 years' experience in the execution of fire risk assessments
- Demonstrate that the tunnel design and construction reduce the risk of fire in the tunnel and shafts to as low as reasonably practicable
- Be developed in consultation with the responsible Fire & Rescue service
- Be approved by the responsible Fire & Rescue service

7.11.2 Fire Compartmentation

Notwithstanding the minimum compartmentation requirements within TGDB, compartments in Headhouses shall have a minimum Fire Resistance Rating not less than 1 hour, except where TGDB requires a higher rating.

Tunnel access shafts shall be separated from headhouses that function as substations with a minimum 1 hour fire compartmentation, except where the shaft exits adjacent to oil filled plant, in which case a minimum 4 hour fire compartmentation requirement applies.

Fire dampers shall comply with IS EN 15650, shall be tested to comply with IS EN 1366-2 and classified in compliance with IS EN 13501-3.

Fire dampers shall be approved by the Loss Prevention Certification Board (LPCB) with a minimum rating of SR2.

7.11.3 Structural Fire Resistance

The shafts, tunnel structure and all materials used for construction shall be non-combustible.

The shafts and tunnel structure shall be demonstrated to possess structural fire resistance for a duration of not less than four hours when tested as defined in IS EN 1363-1:2020, such that irreversible damage and deformation leading to progressive structural collapse shall be prevented.

The shafts and tunnel structure shall not exhibit explosive spalling when tested as specified above.

The shafts and tunnel structure shall be resistant to the effects of explosive cable joint failure.

7.11.4 Cable Fire Safety

All cables in tunnels and shafts shall be Low Smoke Zero Halogen (LS0H).

All Communications and Low Voltage cables in tunnels and shafts shall have a tested fire resistance not less than 60 minutes in compliance with IS EN 50200.

All cables in shafts shall be tested in compliance with EN 50266-1, EN 50266-2, EN-50266-4 and IET Guidance Note 4 and shall be designed in accordance with IEC 60332, and IEC 60754.

7.11.5 Fire Detection and Alarm

The tunnel shall be provided with a fire detection and alarm system. the system shall be integrated with the TVCMS .

The tunnel shall be provided with a smoke detection system, located near the exhaust point of the tunnel ventilation system, and shall report a fire alarm on detection of smoke. Fire alarms shall be reported to the appropriate control centre via the SCADA system.

7.11.6 Fire Plan

A Fire Plan shall be developed for each facility governed by this specification. The Fire Plan shall detail the pre-planned procedures in place for use in the event of fire and shall be approved by the responsible Fire & Rescue service.

The Fire Plan shall include as a minimum:

- Actions to be taken on discovery of fire
- Contact details for emergency services
- Specific responsibilities in event of fire
- Required training
- Provision of information to responsible and other relevant parties
- How to notify the responsible Fire & Rescue Service
- Plans of the facility, including but not limited to:
  - Routes of escape, including fire exits
  - Locations of places of safety and muster areas
  - How to isolate power and equipment
  - Locations and types of firefighting equipment
  - Any facility-specific hazards

Copies of the Fire Plan shall be provided at each point of access to the facility. The location, storages and contents shall form part of the design and shall be agreed with EirGrid.

A copy of the Fire Plan shall be provided and shall be held electronically in the EirGrid asset database.

7.11.7 Fire-Fighting Systems

Portable fire extinguishers appropriate to the anticipated hazards shall be provided in headhouses and shafts.

Portable fire extinguishers shall be selected in compliance with IS EN 5306-8.

Portable fire extinguishers shall be compliant with the appropriate part(s) of IS EN 3.

A dry riser shall be provided that extends from the exterior of each headhouse to the tunnel invert. The tunnel invert dry riser shall be accessible at grade from the exterior of the headhouse.

The exterior access point for the tunnel invert dry riser shall be secured to prevent unauthorised use and vandalism.

7.11.8 Emergency Communications

The tunnel shall be provided with an emergency communications system that is compatible with the responsible Fire & Rescue Service communication systems and those of other Emergency Services.

The tunnel emergency communications system shall be provided with a dedicated channel for use by the responsible Fire & Rescue Service and other responsible Emergency Services.

Specific details and requirements for the emergency communications system shall be discussed and agreed with the responsible Fire & Rescue Service.