

TECHNICAL SPECIFICATION
FOR
OPTICAL FIBRE CABLE NETWORK

LONDON UNDERGROUND LIMITED
CONTRACT TT250
TRAIN SERVICES FOR NORTHERN LINE

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1.0 INTRODUCTION

- 1.1 The Contractor shall supply an optical fibre backbone cable network to support the transmission of all audio, data and video communications channels required on the Northern Line Sites and associated locations.
- 1.2 The cable network shall interlink all Sites as shown on Contract Drawing 6235-03-250-N001 000-21-DRG 00-160 this is provided for information and is subject to a Site survey as set out in section 6.3 of Schedule, Part E.
- 1.3 The Contractor shall design the fibre connectivity required between Sites to cater for the transmission requirements appropriate to the Final UHF Trunked Radio system and shall liaise with the Company to establish the fibre splicing requirements associated with all additional fibres available within each cable to accommodate future transmission circuits to serve the Northern Line.
- 1.4 The Final UHF Trunked Radio system shall utilise no more than 12 fibres in any cable of the network at any point in the network, refer to Schedule 6, Part C.
- 1.5 The transmission equipment required to support the Final UHF Trunked Radio system shall be supplied by the Contractor whereas the additional transmission equipment for all other communication circuits will be installed at a later date and is outside the Contract.

2.0 SCOPE OF SUPPLY

2.1 General

- 2.1.1 The Contractor shall supply, install, test, commission and document all works pertaining to the optical fibre cable distribution network, up to and including the optical fibre distribution facilities installed within each communication equipment room and equipment room together with the transmission equipment associated with the Final UHF Trunked Radio system. The works shall include:-
- a) main, cables installed between Sites,
 - b) link and spur cables installed within Sites,
 - c) splice boxes for interconnection of fibre optic cables located at platform and ground level,
 - d) all cable routing facilities within each Site as described in Schedule 6, Part F,
 - e) optical fibre distribution facilities within each communication equipment room,
 - f) optical fibre transmission equipment at the appropriate communication equipment room Sites sufficient only to accommodate the Final UHF Trunked Radio system channels (refer to Schedule 6, Part C),
 - g) termination and splicing of all conductors within the optical fibre cables.

2.1.2 The Contractor shall verify all installation details by conducting a detailed survey at each location appropriate to the fibre optic cable network.

2.1.3 The Contractor shall comply with the requirements of BS 7718, "Code of Practice for Fibre Optic Cabling" in the implementation of the work.

2.2 MAIN FACILITIES

The major elements of the cable network shall include, but are not limited to, the following:-

2.2.1 Armoured Fibre Optic Cables

1. These shall consist of:-

- a) main cables based on a combination of either 20, 64 or 96 fibres/cable routed between Sites,
- b) link cables installed locally at each Site which interconnect the splice boxes within which the main cables are terminated. The number of fibres within the link cables shall be identical to the fibre count of the main cables to which they are connected,
- c) spur cables based on 20 fibres/cable which interconnect the splice boxes at each Site to a wall mounted optical fibre distribution panel installed within the communication equipment room at all Sites except for the Northern Line Main Control Centre, the Northern Line Emergency Control Centre and the Police Control Centre where the termination facilities will be installed in a floor mounted optical fibre distribution cabinet within the communication equipment room. The arrangement for splice boxes and spur cables at each Site is shown on Contract Drawings 6235 03 250 N001 100 21 00-601 and 00-602.

2. At surface Sites the cables shall be UV stabilised and of PVC construction but at sub-surface, underground Sites the cables shall be LSNH types.

2.2.2 Ruggedised Fibre Optic Pigtails

Ruggedised fibre optic pigtailed shall interconnect the optical fibre distribution panels or cabinet to the optical fibre transmission equipment installed within the communication equipment room equipment cabinets.

All fibre pigtailed at surface and underground Sites shall be LSNH types.

2.2.3 Stainless Steel Splice Boxes And Protection Cabinets

Splice boxes shall be installed at platform level or in an area adjacent to the main cable runs at each Site, excluding sub-stations. The splice boxes shall terminate and splice together the fibres of the main, link and spur cables.

At sub-stations the main cables shall be terminated directly on to the optical fibre distribution panel.

In platform areas at underground Sites the splice boxes shall be wall mounted and enclosed within a splice box protection cabinet. Precise dimensional details for cabinet fitting shall be obtained by the Contractor from its Site survey.

At surface Sites the splice boxes shall be installed on galvanised purpose built mounting frames anchored to ground foundations supplied by the Contractor in an area adjacent to the main cable run.

2.2.4 Cable Remake Loops

At each splice box a remake frame shall incorporate cable support and anchoring facilities dimensioned so as to accommodate a minimum spare length of 10 m for each main cable.

At underground Sites the remake frame shall be installed within the platform invert and where this is not possible it shall be located within the splice box protection cabinet.

At surface Sites the remake frame shall be incorporated within the mounting frame supporting each splice box.

The Contractor shall be responsible for the splicing of all spur, link and main cables within each splice box and between the spur and fibre pigtails within the optical fibre distribution panel and at optical fibre transmission equipment installed in the Site communication equipment rooms, as appropriate.

The arrangement of fibre splicing shall be agreed with the Project Manager during the course of the work.

2.2.5 Cable Routing

The Contractor shall provide cable routing facilities as described in Schedule 6, Part F.

2.2.6 Optical Fibre Distribution Facilities

The Contractor shall provide fibre distribution facilities within the communication equipment rooms as described in section 5.0 of Schedule 6, Part E.

3.0 NETWORK CONFIGURATION

3.1 Design

- a) The fibre-optic cable system shall be designed so as to support the operation of very high availability transmission networks employing main and alternative transmission routes.
- b) The network design shall ensure, as far as is practicable and subject to the physical constraints at Site upon cable routing segregation, that a common mode failure of the cable system, such as complete cable damage or fibre failure, will not occur which may result in complete loss of communication circuits at any Site location.
- c) The cable network shall employ route redundancy between individual Sites interconnected by the main cable network and locally at each Site between the main cable network and each communication equipment room.
- d) The 'main' inter-Site cables shall provide route redundancy between Sites by using two separate cable systems and associated cable routes which are physically segregated.

These cables shall be routed longitudinally upon existing cable hangers installed along and adjacent to the Northbound ("A" route) and Southbound ("B" route) railway tracks.

- e) At each Site, except sub-stations, the main "A" and "B" routed cables shall be accessible via splice boxes located in an area at trackside level from which spur cables are routed to the communication equipment room.
- f) The "A" routed main cables shall employ two splice boxes, to be designated "A1" and "A2", at each Site and shall be physically segregated. The boxes shall be installed in a suitable area on each Northbound platform with each box located at opposite ends.
- g) The "B" routed main cable shall be terminated on a splice box, to be designated "B1", positioned at one end or the other of each Southbound platform as is convenient to equipment location.
- h) From each splice box to the local communication equipment room a 20 fibre spur cable shall be provided at all Sites, except the Northern Line Main Control Centre, Northern Line Emergency Control Centre and Police Control Centre. At the Northern Line Main Control Centre, the Northern Line Emergency Control Centre and the Police Control Centre spur cables to the

communication equipment room shall incorporate an identical fibre count to that provided within the incoming main cables.

- i) The main 20 fibre cables interconnecting sub-stations and the telephone exchange building at Golders Green, East Finchley, Leicester Square and Embankment to other Sites on the cable network shall be interconnected at the local Sites via the "A1" and "A2" splice boxes.

At the sub-stations and the above listed telephone exchange buildings splice boxes are not required and these main cables shall be terminated directly on to the optical fibre distribution panel installed within the their respective equipment rooms.

- j) At all other Sites such as the Northern Line Main Control Centre, etc., connection to adjacent stations on the main cable network shall be via the splice boxes serving the "A" and "B" cable routes.
- k) Except for the main cables serving the sub-stations and telephone exchange buildings detailed in paragraph (i) above the Contractor shall note that it will not be acceptable to route inter-Site main cables via the communication equipment room or for any splice box to be located within the communication equipment room itself.
- l) Track cross-overs of main cables shall be avoided unless absolutely necessary. In such cases the routing must be via cable bridges or beneath the track ballast via cable ducting.

4.0 SPLICE BOXES

4.1 Type

A common splice box type shall be used to terminate and splice the fibre optic cables at each Site location in compliance with the requirements detailed below:-

4.2 Mechanical Construction

- a) The enclosure shall be fabricated from 2mm (minimum) thick stainless steel sheeting and the complete splice box as installed at Site shall have an internal protection rating of IP65 to BS EN 60529.
- b) External dimensions of the unit shall not exceed 600 mm high x 600 mm wide and 250 mm deep unless otherwise agreed with the Project Manager.

- c) The enclosure shall be suitable for vertical mounting on to a wall or purpose built mounting frame. The design shall include suitable fixings supplied with the unit.
- d) The enclosure shall have a secure locking system, preventing any unauthorised entry. Locking devices utilised shall be common to all units and shall be supplied by the Contractor.
- e) The unit shall be sealed between the cover and body to maintain the required protection rating of IP65 to BS EN 60529.
- f) Cable entry to the enclosure shall be via cable glands which shall mechanically secure and support the cable by clamping the cable armour. Cable entries to the enclosure shall accommodate cable glands sized to terminate cable with various sizes from 20 mm up to 35 mm in external diameter.
- g) A minimum of 6 entry positions shall be incorporated into the enclosure which shall be positioned at the bottom of the unit.
- h) The unused entry positions shall be fitted with metallic blanking plugs.
- i) All materials which are not contained within the enclosure unit must be of an LSNH material at Sites where Section 12 of the Fire Precautions Regulations are in force.
- j) An external earthing stud shall be provided on the exterior of the enclosure for bonding to a common ground in accordance with the earthing requirements detailed in section 7.0.
- k) Within the interior of the unit anchoring facilities shall be provided to enable the central strength member and any metallic moisture barrier to be securely earthed and fastened.
- m) The exterior of the cover shall be fitted with a splice box identification label and a laser warning label.

4.3 FIBRE MANAGEMENT

- a) The fibres shall be managed within the enclosure through the use of cassette organisers. These shall be arranged to provide ready access to all fibres for splicing and any re-splicing work required to cater for future fibre termination.
- b) Sufficient storage shall be provided within the cassette for a minimum length of 2 m of spare fibre after jointing, for any possible re-work.

- c) Each loose tube emanating from the optical fibre cable shall be routed in a neat and tidy manner within the splice box and securely anchored at intermediate positions to provide a spare 2 m length of tube prior to termination and jointing within the splice cassettes.

Spare loose tubes shall be routed within each splice box in a similar manner to enable future access and splicing to be readily implemented.

- d) The total splicing capacity within the enclosure shall be a minimum of 300 fibre splices.

The cassettes shall be held firmly in position so that vibration of the enclosure does not affect spliced joints.

- e) On completion of the installation an 'as-built' fibre splicing drawing shall be fitted into a transparent wallet fixed upon the internal face of the splice box lid.

- f) Each external cable entering the splice box together with the fibre cable loose tubes and copper conductors shall be clearly identified with a collet which shall incorporate the numbering and labelling scheme as agreed with the Project Manager.

The labelling of each bank of cassette organisers and individual cassettes shall be arranged so as to be clearly visible when all cassettes are fully assembled and fixed in their installed configuration.

- g) Each splice box shall incorporate additional cassette organisers to enable fibre couplers to be installed at a later date sufficient to joint 8 incoming fibres to 16 outgoing fibres. The spare loose tube fibres shall be arranged to provide ready access to the fibre couplers for future termination.

- h) A laser warning label shall be fitted to the front of the cassette organisers.

- i) Section 4.4 describes the requirements for establishing speech communications between Sites. The Contractor shall review whether an alternative method using fibre-phones is preferred to provide the functionality specified.

4.4 Copper Twisted Pair Conductors

- a) The splice box shall incorporate termination facilities for the twisted pair, copper conductors contained within the fibre optic cable. These conductors shall provide the transmission facility to enable telephone type

communication to be established between Site personnel engaged in installation, splicing and testing work.

- b) Each box shall be provided with a suitable socket outlet to enable a telephone instrument to be connected to the circuit and for the user to establish communication to any one of the following locations:-
- any communication equipment room or other equipment room location which is connected together via the fibre optic cable network.
 - any splice box location locally or at another Site location. The Contractor shall note that cross-connection between splice boxes serving the Northbound and Southbound cable routes is not required.
- c) The Contractor shall provide safety protection of the circuit by installing voltage arrestor devices within each splice box.

4.5 Splice Box Protection Cabinet

4.5.1 The Contractor shall supply at all Sites where Section 12 of the Fire Precautions Regulations are in force a protective enclosure within which each splice box shall be mounted.

4.5.2 The cabinet shall be constructed in accordance with the following requirements:-

- a) mounted on the platform with additional fixing to the platform wall.
- b) robustly constructed but providing an aesthetically pleasing appearance.
- c) constructed from tubular steel members with outer mild steel sheeting.
- d) front access door, hinged on the left opening 180°, and fitted with a secure locking system.
- e) access door to consist of an aluminium panel with silver anodising to form an advertising board over which a shatterproof and removable glass panel shall be fitted with security access.
- f) sloping roof to prevent objects being placed on it.
- g) between platform structures and cabinet it shall be sealed around the edges with a coloured approved sealant.
- h) painted to a colour and specification which shall be agreed with the Project Manager.
- i) fitted with an external identification label.
- j) there shall be no sharp edges or protrusions on the external structure.

4.5.3 The cabinet shall provide ready access to the splice box for all cabling, installation and testing work.

4.5.4 The dimensions shall not exceed 1800 mm(h) x 1300 mm(w) x 380 mm(d). The overall construction of the cabinet and final dimensions shall be subject to a Site survey by the Contractor at each location.

4.5.5 The design construction and location of each cabinet shall be approved prior to the commencement of the works by the Company's environmental control section via the Project Manager.

5.0 OPTICAL FIBRE DISTRIBUTION WITHIN EQUIPMENT ROOMS

5.1 General

At the Northern Line Main Control Centre, the Northern Line Emergency Control Centre and the Police Control Centre the optical fibre distribution facilities shall be installed within a dedicated standard 19" equipment cabinet that shall be provided by the Contractor.

At all other locations the optical fibre cables shall be terminated in an optical fibre distribution panel.

5.2 Optical Fibre Distribution Panel

- a) An optical fibre distribution panel shall be installed within each communication equipment room to terminate the incoming fibre optic cables and provide a facility to splice together the fibres for distribution to the equipment cabinets housing the optical line terminal equipment associated with the transmission equipment.
- b) The distribution panel shall be wall mounted in an accessible area adjacent to the main distribution frame.
- c) The panel shall incorporate the following design features:-
 - IP52 of BS EN 60529 rated with a maximum width of 600 mm and a depth of 350 mm.
 - manufactured from mild steel or similar materials to provide a robust construction with a corrosion resistant outer coating.
 - equipped with eight gland positions for bottom cable access to accommodate the incoming optical fibre cables routed from each splice box, external fibre optic cables routed to other equipment rooms, where appropriate, and of metallic flexible conduit to route within the communication equipment room the optical fibre pigtailed to the equipment cabinets housing the optical line terminal equipment.
 - equipped with fibre distribution trays sufficient to accommodate a minimum of 100 fibre splices.
 - all fibres shall be terminated on suitable connectors mounted in an accessible position within the distribution panel. the connector attenuation at 1300 nm and 1550 nm shall not exceed 0.2 dB.

- each fibre cable loose tube shall be neatly routed within the panel and securely fixed to provide a minimum spare length of 2 m prior to termination.
- earthing, labelling and telephone socket outlet facilities shall be provided as for the splice boxes.
- fitted with an internally mounted wallet containing the as-built drawing showing the communication equipment room fibre splicing and termination.
- fitted with an external lock common to all distribution panels.
- a suitable telephone device shall be permanently fitted within the cabinet to provide the facility of inter-Site speech communication.

5.3 Optical Fibre Distribution Cabinet

- a) The optical fibre distribution cabinet shall house the fibre optic cable termination and splicing facilities appropriate the Northern Line Main Control Centre, the Northern Line Emergency Control Centre and the Police Control Centre.
- b) The cabinet shall be floor mounted and shall comply with the construction standard detailed in Schedule 6, Part B (sub part 2, section 3.3).
- c) The cabinet shall incorporate similar facilities to that specified for the optical fibre distribution panel and shall accommodate a minimum of 300 fibre splices with up to 30 gland positions for bottom cable entry.

The method of fibre routing and fixing within the cabinet shall ensure ease of access to the fibres for future splicing or re-splicing work and shall provide a neat and tidy installation.

6.0 OPTICAL FIBRE CABLES

6.1 General

- a) The Contractor shall provide armoured 20, 64 and 96 fibre cables incorporating, where appropriate, the requirements of Company Standard S&CSE-ST0014-A1, together with the requirements detailed below.
- b) The cables shall operate continuously without degradation for the lifetime of the installation in temperatures ranging from -15°C to +50°C.
- c) The cables shall be suitable for installation on cable hangers at spacings of 1.2 m and for routing within cable trunking, undertrack crossings and concrete troughing, etc. including continuous submersion in water trapped

within the cable routing systems which may occur from time to time at certain locations throughout the cable network.

- d) All fibres shall be suitable for single mode, dual window operation at the wavelengths of 1300 nm and 1550 nm.
- e) External cables shall be protected against the effects of ultra-violet radiation.
- f) All cables used at Sites where Section 12 of the Fire Precaution Regulations shall be LSNH types complying with the requirements of the Company Code of Practice for Fire Safety of Materials on the Underground.
- g) Each fibre splice shall have a maximum attenuation of 0.15 dB at 1300 nm and 1550 nm.
- h) The fibres shall comply with the requirements of ITU-T Recommendations G.652. Additionally the fibres shall be suitable for operating with both SDH and PDH transmission equipment in accordance with ITU-T and also at transmission rates as specified by ITU-T.

6.2 Cable Labelling

- a) Cables shall utilise a unique cable numbering scheme which shall be subject to agreement from the Project Manager.
- b) The cables shall be identified with a legible and durable cable tag fixed at periodic intervals along the cable routes:-
 - nominally at 100 m intervals along its length.
 - within and external to each splice box and optical fibre distribution panel/cabinet.
 - at the entry and exit points to cable penetrations such as walls, floors, ceilings, etc.
 - at the entry and exit points to undertrack crossings and other cable routing facilities.

6.3 Cable Lengths

The following cable lengths shall be used by the Contractor for system planning and will require to be modified, as appropriate, from accurate lengths to be established by the Contractor from a detailed survey of each cable route prior to installation. Final installed lengths based on optical time domain reflectometer test results shall be provided by the Contractor on completion of system installation and cable testing at Site.

- a) Contract Drawing 6235-03-250-N001 000-21-DRG 00-160, provided for guidance only, shows the inter-Site distances of the main cables which are referenced to the centre of each Site at platform or ground level.
- b) The link cable lengths between splice boxes at each Site shall be assumed to be 150 m per cable.
- c) The spur cable lengths between splice boxes and the Site communication equipment room shall be assumed to be 200 m per cable.
- d) Internal cables within each communication equipment room shall be assumed to be 15 m per cable.

7.0 EARTHING

7.1 General

The Contractor shall be responsible for providing an effective earthing system for the fibre optic cables, cable routes, splice boxes, optical fibre terminating facilities within communication equipment rooms and associated supports and materials in accordance with the requirements of Schedule 6, Part B, and as detailed below:-

7.2 Earthing Method

7.2.1 The Contractor shall assume that there is no separate earth available external to the communications equipment rooms or throughout the inter-Site cable routes.

7.2.2 As the main cables will be routed inter-Site on cable hangers which are located in close proximity to 22.0 kV, power cables the Contractor shall ensure effective earthing of all metallic elements within the fibre optic cables and, where appropriate, shall provide additional safety protection for personnel access to the cable.

7.2.3 A main common earth point will be provided by the Company within each equipment room location and will be located adjacent to the communication equipment room power distribution board.

7.2.4 The Contractor shall utilise this common earth point as the main earth at each Site for the cables and associated facilities of the optical fibre cable network.

7.2.5 The incoming cables to the Site communication equipment room shall be terminated directly within the optical fibre distribution panel or distribution cabinet, as appropriate.

The armours, central strength member and associated metallic cable elements shall be connected to a protective earth bar within the distribution panel/cabinet.

This protective earth bar shall be connected directly to the main common earth point within the communication equipment room via a 35 mm² protective earth cable.

- 7.2.6 At each splice box the following metallic elements shall be connected to a protective earth bar mounted internally:-
- a) armour, central strength members, moisture barriers, other metallic elements and cable glands associated with the main, spur and link cables terminated at the splice box,
 - b) all splice box metalwork and supports,
 - c) remake loops via the externally mounted earth stud.

The splice box and communication equipment room protective earths shall be interconnected for earth continuity via the armour and central strength members of the spur cables.

- 7.2.7 External cable routing facilities shall be earthed at the communication equipment room. However, if route continuity from the splice box to the communication equipment room is not available the earthing of the section nearest the splice box shall be via the splice box earth stud.

8.0 CABLE ROUTING

The Contractor shall provide all cable routing facilities as described in section 6.0 of Schedule 6, Part F.

9.0 SITE SURVEY

- 9.1 The Contractor shall undertake a site survey covering all locations appropriate to the installation of the fibre optic cable network. The survey shall be conducted to a planned programme which shall ensure that sufficient time is available to plan all installation activities and to obtain approval of the appropriate documentation together with adequate advance notification for the Company to rectify any deficiencies within its responsibility in advance of the installation of the Contractor's cable and equipment.

- 9.2 The survey shall include:-
- a) cable routes within communication equipment rooms, locally at each Site and between Sites as described in Schedule 6, Part F,
 - b) splice box location,
 - c) splice box protection cabinet location,
 - d) optical fibre distribution panel and cabinet location,
 - e) equipment and material storage requirements per Site including activities which may require any special protection or safety issues which may impede equipment and cable installation,

- f) all other requirements which are necessary to implement the work.

10.0 TESTING

The Contractor shall perform tests in accordance with the requirements of Schedule 4.

All optical time domain reflectometer tests results appropriate to all stages of the testing programme shall be supplied to the Company as paper copies and on computer disk in machine readable form. Such results shall be adequately indexed for ease of test result traceability.

11.0 CABLE MANAGEMENT SYSTEM

- 11.1 The Contractor shall supply a menu-driven, user-friendly software based cable management system which shall provide a complete record of the optical fibre cable network as installed at Site.

- 11.2 The system shall be arranged in hierarchical form, operator selectable, to provide cable network details in the following categories:-

- a) overall for the complete network,
- b) within each communication equipment room,
- c) from communication equipment rooms to splice boxes at each Site,
- d) inter-Site between splice boxes and communication equipment rooms, as appropriate.

- 11.3 The system shall provide routing details of the fibre optic cables, individual fibres and copper conductors together with specific circuit details appropriate to the connected transmission equipment.

- 11.4 The routing details shall include the source and destination of all individual connections together with the inter-Site details appropriate to the categories described in clause 11.3 above.

- 11.5 The database information shall include all appropriate reference information relating to:-

- a) Site name,
- b) communication equipment room location,
- c) equipment units within communication equipment room,
- d) fibre pigtails,
- e) fibre distribution panels/cabinet,
- f) splice boxes,
- g) spur, link and main cables,
- h) fibre and copper conductor identity per cable,
- i) splicing and cassette details,
- j) connectors,

- k) transmission equipment, circuit identity, card number and termination,
- l) cable and individual fibre lengths together with end to end fibre attenuation,
- m) reference documentation which shall be incorporated within the appropriate sections of the database to view termination drawing details, cable distribution etc.

11.6 The cable management system shall be developed by the Contractor during the course of the cable network installation phase and all database details and formats shall be agreed in advance with the Project Manager.

11.7 The system shall incorporate in its design spare capacity for future expansion which shall be a minimum of 30% for additional entries to the database.

11.8 The Contractor shall supply to the Company on completion of the Site installation and commissioning programme a copy of the software package including operating instructions together with all database details of the as-built installation.

A hard copy printout of the database information shall also be supplied.

11.9 The database information shall be suitable for downloading to the Company's existing cable management package, Isicad Command 5000, to provide full operator access. All details shall be agreed with the Project Manager.

12.0 GENERAL REQUIREMENTS

12.1 Except as otherwise stated herein the optical fibre cable network shall comply with the specified elements of Schedule 6, Part B:-

- a) station equipment - general technical requirements,
- b) materials,
- c) health and safety,
- d) environmental conditions,
- e) software,
- f) power supplies
- g) identification and labelling.

