PART 1

TA 77/97

MOTORWAYS

SUMMARY

This Advice Note describes the infrastructure required to support a motorway communication system. It also describes how the design process should proceed and the factors that should be taken into account.

INSTRUCTIONS FOR USE

This is a new document to be inserted into the manual.

1. Insert TA 77/97 into Volume 9 Section 5.

2. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from the Stationery Office Ltd.
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PART 1

TA 77/97

MOTORWAYS

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1. INTRODUCTION

1.1 General

1. This Advice Note describes the infrastructure required to support a motorway communications system. It also describes how the design process should proceed and the factors that should be taken into account.

1.2 Scope

1. This Advice Note is applicable to the design and provision of infrastructure to support the National Motorway Communications Systems and motorway communications equipment. It can be used within motorway communications, motorway construction and improvement schemes.

2. The specific requirements for each Overseeing Organisation are contained in the relevant Annex to this Advice Note, they are as follows:


   Annex B for Scotland.

   Annex C for Wales.

   Annex D for Northern Ireland.

3. This Advice Note is intended to be used by Overseeing Organisation staff, their consultants, Agents and maintenance contractors.

1.3 Related Standards and Advice Notes

1. There are no Technical Directives related to the design of motorway infrastructure.

2. The following Advice Notes are of relevance:

   TA 70: Introduction

   TA 71: Design and Implementation (Overview)

   TA 72: National Motorway Communications Systems (NMCS)

   TA 75: Motorway Transmission

1.4 Implementation

1. The appropriate Annex should be used forthwith on all motorway communications, motorway construction and improvement schemes currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Design Agents should confirm its application to particular schemes with the Overseeing Organisation.
2. REFERENCES

TA 70: Introduction (DMRB 9.2.1)

TA 71: Design and Implementation (Overview) (DMRB 9.3.1)

TA 72: National Motorway Communications Systems (NMCS) (DMRB 9.4.1)

TA 75: Motorway Transmission (DMRB 9.4.4)
3. ENQUIRIES

Approval of this document for publication is given by the undersigned:

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All technical enquiries or comments on this document should be sent in writing as appropriate to the above.
PART 1

TA 77/97 Annex A (England Only)

MOTORWAYS

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A1. INTRODUCTION

A1.1 General

1. This Annex is for the specific requirement of motorway communications in England.

DMRB Structure

2. Section 1 of Volume 9 of the Design Manual for Roads and Bridges (DMRB) contains Technical Directives (TD) which detail the Standards of Provision.

3. Section 2 onwards contains Technical Advice (TA) Notes which reflect current practice in the field of motorway communications and control.

Design Loop

4. Figure A1.1a shows the ‘Design Loop’ illustrating the general sequence in the iterative design process which starts with the design for emergency telephones and signals followed by transmission and control office designs. Last in the cycle is the design of the infrastructure that will be required to support all communications equipment and systems.

Glossary

5. A Glossary of Terms is given in Chapter A15.

Standard Drawings and Specifications

6. Standard MCX and MCY drawings and MCH and TR Specifications are issued by Traffic Systems and Signing Division (TSS) of the Highways Agency (HA).
A2. OVERVIEW

A2.1 General

1. The Highways Agency operates a national cabling infrastructure for motorway communications. In the past this has been provided using armoured cable, either directly buried or installed in trough. Changes have recently been made for new installations, and the standard method of cable installation is now non armoured cable in a duct network.

2. This method of installation has the following advantages:

   (i) increased network flexibility and durability;
   (ii) increased system and network security;
   (iii) ease of cable installation and removal of redundant cable; and,
   (iv) reduced traffic management requirements.

Ducted Cable Network

3. The scheme should provide a fully ducted cable network with chambers providing access to joints and terminations and for cable installation. The ducted network is sealed from gas and water.

4. The cable installation is fully detailed in the MCX 0800 series and includes the following main features:

   (i) a fully ducted cable network, including detectable marking tape;
   (ii) cable jointing and termination within environmentally sealed underground enclosures; and,
   (iii) non armoured cable.

Cable Types

5. The following types of cable are installed:

   (i) longitudinal 40 pair copper cable;
   (ii) longitudinal 24-fibre cable;
   (iii) longitudinal carrier quad cable where Pulse Code Modulation (PCM) is not in operation;
   (iv) local quad cable to equipment;
   (v) power cable to equipment;
   (vi) coaxial cable to equipment; and,
   (vii) loop detector and feeder cables.

Alternative Methods of Cable Installation

6. When replacing short lengths of existing direct buried or troughed cables it may be inappropriate to provide the standard method of cabling; design guidance is given in Chapter A9.

7. Wherever alternative methods of cable installation are used, it is of paramount importance that the cable is adequately protected from possible damage during future maintenance works and from errant vehicles.

8. Physical constraints, such as structures, may prohibit the installation of standard cable ducts. In these cases other techniques may need to be considered. However, where the use of an alternative installation method is proposed, early advice should be sought from the Highways Agency.
A3. NETWORK DESCRIPTION

A3.1 Introduction

1. The network comprises the following, which are described in this chapter:

   (i) cable network;
   (ii) duct network;
   (iii) roadside electronic equipment;
   (iv) power supplies;
   (v) Telecommunications Interfaces;
   (vi) Control Offices.

2. During the design stage the designer should be aware of the existing cable network and the effect which the design will have upon it.

A3.2 Non-Armoured Cable Network

1. Non armoured cable is installed in ducts.

Longitudinal Copper Cable Network

2. Longitudinal 40 pair copper communications cable carries data and voice circuits between roadside equipment, including telephones and signals, and their respective Control Offices.

3. Transmission Stations (TS) are provided at approximately 20km intervals on the longitudinal cable network.

4. The longitudinal cable is installed between chambers spaced at 500m intervals. Cable is supplied in drum lengths of 1075m, therefore, more than one length is taken from each drum. In order to assist the installation, the cable itself is marked at one metre intervals. Thus the exact amount of cable remaining on a drum can be readily identified.

5. Cable termination is facilitated by the use of Insulation Displacement Connectors (IDC) housed in environmentally sealed Cable Joint Enclosures (CJE). CJE are installed inside underground chambers.

Longitudinal Optical Fibre Cable Network

6. Longitudinal optical fibre cable is provided in addition to 40 pair cable. When fully implemented, it will provide an enhanced transmission medium using Pulse Code Modulation (PCM) data circuits. Optical fibre cable is also used for the transmission of Closed Circuit Television (CCTV) video circuits.

7. Optical fibre cable is supplied and installed in drum lengths of 2060m. Fibre splices are housed in CJE installed inside underground chambers.

Carrier Cable

8. Optical fibre PCM is the preferred medium for national data transmission. However, where it is not available, a carrier quad cable is installed for the provision of carrier circuits. Carrier quad cables are laid in 2000m lengths in duct and terminated in CJE using IDC. Carrier circuits are used both in the national communications network and locally.

Local Cabling

9. Roadside equipment, including emergency telephones and signals, is connected to the longitudinal cable by local quad cables. Connections to the longitudinal cable are made in CJE or Cabinets Type 600 as appropriate.

10. CCTV cameras are connected to longitudinal cables either by local quad and optical fibre, or coaxial cable.

A3.3 Armoured Cable Network

1. Armoured cable is installed in trench (direct burial) or in trough.

Longitudinal Copper Cable Network

2. Longitudinal 30 pair copper cable carries data between roadside equipment including telephones and signals, and their respective Control Offices. It also carries data on the National Transmission Network. Longitudinal cable is installed in nominal 500m lengths. A Cabinet Type 609 is provided at each end of a cable length to house the terminations.
Chapter A3
Network Description

3. Transmission Stations (TS) are provided at approximately 20km intervals on the longitudinal cable network.

Local Cabling

4. Roadside equipment, including emergency telephones and signals, is connected to the longitudinal cable by local quad cables. Connections are made either in Cabinets Type 600 or in Cabinets Type 609, as appropriate.

Optical Fibre Cable

5. Where CCTV is provided, a fibre optic cable is required for longitudinal video transmission. The longitudinal fibre optic cable is terminated at 1000m intervals in Cabinets Type 609. Where provided for CCTV schemes fibre optic cable is also used for PCM transmissions.

A3.4 Duct Network

1. The duct network is described fully in Chapter A7. In summary it comprises:
   (i) 100mm diameter 4-way longitudinal ducting, local ducts to equipment and transverse ducts;
   (ii) main jointing chambers (Type A) at 500m (tolerance +2%:-5%) intervals;
   (iii) intermediate chambers (Type B), where necessary to facilitate cable installation (such as at a structure, a cabinet location or change in direction);
   (iv) chambers at cabinet sites (Type C); and,
   (v) large chambers adjacent to Transmission Stations.

A3.5 Roadside Electronic Equipment

1. Roadside Electronic equipment is housed in Cabinets Type 600. They are sealed and contain thermostatically controlled heaters and power distribution units.

2. This equipment includes Telephone Responders, Transponders, MIDAS Detectors, EMS/MS2 equipment and CCTV equipment.

A3.6 Power Supplies

1. Electricity Supply Company Interface (EI) equipment is housed in Cabinets Type 609 (EI Cabinets) which are installed in the motorway boundary fenceline. The Electricity Supply Company’s equipment and power supply cable are installed on the non-motorway side of the cabinet.

2. Power is distributed from EI Cabinets to power cabinets (Type 609P) and then to equipment on the motorway. 3-core power cable is used for power distribution.

A3.7 Telecommunications Interfaces

1. Where access to Third Party, Private Wire or the Public Switched Telephone Network (PSTN) is required, a cabinet is installed in the motorway fence line to house the Telecommunications Company interface equipment and to connect their telecommunications cable.

2. The telecommunications facilities are then connected to motorway equipment via quad, 40-pair or coaxial cable.

A3.8 Control Offices

1. Control Offices (CO) are generally located in police headquarters buildings. These are often situated near the centres of main towns or cities. They serve as command and control centres for police activities within a specific area, this includes the motorways within that area.

2. Motorway traffic control and communications equipment for the control of telephones, signalling and CCTV is provided in Control Rooms within COs. Supporting telecommunications equipment is provided within adjacent Equipment Rooms.

3. Telecommunications links are required between the Equipment Room and the nearest TS on the motorway network. This link may be provided by a cable, a radio or microwave. The precise form of this link will depend upon such considerations as:
   (i) the relative locations of the CO and the TS;
   (ii) communications security requirements;
   (iii) cost.
A3.9 Protection of Existing Cable

General

1. When planning work on existing motorways special consideration should be given to the protection of the existing motorway communications infrastructure. The longitudinal cable will be part of the national carrier network in addition to its function of carrying local data from signals and telephones. Any damage to the cable will therefore cause disruption to signal and telephone facilities over an extremely wide area.

2. The Design Agent should produce an Existing Communications Report which will include an assessment of how the scheme will affect the existing national 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; details of how to achieve this are given in TA 75/95: Motorway Transmission.

3. During the design stage the location of all cable and equipment should be determined and an assessment made of the risk of damage. In general where works are to be undertaken on the verge containing cable and equipment there will be a significant risk of damage. It should be noted that the opposite verge will also contain telephones and probably power supply cables which will therefore be vulnerable to damage from works on this verge.

Precautions to Avoid Damage

4. The precautions required will depend on many factors including the risk of damage and the communications infrastructure to be provided by the scheme.

5. Where a contractor will be working in close proximity to existing cables or duct the exact location of the cables and duct should be marked clearly prior to the commencement of any works. This operation should be undertaken by the specialist Regional Maintenance Contractor (RMC). It may be possible to fence off the vulnerable area with temporary fencing, taking care not to damage cable or duct whilst installing fence posts.

6. Consideration should be given to programming the works to avoid working adjacent to live cables wherever possible.

7. 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.

Cable Damage and Replacement

8. All instances of damage to cable should be regarded as serious. All cable damage should be reported immediately to the RMC by the Contractor, via the Engineer. The Highways Agency (HA) should be informed as soon as practicable.

9. The RMC will effect whatever temporary repairs are necessary to restore motorway communications.

10. All damaged cables should be replaced at the contractor's cost. Where cable is to be replaced a complete drum length must be replaced. The HA will be able to advise of manufacturers of cable to the required specifications. Ideally replacement will be undertaken during the contract period. If this is not possible then all reasonable costs incurred by the HA in replacing the cable, including traffic management, will be recovered from the contractor.
A4. MOTORWAY CABLES

A4.1 General

Bulk Purchase

1. Cables used for motorway communications are purchased in bulk by the Highways Agency. They are supplied to the scheme and are made available for collection by the cable installation contractor.

Standard Cables

2. There are several standard cable types, all of which are non armoured and are suitable for installation in ducts. They are described and illustrated on the following pages.

Acceptance of Non Armoured Cable

3. These cables have been specified to conform with current industry standards. As such they do not have a graphite coating. Acceptance testing of non-armoured cable is not considered necessary. Cables are tested, during manufacture, by the manufacturer as part of the routine quality control process. The cable installation contractor will accept the cable and will be at liberty to carry out any testing which he considers relevant.

4. The cost of replacing any cable which is found to be damaged or unsatisfactory in any way will be far less than the cost of replacing a directly buried cable. Replacement can be undertaken with minimal traffic management and no interference with adjacent cables.

5. The most common source of sheath damage in the past was the nails which were used to secure battens to the cable drums. This method is no longer employed. If a cable drum is delivered to site with any battens missing it should be rejected as the battens serve to protect the cable.

Armoured Cable

6. Armoured cable is still available for installation where a ducted network is not provided - refer to paragraph A4.2.

Acceptance of Armoured Cable

7. Armoured cable has a graphite coating and is subject to on-drum acceptance testing by the installation contractor. In addition, these cables are tested after backfilling and before termination, to prove the integrity of the cable.
A4.2 NMCS Non Armoured Cable

Copper Communications Cable

1. NMCS non armoured copper communications cable conforms to specification TR 2150 and is illustrated in Figure A4.1a.

2. TR 2150 specifies quad, 5 pair, 10 pair and 40 pair copper cable.

3. This cable is a fully filled copper communication cable sheathed with medium density polyethylene. It is constructed from solid plain copper conductors insulated with cellular or foam-skin polyethylene. It has an aluminium polymer laminate tape which acts as a moisture barrier.

4. See paragraph A5.6 for cable pair allocation.

5. The 40 pair cable is constructed from 4 units each comprising 10 copper pairs which are individually taped and bound together. 40 pair cable is purchased in 1075m drum lengths.

6. Quad cable is illustrated in Figure A4.1b. There are in two variants of quad cable - local quad and carrier quad.

Local Quad

7. The conductor size and insulation thickness are the same as for 40 pair cable. Local quad cable is purchased in 1000m drum lengths.

Carrier Quad

8. This cable has a thicker conductor and insulation, 1.2mm conductor, 3mm overall insulated conductor size. Carrier quad cable is purchased in 2100m drum lengths.
Optical Fibre Communications Cable

9. NMCS non armoured optical fibre communications cable conforms to specification TR 2151 and is illustrated in Figure A4.1c.

10. This cable comprises 24 fibres housed in 3 tubes, 8 fibres per tube.

11. See paragraph A5.6 for fibre allocation.

12. This cable is a fully filled single mode optical fibre cable. The cable is sheathed in polyethylene and is 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. Each of the 24 fibres is individually coloured.

Coaxial Communications Cable

13. This cable is purchased in drum lengths of 2060m.

14. NMCS non armoured coaxial communications cable conforms to Specification TR 2152 and is illustrated in Figure A4.1d.

15. This cable is a 75Ω semi air spaced coaxial cable sheathed with medium density polyethylene. It is constructed with an inner conductor of solid plain annealed copper and a 5 cell semi airspaced polyethylene dielectric. The outer conductor consists of a plain annealed copper tape covered with a plain annealed copper braid with a polyester isolating tape applied helically. An aluminium polymer laminate tape is provided.

16. This cable is purchased in 1000m drum lengths.

Power Cable

17. NMCS non armoured Power cable conforms to Specification TR 2153 and is illustrated in Figure D4.1e.

18. The two standard sizes of cable are 10mm² and 25mm². Other sizes may be required and can be supplied to suit local conditions, subject to the capacity of the duct network and the practicalities of installation. Approval from the Highways Agency must be obtained during the design stage if non standard cable sizes are being considered.

19. This cable is a three core stranded copper conductor energy cable sheathed with medium density polyethylene. It is constructed from high-conductivity copper, stranded into a circular profile and insulated with cross-linked polyethylene. These conductors are bound together.

20. This cable is purchased in 1000m drum lengths.

Inductive Loop Detector Cable

21. NMCS inductive loop detector cable conforms to Specification TR 2029. It is installed in slots cut into the carriageway. Non armoured cable is used for all applications.

22. This cable is a single core multistrand flexible cable sheathed with polychloroprene. The single tinned copper conductor is insulated with ethylene propylene rubber.

23. This cable is purchased in 1000m drum lengths.

Feeder Cable For Inductive Loop Detectors

24. NMCS feeder cable for inductive loop detectors conforms to Specification TR 2031. Feeder cable is available as a non armoured cable and also as an armoured cable. It is available as either a 2 core or 4 core cable.
Chapter A4  
Motorway Cables

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25. This cable is a copper communications cable sheathed with medium density polyethylene. This cable is constructed from solid plain copper conductors insulated with solid polyethylene.

26. This cable is purchased in 1000m drum lengths.

A4.3 NMCS Armoured Cable

1. The following types of armoured cable are available for installation by direct burial where cable ducts are not provided:

(i) quad, 10 pair and 30 pair copper communications cable to TR 2158;

(ii) composite optical fibre/copper cable to TR 2017;

(iii) coaxial cable to TR 2160;

(iv) energy cable to TR 2161;

(v) feeder cable for inductive loop detectors to TR 2031.

Copper Communications Cable

2. This cable is a fully filled copper communications cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. The make up of the cable is in the form of a centre and a number of concentric layers. It is constructed from solid plain copper conductors insulated with solid polyethylene and twisted together to form pairs.

Composite Optical Fibre/Copper Cable

3. This cable is fully filled single mode composite optical fibre cable, designed for direct burial. It contains 12 fibres individually tubed, and 11 pairs of 0.9mm copper conductors. The cable is sheathed in polyethylene and is 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 cable has a galvanised steel wire armour applied to the inner sheath and a polyethylene outer sheath.

Coaxial Cable

5. This cable is a 75 $\Omega$ semi airspaced coaxial cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. It is constructed with an inner conductor of solid plain annealed copper and a 5 cell semi airspaced polyethylene dielectric. The outer conductor consists of a plain annealed copper tape covered with a plain annealed copper braid with a polyester isolating tape applied helically. An aluminium polymer laminate tape is provided as a moisture barrier.
A5. NETWORK DESIGN

A5.1 General Procedure

1. This chapter deals with the design of ducted cable networks.

Design Process

2. The design process is iterative. All items of roadside equipment and cable joints will have their ‘ideal’ locations, however the most efficient design will be one which achieves the balance between ideal locations, physical constraints and cost. For instance, minor adjustments to locations may result in duct, cable or equipment savings.

3. The first stage in the design of a communications network is to correctly site signals and telephones on 1:10000 scale drawings. This design is transferred to the 1:2500 scale drawings, and a schematic design is produced. The longitudinal cables are then designed and added to the drawings. All local cables and items of equipment are then added to the schematic design which is then transferred back to the 1:2500 scale drawings. The locations of equipment, chambers and cabinets are then checked against physical constraints and adjusted accordingly to ensure that staff access can be maintained.

Transmission Stations

4. The location of Transmission Stations (TS) should be finalised before starting schematic design as this has a fundamental effect on the design of the cable network. Copper cables are terminated in Marshalling cabinets which are sited immediately outside TS buildings. Optical fibre and coaxial cables are terminated within the TS itself.

Interfaces

5. Where the scheme boundary does not coincide with a TS the cable infrastructure adjacent to the scheme boundary should be taken into account. Where a ducted network will interface with an existing direct buried network an interface cabinet should be provided for the termination of 40 pair and carrier cables with the existing 30 pair cable, refer to the MCX 0800 series for details.

Cable Lengths

6. The characteristics of the cable and transmission equipment dictate that 40 pair cable lengths between terminations must be in the range 500-535m. Optical fibre cable lengths between terminations are limited by the drum length available, which is 2060m. When assessing joint chamber locations the requirement for optical fibre joints and the maximum cable length available should be considered.

7. The actual length of cable between joints may be calculated as follows:

$$\begin{align*}
(a) \quad & \text{duct length between adjacent jointing chambers} = x \quad \text{m} \\
(b) \quad & \text{snaking allowance (2$\%$ of (x))} = y \quad \text{m} \\
(c) \quad & \text{length housed in jointing chamber} = 15 \quad \text{m} \\
& \text{Total} = x + y + 15 \quad \text{m}
\end{align*}$$

When calculating the length of cable required from a drum, a termination/installation allowance should be added (2m for copper, 3m for fibre cables).

8. The 7.5m length is housed within the chamber, supported on cable brackets. It allows the cable joint to be taken out of the chamber and into a jointing vehicle parked on the hardshoulder.

9. Cables are terminated in Cable Joint Enclosures (CJE) which are housed within underground chambers (Type A).

10. In exceptional circumstances, where site conditions preclude the laying of 500-535m of 40 pair cable in one longitudinal length advice from the Highways Agency (HA) should be obtained before proceeding with design.
Longitudinal Cable Design

11. The longitudinal cable design commences with the plotting of the longitudinal cables and associated CJEs. The plotting of CJE positions should commence at both TS working towards the centre of the transmission section. The loading pattern should be checked at this stage (see paragraph A5.5).

12. Signals, telephones and all associated equipment are then added to the schematic design (see paragraph A5.2 for typical schematic details).

13. All items of equipment on the motorway are connected into the longitudinal 40 pair copper and optical fibre cable networks within local CJEs.

Duct and Chamber Design

14. Following the initial schematic communications design, ducts and chambers should be positioned; refer to Chapters A7 and A8 for details.

15. Provisional sites should then be refined to site CJE and chambers in the optimum positions. Guidance on the siting of chambers is given in Chapter A8.

Cabinets for Electronic Equipment

16. Transponders and Telephone Responders, are housed within Cabinets Type 600. Those cabinets should always be located adjacent to a Longitudinal Cable Joint. The distance between Cabinet and Joint should not exceed 30m.

Non Ducted Systems

17. Non ducted systems are dealt with in Chapter A9.

A5.2 Schematic Design

1. The following paragraphs and drawings describe how the various items of equipment are connected to the longitudinal cable network. Schematic drawings are used to illustrate how this is achieved. The symbols used are those shown on MCX 0801 (repeated in Figure A5.2a).
Figure A5.2a  Schematic Symbols
Emergency Telephones

2. The cabling arrangements for emergency telephones are shown schematically in Figure A5.2b.

3. The telephone instrument may be isolated from the local quad cable by means of a Cable Joint Enclosure (CJE) housed in a chamber adjacent to the telephone post.

4. Where emergency telephones are located within 250m of a Telephone Responder, the cabling arrangement is as shown on Figure A5.2b(ii).

5. Connections to telephones are detailed on MCX 0135, and to local CJEs in the MCX 0800 series. Wiring within a 600 cabinet is detailed in the MCX 0800 series.

![Figure A5.2b  Telephone Schematic]
Post Mounted Signals

6. The cabling arrangements for post mounted signals are shown schematically in Figure A5.2c.

7. A CJE Type RSI (Rural Signal Interface) is mounted within the ‘B’ side of the 609P cabinet, this affords local access from the motorway verge to the signal control (RS485) circuit during commissioning and maintenance. Where a dedicated P cabinet is not provided an additional 609 cabinet should be provided to house the CJE. This is the only type of CJE which is not housed underground.

8. Connections to the signal, the ST (where applicable), the CJE Type RSI and the underground CJE are shown in the MCX 0800 series.

9. Where post mounted signals are within 50m of a Transponder, the cabling arrangement is as shown on Figure A5.2c(ii). The signal will be connected to Port 2 (local) of the ST. Where the signals are less than 150m, but greater than 50m from an ST, the cabling arrangement shown on Figure A5.2c(ii) is used with the addition of a 609P cabinet local to the signal.

Figure A5.2c  Post Mounted Signal Schematic
Gantry Mounted Signals

10. Gantry Mounted Signals
11. Gantry Mounted Signals are equipped with matrix signals and an Enhanced Message Sign (EMS) for driver information.

12. The cabling arrangements for gantry mounted signals are shown schematically in Figure A5.2d.

13. In this case access to the signal control (RS485) circuit is afforded from the 600 Cabinet used for EMS control.

14. Connections to the gantry, the EMS cabinet and the CJE are shown on MCX 0151 and the MCX 0800 series.

Motorway Signal Mark 2

15. Motorway Signal Mark 2 (MS2) are used for signalling on motorways with up to three lanes and are cantilever mounted.

16. An MS2 comprises an Enhanced Matrix Indicator (EMI) for signalling and an Enhanced Message Sign (EMS) for driver information. The EMI is equipped with four amber lantern units (MS2 Type A1) or with four amber and four red lantern units (MS2 Type A2).

17. The EMI is controlled either by NMCS2 or by Stand Alone Control.

18. The cabling arrangements for MS2 are shown schematically in Figure A5.2e. The arrangement is suitable for both types of control.

19. Connections to the MS2 cabinet 600 and the CJE are shown on the MCX 0800 series.

Figure A5.2d  Gantry Mounted Signal Schematic

Figure A5.2e  MS2 Schematic
EMS Type B

20. An EMS Type B is an EMS mounted on a cantilever.

21. The cabling arrangements for an EMS Type B are shown schematically in Figure A5.2f.

Figure A5.2f  EMS Type B Schematic
MIDAS Loop Detectors

22. The requirements for MIDAS Loop Detectors are described in MCH 1589 Guide To The Siting Of Inductive Loop Detectors On Motorways. The cabling arrangements for MIDAS outstations are shown schematically in Figure A5.2g.

23. The joints between Loop Detector Cables and Loop Feeder Cables are located in roadside chambers conforming to Highway Construction Detail (HCD) G13 and MCX 0592. Loop Feeder Cables are terminated in a MIDAS Detector Cabinet 600, the maximum length of Feeder Cable is 200m.

24. Connections to the MIDAS Detector (MD) cabinet and the CJE are shown on the MCX 0800 series.

25. Where a MIDAS Transponder is also required, the arrangement is as shown on Figure A5.2g(ii).

![MIDAS Schematic](image_url)

Figure A5.2g  MIDAS Schematic
CCTV Outstations

26. CCTV Outstations are described in Specification MCE 2015. The cabling arrangements for CCTV are shown schematically on Figure A5.2h.

27. Composite video signals are transmitted to the CO along the longitudinal OF Cable network. Connection to this network is obtained from the nearest fibre CJE on a single fibre in an OF spur cable.

28. Camera control is exercised from the CO using the longitudinal 40-pair cable. Connection to this network is obtained from the nearest CJE using three quad cables.

29. The connection between the CCTV Cabinet 600 and the camera is made using proprietary cable provided by the CCTV Contractor.

30. Power is supplied from an adjacent Power Cabinet 609.

31. The use of optical fibre cable is the preferred method, however, where CCTV cameras are within 1km of a TS, the use of coaxial cable in place of OF cable may be considered, subject to the approval of the HA. The arrangements are shown in Figure A5.2h.

Figure A5.2h  CCTV Schematic
Isolated Equipment

32. Where isolated equipment is to be installed the cabling arrangements are shown in Figure A5.2i.

Figure A5.2i  Isolated Equipment Schematic
A5.3 Selection of Duct Route

1. One of the earliest tasks during the design is to determine the most suitable route for the longitudinal duct route. The planning of the route will involve plotting a suitable route on drawings at 1:2500 scale and a survey of the site to confirm the suitability of the chosen route. A record of this survey on video proves an invaluable aid when locating equipment and chambers.

2. All ducts should be laid within the motorway boundary. The only exception is at Transmission Stations (TS) where they may be laid into a works unit compound.

3. Where bases for equipment such as CCTV cameras or large signs coincide with the duct route these bases should be designed to allow ducts to be built in.

4. When planning the duct route the precise locations of all proposed and existing communications cables, duct routes and other relevant features should be plotted, from the schematic design, onto drawings at 1:2500 scale. Relevant features include:

   (i) Cuttings/Embankments;
   (ii) Structures including bridges, retaining walls; and
   (iii) Drains;
   (iv) Safety fences;
   (v) Lighting and other cables;
   (vi) Gantries or verge mounted signs;
   (vii) Noise fences;
   (viii) Environmental mounds;
   (ix) Trees.

5. The presence of particular features may require the use of special methods of construction or special items of plant or machinery. For example, installing ducts behind safety fencing on a steep embankment would be beyond the capabilities of standard mechanical excavators. This may, in turn, require special traffic management arrangements or result in the need for night working. All such details should be included in tender documentation.

6. The longitudinal cable should normally be kept on the same side of the motorway throughout its length, or at least, for a substantial distance. The side chosen will depend on the balance of advantages and disadvantages after considering such features as:

   (i) Cuttings/Embankments;
   (ii) Flood plains;
   (iii) Overhead power lines or electrified railway or buried power cables;
   (iv) Relationship to Transmission Stations and cables/ducts on adjacent sections of motorway;
   (v) Ease of siting cabinets including access and safety protection;
   (vi) Ease of providing power supplies;
   (vii) Ease of routing duct.

7. Where there is a risk of interference from external electrical sources, eg power lines which run parallel to the motorway and are within 100m of it for a substantial distance, the longitudinal cable should be installed on the opposite side of the motorway to reduce the risk of interference. However, the longitudinal cable should not be repeatedly changed from one side of the motorway to the other. The HA should be consulted if necessary.

8. Ducts to local equipment should occupy the same trench as longitudinal ducts as far as possible. When choosing the route for a local duct the guidance given for longitudinal duct route selection will apply equally.

A5.4 Copper Cable Terminations

1. Cable terminations are contained in environmentally sealed Cable Joint Enclosures (CJE) - these are constructed from a plastic material and are housed in underground chambers. CJE may be opened and resealed without the need for any specialist tools or equipment. CJE are detailed in the MCX 0800 series and are manufactured in accordance with MCE 2183.

2. Cable terminations are made by using Insulation Displacement Connectors (IDC). Cable is inserted into an IDC using a purpose made tool. The IDC cuts through the cable insulation and makes a connection to the copper conductor.
3. There are 7 types of CJE available for copper termination as detailed in Table A5.4a:

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
<th>No of Cables to be Accommodated</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>Unloaded.</td>
</tr>
<tr>
<td>2</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 22 circuits loaded at 22mH.</td>
</tr>
<tr>
<td>3</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 6 circuits loaded at 88mH.</td>
</tr>
<tr>
<td>4</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 28 circuits loaded at 22mH.</td>
</tr>
<tr>
<td>L</td>
<td>Local distribution</td>
<td>3 x 40 pair and 6 x quad</td>
<td></td>
</tr>
<tr>
<td>RSI</td>
<td>Rural Signal Interface</td>
<td>4 x quad</td>
<td></td>
</tr>
<tr>
<td>HFC</td>
<td>High Frequency Carrier</td>
<td>4 x carrier quad</td>
<td></td>
</tr>
</tbody>
</table>

Table A5.4a Types of CJE for copper termination

A5.5 Loading Design

1. Once the chamber sites and the individual cable lengths have been confirmed a cable loading scheme should be prepared.

2. Cable loading practice is described in MCL 5502.

3. The cable loading design should be based on nominal 500m chamber spacing starting from both Transmission Stations.

4. Where the distance between the two terminations in the middle of the transmission section is less than 450 metres it should be corrected by re-positioning the other provisional sites; where this is not possible a non-standard length of cable will be necessary. Capacitors will be added in the CJEs to give an equivalent electrical length of 500 metres - ‘building out’. There may be other places where using a cable length of less than 450-metres is unavoidable. Any such circumstances should be brought to the attention of the HA as early as possible.

5. It should be noted that the instructions for siting TS specify a maximum linear spacing of 20km. Once all the CJE and chambers have been sited and lengths of individual cables checked, the number of cable lengths should be counted. The HA should be consulted in all cases where more than 40 lengths of cable between adjacent TSs are proposed.

6. Instructions for the preparation of a cable loading scheme and calculation of values of building out capacitors are given in MCL 5502. The loading pattern and build out should be submitted for approval by the HA at an early stage of the design.

7. The normal loading pattern to allow for 2 wire telephone operation is shown in Table A5.5a.

<table>
<thead>
<tr>
<th>Distance from Transmission Station (m)</th>
<th>Loading (mH)</th>
<th>CJE Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data</td>
<td>Telephone</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>Marshalling Cabinet</td>
</tr>
<tr>
<td>500</td>
<td>22</td>
<td>15 - 2</td>
</tr>
<tr>
<td>1000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>1500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>2000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>3000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>3500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>4000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>17000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>17500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>18000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>18500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>19000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>19500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>20000</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table A5.5a Loading pattern for 2 Wire Operation
Notes:
1. Distances are nominal, the tolerance on the nominal 500m duct length is +2%, -5%.

2. For 4 wire operations the pattern is
   15-4 : 15-1: 15-4 : 15-1: 15-4

8. For 2 wire telephone operation:
   (i) data pairs are loaded with 22mH coils at nominal 1000m intervals, the first set of coils are located 500m (+2%, -5%) from the TS;

   (ii) telephone pairs are loaded with 88mH coils at nominal 2000m intervals, the first set of coils is located 1000m (+2%, -5%) from the TS;

   (iii) all other pairs are unloaded.

9. For 4 wire telephone operation:
   (i) data and telephone pairs are loaded with 22mH coils at nominal 1000m intervals, the first set of coils are located 500m (+2%, -5%) from the TS.

A5.6 Allocation of Cable Pairs and Fibres
1. Cable pair allocation is detailed in Tables A5.6a (longitudinal) and A5.6b (local).

2. Fibre allocation is detailed in Table A5.6c.

A5.7 Optical Fibre Termination
1. Optical fibre cables are terminated in CJE Type 15F which are housed in underground chambers.

2. At Transmission Stations, optical fibre cables are installed in accordance with MCX 0865.

A5.8 Cable Testing
1. Non armoured cable is tested in accordance with MCG 1099.

A5.9 Non Armoured Cables on Gantries
1. Mechanical protection is required where non armoured cables are installed on gantries. This can be achieved by installing the cable in a covered cable tray.
<table>
<thead>
<tr>
<th></th>
<th>UNIT 1 (Blue)</th>
<th>UNIT 2 (Orange)</th>
<th>UNIT 3 (Green)</th>
<th>UNIT 4 (Brown)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAIR 1</strong>&lt;br&gt;(W/Blue)</td>
<td>HDLC Signals Control</td>
<td>HDLC CCTV Control</td>
<td>Telephone Line 1 2W (Line 1 TX 4W)</td>
<td>Telephone Line 4 TX 4W</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>22mH</td>
<td>88mH* (22mH)</td>
<td>22mH</td>
</tr>
<tr>
<td><strong>PAIR 2</strong>&lt;br&gt;(W/Orange)</td>
<td>HDLC Signals Reply</td>
<td>HDLC CCTV Reply</td>
<td>Telephone Line 2 2W (Line 1 TX 4W)</td>
<td>Telephone Line 4 RX 4W</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>22mH</td>
<td>88mH* (22mH)</td>
<td>22mH</td>
</tr>
<tr>
<td><strong>PAIR 3</strong>&lt;br&gt;(W/Green)</td>
<td>RS 485 Signals None</td>
<td>RS 485 CCTV None</td>
<td>Telephone Line 3 2W (Line 1 TX 4W)</td>
<td>Telephone Line 5 TX 4W</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
<td>88mH* (22mH)</td>
<td>22mH</td>
</tr>
<tr>
<td><strong>PAIR 4</strong>&lt;br&gt;(W/Brown)</td>
<td>HDLC EMS Control</td>
<td>Engineer’s Audio</td>
<td>Telephone Line 4 2W (Line 2 RX 4W)</td>
<td>Telephone Line 5 RX 4W</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>22mH</td>
<td>88mH* (22mH)</td>
<td>22mH</td>
</tr>
<tr>
<td><strong>PAIR 5</strong>&lt;br&gt;(W/Slate)</td>
<td>HDLC EMS Reply</td>
<td>Engineer’s Audio</td>
<td>Telephone Line 5 2W (Line 3 TX 4W)</td>
<td>Telephone Line 6 TX 4W</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>22mH</td>
<td>88mH* (22mH)</td>
<td>22mH</td>
</tr>
<tr>
<td><strong>PAIR 6</strong>&lt;br&gt;(R/Blue)</td>
<td>HDLC MIDAS Control</td>
<td>Spare None</td>
<td>Telephone Line 6 2W (Line 3 RX 4W)</td>
<td>Telephone Line 6 RX 4W</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>None</td>
<td>88mH* (22mH)</td>
<td>22mH</td>
</tr>
<tr>
<td><strong>PAIR 7</strong>&lt;br&gt;(R/Orange)</td>
<td>HDLC MIDAS Reply</td>
<td>Spare 22mH</td>
<td>Remote Telephone Line 1 2W Line 1 TX 4W</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>22mH</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>PAIR 8</strong>&lt;br&gt;(R/Green)</td>
<td>RS 485 MIDAS None</td>
<td>Spare 22mH</td>
<td>Remote Telephone Line 2 2W Line 1 RX 4W</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>22mH</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>PAIR 9</strong>&lt;br&gt;(R/Brown)</td>
<td>Telemetry</td>
<td>Spare 22mH</td>
<td>Remote Telephone Line 3 2W Line 2 TX 4W</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>22mH</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>PAIR 10</strong>&lt;br&gt;(R/Slate)</td>
<td>Telemetry</td>
<td>Spare 22mH</td>
<td>Remote Telephone Line 4 2W Line 2 RX 4W</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>22mH</td>
<td>22mH</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Table A5.6a Longitudinal Cable Pair Allocation**

**NOTE:** *88mH for 2 wire telephone operation.
<table>
<thead>
<tr>
<th>Pair</th>
<th>Service</th>
<th>Unit 1 (Blue)</th>
<th>Unit 2 (Orange)</th>
<th>Unit 3 (Green)</th>
<th>Unit 4 (Brown)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HDLC Signals Control</td>
<td>Engineer’s Audio</td>
<td>Telephone Line 1 2W (Line 1 TX 4W)</td>
<td>(Telephone Line 4 TX 4W)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HDLC Signals Reply</td>
<td>Engineer’s Audio</td>
<td>Telephone Line 2 2W (Line 1 RX 4W)</td>
<td>(Telephone Line 4 RX 4W)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RS 485 Signals Port 0</td>
<td>HDLC CCTV Control</td>
<td>Telephone Line 3 2W (Line 2 TX 4W)</td>
<td>(Telephone Line 5 TX 4W)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RS 485 Signals Port 1</td>
<td>HDLC CCTV Reply</td>
<td>Telephone Line 4 2W (Line 2 RX 4W)</td>
<td>(Telephone Line 5 RX 4W)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>HDLC EMS Control</td>
<td>RS 485 CCTV Port 0</td>
<td>Telephone Line 5 2W (Line 3 TX 4W)</td>
<td>(Telephone Line 6 TX 4W)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>HDLC EMS Reply</td>
<td>RS 485 CCTV Port 1</td>
<td>Telephone Line 6 2W (Line 3 RX 4W)</td>
<td>(Telephone Line 6 RX 4W)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>HDLC MIDAS Control</td>
<td>Remote Telephone Cable B, Line 1 2W (Line 1 TX 4W)</td>
<td>Remote Telephone Cable A, Line 1 2W (Line 1 4W TX)</td>
<td>Remote Telephone/Local</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>HDLC MIDAS Reply</td>
<td>Remote Telephone Cable B, Line 2 2W (Line 1 RX 4W)</td>
<td>Remote Telephone Cable A, Line 2 2W (Line 1 4W RX)</td>
<td>Remote Telephone/Local</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>RS 485 MIDAS Port 0</td>
<td>Remote Telephone Cable B, Line 3 2W (Line 2 TX 4W)</td>
<td>Remote Telephone Cable A, Line 3 2W (Line 2 4W TX)</td>
<td>Remote Telephone/Local</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>RS 485 MIDAS Port 1</td>
<td>Remote Telephone Cable B, Line 4 2W (Line 2 RX 4W)</td>
<td>Remote Telephone Cable A, Line 4 2W (Line 2 4W RX)</td>
<td>Remote Telephone/Local</td>
<td></td>
</tr>
</tbody>
</table>

Table A5.6b  Local Cable Pair Allocation
## Table A5.6c Fibre Allocation

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Red Tube</th>
<th>Neutral Tube</th>
<th>Green Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Service</td>
<td>Service</td>
<td>Service</td>
</tr>
<tr>
<td></td>
<td>(Transmission)</td>
<td>(Spare)</td>
<td>(CCTV)</td>
</tr>
<tr>
<td>1 Blue</td>
<td>PCM</td>
<td>Spare</td>
<td>CCTV</td>
</tr>
<tr>
<td>2 Orange</td>
<td>PCM</td>
<td>Spare</td>
<td>CCTV</td>
</tr>
<tr>
<td>3 Green</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
</tr>
<tr>
<td>4 Red</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
</tr>
<tr>
<td>5 Grey</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
</tr>
<tr>
<td>6 Yellow</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
</tr>
<tr>
<td>7 Brown</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
</tr>
<tr>
<td>8 Violet</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
</tr>
</tbody>
</table>
A6. POWER SUPPLY DESIGN

A6.1 Overview

1. 230 volt (+10%, -6%) single phase AC mains power supplies will be required for every item of outstation control equipment, Transmission Station (TS) buildings, and Control Office (CO) equipment.

2. Although all motorway communications equipment operates at 230v single phase, many communications power distribution centres are 3 phase, especially where combined with a lighting supply.

A6.2 Types of Installation

Motorway Supplies

1. Power supplies will normally be obtained from the Electricity Supply Company (ESC). On existing motorways, the existing supplies may need to be updated. The ESC will usually require at least 12 weeks notice for provision of new or increased supplies.

2. The Design Agent should site the supply points so that they are accessible both from within and outside the motorway boundary.

3. Supplies to roadside equipment are, at present, un-metered. However, should the ESC insist on a metered supply the Highways Agency (HA) cannot object.

4. Where there is no road lighting, the ESC supply will feed only the communications system. This supply should be brought onto the motorway at the nearest practical point in terms of providing reasonable access for maintenance and minimising the cost of providing the supply. The cable should be terminated in an interface cabinet sited in the motorway fence. This cabinet is known as an EI cabinet.

5. EI cabinets are usually Type 609, however, for larger distribution needs an alternative type of cabinet may be required.

6. Where the motorway is lit, the EI will usually provide a supply to a lighting feeder pillar which will also have a loop on the ESC side of the feeder pillar looping out to a separate communications EI cabinet. This practice avoids the tripping out of the communications system by a lighting circuit fault.

7. Older installations may have a single interface cabinet, even shared power circuits. These arrangements should be upgraded whenever practicable.

Local Supplies

8. Local supplies to equipment housed in Cabinet Types 600, 617, 620, a gantry or a cantilever, will require a local power isolation cabinet. This is usually a Cabinet Type 609 and is given the designation P.

9. Where a portal gantry carries both signals and illuminated signs, a single supply cable terminated in a P Cabinet near the base of the gantry will be required. The communications and sign lighting supplies will then be distributed from the P Cabinet.

Transmission Station Buildings

10. Power requirements for new TS buildings are detailed in MCL 10470. For existing Transmission Stations, refer to the HA.

Control Offices

11. Within COs, provision of power supplies should be decided following consultation with the police. The installation of NMCS2, air conditioning or CCTV equipment can increase the power requirements considerably.

12. CO equipment may require Uninterruptible Power Supplies (UPS), standby generators, and/or battery backup.

A6.3 Operational and Design Regulations

1. Electrical installations should conform, where applicable, with the following regulations:

   (i) BS 7671;

   (ii) Electrical Supply Regulations 1988 (as amended);

   (iii) Electricity at Work Regulations 1989;

Note: ii and iii are statutory regulations.
2. Where a consumer’s installation does not comply with the requirements of Chapter 13 of BS 7671 (Fundamental Requirements for Safety), the supplier is not compelled to provide a supply to that installation.

A6.4 Design - BS 7671 (IEE Wiring Regulations)

Background

1. BS 7671 shall be used for all installations.

2. Compliance with BS 7671 will achieve compliance with the relevant aspects of the Electricity at Work Regulations 1989.

Design Constraints

3. The following pointers are derived from BS 7671 and refer to the provision of power supplies to street furniture on motorways. They are not comprehensive and should not be used as a designer’s checklist; they do provide a good basis from which to work.

(i) Chapter 13 ‘Fundamental Requirements for Safety’.
These requirements should be met in full for every installation.

(ii) Chapter 31 ‘Purpose, Supplies and Structure’.
This indicates the need to consult the supplier to determine the nature of the supply and the need to sub-divide installations for reasons of safety and maintenance.

(iii) Chapter 32 ‘External Influences’.
This provides a checklist of environmental factors which may influence the design including:

(a) water (siting consideration),
(b) corrosion (oil and salt contamination possible in motorway environments),
(c) impact (siting consideration).

(iv) Chapter 34 ‘Maintainability’.
This requires that the frequency of maintenance and equipment down time is considered.

(v) Chapter 51 ‘Common Rules, Section 514’. This describes the requirements for labelling, notices and identification of equipment and circuits. With reference to Cabinet Types 600 and 609 containing power supplies, they comprise the following:

(a) a circuit diagram in every cabinet in accordance with Clause 514-09-01;
(b) A voltage warning notice on every cabinet in accordance with Clause 514-10-01;
(c) an isolation warning notice, where required, in accordance with Clause 514-11-01.
(d) an earthing and bonding notice where required, in accordance with Clause 514-13-01;
(e) an equipotential bonding notice where required in accordance with Clause 514 Section 611-Highway Power Supplies and Street Furniture.

Voltage Considerations

4. In accordance with Clause 525-01-02 of BS 7671, the voltage drop within the installation shall be restricted to a maximum of 4%.

Safety Considerations

5. In the case of alterations and additions to an installation, Clause 721-01-02 shall be met. This means that whenever power work is carried out in a Cabinet Type 600 or 609, the whole installation shall be reviewed.

6. A maximum disconnection time of 5 seconds shall be provided in accordance with Clause 611-02-04.

7. Where a gantry spans both carriageways a P cabinet shall be provided in both verges. The switching arrangement shall be such that the gantry can be isolated from either cabinet.

8. To meet the requirement of 412-03-04 (protection by barriers or enclosures), power isolation locations are needed to ‘switch off’ power. Whilst maintenance or alteration is carried out, these power isolation locations should be locked in the ‘off’ position. The key should be left with the senior person working on the installation.
A6.5 Design - Particular Requirements for Motorway Installations

Power Distribution

1. Power distribution networks for motorway communications should be star networks centred on EIs.

2. Luminaires on gantries are required to be divided equally into two separate circuits. Each circuit should be connected to the gantry isolation Cabinet Type 609 distribution unit.

3. With NMCS2, post mounted signals may be situated up to 4km away from the controlling Standard Transponder. Therefore, a Cabinet Type 609P should be installed in the verge opposite the central reserve mounted site equipment, for local isolation purposes.

4. Cabinets Type 600 which house NMCS2 electronic equipment are fitted with a PDU Type 1003D. This has a Residual Current Device (RCD) fitted across the incoming mains power supply to the cabinet. To avoid potential nuisance tripping from site equipment, all power supplies to site equipment local to the Cabinet 600 housing the Transponder, are obtained from a separate Cabinet Type 609P. This is located within 10m of the Cabinet Type 600.

Use of Alternative Cabinets

5. Where the Cabinet Type 609 does not provide sufficient space for terminations an alternative, non-standard type of cabinet may need to be provided.

6. Alternative cabinets shall provide similar or better protection from weather to that provided by a Cabinet Type 609.

A6.6 Design - Equipment Loads

General

1. Cable sizes should be calculated based on the equipment loads shown in Tables A6.6a - A6.6c and the cable characteristics given in Table A6.7a.

2. Design values should be checked with the Highways Agency during detailed design.

3. Each site should be designed for a minimum load of 2000W or 5000W for portal gantry or cantilever Motorway Signal Mark 2 (MS2) or Enhanced Message Sign (EMS).

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal (single sided) including signal controller</td>
<td>225</td>
</tr>
<tr>
<td>Signal (double sided) including signal controller</td>
<td>450</td>
</tr>
<tr>
<td>NMCS1 Responder including Cabinet 600 heater</td>
<td>250</td>
</tr>
<tr>
<td>NMCS2 Telephone Responder including Cabinet 600 heater</td>
<td>250</td>
</tr>
<tr>
<td>NMCS2 Standard Responder including Cabinet 600 heater</td>
<td>720</td>
</tr>
<tr>
<td>Cabinet 600 or 617 complete with heater</td>
<td>180</td>
</tr>
<tr>
<td>Cabinet 620 complete with heater</td>
<td>120</td>
</tr>
<tr>
<td>Loop Detector equipment</td>
<td>120</td>
</tr>
<tr>
<td>Fog Detector equipment</td>
<td>50</td>
</tr>
<tr>
<td>CCTV Camera outstation including Cabinet 600 heater</td>
<td>750</td>
</tr>
<tr>
<td>Fibre Optic Transmission Cabinet including heater</td>
<td>480</td>
</tr>
<tr>
<td>Telephone Bridging Unit (TBU) including Cabinet 617 heater</td>
<td>250</td>
</tr>
</tbody>
</table>

Table A6.6a Nominal Power Loads of Motorway Communications Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Message Sign (320 or 420mm) comprising EMS, Cantilever and Signal Driver cabinet and heaters</td>
<td>2500</td>
</tr>
<tr>
<td>Motorway Signal Mk2 (MS2) comprising EMS, EMI and Signal Driver cabinet and heaters</td>
<td>3500</td>
</tr>
</tbody>
</table>

Table A6.6b Design Maximum Power Loads of Enhanced Signals
Table A6.6c Nominal Power Loads of Gantry Sign Lighting

A6.7 Design - Power Cables

1. Bulk purchased 10mm² and 25mm² Power cable to TR 2153 should be used. Installation of cable of larger diameters should be avoided wherever possible as often the cost of providing, installing and maintaining these cables outweighs the cost of providing an additional supply local to the equipment concerned.

2. The electrical characteristics of 10mm² and 25mm² Power cable to TR 2153 are given in Table A6.7a and should be used for design.

### Table A6.7a Electrical Characteristics of Power Cable

<table>
<thead>
<tr>
<th>Cable Size (mm²)</th>
<th>Conductor Resistance</th>
<th>Maximum Current Rating Laid in Duct (A)</th>
<th>Volt Drop per Amp per Metre at Rated Current (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.83</td>
<td>75</td>
<td>4.1</td>
</tr>
<tr>
<td>25</td>
<td>0.727</td>
<td>124</td>
<td>1.65</td>
</tr>
</tbody>
</table>

A6.8 Power Cable on All Purpose Roads

1. Where power cable is installed on an All Purpose Road, armoured cable should always be used. The mechanical protection effected by the duct installation may not offer sufficient security on an All Purpose Road where excavation of the road is more common and less controlled than on the motorway.
A7. CABLE DUCTS

A7.1 General

1. The standard method of cable installation is non-armoured cable installed in duct.

2. The ducted network consists of 100mm diameter longitudinal ducts located in the verge or earthworks, offset at a nominal 2m from the back of hard shoulder, and transverse ducts at 500m centres crossing beneath the carriageway at right angles to it.

3. The ducted network is sealed.

4. Cable jointing chambers should be incorporated in the longitudinal duct runs every 500m (+2%, -5%) into which the transverse ducts will terminate. Additional chambers may also be required at obstructions and at cabinet sites to facilitate cable installation.

5. Cables for street lighting must not be laid in the same duct as cables for motorway communications.

A7.2 Material and Installation Standards

1. The material specification for ducts is given in the 1500 Series of the Specification For Highway Works (SHW). Ducts are manufactured from thermoplastic material.

2. Each length of ducting should be fitted with a non-rotting stranded draw cord and the duct ends fitted with purpose made compression plugs providing a water, air and gas tight seal, as detailed in the SHW.

3. Joints between adjacent lengths of ducts should be air and water tight. It is imperative that material such as silt, grout or concrete is prevented from entering the duct during the jointing process. Material such as this will cause damage to the cable during installation.

4. Ideally ducts should be laid in straight lines from one chamber to the next. In practice this will rarely be achievable due to the alignment of the motorway. Ducts should be installed to a smooth alignment which follows the road layout. Any changes in horizontal or vertical alignment will form pinch points where cables will incur damage during installation.

5. Longitudinal ducts should be located to the rear of all other services and equipment including safety fence, drainage and lighting columns. The nominal offset from the back of the hard shoulder should be 2m. Ducts should be installed in a trench with 600 mm of cover. Trench details for ducts are given on MCX 0814.

6. The optimum location for cable ducts is within a flat verge. This will automatically be achieved in areas where verge widening occurs or where additional land adjacent to the carriageway is required for other purposes, such as landscaping. However, the benefits of locating the ducts in a flat verge should be borne in mind during the early stages of design and additional verge width should be provided if there is opportunity to do so at no extra cost.

7. In some circumstances it will be necessary to deviate from the nominal offset. For example, where there is limited width available or non-existent conventional verges, such as in areas of retained cutting. In these cases the duct may be located under the hardened verge. Cable draw pits can be located either in the centre of the wheel-track zone in the hard shoulder or within the hardened verge.
8. Special consideration should be given to the installation of ducts at structures. If possible ducts should be buried in the hardened verge, but the presence of other services, or the design of the structure, may prohibit this and alternative arrangements should be made. It is important that 4 x 100mm ducts are provided. In the instances where it is not possible to provide 4 x 100mm ducts these locations should be marked clearly on the drawings to allow the cable designer to adjust the design accordingly. The Design Agent will require clearance to proceed from the Highways Agency (HA) where 4 x 100mm ducts are not proposed.

A7.4 Geotechnical Considerations

1. In the majority of cases, the ducts will be located within the earthworks slopes. The excavating of trenches in these slopes can lead to problems with slope stability. The geotechnical implications of this should be checked for each scheme. The problems can be overcome by taking the necessary precautionary measures during the design stage and by maintaining high standards of workmanship and control during construction.

2. In the early stages of design a geotechnical desk study should be undertaken using records compiled by the HA of all motorway earthwork slopes. Consultation with the Regional Geotechnical Engineer at an early stage is essential. Additional information, for example from trial pits, may be required.

3. The excavation of a trench at the toe of a cutting should be dealt with carefully as poor design and poor workmanship could lead to a local failure of the slope. Problems can be avoided by the use of a narrow trench (typically 0.5 m) and by ensuring that, during construction, trenches are excavated in relatively short lengths and not left open for extended periods. Proper specification of trench fill material combined with high standards of compaction will also minimise the risk of failure. Where a slope is identified as being at risk special precautions will be required in both design and construction.

4. The excavation of a trench at the crown of an embankment slope should also be approached with care. The problem in this instance would be that the trench could act as a drain, collecting surface run-off without having an outfall. The build up of water would, in cohesive soils, eventually saturate and weaken the surrounding soil. This problem can quite readily be avoided by the use of a properly specified and constructed trench detail and where necessary, by the use of special details such as a geotextile seal near the surface of the trench.

5. The location of longitudinal ducts within a flat verge, cutting and embankment is shown on MCX 0810.

A7.5 Transverse Ducts

1. Transverse ducts provide the means by which cables may cross carriageways from one verge to the other, from verge to central reserve and from one side of a slip road to the other.

2. Standard provision is for a group of four 100 mm diameter ducts at nominal 500m intervals as detailed on MCX 0814.

3. MCX 0810 shows a typical arrangement of carriageway crossings at slip roads and link roads.

4. The depth of transverse ducts is dictated by the following factors:

   (i) the pavement construction depth;
   (ii) the method of duct installation to be used;
   (iii) the need to ensure that adequate protection to the duct is achieved, both during construction and under long term vehicular loading;
   (iv) the location of drains; and,
   (v) whether the road is new or existing.

New Roads

5. For new roads, transverse ducts should be laid in a trench excavated in the material below the capping layer. Ducts should not be located within the capping layer as this could result in the formation of hard spots which could affect the surface of the carriageway above. The minimum cover to transverse ducts should be either:

   (i) 900 mm if the ducts are covered by a 150 mm thick concrete slab, or
   (ii) 1200 mm if no concrete cover is provided.
6. In all cases the ducts should be located at least 150 mm below the bottom of the capping layer, or if no capping layer is required, at least 150 mm below the formation level.

Existing Roads

7. Transverse ducts should be installed beneath existing carriageways, using trenchless techniques. The depths of these ducts will be dependent upon the material in which the ducts are to be located, the likely impact of the installation method on the surrounding ground and the location of drainage pipes. The minimum depths detailed above for ducts in trenches apply also to trenchless ducts, but these depths may have to be increased to ensure that the displacement of the surrounding ground does not affect the structural integrity of the pavement construction or capping layer.

8. It is imperative that as-installed records of pavement construction drainage and other services and geotechnical records are consulted when planning trenchless crossings of motorways.

9. A number of reliable well proven methods of trenchless duct provision are currently available including:

(i) Auger boring;
(ii) Guided, steerable moles;
(iii) Thrust boring;
(iv) Impact moling;
(v) Pipe ramming.

10. Careful consideration of factors such as ground conditions and local topography will be required before choosing a method of installation. The choice of an unsuitable method can have costly implications. It should be noted that when installing ducts in this manner it is advisable not to install ducts in close proximity to each other to avoid ducts clashing.

Special Arrangements at Structures

11. On long structures special arrangements may be necessary if transverse ducting at 500 m intervals cannot be provided. Early advice should be sought from the HA.

12. Special details will be required where ducts cross expansion joints.

13. Where separate viaducts are constructed for each carriageway, provision for cabling between the structures may be required.

A7.6 Local Ducts

1. Local ducts are used to connect equipment to the longitudinal and transverse duct network. One of the four ducts in the longitudinal network is allocated for local cabling.

2. Where additional local ducts are required for cabinets and signals they should be 100mm internal diameter and should run from the nearest type A or B chamber either directly to the signal or, via type C chambers, to the cabinet site. Separate ducts for communications and power cables should be provided. Local ducts forming connections to telephones should be 50 mm diameter.

3. Local ducts should be laid in the same trench as longitudinal ducts. MCX 0814 shows the standard trench detail for local ducts.

4. The connection of local ducts to cabinet sites, signals and telephones is shown on MCX 0811.

5. Where a cabinet site is located within 120m of a Type A chamber the local duct should be laid directly from the Type A chamber to the Type C chamber at the cabinet site as shown on MCX 0811.

6. Where the distance between the cabinet site and the nearest Type A chamber is more than 120m, a Type B chamber should be installed, on the line of the main duct run, at the cabinet site as shown on MCX 0812. A local duct is then installed from the Type B chamber to the Type C chamber at the cabinet site. The ducts allocated to longitudinal cables and spare should be continuous through the Type B chamber at this location.

A7.7 Use of Existing Ducts

1. Existing ducts are likely to be limited to transverse ducts and ducts at structures.
Transverse Ducts

2. Transverse ducts are often extremely difficult to locate on existing motorways. The most common reason for this being that duct marker posts and blocks were not provided and where they have been provided they have rarely been maintained. Inaccurate as-installed information regarding ducts is also a common problem. Agent Authorities should keep records of duct location and usage up to date.

3. As the cost of providing new transverse ducts is relatively high, the utilisation of existing ducts should be considered. This will only be acceptable where the existing ducts meet the material and installation standards described earlier in this TA, and where they occur at locations which suit the proposed cable network.

4. A locational survey of existing ducts should be undertaken during the design stage to establish where existing ducts can be used, where new ducts are required and where cable routes may be revised to avoid the need for new ducts. If approved by the HA, a CCTV survey should also be undertaken.

5. The survey should include accurate details of duct location (chainage and offset) and type, soundness of duct, its depth, diameter and the number and type of cables installed.

6. Empty ducts should be proved and cleared of debris using a mandrel.

7. Ducts containing existing cables should be used with extreme caution as cables will probably be snaked and twisted, the duct may be damaged internally and debris may have accumulated within the duct. Wherever possible, redundant cables should be identified and removed by the specialist Regional Maintenance Contractor (RMC).

Ducts at Structures

8. It will frequently be found that where longitudinal ducts have been installed at structures, they have been provided only for existing cables with no additional capacity. This additional capacity can generally be provided by one of the following methods:

   (i) At a bridge which has a safety barrier and separate fence or parapet, it is often possible to lay ducts between them;

   (ii) At a bridge which has no separate safety fence it may be practicable to attach ducts to the outside of a parapet;

   (iii) It may be possible to install ducts in the hardened verge;

   (iv) It may be possible to install ducts beneath the bridge surface, using the structure itself. For example, within a concrete box section or attached to steel girder sections.

The agreement of the Highway Agency’s Bridges Section responsible for the structure is required before proceeding with any of these options.

A7.8 Equipment Siting on Existing Motorways

1. When siting telephones, signals and other equipment on existing motorways, their locations should be planned such that the number of new duct crossings is minimised. In addition to cost, consideration should be given to the following factors:

   (i) the requirement for pairs of telephones (A and B carriageway) to be sited opposite each other (mandatory requirement);

   (ii) the maintenance advantages in having signals opposite their Transponder;

   (iii) the maximum desirable and permissible cable length between Transponders and their dependent signals;

   (iv) the vulnerability of cable in the central reserve to damage and the problems of subsequent repair or replacement.

A7.9 Ducts At Junctions

1. Ducts should be provided at junctions as shown in Figure A7.9a. It is important that all ducts start and finish on land belonging to the HA.

A7.10 Marker Tape

1. Ducts are installed in a trench as detailed on MCX 0814. The trench detail includes the installation of a detectable marker tape which will allow the ducts to be
located using electronic cable detecting equipment. It is important that adjacent lengths of marker tape are jointed correctly to achieve electrical continuity.

**A7.11 Duct Allocation**

1. Cables are installed into nominated ducts as detailed in the MCX 0800 series.

**A7.12 Cable Installation**

1. Cable installation should be undertaken strictly in accordance with the SHW and the Site Installation TAs.

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**Figure A7.9a Duct Arrangements at Junctions**

<table>
<thead>
<tr>
<th>NOTES</th>
<th>KEY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ducts shown are for communication requirements only. Additional ducts are required for lighting</td>
<td>4 100mm internal diameter ducts</td>
</tr>
<tr>
<td>2 The provision of ducts in the bridge structure and beneath the side roads may be required.</td>
<td>Ducts - see 2</td>
</tr>
</tbody>
</table>
A8. CHAMBERS

A8.1 Chamber Types

1. Three types of chambers are utilised within the ducted network as described below.

2. **Type A** - these are Main/Joint chambers. They are required to accommodate cable joints and at the junction of transverse and longitudinal ducts. They are 1.3m x 0.75m in plan and are sufficiently large to accommodate transverse, longitudinal and local ducts as well as joints and coiled cable. Details of this type of chamber are given on MCX 0815. Minimum depth of a jointing chamber is 1.2m.

3. **Type B** - these are intermediate chambers which should be located on longitudinal duct runs where changes in direction are encountered. They may be required where cabinet sites are located at a distance of more than 120m from the nearest A chamber. The maximum depth of a Type B chamber is 1.0m, where a deeper chamber is required a Type A chamber should be used. Details of this type of chamber are given on MCX 0815.

4. **Type C** - these are shallow chambers and are required in front of cabinets to ensure that the duct network remains enclosed. Details of this type of chamber are given on MCX 0815.

5. Additional chambers are required at other locations such as slip road crossings and at structures.

6. Where a Type B chamber is provided for access equipment/cabinet sites the ducts allocated for longitudinal cables and spare should run continuously, without a break, through the chamber.

A8.2 Chamber Siting

1. The siting of chambers will be determined by the cable network design and the location of ducts and equipment.

2. Type A chambers shall be located at cable joint locations, typically at 500m (+2%, -5%) intervals along the length of the longitudinal ducts. Preferably they will coincide with the position of transverse ducts and MIDAS loops (where present).

3. Type B chambers should be provided, as required, on the longitudinal duct run. Cabinets should generally be sited at the main/joint chamber locations. Type B chambers should only be required where equipment sites are further than 120m from the nearest Type A chamber and at changes of direction.

4. Type C chambers should be provided at cabinet sites as detailed on MCX 0812.

5. Type A and B chambers will generally be located at an offset of 2.0 m from the hard shoulder. It is likely that retaining walls may therefore be required at chamber locations. They should be designed to suit scheme specific topographical/geotechnical conditions. Consideration should be given, where appropriate, to adjusting the level of the top of the chamber in order to overcome the need for a retaining wall.

6. Where there is limited width available or non-existent conventional verges, such as in areas of retained cutting, chambers can be located either under the hardshoulder or within the hardened verge. It should be noted that wherever possible, chambers should be located away from obstructions or retained cuttings.

A8.3 Chambers at Structures

1. Where ducts are installed in structures, it is likely that they will be located at a different depth and offset to the main longitudinal duct run. This is due to the physical constraints of the structure.

2. At all such locations a chamber should be provided to allow cables to be installed. Generally, a Type B chamber should be provided; however, where the depth of the chamber will exceed 1m a Type A chamber will be required.

3. The difference in offset may require the provision of two chambers at each end of a bridge.

4. The location of safety fencing may affect the siting and construction of the chamber.
A8.4 Access

1. Cable Joint Enclosures and cable terminations are designed to be maintenance free. Therefore access to chambers will only be required during installation.

A8.5 Drainage

1. During the design of the duct network the drainage of water from chambers should be considered. A suitable method should be provided to allow the free drainage of water from chambers. This can be achieved either by the use of a soakaway or by a connection to the highway drainage network. Liaison with the Highways Agency’s drainage engineers will be required in order to arrive at the most appropriate design.

2. Chambers Type A and B are provided with a sump to allow the pumping out of water.

A8.6 Labelling

1. Chambers shall be labelled in accordance with the requirements of the Specification for Highway Works 1500 Series. This will involve either a metallic label on the chamber cover or an embossed legend reading ‘MOTORWAY COMMUNICATIONS’.
A9. ARMOURED CABLE INSTALLATIONS

A9.1 Direct Burial

1. Direct burial is no longer standard practice for the installation of motorway communication cables. However, there may be exceptional cases where this method is appropriate, such as in the replacement of short lengths of existing direct buried cable or a local improvement scheme.

2. MCX 0141 illustrates the trench detail to be used for direct burial.

3. All communications cables following a common route should share a common trench.

4. Power supply cables, other than those associated directly with the motorway communications system, should not share the same trench as communications cables. A minimum spacing of 0.5 m is required.

A9.2 Cable Trough

1. The use of trough units for longitudinal cables is not standard practice. Early advice from the Highways Agency should be sought where troughing is considered.

2. Standard details for the installation of cable trough are illustrated on MCX 0153.

3. Troughs should have a clear space, free from rubble and smooth internally, of 150 mm x 150 mm minimum or agreed alternative internal dimensions with covers in place.

4. Trough covers should be capable of being removed by one man. They should not break if dropped and should be able to withstand the effects of traffic passing over them without collapsing or damaging the cables within.

5. Troughing should be constructed on a straight grade and be self draining.

6. Trough units should not be laid on the surface as they will act as a ramp for errant vehicles and possibly cause a vehicle to overturn.

7. Special consideration should be given to the transition between trough and duct/trench where cables will be laid at shallow depths. Care should be taken to ensure adequate protection of cable.

A9.3 Cable Types

1. Where cable is to be installed by either direct burial or troughing, armoured cable, which is available from bulk purchase, should be installed (see Chapter A4 for cable types).

2. NMCS2 requires a 30-pair longitudinal cable. NMCS1 requirement is for 20-pair cable with 30-pair cable being used in certain high traffic areas.

3. Armoured cable requires testing by the installation contractor prior to acceptance to confirm the integrity of the cable sheath. The cable is coated with graphite to facilitate this testing.

4. Every length of armoured cable requires testing in accordance with MCG 1022 (Copper) or MCG 1055 (Composite Copper/Optical Fibre) by the installation contractor prior to termination.

A9.4 Armoured Cable Terminations

1. Armoured cable is terminated in Cabinets Type 609 using Termination Frames Type 13 for 20-pair, type 14 for 30 pair, enclosed in Boxes Type 615B.

2. The Box Type 615 originally had two large cable holes and two small cable holes. With the advent of NMCS2 and the requirement for many 2-pair connections, Box 615B was introduced. This has two large cable holes and six small cable holes.

3. Termination Frames Types 13 and 14 are available in three types as follows:

   (i) Type A - unloaded;

   (ii) Type B - fitted with 22mH loading coils; and,

   (iii) Type C - fitted with 22mH and 88mH loading coils.
4. The standard pattern for Termination Frames in Cabinets 609 at standard spacing (cable lengths of 500m) is:

... A - B - A - C - A - B - A - C - A ...

5. The first cabinet after the marshalling cabinet at a transmission station should contain a C frame; refer to MCL 5502 for further details.

6. An exception to this occurs with NMCS2 on the 88mH loaded pairs where Sector Interfaces and Sector Blocks are inserted. In these situations, the Sector Interface or Sector Block should be regarded as a TS as far as the loading pattern is concerned.

7. Fibre optic cables are terminated in accordance with MCX 0489.

**NMCS2 Main Longitudinal Cabling**

8. Type 14 Frames are fitted with two terminal blocks, at the top of the frame. These provide permanent tee-offs from the main longitudinal conductors. The pairs teed-off and their allocation are:

(i) pairs 1, 2 (HDLC)

(ii) pairs 3, 4, 5, 6, 17, 18 (telephone lines)

(iii) pair 21 (RS485 standard)

(iv) pair 22 (RS485 ATS).

9. Two spare pairs are also teed-off. The spare pairs are not soldered to the main conductor in the initial configuration of the frame. However, the tails will be connected into the BK12 terminal blocks at the top of the frame. The remote ends of the tails are provided long enough to reach the main conductors. Where this tee-off connection is required in the system design, the installation contractor solders the tails to the requisite main conductor(s) on the frame during installation. Numbered collets will be provided to all permanent teed connections. The spare tee-offs will not be provided with number collets.

10. Only the first carrier pairs (ie 13 and 14) will normally be soldered through. The secondary carrier pair terminal blocks (ie 15 and 16) will be provided with the normal cross connecting links between both sides of the frame.

11. Loading coils will be fitted and connected on the following pairs: 22mH coils to pairs 1 and 2 88mH to pairs 3,4,5,6,17 and 18.

12. When termination resistors are to be fitted to frames (eg on RS485 lines) the tee connection should be unsoldered from the link conductor. The link conductor should be disconnected.

13. Any cross-connection of cable pairs (ie the point of cable pair colour change) should take place in the local Box Type 615.

14. Loading patterns on longitudinal cables should be arranged in the same manner as NMCS1 installations for the 22mH loaded pairs.

15. Further information on termination frames is provided on MCX 0132.

**Build-Out Capacitors**

16. The arrangements for installing Build-out Capacitors are detailed in MCL 5502.
A10. CABINET SITING

A10.1 Cabinet Siting

Positioning

1. When assessing suitable sites for cabinets the designer should aim to provide sites which are safe both for maintenance personnel and motorists, and should have due regard for cost and for aesthetics. On a ducted network, cabinets should be located at the main/joint chamber sites to minimise the number of intermediate chambers required, and the length of local ducts.

2. Since cabinets are weatherproof, but not waterproof, they should be sited well above any likely flood level.

3. Cabinets should be grouped together wherever possible as this has maintenance and cost advantages.

4. Where the motorway is sited in a cutting or on an embankment, care should be taken to ensure that cabinets do not cause visual intrusion for local residents or users of adjacent land.

5. Care should be taken to ensure that proposed or existing landscaping planting will not cause access problems or obscure cabinets in future years. Liaison with the Highways Agency Landscape Architect during the planning stage is therefore necessary to coordinate the location of communications infrastructure and tree planting. When planning works on existing motorways, liaison with the Landscape Architect will be necessary in order to arrange for the removal of trees and shrubs.

Safety Fence

6. Safety fencing will be required for the protection of motorists and communication equipment at sites where cabinets or signal posts are sited less than 10m behind and 1m above the hard shoulder. It may be possible to site cabinets downstream of bridge piers or behind existing or planned safety fence. It may be possible to site a cabinet where it can be protected by an extension to existing or planned safety fence, this is more acceptable on both economic and safety grounds. Short gaps between adjacent lengths of safety fence should be avoided. Where necessary, additional fencing should be provided to close such gaps.

Retaining Walls

7. Special consideration should be given to the siting of cabinets in retained cuttings. Where cabinets are to be located at the top of such retaining walls, access from the hard shoulder should be provided. Where cabinets are located in cut-outs in retaining walls there may be difficulties in routing cables to cabinets.

8. Where retaining walls are required for cabinets they should be designed and detailed by the Design Agent.

Access

9. The siting of all cabinets should allow for maintenance access. The requirement is that access should be readily and easily available from a vehicle parked on the hard shoulder. This may require the provision of a safe means of access and egress for vehicles.

10. Cabinets which are sited remotely from the carriageway may require the provision of access steps as detailed on MCX 0138.

11. Maintenance staff are required to carry heavy test equipment to Cabinets Type 600. Therefore steps should be provided where access involves a gradient exceeding 1 in 2 for a height exceeding 400mm.

12. Where noise fences or environmental barriers are installed between a cabinet and the motorway, special provision should be made to allow access to the cabinet whilst maintaining an effective noise/environmental barrier.

13. Paved areas, constructed from standard paving slabs, should be constructed between access steps, cabinet hardstandings and the hard shoulder to provide a continuous, safe path.

A10.2 Special Arrangements

Telecommunications and Electricity Supply Interface Cabinets

1. Interface cabinets should be constructed in the line of the motorway boundary fence as detailed on MCX 0153 and MCX 0146. Cabinets should be sited so
that the whole of the foundation lies within land belonging to the Highways Agency.

**Marshalling Chambers at Transmission Station Buildings**

2. A marshalling chamber is required immediately adjacent to a Transmission Station (TS). All copper communications cables leading into a TS are terminated within the marshalling cabinet. Link cables are then installed between the TS and adjacent marshalling chamber. The cabinet and chamber arrangements are shown on MCX 0813.

**Cabinets on All-Purpose Roads Fed from Motorways**

3. This arrangement is shown on MCX 0566. Power cables installed on all purpose roads should be armoured cables.
A11. CONSTRUCTION DETAILS

A11.1 Foundations

Cabinet Bases

1. Cabinet Types 600, 609, 617 and 620 are manufactured for mounting onto a standard plinth (Plinth 610) which is bulk purchased by the Highways Agency (HA).

2. The foundation for a cabinet comprises a Plinth 610 cast into a concrete base as detailed on MCX 0140 and MCX 0812. It should be noted that the size of the foundation is to be determined by the Design Agent.

3. Foundations for other cabinet types are not covered by the standard details, they are designed by the Design Agent and submitted to the HA for approval.

4. Cabinet bases are filled with pea gravel; in addition, the bases of Cabinet Types 600 & 620 are sealed with epoxy resin to provide a waterproof environment inside the cabinet.

Signal Post Foundations

5. Foundations for signal posts will be designed by the Design Agent based upon the parameters given on MCX 0144. It should be noted that these foundations are subject to the Approval In Principle procedure. Adequate time should be allowed for this procedure.

A11.2 Hardstandings and Steps

Hardstanding

1. The standard of provision for hardstandings at cabinet and signal sites is given on MCX 0812. Generally, a hardstanding should be provided at every cabinet door. Where two or more cabinets occur at one site, they should be linked by a paved area.

2. Where cabinets are situated on cutting or embankment slopes, consideration should be given to the provision of handrailing to protect maintenance personnel from the risk of falling.

Steps

3. Typical access steps for cabinets are detailed on MCX 0138.

4. Where steps are specified, the designer should consider the Health and Safety implications of the specified layout. Consideration should be given to the provision of handrailing alongside steps and also landings with guardrails to limit the height of individual flights of steps.

5. Where steps are provided, they should be linked to cabinet sites by a path constructed from standard paving slabs.

A11.3 Duct Installation Details

1. Ducts are installed in trenches as detailed on MCX 0814.

A11.4 Chamber Details

1. Chambers are constructed in accordance with MCX 0815.
A12. TRANSMISSION STATIONS

A12.1 Overview

1. The motorway communications cable system has a transmission network based on Transmission Stations (TSs). These are located at all interchanges and at intervals not exceeding 20km between interchanges. Transmission Stations are housed either in purpose built buildings or in Cabinets Type 617.

2. TSs housed in cabinets provide facilities for amplification of speech and control circuit signals. They also provide facilities for cross-connection within or between the Highways Agency's (HA's) cables or between the HA's cables and the Private Wire (PW) network.

3. TSs housed in buildings provide all facilities and a multi-channel High Frequency (HF) carrier system which provides a countrywide figure of eight network.

4. The amount of equipment required in a TS, particularly one associated with CCTV equipment, may justify the provision of a building (even if HF carrier equipment is not involved). Therefore, the designer will need to confirm the requirements for each TS with the HA at an early stage.

A12.2 Siting Considerations

1. All TS require a mains power supply, access to the Public Switched Telephone Network (PSTN) and provision of dedicated PW. They also require, where possible, access from all-purpose roads so that maintenance staff can attend to equipment without using the motorway. Connection to the PW network can be achieved by using a length of motorway cable, this allows the interface cabinets to be sited remote from the TS.

2. Sites need to be selected with a view to their relationship to the main cable run; cable between the TS and the main longitudinal cables should be kept to the minimum. The route selected should be reasonably immune from the risk of cable damage by trenching, tree planting or similar activities.

3. Cables installed outside the motorway boundary (eg in works units) require mechanical protection against damage from excavation.

4. Works units frequently provide suitable sites for a TS. When these are used, care should be taken to keep away from salt stores. Also, arrangements need to be made to ensure 24-hour access to the TS.

5. When siting a TS, particular care should be taken to ensure the following:

   (i) Reasonable facilities are available for parking;

   (ii) Access is available for staff carrying test equipment from the all-purpose road and the motorway;

   (iii) Hardstanding for emergency trailer is available;

   (iv) All cabinets buildings and parking areas are sited on motorway land;

   (v) All cabinets and buildings are safe from vehicles straying from the motorway. This can be achieved by siting the station on the downstream side of a bridge or by the provision of safety fencing.

6. It is most important that the site chosen, whether for a building or a cabinet, should be immune from flood risk.

7. In certain areas it may be necessary to plant a screen of trees or take other measures to reduce the environmental intrusion caused by a TS building.

Transmission Station Building Specification

8. Refer to MCL 10470, for the Transmission Station Building Specification.

Cabinet Type 617

9. The Cabinet Type 617 TS fits onto the standard 610 plinth. Designers should seek the advice of the HA if proposing to install a new Transmission Station in a Cabinet Type 617.

Further Information

10. For further information on Transmission Stations refer to TA 75/95 : Motorway Transmission.
A13. GEOGRAPHIC ADDRESSING

A13.1 Motorway Address Coding

General

1. Motorway roadside equipment such as telephones, signals and CCTV cameras is identified by means of an address code. This address comprises three elements:

(i) Motorway identifier;

(ii) Marker post reference; and,

(iii) Carriageway identifier.

These elements combine to produce an address in the form:

1 2 3 4 A

where:

1 is the motorway identifier

234 relates to the nearest marker post (in this case mp 23/4)

A is the carriageway identifier.

A fifth digit may be added after the letter if it is necessary to identify a carriageway lane. Lane signals, for example, will have a number to identify the lane to which they apply.

Motorway Identifier

2. Every motorway has its own identifier as shown in Table A13.1a.

3. The identifiers have been chosen to avoid, where possible, the duplication of numbers within Control Office Areas.

Carriageway Identifier

4. The mainline carriageways are identified as A and B carriageways. Where motorways emanate from London the outward carriageway is designated A. On other motorways the designations A and B are arbitrary. Marker post numbers always increase in the direction of travel on the A carriageway.

<table>
<thead>
<tr>
<th>Motorway</th>
<th>Identifier</th>
<th>Motorway</th>
<th>Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>2000</td>
<td>M66</td>
<td>4000</td>
</tr>
<tr>
<td>M2</td>
<td>8000</td>
<td>M67</td>
<td>8000</td>
</tr>
<tr>
<td>M3</td>
<td>1000</td>
<td>M69</td>
<td>7000</td>
</tr>
<tr>
<td>M4</td>
<td>2000</td>
<td>M79</td>
<td>1000</td>
</tr>
<tr>
<td>M5</td>
<td>7000</td>
<td>M180</td>
<td>1000</td>
</tr>
<tr>
<td>M6</td>
<td>5000</td>
<td>M181</td>
<td>1000</td>
</tr>
<tr>
<td>M10</td>
<td>1000</td>
<td>M211</td>
<td>2000</td>
</tr>
<tr>
<td>M11</td>
<td>6000</td>
<td>M245</td>
<td>5000</td>
</tr>
<tr>
<td>M18</td>
<td>7000</td>
<td>M271</td>
<td>9000</td>
</tr>
<tr>
<td>M20</td>
<td>6000</td>
<td>M275</td>
<td>9000</td>
</tr>
<tr>
<td>M23</td>
<td>3000</td>
<td>M381</td>
<td>4000</td>
</tr>
<tr>
<td>M25</td>
<td>4000</td>
<td>M382</td>
<td>3000</td>
</tr>
<tr>
<td>M26</td>
<td>2000</td>
<td>M383</td>
<td>5000</td>
</tr>
<tr>
<td>M27</td>
<td>9000</td>
<td>M384</td>
<td>6000</td>
</tr>
<tr>
<td>M32</td>
<td>5000</td>
<td>M602</td>
<td>6000</td>
</tr>
<tr>
<td>M40</td>
<td>8000</td>
<td>M606</td>
<td>2000</td>
</tr>
<tr>
<td>M42</td>
<td>6000</td>
<td>M621</td>
<td>1000</td>
</tr>
<tr>
<td>M45</td>
<td>5000</td>
<td>A01(M)</td>
<td>9000</td>
</tr>
<tr>
<td>M50</td>
<td>2000</td>
<td>A1(M)</td>
<td>9000</td>
</tr>
<tr>
<td>M53</td>
<td>9000</td>
<td>A3(M)</td>
<td>5000</td>
</tr>
<tr>
<td>M54</td>
<td>3000</td>
<td>A20(M)</td>
<td>7000</td>
</tr>
<tr>
<td>M55</td>
<td>5000</td>
<td>A38(M)</td>
<td>3000</td>
</tr>
<tr>
<td>M56</td>
<td>8000</td>
<td>A48(M)</td>
<td>4000</td>
</tr>
<tr>
<td>M57</td>
<td>2000</td>
<td>A66(M)</td>
<td>4000</td>
</tr>
<tr>
<td>M58</td>
<td>7000</td>
<td>A329(M)</td>
<td>9000</td>
</tr>
<tr>
<td>M61</td>
<td>2000</td>
<td>A404(M)</td>
<td>2000</td>
</tr>
<tr>
<td>M62</td>
<td>1000</td>
<td>A5103</td>
<td>5000</td>
</tr>
<tr>
<td>M63</td>
<td>3000</td>
<td>A627(M)</td>
<td>6000</td>
</tr>
<tr>
<td>M65</td>
<td>4000</td>
<td>A901(M)</td>
<td>0000</td>
</tr>
</tbody>
</table>

Table A13.1a Motorway Identifiers

5. Slip roads are lettered as follows:

(i) J - exit from A Carriageway;

(ii) K - entry to A Carriageway;

(iii) L - exit from B Carriageway;

(iv) M - entry to B Carriageway.

This is illustrated on Figure A13.1a.
6. These letters are used within interchanges - refer to D13.2 for the procedure to be followed at interchanges.

7. Carriageway lanes are numbered from the rearside; the lane adjacent to the hardshoulder is numbered 1.

Link Roads (Collector - Distributors)

8. Proposals for labelling link roads (formerly designated Collector - Distributors) should be submitted to the DOENI at an early stage.

A13.2 Motorway Interchanges

1. At motorway interchanges there are several linking roads to identify. In an ideal full cloverleaf, there are eight links, each of which originates from and connects to a motorway.

In practice the following may occur:

(i) There may be considerable variations in geometry;

(ii) One or more of the eight links may be missing;

(iii) Links may merge, such that a section of road combines the functions of two or more links.

2. For each section of linking road, its function should be determined, in terms of which carriageway it takes traffic from, and which carriageway it takes traffic to. It should be determined whether this represents a left turn or a right turn. For sections of road with more than one function left turns should take precedence.

3. Linking roads representing left turns are numbered and lettered from the motorway having the lower identifier. The motorway with the lower identity number may have a higher motorway number. For example M6/M62; M6 identifier is 5000, and M62 identifier is 1000. Linking roads representing right turns are numbered and lettered from the motorway having the higher identifier.

4. Linking road ‘site’ numbers are produced by taking the number of the marker post at the centre of the interchange and replacing the last digit by 0. The first item of equipment to be installed on the linking road is identified by adding 1 to the number, the second by adding 2, and so on.

5. The above explanation is illustrated by Figure A13.2a, which shows a hypothetical interchange between motorway identity number 2000 at centre marker post 72.0 and motorway identity number 6000 at centre marker post 21.3.

6. Arrangements sometimes need to be varied to suit individual layouts, particularly when an interchange is combined with a junction or when more than two motorways are present at an interchange. Consultation with the Highways Agency is required where such non-standard arrangements are being considered.
Figure A13.2a Motorway to Motorway - Example of Interchange Telephone Address Coding
A14. LABELLING

A14.1 General

1. Address code labels are used by the police on site when requesting the setting of signals. The address code label on emergency telephones enables motorists to inform the police control office of their precise location. The accuracy and legibility of these labels is therefore of prime importance.

2. Accurate and legible informatory labels on the outside of cabinets are essential for the efficient working and safety of maintenance personnel.

3. It should be noted that the Engineer is responsible for specifying names, numbers and lettering on informatory and address coding labels.

Chambers

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

Cabinets

5. Informatory, address coding and warning labels should be provided on cabinets and signal posts in accordance with MCX 0145 or MCX 0306.

Signals

6. Gantry legs should be provided with labels showing their address code in accordance with MCX 0145.

Telephones

7. Address coding labels are to be provided on telephones as shown on MCX 0147.

Warning Labels

8. A ‘laser’ warning label in accordance with MCX 0306 should be fitted to all equipment containing fibre optic cable terminations.

9. It should be noted that an Electrical Safety and Inspection Label in accordance with MCX 0171 should be fitted (and maintained) inside all signal posts and Cabinet Types 600, 617, 620 and 609 power cabinets.

10. Other equipment which is connected to an electrical supply (eg, Signal Controllers, IPDUs, Distributors 901) should be fitted with electricity warning labels as shown on MCX 0145.

11. Cabinets and equipment should be labelled internally in accordance with BS 7671.

Cables

12. Cables should be identified using labels as detailed in the MCX 0800 series of drawings.

Cable Joint Enclosures

13. Cable Joint Enclosures should be labelled as detailed in MCE 2183.
A15. GLOSSARY

Armoured Cable
A cable which incorporates a layer of steel wire wrapped helically around the cable to provide mechanical protection from damage. The armour wire is protected from moisture by a polyethylene sheath. The sheath is coated with graphite - this graphite coating is used when testing the integrity of the sheath.

Box Type 615
A standard enclosure which is used to house termination frames in 609 Cabinets.

Break Jack
A plastic plug which is inserted into an Insulation Displacement Connector (IDC) to break the internal connection.

Build Out Capacitor
Capacitors use to equalise cable lengths to the standard length of 500m. The additional capacitance equates to that required to make the cable length appear to be 500m. Located in the Cable Joint Enclosure (CJE) furthest from both TS.

Bulk Purchase
Standard items of motorway communications equipment are purchased by the Highways Agency in quantity. This ensures the equipment conforms to the relevant specifications, is available from several sources and benefits from economies of scale.

Cabinet Type 600
Standard motorway equipment cabinet, for use on motorway verges, to house equipment such as Standard Transponders, MIDAS Transponders, Responders, Sector Interfaces and Sector Blocks. Also used as a Marshalling Cabinet.

Cabinet Type 609
Standard motorway cable connection cabinet, for use on motorway verges, to house connection boxes for data, and also used to house (separately) electrical power supply distribution and isolation equipment.

Cabinet Type 617
Standard motorway cabinet, for use on motorway verges, to house transmission equipment.

Cabinet Type 620
Standard motorway cabinet, for use on motorway verges, to house interfacing to circuits provided by a Public Telecommunications Operator.

Cable Joint Enclosures (CJE)
Environmentally sealed enclosure housed in underground chambers used to contain cable terminations, and in some cases, loading coils. CJE are available in the following types:

<table>
<thead>
<tr>
<th>Type 15</th>
<th>Use</th>
<th>No. of Cables to be Accommodated</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>Unloaded</td>
</tr>
<tr>
<td>2</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 22 circuits loaded at 22mH.</td>
</tr>
<tr>
<td>3</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 6 circuits loaded at 88mH.</td>
</tr>
<tr>
<td>4</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 28 circuits loaded as 22mH.</td>
</tr>
<tr>
<td>L</td>
<td>Local distribution 3 x 40 pair and 6 x quad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSI</td>
<td>Rural signal interface 4 x quad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFC</td>
<td>High frequency carrier joint 4 x carrier quad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Optical Fibre Cables 3 x 24 fibre</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Type RSI are housed in Cabinets Type 609

Carrier
A signal comprising several individual signals multiplexed together. The carrier signal is at a higher frequency than the individual signals in analogue transmission and at a higher bit rate in digital transmission.
**Carrier Quad Cable**
A cable comprising 4 conductor wires used for transmitting high frequency Frequency Division Multiplex (FDM) signals.

**Chambers**
Underground structures of a standard size used to house cable joints and to facilitate cable installation.

<table>
<thead>
<tr>
<th>Type</th>
<th>Plan Size (mm)</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1300 x 750</td>
<td>To house cable joints</td>
</tr>
<tr>
<td>B</td>
<td>600 x 600</td>
<td>Cable installation at changes of direction; access to Transverse ducts.</td>
</tr>
<tr>
<td>C</td>
<td>450 x 450</td>
<td>Cable distribution at cabinet sites.</td>
</tr>
</tbody>
</table>

Chambers may be constructed from brick, plastic or concrete.

**Closed Circuit Television (CCTV)**
A system using remotely controlled television cameras to monitor traffic patterns at sites susceptible to traffic congestion such as tunnels, junctions and interchanges. The images are transmitted from the camera to the Control Office (CO) over the fibre optic cable infrastructure.

**Control Office (CO)**
The Control Office (CO) is the location from where the Highways Agency’s motorway communications equipment, for the motorways in a given Police Force Area, are controlled. The CO is used by the Police Authority for day-to-day control of motorway traffic. More than thirty Police Authorities are involved in operating the national system, each Police Authority being issued with a code of practice approved by the Association of Chief Police Officers, in order to standardise the use of motorway signals for each region.

**Control Room**
The part of the Control Office where the operators answer telephone calls, set signals and, where available, monitor CCTV and operate other equipment. Sometimes shared with other Police Operations and equipment.

**Direct Burial**
A method of cable installation which involves burying armoured cable in a trench.

**Distributor Type 901**
Electrical distribution switch for use with signals on gantries.

**Duct**
A plastic pipe buried in the ground.

**Duct Plug**
A mechanical device which is inserted into the end of a duct within a chamber. It seals the end of the duct from gas, air and water. Allows the installation or removal of cable into or from the duct.

**Ducted Cable Network**
A sealed network of buried ducts in the motorway verge, with connections crossing beneath the carriageway. The ducted network is used for the installation of motorway communications cables. Cables are jointed in sealed joints which are housed in underground chambers.

**Electricity Supply Company (ESC)**
A company that provides electricity supplies.

**Electricity Supply Company Interface (EI)**
An electrical power supply provided by an Electricity Supply Company at the motorway boundary.

**Enhanced Message Sign (EMS)**
A sign which is used to display a variety of legends or messages. The legend or message is controlled from the instation. EMS has 2 rows of 12 characters. Can be mounted on a gantry or cantilever.

**Equipment Room**
The part of the Control Office (CO) that houses the electronic equipment required to interface with the outstation devices and the operator interfaces within the Control Room.

**High Frequency Carrier (HFC)**
The High Frequency Carrier system is an analogue transmission system where individual 4KHz bandwidth signals are multiplexed with a higher frequency signal, the carrier, to allow the signals to share the transmission circuit.
High-level Data Link Control (HDLC)
A protocol, at link level, which forms the basis of all inter-station communications on the NMCS2 data system, Closed Circuit Television (CCTV) system and the Regional Communications Controller (RCC) network. When each station communications link is set up, point to point or multidrop, the delivery, security and integrity of each frame of data is assured.
HDLC is the basis of a family of protocols which form the main data highway(s) for communication between Data Base Processor, Local Communications Controller, Regional Communications Controller and Transponders providing the packet message handling network.

Insulation Displacement Connector (IDC)
A terminal that makes contact with the conductive metal core of a wire by cutting into the insulation such that the insulation is displaced but not removed.

Indicator Panel Drive Unit (IPDU)
An NMCS2 unit local to a signal.

Loading/Loaded
A cable pair is said to be loaded when its characteristic impedance has been altered. Loading is achieved by including inductance coils over the total length at joints between individual cable lengths.

Local Cabling
Cabling other than the longitudinal cabling, used to connect devices to the longitudinal cable or control equipment.

Longitudinal Cable
The 40 pair copper and 24 fibre cables (two separate cables) running parallel to the motorway in the duct network, each pair and fibre is dedicated to a specific purpose. Historically 20 pair NMCS1 and 30 pair NMCS2 cables were direct buried. The 20/30 pair copper cables may be augmented by composite copper/optical fibre cables dedicated to CCTV or carrier circuits.

Marker Tape
A plastic tape buried in the ground above ducts and cables to indicate their presence. Marker tape used on the ducted network includes a metallic film which allows the type (and therefore the ducts) to be detected, using detection equipment, without disturbing the surface.

Marshalling Cabinet
A Cabinet Type 600 immediately outside a Transmission Station (TS) into which all the longitudinal copper cables are terminated and jointed to cables from the TS.

Microwave Radio Link
Non cable based radio transmission system using frequencies in the GHz range. Can use either digital or analogue transmission.

MIDAS Detector
Equipment installed in a Cabinet Type 600 which processes information received from cable loops buried in the carriageway which detect the presence of vehicles. The configuration of loops allows speed to be determined.

MIDAS Transponder
A Transponder dedicated to MIDAS and not used by other devices or subsystems.

Motorway Incident Detection and Automatic Signalling (MIDAS)
A Control Office Base System (COBS) Subsystem which monitors traffic flow conditions and interacts with signal subsystems to automatically set signals without operator intervention. Signals are set when a queuing traffic is detected.

Motorway Signal Mark 2 (MS2)
A motorway signal comprising an Enhanced Matrix indicator (EMI) and an Enhanced Message Sign (EMS) mounted on a cantilever structure.

Multidrop Link
A transmission channel that allows a master device to communicate with several devices over the same channel.

National Motorway Communications System (NMCS)
The motorway traffic control and emergency telephone network adopted to serve the motorways of England.

National Motorway Communications System 1 (NMCS1)
A combined signalling and telephone system controlled from Regional and National central processors, installed up to 1988.

National Motorway Communications System 2 (NMCS2)
A system using locally based distributed processing to control telephones and signals, installed from 1988.
National Transmission Network
The National data transmission network linked by the Regional Communications Controllers (RCC).

Power Distribution Unit (PDU)
A Power Distribution Unit provides distribution and isolation, for equipment within a cabinet. Separate protected outgoing circuits (ways) are provided for equipment from the incoming circuit, together with a circuit for the cabinet heater (Cabinets Type 600, 617 and 620 have anti-condensation heaters).

Private Wire (PW)
A dedicated permanent circuit provided by a Public Telecommunications Operator between two locations.

Public Telecommunications Operator (PTO)
A licensed provider of Public accessible telecommunications services (eg. British Telecommunications Ltd, Mercury Communications Limited).

Public Switched Telephone Network (PSTN)
PSTN is provided by a Public Telecommunications Operator (eg. British Telecommunications Ltd, Mercury Communications Limited), ie a telephone connection accessed by the user dialling numbers.

Pulse Code Modulation (PCM)
Pulse Code Modulation is a process of converting an analogue signal into a digital signal. A sample of the analogue signal is taken and equated to the nearest digital level. Each digital level is associated with a binary code. This code is transmitted instead of the analogue signal. This process operates on an individual signal and does not create additional capacity. The analogue signals are sampled at 8KHz and produce 8-bit codes. This gives a single channel with a bit rate of 64,000 bits per second or 64Kbit/s.

PCM is commonly used to describe multi channel digital transmission systems. This is not totally correct as PCM is not a transmission system. PCM is generally used with Time Division Multiplexing (TDM) transmission systems.

Quad Cable
A 4 wire cable in which all the wires are twisted (laid) together, rather than in 2 pairs. This reduces cross pair interference where the pairs are used as the same channel.

Regional Maintenance Contractor (RMC)
A Contractor responsible for the day to day maintenance of instation and outstation equipment. Also has first line responsibilities for the transmission equipment in their region.

Residual Current Device (RCD)
An electrical safety device that isolates (disconnects) a circuit from the power source when a fault occurs.

RS485
A data protocol (EIA RS485) and practice adopted for use by NMCS2 between the Standard Transponder and motorway devices.

The RS485 Multidrop Link is the lowest hierarchical level of transmission in an NMCS2 data system and provides the means, parameters and protocol of communication between Transponders and motorway devices. It allows the Transponder to control several devices at once or individual devices. However, individual devices can only transmit to the Transponder. Transmission is half duplex, ie transmission in only one direction at once. Each link caters for up to 30 motorway devices. Each message comprises 5 characters of 8 data, 1 parity, 1 start and 1 stop bits. The characters represent address, command, data byte 1, data byte 2 and longitudinal parity.

Sector Block
An NMCS2 telephone system unit, it is a term for a Sector Switch operating in a subordinate role to a Sector Switch and is capable of switching Blocks only. Sector Blocks are only used when the complexities of the telephone do not require this additional level of switching.

Sector Interface
An NMCS2 telephone system unit. Sited at the most strategic point in the motorway, the SI is the most significant telephone node in the Control Office area network. The SI provides, for the telephone system, the transmission system facility for common speech and data circuits. It comprises 4 ports which are themselves comprised of Sector Switches needing one Sector Switch for each Telephone Line Controller the port serves. It provides an interface between the Telephone Line Controller and the lower order telephone switching stations.
Signal Controller
An outstation device local to a signal dedicated to controlling a signal.

Standard Transponder (ST)
Standard Transponder is at the lowest hierarchical level within the Control Office Area. It interfaces to Local Communications Controller/HDLC links and provides a star point on the RS485 local links. It also provides some of the signal sub-system functions and a post box service to other sub-systems. It controls up to 120 motorway devices.

Telephone Responder
A motorway based mini telephone exchange controlling the connection of telephones with an NMCS2 Control Office.

Transmission
Telecommunications terminology for the sending and receiving of signals.

Transmission Station (TS)
A Transmission station is an outstation unit provided to house telecommunication equipment required to allow successful communications between the Instation and Outstation Services. The TS are either buildings or cabinets Type 617 and are spaced at approximately 20km intervals within a Control Office area.

Uninterruptible Power Supply (UPS)
A power supply device which prevents failure of the main power supply from disrupting the operation of equipment. A UPS will usually be of sufficient capacity to allow a secondary power supply (eg a generator) to be brought into operation, initiate alarms and in some cases initiate a controlled shutdown of equipment.

2 Wire
A circuit which uses 2 conductors, a single pair for both transmitting and receiving.

4 Wire
A circuit which uses 4 conductors, 2 wires for transmitting and the other 2 wires for receiving. The cable may be constructed in pairs or as a quad cable.
A16. REFERENCES

BS 7671 - Requirements for Electrical Installations
Electricity Supply Regulations
Electricity at Work Regulations
TA 75/95 : Motorway Transmission (DMRB 9a.4.4)
Manual of Contract Documents for Highway Works:
  Volume 1 - Specification for Highway Works
  Volume 3 - Highway Construction Details
TR 2029 - Inductive Loop Cable for Inductive Loop Systems
TR 2031 - Armoured Feeder Cable for Inductive Loop Systems
TR 2150 - NMCS Copper Communications Cable
TR 2151 - NMCS Optical Fibre Communications Cable
TR 2152 - NMCS Co-Axial Communications Cable
TR 2153 - NMCS Energy Cable
TR 2158 - NMCS Armoured Copper Communications Cable
TR 2159 - NMCS Armoured Optical Fibre Communications Cable
TR 2160 - NMCS Armoured Co-Axial Communications Cable
TR 2161 - NMCS Armoured Energy Cable
MCE 2015 - CCTV Control Systems
MCE 2183 - Ducted Cable Network - Cable Joint Enclosure Specification
MCG 1022 - Testing for Newly Installed Communications and Power Cable
MCG 1055 - Testing newly installed Mono-Mode Fibre Optic Communications Cable
MCG 1099 - Ducted Cable Network - Cable Testing Specification
MCH 1589 - Guide to the Siting of Inductive Loop Detectors on Motorways
MCL 5502 - Technical Guide to Loading of DTP Motorway Communications Cables
MCL 10470 - Transmission Station Building Specification
PART 1

TA 77/97 Annex C (Wales only)

MOTORWAYS

SUMMARY
This Annex to Advice Note TA 77/97 is for the specific requirement of motorway communications in Wales.

INSTRUCTIONS FOR USE
This is a new document to be inserted into the Manual.

1. Insert TA 77/97 Annex C into Volume 9 Section 5.

2. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from the Stationery Office Ltd.
VOLUME 9 NETWORK - TRAFFIC CONTROL AND COMMUNICATIONS
SECTION 5 INFRASTRUCTURE DESIGN

PART 1

TA 77/97 Annex C (Wales Only)

MOTORWAYS

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10. Cabinet Siting
11. Construction Details
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15. Glossary
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C1. INTRODUCTION

C1.1 General

1. This Annex is for the specific requirement of motorway communications in Wales.

DMRB Structure

2. Volume 9 of the Design Manual for Roads and Bridges (DMRB) is a compilation of Technical Advice (TA) Notes reflecting current practice in the field of motorway communications and control.

3. Related Technical Directives (TD) which detail the Standards of Provision are contained in Volume 9 of DMRB.

Design Loop

4. Figure C1.1a shows the ‘Design Loop’ illustrating the general sequence in the iterative design process which starts with the design for emergency telephones and signals followed by transmission and control office designs. Last in the cycle is the design of the infrastructure that will be required to support all communications equipment and systems.

Glossary

5. A Glossary of Terms is given in Chapter C15.

Standard Drawings and Specifications

6. Standard drawings and specifications are issued by the Welsh Office Highways Directorate (WOHD); reference may be necessary to other related documents that are issued by Network Control Division (NCD) of the Highways Agency (HA), eg, MCX, MCH and TR documents.

Figure C1.1a Structure of Volume 9 and 9a of the Design Manual for Roads and Bridges
C2. OVERVIEW

C2.1 General

1. The WOHD has upgraded its infrastructure from 20-pair copper to 30-pair copper cable and 24-fibre optic cable. The Welsh Office consider that this infrastructure will accommodate their requirements for the foreseeable future.

2. Cables are buried in the soft verge beyond the hard shoulder of the motorway, the method being described in greater detail in Chapter C9.

Cable Types

3. The following types of cable are installed:

   (i) longitudinal 30 pair copper cable;
   
   (ii) longitudinal 24-fibre cable;
   
   (iii) local 2-pair cable to equipment;
   
   (iv) power cable to equipment;
   
   (v) coaxial cable to equipment; and,
   
   (vii) loop detector and feeder cables.

4. Whatever methods of cable installation are used, it is of paramount importance that the cable is adequately protected from possible damage during future maintenance works and from errant vehicles.

5. Physical constraints, such as structures, may cause a departure from the normal method. In these cases other techniques may need to be considered. However, where the use of an alternative installation method is proposed, early advice should be sought from the WOHD.
C3. NETWORK DESCRIPTION

C3.1 Introduction

1. The network comprises the following, which are described in this Chapter:

   (i) cable network;
   (ii) ducts;
   (iii) roadside electronic equipment;
   (iv) power supplies;
   (v) Telecommunications Interfaces;
   (vi) Control Offices.

2. During the design stage the designer should be aware of the existing cable network and the effect which the design will have upon it.

C3.2 Non-Armoured Cable Network

1. Non armoured cable installed in ducts is not employed in Wales.

C3.3 Armoured Cable Network

1. Armoured cable is installed in trench (direct burial) or in trough.

Longitudinal Copper Cable Network

2. Longitudinal 30-pair copper cable carries data between roadside equipment, including telephones and signals, and their respective Control Offices. Longitudinal cable is installed in nominal 500m lengths. A Cabinet 609C(W) is provided at each end of a cable length to house the terminations.

3. Transmission Stations (TS) are provided at approximately 20km intervals on the longitudinal cable network.

Local Cabling

4. Roadside equipment, including emergency telephones and signals, is connected to the longitudinal cable by local 2-pair cables. Connections are made either in Cabinets 600(W) or in Cabinets 609C(W), as appropriate.

Optical Fibre Cable

5. An optical fibre cable, with 24 fibres, is being installed for longitudinal video transmission required by the Closed Circuit Television (CCTV) system. The longitudinal optical fibre cable is terminated at nominal 1000m intervals in Cabinets 609C(W). Where provided for CCTV schemes optical fibre cable is also used for Pulse Code Modulation (PCM) transmissions in Wales.

C3.4 Ducts

1. Ducts are used for cable access between opposite sides of the carriageway and to the central reserve for matrix signals.

C3.5 Roadside Electronic Equipment

1. Roadside electronic equipment is housed in Cabinets 600(W). They are sealed and contain thermostatically-controlled heaters and power distribution units.

2. This equipment includes Emergency Telephone Bridging Units, Standard Transponders, MIDAS Detectors, EMS/MS2 equipment and CCTV equipment.

C3.6 Power Supplies

1. The Regional Electricity Company (REC) interface equipment is housed in Cabinets 609C(W) Electricity Board (EB) cabinets which are installed in the motorway boundary fenceline. The REC’s equipment and power supply cable are installed on the non-motorway side of the cabinet.

2. Power is distributed from EB Cabinets to Power Cabinets 609C(W) and then to equipment on the motorway. 3-core power cable is used for power distribution.
C3.7 Telecommunications Interfaces

1. Where access to Third Party, Private Wire or the Public Switched Telephone Network (PSTN) is required, a cabinet is installed in the motorway fence line to house the Telecommunications Company interface equipment and to connect their telecommunications cable.

2. The telecommunications facilities are then connected to motorway equipment via 2-pair, 30-pair or co-axial cable.

C3.8 Control Offices

1. Control Offices (CO) are generally located in police headquarters buildings. These are often situated near the centres of main towns or cities. Specifically the COs for the M4 in Wales are in police buildings at Cwmbran and Bridgend. They serve as command and control centres for police activities within a specific area, this includes the motorways within that area.

2. Motorway traffic control and communications equipment for the control of telephones, signalling and CCTV is provided in Control Rooms within the COs. Supporting telecommunications equipment is provided within adjacent Equipment Rooms.

3. Telecommunications links are required between the Equipment Room and the nearest TS on the motorway network. This link may be provided by a cable, rented circuits from a telecommunications service provider or microwave radio link. The precise form of this link will depend upon such considerations as:

   (i) the relative locations of the CO and the TS;
   (ii) communications security requirements;
   (iii) cost.

C3.9 Protection of Existing Cable

General

1. When planning work on existing motorways special consideration should be given to the protection of the existing motorway communications infrastructure. The longitudinal cable will be part of the area communications network in addition to its function of carrying local data from signals and telephones. Any damage to the cable will therefore cause disruption to signal and telephone facilities over a wide area.

2. The Design Agent should produce an Existing Communications Report which will include an assessment of how the scheme will affect the existing national 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; details of how to achieve this are given in TA 75 : Motorway Transmission (DMRB 9.4.4, Annex C).

3. During the design stage the location of all cable and equipment should be determined and an assessment made of the risk of damage. In general where works are to be undertaken on the verge containing cable and equipment there will be a significant risk of damage. It should be noted that the opposite verge will also contain telephones and probably power supply cables which will therefore be vulnerable to damage from works on this verge.

Precautions to Avoid Damage

4. The precautions required will depend on many factors including the risk of damage, the type of work to be undertaken and the communications infrastructure to be provided by the scheme.

5. Where a contractor will be working in close proximity to existing cables or duct, the exact location of the cables and duct should be marked clearly prior to the commencement of any works. This operation should be undertaken by the specialist Regional Maintenance Contractor (RMC). It may be possible to fence off the vulnerable area with temporary fencing, taking care not to damage cable or duct whilst installing fence posts.

6. Consideration should be given to programming the works to avoid working adjacent to live cables wherever possible.
7. 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.

Cable Damage and Replacement

8. All instances of damage to cable should be regarded as serious. All cable damage should be reported immediately to the RMC by the Contractor, via the Engineer. The WOHD should be informed as soon as practicable.

9. The RMC will effect whatever temporary repairs are necessary to restore motorway communications.

10. All damaged cables should be replaced at the Contractor's cost. Where cable is to be replaced a complete drum length must be replaced. The WOHD will be able to advise of manufacturers of cable to the required specifications. Ideally replacement will be undertaken during the contract period. If this is not possible then all reasonable costs incurred by the WOHD in replacing the cable, including traffic management, will be recovered from the Contractor.
C4. MOTORWAY CABLES

C4.1 General

Bulk Purchase

1. Cables used for motorway communications are purchased in bulk by the WOHD. They are supplied to the scheme and are made available for collection by the cable installation contractor.

Armoured Cable

2. Armoured cables for installation either direct buried or within trough are manufactured to stringent specifications as detailed in paragraph C4.2.

Acceptance of Armoured Cable

3. Armoured cable has a graphite coating and is subject to on-drum acceptance testing by the installation contractor. In addition, these cables are tested after backfilling and before termination, to prove the integrity of the cable.

C4.2 NMCS Armoured Cable

1. The following types of armoured cable are for installation by direct burial:
   (i) 2-pair and 30-pair communications cable to Highways Agency specifications TR 1173;
   (ii) co-axial cable to WOHD specification WOTR 4106;
   (iii) power cable to BS 5467;
   (iv) optical fibre cable to WOHD specification WOTR 4106;
   (v) feeder cable for inductive loop detectors to WOHD specification WOTR 1012.

Multi-pair Copper Communications Cable

2. This cable is a fully-filled copper communications cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. The make-up of the cable is in the form of a centre and a number of concentric layers. It is constructed from solid plain copper conductors insulated with solid polyethylene and twisted together to form pairs.

Co-axial Cable

3. This cable is a 75 Ω semi-airspaced co-axial cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. It is constructed with an inner conductor of solid plain annealed copper and a 5 cell semi-airspaced polyethylene dielectric. The outer conductor consists of a plain annealed copper tape covered with a plain annealed copper braid with a polyester isolating tape applied helically. An aluminium polymer laminate tape is provided as a moisture barrier.

Power Cable

4. This cable is a three-core stranded copper conductor power cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. It is constructed from high-conductivity copper, stranded into a circular profile and insulated with cross-linked polyethylene.

C4.3 Inductive Loop Vehicle Detection

1. Cables used for vehicle detection loops are unarmoured. Within the carriageway and hard shoulder the loop cables are resin-encapsulated in slots. Between the hard shoulder and the verge loop joint chamber the loop cable is protected by a duct.

2. The loop cable is manufactured to WOHD specification WOTR 1012, and comprises a single-core multi-strand flexible core, insulated with ethylene propylene rubber and sheathed with polychloroprene.
3. The loop feeder cable between the verge loop joint chamber and the electronic equipment cabinet is ducted. The cable is manufactured to Welsh Office specification WOTR 1012, and is either 2-core, 4-core or multi-pair, polyethylene-insulated, steel-wire-armoured, and polyethylene-sheathed.

4. Welsh Office specification WOIP 1000 details the installation requirements for loop cable and feeder cable.
C5. NETWORK DESIGN

C5.1 General Procedure

1. This Chapter deals with the design of the cable networks.

Design Process

2. The design process is iterative. All items of roadside equipment and terminating cabinets will have their ‘ideal’ locations; however the most efficient design will be one which achieves the balance between ideal locations, physical constraints and cost. For instance, minor adjustments to locations may result in cable or equipment savings.

3. The first stage in the design of a communications network is to correctly site signals and telephones on 1:10 000 scale drawings. This design is transferred to the 1:2 500 scale drawings, and a schematic design is produced. The longitudinal cables are then designed and added to the drawings. All local cables and items of equipment are then added to the schematic design which is then transferred back to the 1:10 000 scale drawings. The locations of equipment, chambers and cabinets are then checked against physical constraints and adjusted accordingly to ensure that staff access can be maintained.

Transmission Stations

4. The location of Transmission Stations (TS) should be finalised before starting schematic design as this has a fundamental effect on the design of the cable network. Copper cables are routed via Cabinets 609(W) sited outside the TS and terminated in Marshalling Cabinets within the TS. Optical fibre and co-axial cables are also terminated within the TS.

Interfaces

5. Where the scheme boundary does not coincide with a TS, the cable infrastructure adjacent to the scheme boundary should be taken into account. Cable lengths and loading and build-out capacitors need to be considered, for correct cable transmission characteristics.

Cable Lengths

6. 30-pair cable lengths between terminations shall be in the range 500m +/- 10%. Optical fibre cable lengths between terminations are limited by the drum length available, which is 1100m. When assessing Cabinet 609(W) locations the requirement for optical fibre joints and the maximum cable length available should be considered.

7. The actual length of cable between joints is calculated as follows:

   (a) trench length between adjacent jointing Cabinets 609(W) = x m

   (b) snaking allowance (2% of (x)) = y m

   (c) length buried in service loop (7.5m each end) = 15 m

   Total = x + y + 15 m

When calculating the length of cable required from a drum, a termination/installation allowance should be added (2m for copper, 3m for fibre cables).

8. The 7.5m length is buried adjacent to the termination cabinet as a contingency against any damage to the cable end during installation or termination.

9. Cables are terminated in Boxes 615(W) mounted within Cabinets 609C(W).

10. In exceptional circumstances, where site conditions preclude the laying of full length of 30-pair cable in one longitudinal length, advice from the WOHD should be obtained before proceeding with design.
Longitudinal Cable Design

11. The longitudinal cable design commences with the plotting of the longitudinal cables and associated Cabinets 609C(W). The plotting of the positions should commence at both TSs working towards the centre of the transmission section. The loading pattern should be checked at this stage (see paragraph C5.5).

12. Signals, telephones and all associated equipment are then added to the schematic design (see paragraph C5.2 for typical schematic details).

13. All items of equipment on the motorway are connected into the longitudinal 30-pair copper and optical fibre cable networks within local Cabinets.

Trench Layout

14. Following the initial schematic communications design, the trench placing should be considered; with respect to obstructions that may be at the roadside.

15. Provisional sites should then be refined to sit cabinets in the optimum positions.

Cabinets for Electronic Equipment

16. Standard Transponders and Emergency Telephone Bridging Units, are housed within Cabinets 600(W). These cabinets should always be located adjacent to a Longitudinal Cable termination cabinet. The distance between the Cabinet 600(W) and the Cabinet 600C(W) should not exceed 50m.

C5.2 Schematic Design

1. The following paragraphs and drawings describe how the various items of equipment are connected to the longitudinal cable network. Schematic drawings are used to illustrate how this is achieved. The symbols used are those shown on WOHD specification WOIP 0003 (repeated in Figure C5.2a).

Emergency Telephones

2. The cabling arrangements for emergency telephones to the Welsh Offices Emergency Telephone System (WOETS) specification are shown schematically in Figure C5.2b.

3. Four pairs of the longitudinal cable, giving two 4-wire circuits, service Emergency Telephone Bridging Units (ETBU) installed in either Cabinets 600(W) or at TSs positioned at intervals along the motorway. These in turn communicate along the longitudinal cable with up to sixteen Telephone Switching Units (TSU) split in each direction, housed in Boxes 615(W) mounted in Cabinets 609C(W). The connections to the local telephones are made in 2-pair armoured cable.

4. Typical telephone wiring within the local Box 615(W) is shown on Welsh Office (WO) drawing T1071/T/050/0082. Connections to telephones are detailed on WO drawing T1071/T/050/0065.

Post Mounted Signals

5. The cabling arrangements for post mounted signals are shown schematically in Figure C5.2c.

6. The post-mounted signal contains within its base a Data Link Connection Box (DLCB) type 9902. A 2-pair armoured cable is fed from the local Box 615(W) via a duct to the DLCB, together with the power cable from its local power cabinet.
Cabinet 609C(W) housing longitudinal cable terminating equipment (text represents frame type)
Cabinet 609C(W) housing OFC jointing equipment
Cabinet 600(W)
Cabinet 600(W) housing loop detector equipment
Cabinet 600(W) housing VMS equipment
Cabinet 600(W) housing OFC equipment
Cabinet 600(W) housing OFC and CCTV equipment
Cabinet 600(W) housing standard transponder
Cabinet 600(W) housing telephone bridging unit
Cabinet 600(W) housing standard transponder and telephone bridging unit
Draw pit
Cabinet 600(W) housing EMS equipment
Cabinet 600(W) housing MS2 equipment
Cabinet 600(W) housing Icc warning station
Wind speed and direction measuring equipment (anemometer)
Cabinet 609C(W) electricity board interface
Cabinet 609C(W) local power cabinet
Cabinet 609C(W) gantry isolation cabinet
CCTV terminal unit cabinet

Figure C5.2a  Schematic Symbols
Figure C5.2a  Schematic Symbols
Figure C5.2a  Schematic Symbols

- Loop array for (single carriageway)
- 2 lane motorway with hardshoulder
- Loop array for (single carriageway)
- 3 lane motorway with hardshoulder
- 30 pair communication cable (longitudinal)
- 30 pair communication cable (local)
- 20 pair communication cable (longitudinal)
- 20 pair communication cable (local)
- 2 pair communication cable
- 5 pair communication cable
- 10 pair communication cable
- Optical fibre cable
- Power cable
- TV multi-cable TV66
- Coaxial cable
- Loop feeder cable

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\{ Power cable

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Gantry-mounted variable message sign

Double post-mounted variable message sign

Post 75 existing with 2 No. matrix signals
Post 75 existing with 1 No. matrix signals
Post 75 existing with a slip road matrix signal with red stop lanterns

Post 75 new with 2 No. matrix signals
Post 75 new with 1 No. matrix signals
Post 75 new with a slip road matrix signal with red stop lanterns

Gantry-mounted matrix signal with red stop lanterns

As above with additional leg-mounted matrix signal

Gantry-mounted matrix signal with red stop Signals and Enhanced Message Sign (EMS)

MS2 Cantilever-mounted signal with Enhanced Matrix Indicator (EMI) and Enhanced Message Sign (EMS)

Figure C5.2a  Schematic Symbols
Figure C5.2b  Telephone Schematic

Figure C5.2c  Post Mounted Signal Schematic
7. Typical wiring of the local Box 615(W) is shown in WO drawing T1071/T/050/0082.

8. A Standard Transponder can drive up to 3.5km in both directions, and can control all the signals within that distance.

Gantry Mounted Signals

9. Gantries for lane signalling are equipped with matrix signals and an Enhanced Message Sign (EMS) for driver information.

10. The cabling arrangements for gantry mounted signals are shown schematically in Figure C5.2d.

11. In this case access to the signal control (RS485) circuit is afforded from the Cabinet 600(W) used for EMS control.

12. Connections to the gantry, the EMS cabinet and the local Box 615(W) are shown on WO drawing T1071/T/050/0082.

Motorway Signal Mark 2

13. Motorway Signals Mark 2 (MS2) are used for signalling on motorways with up to three lanes and are cantilever-mounted.

14. An MS2 comprises an Enhanced Matrix Indicator (EMI) for signalling and an Enhanced Message Sign (EMS) for driver information. The EMI is equipped with four amber lantern units (MS2 Type A1) or with four amber and four red lantern units (MS2 Type A2).

15. The EMI is controlled either by NMCS2 or by Stand Alone Control.

16. The cabling arrangements for MS2 are shown schematically in Figure C5.2e. The arrangement is suitable for both types of control.

17. Connections between the MS2 Cabinet 600(W) and the local Box 615(W) are shown on HA drawing MCX 0590, included in document TRH 1677, Installation Drawings for MS2 and MIDAS.
EMS Type B

18. An EMS Type B is an EMS mounted on a cantilever.

19. The cabling arrangements for an EMS Type B are shown schematically in Figure C5.2f.

\[\text{Figure C5.2f  EMS Type B Schematic}\]

MIDAS Loop Detectors

20. The requirements for MIDAS Loop Detectors are described in MCH 1589 Guide To The Siting Of Inductive Loop Detectors On Motorways. The cabling arrangements for MIDAS outstations are shown schematically in Figure C5.2g. Installation of inductive loops on motorways is detailed in the WO specification WOIP 1000.

21. The joints between Loop Detector Cables and Loop Feeder Cables are located in roadside chambers conforming to Highway Construction Detail G13 and MCX 0592. Loop Feeder Cables are terminated in a MIDAS Detector Cabinet 600(W), the maximum length of Feeder Cable is 200m.

22. Connections to the loop detector cabinet are shown on WO drawing W1436/T/080/0028.

23. Where a MIDAS Transponder is also required, the arrangement is as shown on Figure C5.2g(ii).
Figure C5.2g  MIDAS Schematic
CCTV Outstations

24. CCTV Outstations are described in Highways Agency Specification MCE 2015. The cabling arrangements for CCTV are shown schematically on Figure C5.2h.

25. Composite video signals are transmitted to the CO along the longitudinal OF cable network. Connection to this network is obtained from the nearest fibre Cabinet 609C(W) with a co-axial cable connecting to the CCTV Cabinet 600(W) containing the CCTV Terminal Unit.

26. Camera control is exercised from the CO using the longitudinal 30-pair cable. Connection to this network is obtained from the nearest Cabinet 609C(W) using 2-pair cable.

27. The connection for signals and power between the CCTV Cabinet 600(W) and the camera is made using proprietary multipair/co-axial composite cable, TV66, provided by the CCTV contractor or equipment manufacturer.

28. Power is supplied from an adjacent Power Cabinet 609C(W).

29. The use of optical fibre cable is the preferred transmission medium. However, where CCTV cameras are within 1km of an optical fibre connection point or a TS, they may on the advice of the WOHD use co-axial cable in place of OF cable. The arrangements are shown in Figure C5.2h.

Figure C5.2h  CCTV Schematic
Isolated Equipment

30. Where isolated equipment is to be installed the cabling arrangements are shown in Figure C5.2i.

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Figure C5.2i  Isolated Equipment Schematic
C5.3 Selection of Cable Route

1. One of the earliest tasks during the design is to determine the most suitable route for the longitudinal cable route. The planning of the route will involve plotting a suitable route on drawings at 1:2500 scale and a survey of the site to confirm the suitability of the chosen route. A record of this survey on video proves an invaluable aid when locating equipment and chambers.

2. All ducts should be laid within the motorway boundary. The only exception is at Transmission Stations (TS) where they may be laid into a works unit compound.

3. When planning the cable route the precise locations of all proposed and existing communications cables, duct routes and other relevant features should be plotted, from the schematic design, onto drawings at 1:2500 scale. Relevant features include:

   (i) cuttings/embankments;
   (ii) structures including bridges, retaining walls; and
   (iii) drains;
   (iv) safety fences;
   (v) lighting and other cables;
   (vi) gantries or verge mounted signs;
   (vii) noise fences;
   (viii) environmental mounds;
   (ix) trees.

4. The presence of particular features may require the use of special methods of construction or special items of plant or machinery. This may, in turn, require special traffic management arrangements or result in the need for night working. All such details should be included in tender documentation.

5. The longitudinal cable should normally be kept on the same side of the motorway throughout its length, or at least, for a substantial distance. The side chosen will depend on the balance of advantages and disadvantages after considering such features as:

   (i) cuttings/embankments;
   (ii) flood plains;
   (iii) overhead power lines or electrified railway or buried power cables;
   (iv) relationship to Transmission Stations and cables/ducts on adjacent sections of motorway;
   (v) ease of siting cabinets including access and safety protection;
   (vi) ease of providing power supplies;
   (vii) ease of routing.

6. Where there is a risk of interference from external electrical sources, e.g., power lines which run parallel to the motorway and are within 100m of it for a substantial distance, the longitudinal cable should be installed on the opposite side of the motorway to reduce the risk of interference. However, the longitudinal cable should not be repeatedly changed from one side of the motorway to the other. The WOHD should be consulted if necessary.

C5.4 Copper Cable Terminations

1. At intervals of approximately 500m along the motorway are Cabinets 609C(W) for the joining of the longitudinal 30-pair cables. Two cable ends are terminated on a WOHD Terminator Frame inside a Box 615(W), as shown typically in WO drawing T1071/T/050/0081. Details of the Cabinet 609C(W) are given in WO drawing T1071/T/050/0061. Mechanical details of the Box 615(W) are given in WO drawings T1071/T/050/0057 to 0059. Mechanical details of the Terminator Frame 14(W) are given in WO drawings T1071/T/050/0049-0053.

2. Terminator Frames, on which the cables are terminated, are of three types, A, B or C, depending upon the loading coils fitted in certain cable pairs to equalise the losses incurred at different frequencies.
3. The correct frame is to be fitted into the Box 615(W)(Transmission) in accordance with the overall scheme.

C5.5 Loading Design

1. Once the cabinet sites and the individual cable lengths have been confirmed a cable loading scheme should be prepared.

2. Cable loading practice is described in HA specification MCL 5502.

3. The cable loading design should be based on nominal 500m cabinet spacing starting from both Transmission Stations.

4. Where the distance between the two terminations in the middle of the transmission section is less than 450 metres it should be corrected by re-positioning the other provisional sites; where this is not possible a non-standard length of cable will be necessary. Capacitors will be added to the Terminator Frames to give an equivalent electrical length of 500 metres - ‘building out’. There may be other places where using a cable length of less than 450 metres is unavoidable. Any such circumstances should be brought to the attention of the WOHD as early as possible.

5. It should be noted that the instructions for siting TS specify a maximum linear spacing of 20km. Once all the Cabinets 609C(W) have been sited and lengths of individual cables checked, the number of cable lengths should be counted. The WOHD should be consulted in all cases where more than 40 lengths of cable between adjacent TSs are proposed.

6. Instructions for the preparation of a cable loading scheme and calculation of values of building out capacitors are given in HA specification MCL 5502. The loading pattern and building-out proposals should be submitted for approval by the WOHD at an early stage of the design.

7. The normal loading pattern to allow for 4-wire telephone operation as used by the WOETS is as given in HA specification MCL 5502, and is given briefly in Table C5.5a below.

<table>
<thead>
<tr>
<th>Distance from Terminator Station (m)</th>
<th>Loading (mH)</th>
<th>Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Telephone</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>14A</td>
</tr>
<tr>
<td>500</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>1000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>2000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2500</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>3000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17500</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>18000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>18500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>19000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19500</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>20000</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table C5.5a Loading pattern

8. For Welsh Office operation:

(i) data pairs are loaded with 22mH coils at nominal 1000m intervals, the first set of coils are located 500m (+2%, -5%) from the TS;

(ii) telephone pairs are loaded with 88mH coils at nominal 2000m intervals, the first set of coils is located 500m (+2%, -5%) from the TS;

(iii) all other pairs are unloaded.

C5.6 Allocation of Cable Pairs and Fibres

1. Cable pair allocation for 30-pair cable is detailed in Table C5.6a.

2. Fibre allocation is detailed in Table C5.6b
<table>
<thead>
<tr>
<th>PAIR NO.</th>
<th>COLOUR PAIRS</th>
<th>LOADING PER 1000m</th>
<th>TERMINATOR</th>
<th>ALLOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black/Blue</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>NMCS1 (local data)</td>
</tr>
<tr>
<td>2</td>
<td>Black/Orange</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>NMCS1 (local data)</td>
</tr>
<tr>
<td>3</td>
<td>Black/Green</td>
<td>-</td>
<td>R2 = 1200Ω</td>
<td>ETS S + DX1</td>
</tr>
<tr>
<td>4</td>
<td>Black/Brown</td>
<td>L2 = 88mH</td>
<td>R2 = 1200Ω</td>
<td>ETS S + DX1</td>
</tr>
<tr>
<td>5</td>
<td>Black/Grey</td>
<td>-</td>
<td>R2 = 1200Ω</td>
<td>ETS S + DX2</td>
</tr>
<tr>
<td>6</td>
<td>Blue/White</td>
<td>-</td>
<td>R2 = 1200Ω</td>
<td>ETS S + DX2</td>
</tr>
<tr>
<td>7</td>
<td>Blue/Orange</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>not allocated</td>
</tr>
<tr>
<td>8</td>
<td>Blue/Green</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>not allocated</td>
</tr>
<tr>
<td>9</td>
<td>Blue/Brown</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>NMCS1 (main data)</td>
</tr>
<tr>
<td>10</td>
<td>Blue/Grey</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>NMCS1 (main data)</td>
</tr>
<tr>
<td>11</td>
<td>Orange/White</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>LCC/RCC circuits</td>
</tr>
<tr>
<td>12</td>
<td>Orange/Green</td>
<td>L1 = 22mH</td>
<td>R1 = 750R</td>
<td>LCC/RCC circuits</td>
</tr>
<tr>
<td>13</td>
<td>Orange/Brown</td>
<td>unloaded/soldered through</td>
<td>-</td>
<td>not allocated</td>
</tr>
<tr>
<td>14</td>
<td>Orange/Grey</td>
<td>unloaded/soldered through</td>
<td>-</td>
<td>not allocated</td>
</tr>
<tr>
<td>15</td>
<td>Green/White</td>
<td>unloaded/soldered through</td>
<td>-</td>
<td>not allocated</td>
</tr>
<tr>
<td>16</td>
<td>Green/Brown</td>
<td>unloaded/soldered through</td>
<td>-</td>
<td>not allocated</td>
</tr>
<tr>
<td>17</td>
<td>Green/Grey</td>
<td>L2 = 88mH</td>
<td>R2 = 1KΩ</td>
<td>not allocated</td>
</tr>
<tr>
<td>18</td>
<td>Brown/White</td>
<td>-</td>
<td>R2 = 1KΩ</td>
<td>not allocated</td>
</tr>
<tr>
<td>19</td>
<td>Brown/Grey</td>
<td>unloaded</td>
<td>-</td>
<td>CCTV control</td>
</tr>
<tr>
<td>20</td>
<td>Grey/White</td>
<td>unloaded</td>
<td>-</td>
<td>OFC control</td>
</tr>
<tr>
<td>21</td>
<td>Black/White</td>
<td>unloaded</td>
<td>-</td>
<td>matrix signals</td>
</tr>
<tr>
<td>22</td>
<td>Black/Red</td>
<td>unloaded</td>
<td>-</td>
<td>device link loops</td>
</tr>
<tr>
<td>23</td>
<td>Black/Yellow</td>
<td>unloaded</td>
<td>-</td>
<td>VMS control</td>
</tr>
<tr>
<td>24</td>
<td>Black/Violet</td>
<td>unloaded</td>
<td>-</td>
<td>feeder pillar telemetry</td>
</tr>
<tr>
<td>25</td>
<td>White/Red</td>
<td>unloaded</td>
<td>-</td>
<td>ETS speech 1</td>
</tr>
<tr>
<td>26</td>
<td>White/Yellow</td>
<td>unloaded</td>
<td>-</td>
<td>ETS speech 1</td>
</tr>
<tr>
<td>27</td>
<td>White/Violet</td>
<td>unloaded</td>
<td>-</td>
<td>ETS speech 2</td>
</tr>
<tr>
<td>28</td>
<td>Blue/Red</td>
<td>unloaded</td>
<td>-</td>
<td>ETS speech 2</td>
</tr>
<tr>
<td>29</td>
<td>Blue/Yellow</td>
<td>loaded</td>
<td>600Ω</td>
<td>ETS control</td>
</tr>
<tr>
<td>30</td>
<td>Blue/Violet</td>
<td>unloaded</td>
<td>-</td>
<td>ETS power</td>
</tr>
</tbody>
</table>

ETS S + DX = Emergency Telephone System Speech and Data

Table C5.6a Standard Loading, Terminating and Allocation Details for 30-pair Longitudinal Cable
<table>
<thead>
<tr>
<th>Fibre no.</th>
<th>Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>2</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>3</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>4</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>5</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>6</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>7</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>8</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>9</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>10</td>
<td>CCTV camera link to TS</td>
</tr>
<tr>
<td>11</td>
<td>CCTV video trunk</td>
</tr>
<tr>
<td>12</td>
<td>CCTV video trunk</td>
</tr>
<tr>
<td>13</td>
<td>Roadworks CCTV</td>
</tr>
<tr>
<td>14</td>
<td>Roadworks CCTV</td>
</tr>
<tr>
<td>15</td>
<td>Reserved</td>
</tr>
<tr>
<td>16</td>
<td>Reserved</td>
</tr>
<tr>
<td>17</td>
<td>Reserved</td>
</tr>
<tr>
<td>18</td>
<td>Reserved</td>
</tr>
<tr>
<td>19</td>
<td>Reserved</td>
</tr>
<tr>
<td>20</td>
<td>Reserved</td>
</tr>
<tr>
<td>21</td>
<td>Reserved</td>
</tr>
<tr>
<td>22</td>
<td>Reserved</td>
</tr>
<tr>
<td>23</td>
<td>Digital PCM Transmission</td>
</tr>
<tr>
<td>24</td>
<td>Digital PCM Transmission</td>
</tr>
</tbody>
</table>

Table C5.6b  Fibre Allocation
C5.7 Optical Fibre Termination

1. Optical fibre cables are terminated in Cabinets 609C(W) or Cabinets 600(W), as shown in WO drawings W1436/T/080/0051 and T1071/T/050/0033, respectively.

2. At Transmission Stations, optical fibre cables are installed in accordance with WO drawing T1071/T/050/0007.

C5.8 Cable Testing

1. Armoured cable is tested in accordance with WOTD 4003.
C6. POWER SUPPLY DESIGN

C6.1 Overview
1. 230 volt (+10%, -6%) single phase AC mains power supplies will be required for every item of outstation control equipment, Transmission Station (TS) building, and Control Office (CO) equipment.

2. Although all motorway communications equipment operates at 230v single phase, some communications power distribution centres are 3 phase.

C6.2 Types of Installation

Motorway Communications Supplies
1. Power supplies will normally be obtained from the Regional Electricity Company (REC). On existing motorways, the existing REC supplies may need to be updated. The REC will usually require at least 12 weeks’ notice for provision of new or increased supplies.

2. The Design Agent should (wherever possible) site the supply injection points so that they are easily accessible both from within and outside the motorway boundary.

3. Supplies to roadside equipment are, at present, un-metered. However, should the REC insist on a metered supply the WOHD cannot object.

4. All new REC (communications) supplies will feed only the communications system. This supply should be brought onto the motorway at the nearest practical point in terms of providing reasonable access for maintenance and minimising the cost of providing the supply. The cable should be terminated in an interface cabinet sited in the motorway fence. This cabinet is known as an Electricity Board (EB) cabinet.

5. EB cabinets are usually Cabinets 609C(W); however, for larger distribution needs an alternative type of cabinet may be required.

6. Where the motorway is lit, the REC will provide a supply to a lighting feeder pillar. The REC supply will also include a joint to a communications EB cabinet. This practice avoids the tripping out of the communications system by a lighting circuit fault and vice versa.

7. Older installations may have a single interface cabinet for communications and lighting supplies, or even shared power circuits. These arrangements should be upgraded whenever practicable.

Local Supplies
8. Local supplies to Cabinets 600(W), 617(W), signalling equipment etc will require local power isolation. This will be via a power cabinet, gantry isolation cabinet or Electricity Board interface cabinet 609C(W) (designated P, G and EB respectively). The EB cabinet can be used instead of a P cabinet (but not a G cabinet) when it is local to the relevant equipment.

9. Where a portal gantry carries both signals and illuminated signs, the sign lighting is usually fed via a joint in the lighting circuit. This lighting supply and the communications supply are both terminated in a G cabinet near the base of the gantry. At such locations, the two incoming supplies to the G cabinet MUST be of the same phase. The individual communications and sign lighting supplies will then be distributed from the G cabinet. The G cabinet provides an emergency isolation facility which utilises a single rotary switch to de-energise all power supplies to the gantry in an emergency situation (as well as the normal maintenance isolation facilities). For gantries spanning both carriageways, a G cabinet must be installed near the gantry leg on both carriageways. Cables should then be installed between the two cabinets to connect the emergency isolation switches in series, such that the operation of either switch de-energises all supplies to the gantry.

10. Each MS2 signal shall have a local G cabinet to provide local maintenance isolation together with the emergency isolation facility.

Transmission Station Buildings
11. Power requirements for new TS buildings are estimated from the loadings of the equipment to be installed. For existing Transmission Stations, refer to the WOHD.
Control Offices

12. Within COs, provision of power supplies should be decided following consultation with the police. The installation of NMCS2, air conditioning or CCTV equipment can increase the power requirements considerably.

13. CO equipment may require Uninterruptible Power Supplies (UPS), standby generators, and/or battery backup.

C6.3 Operational and Design Regulations

1. Electrical installations should conform, where applicable, with the following regulations:

(i) BS 7671;

(ii) Electrical Supply Regulations 1988 (as amended);

(iii) Electricity at Work Regulations 1989;

Note: ii and iii are statutory regulations.

2. Where a consumer’s installation does not comply with the requirements of Chapter 13 of BS 7671 (Fundamental Requirements for Safety), the supplier is not compelled to provide a supply to that installation.

C6.4 Design - BS 7671 (IEE Wiring Regulations)

Background

1. All electrical installations shall comply with BS 7671.

2. Compliance with BS 7671 will achieve compliance with the relevant aspects of the Electricity at Work Regulations 1989.

Design Constraints

3. The following pointers are derived from BS 7671 and refer to the provision of power supplies to street furniture on motorways. They are not comprehensive and should not be used as a designer’s checklist; they do provide a good basis from which to work.

(i) Chapter 13 ‘Fundamental Requirements for Safety’. These requirements should be met in full for every installation.

(ii) Chapter 31 ‘Purpose, Supplies and Structure’. This indicates the need to consult the supplier to determine the nature of the supply and the need to sub-divide installations for reasons of safety and maintenance.

(iii) Chapter 32 ‘External Influences’. This provides a checklist of environmental factors which may influence the design including:

(a) water (siting consideration),

(b) corrosion (oil and salt contamination possible in motorway environments),

(c) impact (siting consideration).

(iv) Chapter 34 ‘Maintainability’. This requires that the frequency of maintenance and equipment down time is considered.

(v) Chapter 51 ‘Common Rules, Section 514’. This describes the requirements for labelling, notices and identification of equipment and circuits. With reference to Cabinet Types 600(W) and 609C(W) and equipment containing power supplies, they comprise the following:

(a) a circuit diagram in every cabinet in accordance with Clause 514-09-01;

(b) a voltage warning notice, where required, in accordance with Clause 514-10-01;

(c) an isolation warning notice, where required, in accordance with Clause 514-11-01.

(d) an inspection and testing notice in cabinets with REC interface equipment in accordance with Clause 514-12-01;

(e) a test notice in all cabinets containing an RCD in accordance with Clause 514-12-02;
(f) an earthing and bonding notice, where required, in accordance with Clause 514-13-01;

(e) an equipotential bonding notice, where required, in accordance with Clause 514 -13-02.

Voltage Considerations

4. In accordance with Clause 525-01-02 of BS 7671, the voltage drop within the installation shall be restricted to a maximum of 4% of the nominal supply voltage.

Safety Considerations

5. In the case of alterations and additions to an installation, Clause 721-01-02 shall be met. This means that whenever a permanent modification to a network is made, the whole installation shall be reviewed.

6. A maximum disconnection time of 5 seconds shall be provided in accordance with Clause 611-02-04.

7. Where a gantry spans both carriageways a G cabinet shall be provided in both verges. The switching arrangement shall be such that the gantry can be completely isolated from either cabinet.

8. To meet the requirement of 412-03-04 (protection by barriers or enclosures), power isolation locations are needed to switch off power. Whilst maintenance or alteration is carried out, these power isolation locations should be locked in the ‘off’ position. The key should be left with the senior person working on the installation.

C6.5 Design - Particular Requirements for Motorway Installations

Power Distribution

1. Power distribution networks for motorway communications should be star networks centred on EBs.

2. Gantry lighting derive their power supplies from the motorway lighting power supplies. The motorway lighting is operated by group switching via photo electric cell control. A lighting cable is routed via the emergency isolation switch in the G cabinet to a lighting distribution unit mounted on the gantry structure.

3. With NMCS2, post mounted signals may be situated up to 4km away from the controlling Standard Transponder. Therefore, for local isolation purposes, a cabinet should be installed in the verge either opposite the central reserve mounted signals or adjacent to one of the slip road entry signals.

4. Cabinets 600(W) are fitted with a Power Distribution Unit (PDU). This comprises a double pole isolator to terminate the incoming supply. This then feeds a consumer unit with (a maximum of) 10 No. outgoing ways. The consumer unit is supplied fitted with a Residual Current Device (RCD) across the incoming supply. To avoid potential nuisance tripping from site equipment the power supplies to NMCS2 site equipment (with the exception of EMS and MS2 signs) are derived from a local EB, P or G cabinet. EMS and MS2 signs derive their power supplies from their respective 600(W) cabinets.

Use of Alternative Cabinets

5. Where the Cabinet 609C(W) does not provide sufficient space for the required switchgear and termination equipment an alternative Cabinet 600(W) may need to be provided.

6. Any alternative cabinets shall provide similar or better ingress protection to that provided by a Cabinet 609C(W).

C6.6 Design - Equipment Loads

General

1. Cable sizes should be calculated based on the equipment loads shown in Tables C6.6a - C6.6c and the cable characteristics given in Table C6.7a.

2. Design values should be checked with the WOHD during detailed design.

3. Each site should be designed for a minimum load of 2000W or 5000W for portal gantry or cantilever Motorway Signal Mark 2 (MS2) or Enhanced Message Sign (EMS).
### Table C6.6a Nominal Power Loads of Motorway Communications Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal (single sided) including signal controller</td>
<td>225</td>
</tr>
<tr>
<td>Signal (double sided) including signal controller</td>
<td>450</td>
</tr>
<tr>
<td>NMCS1 Responder including Cabinet 600 heater</td>
<td>250</td>
</tr>
<tr>
<td>NMCS2 Telephone Responder including Cabinet 600 heater</td>
<td>250</td>
</tr>
<tr>
<td>NMCS2 Standard Transponder including Cabinet 600 heater</td>
<td>720</td>
</tr>
<tr>
<td>Cabinet 600 or 617 complete with heater</td>
<td>180</td>
</tr>
<tr>
<td>Cabinet 620 complete with heater</td>
<td>120</td>
</tr>
<tr>
<td>Loop Detector equipment</td>
<td>120</td>
</tr>
<tr>
<td>Fog Detector equipment</td>
<td>50</td>
</tr>
<tr>
<td>CCTV Camera outstation including Cabinet 600 heater</td>
<td>750</td>
</tr>
<tr>
<td>Fibre Optic Transmission Cabinet including heater</td>
<td>480</td>
</tr>
<tr>
<td>Telephone Bridging Unit (TBU) including Cabinet 617 heater</td>
<td>250</td>
</tr>
</tbody>
</table>

### Table C6.6b Design Maximum Power Loads of Enhanced Signals

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Message Sign (320 or 420mm) comprising EMS, Cantilever and Signal Driver cabinet and heaters</td>
<td>2500</td>
</tr>
<tr>
<td>Motorway Signal Mk2 (MS2) comprising EMS, EMI and Signal Driver cabinet and heaters</td>
<td>3500</td>
</tr>
</tbody>
</table>

### Table C6.6c Nominal Power Loads of Gantry Sign Lighting

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250W MBFU luminaire</td>
<td>273</td>
</tr>
<tr>
<td>125W MBFU luminaire</td>
<td>142</td>
</tr>
<tr>
<td>80W MBFU luminaire</td>
<td>96</td>
</tr>
</tbody>
</table>

### C6.7 Design - Power Cables

1. Bulk purchased 3 core 10mm² and 16mm² armoured Power cable with copper conductors to BS 5467 should be used. Installation of cable of larger diameters should be avoided wherever possible as often the cost of providing, installing and maintaining these cables outweighs the cost of providing an additional supply local to the equipment concerned. Where larger cables are unavoidable, they shall be 3 core armoured cables with copper conductors to BS 5467.

2. The electrical characteristics of 10mm² and 16mm² Power cable with copper conductors to BS 5467 are given in Table C6.7a and should be used for design. Where larger cables are utilised, the equivalent electrical characteristics of these cables shall be derived from the appropriate British Standards.

### Table C6.7a Electrical Characteristics of Power Cable

<table>
<thead>
<tr>
<th>Cable Size (mm²)</th>
<th>Conductor Resistance (Ω)</th>
<th>Maximum Current Rating Laid in Duct (A)</th>
<th>Volt Drop per Amp per Metre at Rated Current (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.83</td>
<td>75</td>
<td>4.0</td>
</tr>
<tr>
<td>16</td>
<td>1.15</td>
<td>96</td>
<td>2.5</td>
</tr>
</tbody>
</table>

### Table C6.7b Design Maximum Power Loads of Enhanced Signals

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Message Sign (320 or 420mm) comprising EMS, Cantilever and Signal Driver cabinet and heaters</td>
<td>2500</td>
</tr>
<tr>
<td>Motorway Signal Mk2 (MS2) comprising EMS, EMI and Signal Driver cabinet and heaters</td>
<td>3500</td>
</tr>
</tbody>
</table>
C7. CABLE DUCTS

C7.1 General

1. Ducts are used principally for ease of cabling across motorways and for access to the central reserve.

2. The transverse duct system uses a number of 100mm diameter ducts at 500m centres crossing beneath the carriageway at right angles to it, and is discussed in greater detail in Section C7.5.

C7.2 Material and Installation Standards

1. The material specification for ducts is given in the 1500 Series of the Specification for Highway Works (SHW). Ducts are manufactured from thermoplastic material.

2. Each length of ducting should be fitted with a non-rotting stranded draw cord and the duct ends fitted with purpose-made compression plugs providing a water, air and gas tight seal, as detailed in the SHW.

3. Joints between adjacent lengths of ducts should be air and water tight. It is imperative that material such as silt, grout or concrete is prevented from entering the duct during the jointing process. Material such as this will cause damage to the cable during installation.

C7.3 Longitudinal Ducts

1. Longitudinal ducts are only used in Wales for traversing structures, e.g. viaducts.

C7.4 Geotechnical Considerations

1. These do not apply for traverse ducts where the material traversed is totally under the control of the Civil Contractor. However, these considerations should be borne in mind when considering the excavation of cable trenches.

2. In the early stages of design a geotechnical desk study should be undertaken using records compiled by the WOHD of all motorway earthwork slopes. Consultation with the Regional Geotechnical Engineer at an early stage is essential. Additional information, for example from trial pits or bore holes, may be required.

3. The excavation of a trench at the toe of a cutting should be dealt with carefully as poor design and poor workmanship could lead to a local failure of the slope. Problems can be avoided by the use of a narrow trench (typically 0.5 m) and by ensuring that, during construction, trenches are excavated in relatively short lengths and not left open for extended periods. Proper specification of trench fill material combined with high standards of compaction will also minimise the risk of failure. Where a slope is identified as being at risk special precautions will be required in both design and construction.

4. The excavation of a trench at the crown of an embankment slope should also be approached with care. The problem in this instance would be that the trench could act as a drain, collecting surface run-off without having an outfall. The build up of water would, in cohesive soils, eventually saturate and weaken the surrounding soil. This problem can quite readily be avoided by the use of a properly specified and constructed trench detail and where necessary, by the use of special details such as a geotextile seal near the surface of the trench.

C7.5 Transverse Ducts

1. Transverse ducts provide the means by which cables may cross carriageways from one verge to the other, from verge to central reserve and from one side of a slip road to the other.

2. Standard provision is for a group of four 100 mm diameter ducts at nominal 500m intervals.

3. Details of draw-pits and ducts are given in WO drawing W1436/T/080/0029.

4. The depth of transverse ducts is dictated by the following factors:
   (i) the pavement construction depth;
   (ii) the method of duct installation to be used;
   (iii) the need to ensure that adequate protection to the duct is achieved, both during construction and under long term vehicular loading;
(iv) the location of drains; and,
(v) whether the road is new or existing.

New Roads

5. For new roads, transverse ducts should be laid in a trench excavated in the material below the capping layer. Ducts should not be located within the capping layer as this could result in the formation of hard spots which could affect the surface of the carriageway above. The minimum cover to transverse ducts should be either:

(i) 900 mm if the ducts are covered by a 150 mm thick concrete slab, or
(ii) 1200 mm if no concrete cover is provided.

6. In all cases the ducts should be located at least 150 mm below the bottom of the capping layer, or if no capping layer is required, at least 150 mm below the formation level.

Existing Roads

7. Transverse ducts should be installed beneath existing carriageways, using trenchless techniques. The depths of these ducts will be dependent upon the material in which the ducts are to be located, the likely impact of the installation method on the surrounding ground and the location of drainage pipes. The minimum depths detailed above for ducts in trenches apply also to trenchless ducts, but these depths may have to be increased to ensure that the displacement of the surrounding ground does not affect the structural integrity of the pavement construction or capping layer.

8. It is imperative that as-installed records of pavement construction drainage and other services and geotechnical records are consulted when planning trenchless crossings of motorways.

9. A number of reliable well proven methods of trenchless duct provision are currently available including:

(i) auger boring;
(ii) guided, steerable moles;
(iii) thrust boring;
(iv) impact moling;
(v) pipe ramming.

10. Careful consideration of factors such as ground conditions and local topography will be required before choosing a method of installation. The choice of an unsuitable method can have costly implications. It should be noted that when installing ducts in this manner it is advisable not to install ducts in close proximity to each other to avoid ducts clashing.

Special Arrangements at Structures

11. On long structures special arrangements may be necessary if transverse ducting at 500 m intervals cannot be provided. Early advice should be sought from the WOHD.

12. Special details will be required where ducts cross expansion joints.

13. Where separate viaducts are constructed for each carriageway, provision for cabling between the structures may be required.

C7.6 Local Ducts

1. Local ducts are used in Wales between loop jointing boxes and the local cabinet.

C7.7 Use of Existing Ducts

1. Existing ducts are likely to be limited to transverse ducts and ducts at structures.

Transverse Ducts

2. Transverse ducts are often extremely difficult to locate on existing motorways. The most common reason for this being that duct marker posts and blocks were not provided and where they have been provided they have rarely been maintained. Inaccurate as-installed information regarding ducts is also a common problem. Agent Authorities should keep records of duct location and usage up to date.

3. As the cost of providing new transverse ducts is relatively high, the utilisation of existing ducts should be considered. This will only be acceptable where the existing ducts meet the material and installation standards described earlier in this Guide, and where they occur at locations which suit the proposed cable network.
4. A locational survey of existing ducts should be undertaken during the design stage to establish where existing ducts can be used, where new ducts are required and where cable routes may be revised to avoid the need for new ducts. If approved by the WOHD, a CCTV survey should also be undertaken.

5. The survey should include accurate details of duct location (chainage and offset) and type, soundness of duct, its depth, diameter and the number and type of cables installed.

6. Empty ducts should be proved and cleared of debris using a mandrel.

7. Ducts containing existing cables should be used with extreme caution as cables will probably be snaked and twisted, the duct may be damaged internally and debris may have accumulated within the duct. Wherever possible, redundant cables should be identified and removed by the specialist RMC.

**Ducts in Structures**

8. It will frequently be found that where ducts have been installed at structures, they have been provided only for existing cables with no additional capacity. This additional capacity can generally be provided by one of the following methods:

(i) at a bridge which has a safety barrier and separate fence or parapet, it is often possible to lay ducts between them;

(ii) at a bridge which has no separate safety fence it may be practicable to attach ducts to the outside of a parapet;

(iii) it may be possible to install ducts in the hardened verge;

(iv) it may be possible to install ducts beneath the bridge surface, using the structure itself. For example, within a concrete box section or attached to steel girder sections.

The agreement of the WOHD or their consultants responsible for the structure is required before proceeding with any of these options.

**C7.8 Equipment Siting on Existing Motorways**

1. When siting telephones, signals and other equipment on existing motorways, their locations should be planned such that the number of new duct crossings is minimised. In addition to cost, consideration should be given to the following factors:

(i) the requirement for pairs of telephones (A and B carriageway) to be sited opposite each other (mandatory requirement);

(ii) the maintenance advantages in having signals opposite their Transponder;

(iii) the maximum desirable and permissible cable length between Transponders and their dependent signals;

(iv) the vulnerability of cable in the central reserve to damage and the problems of subsequent repair or replacement.

**C7.9 Ducts At Junctions**

1. Ducts should be provided at junctions as shown in Figure C7.9a. It is important that all ducts start and finish on land belonging to the Welsh Office.

**C7.10 Marker Tape**

1. Trenches should include for the installation of a marker tape which will allow the presence of the cables to be indicated to anybody digging in the vicinity. Electronic Duct Markers are used at all cable entry and exit points, and at other positions as decided by the engineer on site.

**C7.11 Duct Allocation**

1. Details of ducts used by specific cables should be noted on the as-installed drawings.

**C7.12 Cable Installation**

1. Cable installation should be undertaken strictly in accordance with the Specification for Highways Works and with WO specification WOIP 4003.
Figure C7.9a Duct Arrangements at Junctions

NOTES

1/ Ducts shown are for communication requirements only. Additional ducts are required for lighting.

2/ The provision of ducts in the bridge structure and beneath the side roads may be required.

KEY

- - 4 x 100mm internal diameter ducts
- - Ducts - see 2
C8. DRAW-PITS

C8.1 General

1. It is WO policy to have draw-pits at either side of the motorway and in the central reserve to facilitate the installation of cables in transverse ducts.

2. Details of the draw-pits are given in WO drawing W1436/T/080/0029.

C8.2 Access

1. There is neither active equipment nor termination requiring a break in cable sheathing within the duct and draw-pit. Therefore access to draw-pits will only be required during installation.

C8.3 Drainage

1. During the design of the duct network the drainage of water from draw-pits should be considered. A soak-away is often provided to allow the free drainage of water from draw-pits, but its effectiveness depends upon the height of the water-table in the vicinity.

2. Draw-pits could be provided with a sump to allow the pumping out of water.

C8.4 Labelling

1. There is no requirement for WO draw-pits to be labelled.
Chapter C9

C9. ARMOUR ED CABLE INSTALLATIONS

C9.1 Direct Burial

1. Direct burial is no longer standard practice within Wales for the installation of motorway communication cables. Inter-connection with roadside equipment is generally considered in Section C5. Installation of the cable is considered in this Section.

2. Direct burial of cables is to be carried out in accordance with the details given in HA drawing MCX 0141.

3. All communications cables following a common route should share a common trench wherever possible.

4. Power supply cables, other than those associated directly with the motorway communications system, should not share the same trench as communications cables. A minimum spacing of 150 mm is required for cables carrying 230 v. Cables with voltages up to 600 v require a spacing of 0.5 m from communications cables. Spacing of cables with greater voltages are subject to agreement during the design phase.

C9.2 Cable Trough

1. The use of trough units for longitudinal cables is not standard practice. Advice from the WOHD should be sought where troughing is being considered.

2. Standard details for the installation of cable trough are illustrated on HA drawing MCX 0153, sheet 2 of 2.

3. Troughs should have a clear space, free from rubble and smooth internally, of 150 mm x 150 mm minimum or agreed alternative internal dimensions with covers in place.

4. Trough covers should be capable of being removed by one man. They should not break if dropped and should be able to withstand the effects of traffic passing over them without collapsing or damaging the cables within.

5. Troughing should be constructed on a straight grade and be self-draining.

6. Trough units should not be laid on the surface as they will act as a ramp for errant vehicles and possibly cause a vehicle to overturn.

7. Special consideration should be given to the transition between trough and duct/trench where cables will be laid at shallow depths. Care should be taken to ensure adequate protection of cables.

C9.3 Cable Types

1. Where cable is to be installed by either direct burial or troughing, armoured cable, which is available from bulk purchase, should be installed (see Chapter C4 for cable types).

2. NMCS2 requires a 30-pair longitudinal cable.

3. Armoured cable requires testing by the installation contractor prior to acceptance to confirm the integrity of the cable sheath. The cable is coated with graphite to facilitate this testing.

4. Every length of armoured cable requires testing in accordance with WO specifications WOTR 4106 by the installation contractor prior to termination.

C9.4 Armoured Cable Terminations

1. The armoured 30-pair longitudinal communications cable is terminated in Cabinets 609C(W) using Termination Frames 14(W), enclosed in Boxes 615(W).

2. The Box 615(W) has since the advent of NMCS2 and the requirement for many 2-pair connections, two large cable holes and six small cable holes.

3. Terminator Frames 14(W) are available in three types as follows:

   (i) Type A - unloaded;

   (ii) Type B - fitted with 22mH loading coils; and,

   (iii) Type C - fitted with 22mH and 88mH loading coils.
4. The standard pattern for Terminator Frames in Cabinets 609C(W) at standard spacing (cable lengths of 500m) is:

... C - A - B - A - C - A - B - A - C - A ...

This sequence may be varied due to local conditions, and advice should be sought from the WOHD.

5. The first cabinet after the Cabinet 609C(W) outside the ‘A’ Transmission Station, ie at 500m from the TS, should contain a C Frame. Thereafter the above sequence should be followed. Ideally, the cabinet 500m before the next TS, the ‘B’ TS, will contain a C Frame. If this is not the case then the sequence will need to be modified; refer to HS specification MCL 5502 for further details.

6. Armoured fibre optic cables are terminated in Cabinet 600(W) and 609C(W) in accordance with WO drawings nos. T1071/T/050/0033 and W1436/T/080/0051.

NMCS2 Longitudinal Cabling

7. Terminator Frames 14(W) are fitted with two BK12 terminal blocks, TBT11 and TBT12, at the bottom of the frame. These provide permanent tee-offs from the main longitudinal conductors. The pairs teed-off to TBT11 and their allocations are:

(i) pairs 1, 2 (TPR/LCC);

(ii) pairs 3, 4, 5, 6 (telephone lines).

8. TBT12 is also wired; the remote tails are provided long enough to reach any of the main conductors, but are not soldered to the main conductors in the initial configuration of the frame. Where this tee-off connection is required in the system design, the installation contractor identifies, by means of numbered collets, the appropriate tails and connects them to the requisite main conductors on the frame during installation. Numbered collets referencing the terminal number on TBT11 and 12 will be provided to both the permanent teed connections and the spare tails.

9. The carrier pairs (ie 13 to 16) will normally be soldered through by the installation contractor.

10. Loading coils will be fitted and connected during manufacture on the following pairs: 22mH coils to pairs 1, 2, 7, 8, 9, 10, 11 and 12; and 88mH to pairs 3, 4, 5, 6, 17 and 18.

11. Where termination resistors are to be fitted to frames (eg at the end of RS485 lines) link connectors and the tee wiring should be removed, and the terminating resistors put in their place.

12. Any cross-connection of cable pairs (ie the point of cable pair colour change) should take place in the local Box 615(W).

13. Further information on terminator frames is provided on WO drawings T1071/T/050/0049-0053.

Build-out Capacitors

14. The arrangements for installation Building-out Capacitors are described in Section C5.5 in this Annex, and are detailed in MCL 5502.

Cabling to Local Devices

15. Cabling to local cabinets via armoured 30-pair, 2-pair or co-axial cables, from the local side Box 615(W) installed in the Cabinet 609(W), connected to the transmission side Box 615(W) and wired in accordance with WO drawing no. T1071/T/050/0082.

16. The colour-coding of the 30-pair cable is maintained through the interconnecting wiring to the local side Box 615(W).
C10. CABINET SITING

C10.1 Cabinet Siting

Positioning

1. When assessing suitable sites for cabinets the designer should aim to provide sites which are safe both for maintenance personnel and motorists, and should have due regard for cost and for aesthetics.

2. Since cabinets are weatherproof, but not waterproof, they should be sited well above any likely flood level.

3. Cabinets should be grouped together wherever possible as this has maintenance and cost advantages.

4. Where the motorway is sited in a cutting or on an embankment, care should be taken to ensure that cabinets do not cause visual intrusion for local residents or users of adjacent land.

5. Care should be taken to ensure that proposed or existing landscaping planting will not cause access problems or obscure cabinets in future years. Liaison with the WOHD’s Landscape Architect during the planning stage is therefore necessary to co-ordinate the location of communications infrastructure and tree planting. When planning works on existing motorways, liaison with the Landscape Architect will be necessary in order to arrange for the removal of trees and shrubs.

Safety Fence

6. Safety fencing will be required for the protection of motorists and communication equipment at sites where cabinets or signal posts are sited less than 10m behind and 1m above the hard shoulder. It may be possible to site cabinets downstream of bridge piers or where they can be protected by an extension to existing or planned safety fence; this is more acceptable on both economic and safety grounds. Short gaps between adjacent lengths of safety fence should be avoided. Where necessary, additional fencing should be provided to close such gaps.

Retaining Walls

7. Special consideration should be given to the siting of cabinets in retained cuttings. Where cabinets are to be located at the top of such retaining walls, access from the hardshoulder should be provided. Where cabinets are located in cut-outs in retaining walls there may be difficulties in routeing cables to cabinets.

8. Where retaining walls are required for cabinets they should be designed and detailed by the Design Agent.

Access

9. The siting of all cabinets should allow for maintenance access. The requirement is that access should be readily and easily available from a vehicle parked on the hardshoulder. This may require the provision of a safe means of access and egress for vehicles.

10. Cabinets which are sited remotely from the carriageway may require the provision of access steps as detailed on WO drawing W1436/T/080/0004.

11. Maintenance staff are required to carry heavy test equipment to Cabinets 600(W). Therefore steps should be provided where access involves a gradient exceeding 1 in 2 for a height exceeding 400mm.

12. Where noise fences or environmental barriers are installed between a cabinet and the motorway, special provision should be made to allow access to the cabinet whilst maintaining an effective noise/environmental barrier.

13. Paved areas, constructed from standard paving slabs, should be constructed between access steps, cabinet hardstandings and the hardshoulder to provide a continuous, safe path. Details of cabinet hardstandings are given in WO drawing W1436/T/080/0003.
C10.2 Special Arrangements

Telecommunications and Electricity Supply
Interface Cabinets

1. Interface cabinets should be constructed in the line of the motorway boundary fence as detailed on MCX 0153 and MCX 0146. Cabinets should be sited so that the whole of the foundation lies within land belonging to the WOHD.

Draw-pits at Transmission Station Buildings

2. Draw-pits are built immediately adjacent to a Transmission Station (TS) to allow cables to pass directly into the sub-floor cavity. Copper communications cables leading into a TS pass first through a Cabinet 609(W) adjacent to the TS, as described in paragraph 5.1.4, before being terminated in the marshalling cabinet within the TS. A typical layout is shown in WO drawing W1436/T/036/0064.
C11. CONSTRUCTION DETAILS

C11.1 Foundations

Cabinet Bases

1. Cabinets 600(W), 609C(W), and 617(W) are manufactured for mounting onto a standard plinth (Plinth 610) which is bulk purchased by the WOHD.

2. The foundation for a cabinet comprises a Plinth 610 cast into a concrete base as detailed on MCX 0140. The plinth is shown on WO drawing W1436/T/080/0102.

3. Foundations for other cabinet types, such as the WOHD Enclosure 1600, are not covered by the standard details; they are, however, designed by the Design Agent and submitted to the WOHD for approval.

4. Cabinet bases are filled with pea gravel; in addition, the base of the Cabinet 600(W) is sealed with epoxy resin to provide a waterproof environment inside the cabinet.

Signal Post Foundations

5. Foundations for signal posts will be designed by the Design Agent based upon the parameters given on WO drawing W1436/T/080/0004. It should be noted that these foundations are subject to the approval: all contract documents have to be approved by the WO. Adequate time should be allowed for this procedure.

C11.2 Hardstandings and Steps

Hardstanding

1. The standard of provision for hardstandings at cabinet and signal/telephone sites is given on WO drawing W1436/T/080/0003 and 0004. Generally, a hardstanding should be provided at every cabinet door. Where two or more cabinets occur at one site, they should be linked by a paved area.

2. Where cabinets are situated on cutting or embankment slopes, consideration should be given to the provision of handrailing to protect maintenance personnel from the risk of falling.

Steps

3. Typical access steps for cabinets are detailed on WO drawing W1436/T/080/0004.

4. Where steps are specified, the designer should consider the Health and Safety implications of the specified layout. Consideration should be given to the provision of handrailing alongside steps and also landings with guardrails to limit the height of individual flights of steps.

5. Where steps are provided, they should be linked to cabinet sites by a path constructed from standard paving slabs.

C11.3 Duct Installation Details

1. Ducts are installed in trenches as detailed on WO drawing W1436/T/080/0029.

C11.4 Draw-Pit Details

1. Chambers are constructed in accordance with WO drawing W1436/T/080/0029.
C12. TRANSMISSION STATIONS

C12.1 Overview

1. The motorway communications cable system has a transmission network based on Transmission Stations (TSs). These are located at all interchanges and at intervals not exceeding 20km between interchanges. Transmission Stations are housed either in purpose-built buildings or in Cabinets 617(W).

2. TSs housed in cabinets provide facilities for amplification of speech and control circuit signals. They also provide facilities for cross-connection within or between the WOHD’s cables or between the WOHD’s cables and the Private Wire (PW) network.

3. TSs housed in buildings provide all the above facilities and provide terminal access to systems such as CCTV and PCM systems.

4. The amount of equipment required in a TS, particularly one associated with CCTV equipment, may justify the provision of a building. Therefore, the designer will need to confirm the requirements for each TS with the WOHD at an early stage.

C12.2 Siting Considerations

1. All TS require a mains power supply, access to the Public Switched Telephone Network (PSTN) and provision of dedicated PW. They also require, where possible, access from all-purpose roads so that maintenance staff can attend to equipment without using the motorway. Connection to the PW network can be achieved by using a length of motorway cable; this allows the interface cabinets to be sited remote from the TS.

2. Sites need to be selected with a view to their relationship to the main cable run; cable between the TS and the main longitudinal cables should be kept to the minimum. The route selected should be reasonably immune from the risk of cable damage by trenching, tree planting or similar activities.

3. Cables installed outside the motorway boundary (eg in works units) require mechanical protection against damage from excavation.

4. Works units frequently provide suitable sites for a TS. When these are used, care should be taken to keep away from salt stores. Also, arrangements need to be made to ensure 24-hour access to the TS.

5. When siting a TS, particular care should be taken to ensure the following:

   (i) reasonable facilities are available for parking;

   (ii) access is available for staff carrying test equipment from the all-purpose road and the motorway;

   (iii) hardstanding for emergency trailer is available;

   (iv) all cabinets, buildings and parking areas are sited on motorway land;

   (v) all cabinets and buildings are safe from vehicles straying from the motorway. This can be achieved by siting the station on the downstream side of a bridge or by the provision of safety fencing.

6. It is most important that the site chosen, whether for a building or a cabinet, should be immune from flood risk.

7. In certain areas it may be necessary to plant a screen of trees or take other measures to reduce the environmental intrusion caused by a TS building.

Transmission Station Building Specification

8. A typical Transmission Station Building is shown on WO drawing W1436.052/SW-TE/401.

Further Information

9. For further information on Transmission Stations refer to TA 75 : Motorway Transmission (DMRB 9.4.4, Annex C).
C13. GEOGRAPHIC ADDRESSING

C13.1 Motorway Address Coding

General

1. Motorway roadside equipment such as telephones, signals and CCTV cameras is identified by means of an address code. This address comprises three elements:
   
   (i) motorway identifier;
   (ii) marker post reference; and,
   (iii) carriageway identifier.

These elements combine to produce an address in the form:

1 2 3 4 A

where:

1 is the motorway identifier
234 relates to the nearest marker post (in this case mp 23/4)
A is the carriageway identifier.

A fifth digit may be added after the letter if it is necessary to identify a carriageway lane. Lane signals, for example, will have a number to identify the lane to which they apply.

Motorway Identifier

2. The M4 motorway has its own identifier number 2000.

Carriageway Identifier

3. The mainline carriageways are identified as A and B carriageways. Where motorways emanate from London the outward carriageway is designated A. On other motorways the designations A and B are arbitrary. Marker post numbers always increase in the direction of travel on the A carriageway.

4. Slip roads are lettered as follows:
   (i) J - exit from A Carriageway;
   (ii) K - entry to A Carriageway;
   (iii) L - exit from B Carriageway;
   (iv) M - entry to B Carriageway.

This is illustrated on Figure C13.1a.

5. These letters are used between interchanges - refer to C13.2 for the procedure to be followed at interchanges themselves.

6. Carriageway lanes are numbered from the nearside; the lane adjacent to the hardshoulder is numbered 1.
C13.2 Motorway Interchanges

1. At motorway interchanges there are several slip roads and linking roads to identify. In describing the method of allocating addresses the term slip road will be used for a road which either originates or connects directly to a motorway. The term linking road will be used for a road which does not connect directly to a motorway.

2. Slip roads directly between motorways are numbered and lettered from the motorway having the lower identifier. The motorway with the lower identity number may have a higher motorway number. For example M6/M62; M6 identifier is 5000, and M62 identifier is 1000. Linking roads joining the slip roads are numbered and lettered from the motorway having the higher number - either identifier or motorway number.

3. Linking roads ‘site’ numbers are produced by taking the number of the marker post at the centre of the interchange and replacing the last digit by 0. The first item of equipment to be installed on the linking road is identified by adding 1 to the number, the second by adding 2, and so on.

4. The above explanation is illustrated by Figure C13.2a, which shows a hypothetical interchange between motorway identity number 2000 at centre marker post 72/8 and motorway identity number 6000 at centre marker post 21/3.

5. Arrangements sometimes need to be varied to suit individual layouts, particularly when an interchange is combined with a junction or when more than two motorways are present at an interchange. Consultation with the WOHD is required where such non-standard arrangements are being considered.
Figure C13.2a Motorway to Motorway - Example of Interchange Telephone Address Coding
C14. LABELLING

C14.1 General

1. Cabinets and equipment should be labelled in accordance with BS 7671.

2. Address code labels are used by the police on site when requesting the setting of signals. The address code label on emergency telephones enables motorists to inform the police control office of their precise location. The accuracy and legibility of these labels is therefore of prime importance.

3. Accurate and legible informatory labels on the outside of cabinets are essential for the efficient working and safety of maintenance personnel.

4. It should be noted that the Engineer is responsible for specifying names, numbers and lettering on informatory and address coding labels.

Cabinets


Signals

6. Gantry legs should be provided with labels showing their address code in accordance with WO drawings T1071/T/050/0102 and W1436/T/080/0043. Post-mounted signals should be labelled in accordance with WO drawing W1436/T/080/0030.

Telephones

7. Address coding, external and internal labels should be provided in accordance with WO drawings W1436/T/080/0045 and W1436/T/080/0047.

Cables
C15. GLOSSARY

8. Cables should be identified using labels as detailed on WO drawing W1436/T/080/0045.

Armoured Cable
A cable which incorporates a layer of steel wire wrapped helically around the cable to provide mechanical protection from damage. The armour wire is protected from moisture by a polyethylene sheath. The sheath is coated with graphite - this graphite coating is used when testing the integrity of the sheath.

Box Type 615
A standard enclosure which is used to house termination frames in 609(W) Cabinets.

Break Jack
A plastic plug which is inserted into an Insulation Displacement Connector (IDC) to break the internal connection.

Build Out Capacitor
Capacitors used to equalise cable lengths to the standard length of 500m. The additional capacitance equates to that required to make the cable length appear to be 500m. Located in the Cable Joint Enclosure (CJE) furthest from both TS.

Bulk Purchase
Standard items of motorway communications equipment are purchased by the Highways Agency in quantity. This ensures the equipment conforms to the relevant specifications, is available from several sources and benefits from economies of scale.

Cabinet Type 600(W)
Standard motorway equipment cabinet, for use on motorway verges, to house equipment such as Standard Transponders, MIDAS Transponders, Responders, Sector Interfaces and Sector Blocks. Also used as a Marshalling Cabinet.

Cabinet Type 609(W)
Standard motorway cable connection cabinet, for use on motorway verges, to house connection boxes for data, and also used to house (separately) electrical power supply distribution and isolation equipment.

Cabinet Type 617
Standard motorway cabinet, for use on motorway verges, to house transmission equipment.

Cabinet Type 620
Standard motorway cabinet, for use on motorway verges, to house interfacing to circuits provided by a Public Telecommunications Operator.

Chambers
Underground structures of a standard size used to house cable joints and to facilitate cable installation.

<table>
<thead>
<tr>
<th>Type</th>
<th>Plan Size (mm)</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1300 x 750</td>
<td>To house cable joints</td>
</tr>
<tr>
<td>B</td>
<td>600 x 600</td>
<td>Cable installation at changes of direction; access to Traverse ducts</td>
</tr>
<tr>
<td>C</td>
<td>450 x 450</td>
<td>Cable distribution at cabinet sites</td>
</tr>
</tbody>
</table>

Chambers may be constructed from brick, plastic or concrete.

Closed Circuit Television (CCTV)
A system using remotely controlled television cameras to monitor traffic patterns at sites susceptible to traffic congestion such as tunnels, junctions and interchanges. The images are transmitted from the camera to the Control Office (CO) over the fibre optic cable infrastructure.

Control Office (CO)
The Control Office (CO) is the location from where the Welsh Office’s motorway communications equipment, for the motorways in a given Police Force Area, are controlled. The CO is used by the Police Authority for day-to-day control of motorway traffic.

Control Room
The part of the Control Office where the operators answer telephone calls, set signals and, where available, monitor CCTV and operate other equipment. Sometimes shared with other police operations and equipment.

Direct Burial
A method of cable installation which involves burying armoured cable in a trench.

Distributor Type 901
Electrical distribution switch for use with signals on gantries.
**Duct**
Provide the means by which cables may cross carriageways from one verge to the other, from one verge to the central reserve and one side of a slip to the other. The standard provision is for a group of four 100mm diameter ducts at nominal 500 metre intervals.

**Electricity Supply Company (ESC)**
A company that provides electricity supplies.

**Electricity Supply Company Interface (EI)**
An electrical power supply provided by an Electricity Supply Company at the motorway boundary.

**Enhanced Matrix Indicator (EMI)**
A matrix signal which has additional aspects for use on four lane carriageways. EMI are mounted on Cantilevers only. When used in conjunction with an Enhanced Message Sign (EMS), it forms a Motorway Signal Mark 2 (MS2).

**Enhanced Message Sign (EMS)**
A sign which is used to display a variety of legends or messages. The legend or message is controlled from the instation. EMS has 2 rows of 12 characters. Can be mounted on a gantry or cantilever.

**Equipment Room**
The part of the Control Office (CO) that houses the electronic equipment required to interface with the outstation devices and the operator interfaces within the Control Room.

**High Frequency Carrier (HFC)**
The High Frequency Carrier system is an analogue transmission system where individual 4KHz bandwidth signals are multiplexed with a higher frequency signal, the carrier, to allow the signals to share the transmission circuit.

**High-Level Data Link Control (HDLC)**
A protocol, at link level, which forms the basis of all inter-station communications on the NMCS2 data system, Closed Circuit Television (CCTV) system and the Regional Communications Controller (RCC) network. When each station communications link is set up, point to point or multidrop, the delivery, security and integrity of each frame of data is assured.

HDLC is the basis of a family of protocols which form the main data highway(s) for communication between Data Base Processor, Local Communications Controller, Regional Communications Controller and Transponders providing the packet message handling network.

**Insulation Displacement Connector (IDC)**
A terminal that makes contact with the conductive metal core of a wire by cutting into the insulation such that the insulation is displaced but not removed.

**Indicator Driver Power Unit (IDPU)**
An NMCS2 unit local to a signal.

**Loading/Loaded**
A cable pair is said to be loaded when its characteristic impedance has been altered. Loading is achieved by including inductance coils over the total length at joints between individual cable lengths.

**Local Cabling**
Cabling other than the longitudinal cabling, used to connect devices to the longitudinal cable or control equipment.

**Local Communications Control (LCC)**
An NMCS2 data system message switching unit, the most significant CO area data system communication node. Sited at the most strategic point on the motorway network, it provides the downside on the COBS - LCC level 2 link and the master on the four LCC - Transponder HDLC links.

**Longitudinal Cable**
The 30-pair copper and 24-fibre armoured cables (two separate cables) running parallel to the motorway in direct buried trenches. The 30-pair copper cable is nominally jointed at intervals of 500 metres and the 24-fibre cable is nominally jointed at intervals of 1000 metres.

**Marker Tape**
A plastic tape buried in the ground above ducts and cables to indicate their presence. Marker tape used on the ducted network includes a metallic film which allows the type (and therefore the ducts) to be detected, using detection equipment, without disturbing the surface.

**Marshalling Cabinet**
A Cabinet Type 600 immediately outside a Transmission Station (TS) into which all the longitudinal copper cables are terminated and jointed to cables from the TS.
Matrix Signal (MS)
A signal used for displaying traffic control legends to motorists. The legend (Aspect) is constructed from a matrix of lights. Each MS can display a predefined set of aspects only, such as ‘Fog’, ‘End’, speed restrictions and lane restrictions using ‘wickets’.

Microwave Radio Link
Non cable based radio transmission system using frequencies in the GHz range. Can use either digital or analogue transmission.

MIDAS Detector
Equipment installed in a Cabinet Type 600 which processes information received from cable loops buried in the carriageway which detect the presence of vehicles. The configuration of loops allows speed to be determined.

MIDAS Transponder
A Transponder dedicated to MIDAS and not used by other devices or subsystems.

Motorway Incident Detection and Automatic Signalling (MIDAS)
A Control Office Base System (COBS) Subsystem which monitors traffic flow conditions and interacts with signal subsystems to automatically set signals without operator intervention. Signals are set when queuing traffic is detected.

Motorway Signal Mark 2 (MS2)
A motorway signal comprising an Enhanced Matrix Indicator (EMI) and an Enhanced Message Sign (EMS) mounted on a cantilever structure.

Multidrop Link
A transmission channel that allows a master device to communicate with several devices over the same channel.

National Motorway Communications System (NMCS)
The motorway traffic control and emergency telephone network adopted to serve the motorways of England.

National Motorway Communications System 1 (NMCS1)
A combined signalling and telephone system controlled from Regional and National central processors, installed up to 1988.

National Motorway Communications System 2 (NMCS2)
A system using locally based distributed processing to control telephones and signals, installed from 1988.

National Transmission Network
The National data transmission network linked by the Regional Communications Controllers (RCC).

Operator Control Panel (OCP)
Is the interface between the police operator and the WOETS. A screen displays the queued calls and a key pad allows the operator to select, hold or cancel an incoming connection or to make an outgoing call.

Power Distribution Unit (PDU)
A Power Distribution Unit provides distribution and isolation, for equipment within a cabinet. Separate protected outgoing circuits (ways) are provided for equipment from the incoming circuit, together with a circuit for the cabinet heater (Cabinets Type 600, 617 and 620 have anti-condensation heaters).

Private Wire (PW)
A dedicated permanent circuit provided by a Public Telecommunications Operator between two locations.

Public Telecommunications Operator (PTO)
A licensed provider of Public accessible telecommunications services (eg. British Telecommunications Ltd, Mercury Communications Limited).

Public Switched Telephone Network (PSTN)
PSTN is provided by a Public Telecommunications Operator (eg. British Telecommunications Ltd, Mercury Communications Limited), ie a telephone connection accessed by the user dialling numbers.

Pulse Code Modulation (PCM)
Pulse Code Modulation is a process of converting an analogue signal into a digital signal. A sample of the analogue signal is taken and equated to the nearest digital level. Each digital level is associated with a binary code. This code is transmitted instead of the analogue signal. This process operates on an individual signal and does not create additional capacity. The analogue signals are sampled at 8KHz and produce 8-bit codes. This gives a single channel with a bit rate of 64,000 bits per second or 64Kbit/s.
PCM is commonly used to describe multi channel digital transmission systems. This is not totally correct as PCM is not a transmission system. PCM is generally used with Time Division Multiplexing (TDM) transmission systems.

**Regional Maintenance Contractor (RMC)**
A Contractor responsible for the day to day maintenance of instation and outstation equipment. Also has first line responsibilities for the transmission equipment in their region.

**Residual Current Device (RCD)**
An electrical safety device that isolates (disconnects) a circuit from the power source when a fault occurs.

**RS485**
A data protocol (EIA RS485) and practice adopted for use by NMCS2 between the Standard Transponder and motorway devices.

The RS485 Multidrop Link is the lowest hierarchical level of transmission in an NMCS2 data system and provides the means, parameters and protocol of communication between Transponders and motorway devices. It allows the Transponder to control several devices at once or individual devices. However, individual devices can only transmit to the Transponder.

Transmission is half duplex, ie transmission in only one direction at once. Each link caters for up to 30 motorway devices. Each message comprises 5 characters of 8 data, 1 parity, 1 start and 1 stop bits. The characters represent address, command, data byte 1, data byte 2 and longitudinal parity.

**Signal Controller**
An outstation device local to a signal dedicated to controlling a signal.

**Standard Transponder (ST)**
Standard Transponder is at the lowest hierarchical level within the Control Office area. It interfaces to Local Communications Controller/HDLN links and provides a star point on the RS485 local links. It also provides some of the signal sub-system functions and a post box service to other sub-systems. It controls up to 120 motorway devices.

**Telephone Switching Unit (TSU)**
Provides the interface between two road side telephones and the ETBU.

**Transmission**
Telecommunications terminology for the sending and receiving of signals.

**Transmission Station (TS)**
A TS is an outstation unit provided to house telecommunication equipment required to allow successful communications between the Instation and Outstation Services. The TS are either buildings or cabinets Type 617 and are spaced at approximately 20km intervals within a Control Office area.

**Uninterruptible Power Supply (UPS)**
A power supply device which prevents failure of the main power supply from disrupting the operation of equipment. A UPS will usually be of sufficient capacity to allow a secondary power supply (eg a generator) to be brought into operation, initiate alarms and in some cases initiate a controlled shutdown of equipment.

**Welsh Office Emergency Telephone System (WOETS)**
Is based on a noise cancelling 4-wire system designed specifically to improve the communication between the police and a roadside user in noisy locations such as tunnels and cuttings.

**2 Wire**
A circuit which uses 2 conductors, a single pair for both transmitting and receiving.

**4 Wire**
A circuit which uses 4 conductors, 2 wires for transmitting and the other 2 wires for receiving. The cable may be constructed in pairs or as a quad cable.
C16. REFERENCES

TA 75/96: Motorway Transmission (DMRB 9.4.4 Annex C)

BS 5467
BS 7671
Electricity Supply Regulations (1988)
Electricity at Work Regulations (1989)

Manual of Contract Documents for Highway Works:
Volume 1 - Specification for Highway Works
Volume 3 - Highway Construction Details

TR 1173
TR 2129

TR 2158 - NMCS Armoured Copper Communications Cable
TR 2159 - NMCS Armoured Optical Fibre Communications Cable
TR 2160 - NMCS Armoured Co-Axial Communications Cable
TR 2161 - NMCS Armoured Energy Cable

MCE 2015 - CCTV Control Systems

MCE 2183 - Ducted Cable Network - Cable Joint Enclosure Specification

MCG 1022 - Testing for Newly Installed Communications and Power Cable

MCG 1055 - Testing newly installed Mono-Mode Fibre Optic Communications Cable

MCG 1099 - Ducted Cable Network - Cable Testing Specification

MCH 1589 - Guide to the Siting of Inductive Loop

Detectors on Motorways
MCL 5502

MCL 10470

Welsh Office Drawings:
W1436/T/036/0064 - Draw-Pits at Transmission Station
W1436/T/080/0003 - Typical Detail of Hardstanding to Cabinets
W1436/T/080/004 - Typical detail of Steps and Hardstandings
W1436/T/080/0029 - Draw-pit and Ducting Detail
W1436/T/080/0030 - Labels for Post 75E (W)
W1436/T/080/0043 - Label Details for Gantries
W1436/T/080/0044 - NMCS Labels for Cabinets, Installation Drawing
W1436/T/080/0045 - Labels for Cables and Telephone Housings
W1436/T/080/0046 - NMCS Labels for Cabinets 600(W) and 609C(W) (external fittings)
W1436/T/080/0047 - NMCS Telephone ‘Instructions for Use’ label
W1436/T/080/0051 - Optical Fibre Installation in Cabinet 609C(W)
W1436.052/SW-TE/401 - Typical Transmission Station and Equipment Layout
T1071/T/050/0049-0053 - Terminator Frames
T1071/T/050/0054-0056 - Cabinet 609C(W)
T1071/T/050/0057-0059 - Box 615(W)

T1071/T/050/0061 - Installation in Cabinet 609C(W)

T1071/T/050/0065 - Installation of Telephone 352

T1071/T/050/0081 - Box 615(W) Local Side

T1071/T/050/0097 - Internal Label Details for Cabinets

Welsh Office Specifications:

WOEM 1000 - Installation of Inductive Loops for Vehicle Detection

WOEM 1008 - Inductive Loop Cable for Vehicle Detection

WOEM 1009 - Feeder Cables for Inductive Loop Vehicle Detection

WOEM 4000 - Technical and Quality Control Requirements for Systems Manufactured, Supplied, Installed or Maintained

WOEM 4003 - Supply, Installation and Testing of Cable and Equipment for a Motorway Communication System

WOEM 4407 - Co-axial Cable

WOEM 4421 - Optical Fibre Cable

WOIP 0003 - Production of CAD System Communications Record Drawings, including Standard WO Symbols
PART 1

TA 77/97 Annex D (Northern Ireland Only)

MOTORWAYS

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D1. INTRODUCTION

D1.1 General

1. This Annex is for the specific requirement of motorway communications in Northern Ireland.

DMRB Structure

2. Section 1 of Volume 9 of the Design Manual for Roads and Bridges (DMRB) contains Technical Directives (TD) which detail the Standards of Provision.

3. Section 2 onwards contains Technical Advice (TA) Notes which reflect current practice in the field of motorway communications and control.

Design Loop

4. Figure D1.1a shows the ‘Design Loop’ illustrating the general sequence in the iterative design process which starts with the design for emergency telephones and signals followed by transmission and control office designs. Last in the cycle is the design of the infrastructure that will be required to support all communications equipment and systems.

Glossary

5. A Glossary of Terms is given in Chapter D15.

Standard Drawings and Specifications

6. Standard MCX and MCY drawings and MCH and TR Specifications are issued by Network Control Division (NCD) of the Highways Agency (HA).

Figure D1.1a Structure of Volume 9 of the Design Manual for Roads and Bridges
D2. OVERVIEW

D2.1 General

1. The Department of the Environment for Northern Ireland (DOENI) operates a national cabling infrastructure for motorway communications. In the past this has been provided using armoured cable, either directly buried or installed in trough. Changes have recently been made for new installations, and the recommended method of cable installation is now non armoured cable in a duct network.

2. This method of installation has the following advantages:
   (i) increased network flexibility and durability;
   (ii) increased system and network security;
   (iii) ease of cable installation and removal of redundant cable; and,
   (iv) reduced traffic management requirements.

Ducted Cable Network

3. The scheme should provide a fully ducted cable network with chambers providing access to joints and terminations and for cable installation. The ducted network is sealed from gas and water.

4. The cable installation is fully detailed in the MCX 0800 series and includes the following main features:
   (i) a fully ducted cable network, including detectable marking tape;
   (ii) cable jointing and termination within environmentally sealed underground enclosures; and,
   (iii) non armoured cable.

Cable Types

5. The following types of cable are installed:
   (i) longitudinal 30/40 pair copper cable;
   (ii) longitudinal 12/24 pair fibre cable;
   (iii) longitudinal carrier quad cable where Pulse Code Modulation (PCM) is not in operation;
   (iv) local quad cable to equipment;
   (v) power cable to equipment;
   (vi) coaxial cable to equipment; and,
   (vii) loop detector and feeder cables.

Alternative Methods of Cable Installation

6. When replacing short lengths of existing direct buried or troughed cables it may be inappropriate to provide the standard method of cabling; design guidance is given in Chapter D9.

7. Wherever alternative methods of cable installation are used, it is of paramount importance that the cable is adequately protected from possible damage during future maintenance works and from errant vehicles.

8. Physical constraints, such as structures, may prohibit the installation of standard cable ducts. In these cases other techniques may need to be considered. However, where the use of an alternative installation method is proposed, early advice should be sought from the DOENI.
D3. NETWORK DESCRIPTION

D3.1 Introduction

1. The network comprises the following, which are described in this chapter:

   (i) cable network;
   (ii) duct network;
   (iii) roadside electronic equipment;
   (iv) power supplies;
   (v) Telecommunications Interfaces;
   (vi) Control Offices.

2. During the design stage the designer should be aware of the existing cable network and the effect which the design will have upon it.

D3.2 Non-Armoured Cable Network

1. Non armoured cable is installed in ducts.

   Longitudinal Copper Cable Network

2. Longitudinal 40 pair copper communications cable carries data and voice circuits between roadside equipment, including telephones and signals, and their respective Control Offices.

3. Transmission Stations (TS) are provided at approximately 20km intervals on the longitudinal cable network.

4. The longitudinal cable is installed between chambers spaced at 500m intervals. Cable is supplied in drum lengths of 1075m, therefore, more than one length is taken from each drum. In order to assist the installation, the cable itself is marked at one metre intervals. Thus the exact amount of cable remaining on a drum can be readily identified.

5. Cable termination is facilitated by the use of Insulation Displacement Connectors (IDC) housed in environmentally sealed Cable Joint Enclosures (CJE). CJE are installed inside underground chambers.

   Longitudinal Optical Fibre Cable Network

6. Longitudinal optical fibre cable is provided in addition to 40 pair cable. When fully implemented, it will provide an enhanced transmission medium using Pulse Code Modulation (PCM) data circuits. Optical fibre cable is also used for the transmission of Closed Circuit Television (CCTV) video circuits.

7. Optical fibre cable is supplied and installed in drum lengths of 2060m. Fibre splices are housed in CJE installed inside underground chambers.

   Carrier Cable

8. Optical fibre PCM is the preferred medium for national data transmission. However, where it is not available a carrier quad cable is installed for the provision of carrier circuits. Carrier quad cables are laid in 2000m lengths in duct and terminated in CJE using IDC. Carrier circuits are used both in the national communications network and locally.

   Local Cabling

9. Roadside equipment, including emergency telephones and signals, is connected to the longitudinal cable by local quad cables. Connections to the longitudinal cable are made in CJE or Cabinets Type 600 as appropriate.

10. CCTV cameras are connected to longitudinal cables either by local quad and optical fibre, or coaxial cable.

D3.3 Armoured Cable Network

1. Armoured cable is installed in trench (direct burial) or in trough.

   Longitudinal Copper Cable Network

2. Longitudinal 30 pair copper cable carries data between roadside equipment including telephones and signals, and their respective Control Offices. It also carries data on the National Transmission Network. Longitudinal cable is installed in nominal 500m lengths. A Cabinet Type 609 is provided at each end of a cable length to house the terminations.
3. Transmission Stations (TS) are provided at approximately 20km intervals on the longitudinal cable network.

Local Cabling

4. Roadside equipment, including emergency telephones and signals, is connected to the longitudinal cable by local quad cables. Connections are made either in Cabinets Type 600 or in Cabinets Type 609, as appropriate.

Optical Fibre Cable

5. Where CCTV is provided, a fibre optic cable is required for longitudinal video transmission. The longitudinal fibre optic cable is terminated at 1000m intervals in Cabinets Type 609. Where provided for CCTV schemes fibre optic cable is also used for PCM transmissions.

D3.4 Duct Network

1. The duct network is described fully in Chapter D7. In summary it comprises:
   (i) 100/150mm diameter 4-way longitudinal ducting, local ducts to equipment and transverse ducts;
   (ii) main jointing chambers (Type A) at 500m (tolerance +2%-5%) intervals;
   (iii) intermediate chambers (Type B), where necessary to facilitate cable installation (such as at a structure, a cabinet location or change in direction);
   (iv) chambers at cabinet sites (Type C); and,
   (v) large chambers adjacent to Transmission Stations.

D3.5 Roadside Electronic Equipment

1. Roadside Electronic equipment is housed in Cabinets Type 600. They are sealed and contain thermostatically controlled heaters and power distribution units.

2. This equipment includes Telephone Responders, Transponders, MIDAS Detectors, EMS/MS2 equipment and CCTV equipment.

D3.6 Power Supplies

1. Electricity Supply Company Interface (EI) equipment is housed in Cabinets Type 609 (EI Cabinets) which are installed in the motorway boundary fenceline. The Electricity Supply Company’s equipment and power supply cable are installed on the non-motorway side of the cabinet.

2. Power is distributed from EI Cabinets to power cabinets (Type 609P) and then to equipment on the motorway. 3-core or split concentric power cable is used for power distribution.

D3.7 Telecommunications Interfaces

1. Where access to Third Party, Private Wire or the Public Switched Telephone Network (PSTN) is required, a cabinet is installed in the motorway fence line to house the Telecommunications Company interface equipment and to connect their telecommunications cable.

2. The telecommunications facilities are then connected to motorway equipment via quad, 40-pair or coaxial cable.

D3.8 Control Offices

1. Control Offices (CO) are generally located in police headquarters buildings. These are often situated near the centres of main towns or cities. They serve as command and control centres for police activities within a specific area, this includes the motorways within that area.

2. Motorway traffic control and communications equipment for the control of telephones, signalling and CCTV is provided in Control Rooms within COs. Supporting telecommunications equipment is provided within adjacent Equipment Rooms.

3. Telecommunications links are required between the Equipment Room and the nearest TS on the motorway network. This link may be provided by a cable, a radio or microwave. The precise form of this link will depend upon such considerations as:
   (i) the relative locations of the CO and the TS;
   (ii) communications security requirements;
   (iii) cost.
D3.9 Protection of Existing Cable

General

1. When planning work on existing motorways special consideration should be given to the protection of the existing motorway communications infrastructure. The longitudinal cable will be part of the national carrier network in addition to its function of carrying local data from signals and telephones. Any damage to the cable will therefore cause disruption to signal and telephone facilities over an extremely wide area.

2. The Design Agent should produce an Existing Communications Report which will include an assessment of how the scheme will affect the existing national 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; details of how to achieve this are given in TA 75/95 : Motorway Transmission.

3. During the design stage the location of all cable and equipment should be determined and an assessment made of the risk of damage. In general where works are to be undertaken on the verge containing cable and equipment there will be a significant risk of damage. It should be noted that the opposite verge will also contain telephones and probably power supply cables which will therefore be vulnerable to damage from works on this verge.

Precautions to Avoid Damage

4. The precautions required will depend on many factors including the risk of damage and the communications infrastructure to be provided by the scheme.

5. Where a contractor will be working in close proximity to existing cables or duct the exact location of the cables and duct should be marked clearly prior to the commencement of any works. This operation should be undertaken by the specialist Regional Maintenance Contractor (RMC). It may be possible to fence off the vulnerable area with temporary fencing, taking care not to damage cable or duct whilst installing fence posts.

6. Consideration should be given to programming the works to avoid working adjacent to live cables wherever possible.

7. 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.

Cable Damage and Replacement

8. All instances of damage to cable should be regarded as serious. All cable damage should be reported immediately to the RMC by the Contractor, via the Engineer. The Department of the Environment for Northern Ireland (DOENI) should be informed as soon as practicable.

9. The RMC will effect whatever temporary repairs are necessary to restore motorway communications.

10. All damaged cables should be replaced at the contractor's cost. Where cable is to be replaced a complete drum length must be replaced. The DOENI will be able to advise of manufacturers of cable to the required specifications. Ideally replacement will be undertaken during the contract period. If this is not possible then all reasonable costs incurred by the DOENI in replacing the cable, including traffic management, will be recovered from the contractor.
D4. MOTORWAY CABLES

D4.1 General

Bulk Purchase

1. Cables used for motorway communications are purchased in bulk by the Department of the Environment for Northern Ireland (DOENI). They are supplied to the scheme and are made available for collection by the cable installation contractor.

Standard Cables

2. There are several standard cable types, all of which are non armoured and are suitable for installation in ducts. They are described and illustrated on the following pages.

Acceptance of Non Armoured Cable

3. These cables have been specified to conform with current industry standards. As such they do not have a graphite coating. Acceptance testing of non-armoured cable is not considered necessary. Cables are tested, during manufacture, by the manufacturer as part of the routine quality control process. The cable installation contractor shall satisfy himself that the cable is acceptable before installation in a duct.

4. The cost of replacing any cable which is found to be damaged or unsatisfactory in any way will be far less than the cost of replacing a directly buried cable. Replacement can be undertaken with minimal traffic management and no interference with adjacent cables.

5. The most common source of sheath damage in the past was the nails which were used to secure battens to the cable drums. This method is no longer employed. If a cable drum is delivered damaged to site, it will be rejected as the battens serve to protect the cable.

Armoured Cable

6. Armoured cable is still available for installation where a ducted network is not provided - refer to paragraph D4.2.

Acceptance of Armoured Cable

7. Armoured cable has a graphite coating and is subject to on-drum acceptance testing by the installation contractor. In addition, these cables are tested after backfilling and before termination, to prove the integrity of the cable.
D4.2 NMCS Non Armoured Cable

Copper Communications Cable

1. NMCS non armoured copper communications cable conforms to specification TR 2150 and is illustrated in Figure D4.1a.

2. TR 2150 specifies quad, 5 pair, 10 pair and 40 pair copper cable.

3. This cable is a fully filled copper communication cable sheathed with medium density polyethylene. It is constructed from solid plain copper conductors insulated with cellular or foam-skin polyethylene. It has an aluminium polymer laminate tape which acts as a moisture barrier.

4. See paragraph D5.6 for cable pair allocation.

5. The 40 pair cable is constructed from 4 units each comprising 10 copper pairs which are individually taped and bound together. 40 pair cable is purchased in 1075m drum lengths.

6. Quad cable is illustrated in Figure D4.1b. There are two variants of quad cable - local quad and carrier quad.

   Local Quad

   7. The conductor size and insulation thickness are the same as for 40 pair cable. Local quad cable is purchased in 1000m drum lengths.

   Carrier Quad

   8. This cable has a thicker conductor and insulation, 1.2mm conductor, 3mm overall insulated conductor size. Carrier quad cable is purchased in 2100m drum lengths.
Optical Fibre Communications Cable

9. NMCS non armoured optical fibre communications cable conforms to specification TR 2151 and is illustrated in Figure D4.1c.

10. This cable comprises 24 fibres housed in 3 tubes, 8 fibres per tube.

11. See paragraph D5.6 for fibre allocation.

12. This cable is a fully filled single mode optical fibre cable. The cable is sheathed in polyethylene and is 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. Each of the 24 fibres is individually coloured.

Coaxial Communications Cable

13. This cable is purchased in drum lengths of 2060m.

14. NMCS non armoured coaxial communications cable conforms to Specification TR 2152 and is illustrated in Figure D4.1d.

15. This cable is a 75Ω semi air spaced coaxial cable sheathed with medium density polyethylene. It is constructed with an inner conductor of solid plain annealed copper and a 5 cell semi airspaced polyethylene dielectric. The outer conductor consists of a plain annealed copper tape covered with a plain annealed copper braid with a polyester isolating tape applied helically. An aluminium polymer laminate tape is provided.

16. This cable is purchased in 1000m drum lengths.

Power Cable

17. NMCS non armoured power cable conforms to Specification TR 2153 and is illustrated in Figure D4.1e.

18. The two standard sizes of cable are 10mm² and 25mm². Other sizes may be required and can be supplied to suit local conditions, subject to the capacity of the duct network and the practicalities of installation. Approval from the DOENI must be obtained during the design stage if non standard cable sizes are being considered.

19. This cable is a three core stranded copper conductor energy cable sheathed with medium density polyethylene. It is constructed from high-conductivity copper, stranded into a circular profile and insulated with cross-linked polyethylene. These conductors are bound together.

20. This cable is purchased in 1000m drum lengths.

Inductive Loop Detector Cable

21. NMCS inductive loop detector cable conforms to Specification TR 2029. It is installed in slots cut into the carriageway. Non armoured cable is used for all applications.

22. This cable is a single core multistrand flexible cable sheathed with polychloroprene. The single tinned copper conductor is insulated with ethylene propylene rubber.

23. This cable is purchased in 1000m drum lengths.

Feeder Cable For Inductive Loop Detectors

24. NMCS feeder cable for inductive loop detectors conforms to Specification TR 2031. Feeder cable is available as a non armoured cable and also as an armoured cable. It is available as either a 2 core or 4 core cable.
25. This cable is a copper communications cable sheathed with medium density polyethylene. This cable is constructed from solid plain copper conductors insulated with solid polyethylene.

26. This cable is purchased in 1000m drum lengths.

D4.3 NMCS Armoured Cable

1. The following types of armoured cable are available for installation by direct burial where cable ducts are not provided:

(i) quad, 10 pair and 30 pair copper communications cable to TR 2158;

(ii) composite optical fibre/copper cable to TR 2017;

(iii) coaxial cable to TR 2160;

(iv) energy cable to TR 2161;

(v) feeder cable for inductive loop detectors to TR 2031.

Copper Communications Cable

2. This cable is a fully filled copper communications cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. The make up of the cable is in the form of a centre and a number of concentric layers. It is constructed from solid plain copper conductors insulated with solid polyethylene and twisted together to form pairs.

Composite Optical Fibre/Copper Cable

3. This cable is fully filled single mode composite optical fibre cable, designed for direct burial. It contains 12 fibres individually tubed, and 11 pairs of 0.9mm copper conductors. The cable is sheathed in polyethylene and is 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 cable has a galvanised steel wire armour applied to the inner sheath and a polyethylene outer sheath.

Coaxial Cable

5. This cable is a 75 Ω semi airspaced coaxial cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. It is constructed with an inner conductor of solid plain annealed copper and a 5 cell semi airspaced polyethylene dielectric. The outer conductor consists of a plain annealed copper tape covered with a plain annealed copper braid with a polyester isolating tape applied helically. An aluminium polymer laminate tape is provided as a moisture barrier.

Power Cable

6. This cable is a three core stranded copper conductor energy cable sheathed with medium density polyethylene with a single layer of galvanised steel wire armour designed for direct burial in the ground. It is constructed from high-conductivity copper, stranded into a circular profile and insulated with cross-linked polyethylene.
D5. NETWORK DESIGN

D5.1 General Procedure

1. This chapter deals with the design of ducted cable networks.

Design Process

2. The design process is iterative. All items of roadside equipment and cable joints will have their ‘ideal’ locations, however the most efficient design will be one which achieves the balance between ideal locations, physical constraints and cost. For instance, minor adjustments to locations may result in duct, cable or equipment savings.

3. The first stage in the design of a communications network is to correctly site signals and telephones on 1:10000 scale drawings. This design is transferred to the 1:2500 scale drawings, and a schematic design is produced. The longitudinal cables are then designed and added to the drawings. All local cables and items of equipment are then added to the schematic design which is then transferred back to the 1:2500 scale drawings. The locations of equipment, chambers and cabinets are then checked against physical constraints and adjusted accordingly to ensure that staff access can be maintained.

Transmission Stations

4. The location of Transmission Stations (TS) should be finalised before starting schematic design as this has a fundamental effect on the design of the cable network. Copper cables are terminated in Marshalling cabinets which are sited immediately outside TS buildings. Optical fibre and coaxial cables are terminated within the TS itself.

Interfaces

5. Where the scheme boundary does not coincide with a TS the cable infrastructure adjacent to the scheme boundary should be taken into account. Where a ducted network will interface with an existing direct buried network an interface cabinet should be provided for the termination of 40 pair and carrier cables with the existing 30 pair cable, refer to the MCX 0800 series for details.

Cable Lengths

6. The characteristics of the cable and transmission equipment dictate that 40 pair cable lengths between terminations must be in the range 500-535m. Optical fibre cable lengths between terminations are limited by the drum length available, which is 2060m. When assessing joint chamber locations the requirement for optical fibre joints and the maximum cable length available should be considered.

7. The actual length of cable between joints may be calculated as follows:

\[
\text{(a) duct length between adjacent jointing chambers} = x \text{ m} \\
\text{(b) snaking allowance (2\% of (x))} = y \text{ m} \\
\text{(c) length housed in jointing chamber} = 15 \text{ m} \\
\text{Total} = x + y + 15 \text{ m}
\]

When calculating the length of cable required from a drum a termination/installation allowance should be added (2m for copper, 3m for fibre cables).

8. The 7.5m length is housed within the chamber, supported on cable brackets. It allows the cable joint to be taken out of the chamber and into a jointing vehicle parked on the hardshoulder.

9. Cables are terminated in Cable Joint Enclosures (CJE) which are housed within underground chambers (Type A).

10. In exceptional circumstances, where site conditions preclude the laying of 500-535m of 40 pair cable in one longitudinal length advice from the Department of the Environment for Northern Ireland (DOENI) should be obtained before proceeding with design.
Chapter D5
Network Design

Volume 9 Section 5
Part 1 TA 77/97 Annex D (Northern Ireland Only)

D5.2 Schematic Design

1. The following paragraphs and drawings describe how the various items of equipment are connected to the longitudinal cable networks, schematic drawings are used to illustrate how this is achieved. The symbols used are those shown on MCX 0801 (repeated in Figure D5.2a).

Longitudinal Cable Design

11. The longitudinal cable design commences with the plotting of the longitudinal cables, associated CJEs, high voltage power lines and road structures. The plotting of CJE positions should commence at both TS working towards the centre of the transmission section. The loading pattern should be checked at this stage (see paragraph D5.5).

12. Signals, telephones and all associated equipment are then added to the schematic design (see paragraph D5.2 for typical schematic details).

13. All items of equipment on the motorway are connected into the longitudinal 40 pair copper and optical fibre cable networks within local CJEs.

Duct and Chamber Design

14. Following the initial schematic communications design, ducts and chambers should be positioned; refer to Chapters D7 and D8 for details.

15. Provisional sites should then be refined to site CJE and chambers in the optimum positions. Guidance on the siting of chambers is given in Chapter D8.

Cabinets for Electronic Equipment

16. Transponders and Telephone Responders, are housed within Cabinets Type 600. Those cabinets should always be located adjacent to a Longitudinal Cable Joint. The distance between Cabinet and Joint should not exceed 30m.

Power Transmission Lines

17. The locations of all underground and overhead power transmission lines shall be ascertained and recorded on the design drawings. The location of such power lines may affect the positioning of longitudinal cables and equipment.

Non Ducted Systems

18. Non ducted systems are dealt with in Chapter D9.
Figure D5.2a  Schematic Symbols
Emergency Telephones

2. The cabling arrangements for emergency telephones are shown schematically in Figure D5.2b.

3. The telephone instrument may be isolated from the local quad cable by means of a Cable Joint Enclosure (CJE) housed in a chamber adjacent to the telephone post.

4. Where emergency telephones are located within 250m of a Telephone Responder, the cabling arrangement is as shown on Figure D5.2b(ii).

5. Connections to telephones are detailed on MCX 0135, and to local CJEs in the MCX 0800 series. Wiring within a 600 cabinet is detailed in the MCX 0800 series.

Figure D5.2b  Telephone Schematic
Post Mounted Signals

6. The cabling arrangements for post mounted signals are shown schematically in Figure D5.2c.

7. A CJE Type RSI (Rural Signal Interface) is mounted within the ‘B’ side of the 609P cabinet, this affords local access from the motorway verge to the signal control (RS485) circuit during commissioning and maintenance. Where a dedicated P cabinet is not provided an additional 609 cabinet should be provided to house the CJE. This is the only type of CJE which is not housed underground.

8. Connections to the signal, the ST (where applicable), the CJE Type RSI and the underground CJE are shown in the MCX 0800 series.

9. Where post mounted signals are within 50m of a Transponder, the cabling arrangement is as shown on Figure D5.2c(ii). The signal will be connected to Port 2 (local) of the ST. Where the signals are less than 150m, but greater than 50m from an ST, the cabling arrangement shown on Figure D5.2c(ii) is used with the addition of a 609P cabinet local to the signal.

Figure D5.2c  Post Mounted Signal Schematic
Gantry Mounted Signals

10. Gantry mounted signals are equipped with matrix signals and an Enhanced Message Sign (EMS) for driver information.

12. The cabling arrangements for gantry mounted signals are shown schematically in Figure D5.2d.

13. In this case access to the signal control (RS485) circuit is afforded from the 600 cabinet used for EMS control.

14. Connections to the gantry, the EMS cabinet and the CJE are shown on MCX 0151 and the MCX 0800 series.

![Figure D5.2d  Gantry Mounted Signal Schematic](image)

Motorway Signal Mark 2

15. Motorway Signals Mark 2 (MS2) are used for signalling on motorways with up to three lanes and are cantilever mounted.

16. An MS2 comprises an Enhanced Matrix Indicator (EMI) for signalling and an Enhanced Message Sign (EMS) for driver information. The EMI is equipped with four amber lantern units (MS2 Type A1) or with four amber and four red lantern units (MS2 Type A2).

17. The EMI is controlled either by NMCS2 or by Stand Alone Control.

18. The cabling arrangements for MS2 are shown schematically in Figure D5.2e. The arrangement is suitable for both types of control.

19. Connections to the MS2 cabinet 600 and the CJE are shown on the MCX 0800 series.

![Figure D5.2e  MS2 Schematic](image)
EMS Type B

20. An EMS Type B is an EMS mounted on a cantilever.

21. The cabling arrangements for an EMS Type B are shown schematically in Figure D5.2f.

Figure D5.2f EMS Type B Schematic
MIDAS Loop Detectors

22. The requirements for MIDAS Loop Detectors are described in MCH 1589 Guide To The Siting Of Inductive Loop Detectors On Motorways. The cabling arrangements for MIDAS outstations are shown schematically in Figure D5.2g.

23. The joints between Loop Detector Cables and Loop Feeder Cables are located in roadside chambers conforming to Highway Construction Detail (HCD) G13 and MCX 0592. Loop Feeder Cables are terminated in a MIDAS Detector Cabinet 600, the maximum length of Feeder Cable is 200m.

24. Connections to the MIDAS Detector (MD) cabinet and the CJE are shown on the MCX 0800 series.

25. Where a MIDAS Transponder is also required, the arrangement is as shown on Figure D5.2g(ii).

![Figure D5.2g  MIDAS Schematic](image-url)
CCTV Outstations

26. CCTV Outstations are described in Specification MCE 2015. The cabling arrangements for CCTV are shown schematically on Figure D5.2h.

27. Composite video signals are transmitted to the CO along the longitudinal OF Cable network. Connection to this network is obtained from the nearest fibre CJE on a single fibre in an OF spur cable.

28. Camera control is exercised from the CO using the longitudinal 40-pair cable. Connection to this network is obtained from the nearest CJE using three quad cables.

29. The connection between the CCTV Cabinet 600 and the camera is made using proprietary cable provided by the CCTV Contractor.

30. Power is supplied from an adjacent Power Cabinet 609.

31. The use of optical fibre cable is the preferred method, however, where CCTV cameras are within 1km of a TS, they may on the advice of the DOENI use coaxial cable in place of OF cable. The arrangements are shown in Figure D5.2h.

Figure D5.2h  CCTV Schematic
Isolated Equipment

32. Where isolated equipment is to be installed the cabling arrangements are shown in Figure D5.2i.

![Isolated Equipment Schematic](image-url)

Figure D5.2i  Isolated Equipment Schematic
D5.3 Selection of Duct Route

1. One of the earliest tasks during the design is to determine the most suitable route for the longitudinal duct route. The planning of the route will involve plotting a suitable route on drawings at 1:2500 scale and a survey of the site to confirm the suitability of the chosen route. A record of this survey on video proves an invaluable aid when locating equipment and chambers.

2. All ducts should be laid within the motorway boundary. The only exception is at Transmission Stations (TS) where they may be laid into a works unit compound.

3. Where bases for equipment such as CCTV cameras or large signs coincide with the duct route these bases should be designed to allow ducts to be built in.

4. When planning the duct route the precise locations of all proposed and existing communications cables, duct routes and other relevant features should be plotted, from the schematic design, onto drawings at 1:2500 scale. Relevant features include:

   (i) Cuttings/Embankments;
   (ii) Structures including bridges, retaining walls; and
   (iii) Drains;
   (iv) Safety fences;
   (v) Lighting and other cables;
   (vi) Gantries or verge mounted signs;
   (vii) Noise fences;
   (viii) Environmental mounds;
   (ix) Trees.

5. The presence of particular features may require the use of special methods of construction or special items of plant or machinery. For example, installing ducts behind safety fencing on a steep embankment would be beyond the capabilities of standard mechanical excavators. This may, in turn, require special traffic management arrangements or result in the need for night working. All such details should be included in tender documentation.

6. The longitudinal cable should normally be kept on the same side of the motorway throughout its length, or at least, for a substantial distance. The side chosen will depend on the balance of advantages and disadvantages after considering such features as:

   (i) Cuttings/Embankments;
   (ii) Flood plains;
   (iii) Overhead power lines or electrified railway or buried power cables;
   (iv) Relationship to Transmission Stations and cables/ducts on adjacent sections of motorway;
   (v) Ease of siting cabinets including access and safety protection;
   (vi) Ease of providing power supplies;
   (vii) Ease of routing duct.

7. Where there is a risk of interference from external electrical sources, eg power lines which run parallel to the motorway and are within 100m of it for a substantial distance, the longitudinal cable should be installed on the opposite side of the motorway to reduce the risk of interference. However, the longitudinal cable should not be repeatedly changed from one side of the motorway to the other. The DOENI should be consulted if necessary.

8. Ducts to local equipment should occupy the same trench as longitudinal ducts as far as possible. When choosing the route for a local duct the guidance given for longitudinal duct route selection will apply equally.

D5.4 Copper Cable Terminations

1. Cable terminations are contained in environmentally sealed Cable Joint Enclosures (CJE) - these are constructed from a plastic material and are housed in underground chambers. CJE may be opened and resealed without the need for any specialist tools or equipment. CJE are detailed in the MCX 0800 series and are manufactured in accordance with MCE 2183.

2. Cable terminations are made by using Insulation Displacement Connectors (IDC). Cable is inserted into an IDC using a purpose made tool. The IDC cuts through the cable insulation and makes a connection to the copper conductor.
3. There are 7 types of CJE available for copper termination as detailed in Table D5.4a:

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
<th>No of Cables to be Accommodated</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>Unloaded.</td>
</tr>
<tr>
<td>2</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 22 circuits loaded at 22mH.</td>
</tr>
<tr>
<td>3</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 6 circuits loaded at 88mH.</td>
</tr>
<tr>
<td>4</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 28 circuits loaded at 22mH.</td>
</tr>
</tbody>
</table>

| L    | Local distribution         | 3 x 40 pair and 6 x quad      |                           |
| RSI  | Rural Signal Interface     | 4 x quad                      |                           |
| HFC  | High Frequency Carrier     | 4 x carrier quad              |                           |

**Table D5.4a** Types of CJE for copper termination

D5.5 Loading Design

1. Once the chamber sites and the individual cable lengths have been confirmed a cable loading scheme should be prepared.

2. Cable loading practice is described in MCL 5502.

3. The cable loading design should be based on nominal 500m chamber spacing starting from both Transmission Stations.

4. Where the distance between the two terminations in the middle of the transmission section is less than 450 metres it should be corrected by re-positioning the other provisional sites; where this is not possible a non-standard length of cable will be necessary. Capacitors will be added in the CJE to give an equivalent electrical length of 500 metres - 'building out'. There may be other places where using a cable length of less than 450-metres is unavoidable. Any such circumstances should be brought to the attention of the DOENI as early as possible.

5. It should be noted that the instructions for siting TS specify a maximum linear spacing of 20km. Once all the CJE and chambers have been sited and lengths of individual cables checked, the number of cable lengths should be counted. The DOENI should be consulted in all cases where more than 40 lengths of cable between adjacent TSs are proposed.

6. Instructions for the preparation of a cable loading scheme and calculation of values of building out capacitors are given in MCL 5502. The loading pattern and build out should be submitted for approval by the DOENI at an early stage of the design.

7. The normal loading pattern to allow for 2 wire telephone operation is shown in Table D5.5a.

<table>
<thead>
<tr>
<th>Distance from Transmission Station (m)</th>
<th>Loading (mH)</th>
<th>CJE Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data</td>
<td>Telephone</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>1000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>1500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>2000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>3000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>3500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>4000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16500</td>
<td>22</td>
<td>15 - 2</td>
</tr>
<tr>
<td>17000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>17500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>18000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>18500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>19000</td>
<td>-</td>
<td>88</td>
</tr>
<tr>
<td>19500</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>20000</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table D5.5a** Loading pattern for 2 Wire Operation
## Table D5.6a Longitudinal Cable Pair Allocation

<table>
<thead>
<tr>
<th>Service</th>
<th>Loading</th>
<th>Service</th>
<th>Loading</th>
<th>Service</th>
<th>Loading</th>
<th>Service</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAIR 1</strong> (W/Blue)</td>
<td>HDLC Signals Control</td>
<td>22mH</td>
<td>HDLC CCTV Control</td>
<td>22mH</td>
<td>Telephone Line 1 2W (Line 1 TX 4W)</td>
<td>88mH* (22mH)</td>
<td>Telephone Line 4 TX 4W</td>
</tr>
<tr>
<td><strong>PAIR 2</strong> (W/Orange)</td>
<td>HDLC Signals Reply</td>
<td>22mH</td>
<td>HDLC CCTV Reply</td>
<td>22mH</td>
<td>Telephone Line 2 2W (Line 1 RX 4W)</td>
<td>88mH* (22mH)</td>
<td>Telephone Line 4 RX 4W</td>
</tr>
<tr>
<td><strong>PAIR 3</strong> (W/Green)</td>
<td>RS 485 Signals None</td>
<td>None</td>
<td>RS 485 CCTV None</td>
<td>None</td>
<td>Telephone Line 3 2W (Line 2 TX 4W)</td>
<td>88mH* (22mH)</td>
<td>Telephone Line 5 TX 4W</td>
</tr>
<tr>
<td><strong>PAIR 4</strong> (W/Brown)</td>
<td>HDLC EMS Control</td>
<td>22mH</td>
<td>Engineer’s Audio</td>
<td>22mH</td>
<td>Telephone Line 4 2W (Line 2 RX 4W)</td>
<td>88mH* (22mH)</td>
<td>Telephone Line 5 RX 4W</td>
</tr>
<tr>
<td><strong>PAIR 5</strong> (W/Slate)</td>
<td>HDLC EMS Reply</td>
<td>22mH</td>
<td>Engineer’s Audio</td>
<td>22mH</td>
<td>Telephone Line 5 2W (Line 3 TX 4W)</td>
<td>88mH* (22mH)</td>
<td>Telephone Line 6 TX 4W</td>
</tr>
<tr>
<td><strong>PAIR 6</strong> (R/Blue)</td>
<td>HDLC MIDAS Control</td>
<td>22mH</td>
<td>Spare None</td>
<td>Telephone Line 6 2W (Line 3 RX 4W)</td>
<td>88mH* (22mH)</td>
<td>Telephone Line 6 RX 4W</td>
<td>22mH</td>
</tr>
<tr>
<td><strong>PAIR 7</strong> (R/Orange)</td>
<td>HDLC MIDAS Reply</td>
<td>22mH</td>
<td>Spare None</td>
<td>Remote Telephone Line 1 2W Line 1 TX 4W</td>
<td>None</td>
<td>Remote Telephone/Local Line 1 2W Line 1 4W TX</td>
<td>None</td>
</tr>
<tr>
<td><strong>PAIR 8</strong> (R/Green)</td>
<td>RS 485 MIDAS None</td>
<td>None</td>
<td>Spare None</td>
<td>Remote Telephone Line 2 2W Line 1 RX 4W</td>
<td>None</td>
<td>Remote Telephone/Local Line 2 2W Line 2 4W RX</td>
<td>None</td>
</tr>
<tr>
<td><strong>PAIR 9</strong> (R/Brown)</td>
<td>Telemetry 22mH</td>
<td>None</td>
<td>Spare None</td>
<td>Remote Telephone Line 3 2W Line 2 TX 4W</td>
<td>None</td>
<td>Remote Telephone/Local Line 3 2W Line 2 4W TX</td>
<td>None</td>
</tr>
<tr>
<td><strong>PAIR 10</strong> (R/Slate)</td>
<td>Telemetry 22mH</td>
<td>None</td>
<td>Spare None</td>
<td>Remote Telephone Line 4 2W Line 2 RX 4W</td>
<td>None</td>
<td>Remote Telephone/Local Line 4 2W Line 2 4W RX</td>
<td>None</td>
</tr>
</tbody>
</table>

**NOTE:** *88mH for 2 wire telephone operation.
### Table D5.6b  Local Cable Pair Allocation

<table>
<thead>
<tr>
<th></th>
<th>UNIT 1  (Blue)</th>
<th>UNIT 2  (Orange)</th>
<th>UNIT 3  (Green)</th>
<th>UNIT 4  (Brown)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td>HDLC Signals Control</td>
<td>Engineer’s Audio</td>
<td>Telephone Line 1 2W</td>
<td>(Telephone Line 4 TX 4W)</td>
</tr>
<tr>
<td></td>
<td>(W/Blue)</td>
<td></td>
<td>(Line 1 TX 4W)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HDLC Signals Reply</td>
<td>Engineer’s Audio</td>
<td>Telephone Line 2 2W</td>
<td>(Telephone Line 4 RX 4W)</td>
</tr>
<tr>
<td></td>
<td>(W/Orange)</td>
<td></td>
<td>(Line 1 RX 4W)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS 485 Signals Port 0</td>
<td>HDLC CCTV Control</td>
<td>Telephone Line 3 2W</td>
<td>(Telephone Line 5 TX 4W)</td>
</tr>
<tr>
<td></td>
<td>(W/Green)</td>
<td>Reply</td>
<td>(Line 2 TX 4W)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS 485 Signals Port 1</td>
<td>HDLC CCTV Reply</td>
<td>Telephone Line 4 2W</td>
<td>(Telephone Line 5 RX 4W)</td>
</tr>
<tr>
<td></td>
<td>(W/Brown)</td>
<td></td>
<td>(Line 2 RX 4W)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HDLC EMS Control</td>
<td>RS 485 CCTV Port 0</td>
<td>Telephone Line 5 2W</td>
<td>(Telephone Line 6 TX 4W)</td>
</tr>
<tr>
<td></td>
<td>(W/Slate)</td>
<td></td>
<td>(Line 3 TX 4W)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HDLC EMS Reply</td>
<td>RS 485 CCTV Port 1</td>
<td>Telephone Line 6 2W</td>
<td>(Telephone Line 6 RX 4W)</td>
</tr>
<tr>
<td></td>
<td>(R/Blue)</td>
<td></td>
<td>(Line 3 RX 4W)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HDLC MIDAS Control</td>
<td>Remote Telephone Cable B, Line 1 2W (Line 1 TX 4W)</td>
<td>Remote Telephone Cable A, Line 1 2W (Line 1 4W TX)</td>
<td>Remote Telephone/Local</td>
</tr>
<tr>
<td></td>
<td>(R/Orange)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HDLC MIDAS Reply</td>
<td>Remote Telephone Cable B, Line 2 2W (Line 1 RX 4W)</td>
<td>Remote Telephone Cable A, Line 2 2W (Line 1 4RX TX)</td>
<td>Remote Telephone/Local</td>
</tr>
<tr>
<td></td>
<td>(R/Green)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS 485 MIDAS Port 0</td>
<td>Remote Telephone Cable B, Line 3 2W (Line 2 TX 4W)</td>
<td>Remote Telephone Cable A, Line 3 2W (Line 2 4W TX)</td>
<td>Remote Telephone/Local</td>
</tr>
<tr>
<td></td>
<td>(R/Brown)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS 485 MIDAS Port 1</td>
<td>Remote Telephone Cable B, Line 4 2W (Line 2 RX 4W)</td>
<td>Remote Telephone Cable A, Line 4 2W (Line 2 4RX RX)</td>
<td>Remote Telephone/Local</td>
</tr>
<tr>
<td>Fibre</td>
<td>Red Tube</td>
<td>Neutral Tube</td>
<td>Green Tube</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>--------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Service (Transmission)</td>
<td>Service (Spare)</td>
<td>Service (CCTV)</td>
<td></td>
</tr>
<tr>
<td>1 Blue</td>
<td>PCM</td>
<td>Spare</td>
<td>CCTV</td>
<td></td>
</tr>
<tr>
<td>2 Orange</td>
<td>PCM</td>
<td>Spare</td>
<td>CCTV</td>
<td></td>
</tr>
<tr>
<td>3 Green</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
<td></td>
</tr>
<tr>
<td>4 Red</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
<td></td>
</tr>
<tr>
<td>5 Grey</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
<td></td>
</tr>
<tr>
<td>6 Yellow</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
<td></td>
</tr>
<tr>
<td>7 Brown</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
<td></td>
</tr>
<tr>
<td>8 Violet</td>
<td>Transmission (Spare)</td>
<td>Spare</td>
<td>Local Camera</td>
<td></td>
</tr>
</tbody>
</table>

Table D5.6c Fibre Allocation
Chapter D6

D6. POWER SUPPLY DESIGN

D6.1 Overview

1. 230 volt (+10%, -6%) single phase AC mains power supplies will be required for every item of outstation control equipment, Transmission Station (TS) buildings, and Control Office (CO) equipment.

2. Although all motorway communications equipment operates at 230v single phase, many communications power distribution centres are 3 phase, especially where combined with a lighting supply.

D6.2 Types of Installation

Motorway Supplies

1. Power supplies will normally be obtained from the Electricity Supply Company (ESC). On existing motorways, the existing supplies may need to be updated. The ESC will usually require at least 12 weeks’ notice for provision of new or increased supplies.

2. The Design Agent should site the supply points so that they are accessible both from within and outside the motorway boundary.

3. Supplies to roadside equipment are, at present, un-metered. However, should the ESC insist on a metered supply the DOENI cannot object.

4. Where there is no road lighting, the ESC supply will feed only the communications system. This supply should be brought onto the motorway at the nearest practical point in terms of providing reasonable access for maintenance and minimising the cost of providing the supply. The cable should be terminated in an interface cabinet sited in the motorway fence. This cabinet is known as an EI cabinet.

5. EI cabinets are usually Type 609, however, for larger distribution needs an alternative type of cabinet may be required.

6. Where the motorway is lit, the EI will usually provide a supply to a lighting feeder pillar which will also have a loop on the ESC side of the feeder pillar looping out to a separate communications EI cabinet. This practice avoids the tripping out of the communications system by a lighting circuit fault.

7. Older installations may have a single interface cabinet, even shared power circuits. These arrangements should be upgraded whenever practicable.

Local Supplies

8. Local supplies to equipment housed in Cabinet Types 600, 617, 620, a gantry or a cantilever, will require a local power isolation cabinet. This is usually a Cabinet Type 609 and is given the designation P.

9. Where a portal gantry carries both signals and illuminated signs, a single supply cable terminated in a P Cabinet near the base of the gantry will be required. The communications and sign lighting supplies will then be distributed from the P Cabinet.

Transmission Station Buildings

10. Power requirements for new TS buildings are detailed in MCL 10470. For existing Transmission Stations, refer to the DOENI.

Control Offices

11. Within COs, provision of power supplies should be decided following consultation with the DOENI. The installation of NMCS2, air conditioning or CCTV equipment can increase the power requirements considerably.

12. CO equipment may require Uninterruptible Power Supplies (UPS), standby generators, and/or battery backup.

D6.3 Operational and Design Regulations

1. Electrical installations should conform, where applicable, with the following regulations:

   (i) BS 7671;

   (ii) Electrical Supply Regulations 1988 (as amended);

   (iii) Electricity at Work Regulations 1989;

   (iv) Building Regulations (NI) 1994; and

   (v) Electricity at Work Regulations (Northern Ireland) 1991.
2. Where a consumer’s installation does not comply with the requirements of Chapter 13 of BS 7671 (Fundamental Requirements for Safety), the supplier is not compelled to provide a supply to that installation.

D6.4 Design - BS 7671 (IEE Wiring Regulations)

Background

1. BS 7671 shall be used for all installations.
2. Compliance with BS 7671 will achieve compliance with the relevant aspects of the Electricity at Work Regulations 1989.

Design Constraints

3. The following pointers are derived from BS 7671 and refer to the provision of power supplies to street furniture on motorways. They are not comprehensive and should not be used as a designer’s checklist; they do provide a good basis from which to work.

(i) Chapter 13 ‘Fundamental Requirements for Safety’.
These requirements should be met in full for every installation.

(ii) Chapter 31 ‘Purpose, Supplies and Structure’.
This indicates the need to consult the supplier to determine the nature of the supply and the need to sub-divide installations for reasons of safety and maintenance.

(iii) Chapter 32 ‘External Influences’.
This provides a checklist of environmental factors which may influence the design including:

(a) water (siting consideration),
(b) corrosion (oil and salt contamination possible in motorway environments)
(c) impact (siting consideration),

(iv) Chapter 34 ‘Maintainability’.
This requires that the frequency of maintenance and equipment down time is considered.

(v) Chapter 51 ‘Common Rules, Section 514’. This describes the requirements for labelling, notices and identification of equipment and circuits. With reference to Cabinet Types 600 and 609 containing power supplies, they comprise the following:

(a) a circuit diagram in every cabinet in accordance with Clause 514-09-01;
(b) a voltage warning notice on every cabinet in accordance with Clause 514-10-01;
(c) an isolation warning notice, where required, in accordance with Clause 514-11-01.
(d) an earthing and bonding notice where required, in accordance with Clause 514-13-01;
(e) an equipotential bonding notice where required in accordance with Clause 514 Section 611-Highway Power Supplies and Street Furniture.

Voltage Considerations

4. In accordance with Clause 525-01-02 of BS 7671, the voltage drop within the installation shall be restricted to a maximum of 4%.

Safety Considerations

5. In the case of alterations and additions to an installation, Clause 721-01-02 shall be met. This means that whenever power work is carried out in a Cabinet Type 600 or 609, the whole installation shall be reviewed.

6. A maximum disconnection time of 5 seconds shall be provided in accordance with Clause 611-02-04.

7. Where a gantry spans both carriageways a P cabinet shall be provided in both verges. The switching arrangement shall be such that the gantry can be isolated from either cabinet.

8. To meet the requirement of 412-03-04 (protection by barriers or enclosures), power isolation locations are needed to ‘switch off’ power. Whilst maintenance or alteration is carried out, these power isolation locations should be locked in the ‘off’ position. The key should be left with the senior person working on the installation.
D6.5 Design - Particular Requirements for Motorway Installations

Power Distribution

1. Power distribution networks for motorway communications should be star networks centred on EIs.

2. Luminaires on gantries are required to be divided equally into two separate circuits. Each circuit should be connected to the gantry isolation Cabinet Type 609 distribution unit.

3. With NMCS2, post mounted signals may be situated up to 4km away from the controlling Standard Transponder. Therefore, a Cabinet Type 609P should be installed in the verge opposite the central reserve mounted site equipment, for local isolation purposes.

4. Cabinets Type 600 which house NMCS2 electronic equipment are fitted with a PDU Type 1003D. This has a Residual Current Device (RCD) fitted across the incoming mains power supply to the cabinet. To avoid potential nuisance tripping from site equipment, all power supplies to site equipment local to the Cabinet 600 housing the Transponder, are obtained from a separate Cabinet Type 609P. This is located within 10m of the Cabinet Type 600.

Use of Alternative Cabinets

5. Where the Cabinet Type 609 does not provide sufficient space for terminations an alternative, non-standard type of cabinet may need to be provided.

6. Alternative cabinets shall provide similar or better protection from weather to that provided by a Cabinet Type 609.

D6.6 Design - Equipment Loads

General

1. Cable sizes should be calculated based on the equipment loads shown in Tables D6.6a - D6.6c and the cable characteristics given in Table D6.7a.

2. Design values should be checked with The Department of the Environment for Northern Ireland (DOENI) during detailed design.

3. Each site should be designed for a minimum load of 2000W or 5000W for portal gantry or cantilever Motorway Signal Mark 2 (MS2) or Enhanced Message Sign (EMS).

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal (single sided) including signal controller</td>
<td>225</td>
</tr>
<tr>
<td>Signal (double sided) including signal controller</td>
<td>450</td>
</tr>
<tr>
<td>NMCS1 Responder including Cabinet 600 heater</td>
<td>250</td>
</tr>
<tr>
<td>NMCS2 Telephone Responder including Cabinet 600 heater</td>
<td>250</td>
</tr>
<tr>
<td>NMCS2 Standard Responder including Cabinet 600 heater</td>
<td>720</td>
</tr>
<tr>
<td>Cabinet 600 or 617 complete with heater</td>
<td>180</td>
</tr>
<tr>
<td>Cabinet 620 complete with heater</td>
<td>120</td>
</tr>
<tr>
<td>Loop Detector equipment</td>
<td>120</td>
</tr>
<tr>
<td>Fog Detector equipment</td>
<td>50</td>
</tr>
<tr>
<td>CCTV Camera outstation including Cabinet 600 heater</td>
<td>750</td>
</tr>
<tr>
<td>Fibre Optic Transmission Cabinet including heater</td>
<td>480</td>
</tr>
<tr>
<td>Telephone Bridging Unit (TBU) including Cabinet 617 heater</td>
<td>250</td>
</tr>
</tbody>
</table>

Table D6.6a Nominal Power Loads of Motorway Communications Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Message Sign (320 or 420mm) comprising EMS, Cantilever and Signal Driver</td>
<td>2500</td>
</tr>
<tr>
<td>Motorway Signal Mk2 (MS2) comprising EMS, EMI and Signal Driver cabinet and heaters</td>
<td>3500</td>
</tr>
</tbody>
</table>

Table D6.6b Design Maximum Power Loads of Enhanced Signals
### Table D6.6c Nominal Power Loads of Gantry Sign Lighting

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250W MBFU luminaire</td>
<td>273</td>
</tr>
<tr>
<td>125W MBFU luminaire</td>
<td>142</td>
</tr>
<tr>
<td>80W MBFU luminaire</td>
<td>96</td>
</tr>
</tbody>
</table>

#### D6.7 Design - Power Cables

1. Bulk purchased 10mm² and 25mm² Power cable to TR 2153 should be used. Installation of cable of larger diameters should be avoided wherever possible as often the cost of providing, installing and maintaining these cables outweighs the cost of providing an additional supply local to the equipment concerned.

2. The electrical characteristics of 10mm² and 25mm² Power cable to TR 2153 are given in Table D6.7a and should be used for design.

<table>
<thead>
<tr>
<th>Cable Size (mm²)</th>
<th>Conductor Resistance</th>
<th>Maximum Current Rating Laid in Duct (A)</th>
<th>Volt Drop per Amp per Metre at Rated Current (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.83</td>
<td>75</td>
<td>4.1</td>
</tr>
<tr>
<td>25</td>
<td>0.727</td>
<td>124</td>
<td>1.65</td>
</tr>
</tbody>
</table>

#### Table D6.7a Electrical Characteristics of Power Cable

#### D6.8 Power Cable on All Purpose Roads

1. Where power cable is installed on an All Purpose Road, armoured cable should always be used. The mechanical protection effected by the duct installation may not offer sufficient security on an All Purpose Road where excavation of the road is more common and less controlled than on the motorway.
D7. CABLE DUCTS

D7.1 General

1. The standard method of cable installation is non-armoured cable installed in duct.

2. The ducted network consists of 100mm diameter longitudinal ducts located in the verge or earthworks, offset at a nominal 2m from the back of hard shoulder, and transverse ducts at 500m centres crossing beneath the carriageway at right angles to it.

3. The ducted network is sealed.

4. Cable jointing chambers should be incorporated in the longitudinal duct runs every 500m (+2%, -5%) into which the transverse ducts will terminate. Additional chambers may also be required at obstructions and at cabinet sites to facilitate cable installation.

5. Cables for street lighting must not be laid in the same duct as cables for motorway communications. The transverse clearance between longitudinal street lighting cables and communications shall be 500mm minimum.

D7.2 Material and Installation Standards

1. The material specification for ducts is given in the 1500 Series of the Specification For Highway Works (SHW). Ducts are manufactured from thermoplastic material.

2. Each length of ducting should be fitted with a non-rotting stranded draw cord and the duct ends fitted with purpose made compression plugs providing a water, air and gas tight seal, as detailed in the SHW.

3. Joints between adjacent lengths of ducts should be air and water tight. It is imperative that material such as silt, grout or concrete is prevented from entering the duct during the jointing process. Material such as this will cause damage to the cable during installation.

D7.3 Longitudinal Ducts

1. Design standards are detailed on the MCX 0800 series.
8. Special consideration should be given to the installation of ducts at structures. If possible ducts should be buried in the hardened verge, but the presence of other services, or the design of the structure, may prohibit this and alternative arrangements should be made. It is important that 4 x 100mm ducts are provided. In the instances where it is not possible to provide 4 x 100mm ducts these locations should be marked clearly on the drawings to allow the cable designer to adjust the design accordingly. The Design Agent will require clearance to proceed from the Department of the Environment for Northern Ireland (DOENI) where 4 x 100mm ducts are not proposed.

D7.4 Geotechnical Considerations

1. In the majority of cases, the ducts will be located within the earthworks slopes. The excavating of trenches in these slopes can lead to problems with slope stability. The geotechnical implications of this should be checked for each scheme. The problems can be overcome by taking the necessary precautionary measures during the design stage and by maintaining high standards of workmanship and control during construction.

2. In the early stages of design a geotechnical desk study should be undertaken using records compiled by the DOENI of all motorway earthwork slopes. Consultation with the Regional Geotechnical Engineer at an early stage is essential. Additional information, for example from trial pits, may be required.

3. The excavation of a trench at the toe of a cutting should be dealt with carefully as poor design and poor workmanship could lead to a local failure of the slope. Problems can be avoided by the use of a narrow trench (typically 0.5 m) and by ensuring that, during construction, trenches are excavated in relatively short lengths and not left open for extended periods. Proper specification of trench fill material combined with high standards of compaction will also minimise the risk of failure. Where a slope is identified as being at risk special precautions will be required in both design and construction.

4. The excavation of a trench at the crown of an embankment slope should also be approached with care. The problem in this instance would be that the trench could act as a drain, collecting surface run-off without having an outfall. The build up of water would, in cohesive soils, eventually saturate and weaken the surrounding soil. This problem can quite readily be avoided by the use of a properly specified and constructed trench detail and where necessary, by the use of special details such as a geotextile seal near the surface of the trench.

5. The location of longitudinal ducts within a flat verge, cutting and embankment is shown on MCX 0810.

D7.5 Transverse Ducts

1. Transverse ducts provide the means by which cables may cross carriageways from one verge to the other, from verge to central reserve and from one side of a slip road to the other.

2. Standard provision is for a group of four 100 mm diameter ducts at nominal 500m intervals as detailed on MCX 0814.

3. MCX 0810 shows a typical arrangement of carriageway crossings at slip roads and link roads.

4. The depth of transverse ducts is dictated by the following factors:

   (i) the pavement construction depth;

   (ii) the method of duct installation to be used;

   (iii) the need to ensure that adequate protection to the duct is achieved, both during construction and under long term vehicular loading;

   (iv) the location of drains; and,

   (v) whether the road is new or existing.

New Roads

5. For new roads, transverse ducts should be laid in a trench excavated in the material below the capping layer. Ducts should not be located within the capping layer as this could result in the formation of hard spots which could affect the surface of the carriageway above. The minimum cover to transverse ducts should be either:

   (i) 900 mm if the ducts are covered by a 150 mm thick concrete slab, or

   (ii) 1200 mm if no concrete cover is provided.
6. In all cases the ducts should be located at least 150 mm below the bottom of the capping layer, or if no capping layer is required, at least 150 mm below the formation level.

**Existing Roads**

7. Transverse ducts should be installed beneath existing carriageways, using trenchless techniques. The depths of these ducts will be dependent upon the material in which the ducts are to be located, the likely impact of the installation method on the surrounding ground and the location of drainage pipes. The minimum depths detailed above for ducts in trenches apply also to trenchless ducts, but these depths may have to be increased to ensure that the displacement of the surrounding ground does not affect the structural integrity of the pavement construction or capping layer.

8. It is imperative that as-installed records of pavement construction drainage and other services and geotechnical records are consulted when planning trenchless crossings of motorways.

9. A number of reliable well proven methods of trenchless duct provision are currently available including:
   
   (i) Auger boring;
   
   (ii) Guided, steerable moles;
   
   (iii) Thrust boring;
   
   (iv) Impact moling;
   
   (v) Pipe ramming.

10. Careful consideration of factors such as ground conditions and local topography will be required before choosing a method of installation. The choice of an unsuitable method can have costly implications. It should be noted that when installing ducts in this manner it is advisable not to install ducts in close proximity to each other to avoid ducts clashing.

**Special Arrangements at Structures**

11. On long structures special arrangements may be necessary if transverse ducting at 500 m intervals cannot be provided. Early advice should be sought from the DOENI.

12. Special details will be required where ducts cross expansion joints.

13. Where separate viaducts are constructed for each carriageway, provision for cabling between the structures may be required.

**D7.6 Local Ducts**

1. Local ducts are used to connect equipment to the longitudinal and transverse duct network. One of the four ducts in the longitudinal network is allocated for local cabling.

2. Where additional local ducts are required for cabinets and signals they should be 100mm internal diameter and should run from the nearest type A or B chamber either directly to the signal or, via type C chambers, to the cabinet site. Separate ducts for communications and power cables should be provided. Local ducts forming connections to telephones should be 50 mm diameter.

3. Local ducts should be laid in the same trench as longitudinal ducts. MCX 0814 shows the standard trench detail for local ducts.

4. The connection of local ducts to cabinet sites, signals and telephones is shown on MCX 0811.

5. Where a cabinet site is located within 120m of a Type A chamber the local duct should be laid directly from the Type A chamber to the Type C chamber at the cabinet site as shown on MCX 0811.

6. Where the distance between the cabinet site and the nearest Type A chamber is more than 120m, a Type B chamber should be installed, on the line of the main duct run, at the cabinet site as shown on MCX 0812. A local duct is then installed from the Type B chamber to the Type C chamber at the cabinet site. The ducts allocated to longitudinal cables and spare should be continuous through the Type B chamber at this location.

**D7.7 Use of Existing Ducts**

1. Existing ducts are likely to be limited to transverse ducts and ducts at structures.
Transverse Ducts

2. Transverse ducts are often extremely difficult to locate on existing motorways. The most common reason for this being that duct marker posts and blocks were not provided and where they have been provided they have rarely been maintained. Inaccurate as-installed information regarding ducts is also a common problem. Agent Authorities should keep records of duct location and usage up to date.

3. As the cost of providing new transverse ducts is relatively high, the utilisation of existing ducts should be considered. This will only be acceptable where the existing ducts meet the material and installation standards described earlier in this TA, and where they occur at locations which suit the proposed cable network.

4. A locational survey of existing ducts should be undertaken during the design stage to establish where existing ducts can be used, where new ducts are required and where cable routes may be revised to avoid the need for new ducts. If approved by the DOENI, a CCTV survey should also be undertaken.

5. The survey should include accurate details of duct location (chainage and offset) and type, soundness of duct, its depth, diameter and the number and type of cables installed.

6. Empty ducts should be proved and cleared of debris using a mandrel.

7. Ducts containing existing cables should be used with extreme caution as cables will probably be snaked and twisted, the duct may be damaged internally and debris may have accumulated within the duct. Wherever possible, redundant cables should be identified and removed by the specialist Regional Maintenance Contractor (RMC).

Ducts at Structures

8. It will frequently be found that where longitudinal ducts have been installed at structures, they have been provided only for existing cables with no additional capacity. This additional capacity can generally be provided by one of the following methods:

(i) At a bridge which has a safety barrier and separate fence or parapet, it is often possible to lay ducts between them.

(ii) At a bridge which has no separate safety fence it may be practicable to attach ducts to the outside of a parapet.

(iii) It may be possible to install ducts in the hardened verge.

(iv) It may be possible to install ducts beneath the bridge surface, using the structure itself. For example, within a concrete box section or attached to steel girder sections.

The agreement of the DOENI’s Bridges Section responsible for the structure is required before proceeding with any of these options.

D7.8 Equipment Siting on Existing Motorways

1. When siting telephones, signals and other equipment on existing motorways, their locations should be planned such that the number of new duct crossings is minimised. In addition to cost, consideration should be given to the following factors:

(i) the requirement for pairs of telephones (A and B carriageway) to be sited opposite each other (mandatory requirement);

(ii) the maintenance advantages in having signals opposite their Transponder;

(iii) the maximum desirable and permissible cable length between Transponders and their dependent signals;

(iv) the vulnerability of cable in the central reserve to damage and the problems of subsequent repair or replacement.

D7.9 Ducts At Junctions

1. Ducts should be provided at junctions as shown in Figure D7.9a. It is important that all ducts start and finish on land belonging to the DOENI.
D7.10 Marker Tape

1. Ducts are installed in a trench as detailed on MCX 0814. The trench detail includes the installation of a detectable marker tape which will allow the ducts to be located using electronic cable detecting equipment. It is important that adjacent lengths of marker tape are jointed correctly to achieve electrical continuity.

D7.11 Duct Allocation

1. Cables are installed into nominated ducts as detailed in the MCX 0800 series.

D7.12 Cable Installation

1. Cable installation should be undertaken strictly in accordance with the SHW and the Site Installation TAs.

Figure D7.9a Duct Arrangements at Junctions
D8. CHAMBERS

D8.1 Chamber Types

1. Three types of chambers are utilised within the ducted network as described below.

2. **Type A** - these are Main/Joint chambers. They are required to accommodate cable joints and at the junction of transverse and longitudinal ducts. They are 1.3m x 0.75m in plan and are sufficiently large to accommodate transverse, longitudinal and local ducts as well as joints and coiled cable. Details of this type of chamber are given on MCX 0815. Minimum depth of a jointing chamber is 1.2m.

3. **Type B** - these are intermediate chambers which should be located on longitudinal duct runs where changes in direction are encountered. They may be required where cabinet sites are located at a distance of more than 120m from the nearest A chamber. The maximum depth of a Type B chamber is 1.0m. Where a deeper chamber is required, a Type A chamber should be used. Details of this type of chamber are given on MCX 0815.

4. **Type C** - these are shallow chambers and are required in front of cabinets to ensure that the duct network remains enclosed. Details of this type of chamber are given on MCX 0815.

5. Additional chambers are required at other locations such as slip road crossings and at structures.

6. Where a Type B chamber is provided for access equipment/cabinet sites the ducts allocated for longitudinal cables and spare should run continuously, without a break, through the chamber.

D8.2 Chamber Siting

1. The siting of chambers will be determined by the cable network design and the location of ducts and equipment.

2. Type A chambers shall be located at cable joint locations, typically at 500m (+2%, -5%) intervals along the length of the longitudinal ducts. Preferably they will coincide with the position of transverse ducts and MIDAS loops (where present).

3. Type B chambers should be provided, as required, on the longitudinal duct run. Cabinets should generally be sited at the main/joint chamber locations. Type B chambers should only be required where equipment sites are further than 120m from the nearest Type A chamber and at changes of direction.

4. Type C chambers should be provided at cabinet sites as detailed on MCX 0812.

5. Type A and B chambers will generally be located at an offset of 2.0 m from the hard shoulder. It is likely that retaining walls may therefore be required at chamber locations. They should be designed to suit scheme specific topographical/geotechnical conditions. Consideration should be given, where appropriate, to adjusting the level of the top of the chamber in order to overcome the need for a retaining wall.

6. Where there is limited width available or non-existent conventional verges, such as in areas of retained cutting, chambers can be located either under the hard shoulder or within the hardened verge. It should be noted that wherever possible, chambers should be located away from obstructions or retained cuttings.

D8.3 Chambers at Structures

1. Where ducts are installed in structures, it is likely that they will be located at a different depth and offset to the main longitudinal duct run. This is due to the physical constraints of the structure.

2. At all such locations a chamber should be provided to allow cables to be installed. Generally, a Type B chamber should be provided; however, where the depth of the chamber will exceed 1m a Type A chamber will be required.

3. The difference in offset may require the provision of two chambers at each end of a bridge.

4. The location of safety fencing may affect the siting and construction of the chamber.
D8.4 Access

1. Cable Joint Enclosures and cable terminations are designed to be maintenance free. Therefore access to chambers will only be required during installation.

D8.5 Drainage

1. During the design of the duct network the drainage of water from chambers should be considered. A suitable method should be provided to allow the free drainage of water from chambers. This can be achieved either by the use of a soakaway or by a connection to the highway drainage network. Liaison with the Department of the Environment for Northern Ireland (DOENI) drainage engineers will be required in order to arrive at the most appropriate design.

2. Chambers Type A and B are provided with a sump to allow the pumping out of water.

D8.6 Labelling

1. Chambers shall be labelled in accordance with the requirements of the Specification for Highway Works 1500 Series. This will involve either a metallic label on the chamber cover or an embossed legend reading ‘MOTORWAY COMMUNICATIONS’.
D9. ARMOURCED CABLE INSTALLATIONS

D9.1 Direct Burial

1. Direct burial is no longer standard practice for the installation of motorway communication cables. However, there may be exceptional cases where this method is appropriate, such as in the replacement of short lengths of existing direct buried cable or a local improvement scheme.

2. MCX 0141 illustrates the trench detail to be used for direct burial.

3. All communications cables following a common route should share a common trench.

4. Power supply cables, other than those associated directly with the motorway communications system, should not share the same trench as communications cables. A minimum spacing of 0.5 m is required.

D9.2 Cable Trough

1. The use of trough units for longitudinal cables is not standard practice. Early advice from the Department of the Environment for Northern Ireland (DOENI) should be sought where troughing is considered.

2. Standard details for the installation of cable trough are illustrated on MCX 0153.

3. Troughs should have a clear space, free from rubble and smooth internally, of 150 mm x 150 mm minimum or agreed alternative internal dimensions with covers in place.

4. Trough covers should be capable of being removed by one man. They should not break if dropped and should be able to withstand the effects of traffic passing over them without collapsing or damaging the cables within.

5. Troughing should be constructed on a straight grade and be self draining.

6. Trough units should not be laid on the surface as they will act as a ramp for errant vehicles and possibly cause a vehicle to overturn.

7. Special consideration should be given to the transition between trough and duct/trench where cables will be laid at shallow depths. Care should be taken to ensure adequate protection of cable.

D9.3 Cable Types

1. Where cable is to be installed by either direct burial or troughing, armoured cable, which is available from bulk purchase, should be installed (see Chapter D4 for cable types).

2. NMCS2 requires a 30-pair longitudinal cable. NMCS1 requirement is for 20-pair cable with 30-pair cable being used in certain high traffic areas.

3. Armoured cable requires testing by the installation contractor prior to acceptance to confirm the integrity of the cable sheath. The cable is coated with graphite to facilitate this testing.

4. Every length of armoured cable requires testing in accordance with MCG 1022 (Copper) or MCG 1055 (Composite Copper/Optical Fibre) by the installation contractor prior to termination.

D9.4 Armoured Cable Terminations

1. Armoured cable is terminated in Cabinets Type 609 using Termination Frames Type 13 for 20-pair, type 14 for 30 pair, enclosed in Boxes Type 615B.

2. The Box Type 615 originally had two large cable holes and two small cable holes. With the advent of NMCS2 and the requirement for many 2-pair connections, Box 615B was introduced. This has two large cable holes and six small cable holes.

3. Termination Frames Types 13 and 14 are available in three types as follows:

(i) Type A - unloaded;

(ii) Type B - fitted with 22mH loading coils; and

(iii) Type C - fitted with 22mH and 88mH loading coils.
4. The standard pattern for Termination Frames in Cabinets 609 at standard spacing (cable lengths of 500m) is:


5. The first cabinet after the marshalling cabinet at a transmission station should contain a C frame; refer to MCL 5502 for further details.

6. An exception to this occurs with NMCS2 on the 88mH loaded pairs where Sector Interfaces and Sector Blocks are inserted. In these situations, the Sector Interface or Sector Block should be regarded as a TS as far as the loading pattern is concerned.

7. Fibre optic cables are terminated in accordance with MCX 0489.

**NMCS2 Main Longitudinal Cabling**

8. Type 14 Frames are fitted with two terminal blocks, at the top of the frame. These provide permanent tee-offs from the main longitudinal conductors. The pairs teed-off and their allocation are:

   (i) pairs 1, 2 (HDLC)

   (ii) pairs 3, 4, 5, 6, 17, 18 (telephone lines)

   (iii) pair 21 (RS485 standard)

   (iv) pair 22 (RS485 ATS).

9. Two spare pairs are also teed-off. The spare pairs are not soldered to the main conductor in the initial configuration of the frame. However, the tails will be connected into the BK12 terminal blocks at the top of the frame. The remote ends of the tails are provided long enough to reach the main conductors. Where this tee-off connection is required in the system design, the installation contractor solders the tails to the requisite main conductor(s) on the frame during installation. Numbered collets will be provided to all permanent teed connections. The spare tee-offs will not be provided with number collets.

10. Only the first carrier pairs (ie 13 and 14) will normally be soldered through. The secondary carrier pair terminal blocks (ie 15 and 16) will be provided with the normal cross connecting links between both sides of the frame.

11. Loading coils will be fitted and connected on the following pairs: 22mH coils to pairs 1 and 2 88mH to pairs 3, 4, 5, 6, 17 and 18.

12. When termination resistors are to be fitted to frames (eg on RS485 lines) the tee connection should be unsoldered from the link conductor. The link conductor should be disconnected.

13. Any cross-connection of cable pairs (ie the point of cable pair colour change) should take place in the local Box Type 615.

14. Loading patterns on longitudinal cables should be arranged in the same manner as NMCS1 installations for the 22mH loaded pairs.

15. Further information on termination frames is provided on MCX 0132.

**Build-Out Capacitors**

16. The arrangements for installing Build-out Capacitors are detailed in MCL 5502.
D10. CABINET SITING

D10.1 Cabinet Siting

Positioning

1. When assessing suitable sites for cabinets the designer should aim to provide sites which are safe both for maintenance personnel and motorists, and should have due regard for cost and for aesthetics. On a ducted network, cabinets should be located at the main/joint chamber sites to minimise the number of intermediate chambers required, and the length of local ducts.

2. Since cabinets are weatherproof, but not waterproof, they should be sited well above any likely flood level.

3. Cabinets should be grouped together wherever possible as this has maintenance and cost advantages.

4. Where the motorway is sited in a cutting or on an embankment, care should be taken to ensure that cabinets do not cause visual intrusion for local residents or users of adjacent land.

5. Care should be taken to ensure that proposed or existing landscaping planting will not cause access problems or obscure cabinets in future years. Liaison with the Department of the Environment for Northern Ireland (DOENI) Landscape Architect during the planning stage is therefore necessary to coordinate the location of communications infrastructure and tree planting. When planning works on existing motorways, liaison with the Landscape Architect will be necessary in order to arrange for the removal of trees and shrubs.

Safety Fence

6. Safety fencing will be required for the protection of motorists and communication equipment at sites where cabinets or signal posts are sited less than 10m behind and 1m above the hard shoulder. It may be possible to site cabinets downstream of bridge piers or behind an existing or planned safety fence. It may be possible to site a cabinet where it can be protected by an extension to an existing or planned safety fence, this is more acceptable on both economic and safety grounds. Short gaps between adjacent lengths of safety fence should be avoided. Where necessary, additional fencing should be provided to close such gaps.

Retaining Walls

7. Special consideration should be given to the siting of cabinets in retained cuttings. Where cabinets are to be located at the top of such retaining walls, access from the hardshoulder should be provided. Where cabinets are located in cut-outs in retaining walls there may be difficulties in routing cables to cabinets.

8. Where retaining walls are required for cabinets they should be designed and detailed by the Design Agent.

Access

9. The siting of all cabinets should allow for maintenance access. The requirement is that access should be readily and easily available from a vehicle parked on the hardshoulder. This may require the provision of a safe means of access and egress for vehicles.

10. Cabinets which are sited remotely from the carriageway may require the provision of access steps as detailed on MCX 0138.

11. Maintenance staff are required to carry heavy test equipment to Cabinets Type 600. Therefore steps should be provided where access involves a gradient exceeding 1 in 2 for a height exceeding 400mm.

12. Where noise fences or environmental barriers are installed between a cabinet and the motorway, special provision should be made to allow access to the cabinet whilst maintaining an effective noise/environmental barrier.

13. Paved areas, constructed from standard paving slabs, should be constructed between access steps, cabinet hardstandings and the hardshoulder to provide a continuous, safe path.

D10.2 Special Arrangements

Telecommunications and Electricity Supply Interface Cabinets

1. Interface cabinets should be constructed in the line of the motorway boundary fence as detailed on MCX 0153 and MCX 0146. Cabinets should be sited so
that the whole of the foundation lies within land
belonging to the DOENI.

**Marshalling Chambers at Transmission Station**

**Buildings**

2. A marshalling chamber is required immediately
adjacent to a Transmission Station (TS). All copper
communications cables leading into a TS are terminated
within the marshalling cabinet. Link cables are then
installed between the TS and adjacent marshalling
chamber. The cabinet and chamber arrangements are
shown on MCX 0813.

**Cabinets on All-Purpose Roads Fed from Motorways**

3. This arrangement is shown on MCX 0566. Power
cables installed on all purpose roads should be armoured
cables.
D11. CONSTRUCTION DETAILS

D11.1 Foundations

Cabinet Bases

1. Cabinet Types 600, 609, 617 and 620 are manufactured for mounting onto a standard plinth (Plinth 610) which is bulk purchased by the Department of the Environment for Northern Ireland (DOENI).

2. The foundation for a cabinet comprises a Plinth 610 cast into a concrete base as detailed on MCX 0140 and MCX 0812. It should be noted that the size of the foundation is to be determined by the Design Agent.

3. Foundations for other cabinet types are not covered by the standard details, they are designed by the Design Agent and submitted to the DOENI for approval.

4. Cabinet bases are filled with pea gravel; in addition, the bases of Cabinet Types 600 & 620 are sealed with epoxy resin to provide a waterproof environment inside the cabinet.

Signal Post Foundations

5. Foundations for signal posts will be designed by the Design Agent based upon the parameters given on MCX 0144. It should be noted that these foundations are subject to the Approval In Principle procedure. Adequate time should be allowed for this procedure.

D11.2 Hardstandings and Steps

Hardstanding

1. The standard of provision for hardstandings at cabinet and signal sites is given on MCX 0812. Generally, a hardstanding should be provided at every cabinet door. Where two or more cabinets occur at one site, they should be linked by a paved area.

2. Where cabinets are situated on cutting or embankment slopes, consideration should be given to the provision of handrailing to protect maintenance personnel from the risk of falling.

Steps

3. Typical access steps for cabinets are detailed on MCX 0138.

4. Where steps are specified, the designer should consider the Health and Safety implications of the specified layout. Consideration should be given to the provision of handrailing alongside steps and also landings with guardrails to limit the height of individual flights of steps.

5. Where steps are provided, they should be linked to cabinet sites by a path constructed from standard paving slabs.

D11.3 Duct Installation Details

1. Ducts are installed in trenches as detailed on MCX 0814.

D11.4 Chamber Details

1. Chambers are constructed in accordance with MCX 0815.

D12.1 Overview

1. The motorway communications cable system has a transmission network based on Transmission Stations
D12. TRANSMISSION STATIONS

(TSs). These are located at all interchanges and at intervals not exceeding 20km between interchanges. Transmission Stations are housed either in purpose built buildings or in Cabinets Type 617.

2. TSs housed in cabinets provide facilities for amplification of speech and control circuit signals. They also provide facilities for cross-connection within or between the Department of the Environment for Northern Ireland (DOENI) cables or between the DOENI’s cables and the Private Wire (PW) network.

3. TSs housed in buildings provide all facilities and a multi-channel High Frequency (HF) carrier system which provides a countrywide figure of eight network.

4. The amount of equipment required in a TS, particularly one associated with CCTV equipment, may justify the provision of a building (even if HF carrier equipment is not involved). Therefore, the designer will need to confirm the requirements for each TS with the DOENI at an early stage.

D12.2 Siting Considerations

1. All TS require a mains power supply, access to the Public Switched Telephone Network (PSTN) and provision of dedicated PW. They also require, where possible, access from all-purpose roads so that maintenance staff can attend to equipment without using the motorway. Connection to the PW network can be achieved by using a length of motorway cable, this allows the interface cabinets to be sited remote from the TS.

2. Sites need to be selected with a view to their relationship to the main cable run; cable between the TS and the main longitudinal cables should be kept to the minimum. The route selected should be reasonably immune from the risk of cable damage by trenching, tree planting or similar activities.

3. Cables installed outside the motorway boundary (eg in works units) require mechanical protection against damage from excavation.

4. Works units frequently provide suitable sites for a TS. When these are used, care should be taken to keep away from salt stores. Also, arrangements need to be made to ensure 24-hour access to the TS.

5. When siting a TS, particular care should be taken to ensure the following:

(i) Reasonable facilities are available for parking;

(ii) Access is available for staff carrying test equipment from the all-purpose road and the motorway;

(iii) Hardstanding for emergency trailer is available;

(iv) All cabinets buildings and parking areas are sited on motorway land;

(v) All cabinets and buildings are safe from vehicles straying from the motorway. This can be achieved by siting the station on the downstream side of a bridge or by the provision of safety fencing.

6. It is most important that the site chosen, whether for a building or a cabinet, should be immune from flood risk.

7. In certain areas it may be necessary to plant a screen of trees or take other measures to reduce the environmental intrusion caused by a TS building.

Transmission Station Building Specification

8. Refer to MCL 10470, for the Transmission Station Building Specification.

Cabinet Type 617

9. The Cabinet Type 617 TS fits onto the standard 610 plinth. Designers should seek the advice of the DOENI if proposing to install a new Transmission Station in a Cabinet Type 617.

Further Information

10. For further information on Transmission Stations refer to TA 75/95: Motorway Transmission.

D13.1 Motorway Address Coding

General
D13. GEOGRAPHIC ADDRESSING

1. Motorway roadside equipment such as telephones, signals and CCTV cameras is identified by means of an address code. This address is determined by the Department of the Environment for Northern Ireland (DOENI) and comprises:

(i) Motorway identifier;

(ii) Marker post reference; and,

(iii) Carriageway identifier.

2. The mainline carriageways are identified as A and B carriageways. Where motorways emanate from London the outward carriageway is designated A. On other motorways the designations A and B are arbitrary. Marker post numbers always increase in the direction of travel on the A carriageway.

3. Slip roads are lettered as follows:

(i) J - exit from A Carriageway;

(ii) K - entry to A Carriageway;

(iii) L - exit from B Carriageway;

(iv) M - entry to B Carriageway.

4. These letters are used within interchanges - refer to D13.2 for the procedure to be followed at interchanges.

5. Carriageway lanes are numbered from the rear side; the lane adjacent to the hardshoulder is numbered 1.

6. Proposals for labelling link roads (formerly designated Collector - Distributors) should be submitted to the DOENI at an early stage.

D13.2 Motorway Interchanges

1. At motorway interchanges there are several linking roads to identify. In an ideal full cloverleaf, there are eight links, each of which originates from and connects to a motorway. In practice the following may occur:

(i) There may be considerable variations in geometry;

(ii) One or more of the eight links may be missing;

(iii) Links may merge, such that a section of road combines the functions of two or more links.

2. For each section of linking road, its function should be determined, in terms of which carriageway it takes traffic from, and which carriageway it takes traffic to. It should be determined whether this represents a left turn or a right turn. For sections of road with more than one function left turns should take precedence.

3. Linking roads representing left turns are numbered and lettered from the motorway having the lower identifier. The motorway with the lower identity number may have a higher motorway number. For example M6/M62; M6 identifier is 5000, and M62 identifier is 1000. Linking roads representing right turns are numbered and lettered from the motorway having the higher identifier.

4. Linking road ‘site’ numbers are produced by taking the number of the marker post at the centre of the interchange and replacing the last digit by 0. The first item of equipment to be installed on the linking road is identified by adding 1 to the number, the second by adding 2, and so on.

5. The above explanation is illustrated by Figure D13.2a, which shows a hypothetical interchange between motorway identity number 2000 at centre.
marker post 72.0 and motorway identity number 6000 at centre marker post 21.3.

6. Arrangements sometimes need to be varied to suit individual layouts, particularly when an interchange is combined with a junction or when more than two motorways are present at an interchange. Consultation with the DOENI is required where such non-standard arrangements are being considered.

D14.1 General

1. Address code labels are used by the police on site.

Figure D13.2a Motorway to Motorway - Example of Interchange Telephone Address Coding
D14. LABELLING

when requesting the setting of signals. The address code label on emergency telephones enables motorists to inform the police control office of their precise location. The accuracy and legibility of these labels is therefore of prime importance.

2. Accurate and legible informative labels on the outside of cabinets are essential for the efficient working and safety of maintenance personnel.

3. It should be noted that the Engineer is responsible for specifying names, numbers and lettering on informative and address coding labels.

Chambers

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

Cabinets

5. Informative, address coding and warning labels should be provided on cabinets and signal posts in accordance with MCX 0145 or MCX 0306.

Signals

6. Gantry legs should be provided with labels showing their address code in accordance with MCX 0145.

Telephones

7. Address coding labels are to be provided on telephones as shown on MCX 0147.

Warning Labels

8. A ‘laser’ warning label in accordance with MCX 0306 should be fitted to all equipment containing fibre optic cable terminations.

9. It should be noted that an Electrical Safety and Inspection Label in accordance with MCX 0171 should be fitted (and maintained) inside all signal posts and Cabinet Types 600, 617, 620 and 609 power cabinets.

10. Other equipment which is connected to an electrical supply (eg, Signal Controllers, IPDUs, Distributors 901) should be fitted with electricity warning labels as shown on MCX 0145.

11. Cabinets and equipment should be labelled internally in accordance with BS 7671.

Cables

12. Cables should be identified using labels as detailed in the MCX 0800 series of drawings.

Cable Joint Enclosures

13. Cable Joint Enclosures should be labelled as detailed in MCE 2183.

Armoured Cable

A cable which incorporates a layer of steel wire wrapped
helically around the cable to provide mechanical protection from damage. The armour wire is protected from moisture by a polyethylene sheath. The sheath is coated with graphite - this graphite coating is used when testing the integrity of the sheath.

**Box Type 615**
A standard enclosure which is used to house termination frames in 609 Cabinets.

**Break Jack**
A plastic plug which is inserted into an Insulation Displacement Connector (IDC) to break the internal connection.

**Build Out Capacitor**
Capacitors use to equalise cable lengths to the standard length of 500m. The additional capacitance equates to that required to make the cable length appear to be 500m. Located in the Cable Joint Enclosure (CJE) furthest from both TS.

**Bulk Purchase**
Standard items of motorway communications equipment are purchased by the Highways Agency in quantity. This ensures the equipment conforms to the relevant specifications, is available from several sources and benefits from economies of scale.

**Cabinet Type 600**
Standard motorway equipment cabinet, for use on motorway verges, to house equipment such as Standard Transponders, MIDAS Transponders, Responders, Sector Interfaces and Sector Blocks. Also used as a Marshalling Cabinet.

**Cabinet Type 609**
Standard motorway cable connection cabinet, for use on motorway verges, to house connection boxes for data, and also used to house (separately) electrical power supply distribution and isolation equipment.

**Cabinet Type 617**
Standard motorway cabinet, for use on motorway verges, to house transmission equipment.

**Cabinet Type 620**
Standard motorway cabinet, for use on motorway verges, to house interfacing to circuits provided by a Public Telecommunications Operator.

**Cable Joint Enclosures (CJE)**
Environmentally sealed enclosure housed in underground chambers used to contain cable terminations, and in some cases, loading coils. CJE are available in the following types:

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
<th>No. of Cables to be Accommodated</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>Unloaded</td>
</tr>
<tr>
<td>2</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 22 circuits loaded at 22mH.</td>
</tr>
<tr>
<td>3</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 6 circuits loaded at 88mH.</td>
</tr>
<tr>
<td>4</td>
<td>Longitudinal 40 pair joint</td>
<td>3 x 40 pair</td>
<td>As 15-1, with additional module providing 28 circuits loaded as 22mH.</td>
</tr>
<tr>
<td>L</td>
<td>Local distribution</td>
<td>3 x 40 pair and 6 x quad</td>
<td></td>
</tr>
<tr>
<td>RSI</td>
<td>Rural signal interface</td>
<td>4 x quad</td>
<td></td>
</tr>
<tr>
<td>HFC</td>
<td>High frequency carrier joint</td>
<td>4 x carrier quad</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Optical Fibre carrier joint</td>
<td>3 x 24 fibre</td>
<td></td>
</tr>
</tbody>
</table>

**Carrier**
A signal comprising several individual signals multiplexed together. The carrier signal is at a higher frequency than the individual signals in analogue transmission and at a higher bit rate in digital transmission.

**Carrier Quad Cable**
A cable comprising 4 conductor wires used for
transmitting high frequency Frequency Division Multiplex (FDM) signals.

**Chambers**
Underground structures of a standard size used to house cable joints and to facilitate cable installation.

<table>
<thead>
<tr>
<th>Type</th>
<th>Plan Size (mm)</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1300 x 750</td>
<td>To house cable joints</td>
</tr>
<tr>
<td>B</td>
<td>600 x 600</td>
<td>Cable installation at changes of direction; access to Transverse ducts.</td>
</tr>
<tr>
<td>C</td>
<td>450 x 450</td>
<td>Cable distribution at cabinet sites.</td>
</tr>
</tbody>
</table>

Chambers may be constructed from brick, plastic or concrete.

**Closed Circuit Television (CCTV)**
A system using remotely controlled television cameras to monitor traffic patterns at sites susceptible to traffic congestion such as tunnels, junctions and interchanges. The images are transmitted from the camera to the Control Office (CO) over the fibre optic cable infrastructure.

**Control Office (CO)**
The Control Office (CO) is the location from where the Highways Agency’s motorway communications equipment, for the motorways in a given Police Force Area, are controlled. The CO is used by the Police Authority for day-to-day control of motorway traffic. More than thirty Police Authorities are involved in operating the national system, each Police Authority being issued with a code of practice approved by the Association of Chief Police Officers, in order to standardise the use of motorway signals for each region.

**Control Room**
The part of the Control Office where the operators answer telephone calls, set signals and, where available, monitor CCTV and operate other equipment. Sometimes shared with other Police Operations and equipment.

**Direct Burial**
A method of cable installation which involves burying armoured cable in a trench.

**Distributor Type 901**
Electrical distribution switch for use with signals on gantries.

**Duct**
A plastic pipe buried in the ground.

**Duct Plug**
A mechanical device which is inserted into the end of a duct within a chamber. It seals the end of the duct from gas, air and water. Allows the installation or removal of cable into or from the duct.

**Ducted Cable Network**
A sealed network of buried ducts in the motorway verge, with connections crossing beneath the carriageway. The ducted network is used for the installation of motorway communications cables. Cables are jointed in sealed joints which are housed in underground chambers.

**Electricity Supply Company (ESC)**
A company that provides electricity supplies.

**Electricity Supply Company Interface (EI)**
An electrical power supply provided by an Electricity Supply Company at the motorway boundary.

**Enhanced Message Sign (EMS)**
A sign which is used to display a variety of legends or messages. The legend or message is controlled from the instation. EMS has 2 rows of 12 characters. Can be mounted on a gantry or cantilever.

**Equipment Room**
The part of the Control Office (CO) that houses the electronic equipment required to interface with the outstation devices and the operator interfaces within the Control Room.

**High Frequency Carrier (HFC)**
The High Frequency Carrier system is an analogue transmission system where individual 4KHz bandwidth signals are multiplexed with a higher frequency signal, the carrier, to allow the signals to share the transmission circuit.

**High-level Data Link Control (HDLC)**
A protocol, at link level, which forms the basis of all...
inter-station communications on the NMCS2 data system, Closed Circuit Television (CCTV) system and the Regional Communications Controller (RCC) network. When each station communications link is set up, point to point or multidrop, the delivery, security and integrity of each frame of data is assured. HDLC is the basis of a family of protocols which form the main data highway(s) for communication between Data Base Processor, Local Communications Controller, Regional Communications Controller and Transponders providing the packet message handling network.

**Insulation Displacement Connector (IDC)**
A terminal that makes contact with the conductive metal core of a wire by cutting into the insulation such that the insulation is displaced but not removed.

**Indicator Panel Drive Unit (IPDU)**
An NMCS2 unit local to a signal.

**Loading/Loaded**
A cable pair is said to be loaded when its characteristic impedance has been altered. Loading is achieved by including inductance coils over the total length at joints between individual cable lengths.

**Local Cabling**
Cabling other than the longitudinal cabling, used to connect devices to the longitudinal cable or control equipment.

**Longitudinal Cable**
The 40 pair copper and 24 fibre cables (two separate cables) running parallel to the motorway in the duct network, each pair and fibre is dedicated to a specific purpose. Historically 20 pair NMCS1 and 30 pair NMCS2 cables were direct buried. The 20/30 pair copper cables may be augmented by composite copper/optical fibre cables dedicated to CCTV or carrier circuits.

**Marker Tape**
A plastic tape buried in the ground above ducts and cables to indicate their presence. Marker tape used on the ducted network includes a metallic film which allows the type (and therefore the ducts) to be detected, using detection equipment, without disturbing the surface.

**Marshalling Cabinet**
A Cabinet Type 600 immediately outside a Transmission Station (TS) into which all the longitudinal copper cables are terminated and jointed to cables from the TS.

**Microwave Radio Link**
Non cable based radio transmission system using frequencies in the GHz range. Can use either digital or analogue transmission.

**MIDAS Detector**
Equipment installed in a Cabinet Type 600 which processes information received from cable loops buried in the carriageway which detect the presence of vehicles. The configuration of loops allows speed to be determined.

**MIDAS Transponder**
A Transponder dedicated to MIDAS and not used by other devices or subsystems.

**Motorway Incident Detection and Automatic Signalling (MIDAS)**
A Control Office Base System (COBS) Subsystem which monitors traffic flow conditions and interacts with signal subsystems to automatically set signals without operator intervention. Signals are set when queuing traffic is detected.

**Motorway Signal Mark 2 (MS2)**
A motorway signal comprising an Enhanced Matrix Indicator (EMI) and an Enhanced Message Sign (EMS) mounted on a cantilever structure.

**Multidrop Link**
A transmission channel that allows a master device to communicate with several devices over the same channel.

**National Motorway Communications System (NMCS)**
The motorway traffic control and emergency telephone network adopted to serve the motorways of England.

**National Motorway Communications System 1 (NMCSI)**
A combined signalling and telephone system controlled from Regional and National central processors, installed up to 1988.

**National Motorway Communications System 2 (NMCS2)**
A system using locally based distributed processing to control telephones and signals, installed from 1988.

**National Transmission Network**
The National data transmission network linked by the Regional Communications Controllers (RCC).

**Power Distribution Unit (PDU)**
A Power Distribution Unit provides distribution and isolation, for equipment within a cabinet. Separate protected outgoing circuits (ways) are provided for equipment from the incoming circuit, together with a circuit for the cabinet heater (Cabinets Type 600, 617 and 620 have anti-condensation heaters).

**Private Wire (PW)**
A dedicated permanent circuit provided by a Public Telecommunications Operator between two locations.

**Public Telecommunications Operator (PTO)**
A licensed provider of Public accessible telecommunications services (eg. British Telecommunications Ltd, Mercury Communications Limited).

**Public Switched Telephone Network (PSTN)**
PSTN is provided by a Public Telecommunications Operator (eg. British Telecommunications Ltd, Mercury Communications Limited), ie a telephone connection accessed by the user dialling numbers.

**Pulse Code Modulation (PCM)**
Pulse Code Modulation is a process of converting an analogue signal into a digital signal. A sample of the analogue signal is taken and equated to the nearest digital level. Each digital level is associated with a binary code. This code is transmitted instead of the analogue signal. This process operates on an individual signal and does not create additional capacity. The analogue signals are sampled at 8KHz and produce 8-bit codes. This gives a single channel with a bit rate of 64,000 bits per second or 64Kbit/s.

PCM is commonly used to describe multi channel digital transmission systems. This is not totally correct as PCM is not a transmission system. PCM is generally used with Time Division Multiplexing (TDM) transmission systems.

**Quad Cable**
A 4 wire cable in which all the wires are twisted (laid) together, rather than in 2 pairs. This reduces cross pair interference where the pairs are used as the same channel.

**Regional Maintenance Contractor (RMC)**
A Contractor responsible for the day to day maintenance of instation and outstation equipment. Also has first line responsibilities for the transmission equipment in their region.

**Residual Current Device (RCD)**
An electrical safety device that isolates ( disconnects) a circuit from the power source when a fault occurs.

**RS485**
A data protocol (EIA RS485) and practice adopted for use by NMCS2 between the Standard Transponder and motorway devices.

The RS485 Multidrop Link is the lowest hierarchical level of transmission in an NMCS2 data system and provides the means, parameters and protocol of communication between Transponders and motorway devices. It allows the Transponder to control several devices at once or individual devices. However, individual devices can only transmit to the Transponder.

Transmission is half duplex, ie transmission in only one direction at once. Each link caters for up to 30 motorway devices. Each message comprises 5 characters of 8 data, 1 parity, 1 start and 1 stop bits. The characters represent address, command, data byte 1, data byte 2 and longitudinal parity.

**Sector Block**
An NMCS2 telephone system unit, it is a term for a Sector Switch operating in a subordinate role to a Sector Switch and is capable of switching Blocks only. Sector Blocks are only used when the complexities of the telephone do not require this additional level of switching.

**Sector Interface**
An NMCS2 telephone system unit. Sited at the most strategic point in the motorway, the SI is the most significant telephone node in the Control Office area network. The SI provides, for the telephone system, the transmission system facility for common speech and data circuits. It comprises 4 ports which are themselves comprised of Sector Switches needing one Sector Switch for each Telephone Line Controller the port serves. It provides an interface between the Telephone Line
Controller and the lower order telephone switching stations.

**Signal Controller**
An outstation device local to a signal dedicated to controlling a signal.

**Standard Transponder (ST)**
Standard Transponder is at the lowest hierarchical level within the Control Office Area. It interfaces to Local Communications Controller/HDLC links and provides a star point on the RS485 local links. It also provides some of the signal sub-system functions and a post box service to other sub-systems. It controls up to 120 motorway devices.

**Telephone Responder**
A motorway based mini telephone exchange controlling the connection of telephones with an NMCS2 Control Office.

**Transmission**
Telecommunications terminology for the sending and receiving of signals.

**Transmission Station (TS)**
A Transmission station is an outstation unit provided to house telecommunication equipment require to allow successful communications between the Instation and Outstation Services. The TS are either buildings or cabinets Type 617 and are spaced at approximately 20km intervals within a Control Office area.

**Uninterruptible Power Supply (UPS)**
A power supply device which prevents failure of the main power supply from disrupting the operation of equipment. A UPS will usually be of sufficient capacity to allow a secondary power supply (e.g., a generator) to be brought into operation, initiate alarms and in some cases initiate a controlled shutdown of equipment.

**2 Wire**
A circuit which uses 2 conductors, a single pair for both transmitting and receiving.

**4 Wire**
A circuit which uses 4 conductors, 2 wires for transmitting and the other 2 wires for receiving. The cable may be constructed in pairs or as a quad cable.

BS 7671 - Requirements for Electrical Installations
D16. REFERENCES

Electricity Supply Regulations
Electricity at Work Regulations
TA 75/95 : Motorway Transmission (DMRB 9a.4.4)
Manual of Contract Documents for Highway Works:
  Volume 1 - Specification for Highway Works
  Volume 3 - Highway Construction Details
TR 2017 - Single Mode Fibre Optic and Copper Comms Cable
TR 2029 - Inductive Loop Cable for Vehicle Detection Systems
TR 2031 - Armoured Feeder Cable for Inductive Loop Systems
TR 2150 - NMCS Copper Communications Cable
TR 2151 - NMCS Optical Fibre Communications Cable
TR 2152 - NMCS Co-Axial Communications Cable
TR 2153 - NMCS Energy Cable
TR 2158 - NMCS Armoured Copper Communications Cable
TR 2159 - NMCS Armoured Optical Fibre Communications Cable
TR 2160 - NMCS Armoured Co-Axial Communications Cable
TR 2161 - NMCS Armoured Energy Cable
MCE 2015 - CCTV Control Systems
MCE 2183 - Ducted Cable Network - Cable Joint Enclosure Specification
MCG 1022 - Testing for Newly Installed Communications and Power Cable
MCG 1055 - Testing newly installed Mono-Mode Fibre optic Communications Cable
MCG 1099 - Ducted Cable Network - Cable Testing Specification
MCH 1589 - Guide to the Siting of Inductive Loop Detectors on Motorways
MCL 5502 - Technical Guide to Loading of DTP Motorway Communications Cables
MCL 10470 - Transmission Station Building Specification
MCG 1099 - Ducted Cable Network - Cable Testing Specification
MCH 1589 - Guide to the Siting of Inductive Loop Detectors on Motorways
MCL 5502 - Technical Guide to Loading of DTP Motorway Communications Cables
MCL 10470 - Transmission Station Building Specification