

TECHNICAL SPECIFICATION

FOR

TRUNKING AND CABLE ROUTING FACILITIES

LONDON UNDERGROUND LIMITED
CONTRACT TT250
TRAINS SERVICE FOR NORTHERN LINE

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SCHEDULE 6, PART F - TRUNKING AND CABLE ROUTING

1.0 INTRODUCTION

- 1.1 The Contractor shall be responsible for the provision of all cable routing facilities except as described in section 1.2 below, which are required to complete the work associated with the installation of all cables appropriate to each of the following systems:
- (a) track to Train CCTV system described in Schedule 6, Part B,
 - (b) Final UHF Trunked Radio system described in Schedule 6, Part C,
 - (c) track to Train data transfer system described in Schedule 6, Part D,
 - (d) optical fibre cable network described in Schedule 6, Part E.

The Contractor shall incorporate the Company's requirements for other cable routes and other works into the design of its cable routes.

- 1.2 Existing main cable routes are available at trackside/ground level running adjacent to the Northbound and Southbound rail tracks. The Contractor shall use these routes as appropriate, for cable installation within and between Sites.

- 1.3 Spare capacity shall be provided by the Contractor as specified in section 15.3.

- 1.4 The whole of the installation shall be installed by the Contractor in accordance with BS7671. 'IEE Wiring Regulations, 16th Edition', the Electricity at Work Regulations, Company Standards and specifications as detailed herein and the manufacturer's recommendations, as appropriate.

- 1.5 Schedule 6 - Part F outlines the major facilities required to implement the work. The Contractor shall, however, be responsible for determining from his site survey any additional facilities required to complete the work and implementing these at Site, subject to the agreement of the Project Manager. The completed works shall be fit for purpose and shall provide a safe, secure, reliable and functional cable routing installation.

2.0 SCOPE OF WORK

- 2.1 The cable routing facilities shall be provided:
- (a) within communication equipment rooms,
 - (b) between communication equipment rooms and the main cable routes, other equipment room areas and equipment/facilities installed at trackside locations, as appropriate.
- 2.2 The cable routing works to be supplied by the Contractor shall include inter alia;
- (a) galvanised steel trunking, cable tray and conduit within stations and other Site locations,
 - (b) concrete troughing for cable routing adjacent to the track at surface Sites,

- (c) vitrified clay ducts and draw pits for cable routing at surface and underground Sites,
- (d) polyethylene ducts and track hosing for cabling routing on the track ballast. polyethylene ducts may be used at surface Sites only,
- (e) galvanised cable hangers to route cables under the platform nosing for cables, excluding radiating feeder cables, where existing cable routes are not available,
- (f) fire barriers and sealants to maintain the fire and IP rating of the installation,
- (g) fixings, supports, penetrations, and where appropriate, foundations for all cable routing facilities.
- (h) dismantling, removal and disposal of all redundant equipment and cables, refer to Schedule 4.
- (i) making good of all accommodation on completion of the installation work,
- (k) painting of all cable routing facilities and metalwork which are located in areas of public view,
- (l) earthing of all cable routing facilities and metalwork,
- (m) all other facilities necessary to complete the works.

3.0 INSTALLATION LIFETIME AND WORKMANSHIP

3.1 Lifetime

The cable routing installation shall remain safe and secure whilst carrying out its function satisfactorily for the Contract Duration and whilst subjected to the rigorous service and environmental conditions including vibration, appropriate to an underground railway.

3.2 Workmanship

The cable routing facilities shall be installed to a high standard of workmanship providing as far as is possible, an aesthetically pleasing appearance.

All work shall be completed to the satisfaction of the Project Manager.

4.0 SUPPORT STEELWORK AND MECHANICAL PROTECTION

4.1 Support Steelwork

- (a) The Contractor shall provide and install all cable routing support steelwork and fixings necessary to complete the work.
- (b) All steelwork shall be hot dip galvanised after fabrication to BS 729. No other method of protection shall be used except as otherwise approved by the Project Manager.

- (c) Where appropriate, damaged or exposed metalwork shall be rubbed down to the bare metal, suitably prepared and treated with a type approved zinc rich paint.

4.2 Mechanical Protection

- (a) Any cable, conduit or trunking route which may be subjected to mechanical damage shall be protected by mechanical shields or guards.
- (b) These protection facilities shall be fixed in accordance with section 18.
- (c) The mechanical shields or guards and their fixings shall be capable of sustaining a minimum impact of 120 kJ/m².

5.0 CABLE ROUTING CRITERIA

5.1 General

- (a) The cable routes shall be designed paying particular regard to the segregation criteria appropriate to the optical fibre cable network involving spur, link and main cables as described in Schedule 6, Part E.
- (b) As far as is possible the cables to all other systems shall utilise these routes to provide an integrated and combined cable routing installation.
- (c) The routes shall, where practicable, contain a balanced cable count within each run and the allocation of cables to a specific route shall be arranged so as to avoid system failure occurring as a result of a common and major failure of a single cable route.

5.2 Routing From communication equipment room to Trackside Level

- (a) A separate cable route is required from the Site communication equipment room to each of the splice boxes located at platform or ground level adjacent to the track for each fibre optic spur cable.
- (b) At the majority of Sites three spur cable routes are required each of which shall be physically segregated, as far as is possible, subject to the physical structural constraints at each location.

- Cable Route 1 - to splice box "A1", refer to Schedule 6, Part E, located at one end of the northbound platform.
- Cable Route 2 - to splice box "A2", refer to Schedule 6, Part E, located at the other end of the northbound platform.
- Cable Route 3 - to splice box "B1", refer to Schedule 6, Part E, located at one end or the other of the southbound platform.

- (c) Each of the above cable routes shall be extended horizontally from end to end along their respective platforms at each Site.
- (d) From these horizontal cable routes a number of spur routes shall be established, as appropriate, to run cables:-
 - to platform installed equipment
 - under the platform nosing
 - to the existing main cable routes installed at track level within and between Sites.

5.3 Communication Equipment Room to Other Equipment Rooms

- (a) Cables to other equipment room areas such as between the communication equipment room and the signalling equipment room shall be provided by the Contractor and shall, where possible, utilise the cable routes described in section 5.2.

5.4 Within Communication Equipment Rooms and Equipment Rooms

- (a) Sites Excluding Control Centres

These cable routes will for the majority of Sites be installed within the false, computer type, floor except at a limited number of Sites where a computer floor is not available and an overhead cable routing facility is required.

Independent cable routes are not required within communication equipment rooms and equipment rooms other than what is necessary to provide circuit segregation to comply with BS 7671 and OFTEL recommendations.

- (b) Main, Emergency and Police Control Centres

At the Northern Line Main Control Centre, the Northern Line Emergency Control Centre and the Police Control Centre the cable routes shall be installed within a false, computer type, floor.

The Contractor shall give careful consideration to the cable routing design in view of the large quantity of cables which will be required between equipment cabinets and to external locations.

The cable routes shall be easily accessible for cable installation including future requirements and shall be arranged to maintain the IP rating of the equipment cabinets.

The Northern Line Main Control Centre, the Northern Line Emergency Control Centre and the Police Control Centre shall be provided with a

protection earth bar grid installed within the false floor and providing a minimum of two independent earth paths to the main control room earth from each equipment cabinet.

6.0 GALVANISED STEEL CABLE TRUNKING

6.1 General

- (a) Trunking shall be used within each Site to route cables:
 - (i) within communication equipment rooms and equipment rooms.
- (b) Between communication equipment rooms and the main cable routes or other equipment room areas or to equipment mounted within other areas throughout the Site.
- (b) Trunking shall be fixed rigidly at intervals and shall be supplied complete with purpose manufactured fittings, connectors, dividers, flanges, cable retaining clips, racks, copper earth continuity links and all other facilities necessary to complete the works.
- (c) All cut edges shall be filed smooth, prepared and treated with a type approved zinc rich paint.

6.2 Trunking External to Communication Equipment Rooms

- (a) Cable supports shall be fitted at a maximum of 1200 mm centres in all vertical trunking runs of 3000 mm and above to avoid undue compression or stress of the cable installation.
- (b) All trunking shall be kept clear of any gas, water or other pipes, including ventilation trunking, by a minimum distance of 75 mm unless a reduction is agreed with the Project Manager. The Contractor shall take reasonable steps during Site surveys to identify locations where this requirement cannot be met. In such case the Contractor shall request a concession from the Project Manager. In the case of locations where this condition cannot be met and where Site surveys did not reveal such conditions the Contractor shall inform the Project Manager or his representative during, or the immediate day after, the shift in which such conditions were found. The Project Manager shall have the right to inspect all non-compliant locations and to require changes to trunking etc. at the Contractor's expense.
- (c) At all fire wall penetrations, a fixed section of lid shall be fitted, which shall protrude a maximum of 75 mm on each side of the wall. At these points, the trunking shall be fire-stopped internally, after completion of wiring, using high density resin bonded rock wool with steel retaining plates.

- (d) All bends, tees, etc shall be manufactured and not Site fabricated unless agreed by the Project Manager.
- (e) Throughout the entire trunking installation all burrs, sharp corners or other defects likely to damage the coverings of the cables shall be eliminated to the satisfaction of the Project Manager. All trunking lids shall be securely fixed with threaded screws or type approved fastenings. Self tapping screws shall not be used on any trunking system.
- (f) All trunking runs shall be bonded to earth at the point of origin, normally the communication equipment room or other equipment room. Copper links for earth continuity shall be fixed at every trunking joint. Trunking shall not be used as a circuit protective conductor.

6.3 Trunking within communication equipment rooms and Equipment Rooms

- (a) Under floor ducting and trunking systems shall be designed and constructed in accordance with BS 4678.
- (b) The ducting or trunking shall be manufactured from the best quality mild steel with a minimum thickness of 2 mm and provided with a hot dip galvanised finish to BS 729.
- (c) The ducting or trunking shall be mechanically and electrically continuous.
- (d) Copper earth continuity links shall be fixed at every joint.
- (e) Where ducting or trunking systems have a continuous length in excess of 15,000 mm a slip expansion joint shall be fitted.
- (f) The expansion joints shall be fitted with a 10 mm² csa copper braided cable bonded either side of the joint. The expansion joint shall be positioned to coincide with the structural expansion joints and at any other point where structural expansion may occur.
- (g) Steel bridges shall be provided where ducting or trunking spans through a wall.
- (h) Chases in floor screeds, where appropriate, shall allow 5 mm clearance at the sides and underneath the ducting or trunking to facilitate a flush fit with the floor level.
- (i) Chases shall be free from building rubble and dirt prior to trunking being installed.

- (j) Ducting or trunking shall be fixed at intervals not exceeding 1200 mm for linear sections. Joints and junctions shall be mechanically supported at a maximum distance of 300mm either side of the intersection.
- (k) Lids for the ducting and trunking shall be constructed of a minimum thickness of 3 mm mild steel, galvanised to BS 729, and secured as clause 6.2(e)
- (l) Ducting and trunking shall only be fitted with purpose manufactured accessories; no made on Site manufactured accessories shall be used.
- (m) The optical fibre pigtails routed within trunking from the fibre distribution panel to the equipment cabinets within the communication equipment rooms shall be additionally protected by flexible metal conduit which shall be glanded at both ends.

The conduit shall be sufficiently flexible to provide additional mechanical protection and avoid damage to the pigtail from cable installation works.

7.0 GALVANISED STEEL CABLE TRAYS

7.1 General

In platform inverts and in areas which are not in public view galvanised cable trays may be used provided the cables are armoured or contain a continuous metal sheath such as MICC cable. The use of cable trays shall be subject to the approval of the Project Manager.

7.2 Cable Tray

- (a) Cable trays shall be the perforated type, formed from plain (1.5 mm minimum thickness) steel sheet in accordance with BS 1449. All cable tray and associated fixings shall be hot dip galvanised in accordance with BS 729.
- (b) The minimum height of the return flange shall be 25 mm for tray width up to 225 mm and 50 mm for wider trays.
- (c) Site fabrication shall be kept to a minimum and manufacturers standard items shall be used wherever practicable. The cable tray shall only be cut along a line of plain metal and not through the perforations. All cut edges shall be filed smooth, prepared and treated with a type approved zinc rich paint. No holes shall be cut in the tray for the passage of cables.

- (d) Joints shall be made either by tapered overlaps or with separate fix-plates. A minimum of four galvanised mushroom head set screws or set bolts and nuts shall be used to secure each joint. The nuts shall be on the non-cable side of the tray.
- (e) All gaps between cable trays shall be bridged by means of a suitably sized insulated earthing cable, securely bonded to each tray to provide earth continuity. All cable trays shall be bonded to earth at their point of origin.
- (f) Where cable trays attach directly to structural surfaces, stand-off brackets shall be used to give a minimum clearance of 40 mm.
- (g) Where cable trays are suspended, purpose made brackets shall be used. These may consist of threaded rod suspension (8 mm minimum diameter) or steel section channel, as required to produce a rigid installation.
- (h) All cable tray shall be supported at a maximum of 150 mm from joints at changes in direction or tray termination and at the following maximum spacing:

50 mm tray width -	500 mm
75 mm tray width -	600 mm
100 mm tray width -	1000 mm
- (i) Fixings shall support the full width of the tray, and shall be fabricated from mild steel flat bar complying with BS 4360. Alternatively, manufactured channel may be used which is hot dipped galvanised to BS 729.
- (j) Where cable trays cross an expansion joint the tray shall terminate 125 mm either side of the joint. The fixing holes in the coupling piece shall be elongated to allow expansion of the cable tray.
- (k) A copper braid earth connection of appropriate size shall be bonded to either side of the joint.

8.0 GALVANISED STEEL CABLE HANGERS

- 8.1 In station areas where cables, excluding radiating feeder cables, require to be routed under the platform nosing and existing cable routing facilities are not available, J hangers shall be installed at a maximum of 500 mm centres.
- 8.2 The hangers shall be galvanised to BS 729 and shall have a minimum internal cable carrying capacity of 120 mm x 80 mm.

8.3 The hangers shall be heavy duty type, of robust construction providing high impact strength.

9.0 CABLE CONDUIT

9.1 General

- (a) Galvanised steel conduit shall be used to route the cables from the major cable trunking runs to individual items of equipment installed external to communication equipment rooms and to other equipment room areas.

Final conduit connections may be of the flexible type as described in section 9.2.

- (b) All conduit systems shall be complete before any wiring is installed.

9.2 Galvanised Steel Conduit

- (a) All conduit work up to 50 mm diameter shall be carried out using threaded heavy duty gauge steel welded galvanised conduit, fittings and accessories in accordance with BS 31 Class B, BS 4568 Class 4 and IEC 614 where applicable. All threaded conduit, fittings and accessories shall be galvanised.
- (b) Circular boxes shall be manufactured of galvanised malleable iron and adaptable boxes from galvanised pressed sheet metal. Non-ferrous metals or alloys shall not be permitted, except in the case of brass brushes and milled edged locknuts. All boxes shall be fixed independently using a minimum of two screws per box, complete with lead washers to prevent ingress of moisture.
- (c) The size of conduit used shall be not less than that specified in BS 7671 for the given number and size of cable to be installed. In all cases no conduit less than 20 mm diameter shall be used. All conduit fittings shall be of ample size to enable cables to be drawn in and out easily and without damage to the cable sheath.
- (d) No more than two right angle bends shall be permitted without the interposition of a draw box. Generally long straight runs shall have draw boxes installed at maximum 10,000 mm intervals. Inspection or solid types of tees and elbows, etc shall not be manufactured on Site.
- (e) All bends in the conduit shall be of easy sweeping curves, having an internal radius of not less than six times the diameter of the conduit. All such bends shall be made so as not to distort the cross section of the tube (i.e. bends shall be formed using the correct apparatus and formers).

- (f) All conduit runs, unless specified otherwise, shall be concealed such as within ceiling voids or below the wall surface. All conduits shall be installed in a neat and orderly manner. Where conduits cross, a gap of 3 mm minimum shall exist between conduits.
- (g) All conduits shall be securely fixed in Passenger areas, train pits, tile surfaces, by means of hospital type saddles to keep it clear of walls or beams by not less than 12 mm \pm 2 mm. In other non-public areas distance saddles may be used. The distance between saddles shall not be greater than 1200 mm and a maximum of 200 mm from the centres of all bends or boxes.
- (h) The entire conduit system shall be free of flaws, vice marks, imperfections, burrs and sharp edges. These and any other defects likely to damage the coverings of the cables shall be eliminated to the satisfaction of the Project Manager. All exposed threads and any damaged areas of conduit shall be adequately prepared and painted a type approved zinc rich paint.
- (i) All conduits wherever possible shall be laid so that all condensed moisture is drained to a terminal box or fitting in which suitable means of free drainage is provided. Swabs shall be pulled through all conduits to ensure that they are dry before any wiring is installed.
- (j) Rubber gaskets shall be fitted to all conduit boxes and adaptable boxes to maintain an IP54 rating to BS EN 60529 where boxes are installed in areas exposed to the weather.
- (k) The ends of all conduit shall be solidly screwed into all types of couplings. Where conduits terminate in adaptable boxes, etc, they shall be connected by means of smooth bore male brass bushes, compression washers and sockets which maintain the specified IP rating of the equipment.
- (l) Brass bushes shall be fitted to all points where cables emerge from the conduit. In conduit runs, there shall be no exposed nipping, except runners which shall be kept to a minimum. Sockets shall be run up tight to the fittings.
- (m) Where conduits are installed within areas and all equipment is required to have an IP54 or higher rating of BS EN 60529, special precautions shall be taken. In such circumstances, conduit boxes shall not be drilled, or provided with drain holes etc, in order to maintain the IP rating. All boxes shall have manufactured exterior fixing lugs.

- (n) All conduit runs shall be electrically continuous and shall be efficiently bonded to earth and to the metal of all equipment and other fittings. Conduit shall not be used as a circuit protective conductor.
- (o) Cable installed within vertical lengths of conduit exceeding 5000 mm shall be supported against undue compression or stress of the insulation.

9.3

Flexible Conduit

- (a) Final conduit connections to equipment which requires freedom of movement or is subject to vibration shall be connected via flexible conduit. All flexible conduit shall be the metallic type and shall only be used as approved by the Project Manager. The flexible conduit shall comply with BS 731.
- (b) The fixed wiring system shall be brought as close as possible to the equipment in order to keep the flexible conduit as short as possible. The maximum length shall not exceed 400 mm, except as otherwise agreed by the Project Manager. The cable change box between the fixed and flexible conduit system shall be independently and rigidly supported and the flexible conduit independently bonded to earth.
- (c) All lengths of flexible conduit shall be glanded to the equipment or cable routing facilities at each end, as appropriate.

10.0

CONCRETE TROUGHING AT SURFACE SITES

10.1

In external surface areas adjacent to the track where there are no existing cable routes available for the installation of the fibre optic open cables the Contractor shall provide concrete troughing to meet the following requirements:

- (a) For troughing required in the cess and in embankment areas running parallel to the track, the internal dimensions shall as a minimum be in the region of 350 mm width and 130 mm depth. The troughing shall be positioned as far as practicable from the track and not closer than 1571 mm from the running edge of the inner rail.
- (b) In other locations where it is not required to route the troughing parallel to the track, the internal dimensions shall as a minimum be in the region of 190 mm width and 130 mm depth. The troughing shall be positioned a minimum of 600 mm from the nearest edge of the trough to the ballast shoulder.
- (c) All troughing shall be installed in a straight line, as far as is possible, with all lid covers level to each other and constructed with a non-slip surface. The lids shall be solidly constructed to withstand day to day

impact associated with permanent way operations and shall be suitable as a walkway which will be used by persons operating in and around the track.

11.0 CABLE DUCTS AND DRAW PITS AT SURFACE AND UNDERGROUND SITES

11.1 Where cables require to be routed across tracks existing cable bridges and undertrack concrete ducts shall be used where these are situated in an area adjacent to the cable route required subject to the approval of the Project Manager.

11.2 At Sites where such facilities may not be available, the Contractor shall provide:

- (a) Cable ducting installed underneath the track ballast at both surface and underground Sites for the routing of main and link fibre optic cables. Cable pits shall be provided for access to the ducts for cable installation or removal.
- (b) At surface Sites cables other than those mentioned in sub-section (a) above may be routed via an orange polyethylene pipe, installed on the surface of the ballast between sleepers, subject to the approval of the Project Manager.

11.3 Cable Ducts

- (a) All cable ducts shall be 150 mm internal diameter using unglazed, vitrified clay to BS 65 (super strength). Drainpipes will NOT be accepted.
- (b) Ducts shall be encased in concrete with a minimum of 75 mm cover and with a minimum radius of bends of 600 mm.
- (c) Details of standard duct run cross sections and cable riser are shown on Contract Drawings 1-9510 - L3664, 3-9510-L28785 and 3-9510 - L2179, respectively.
- (d) All ducts shall be firmly fixed in position and properly jointed to prevent the inflow of grout during concreting operations. A rat device shall be pulled through each duct immediately before and after concreting in order to prove the duct to the satisfaction of the Project Manager.
- (e) The rat devices used for tests shall be supplied by the Contractor and shall be 12 mm less in diameter than the duct, 1500 mm long overall and with a 45° chamfer, 25 mm long at each end.
- (f) The bore of each duct shall be left clean and free from any foreign matter and shall be provided throughout its length with a non-corrosive

draw wire of high tensile strength. The draw wire shall protrude 1m at each end of the duct and the ends of each duct shall be sealed on completion. The ducts shall be resealed after cable installation.

11.4 Track Ducts

- (a) At surface Sites cables as described in section 11.2(b) above may be routed in the ballast and across the tracks via polymer duct.
- (b) The duct shall be orange coloured and shall be constructed from MDPE (medium density polyethylene) materials providing high impact strength together with environmental and chemical resistance.
- (c) Only one duct shall be installed per ballast bed. The duct shall be laid in one continuous length providing a straight and level run square to the track in the middle of the ballast bed.
- (d) The duct shall be installed such that the adjacent ballast bed, on either side, is clear of other pipes and obstructions.
- (e) The duct shall not be installed in a ballast bed which contains a stretcher bar and its position shall be arranged so as to avoid catch pits, associated drains and point mechanisms.
- (f) Prior to installation, the ballast shall be removed to a depth of 90 mm along the duct run and the ballast shoulder shall be restored on completion of duct installation.
- (g) The top of the duct shall be fully visible throughout its run. It shall not protrude above the top level of the sleepers and in the Cess the duct shall be routed below the ballast.
- (h) Suitable "push fast" couplings shall be used for duct jointing.
- (i) Approved type of track hosing as described in section 12.0 shall be used to provide additional cable protection within the confines of the track from the duct entry and exit positions.
- (j) All installation details shall be submitted in a timely manner in advance for approval by the Company's Permanent Way Department, via the Project Manager.

12.0 TRACK HOSING

12.1 In track areas where cables are routed along or across the track ballast for short distances, the cables shall be installed within track hosing to provide the necessary mechanical protection.

12.2 The hosing shall be sized sufficient only to accommodate each individual cable and shall be suitable for Sites where Section 12 of the Fire Precaution Regulations are in force and and vice versa.

12.3 Details of the approved supplier will be advised by the Company.

13.0 PENETRATIONS

13.1 General

(a) The Contractor shall be responsible for providing all penetrations which are necessary throughout the Site structures such as walls, floors, ceilings and inverts to enable the cable routing installation to be completed.

(b) Prior to performing the work the Contractor shall obtain written approval from the Project Manager on the scope and detail of the work to be undertaken for each individual Site.

(c) All penetrations shall be sealed with a fire barrier compound as described in section 14.0.

(d) All work shall be carried out with the minimum of disruption and damage to the structural finish of the Site buildings.

13.2 Holes Through Site Structures

(a) The Contractor shall carry out the drilling of the structure using a suitable concrete/masonry core cutter (diamond drilling) to provide a smoothly bored hole which shall be lined with a 70 mm diameter pipe or other alternative size as agreed with the Project Manager.

(b) The pipe shall be firmly anchored and bedded in concrete with the surface ends providing a smooth and cleanly cut finish.

(c) All debris shall be removed from within the finished penetration prior to and on completion of cable installation.

13.3 Holes for Conduit, Trunking and Cable Trays

- (a) Where conduit, trunking and cable trays are required to pass through walls, the minimum quantity of brickwork or concrete shall be removed by a combination of drilling and chiselling.
- (b) On completion of the installation of conduit, trunking or cable tray, the surface area surrounding the penetration shall be filled with cement rendering or other approved method and overlaid with a suitable weatherproof sealant as described in section 14.0. The structure shall be reinstated to its original colour and finish.

14.0 FIRE BARRIERS AND SEALANTS

- 14.1 Fire barriers shall be installed within trunking and, where appropriate, within other cable routing facilities to maintain the fire rating of the Site buildings and in compliance with the requirements of BS 7671.
- 14.2 Fire sealants shall be used between the outer surface of the cable routing facilities and structural penetrations.
- 14.3 The application of fire stopping materials and penetration seals shall be in compliance with Company Standard PEE-SPE-25-012.
- 14.4 Seals shall also be used at the ends of all cable ducts, tamperect ducts and track hosing to ensure the cable ways remain clean and clear of foreign matter throughout their length.

15.0 INSTALLATION REQUIREMENTS FOR CABLE ROUTES

15.1 Cable Segregation

- (a) Separate cable ways shall be provided for differing categories of cables as listed below, as appropriate. Cables shall not be run, or bunched, with cables of a different category. Where space is limited, safety extra low voltage cables may be run with normal supply lighting and power cables when written permission has been obtained from the Project Manager.
- (b) Segregated circuits shall include the following examples and does not exclude any specific requirement detailed by the Project Manager.

Communication Cables

Signal Cables

Safety Extra Low Voltage Cables (55-0-55V)

Lighting and Power Cables (Normal Supply)

Lighting and Power Cables (Emergency Supply)

High Voltage Cables (as defined by BS 7671)

Direct Current Cables
Fire Protection Cables

Where possible at least 300 mm distance shall be allowed between categories of cable. For telecommunication cables the spacing and wiring practices used shall as a minimum conform to the OFTEL Wiring Codes, Parts 1, 2 and 3, as appropriate.

15.2 Routing Criteria

- (a) Subject to the agreement of the Project Manager, the cables shall use existing cable routes wherever possible.
- (b) Except as otherwise approved by the Project Manager, the following conditions shall be met when determining a new cable route:
 1. The cable route shall not pass over or within 300 mm of heaters, transformers or any other pre-existing heat emitting equipment.
 2. The cable routes shall not pass through designated draft relief shafts, air conditioning plenums, lift shafts, bin rooms or refuse areas.
 3. The cable routes shall be as unobtrusive as possible and shall take account of the surrounding station/Site architecture and finishes. The cable route shall provide easy access for maintenance and future alteration.
 4. No permanent cable routes shall be fixed to any fence, hoarding, barrier, temporary obstacle or similar items.
 5. The cable routes shall follow closely the station contours at all times and shall be run at a height in excess of two metres from the floor level.
 6. The cable run shall not obscure any sign, signal, advertisements or train describer panels or prevent access being made to any adjacent cover, box or door opening.
 7. The cable routes shall not be installed in a position which will impede the transmission performance of radiating co-axial cables and where located in an adjacent position shall provide a minimum of 150 mm segregation.

15.3 Spare Capacity

Except as otherwise stated herein, all cable routes consisting of ducts, trunking, cable tray, brackets, etc shall be designed to have 100% minimum spare capacity over and above the installed cable capacity to accommodate the future installation of cables. The spare capacity shall take account of the space factors required to meet the requirements of BS 7671.

The specified spare capacity shall be available for Company use for any purpose and use of this spare capacity shall be agreed between the Contractor and the Project Manager and shall comply with the requirements of this Contract.

15.4 Bending Radius

Unless otherwise stated herein, all cable routes shall be designed to accommodate cables with a minimum bending radius of 450 mm. Spur conduit runs shall be designed to accommodate the bending radius of the cable to be installed in accordance with the requirements of the manufacturer or BS 7671, as appropriate.

16.0 INSTALLATION REQUIREMENTS FOR CABLES

16.1 General

- (a) The Contractor shall exercise sufficient care when laying cables to avoid damage due to excess cable tension or abrasion.
- (b) To avoid the risk of cable damage during handling, the cable shall be installed only when the ambient temperature is above 0°C and has been so for the previous 24 hours, or where precautions have been taken to maintain the cable above this temperature.
- (c) The cable sheaths and accessories shall be the same colour.
- (d) The cables shall be supported such that they are not subject to flexing, mechanical stress or strain, abrasion, or to ambient temperatures exceeding 40°C.
- (e) The sheath of the cable shall not be in physical contact with any other cable sheath or metalwork at an electrical potential other than zero volts with respect to earth.

Cables shall only be run behind any false ceiling panels, frieze, etc, if the claddings have been designed and installed such that they can be readily removed and replaced for maintenance purposes. All such claddings removed for installation purposes shall be replaced at the

end of the installation work, in the same condition and position as they were found. Any such items removed shall be stored in a secure location for the duration of the works.

- (f) The manufacturer's specified minimum bending radius for the cable shall not be exceeded at any time during the installation.
- (g) All cables shall be independently supported by means of type approved fixings e.g. clips, cleats etc, secured with screws or nuts, as appropriate. Vertical and horizontal supports shall be mounted at the distances specified in BS 7671 Table 4A, or as otherwise recommended by the cable manufacturer if shorter distances are specified. Cable ties shall not be used on horizontal or vertical runs to support cables as permanent fixings (except as stated in clause 16.1m).
- (h) Cables shall not be installed within the cable route until all conduit, trunking and traywork, etc forming a complete and continuous installation has been fixed permanently in position, is complete in every respect, and the cable route has been accepted by the Company's on-Site representative.
- (i) New cables installed and not terminated and awaiting connection shall be protected against damp, mechanical damage and interference. Prior to cables being permanently glanded and connected, all cables shall be sealed at each end with type approved heat shrink sleeve.

The cable shall be fitted with a yellow label stating:

- (a) date of installation,
- (b) name of department/Contractor installing the cable,
- (c) telephone number of installer,
- (d) source point of the cable,
- (e) termination point of the cable.

Labels shall be fitted to the source and termination ends of the cable.

All labels shall remain legible until the cable is finally connected.

- (j) Coloured insulation and sleeving in accordance with BS 3858 shall be used to distinguish conductors in accordance with the colour code defined below as appropriate. The colour code shall apply throughout the distribution system between the source and destination equipment.
 - 1. 230 V AC single phase circuits: all phase conductors coloured red, all neutral conductors coloured black.
 - 2. 415/230 V AC three phase circuits, each conductor to be colour coded as follows:

Phase (1) conductor - Red
Phase (2) conductor - Yellow
Phase (3) conductor - Blue
Neutral (4) conductor - Black

3. Safety, extra low voltage (55-0-55V) AC circuits - all circuit conductors to be coloured red.
 4. Circuit protective conductors and equipotential bonds: - insulation for all cables to be coloured green/yellow (one colour to be between 30% and 70% of the surface).
 5. Telecommunications conductors in accordance with the colour coding specified in the Company's cable specifications and unless otherwise specified, in accordance with the requirements of the appropriate British Standards as agreed with the Project Manager.
- (k) All single wire armoured cables shall be fitted with approved termination glands including cable shrouds of the weatherproof type with armour clamp earth tag. The earth tag shall be connected to the main earth terminal within the equipment.
- (l) Where cable tray is installed on vertical runs, a "two bolt cleat" shall be used to support the cables.
- (m) Where cable tray is installed on horizontal runs the following method of fixings shall be used:
1. For cables which are directly supported and lie within the cable tray, nylon 6.6 cable ties shall be used.
 2. For cables which are not directly supported by the tray where the cable tray channel is mounted vertically, "hook cleats" should be used.
- (n) All unused electrical cores within multicore cables where exposed shall be fitted with green/yellow sheathing and then terminated to the circuit protective conductor at each end.
- All unused telecommunication conductors shall be terminated in insulated terminal strips and fitted with a conductor sleeving marked "spare".
- (o) The installed cables and associated cable routing facilities at trackside level shall not infringe the Train kinematic profile shown on Contract Drawing 88155.

- (p) Additional requirements relating to the radiating medium installation appropriate to the track to Train CCTV and the Final UHF Trunked Radio systems are specified in Schedule 6 - Documents "B" and "C".

17.0 MATERIALS

The general requirements for materials are set out in Schedule 6, Part B, section 11.4.

The Contractor shall provide suitable protection of cables and associated materials at the interface junction between tunnels and surface sections.

All materials used shall provide a weatherproof installation and as a minimum shall maintain the stated IP rating of the equipment to which the cable routing facilities are connected.

18.0 FIXINGS

18.1 General

Fixings shall be appropriate to the type of surfaces which are normally encountered at Sites throughout the line such as fine concrete, brickwork, blockwork, plasterboard and false ceilings. Wall fixings shall include standard methods such as wall plugs (wooden plugs or inserts are not permitted), expansion bolts, spring toggle, etc. All metal fixings shall be galvanised or similar.

18.2 Fixing Methods

Fixings to the various surfaces shall be achieved by the following methods:

(a) Cast Iron Tunnel Segments

Tunnel segments shall not be drilled for any type of fixing without the written permission of the Project Manager.

Where permission is granted, the tunnel segment shall be drilled and tapped (minimum M6) to a depth of 20 mm and then fitted with a galvanised M6 mild steel stud complete with nut and externally serrated locking washer.

Where permission is not granted for drilling, then purpose made clamping brackets shall be fitted.

The brackets shall be made of steel, and hot dipped galvanised to BS 729.

(b) Coarse Aggregate Concrete and Breeze Blocks

Fixings shall be by the use of chemical resin masonry anchors. When fixing into lightweight materials then perforated sleeves and load distribution cones shall be used. In potentially wet locations stainless steel sockets and studs shall be used.

(c) Structural Steelwork

Fixing shall be obtained by purpose manufactured clamp type, bolts and brackets.

The drilling and tapping of the Site structure fabric such as the roof, steel support beams, tunnel segments, etc, is forbidden without the prior written agreement of the Project Manager.

All fixings shall be made into solid structures and not into plaster or other such finishes.

Threaded fastenings shall have either hexagonal, slotted or socket heads. "Phillips, Posidrive" or any variation of these types of heads shall not be used.

No fixing other than those detailed within this document shall be used without the prior written agreement of the Project Manager.

19.0 PAINTING

19.1 Cable routing facilities and associated metalwork shall be painted in areas to which the public normally have access such as stairways, corridors, platforms and concourses, etc. The general requirements in respect of painting are set out in Schedule 4, section 5.2.4.

