
TII492 Intelligent Transport Systems (ITS) - Equipment Supply and Installation Framework - Generation 2 - Lot 4

Volume A: Works Requirements

**Part 3: Technical Specification
Section 3: Telecommunications**

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1. NETWORK COMMUNICATIONS EQUIPMENT

1.1 Scope of Works

1.1.1 General

The Contractor shall supply, deliver, store and install all materials, communications cables and associated fittings, cabinets and ancillary items as specified herein.

The Contractor shall perform all works, cable terminations and engineering services as necessary to install, test, commission and render operational the complete fibre optic cabling and network equipment as specified herein, detailed in the data sheets and referenced in the project drawings and schedules.

Delivery, receiving, offloading, handling, storing, installation and completion of all equipment shall form part of the Works included in the Framework Agreement Call-offs.

Failure to follow the specifications laid out herein, relevant regulations and guidelines, or instructions set out by the Employer's Representative over the course of the Contract shall require the Contractor to provide the additional material and labour, if necessary, to properly rectify the situation.

2. FIBRE OPTIC CABLING WORKS

2.1 General

The Contractor shall supply, install, test and commission the fibre optic cabling to serve the following ITS equipment as a minimum:

- Traffic Monitoring Units
- Pan-tilt-zoom CCTV Cameras
- Variable Message Signs
- Automatic Number Plate Recognition cameras
- Roadside Units
- Cycle Monitoring Units
- Dynamic Warning Signs
- Emergency Roadside Telephones
- Weigh In Motion
- Automatic Incident Detection
- Advanced Matrix Indicators

The Contractor shall be responsible for fully installing, terminating and testing all aspects of the optical fibre cabling as detailed in the project documentation.

The supplier shall provide warranties ensuring that spares will be available for a period of 10 years from the date of purchase.

The Contractor shall provide a warranty of 1 year following substantial completion of the works. As part of this warranty, the Contractor shall agree to repair or replace all equipment that are found to be faulting in the warranty period. The Contractor shall provide technical support to the ITS Maintenance Contractor during the warranty period.

2.2 Communications Network Equipment

The Contractor shall supply, install, test and commission all Ethernet access switches, Layer 3 distribution switches and core access servers (and associated network hardware) as specified at each roadside ITS cabinet location to provide a fully operational ITS communications network.

2.3 Coordination

The Contractor shall coordinate with the Employer, their Representative, the MOCC Operator and all other contractors on site to ensure that the installation of all services is fully coordinated.

2.4 Materials Equipment and Workmanship

The electrical installation associated with the Motorway Communication systems, including materials and equipment supplied by the Contractor, shall comply with the most recent version of I.S.10101, 'National Rules for Electrical Installations,' by the Electro-Technical Council of Ireland and the regulations, codes of practice and guidelines of ESB Networks.

All such equipment shall be sufficiently compact for satisfactory installation and operation in the accommodation provided for it.

The Contractor shall ensure that enclosures, following the drilling cutting or removal of cable entry knockouts, maintain the manufacturer's quoted IP Classification ratings and are cleaned of all waste and surplus material prior to any further work being undertaken.

All equipment supplied or employed to complete the installation shall comply with the appropriate European Standard published as I.S. EN or CENELEC Harmonisation Document or the equivalent Irish Standard or, in the absence thereof, with the appropriate Irish Standard. Equipment for which none of these standards exist shall comply with the appropriate IEC, ISO or BSI standard.

All equipment supplied or employed to complete the installation shall be clearly CE marked and shall conform to the requirements of all relevant EU Directives.

2.5 Site Records

The Contractor shall keep a daily record in duplicate in a clear and legible form of all work carried out as it proceeds on 'as-built' drawings. One copy shall be kept available for the use of the Employer's Representative during the Contract and shall, at completion certificate stage of the contract, be handed to the Employer's Representative for record purposes. Handover during maintenance period is not acceptable.

The following information shall be recorded on the drawings:

- Cable routes, including cable lengths. Additionally, within a ducted network, the number and type of cable allocated to each duct and the length of each cable.
- Cable size, type and drum number.
- Cabinets:
 - Cabinet positions, type and internal electrical layout.
 - Power supply interfaces and associated electrical load.
 - Telecom and other interfaces.
- Cable chamber locations including type, depth, incoming and outgoing ducts, type of chamber cover and details of cable joints within.
- Devices.
- Joint and sheath repair positions.
- Duct locations including depth, number of ducts, duct material and the number and type of cable in each duct.
- Cabinet and cable chamber references.
- Electrical schematics of installation including circuit protective device arrangement and rating.

The drawings shall be subject to the approval of the Employer's Representative at weekly intervals during the Contract.

Locational measurements shall be taken of the underground equipment to the nearest 100mm from the nearest edge of the carriageway or fence line. Offsets to the cables shall be recorded at 20m intervals and at every change of direction along the line of the cable unless otherwise directed by the

Employer's Representative. Offsets shall be defined longitudinally by distance from a permanent road feature, a marker post or other point agreed with the Employer's Representative.

The Contractor shall keep a daily record of the work in sufficient detail including type and drum number of underground cables to enable site records to be completed. A copy of the daily record shall be provided by the Contractor on the next working day for retention and use by the Employer's Representative.

The Contractor shall keep record sheets for ducts and chambers which shall indicate details of all cables, Cable Joint Enclosures (CJE), Above Ground Joints (AGJ), ironwork and plugs installed and tests undertaken.

2.6 Design Life

Communications infrastructure shall be designed and constructed for a 20-year design service life from the time of handover to the Employer or the Employer's Representative.

3. FIBRE OPTIC CABLING

3.1 Introduction

The following optical fibre cable types shall be installed under the Framework Agreement Call-offs:

- Longitudinal optical fibre cable
- Local optical fibre cable

3.2 Longitudinal Optical Fibre Cable

The longitudinal optical fibre cable shall be a fully filled, rodent proof, external grade, low water peak, category OS2 singlemode 96-core and 48-core optical fibre cable.

The cable shall be compliant with the specifications set out in ITU-T G.652D 'Characteristics of a single-mode optical fibre and cable.'

The cable shall be constructed from a number of cable elements formed around a central strength member producing a loose tube arrangement so that any cable strain is not immediately imparted to the optical fibres.

The outer jacket of the cable shall be coloured as per industry standard for fibre type.

The cable fibres shall be colour coded to facilitate individual fibre identification.

The fibre cable shall be new and of current design and manufacture. The cable manufacturer shall have a minimum of three years' experience in manufacturing fibre optic cable of similar design.

The unique identifier on the cable jacket shall be capable of providing reference to a full set of factory tests performed on a sample from the same master reel.

The fibre optic cable shall be installed in a duct network however the cable type should be suitable for direct burial or aerial lashed applications in the outside plant environment, providing full water blocking protection for external equipment applications.

All components shall be suitable and guaranteed for a working life of 20 years.

3.3 Optical Requirements

3.3.1 Cut-off Wavelength

The operating wavelength of the fibre will be between 1270nm and 1610nm.

3.3.2 Attenuation

The maximum attenuation between 1310nm and 1625nm shall not exceed the following:

- 0.4 dB/km in the interval 1310nm to 1625nm
- 0.25 dB/km in the interval at 1510nm

Fibre attenuation shall be uniform with no discontinuities greater than 0.1dB.

The average change in attenuation at extreme operational temperatures (-40°C to 70°C) shall not exceed 0.05 dB/km at 1550nm.

The magnitude of the maximum attenuation change of each individual fibre shall not be greater than 0.15dB/km at 1550nm.

The change in attenuation measurements shall be in accordance with TIA-455-3 FOTP-3 'Procedure to Measure Temperature Cycling Effects on optical fibre Units, Optical Cable and Other Passive Fiber Components.'

3.3.3 Optical Fibre Data Transmission

The longitudinal optical fibre cabling shall be capable of supporting, at a minimum, the following IEEE Ethernet applications:

- 802.3u 100BASE-LX10
- 802.3u 100BASE-BX10
- 802.3z 1000BASE-LX
- 802.3z 1000BASE-LX10
- 802.3z 1000BASE-BX10
- 802.3ae 10GBASE-LW
- 802.3ae 10GBASE-EW
- 802.3ae 10GBASE-LR
- 802.3ae 10GBASE-LRM
- 802.3ae 10GBASE-ER
- 802.3cc 25GBASE-LR
- 802.3cc 25GBASE-ER
- 802.3cd 50GBASE-LR
- 802.3cd 50GBASE-FR
- 802.3cn 50GBASE-ER
- 802.3bm 40GBASE-LR4
- 802.3bm 40GBASE-ER4
- 802.3bm 40GBASE-FR
- 802.3ba 100GBASE-DR
- 802.3ba 100GBASE-LR4
- 802.3ba 100GBASE-ER4

3.4 Mechanical Specifications

3.4.1 Fibres

All fibres within a given cable shall be from the same manufacturer and shall contain no factory splices. Each fibre shall conform to the following minimum requirements:

- Typical Core Diameter: 8.3µm
- Cladding Diameter: 125.0 + 1.0µm
- Core-to-Cladding Offset: Not to exceed 0.5µm

- Cladding Non-Circularity: Not to exceed 1.0%

3.4.2 Colour Coating

Colour coding of individual fibres shall be in accordance with EIA/TIA-598-B. The fibre colour coding shall be discernible throughout the design life of the cable. Colour concentrates or inks used to colour the optical fibres shall be heat stable and shall not be capable of permeating through the protective fibre coating causing transmission degradation of the optical fibre.

3.4.3 Primary Coating

Each fibre shall have a dual layered, UV acrylate coating applied to it by the manufacturer. The coating shall be mechanically strippable without damaging the fibre. The coating diameter shall be $245 + 10\mu\text{m}$.

3.4.4 Central Strength Member

The strength member shall consist of a dielectric, glass-reinforced plastic rod.

3.4.5 Buffering

All fibres shall be enclosed in non-conductive loose buffer tubes.

Each buffer tube shall contain either twelve or eight fibres as specified.

The Contractor shall submit the fibre count per buffer tube and the buffer tube count configuration to the Employer for approval.

The fibre shall not fuse or bond to the inside of the buffer tube.

Buffer tubes shall be colour coded as per EIA/TIA-359A standards.

In buffer tubes containing multiple fibres, the colours shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling material.

Colours shall not cause fibres to stick together.

Buffer tubes shall be of dual-layer construction.

The buffer tubes shall be filled with a non-hygroscopic gel to prevent water and moisture penetration.

The gel shall contain antioxidant additives and the gel shall be readily removable with conventional solvents.

The gel shall be non-toxic and dermatologically safe to exposed skin.

It shall be chemically and mechanically compatible with all cable components, non-nutritive to fungus, non-hygroscopic and electrically non-conductive.

3.4.6 Stranding

The buffer tubes shall be stranded around the central strength member using the reverse oscillation (S-Z) stranding process.

Water swellable yarns shall be applied longitudinally along the central member during stranding.

3.4.7 Water Swellable Tape

A water swellable tape shall be applied longitudinally over the stranded tubes/fillers.

The water swellable tape shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter.

3.4.8 Tensile Strength Provisions

Aramid yarn shall be helically stranded evenly around the cable core to provide tensile strength. The yarn shall enable the cable to withstand a maximum pulling force of 2700N during installation and 890N long-term installed without changing the characteristics of the optical fibres.

Each length of cable shall have sufficient strength to be installed in continuous lengths as specified on the plans.

3.4.9 Outer Jacket

A medium density polyethylene (or approved equal) outer jacket shall be applied over the entire cable assembly.

The outer jacket shall have a minimum nominal jacket thickness of 1.25mm.

The polyethylene shall contain carbon black and shall not promote the growth of fungus.

Jacketing material shall be applied directly over the strength members and the water swellable tape.

3.4.10 Ripcord

The cable shall contain a ripcord under the sheath to facilitate cable preparation.

3.4.11 Bend Radius

The cable shall withstand a minimum bending radius of ten times its outer diameter during operation and fifteen times its outer diameter during installation without changing the characteristics of the optical fibres.

3.4.12 Protection against Vermin

Cables shall be demonstrated to be rodent proof.

3.4.13 Environmental Characteristics

The supplied cable and equipment shall be suitable for the following environmental conditions:

- Storage Temperature -15°C to 60°C
- Installation Temperature -15°C to 50°C
- Operating Temperature -15°C to 60°C
- Relative Humidity 85-90% + 7°C to 60°C

3.4.14 Lightning Withstand Current

Lightning withstand current shall comply with the updated version of I.S. EN IEC 60071 Series 'Insulation Coordination'.

3.4.15 Cable Life

The cable shall maintain its mechanical and optical performance for an in-service period exceeding 20 years.

3.5 Local Optical Fibre Cable and Equipment Cable

3.5.1 General

The local fibre optic cables and fibre optic equipment cables shall be of equivalent type and specification as the singlemode longitudinal fibre optic cable specified above.

3.5.2 Local Cable

Local fibre optic cables shall be installed in ducting between the longitudinal fibre optic trunk line and the equipment cabinets as shown on the Framework Agreement Call-off drawings.

The cable shall be spliced to the appropriate fibre within approved splice enclosures in chambers adjacent to equipment cabinets as specified.

Cables shall be terminated in each cabinet as to provide communications between the equipment cabinet and the trunk fibre network.

Fibre optic equipment cables shall be installed in ducting between equipment cabinets and the nearest access switch cabinet.

The individual fibres in each local fibre optic cable shall be unterminated on one end and have a factory installed LC connector on the other end. The unterminated end shall be fusion spliced to the appropriate trunk fibre in a splice enclosure and the terminated end shall interface with the cabinet optical fibre distribution frame (ODF) specified.

3.5.3 Fibre Optic Equipment Cable and Patch Cords

The individual fibre pair in each equipment cable and patch cord shall be terminated at both ends with Type LC connectors in duplex configuration and shall interface with the cabinet ODF as specified. The manufacturer shall factory-test the cable assembly and provide results to the Employer's Representative for approval prior to field installation.

Cables shall be available in standard 900 micron tight buffered or ruggedised with additional strength elements.

The following connector types must be available:

- LC/UPC (SM) compliant with I.S. EN 61754-20:2012+A1:2022- Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 20: Type LC connector family

Single-mode fibre equipment cable and patch cords will be provided with OS2 fibre only.

Cables will utilise CPR-rated cable suitable for use in indoor applications.

Cables delivered to site shall be securely stored until handover and shall be handed over with an inventory of the quantities of each batch or package of cables clearly identifying the breakdown of available lengths.

The manufacturer's certificate of conformance shall be handed over at the same time.

Cable plugs shall securely snap into the locking mechanism of installed connectors.

The Contractor shall agree with the Employer's Representative the final quantities before placing an order. Failure to do so may result in the Contractor having to supplement or return the order if there is a surplus or deficit in the numbers and lengths required at no additional cost to the Employer.

3.5.4 Optical Requirements

The local fibre optic cables and fibre optic equipment cables shall have identical optical characteristics as the singlemode longitudinal fibre optic cable specified above.

3.5.5 Material Requirements

The local cables and equipment cables shall be able to withstand a minimum of 445N of pulling force during installation.

3.6 Optical Distribution Frame

The Contractor shall supply and install fibre optical distribution frames (ODF) to organise and store fibre terminations within roadside cabinets. The ODF shall be compatible with the fibre optic terminations and splices specified herein and shall meet the following minimum requirements:

- Comprise of a patching shelf and compatible patching tray from the same manufacturer.
- Contain mounting hardware for EIA equivalent 19" racks.
- The patch trays shall have the capacity for terminating the number of fibres required as per the design plans. It is envisaged that the trays will accommodate a minimum of 12 fibre terminations.
- Have space to house sufficient splice trays to fusion splice at least 50% more fibres than are terminated in the ODF.
- The patch shelf shall have the capacity to handle combinations of two, four, six or eight patch trays.
- The patch shelf shall have the capacity to handle up to 96 fibre terminations.
- Have adjustable cable clamps to provide suitable cable strain relief shall be provided that can accommodate many sizes of outside plant cables.
- Have a two-hole ground lug sized to accept a 4mm² CSA copper wire to permit the installation of a station ground.
- Support rings to maintain minimum fibre bending radius and to prevent accidental physical damage.
- Offer physical protection for the individual fibres.
- Provide terminating facilities for fibre optic connectors, including the through adapter.
- Provide storage facilities for unterminated fibre ends.
- Provide storage facilities for buffer tubes spliced in the enclosure.
- Provide storage facilities for excess pigtail and patch cord lengths.
- A lockable compartment in which fusion splice trays are housed which is separate from the fibre patching area.
- Type LC duplex adapters to I.S. EN 61754-20:2012+A1:2022.

3.7 Optical Fibre Connectors

All fibre optic cable connectors shall be sourced from a single manufacturer.

Fibre connectors must be available for field termination of singlemode fibre.

Connectors shall be compliant with I.S. EN 61754-20:2012+A1:2022.

Connectors shall be fitted with a tight-fitting polymer cap to prevent ingress of dirt and moisture.

Connectors shall be fitted with strain relief boots to ensure durable and robust connection.

Connectors shall be optimally keyed.

Connectors shall be able to withstand 500 mating cycles with a maximum increase in insertion loss of 0.2dB and shall lie within the specified transmission characteristics.

LC connectors shall be pre-radiused to ensure optimal field polishing following termination.

All components shall be suitable and guaranteed for a working life of 20 years.

3.8 Optical Fibre Adapters

Adapters shall be sourced from the same manufacturer that supplies the connectors. These adapters shall be recommended by that manufacturer for use with the specified connector.

Fibre adapters must be available for singlemode fibre.

Adapters shall be fitted with retained tight polymer caps to prevent ingress of dirt and dust.

Adapters used for singlemode fibre optic cables shall be colour coded to distinguish between transmit (yellow) and receive (blue) ends of the elements in a duplex pair using coloured washers or equivalent.

The fibre adapters must be available in simplex, duplex and ganged adapter configurations as part of distribution modules and panels and be compliant with I.S. EN 61754-20:2012+A1:2022.

3.9 Fibre Joints, Terminations and Splices

3.9.1 General

Cable jointing, terminations and splices shall be contained within environmentally sealed Cable Joint Enclosures (CJE) as per the manufacturer's instructions.

CJEs shall be installed inside underground chambers.

The fibres shall be fusion spliced and protected from mechanical strain.

The Contractor shall be responsible for the safe disposal of any fibre waste.

3.9.2 Splice Enclosures (Cable Joint Enclosures)

The Contractor shall furnish and install fibre optic splice enclosures at all locations where it is necessary to splice the trunk fibre.

The enclosure shall be constructed of a rigid, high strength plastic material. The enclosure shall be waterproof with the appropriate gaskets and protection to provide moisture integrity, providing a minimum IP67 level of protection.

When installed, the enclosure shall be capable of withstanding severe conditions of moisture, vibration, impact, cable stress and temperature extremes.

The enclosure shall be capable of holding the type of splice trays specified herein for fusion splices. The enclosure shall have the capability of holding trays from various manufacturers.

The basic enclosure shall have the capacity to hold at least four splice trays with 24 splices per tray.

The basic enclosure shall have the input/output capacity for at least eight fibre optic cables.

Where it is not necessary to break out all fibre cores at a given node, the Contractor shall provide midspan entry enclosures in which the cable jacket is stripped but the unused buffer tubes are coiled inside without opening, while the tube(s) in use will be opened and spliced to other cables.

The enclosure shall be re-enterable without disturbing the fibres or the fibre splices. No special tools shall be required for installation or maintenance of the enclosure. All hardware and miscellaneous parts shall be standard industry equipment.

The splice enclosure shall be mountable to standard U-shaped sign channels using stainless steel hardware, or manufacturer approved hardware. Mounting shall be as shown on the 1500 series drawings.

The splice enclosure shall have a termination block to terminate the central strength members of the fibre optic cables.

The enclosure dome shall have a pressurisation valve to enable the enclosure to be sealed and pressurised to 5psi following installation.

The cable entry seals shall be manufactured from heat-shrinkable material that shall reduce to a size suitable of maintaining the minimum IP67 level of protection.

3.9.3 Splice Trays

The Contractor shall furnish and install fibre optic splice trays to organize and store splices within splice enclosures. The trays shall be compatible with the fibre optic splices and splice enclosures specified herein and shall meet the following minimum requirements:

- The tray shall have the capacity for 24 splices.
- The tray shall be compatible with the fusion splices specified herein but shall also be adaptable to hold mechanical splices.
- The tray shall accommodate up to eight loose tube buffers. No cable ties are to be used. The loose tube buffers shall be secured with a tube guide or channel snap.
- The tray shall accommodate both 250-micron and 900-micron fibre. Slack fibre within the tray shall be placed in an oval shape along an inside wall of the tray.
- The fibre optic splice trays shall be stackable within the splice enclosure. Any tray within a stack shall be accessible without disassembly of any of the other trays.

3.10 Other Specifications

3.10.1 Manufacturer's Certification

The cable manufacturer shall certify that each drum of cable furnished meets or exceeds the following specifications:

3.10.1.1 Fluid Penetration

When a 1m static head of water or equivalent continuous pressure is applied at one end of a one-metre length of filled cable for one hour, no water shall leak through the open cable end.

The water penetration testing shall be performed in accordance with EIA/TIA Standard FOTP82.

3.10.1.2 Compressive Strength

When tested in accordance with EIA/TIA Standard FOTP-41, the cable shall withstand a minimum compressive load of 220N/mm applied uniformly over the length of the sample and applied at the rate of 2.5mm per minute.

The load shall be maintained for a period of one minute and then decreased to 110N/cm. The 110N/cm load shall be maintained for a period of 10 minutes.

Attenuation measurements shall be performed before release of the 110N/cm load. The change in attenuation shall not exceed 0.15dB at 1550nm.

3.10.1.3 Tensile Loading and Bending

When tested in accordance with EIA/TIA Standard FOTP-33, using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a rated tensile load of 2670N and a residual load of 30% of the rated installation load.

The axial fibre strain shall be 20% of the fibre proof level after completion of 10 minutes of conditioning and while the cable is under the residual load.

The change in attenuation at residual load and after load removal shall not exceed 0.15 dB at 1550nm.

3.10.1.4 Impact Resistance

When tested in accordance with EIA/TIA Standard FOTP-25, except that the number of cycles shall be two at three locations along a one-meter cable length and the impact energy shall be at least 4.4Nm (in accordance with ICEA S-87-640), the change in attenuation shall not exceed 0.15 dB at 1550nm.

3.10.1.5 Cable Flex

When tested in accordance with EIA/TIA Standard FOTP-104, the cable shall withstand 25 mechanical flexing cycles around a sheave diameter not greater than 20 times the cable diameter. The fibres shall not experience an attenuation change greater than 0.15dB at 1550nm. The cable jacket shall exhibit no cracking or splitting when observed under 5x magnification.

3.10.1.6 Temperature Cycling

When tested in accordance with EIA/TIA Standard FOTP-3, the change in attenuation at extreme temperatures (-40°C to 70°C) shall not exceed 0.15dB/km at 1550nm.

3.10.1.7 Low or High Temperature Bending

When tested in accordance with EIA/TIA Standard FOTP-37, the cable shall withstand four full turns around a mandrel of 20 times the cable diameter for four hours at test temperatures of -30°C and 60°C.

Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears or other openings. The fibres shall not exhibit a change in attenuation greater than 0.15dB/km at 1550nm.

3.10.1.8 Cable Twist

When tested in accordance with EIA/TIA Standard FOTP-85, a length of cable no longer than two meters shall withstand 10 cycles of mechanical twisting. The fibres shall not experience an attenuation change greater than 0.1dB at 1550nm.

The cable jacket shall exhibit no cracking or splitting when observed under 5X magnification.

4. UNSHIELDED TWISTED-PAIR COPPER CABLING

4.1 Cable Type

Internal horizontal cabling from patch panels to outlets shall be unshielded twisted 4-pair (UTP) 100Ω UTP Category 6A UL tested cable with LSZH over-sheath.

Category 3, 4, 5, 5E & 6 cables shall not be used to support any IP connection/service.

4.2 General Requirements

When configured in worst-case 100m channels the cable shall be capable of delivering the minimum guaranteed channel performance as specified.

The length of each individual run of horizontal UTP cable from the roadside cabinet switch port to the device outlet shall not exceed 90m and shall be continuous without any joints or splices.

The Contractor shall observe the bending radius and pulling strength requirements of the 4 pair UTP cable during handling and installation.

The cable shall be round in construction, with a maximum nominal diameter of no more than 7.5mm

The minimum bend radius for the 4-pair UTP cable under no load shall not exceed the manufacturer's guidance.

The cable will consist of 8 no. 23 AWG copper conductors. Copper-clad aluminium is not permitted.

The cable and cordage shall be low smoke zero halogen (LSZH) compatibility.

4.3 PoE Design Considerations

The UTP cabling shall support 802.3af (PoE), 802.3at (PoE+) and UPOE applications and higher power 4-pair PoE 802.3bt applications.

5. NETWORK OVERVIEW

5.1 General

The communications network comprises an optical network with connected equipment that uses industry standard Internet Protocol (IP) to form an IP network.

Where the optical network is not available, the IP network uses a copper cable network.

Roadside equipment cabinets are co-located by the ITS field equipment locations to house electronic transmission equipment that aggregates all the roadside devices onto the high-bandwidth optical fibre network.

The IP-based architecture provides a resilient and flexible network solution and is based on commercial off-the-shelf equipment, rather than one which is bespoke to the Employer.

All equipment deployed under the Framework Agreement Call-Offs shall be IPv6-enabled, backwards-compatible with IPv4, unless otherwise specified.

5.2 Wired Communications

5.2.1 Communications over Optical Fibre

Optical fibre cables are used to carry generic low- (typically data from VMS, TMU) and high-bandwidth (typically CCTV) data frames over transmission circuits that link transmission nodes.

The number of longitudinal optical fibre cores needed to support the network services will be submitted by the Contractor for approval by the Employer's Representative as part of TII's call off contracts based upon the designer's end device requirements.

5.2.2 Communications over Copper Cabling

Unshielded twisted-pair copper category 6A cables are used to carry data packets from local ITS field devices to the network switching Ethernet devices in the roadside equipment cabinets.

5.2.3 Wireless Communications

In instances where no wired communications services are available, connection to the ITS equipment is achieved using third-party communications links, with the preference being for wireless communications technology.

Provision of data communications over a wireless link shall be approved by the Employer's Representative prior to programming and procurement by the Contractor.

5.3 Network Topology

The network topology is a Ring design with a redundant path to remove a single point-of-failure.

A hybrid solution that optimises the installation and maintenance of the network shall be acceptable provided it does not introduce a single point-of-failure. In any case, the fundamental topology is to remain a Ring design.

The proposed solution shall be scalable to allow further expansion to additional roadside sites.

6. NETWORK EQUIPMENT

6.1 General

In all cases, network equipment and associated works supplied under the Framework Agreement Call-offs shall conform to I.S. EN ISO 14001.

Network equipment shall be affixed with CE marking and shall conform to the requirements of all relevant EU Directives, particularly those related to product liability, safety, electromagnetic compatibility, waste management and restrictions on the use of hazardous substances current at the date of Tender.

Where products supplied do not already have a CE mark applied, the Contractor shall apply a quality system based upon the I.S. EN ISO 9000 quality management system standards suite, certified as appropriate for the design, development and production of the product to be supplied under the Contract. In the any case, no product that does not ship with CE marking affixed by the manufacturer shall be procured without the written approval of the Employer's Representative.

6.2 External Equipment Enclosures

External equipment enclosures and housing shall comply with category IP56 of I.S. EN 60529 unless otherwise stated.

All closing mechanisms shall be by way of single key to key standard MCX 0061 unless otherwise specified.

Operation of the closing mechanism due to vibration shall not be possible as specified in I.S. EN 60068-2-64.

Products including structural metal fabrications from steel, stainless steel or aluminium shall be welded in accordance with the general recommendations in I.S. EN 1011-1 and I.S. EN 1011-2, -3 or -4 for steel, stainless steel or aluminium respectively.

Procedures and acceptance shall be documented as per I.S. EN ISO 15607 and submitted to the Employer's Representative prior to scheduling and/or commencement of works.

All enclosures, frames, housings and external parts shall be protected against corrosion. The Contractor shall demonstrate how compliance with this requirement is to be satisfied in the Tender response.

6.3 Roadside Cabinet-Housed Equipment

Equipment for use in outdoor applications shall be housed in a roadside cabinet. Equipment within this cabinet shall comply with category 2X of I.S. EN 60529 unless otherwise specified.

Mounting of equipment shall be in a standard 19" rack as specified in I.S. EN 60297-3-100 unless otherwise specified.

6.4 Network Equipment Standards and Protocols

The following network equipment standards, as a minimum, shall be considered in the design and delivery of the works under this Framework Agreement Call-offs:

- RFC 1213 Management Information Base for Network Management of TCP/IP- based internets: MIB-II
- RFC 1441 Introduction to version 2 of the Internet-standard Network Management Framework.
- RFC 1518 An Architecture for IP Address Allocation with CIDR
- RFC 1901 Community-Based SNMPv2 (SNMPv2c)
- RFC 1918 Address Allocation for Private Internets
- RFC 2328 Open Shortest Path First Protocol Version 2
- RFC 2453 Routing Information Protocol Version 2
- RFC 3171 IANA Guidelines for IPv4 Multicast Address Assignments
- RFC 3410 Introduction and Applicability Statements for Internet-Standard Management Framework
- RFC 3584 Coexistence between Version 1, Version 2 and Version 3 of the Internet-standard Network Management Framework
- RFC 4271 Border Gateway Protocol 4 (BGP-4)
- RFC 4291 IP Version 6 Addressing Architecture (inc. updates)
- RFC 5798 Virtual Router Redundancy Protocol Version 3
- ITU-T G.694.2 Spectral grids for WDM applications: CWDM wavelength grid
- TR2130E Environmental Tests for Motorway Communications Equipment and Portable and Permanent Road Traffic Control Equipment
- ITU-T G652d Recommendation G652d Single Mode Fibre Detail
- ITU-T H.550 Vehicular gateways and intelligent transportation systems (ITS) – Architecture for vehicular gateways
- I.S. EN 55022 Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
- DIN EN 50022 Low Voltage Switchgear and Controlgear for Industrial Use - Mounting Rails, Top Hat Rails, 35mm wide, For Snap on Mounting of Equipment
- EIA/TIA-568-D
- IEEE 802 Family of IEEE standards dealing with local area networks and metropolitan area networks, notably:
 - IEEE 802.1d MAC Bridges (Spanning Tree)
 - IEEE 802.1w Rapid Spanning Tree Protocol
 - IEEE 802.1s Multiple Spanning Trees
 - IEEE 802.3ad Link Aggregation
 - IEEE 802.1q VLAN Tagging
 - IEEE 802.1p QOS at MAC Level (QoS Priority Queuing)

- IEEE 802.1v VLAN Classification by Protocol and Port
- IEEE 802.1x Standard for Port-Based Network Access Control (PNAC)
- IEEE 802.3ae IEEE Standard for Information Technology - Local & Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Media Access Control (MAC) Parameters, Physical Layer and Management Parameters for 10 Gb/s Operation
- IEEE 802.3x Full Duplex and Flow Control
- 1000BASE-ZX Non-standard industry term to refer to gigabit Ethernet transmission using 1550 nm wavelength to achieve distances of at least 70 km over single-mode fibre

All equipment manufacture and installation shall conform to the ISO/IEC 27001 Quality Management series family.

6.5 Network Transmission Equipment

6.5.1 General Requirements

In addition to the communications protocols already stated, the network devices shall be compliant with the following standards, guidelines, best practice and recommendations:

- Telnet
- SSH
- TCP/IP internet protocol suite
- UDP
- IP (IPv4, IPv6)
- 802.3u (Fast Ethernet 100Mbps)
- 802.3ae (10Gigabit Ethernet)
- 802.3af (Power over Ethernet [PoE])
- 802.3at (PoE+)
- 802.3bt (4PPoE)

Layer 3 network switches shall integrate with all the necessary LAN, WAN and VLAN transmission protocols. A non-exhaustive sample of such protocols includes Synchronous Digital Hierarchy (SDH), Synchronous Optical Network (SONET), Wavelength Division Multiplexing (WDM), Asynchronous Transfer Mode (ATM) and MPLS.

The devices shall be interoperable with other manufactured Ethernet devices while complying with all common Ethernet standards.

The switches shall be able to restore Ethernet services if any optical path on a redundant ring is broken.

All network devices supplied under the Contract shall be manageable through SNMP. The Employer expects a minimum support of SNMPv2c. Compliance with SNMPv3 is considered to be a preferred but optional requirement.

The network shall support RFC 1213 Management Information Base for Network Management of TCP/IP-based internets: MIB-II.

The network devices shall continually diagnose and provide external visible indication of, but will not be limited to, power status, link integrity on each electrical/optical port and data activity on each electrical/optical port.

6.6 Distribution Switches

6.6.1 Functional and Technical Requirements

Each distribution switch shall have the ability to support 48 access layer switches. The distribution layer switch shall be scalable to expand capacity by 50%.

Distribution switches shall be capable of transmitting Ethernet packets at a rate of 1Gbps, as defined by IEEE 802.3x in a full duplex communications mode.

Distribution switches shall be populated with a minimum of four ports that support 1Gbps over singlemode fibre and two ports that support 10Gbps over singlemode fibre.

The distribution switches shall support remote network management intelligence and configuration capabilities. At a minimum, the network management/configuration shall be achieved through a web browser and Telnet/SSH terminal session. The device shall include all software and licenses required.

The devices shall be capable of supporting not less than 1024 MAC Ethernet addresses. The data held in the MAC table shall be automatically aged and managed by the switches to maintain the most current data in the limited MAC addressing table space.

The distribution switches shall be suited to DIN rail mounting to DIN EN 50022 and/or 19" rack mounting or secured to a shelf to facilitate 19" rack mounting. Any required shelf shall be provided with this item.

Switches shall be constructed of a rugged steal enclosure type.

6.6.2 Performance

The device shall have a minimum mean time between failures (MTBF) of 70,000 hours.

Switching latency of the distribution layer switches shall not exceed 10ms.

The distribution switches shall be fully operational in ambient temperatures ranging from – 20°C to +60°C and relative humidity 10-95% non-condensing, or better.

The switches shall withstand a storage temperature range from – 20°C to +60°C or better, without incurring damage.

Switches shall be fanless cooling where possible. A built-in cooling fan may be accepted in circumstances where a fanless cooling configuration is not readily practicable, such as on switches with a higher port count density.

6.6.3 Interface Requirements

Distribution switches shall interface to the fibre optic network through Gigabit Ethernet small form-factor pluggable (SFP) ports.

Optical ports shall have connectors fitted with LC optical connectors to singlemode fibre.

The distribution switches shall be populated with 10/100/1000Base-TX RJ45 Ethernet ports as well as 100/1000Base-FX singlemode fibre ports.

The devices shall support auto-negotiation on all 10/100/1000Base-TX Ethernet ports. All Ethernet ports shall be compliant with the EIA/TIA-568-A standard pinout.

The devices shall have an optical link budget capability to facilitate communications of at least 70km in distance.

The distribution switches' optical receivers shall avoid optical saturation when two of the same devices are connected 100m apart or greater. If optical saturation occurs on links less than 100m apart, the Contractor shall supply optical attenuators to prevent saturation.

Distribution switches shall be populated with the required 1Gbps ports to support all network transmission equipment at any given location.

The Contractor shall supply all interface cables and connectors required to connect the switch to the associated equipment and/or patch panels detailed in the Contract drawings. A schedule of such equipment shall be submitted with the Tender response.

Distribution switches shall be externally powered using input voltage 230V -10% +6%, 50 Hz \pm 5% or a 24VDC \pm 10%. Power supply cords or units shall present no exposed connectors. All power supplies and electrical modules shall suppress unintended radio frequency emissions to CE standards and I.S. EN 55022.

6.7 Access Switches

6.7.1 Functional and Technical Requirements

Access switches shall be capable of transmitting Ethernet packets at a rate of 1Gbps, as defined by the IEEE 802.3x in a full duplex communications mode.

Access switches shall support remote network management intelligence and configuration capabilities.

At a minimum, the system network management/configuration shall be achieved through a web browser and Telnet/SSH terminal session. The device shall include all software and licenses required.

The access switches shall be suited to DIN rail mounting to DIN EN 50022 and/or 19" rack mounting or secured to a shelf to facilitate 19" rack mounting. Any required shelf shall be provided with this item.

Switches shall be constructed of a rugged steel enclosure type.

6.7.2 Performance

The device shall have a minimum mean time between failures (MTBF) of 70,000 hours.

Switching latency of the Ethernet switches shall not exceed 10ms.

The access switches shall be fully operational in external ambient temperatures ranging from – 20°C to +60°C and relative humidity 10-95% non-condensing, or better.

The switches shall withstand a storage temperature range from –20°C to +60°C or better, without incurring damage.

Switches shall be fanless cooling.

6.7.3 Interface Requirements

Access switches shall interface with the distribution switches via 1000Base-FX singlemode fibre ports.

Optical ports shall have connectors fitted with LC optical connectors to singlemode fibre.

The access switches shall interface to ITS equipment via either 10/100/1000Base-TX RJ45 Ethernet ports or 100/1000Base-FX singlemode fibre ports.

The devices shall support auto-negotiation on all 10/100/1000Base-TX Ethernet ports. All Ethernet ports shall be compliant with the EIA/TIA-568-A standard pinout.

The devices shall have an optical link budget capability to facilitate communications of at least 5km in distance.

The access switches optical receivers shall avoid optical saturation when two of the same devices are connected 100m apart or greater. If optical saturation occurs on links less than 100 m apart, the Contractor shall supply optical attenuators to prevent saturation.

Access switches shall be populated with the required Ethernet, Fast Ethernet, Gigabit Ethernet and SFP singlemode fibre ports to support all network transmission equipment at any given location.

The Contractor shall supply interface cables and connectors required to connect the switch to the associated equipment and/or patch panels detailed in the 1500 series RFC Contract drawings.

The access switches shall be externally powered using input voltage of 230V -10% +6%, 50 Hz ±5% or a 24VDC ± 10%.

Distribution switches shall be externally powered using input voltage 230V -10% +6%, 50 Hz ±5% or a 24VDC ± 10%. Power supply cords or units shall present no exposed connectors. All power supplies and electrical modules shall suppress unintended radio frequency emissions to CE standards and I.S. EN 55022.

6.8 Media Convertors

6.8.1 General

This section addresses the requirements for the supply and installation of Ethernet media converters (copper twisted-pair to fibre). These units allow Ethernet copper-to-fibre media conversion, providing for 1000Base-TX to 1000Base-X over singlemode fibre optic cable.

6.8.2 Technical Requirements

The Ethernet media converter shall translate transmission signals from a twisted-pair 10/100/1000Base-TX twisted-pair copper cable to 1000Base-X singlemode fibre optic cable.

The Ethernet media converter shall support both full and half-duplex mode via auto-negotiation on the RJ45 port.

The Ethernet media converter shall convert signals according to IEEE 802.3 standards.

The media converter shall support 802.3af (PoE), 802.3at (PoE+) and higher power 4-pair 4PPoE 802.3bt applications.

The Ethernet media converter shall be DIN rail (as per I.S. EN 60715:2017) or panel mountable and shall be of rugged steel enclosed type.

The Ethernet media converter shall interface to the copper cable via an RJ45 connector and shall interface to the single mode fibre cable via LC small form-factor pluggable (SFP) connectors.

The Ethernet media converter shall be externally powered and shall accept input voltage of 24VDC \pm 10%.

6.8.3 Functional Requirements

The Ethernet media converter shall have a Mean Time Between Failure (MTBF) of at least 35,000 hours.

The Ethernet media converter shall support an operating temperature range of -20°C to $+60^{\circ}\text{C}$ and storage temperature range of -20°C to $+60^{\circ}\text{C}$ with ambient relative humidity of 10- to 95% non-condensing.

7. NETWORK CONFIGURATION

7.1 General Requirements

Each roadside site shall be provisioned with a range of static IP network addresses, in accordance with RFC 1918. The Contractor shall maintain a controlled document detailing accurately each IP address associated with the network and each roadside site.

7.2 Network Monitoring

The network shall be an actively monitored, fully managed private IP network, fully integrated with the Employer's existing SNMP network management package. The Contractor shall coordinate this requirement with the Employer and/or the Employer's Representative.

The Contractor shall provide a MIB-II solution for all network devices.

7.3 Configuration Management

The Contractor shall provide a means to reliably and securely manage all active equipment remotely.

The Contractor shall provide a means to remotely apply configuration changes to multiple network devices concurrently and a mechanism to revert to previous configuration should the need arise.

All maintenance traffic should be of the highest priority and encrypted.

7.3.1 Network Traffic Management

The Contractor shall ensure that the network traffic management adheres to the following conditions:

- Typical types of data to be transported over the network shall include, but not be limited to, diagnostic information for each roadside site, higher priority evidential data, lower priority evidential data and remedial transmission of evidential data following restoration of the network.
- The Employer requires the capability to stream digital video from various and/or multiple simultaneous sites (i.e. multicasting), or to prioritise data from specific roadside sites. As such, the network solution shall be scalable and future proofed as is reasonably practicable. The Contractor shall demonstrate to the Employer how its solution provides this capability without degrading the overall performance of the network.
- The Contractor shall provide details of any traffic engineering (TE), CoS or QoS functionality that the proposed network offers or is capable of supporting. The Contractor shall identify any international standards that these functions comply with and any additional cost associated with their implementation.
- The Contractor shall work with the Employer to design an appropriate QoS template for the network.
- Traffic prioritisation across the network shall support the amendment of priorities and the creation of additional priorities.

7.3.2 Security

The Contractor shall ensure that the level of security and the technical integrity of the Network is sufficient to guarantee the evidential integrity of the data transmitted between the field sites and the head-end sites.

The Contractor shall ensure that the network provides adequate measures for the detection and prevention of all types of malicious attacks to the Employer's network, including but not limited to, Denial-of-Service (DoS), Distributed-Denial-of-Service (DDoS), IP spoofing, password attack, port redirection and all forms of application-layer attacks.

The Contractor shall provide controls to prevent and detect interference with the transmission lines between each node and at each node. Details of such shall be included in the Tender response.

As part of the documentations provided to the Employer, the Contractor shall provide details of:

- Control of physical console access to the network.
- Procedures for detection and correction of software defects and security vulnerabilities and how fixes and patches are applied to the network equipment to correct these.
- Detection, monitoring and correction of failure of network equipment and/or link failure.
- Encryption algorithms used, if any.
- Management of the network in relation to security and data integrity.

The Contractor shall ensure that any encryption used by the various transmission technologies utilised by the Network does not affect the performance, to include, without limitations, throughput and latency.

The network design shall comply with the ISO/IEC 27002 information security standard best practice, where applicable.

7.3.3 Resilience

The network must be resilient to failure to the extent that the probability of failure of the following key elements of the network is minimal.

The equipment supplied as part of this contract shall meet the following conditions:

- An engineered solution that provides availability of 99.999%.
- Full protection of the routes with a redundant link.
- Automatic fall-back to the redundant circuit with minimal manual intervention.

8. INSTALLATION & MAINTENANCE REQUIREMENTS

8.1 General

The Contractor shall supply installation, commissioning and maintenance instructions for the equipment supplied under the Framework Agreement Call-Offs.

In addition, separate instructions, maintenance information cards or booklets shall be supplied for each module or sub-assembly likely to be installed separately and be packaged with the equipment and a copy of the configuration file should be handed over for all switches as per the documentation requirements described elsewhere in this Specification.

To facilitate maintenance at roadside locations equipment shall be constructed from lightweight materials. Units and modules over 10kg shall be marked with their mass. All units shall have instructions for safe handling on the individual packaging and also inserted in the maintenance instructions.

8.2 Design for Maintainability

Equipment shall be designed so that modules and assemblies requiring swap-out can be easily removed with minimal connections to be broken and remade.

8.3 Support Requirements

Equipment shall be maintainable at the roadside with the minimum of basic hand tools and general-purpose test equipment. The requirement for special tools, jigs or diagnostic test equipment shall be limited to maintenance and repair activities at Second and Third Line, i.e. not at roadside locations. At least one example of each special item must be supplied free under this Contract.

8.4 Defects Period

The defects period shall commence after issuance of the Substantial Completion Certificate by the Employer.

During the defects period the responsibilities of the Contractor shall include the collection and replacement of faulty cables and other equipment from the maintenance contractor's premises and correction of problems notified to the Contractor by the Employers Representative.

During the defects period the repair of equipment and/or correction of faults shall be undertaken by the Contractor within the following timescales:

- For serious equipment faults that cause a failure of the operation of a delivered item of equipment, a temporary replacement item shall be provided by the Contractor to the maintenance contractor as soon as is practicable and a permanent replacement item returned to the maintenance contractor within 15 working days of notification.
- All other faulty items that are repairable shall be repaired and returned to the Employer's maintenance contractor within 30 working days of notification.

The Contractor shall maintain an adequate supply of spare parts and cables to ensure that the above repair times are met.

During the defects period, if required by the Employer, the Contractor shall attend on site to assist with the diagnosis and correction of faults on the equipment within 24 hours of notification by the Employer.

The Contractor shall ensure that the design of all the elements of the equipment to be provided takes cognisance of the need to maintain the equipment in a safe manner

8.5 Training

The Contractor shall allow for a period of time to train the Employer's Engineering team on all aspects of the installed fibre optic cabling system provided as part of this contract.

The trainer and course shall be certified and approved by the manufacturer.

The Contractor shall allow up to 2 days of training to cover the phased training requirements of the Employer.

The purpose of the training is to provide an overview of the proposed solution and operation of the equipment, including details of the installation and configurations.

The Contractor shall supply all required consumables, training equipment and any other materials required for training.

The Contractor shall provide training in the operation and maintenance of all cabling elements to provide a thorough understanding of the installation to allow maintenance personnel to perform first-line maintenance activities including fault-finding.

The Contractor shall provide an overview of all the installation activities to maintenance personnel. This includes details of the general design, documentation provided, issues encountered during the installation, testing methodology and results and any other items which will aid the maintenance personnel to perform first-line maintenance activities.

The Contractor shall be responsible for providing a suitable training facility within 20km of a location determined by the Employer and a date and time agreed with the Employer's Representative. The training shall be suitable for up to ten persons and shall include lunch and refreshments as necessary.

9. SOFTWARE/FIRMWARE REQUIREMENTS

9.1 General

Software and/or firmware supplied under the Framework Agreement Call-offs shall be produced to ISO/IEC 20000 and I.S. EN ISO 9001.

The Contractor should ensure the latest firmware is installed prior to testing.

Where software is written or modified for the Employer's use subject to the conditions of the contract, the Contractor shall supply the source code to enable the software to be modified by a third party.

Any changes in licence fees or renewable licence fees payable to a third party must be notified to the Employer and/or their Representative.

The Contractor shall provide at least two sets of all operational software including, where appropriate, site-specific data.

All software supplied shall be clearly identified and include the appropriate issue details and date.

9.1.1.1 Equipment Requirements

In order to avoid the need for roadside visits to modify or upgrade equipment software or firmware, the equipment:

- Shall be capable of meeting all operational requirements of the product using less than 50% of the available processor bandwidth.
- Software and constant data shall occupy less than 50% of the installed non-volatile memory.
- Transient data shall occupy less than 50% of the installed volatile memory, under all operating conditions.
- Shall be capable of remote download of device specific application software, updates and patches.

10. CABLING INSTALLATION

10.1 General

Fibre optic cabling shall be installed in accordance with:

- I.S. EN 50174-3:2013/A1:2017 'Information technology – Cabling Installation – Part 3: Installation Planning and Practices Outside Buildings'
- I.S. EN 50174-1:2018/A1:2020 - 'Information Technology – Cabling Installation – Part 1: Installation Specification and Quality Assurance'
- Approved manufacturer's recommendations

In addition, adherence to the clauses below shall be satisfied.

All fibres in the fibre optic cable shall only be spliced and/or terminated in designated or chambers.

The Contractor shall fully comply with the manufacturer's specification for cable bending radius and pulling strengths. As a rule, the cable bend radii shall be no less than 10 times the cable diameter in an operational situation and no less than 15 times the cable diameter at any time during the installation.

Cables shall not be laid on wet or damp concrete surfaces and any water or moisture subsequently detected after laying shall be assessed for remedial action.

The number of chambers and their locations shall be as shown on the reference design drawings. The Contractor may be required to install the cable one chamber at a time to protect against damage to the cable. The direction of the cable pull shall be determined by the Contractor and shall require the approval of the Employer's Representative.

No fibre optic cable shall be pulled through more than one 90-degree bend. The cable shall not be pulled over edges or corners, over or around obstructions, or through unnecessary curves or bends.

The cable shall be looped in and out of enclosures and chambers as per the cable management drawings and specifications in the RCD 1500 series to provide adequate slack and the least amount of stress on the fibres.

The Contractor shall ensure that the cable is not damaged during storage or installation.

Fibre optic cable ends shall be kept sealed at all times during installation using a method recommended by the cable manufacturer and approved by the Employer's Representative. The cable end shall remain sealed until the Contractor terminates the fibre cables. Cables that are not immediately terminated shall have a minimum of five metres of slack.

When using lubricants, the Specialist shall adhere to the cable manufacturer's requirements for the proper amount, application tools and method and removal of the lubricant from the exposed cable.

Local fibre optic cabling shall be spliced at the locations indicated in the reference design drawings or as directed by the Employer's Representative.

The maximum pulling tensions and minimum bending radii shall not be violated at any time during installation.

The Contractor shall consult with the Employer's Representative concerning existing ducting, chambers and risers, which could force the violation of the minimum bending radius for the fibre optic cable. The Contractor shall obtain approval from the Employer's Representative if modifications to these existing facilities are required. Violation of these parameters shall be cause for rejection of the installed cable.

10.2 Separation of Services

Fibre optic cables shall be routed in dedicated underground duct systems, separated from electrical cables and other services. These are provided by others.

The Contractor shall assure themselves that separation of these services from the fibre ducting shall be adequate to allow for practical installation and future maintenance of the network. Any issues (current or foreseen) shall be brought to the attention of the Employer's Representative.

10.3 Protection of Existing Cable

Special consideration should be given to the protection of existing traffic control and communications infrastructure.

An existing communications report should be produced which will include an assessment of how the scheme will affect the existing communications network and the provisions necessary to maintain the integrity of the network. Where it is impossible to avoid interruption, the existing network should still be maintained operational to the maximum extent possible.

During the design stage the location of all cable and equipment should be determined and an assessment made of the risk of damage.

Where works are to be undertaken in close proximity to existing cables or ducting, the exact location of the cables and duct should be positively identified (horizontal and vertical) and marked clearly prior to the commencement of any works.

Consideration should be given to programming the works to avoid working adjacent to live cables wherever possible. It will not be permissible to excavate by mechanical means in the vicinity of existing cables or ducts. This should be taken into account during the planning stage and due allowance should be made for excavation by hand as appropriate. This may affect the planned duration of site works.

10.4 Cable Damage and Replacement

All instances of damage to cable shall be reported immediately to the Employer's Representative by the Contractor. Transport Infrastructure Ireland should be informed as soon as practicable.

All damaged cables should be replaced at the contractor's cost. Where cable is to be replaced, the complete section between joints must be replaced.

The replacement cable shall, as a minimum, match the specification of the cable being replaced. Ideally replacement will be undertaken during the contract period. If this is not possible then all reasonable costs incurred by Transport Infrastructure Ireland in replacing the cable, including traffic management, will be recovered from the contractor.

10.5 Gantry Cable Trays

A cable tray shall be installed on the walkway of steel portal gantries as detailed in CC-SCD-01817 - Gantry Group 6 - General Arrangement of Gantry Group 6 Sheet 4 of 4 and CC-SCD-01821 - Gantry Group 7 - General Arrangement of Gantry Group 7 Sheet 4 of 4.

The cable tray shall be manufactured from high quality sheet steel to EN 10130 and hot dipped galvanised after manufacture to EN ISO 1461.

The cable tray shall be aligned with the cable duct in the portal gantry structure and shall be securely fixed to the walkway using galvanised self-tapping screws. The cable tray shall be positioned to allow seamless continuation of the cable run between the cable duct in the portal gantry structure and the cable tray on the walkway.

Cable trays shall be heavy duty, perforated with a returned pattern 50mm flange.

10.6 Splicing Requirements

Where splicing is necessary, all optical fibres shall be fusion spliced to provide continuous runs. Splices shall be allowed only at locations designated on the reference design drawings or as approved by the Employer's Representative.

All splices shall be performed in a controlled, clean environment.

Fusion splicing equipment shall be provided by the Contractor and shall be cleaned, calibrated and specifically adjusted to the fibre and environmental conditions at the start of each shift. Splice enclosures, tools and procedures, shall be approved by the cable manufacturer as being compatible with the cable type being delivered.

Only buffered tubes containing fibres to be spliced shall be opened. The other tubes shall be neatly looped and stored within the enclosure.

Each spliced fibre shall be packaged in a protective sleeve or housing. Bare fibres shall be completely re-coated with a protective room temperature vulcanizing (RTV) silicone or similar substance, prior to application of the sleeve or housing, to protect the fibre from scoring, dirt or microbending.

Where splice trays are situated in equipment cabinets, 19" rack-mounted organizer trays shall be used to hold the spliced fibres with each fibre neatly secured to the tray. The Contractor shall coordinate these locations with the Employer's Representative.

No splice loss shall exceed 0.15dB. If a splice is measured to exceed 0.15dB during the splicing process, it shall be remade until its loss falls below 0.15dB or the Employer's Representative waives the 0.15 dB requirement. Each attempt shall be recorded for purposes of acceptance. If the mean exceeds 0.1dB in any link, splices in the link shall be remade until the mean loss does not exceed 0.1dB.

Prior to splicing, the Contractor shall test each fibre of the installed cable for continuity, anomalies (events above 0.3dB) and attenuation using an Optical Time Domain Reflectometer (OTDR) in 20nm increments at wavelengths between 1270nm and 1610nm

All splice losses shall be recorded in tabular form and submitted to the Employer's Representative in paper and electronic formats for approval. If an OTDR is used to record splice loss, chart recordings of the 'signature' shall be submitted with the splice data with a record of all OTDR settings and the OTDR locations written on the trace.

All test equipment will be in calibration according to the manufacturer's specifications and intervals.

10.7 Termination Requirements

The connector loss for complete connection to the terminal equipment shall not exceed a mean of 0.5dB. No connector losses above 0.75dB shall be permitted.

Unused optical fibres shall be properly protected with sealed end caps.

10.8 Fibre Loss Budgets

The Contractor shall be responsible for producing the fibre link models and loss budgets in support of 10Gbps backbone design. Contractor shall liaise with the Employer's IT team to determine the network topology and:

- Expected optical fibre connection paths
- Worst-case optical fibre connection paths

The model and budgets shall be submitted to the Employer's Representative design team for acceptance before proceeding with the cabling infrastructure design.

10.9 Labelling & Identification

The Contractor shall draw up the full details of the labelling and identification scheme for the contract and obtain the agreement of the Employer's Representative before creating any labels. Labels not agreed fully in this way may be subsequently rejected.

An identification coding system shall be agreed prior to commencement of the installation work.

All cables, conductors, terminals and outlets shall be clearly identified and all multi-pair cables shall additionally be identified by colours or number code (this shall conform to the relevant international standards referenced elsewhere in this Specification), terminated in accordance with that colour code and shall be suitable for incorporating into a CAD cable management system.

Labels shall use an agreed typeface size and font.

All labels shall be permanently fixed Traffolyte, legible, durable and robust.

All labels shall be fixed horizontally on fixed equipment or longitudinally along the line of a cable.

Hand-written labels will not be accepted, except on a temporary basis during installation and will not be acceptable for cable testing purposes.

The Contractor shall tag all local, equipment, patch and drop leads with sequential numbering at both ends.

10.10 Documentation

Prior to the installation of cables, the Contractor shall provide the following:

- Catalogue cuts and shop drawings for all cable, connectors, splice equipment, splice enclosures, splice trays and cable installation and test equipment.
- Preliminary locations of all proposed splices.
- Proposed chamber locations where hand assists or intermediate assist winches will be required during installation.

Cable manufacturer's recommended cable installation techniques that verify that the optical and mechanical properties of the cables are not degraded at the time of installation. The proposed recommendations shall include the following:

- Cable manufacturer's approved pulling lubricant for use on the cable and method of application. No other lubricants will be permitted.
- Installation set-up including size and types of rollers, feeder guides, tension gauge make and model number, attachment of pulling jig to jacket and direction of pull.
- Maximum pulling tensions, which shall specify both pulling from the cables conductors and for pulling from the cable's outer jacket.
- Minimum bend radii, which shall specify a radius both loaded and unloaded.
- Method to install multiple cables.

10.11 Warranty and Reliability

The Contractor shall maintain suitable records for a period of at least five years of all optical tests required.

The Contractor shall provide a guarantee that the fibre optic cable, connectors, splice enclosures and trays will be furnished free from defects in design, material and workmanship and will conform to and perform in accordance with this specification when leaving the manufacturer's plant. It shall be the Contractor's responsibility to conduct the required testing to substantiate this guarantee and ensure that design parameters for a 25-year useful life were used, assuming normal conditions of installation and operation.

The cable shall carry an optical, electrical and mechanical performance warranty of five years from the date of the cable shipment from the manufacturer's plant.

After a 15-year period, the installed cables shall exhibit the same optical, electrical and mechanical characteristics as date of purchase.

11. INSPECTION, TESTING & COMMISSIONING

11.1 General Requirements

The Contractor shall allow for phased testing and commissioning of the cabling systems in line with the project programme associated with the Framework Agreement Call-offs.

All test results shall be recorded and included in the certification documentation handed over to the Employer's Representative.

The cabling system shall be tested/examined for incomplete or broken fibres, fibre crosses and for end-to-end connectivity and proper positioning of each fibre cable placed or connected. All cores in a cable should be subject to the tests and all tests should be carried out from both ends of the link.

The Contractor shall provide for the testing of each fibre core prior to the final connection of the fibre cores by the Employer's Representative. The Contractor shall submit details in their Tender response test methodology as to how this is to be achieved and conducted.

The tests shall not be conducted until all appropriate labels have been installed. During the testing procedure, the Contractor shall confirm that each cable and connector has the correct permanent label. If the label is not correct, the formal test of that cable shall be deferred.

The purpose of testing is to demonstrate that the workmanship on site has been adequate and it shall be noted that a successful test of a cable does not assure that the cable is free from faults. Each cable and connector shall be visually inspected for faults and for workmanship standards. Where testing is carried out, the cable test shall demonstrate that the cable installation is to the required standard.

Fibre optic cables or components which fail the test/examination process shall be replaced at the Contractor's expense.

The Contractor shall submit details of their test schedule as part of their Testing and Defect Management Plan.

The Contractor shall provide to the Employer's Representative all test records for the verification of the installed fibre optic cabling.

The test schedule shall allow the Employer's Representative to witness the relevant tests to verify the installation of the fibre optic cabling.

11.2 Test Instruments

11.2.1 General

The Contractor shall submit information on the proposed test instruments to the Employer's Representative for approval prior to carrying out any tests.

Only premium branded field test instruments shall be used.

11.2.2 Calibration

Where a test instrument requiring calibration is to be used, test equipment shall be calibrated before delivery to site. A calibration schedule shall be available for inspection by the Employer's representative throughout the project.

Test equipment for all cabling types shall meet the requirements of the latest relevant EN and ISO standards.

11.3 Fibre Optic Testing

11.3.1 General

Optical loss (insertion loss) test measurements shall be taken bi-directionally at both 1310 and 1550nm with the use of a fibre optic light source and power meter (LSPM).

In addition to the attenuation criteria set out in the optical requirements above, if the loss in a given fibre is measured to be too low, an inline attenuator shall be provided by the Contractor in order to reduce the power at the receiver to acceptable levels.

Using the manufacturer's performance specification, all optical loss budgets shall be calculated on each optical fibre installation. These calculations shall be submitted along with the test results.

Testing of the cabling shall be performed using high-quality test cords of the same fibre type as the cable under test. The test cords shall conform to FOTP-171. The test cord for the optical loss test set (OLTS) testing shall be between 1m and 5m in length.

dB test results and compliance with I.S. EN 50346:2020 shall be included in the test documentation.

Test sources shall match the fibre type, i.e. a laser source shall be used for the singlemode fibre.

All test results shall be recorded on disc and included in the hand-over documents.

In the event of a fibre core not meeting the requirements of the standards (or the requirements as set out in this Specification, with the more onerous requirements taking precedence) these cores shall be brought into compliance by the Contractor at no charge to the Employer.

OS2 single-mode fibres shall fully meet or exceed the specifications in:

- I.S. EN 50173-1:2022 'Information technology – Generic cabling systems – Part 1: General Requirements'
- I.S. EN 50346:2020 'Information technology – Cabling installation – Testing of installed cabling'
- I.S. EN 61280 series 'Fibre optic communication subsystem test procedures'
- ITU-T G.652 (11/2016) Characteristics of a Single-Mode Optical Fibre and Cable

11.3.2 Local and Equipment Cables

Local cables and equipment cables are not required to be independently checked on site.

Faulty local and equipment cables shall be replaced. No attempt shall be made to re-terminate and rectify the cables on site.

11.3.3 Employer's Acceptance Procedures

The fibre optic cabling will not be accepted as complete until acceptance procedures are concluded to the satisfaction of the Employer's Representative.

Employer acceptance procedures require up to 10% of the fibre optic cabling to be tested in their presence or the presence of the Employer's Representative.

An initial series of tests shall be undertaken as part of the Contractor's own testing, commissioning and certification process. The Contractor shall allow for repeating these tests and for performing any additional tests required by and implemented in conjunction with, the Employer's Representative as part of their acceptance procedures to confirm the initial test results and the compliance and satisfactory operation of the network.

On completion of total installation, a minimum of 30% of cabling may be tested independently. A 100% pass rate of all cabling is required before customer acceptance of the fibre optic cabling system takes place. If at this stage a 100% pass rate is not achieved, the Contractor will be instructed to retest the entire installation. After the Contractor provides proof of retest, another independent test of 30% of the finished cabling will be conducted. Any failures detected at this stage will result in the Contractor being requested to re-terminate and re-test the entire installation as the installation will at this stage be considered to be below specification.

The system will not be deemed to be complete until the Employer's acceptance procedures are concluded to the satisfaction of the Employer.

11.3.4 Test Documentation

The Contractor shall include for recording the identification of each cable, its origin and termination and route as the project progresses making this information available upon request.

The results of the inspections and tests, including failures or deviations from specified criteria and standards, shall be recorded and signed and dated by the Contractor.

The full set of results shall be produced and issued to the Employer's Representative in a logical sequence in both hard-copy and electronic format.

The test results shall use the cable identity in full or the Contractor shall provide an electronic schedule of the mnemonics actually used in the test results and the full cable label.

All components and cabling shall have documentation verifying performance and standards compliance, produced by an independent test facility.

The Contractor shall include for detailed hand-over documentation to include:

- Application assurance and extended product warranty – 4 no. copies
- Test results electronically – 4 no. copies
- Labelling drawings and details – 4 no. copies
- As-installed drawings electronically – 4 no. copies
- As-installed drawings on hard copy – 4 no. copies
- Contact telephone numbers for emergency situations – 4 no. copies

Cable test documentation shall be submitted. Test results shall be in the test instrument manufacturer's software and be available from the manufacturer's website at no cost to the Employer.

11.4 Certificates of Conformance

A uniquely numbered certificate of conformance shall be provided for each fibre optic cable reel and for each batch of connectors, pigtailed connectors, local cables and equipment cables.

These certificates shall:

- Confirm that each element is unbroken
- Confirm that the requirements in this Specification are met
- Provide the identity of the supplier and the manufacturing factory

Any cable reel, batch of connectors, pigtailed connectors, local cables and equipment cables with a non-compliant certificate of conformance, or without a certificate of conformance, shall be returned to the supplier. Non-compliant cable reels shall not be stored on site.

11.5 Warranty

The entire fibre optic cable network shall be fully guaranteed for a lifespan of 20 years. The Contractor shall be required to produce warranties and guarantees in this regard.

The Contractor shall provide, as part of the hand-over documentation, confirmation that the manufacturer ratifies it as being fully compliant with their system definition and product warranty.

Warranties shall include for the compliance (with no exception clauses) with:

- IEEE 802.3an
- EIA/TIA-568.3-D
- ISO/IEC 11801
- IS EN 50173 standards series

In addition, warranties shall conform to and/or allow for, the following:

- Independent ETL or UL tested system. No other lab is acceptable.
- Products and labour for replacement of products in the event of a problem.
- No mixing/matching of components from different vendors shall be allowed.
- The warranty must be issued by the manufacturer and not the Contractor or a distributor.
- The warranty must provide full application assurance of current and future applications that have not yet been developed.
- Confirm the manufacturer will review the final design and inspect the site before issuing the warranty.
- Provide details of what in-country support is available to support the warranty from the manufacturer.
- Provide a brief description of the warranty process should it be invoked.

The Contractor shall state the type of system/installation warranty which will be provided on completion of the system.

12. LABELLING

12.1 General

Accurate and legible informatory labels on the outside of cabinets, on cables and chambers shall be provided for the efficient working and safety of maintenance personnel.

Specification of names, numbers and lettering on informatory and address coding labels shall be coordinated by the Contractor with the Employer's Representative.

12.2 Chambers

Covers for chambers should be provided with a label containing the legend "MOTORWAY COMMUNICATIONS" and a label indicating the motorway address.

12.3 Cabinets

Informatory, address coding and warning labels should be provided on cabinets.

All electrical equipment housed within electrical cabinets and pillars should be adequately labelled to allow safe and efficient working by maintenance personnel.

Each section of electrical cabinets/pillars should be clearly labelled showing the designation of the equipment being fed.

12.4 Warning Labels

It should be noted that an Electrical Safety Label in accordance with the National Rules for Electrical Installations by the Electro-Technical Council of Ireland (ETCI) and ESB's National Code of Practice for Customer Interfaces should be fitted (and maintained) to electrical cabinets and pillars.

12.5 Cables

Consideration shall be given to the labelling format required for the cable installation. Each end of every cable should be fitted with an identification tag bearing a cable naming system which has been agreed with the Employer's Representative.

For additional clarity, cables run underground can be fitted with identification tags at all entries to ducts and at all cable chambers.

Identification labels shall, at a minimum, comply with RCD 1500/019 and be supplemented with warning tags to provide additional easy and unambiguous identification of fibre optic cables. Warning messages shall be of type, 'DANGER LASER HAZARD,' 'OPTIC FIBRE CABLE,' or equivalent and contain information identifying the cable destination, cable beginning, etc.

In all cases, the labels shall be approved by the Employer's Representative prior to procurement.

13. DOCUMENTATION REQUIREMENTS

13.1 General

The equipment shall be supplied with technical documentation comprising manuals and handbooks accompanied by plans, drawings, diagrams, specifications, computer programs, flow diagrams, coding lists, library programs.

The documentation shall include all information necessary to enable the Employer or an authorised 3rd-party to install, commission, operate, maintain, dismantle, reassemble, adjust, modify, extend and dispose of all parts of the equipment, including bought-in items. The documentation shall be sufficiently detailed to enable this to take place without requiring future reference back to the Contractor.

All documents shall be written for ease of use and operation for those unfamiliar with the equipment being supplied.

13.2 Requirements

All documentation shall be written in English.

Documentation shall be produced in accordance with I.S. EN 61082-1.

Documentation shall use SI units in accordance with I.S. EN ISO 80000-1.

Upon request, the contractor shall demonstrate compliance with the TII Standards, which includes but are not limited to:

- CC-SCD-01504 - Installation Drawing TCC - Network Ducts Sections;
- CC-SCD-01505 - Installation Drawing TCC - Network Ducts Plan View; and
- CC-SCD-01506 - Installation Drawing TCC - Network Ducts Deep Transverse Ducts.

13.3 Presentation

Documentation shall be organised so that unnecessary repetition is avoided. Topics likely to be frequently referenced by the end user (e.g. installation, commissioning, operating and maintenance instructions) shall be given prominence.

Documents shall be produced in sans-serif (Arial) typeface, 12-point (pica) font size. Where the Contractor is supplying a commercial off-the-shelf product with printed documentation, this requirement may be waived.

Both documents and drawings shall be provided in an electronic format in accordance with ISO/IEC 32000-1 "searchable".pdf text file format (i.e. converted to pdf from the source text file format rather than scanned) using the version current at the time of Tender. Two sets shall be provided. The Contractor shall ensure that all information supplied in electronic format and the media it is supplied on is free any computer viruses or other malevolent software or attributes that may harm or otherwise compromise a computer system. Each disk shall be provided with an index, which shall include hyperlinks to the relevant document on the disk.

When paper copies of text documentation are to be provided, they shall be in A4 format bound into durable binders.

Installation instructions to be included in the package of any item of equipment likely to be installed separately shall be in the form of a leaflet or similar, which may be disposed of or recycled when installation is complete. It shall have sufficient information (with diagrams) for the item concerned to be correctly installed in position and commissioned.

Maintenance information cards or booklets, one set of which is to be secured within each equipment enclosure or cabinet, shall be encapsulated in a durable weatherproof format. They shall show:

- The general layout of equipment and component modules and references in schematic form.
- Component modules.
- A block schematic diagram of the control and monitoring equipment showing all modules and interconnections.
- A power distribution diagram showing 230V AC R.M.S. mains and low-voltage distribution with details of voltages, terminations and fusing and current ratings etc.
- Configuration diagrams for all equipment and PCBs showing the PCB function and required settings for all links and switches etc.
- Operational and diagnostic system menu structure.

The file names for drawing and text files shall be included in the Technical File. A Master Record Index shall be prepared by the Contractor and maintained for the duration of the Contract.

All documentation shall be written in English. The documentation shall be arranged under the following general headings and indicative contents (which are not necessarily exhaustive) as may be appropriate to the equipment being supplied.

13.3.1 Equipment Overview

This shall contain a concise overview of the equipment and include:

- A functional description of the equipment and general design concepts.
- Outline drawings or photographs of the complete equipment.
- Interface requirements for the equipment.
- A list of controlling specifications to which the equipment is produced.

13.3.2 Hardware Details

This shall contain information about the hardware supplied under the Contract and include:

- Basic technical data, type numbers, ratings, product codes, etc.
- Details of energy usage at defined load states.
- Technical description.
- Warnings and restrictions.
- Drawing and parts lists.
- Module identification codes as agreed with the Employer's Representative.
- Mass and overall size of each type-numbered item.

- Packaging material details.

13.3.3 Software Details

This shall contain information about the software supplied by the Contract.

13.3.4 Drawings

13.3.4.1 Mechanical and Structural

These shall be provided for the complete equipment and include:

- General arrangement drawings, with overall dimensions.
- All detail drawings, with detailed dimensions, to enable manufacture by a third-party.

13.3.4.2 Electrical and Electronic

These shall be provided for the complete equipment and include:

- System schematics.
- Circuit diagrams.
- Wiring diagrams.

13.3.5 Installation Instructions

These shall provide comprehensive instructions for the correct installation and connection of all parts of the equipment and include:

- Installation instructions.
- Drawings for any site assembly.
- Instructions relating to each item of equipment likely to be installed separately or assembled prior to installation.

13.3.6 Commissioning Instructions

These shall provide comprehensive instructions for the testing and commissioning of all parts of the equipment and include:

- Set-up details of addresses, operating parameters, control ranges and limits, etc.
- Commissioning procedures and tests.

13.3.7 Maintenance Instructions

This shall include sufficient detailed information to allow a third party to identify, diagnose and rectify faults and include:

- Details of routine maintenance.
- Equipment configuration settings with adjustments and tolerances.
- Fault finding charts with repair and replacement procedures.
- Preventative and routine maintenance procedures, including limits, tolerances and recommended frequency of testing.

- Safety, mechanical and electrical tests and inspections, including limits, tolerances and frequency of testing.
- Test and inspection record pro forma for recording routine maintenance activities.
- Routine cleaning instructions.
- Maintenance information cards or booklets.

13.3.8 Product 'End of Life' Plan

This shall contain information to allow for the safe removal and disposal of the equipment.

13.3.9 Software Documentation

All software documentation shall adhere to ISO/IEC 20000 and I.S. EN ISO 9001.

All documentation, diagrams (including software schematics or automated tool output) and specifications, shall be produced to agreed standards and, apart from where other standards are agreed, shall use conventions, symbols and terminology defined in the appropriate Irish, European, British or International standard or Employer's specification.

The documentation shall include details of all the software development tools used for software design, development testing, acceptance, configuration management and application. This shall also indicate their version status (for compatibility purposes).

The software design documentation supplied shall be fully annotated with issue number, date and section references and shall include the following:

- A concise description of the overall function of the software.
- Details of the target platform upon which the software is deployed and any proprietary software products used, including databases, operating systems and their version/issue status.
- Details of available storage, both volatile and non-volatile.
- Details of the processor bandwidth.

13.3.10 Product Quality Assurance and Verification

13.3.10.1 Tests for Verification of Design

Except where test specifications are provided, the Contractor shall propose specifications for tests which demonstrate the ability of the equipment to comply fully with the Technical Requirements. These shall include schedules and pro forma for recording test results. All test specifications shall be included in the Technical File.

Test specifications shall contain an item-by-item listing of specified requirements correlated to the test or tests proposed to demonstrate compliance with each clause.

Details of the installation and mounting, interconnections and set-up of equipment during testing, sufficient to demonstrate compliance, shall be included in the test specification.

Details of an operational test routine sufficient to demonstrate functionality during the reliability and independently accredited tests shall be included in the Technical File.

13.3.10.2 Compatibility and Integration Requirements

Where required by the Specification equipment shall be subjected to Compatibility Testing carried out in accordance with the requirements of Highways England MCG 1069.

The Contractor shall be responsible for conducting Compatibility Testing and ensuring the equipment integration requirements are demonstrated as part of quality assurance and verification.

It shall be the Contractor's overall responsibility to ensure that the functionality of the interfaces provided for the Equipment is compatible with the Employer's equipment and operational requirements.

14. STANDARDS & REGULATIONS

The following standards shall be adhered to as a minimum in the design and delivery of the proposed works for the project.

The Contractor shall allow for demonstrating compliance to a given standard clause if so requested by the Employer or the Employer's Representative.

The specifications shall apply to each fibre supplied within a cable and the cable construction specifications shall apply to the entire cable.

- I.S. EN 50173-1:2022 'Information technology – Generic cabling systems – Part 1: General Requirements'
- I.S. EN 50174-1:2018 'Information Technology – Cabling Installation – Part 1: Installation Specification and Quality Assurance'
- I.S. EN 50174-3:2013/A1:2017 'Information technology – Cabling Installation – Part 3: Installation Planning and Practices Outside Buildings'
- I.S. EN 50346:2020 'Information technology – Cabling installation – Testing of installed cabling'
- I.S. EN 50575:2014/A1:2016 'Power, control and communication cables - Cables for general applications in construction works subject to reaction to fire requirements'
- I.S. EN 60068-2-38:2009 'Environmental Testing – Part 2-38: Tests – Test Z/Ad: Composite Temperature/Humidity Cyclic Test (Environmental Damp Heat Cycle)'
- I.S. EN IEC 60071 Series 'Insulation Coordination'
- I.S. EN 60297-3 series 'Mechanical structures for electronic equipment. Dimensions of mechanical structures of the 482.6mm (19 in) series'
- I.S. EN 60332 series 'Tests on electric and optical fibre cables under fire conditions'
- I.S. EN IEC 60512 series 'Connectors for electronic equipment'
- I.S. EN 60715:2017 'Dimensions of Low-Voltage Switchgear and Controlgear - Standardized Mounting on Rails For Mechanical Support of Switchgear, Controlgear and Accessories'
- I.S. EN 60754 series 'Test on gases evolved during combustion of materials from cables'
- I.S. EN 60793-1-40:2021 'Optical Fibres – Part 1-40: Measurement Methods and Test Procedures – Attenuation'
- I.S. EN 60793-1-40:2021 'Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres'
- I.S. EN IEC 60794-1-2:2017 'Optical Fibre Cables – Part 1-2: Generic Specification – Basic Optical Cable Test Procedures – General Guidance – F1: Environmental Temperature Cycle'
- I.S. EN 60794-1-21:2015 'Optical Fibre Cables – Part 1-21: Generic Specification – Basic Optical Cable Test Procedures – Mechanical Tests Methods E1: Tensile Performance'

- I.S. EN 60794-1-21:2015 'Optical Fibre Cables – Part 1-21: Generic Specification – Basic Optical Cable Test Procedures – Mechanical Tests Methods E3: Crush'
- I.S. EN 60794-1-21:2015 'Optical Fibre Cables – Part 1-21: Generic Specification – Basic Optical Cable Test Procedures – Mechanical Tests Methods E4: Impact'
- I.S. EN 60794-1-21:2015 'Optical Fibre Cables – Part 1-21: Generic Specification – Basic Optical Cable Test Procedures – Mechanical Tests Methods E10: Kink'
- I.S. EN 60794-1-21:2015 'Optical Fibre Cables – Part 1-21: Generic Specification – Basic Optical Cable Test Procedures – Mechanical Tests Methods E11: Bend'
- IEC 62368-1 'Information technology equipment - Safety - Part 1: General Requirements'
- I.S. EN 61034 series 'Measurement of smoke density of cables burning under defined conditions'
- I.S. EN 61280 series 'Fibre optic communication subsystem test procedures'
- I.S. EN 61754-4 Series 'Fibre Optic Interconnecting Devices and Passive Components – Fibre Optic Connector Interfaces – Part 4'
- I.S. EN 61754-20:2012+A1:2022 Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 20: Type LC connector family
- I.S. EN 62230:2007 'Electric Cables – Spark-Test Method'
- I.S. EN 62305-4 'Protection against lightning - Part 4: Electrical and electronic systems within structures'
- I.S. EN 62949:2017 'Particular safety requirements for equipment to be connected to telecommunication networks'
- I.S. EN 62368-1:2020 'Audio/Video, Information and Communication Technology Equipment - Part 1: Safety Requirements'
- CIBSE AM7 'Application Manual: Information Technology and Buildings'
- Recommendations of the International Telecommunications Union (ITU)
- Standards from the ITU's Telecommunication Standardization Sector (ITU-T)
- ITU-T G.652 (11/2016) Characteristics of a Single-Mode Optical Fibre and Cable
- ITU-T Recommendation G.957 'Optical Interfaces for Equipments and Systems Relating to the Synchronous Digital Hierarchy'
- ITU-T Recommendation G.692 'Optical Interfaces for Multichannel Systems with Optical Amplifiers'
- ITU-T Recommendation L.12 'Optical Fibre Splices'
- Codes of practice and installation guides as set out by the specific system or service supplier
- EIA/TIA-455-59 'Use of Optical Time Domain Reflectometer for Fibre Optic Point Defects'
- EIA/TIA-455-168/175 'Standards for measurement of chromatic dispersion'

- ANSI/TIA-598-D 'Optical Fiber Cable Colour Coding '
- EIA-359A 'Colours for Colour Identification and Coding'
- EIA/TIA-455-164/167/174 'Measurement of Mode Field Diameter'
- RoHS 2011/65/EU
- ISO 9001:2015
- ISO 14001:2015 – Environmental Management Systems
- Health and Safety Authority