SWANSTON TRAMS / YARRA TRAMS

TECHNICAL SPECIFICATION

TRAM OVERHEAD
CONSTRUCTION AND MAINTENANCE
SPECIFICATION

PREPARED BY: DOUG JOWETT

DATE: 18 SEPTEMBER 1998
maintcon.doc
# TABLE OF CONTENTS

## PART A - GENERAL
- A. TRAM ELECTRICAL SAFETY AND OPERATING RULES 1
- B. DEAD LINE WORK 1
- C. HOLD POINTS 1
- D. DESIGNS BY THE CONTRACTOR 1
- E. QUALITY OF WORKMANSHIP 2
- F. SURPLUS AND SCRAP MATERIAL 2
- G. SURVEY WORKS 2
- H. SETTING OUT AND DIMENSIONS 3
- I. PERMITS AND APPROVALS FOR WORKS 4
- J. PROTECTION FROM TRAM TRAFFIC 4
- K. TRAFFIC MANAGEMENT 5
- L. LIGHTING 7
- M. RELOCATION OF SERVICES 7
- N. TEMPORARY WORKS 7
- O. PLANT AND EQUIPMENT 8
- P. TREE TRIMMING 8

## PART B - TECHNICAL SPECIFICATION

### 1 OVERALL SYSTEM SPECIFICATION 9

#### 1.1 GENERAL SYSTEM SPECIFICATION 9
- 1.1.1 MECHANICAL 9
  - 1.1.1.1 Safety Factors 9
  - 1.1.1.2 Corrosion prevention 9
  - 1.1.1.3 Wear Resistance 10
  - 1.1.1.4 Composite Materials 10
- 1.1.2 ELECTRICAL 10
  - 1.1.2.1 Conductor Sizes 10
  - 1.1.2.2 Insulation Levels 11
  - 1.1.2.3 Electrical Clearances 11
  - 1.1.2.4 Electrical Separations 11
  - 1.1.2.5 Current carrying Capacity 11
  - 1.1.2.6 Cleaning and Greasing of Current Carrying Connections 11

#### 1.2 OVERHEAD LINE GEOMETRY 12
- 1.2.1 STRUCTURE GAUGE 12
- 1.2.2 TROLLEY WIRE HEIGHTS 12
  - 1.2.2.1 Trolley Wire Height on Straight Track 12
  - 1.2.2.2 Trolley Wire Sag 13
  - 1.2.2.3 Change in Trolley Wire Levels 13
- 1.2.3 TROLLEY WIRE OFFSET AND STAGGER 13
  - 1.2.3.1 Tangent track (Straight Track) 13
  - 1.2.3.2 Curved track (Fixed System) 14

#### 1.3 OTHER REQUIREMENTS 14
- 1.3.1 DUAL RUNNING 14
- 1.3.2 COMPATIBILITY OF FITTINGS 14
- 1.3.3 ASSEMBLY METHODS 14

#### 1.4 DRAWINGS AND DOCUMENTATION 15
1.5 ALTERNATIVE DESIGNS AND MATERIALS 15

2 COMPONENT AND ASSEMBLY DETAILS 15

2.1 POLES 15
  2.1.1 GENERAL 15
  2.1.2 POLE ERECTION 16
    2.1.2.1 Hole Excavation 16
    2.1.2.2 Pole Setting 16
    2.1.2.3 Raise of Poles 16
  2.1.3 BACK ANCHORS 16
  2.1.4 POLE INSPECTION AND TESTING 18
    2.1.4.1 Timber Poles 18
    2.1.4.2 Steel Poles 18
    2.1.4.3 Concrete Poles 18
    2.1.4.4 Inspection Records 19
  2.1.5 MAINTENANCE PAINTING OF STEEL POLES 19

2.2 LIGHTING ARMS 19

2.3 STRAIGHT STEEL CROSS SPANS 19
  2.3.1 GENERAL SPECIFICATION STEEL CROSS SPAN 19
  2.3.2 DETAILED STEEL CROSS SPAN CONSTRUCTION (REFER DRAWINGS) 20
  2.3.3 TROLLEY WIRE SUSPENSION 21
  2.3.4 POLE ATTACHMENTS 21
  2.3.5 WALL ATTACHMENTS 21
  2.3.6 TROLLEY WIRE STAGGER 22

2.4 SINGLE PENDULUM OR DOUBLE PENDULUM ON BOOM TUBE SUPPORT 22
  2.4.1 BOOM TUBE ATTACHMENT TO POLE 22
  2.4.2 BOOM TUBE 22
  2.4.3 BOOM TUBE INSULATION 23
  2.4.4 BOOM TUBE TIE 23
  2.4.5 SINGLE PENDULUM FITTINGS 24
  2.4.6 DOUBLE PENDULUM FITTINGS 24

2.5 TROLLEY WIRE SUPPORT BENEATH BRIDGES AND WITHIN DEPOTS 25
  2.5.1 TROUHING 26
  2.5.2 TROUHING SUPPORT 27
  2.5.3 ELASTIC SUPPORT ARMS (RESILIENT FITTINGS) 28

2.6 CROSSOVERS 29
  2.6.1 DUAL RUNNING 29
  2.6.2 PANTOGRAPH ONLY 29

2.7 TURNOUTS 30
  2.7.1 DUAL RUNNING 30
  2.7.2 PANTOGRAPH ONLY 31

2.8 FROGS 31
  2.8.1 INSTALLATION REQUIREMENTS 31
2.9 CROSSING PANS 32
   2.9.1 GENERAL INSTALLATION REQUIREMENTS FOR CROSSING PANS 32
   2.9.2 INSTALLATION FOR 15 DEG TO 35 DEG CROSSINGS 32
   2.9.3 INSTALLATION FOR 45 DEG TO 90 DEG CROSSINGS 33

2.10 TROLLEY WIRE 33
   2.10.1 INSTALLATION REQUIREMENTS 33
   2.10.2 TROLLEY WIRE SPECIFICATION 34
   2.10.3 TROLLEY WIRE SIZES 34
   2.10.4 TROLLEY WIRE TERMINATION 34

2.11 TROLLEY WIRE SPlicing (JOINING) 35

2.12 TROLLEY WIRE CURRENT EQUALISER 35

2.13 TROLLEY WIRE ANCHORING FOR SHARP RADIUS CURVES 36
   2.13.1 TROLLEY WIRE ANCHOR ASSEMBLY (HANGER & EAR SUSPENSION) 37
   2.13.2 TROLLEY WIRE ANCHOR ASSEMBLY (PENDULUM/PULL OFF ARM SUSPENSION) 37

2.14 TROLLEY WIRE AND BOOM TUBE ANCHORING (PENDULUM/PULL OFF ARM)
   2.14.1 BOOM TUBE ANCHORING 38
   2.14.2 TROLLEY WIRE ANCHORING 39

2.15 BULL RINGS 40

2.16 CURVES AND JUNCTIONS 40
   2.16.1 SPAN NETWORK 40
   2.16.2 TROLLEY WIRE SUSPENSION 41
   2.16.3 TROLLEY WIRE ANCHORING 41
   2.16.4 FROGS AND CROSSINGS 41
   2.16.5 TROLLEY WIRE OFFSET 41

2.17 SECTION INSULATOR ASSEMBLY 41
   2.17.1 GENERAL 41
   2.17.2 INSTALLATION OF THE STANDARD P.T.C. SECTION INSULATOR 41

2.18 AERIAL SWITCH (ISOLATOR) 42
   2.18.1 AERIAL SWITCH 42
   2.18.2 AERIAL SWITCH OPERATING GEAR 42
   2.18.3 AERIAL SWITCH BOX 43
   2.18.4 EXISTING AERIAL SWITCH BOXES CONTAINING ASBESTOS 43

2.19 SURGE DIVERTER (ARRESTER) 44
   2.19.1 SURGE DIVERTER CHARACTERISTICS 44
   2.19.2 MOUNTING AND CONNECTING DETAILS 44
2.20 SECTION INSULATOR BRIDGING VIA AN AERIAL SWITCH 45

2.21 AERIAL FEEDER CABLES 46
  2.21.1 AERIAL POWER FEEDER CONDUCTORS (CABLES) 46
  2.21.2 AERIAL POWER FEEDER CONDUCTOR TERMINATION 47
  2.21.3 AERIAL POWER FEEDER CONDUCTOR JOINING 48
  2.21.4 FEEDER TAPS 48
    2.21.4.1 Feeder Tap to Trolley Wire General Specification 48
    2.21.4.2 Underground Feeder Cable Taps 49
    2.21.4.3 Feeder Tap Terminal (T Clamp) to Overhead Feeder Cable 49
    2.21.4.4 Feeder Ears 49
    2.21.4.5 Feeder Tap to Trolley Wire Cable 50
  2.21.5 CROSS ARM REPLACEMENT 50

2.22 ELECTROLYSIS FEEDER CONDUCTOR SUPPORT 50

2.23 SUPERVISORY CABLE - AERIAL SUPPORT 51
  2.23.1 SUPPORT OF SUPERVISORY CABLE ON POLE 51
  2.23.2 SUPPORT OF SUPERVISORY CABLE ON PARAFIL CROSS SPAN 51
  2.23.3 UNDERGROUND SUPERVISORY CABLE INSTALLATION 52
  2.23.4 SUPERVISORY CABLE PROTECTION ON POLE 52
  2.23.5 SUPERVISORY CABLE CONNECTION 52

2.24 TESTING AND REINSTATEMENT OF POLE BONDS 52

3 ACCEPTANCE INSPECTION AND TESTING 54

3.1 STATIC INSPECTION AND MEASURING 54
  3.1.1 CROSS SPAN AND OTHER TROLLEY WIRE SUPPORT ASSEMBLIES 54
  3.1.2 TROLLEY WIRE HEIGHT, SAG, STAGGER AND OFFSET 54
  3.1.3 SECTION INSULATORS, FROGS, CROSSINGS AND SPLICES 55
  3.1.4 ELECTRICAL CLEARANCES AND SEPARATIONS 55

3.2 DYNAMIC TESTING - TEST TRAM 56
  3.2.1 LOSS OF CONTACT (ARCING) 56
  3.2.2 STAGGER, OFFSET AND HEIGHT 56
  3.2.3 CARBON PANTOGRAPH PAN AND TROLLEY POLE OPERATION 56
  3.2.4 SECTION INSULATORS, CROSSINGS, FROGS AND SPLICES 56

3.3 ELECTRICAL TESTING 56

TABLE A STANDARD PTC POLES FOR OVERHEAD SUPPORT 57
TABLE B OVERHEAD CABLES AND CONDUCTORS 58
TABLE C TEMPERATURE - SAG - TENSION 60
TABLE D OFFSET OF TROLLEY WIRE AND CENTRE SPAN DISTANCE 61
TABLE E OVERHEAD WORK STANDARD DRAWINGS 62

ATTACHMENT 'A' GENERAL CONDITIONS GOVERNING ATTACHMENTS TO THE CORPORATION'S POLES AND AERIAL CROSSINGS OF THE TRAMWAY
September 1998

TRAM OVERHEAD CONSTRUCTION AND MAINTENANCE SPECIFICATION

OVERHEAD NETWORK. 66

ATTACHMENT 'B' CONDITIONS CONTROLLING THE ERECTION OF DECORATIONS AND/OR ILLUMINATIONS ON THE CORPORATION'S TRAMWAY OVERHEAD POLES AND EQUIPMENT. 67

ATTACHMENT 'C' TROLLEY WIRE STAGGER - DIAGRAMMATIC REPRESENTATION. 68
A  TRAM ELECTRICAL SAFETY AND OPERATING RULES

All work shall be carried out in accordance with the Tram Electrical Safety and Operating Rules, the Electricity Safety Act 1998 and in accordance with the relevant rules and regulations of other Network Operators and Authorities with assets in the vicinity of these works.

B  DEAD LINE WORK

All work shall be undertaken under dead line conditions.

No connection to the existing electrical system shall be made without the express and written approval of the Superintendent.

C  HOLD POINTS

Hold points are those points beyond which the work may not proceed without review by the Superintendent.

Hold points are identified by the letters HP in the left margin and by bold text print.

HP  Work shall not commence until all the appropriate preparation works have been carried out and the consent to proceed is obtained from the Superintendent.

The review by the Superintendent of a hold point will not relieve the Contractor of responsibility for satisfactory execution or performance of the work.

Text which is bolded but not identified by the letters HP in the left margin is not a hold point. These are specified obligations on the Contractor requiring the review or approval of the Superintendent. They are bolded for ease of identification.

D  DESIGNS BY THE CONTRACTOR

Apart from the Drawings supplied, the Contractor shall prepare at his own expense all other drawings (Contractor's shop drawings) which are required for the completion of the Contract.

Such Contractor's shop drawings shall conform in all respects with the sizes and
TEMPORARY WORKS

Any temporary works provided by the Contractor shall be properly designed and constructed for the safe operation of the function they will be required to perform.

All aspects of the design of any temporary structures required to support constructional loads shall comply with the current Australian Standard, Specifications and Codes where such exist, or, in their absence, with British or American Standard Specifications and Codes of Practice.

Any temporary or additional works provided by the Contractor shall be adequate for the purpose and shall be properly designed and constructed for the load which they will be required to carry.

Details of any temporary or additional works proposed by the Contractor shall be forwarded to the Superintendent for approval at least 7 days before intended works.

Any approval of the temporary works by the Superintendent shall not relieve the Contractor of any of his responsibilities for work under the Contract.

PLANT AND EQUIPMENT

The Contractor shall supply and deliver to the site all necessary equipment and shall provide all tools, plant and any other equipment which may be necessary to complete the works. Maintenance records of all plant and equipment shall be available for inspection by the Superintendent prior to use.

Prior to use of any electrical equipment or appliance on the works the particular item shall be presented to the Superintendent for inspection. The Contractor shall maintain in his site office a register of such items, including the date and Superintendent's signature confirming such inspection.

The use of explosives or explosive powered devices by the Contractor, shall be subject to the prior approval of the Superintendent.

The use of mobile plant and equipment near tracks and overhead shall conform with the procedures and guidelines outlined in Attachment 'D' "Procedures for working on PTC property and facilities" and in accordance with the Tram Electrical Safety and Operation Rules.

Plant risk assessment for all tools, plant and equipment as per OHS (Plant) Regulations 1995 shall be available for inspection by the Superintendent prior to use.
TREE TRIMMING

Tree trimming shall be carried out by appropriately trained tree cutting personnel in such a manner as to ensure the safety of the public, the tree cutters, other employees in the vicinity and the protection of the tree, the Corporation's assets as well as other assets around the tree. The trimming shall be carried out in accordance with the regulations of the local council.

Tree trimming shall be carried out on accordance with the Code of Practices for Powerlines Clearance (vegetation) 1996 as published by the Office of the Chief Electrical Inspector.
PART B - TECHNICAL SPECIFICATION

1 OVERALL SYSTEM SPECIFICATION

The ultimate measures of Overhead System performance are service performance, reliability and maintenance requirements.

The sections of overhead designed, built or rehabilitated to this Specification shall not contribute any incidents that cause delays to trams.

1.1 GENERAL SYSTEM SPECIFICATION

1.1.1 MECHANICAL

1.1.1.1 Safety Factors

A safety factor of 3 to 1 over the allowable loading shall apply.

Any fitting inserted in line with strained conductors or support spans shall be stronger than the conductor or the span to which it is attached.

Fittings which are under tension and which are subject to wear (e.g. splice ears and trolley wire tensioner) shall not during their projected life fail at a strain which is less than 2/3 of the Ultimate Tensile Strength of the new conductor and span material with which they are used.

1.1.1.2 Corrosion prevention

Adequate long term corrosion protection shall be provided as follows:

! With the exception of corrosion-resistant steels such as stainless, all ferrous parts shall be hot-dip galvanised upon completion of all fabrication processes.

! Unless a corrosion-resistant material is specified, all bolts, nuts and washers which are of over M10 size shall be hot-dip galvanised.

! All bolts, nuts and washers which are less than M10 size shall be made of a corrosion resistant material such as stainless steel or other material approved by the Superintendent.
Dissimilar metals which would promote galvanic corrosion shall not be used in close proximity.

1.1.1.3 Wear Resistance

The fittings shall be constructed from such material and in such a manner to provide projected life delivery in service with minimum maintenance requirements.

1.1.1.4 Composite Materials

Composite materials shall:

a) Be stabilised against Ultra-Violet Radiation.
b) Be resistant to chemicals that might be encountered in their operating environment.
c) Provide adequate electrical insulation levels.
d) Not sustain combustion.
e) Have good wear characteristics if subject to wear.
f) Be capable of withstanding electric arcing without deterioration
g) Have low moisture absorption characteristics.
h) Have high impact resistance.
i) Aesthetic considerations.

1.1.1.5 Projected Life

It is envisaged that the overhead fittings and systems shall be designed for a minimum projected life of 30 years.

1.1.2 ELECTRICAL

The nominal voltage of the Tram Traction system is 600 volts d.c.. However, the system is constantly raising to 720 volts or greater due to regeneration

1.1.2.1 Conductor Sizes

Conductor sizes shall be determined by both mechanical and electrical ratings, protection and strength considerations.

Deviations from standard sizes in general use, as listed in Table B, shall be made only after both mechanical and electrical considerations have been made and permission has been sought from and granted by the Superintendent.
1.1.2.2 Insulation Levels

All insulators shall be rated for operation at 900V d.c. as a minimum.

All attachments to the poles or other structures shall be at least double insulated from live parts.

All the support spans shall be insulated in such a manner that, should they break, live parts will be maintained at a height no less than 3m above ground level.

1.1.2.3 Electrical Clearances

All electrical clearances from any conductor or part energised at 600V d.c., shall be in accordance with the Electrical Safety Act 1998 and the Tram Electrical Safety and Operating Rules.

1.1.2.4 Electrical Separations

The relative position and separations between conductors and circuits shall be in accordance with the Electrical Safety Act 1998 and the Tram Electrical Safety and Operating Rules.

1.1.2.5 Current carrying Capacity

The current carrying capacity of switches or isolators shall not be less than that of the largest equivalent cross sectional area of conductor/s connected to each of its terminals.

Fittings utilised to join conductors or to provide electrical connection or tapping shall have a resistance less than the equivalent length of conductor.

1.1.2.6 Cleaning and Greasing of Current Carrying Connections

Copper to Copper

All joint assemblies which are designed to permit the transfer of current from one conductor to another shall be prepared as follows and to the satisfaction of the Superintendent.
The conductors, clamps and fittings shall be thoroughly dried and then cleaned with a suitable scratch brush to remove all dirt and surface oxide from the conducting surfaces of the joint.

Before the clamps are tightened, a liberal film of Shell Ensis CB compound or other acceptable electrical jointing compound shall be applied to the conducting surfaces to seal the joint against moisture ingress.

Copper to Aluminium.

Suitable transition fittings and jointing compounds shall be used to terminate any copper to aluminium connection.

1.1.3 INTERFACING WITH EXISTING EQUIPMENT.

The integrity of items that are not to be replaced but are worked upon or handled in the process of installing / replacing mating parts or assemblies shall be preserved when installing a new system or rehabilitating an existing system. The Contractor shall exercise 'due care' and take the necessary steps to ensure the integrity of these items is not jeopardised.

During the process of trolley wire tensioning, the relative position of components and wire stagger at other locations shall not be affected adversely. Prior to terminating in any fittings, the trolley wire tension is to be checked by the Superintendent.

Special care shall be exercised at cable connections and supports.

1.2 OVERHEAD LINE GEOMETRY.

1.2.1 STRUCTURE GAUGE

The structure gauge specified in Drawing P.15556 shall be observed for all works associated with this Contract.

1.2.2 TROLLEY WIRE HEIGHTS

All trolley wire heights shall be referred to rail level.

1.2.2.1 Trolley Wire Height on Straight Track

Where there are no restrictions such as bridges, civil engineering works or electrical separations the height of the trolley wire shall be
5.64m at the support points (taken at 20 degrees Celsius).

The tolerance on the trolley wire height shall be +0, -75mm under these conditions.

Where the trolley wire is suspended under bridges or inside buildings and the 5.64m height cannot be met, then the distance between the bridge underside and the trolley wire shall not exceed 170 mm.

The absolute minimum trolley wire height shall not be less than 3.6m.

The tolerance of heights below 5.64m shall be 25mm.

1.2.2.2 Trolley Wire Sag

The sag of the trolley wire shall be in accordance with the Tension / Sag table (Reduced Tension) for fixed tension designs Table C. The tolerance for the sag shall be 25mm.

1.2.2.3 Change in Trolley Wire Levels

The desired max. trolley wire gradient shall be determined by the formula below:

Desired max. Gradient = 1 in (5 X Ruling Speed in km/h).

The absolute maximum gradient shall be 1 in 75.

Loss of contact, defined as separation between the current collection equipment and the trolley wire and fittings, shall not exceed 1% at normal service speeds.

1.2.3 TROLLEY WIRE OFFSET AND STAGGER.

A mirror gauge shall be correctly utilised to set the trolley wire offset with respect to the centre line of the track.

1.2.3.1 Tangent track (Straight Track))

On tracks converted to pantograph running, the stagger shall be on a
1.2.3.2 Curved track (Fixed System)

The trolley wire shall be offset towards the centre of the curve at the ears in accordance with Table D.

1.3 OTHER REQUIREMENTS

1.3.1 DUAL RUNNING

On the same section of line, all fittings referred to in this contract and used shall facilitate running of trams fitted with either trolley pole or pantograph current collectors.

The design and installation procedure for the fittings shall ensure smooth transition from trolley wire to fitting.

For pantograph passage, a flat surface shall be provided over the entire length of the fitting.

The runner / clamp piece of any fitting attached or clamped to the trolley wire shall not exceed 20mm in width and shall be installed such that a trolley shoe without carbon will adequately clear the fitting during its passage.

1.3.2 COMPATIBILITY OF FITTINGS

All components, fixtures and fittings used shall be fully compatible with existing fittings.

No modification or work on mating parts shall be required for assembly. New parts shall be fully interchangeable with existing parts.

1.3.3 ASSEMBLY METHODS

All components shall be assembled in a manner which ensures that fasteners are tightened to the correct torque and they will not work loose due to vibration or other factors. However, it shall be possible to dismantle fittings for adjustment, maintenance or replacement.

For proprietary items the manufacturer’s installation procedure and Specification shall be adhered to. Thread locking compounds shall not be
1.4 DRAWINGS AND DOCUMENTATION

In general drawings of the fittings will be supplied to the Tenderer as detailed in the Drawing Table for this Specification.

Where Drawings are not supplied then the Corporation will provide samples at the Tenderer's request.

1.5 ALTERNATIVE DESIGNS AND MATERIALS

The use of alternative designs and/or materials may be considered if it can be demonstrated that the alternative fitting's performance is equivalent to or better than the specified fitting and that it complies with all Clauses of this Specification in the Section headed "Other Requirements".

The alternative design shall not necessitate the use of additional tools other than that expected to be used for the fitting specified.

Request for such approval shall be submitted to the Superintendent in writing together with supporting evidence of the benefits of the alternative.

No alteration in design or material shall be implemented unless approved by the Superintendent in writing.

2 COMPONENT AND ASSEMBLY DETAILS

2.1 POLES

2.1.1 GENERAL

Where specified, galvanised steel poles shall be used to support the overhead system.

In some instances the location and number of poles to be installed are dictated by external factors such as planning processes and the presence of underground services or encumbrances. If the position given on concept drawings interferes with any of the above and necessitates the relocation of the pole, the revised position shall not vary from the original in a way that jeopardises the layout of the trolley wire supporting network.
These issues shall be considered in determining the location of the poles.

The poles shall be constructed from two diameters of circular hollow steel section in accordance with Table A. No assets shall be attached to the poles for a minimum period of 7 days after pole installation.

2.1.2 POLE ERECTION

2.1.2.1 Hole Excavation

A survey of underground assets shall be conducted by the Contractor prior to commencing excavation and underground services shall be 'proved' prior to pole installation.

The minimum distance between two poles shall be such that the structural stability of either pole and/or its footing is not adversely affected.

For each pole, a bored hole, of uniform diameter throughout the entire depth and 200mm deeper than the embedment depth specified on the relevant pole drawing, shall be provided.

For standard span poles, a 380mm diameter auger shall be used. For standard anchor poles, a 460mm diameter auger shall be used.

The diameter of the hole shall always be at least 100mm greater than the diameter of the pole.

2.1.2.2 Pole Setting

A red gum base plate, 300 x 240 x 40mm, shall be laid at the bottom of the hole.

The pole shall be installed with the depth mark and identification plate facing the roadway.

The depth mark shall be 1.4m above rail level.

A concrete mix (25 MPa minimum strength) shall be placed then compacted to fill the voids between the pole and the earth surrounding the pole.

After setting the pole rake, the surface of the concrete at the pole
base shall be crowned and neatly finished to ensure no pooling of water at the pole/concrete interface.

2.1.2.3 Rake of Poles

Poles shall rake opposite to the direction of strain application.

For poles strained in more than one direction the pole shall rake opposite to the direction of the resultant strain.

Poles shall be set with the following rakes:

<table>
<thead>
<tr>
<th>Steel Poles</th>
<th>Anchor</th>
<th>1 in 40 rake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Span</td>
<td>1 in 60 rake</td>
</tr>
</tbody>
</table>

Additional allowance should be made for local ground conditions and for the magnitude of the loading. Such judgement is allied with the experience of the pole setter.

2.1.3 BACK ANCHORS

If the ground where the pole is embedded is unstable or if the load to be applied to a pole exceeds the design load capacity of the pole a back anchor shall be applied as directed by the Superintendent. To be effective, the back guy shall act as near as possible in the opposite direction to the resultant strain acting on the pole.

The back anchor shall transfer part of the pole load to adjacent pole/s or structure/s via an 11mm, 6X23(12/6+6/1) RHOL 1 WRC G2070. Galvanised 'Tirfor' wire rope. The wire rope shall be insulated, at both ends, from the pole/s and structure/s by inserting GY2 porcelain strain type insulators at 1750mm from the point of attachment on to the pole or structure. Anchor bands to Drawing O923 shall be used to attach the wire rope to the pole.

Where the guy wire crosses above or below trolley wire or other bare conductor or fittings, which could become energised, the wire rope shall in addition to the GY2 insulators be insulated from the pole or structure via a 200mm disc insulator to Drawing D3771. The disc insulator shall be attached to the pole using a 300mm length of 13mm regular link proof coil chain and an anchoring band to Drawing O923. Additional GY2 insulators shall be installed on either side of the apparatus that can become energised to limit the length of the back anchor wire that can become accidentally energised. Preformed helical terminations shall be used to terminate the steel wire rope incorporating galvanised steel thimbles where necessary.
2.1.4 POLE INSPECTION AND TESTING

The following procedures shall serve as guidelines only.

Irrespective of its apparent condition, any pole which is considered to lean excessively should be investigated and reinstated to its required off vertical rake or replaced as required.

Traditional pole testing as outlined hereunder has been based mainly on visual inspection. To assess pole condition, the Corporation is particularly interested in engaging Contractors who can supplement these inspection procedures by subjecting poles to lateral load tests under controlled conditions. Such loads would simulate the magnitude of the forces that might be applied to the poles should the trolley shoe disengage and its pole entangle the supporting network or cross span. Details of the proposed method, prior notification and approval is required before any such testing may be undertaken.

2.1.4.1 Timber Poles

The surface of the pole shall be examined for any damage, splits or rot.
The circumference of the pole shall be sound tested. Any dead, hollow or flat sounds may be potential indicators of problems.
The region around the pole base is to be excavated to a depth of 300mm and inspected for termite activity or timber rot.
Since internal deterioration commonly occurs in the "swell" region which ranges from just above ground level to approximately 150mm below it, an 16mm diameter inspection hole shall be drilled near the base. The borings shall be examined for any rot and termites. If detected, another inspection hole shall be drilled to confirm that the first observation was not localised and to establish the extent of decay and the residual strength.
The inspection hole shall be filled with a "Polesaver Rod" PS14 diffusible preservative (14mm diameter and 125mm long) and then sealed with a tapered plug.

2.1.4.2 Steel Poles

The surface of the pole shall be examined for any damage, corrosion and rust.
The region around the pole base is to be excavated to a depth of 300mm and inspected for damage, corrosion and rust spots.
2.1.4.3 Concrete Poles

The surface of the pole shall be examined for any damage, cracks and rust stains.

2.1.4.4 Inspection Records

Following inspection, the excavation at the base of the pole shall be backfilled and the site cleaned up.

Where the pole is found to be unserviceable, the road side pole surface shall be marked with an “X”, using paint spray can or brush.

An inspection disc showing the month and year of inspection shall be affixed to each pole at shoulder height and on the road side. Details of each inspection shall be recorded in the Inspection Test Record Log.

2.1.5 MAINTENANCE PAINTING OF STEEL POLES

Where the pole surface requires local repainting, the Contractor shall protect adjoining property, pedestrian, vehicular and other traffic upon or in the vicinity of the structure being painted against disfigurement or damage by paint.

The Contractor shall take all precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before paint is applied.

Cleaning and preparation of surfaces shall be carried out in such a way that the adjoining areas of proposed or freshly painted surfaces are not contaminated. All weld metal and other areas temporarily left unpainted and where the shop paint has been damaged or where the area has been corroded or is otherwise bare, damaged or abraded, shall be painted with one coat of zinc phosphate priming paint. When the priming coat is dry and hard, one finishing coat of “Dulux” oil-based enamel, “Silver Sheen”, Product Code No. 82901193 or approved equivalent paint shall be applied to all of these primed areas.

2.2 LIGHTING ARMS

Installation of the lighting arms onto the poles shall occur at least seven days after pole installation.
A 3mm diameter galvanised steel soft wire (fencing wire) shall be used to provide a draw wire for the arms to allow installation of the lighting cable through each of the arms. Also a length of the same draw wire shall be provided through the centre of the pole to enable the lighting cable to be pulled up through the hollow section of the pole entering through the 50mm hole drilled 500mm from ground level.

2.3 STRAIGHT STEEL CROSS SPANS

2.3.1 GENERAL SPECIFICATION STEEL CROSS SPAN.

Straight support spans shall be constructed using 6mm steel wire rope to Specification No. TMO/04/07/92, GY1 strain insulators to Specification No. TMO/03/07/92 and reel type insulators to Drawing No. O7364.

The wire rope shall be terminated using preformed terminations to Specification No. TMO/05/07/92 or swaged fittings.

The swaged fittings shall be aluminium alloy for machine swaging or copper for hand swaging and shall be sized to suit 6mm wire rope.

Swaged terminations shall not fail at a load lower than the minimum breaking load of the wire rope.

The construction of straight cross spans shall be carried out as per PTC Drawings No. O14-292 pole to pole support, O14-293 pole to wall support and O13-294 wall to wall support.

2.3.2 DETAILED STEEL CROSS SPAN CONSTRUCTION (REFER DRAWINGS)

The steel wire rope cross span shall be formed of 6 No. lengths of 6mm wire rope, 5 No. GY1 insulators and 2 No. reel insulators.

The 2 No. innermost lengths of steel wire rope are to be of standard length and are to be joined midway between the trolley wires through the centre insulator.

Their outer ends shall be threaded through the primary insulators and swaged. Their inner ends shall be threaded through the centre insulator and swaged.
The distance between the centres of the primary insulators shall be 5000mm for standard track centres of 3.353m.

The intermediate lengths of the steel wire rope shall join the primary insulator to the secondary insulator on both sides of the cross span. Their length varies with the width of the road.

The intermediate lengths of the steel wire rope shall be terminated on both sides by using preformed helical terminations threaded through the primary and secondary insulators.

The outermost lengths of the cross span are constructed as follows:

A reel insulator shall be connected to the attachment point using the shackle plate arrangement shown on Drawing No. O7364 and a 1/2" galvanised bolt x 3-1/2".

The reel insulator and shackle plates shall be manufactured to Drawing No. O7364.

At a distance of 1500mm from the centre of the reel insulator the secondary insulator shall be attached via 6mm steel wire rope.
One end of the wire rope shall be wrapped around the reel insulator and swaged.
The other end of the wire rope shall be threaded through the secondary insulator and swaged.

Starting at the end of the hanger, the cross span shall slope upwards from the horizontal and towards the pole or wall attachment.

This upward gradient shall be approximately 1 in 10 for 81sq.mm. trolley wire and 1 in 7 for 129sq.mm. trolley wire.

2.3.3 TROLLEY WIRE SUSPENSION

An adjustable span hanger to Drawing No. O13-983 shall be used to attach the line ear to the steel cross span with two stainless steel 'U' bolts. The hanger horn shall always point towards the nearest pole and shall be adjusted to ensure that the ear sits vertically.

The trolley wire shall be suspended from the support span utilising a 250mm (10") line ear, Fandstan Part No. 91231 or South Eastern Transit Part No. 12000, attached to the adjustable span hanger through a 3/4" stainless steel stud and a brass nut fitted with a stainless steel spring washer.
On straight spans the line ears shall be oriented so their main body faces towards the centre of the road and the clamping plate faces the roadside.

2.3.4 POLE ATTACHMENTS

The reel insulator shall be attached to the pole via its shackle plates onto a standard type pole band to Drawing No. O.6897 Type 2, sized to fit the diameter of the pole.

2.3.5 WALL ATTACHMENTS

All existing wall attachments shall be proof tested by the application of a load of 18kN. A load cell or equivalent equipment shall be utilised to measure the load.

Wall attachments that withstand the designated proof load shall be re-used subject to the Superintendent's approval.
New wall attachments shall be tested as per existing wall brackets but only when the manufacturer's specified curing time for the chemical anchor has elapsed, and prior to the attachment of any other loads.

All new and replacement wall attachments shall be to Drawing No. O14-308.

The reel insulator of the cross span or pull-off shall be attached to the wall attachment. In some instances it may be necessary to incorporate a 'Dee' shackle to enable the reel insulator to be attached.

If a shackle is used it shall have a minimum breaking load of 20 kN or a Working Load Limit of 12 kN.

Any wall attachment that fails the proof test shall be replaced.

2.3.6 TROLLEY WIRE STAGGER

On tracks converted to pantograph running, the stagger shall be on a 230mm either side of centre line pattern, as illustrated in Attachment C. A mirror gauge shall be correctly utilised to set the trolley wire offset with respect to the centre line of the track.

2.4 SINGLE PENDULUM OR DOUBLE PENDULUM ON BOOM TUBE
SUPPORT

The Single Pendulum (or Double Pendulum) assemblies, supported on boom tubes shall be in accordance with Drawings O14-545(typ.),Q6059, Q6060 and O14-531 and shall conform to the following:

2.4.1 BOOM TUBE ATTACHMENT TO POLE

Two pole band assemblies shall be attached to each pole to enable the attachment of the boom tube and the boom tube tie.

For Centre Pole - Back to Back Single Track Cantilever the band assembly shall be to Drawing No. D5076.

For Single Track Cantilever the band assembly shall be to Drawing No. D5075.

The boom tube insulator shall be attached to the lower band assembly pivot. The boom tube tie shall be attached to the upper band assembly pivot.

The pole band shall be sized to suit the pole diameter for each location.

2.4.2 BOOM TUBE

The boom tube shall be manufactured to Drawing No. F12075. The material shall be welded mild steel tube, 60.3mm outside diameter, 5.4mm wall thickness to A.S. 1163 or alternatively refrigerant pipe, with the same dimensions.

The boom tube shall be hot dipped galvanised to A.S. 1650. The inside diameter of the tube shall not be less than 47.0mm after galvanising. The external finish shall be smooth and free of 'run off'.

The length of the boom for each location shall be specified by the P.T.C. on the boom tube assembly Drawings.

2.4.3 BOOM TUBE INSULATION

The boom tube shall be connected to and insulated from the pole by a polymeric strut type insulator to Drawing D3373 Reference D3373/2 or
D3373/3.

The insulator shall have the following characteristics:

**Mechanical**
- Minimum Tensile Breaking Load: 40kN
- Minimum Compression Failing Load: 40kN
- Minimum Bending Breaking Load: 270kN

**Electrical**
- Minimum Creepage Distance: 370mm
- Power Frequency Wet Withstand Voltage: 50kV
- Impulse Withstand Voltage (12/50ms wave): 125kV

2.4.4 **BOOM TUBE TIE**

The boom tube tie shall be constructed from Parafil rope, 2 Tonne minimum breaking load, to Drawing No. D4465. Reference D4465/2.

The parafil rope tie shall be terminated in accordance with Drawing No. D4466.

The termination used shall be to drawing No. D4464, Reference D4464/201 or D4464/204, or approved equivalent.

The boom tube tie shall be attached to the boom tube via a boom connector bracket, manufactured to Drawing No. D4953, retained and located on the boom tube by two 'U' bolts to Drawing No. D3933. Reference D3933/1.

2.4.5 **SINGLE PENDULUM FITTINGS**

In this specification Kummier & Matter single pendulum components are listed. Equivalent compatible alternative designs of single pendulum can be submitted for approval.

A primary insulator shall electrically insulate the boom tube from the trolley wire.

The insulator shall have a minimum wet flashover voltage of 8kV.

The K&M insulator, Part No. 850 D 431 1 or an approved equivalent shall be utilised.

The insulator shall be attached to the boom tube by using two boom tube collars to Drawing No O14-547.

A galvanised steel Eye nut, K&M Part No. 845 E 202 or approved equivalent, with a 5/8” thread shall be attached to the insulator.
A 4mm diameter galvanised steel Hanger (Pendulum Cable), 500mm long as measured eye to eye, shall be attached to the eyenut including a nylon thimble K&M Part No. 856 D 719 1.

A 10mm diameter stainless steel bow, K&M Part No. 872 D 1050 III, shall be threaded through the lower eye of the hanger. A nylon thimble, K&M Part No. 856 D 719 1, shall be included.

On each side of the bow a trolley wire clip, K&M Part No. 872 E 1308, shall connect the trolley wire to the bow.

On the bow the points of clip attachment shall be knurled to ensure there is no relative movement between the clips and the bow.

The assembly shall be adjusted to ensure the trolley wire seats horizontally without any twists, or kinks.

The Manufacturer's installation and adjustment instructions for the single pendulum equipment shall be followed.

2.4.6 DOUBLE PENDULUM FITTINGS

In this specification Kummler & Matter double pendulum components are listed. Equivalent compatible alternative designs of single pendulum can be submitted for approval.

A primary insulator shall electrically insulate the boom tube from the trolley wire.

The insulator shall have a minimum wet flashover voltage of 8kV.

The K&M insulator, Part No. 850 D 431 1 or an approved equivalent shall be utilised.

The insulator shall be attached to the boom tube by using two boom tube collars to Drawing No O14-547.

An upper hanger, K&M Part No. 838 D 136 or approved equivalent, with a 5/8" thread shall be attached to the insulator.

2 No. 4mm diameter galvanised steel Hangers (Pendulum Cable), K&M Part No. 848 D 328/2, 500mm long as measured eye to eye, shall be attached to the upper and lower hangers, the lower hanger being K&M Part No. 838 D 140.

On each side of the lower hanger rod, a trolley wire clamp, K&M Part No. 838 D 134, shall connect the trolley wire to the rod.

The assembly shall be adjusted to ensure the trolley wire seats horizontally
without any twists or kinks. The Manufacturer’s installation and adjustment instructions for the single pendulum equipment shall be followed.

2.5 TROLLEY WIRE SUPPORT BENEATH BRIDGES AND WITHIN DEPOT BUILDINGS

Where trolley wire is installed below a structure such as a bridge or within a depot building provision shall be made to ensure that the current collector cannot bridge electrically the trolley wire and the structure. This is achieved by the installation of troughing made from insulating material. The troughing also protects the trolley pole current collectors from sustaining impact damage should they disengage from the trolley wire.

The troughing shall be supported from structures above, by the “Unistrut” channels, at intervals not exceeding 1.5m. The troughing needs to be attached to the bridge or building with some type of framework or brackets. In most cases, it is desirable that the height of the supporting framework be as compact as possible so that the standard trolley wire height of 5.64 metres can be maintained.

In recent years, one method of achieving this was to use a 75 SHS central steel spine with transverse 50x10 steel flats welded to its upper and lower surfaces at intervals appropriate to the troughing support (lower) and for fixing to the superstructure (upper).

There are circumstances where the bridge superstructure is more than 1 metre above the trolley wire and the trolley wire beneath is adequately supported. A road overpass with large girders spaced along the trolley wire direction is an example. In such cases, alternative protection shall be provided by the installation of durable sheeting (e.g. special plastic or marine ply) adequately affixed so that it maintains a lateral coverage of 1.2 metres on each side of the trolley wire.

The ends of consecutive lengths of troughing shall be butted together. A galvanised steel plate shall be used to splice the “Unistrut” channels of consecutive lengths of troughing. The plate shall be attached to the “Unistrut” channels of each length of troughing by two M10 screws and spring loaded “Unistrut” nuts.

2.5.1 TROUGHING

The fibreglass troughing shall be manufactured in 3 m lengths from a sample supplied.

In order to meet the design requirements the fibreglass troughing shall:
be electrically insulating against a 600V d.c. nominal working voltage.
- be UV stabilised (gelcoat UV stabilised).
- not support combustion (fire retardant resin).
- have high resistance to impact.
- have good surface finish, especially the inside.
- have exterior surfaces which exhibit high water resistance.

The fibreglass walls of the troughing shall have a minimum thickness of 6 mm.

Two lengths of galvanised steel "Unistrut" channel shall be inserted at the back of the troughing to provide means of supporting it onto a structure above and join a number of lengths to form one continuous length. The "Unistruts" shall be 41 mm by 21 mm with a wall thickness of 2.5 mm and shall run the full length of the troughing.

To protect the troughing side walls against impact, steel plate ribs 50mm wide by 3 mm thick shall be formed to follow the profile of the side wall. The ribs shall be spaced at 500 mm intervals and shall be welded to the "Unistrut". The steel ribs shall be embedded in the fibreglass in a manner that ensures there are no protrusions on the inside of the troughing whilst maintaining a minimum fibreglass cover of 4 mm on each side of the steel plate. The plate shall extend horizontally 75 mm from the "Unistrut" channel at the upper end of the wall of the troughing. To ensure proper keying between the fibreglass and the steel plates a number of 5 mm holes shall be drilled on the plate.

Individual troughing lengths shall be joined together using 2 No. 40 x 12 steel flats x 185 long and 4 No. M12 hexagon headed bolts per flat.

2.5.2 TROUGHING SUPPORT

To support the troughing under bridges the following practices shall be adopted:

i) **Steel bridge girders approximately perpendicular to the trolley wire**

"Z" type brackets are to be fabricated. Essentially each bracket comprises a piece of 40 x 12 flat bent so that each end is horizontal and parallel and there is a short vertical step between. The height of the step is to be less than the thickness of the flange. The lower level has 2 No. 14 mm. diameter holes drilled for M12 bolts. The brackets are erected with the underside of the upper level atop the beam flange so that when the bolts through the lower level holes to the troughing
are tightened, the troughing "Unistruts" bear firmly beneath the underside of the flange.

ii) **Steel Bridge Girders approximately parallel to the trolley wire**

A suitable attachment detail for the "Z" type brackets shall be provided. This might consist of a series of steel flats or angles which are firmly clamped or fastened to the flanges of the girders.

Note: Welding is not permitted. No drilling of bridge members or any other modification is permitted without the written approval from the Manager, PTC Structural Engineering or from the owner of the bridge.

The troughing shall be attached to the angle flange or flat by using "Z" type (step) brackets or by bolting directly to these.

iii) **Concrete Bridges**

A suitable attachment detail shall be provided. This might consist of a steel flat which is sufficiently wide to straddle the troughing and which has a short length of flat welded to each end to "step" the plate. The lower dropped plate has 2 No. M14 holes drilled for M12 bolts into the "Unistruts" and the (upper level) end plates shall be drilled for attachment to the concrete bridge soffit. The height of the step must be such that the M12 bolt heads do not bear directly against the bridge soffit.

Note: Prior to any fabrication or field works, approval to attach to any part of the bridge must be obtained from the Manager, PTC Structural Engineering or from the owner of the bridge.

2.5.3 **ELASTIC SUPPORT ARMS (RESILIENT FITTINGS)**

Under structures the trolley wire shall be supported by elastic support arms. The elastic support arms shall be attached to the underside of the troughing.

For the standard trolley wire height of 5.64 m, the spacing of the elastic support arm shall be 6 m. Where the height of the trolley wire drops to below 5.64 m, the spacing of the elastic support arms shall be less than 6 m to compensate for the increased upward force exerted by the
current collector of the tram. If the track beneath is curved, the spacing of the elastic support arms shall be reduced to a spacing of not more than 2 metres.

The elastic support arm shall be attached to the troughing via the cranked plate supplied with it. At the point of installation 2 No. 18 mm diameter holes shall be drilled at 105 mm centres through the upper wall equidistant from and transverse to the longitudinal centreline of the troughing. A spreader plate is manufactured by drilling 2 No. 18 mm diameter holes at 105 mm centres for M16 bolts in a steel plate of dimensions 80 x 3 x 210. To prevent rotation the inserted bolts are welded to the plate and the plate itself is then fibreglass coated. The bolts from the spreader plate are inserted through the holes in the troughing and the cranked plate beneath the troughing and the entire assembly tightened by using the nuts and spring washers supplied.

The bolts used to secure the elastic support arms to the troughing shall be kept clear, by a minimum distance of 80 mm, from any part that can electrically bridge the structure which supports the troughing. The holes shall also be clear from the steel troughing ribs by a minimum of 100 mm.

The trolley wire clips supplied with the elastic support arm shall be fitted with the countersunk or counterbored head bolts with Allen key drive. To accommodate trolley pole current collectors, the overall width of the clamp in the assembled condition, with 129 mm² trolley wire, shall not exceed 20 mm.

2.6 CROSSOVERS

To enable trams to move from one tram track to another a crossover system is used. The three basic variations of crossovers are:

a) Left Hand Crossover
b) Right Hand Crossover
c) Scissor Crossover (Combination of Left and Right Hand)

2.6.1 DUAL RUNNING

The overhead crossover for dual running shall comprise two frogs joined by a piece of trolley wire running centrally over the curved track joining the two
parallel tracks as per Drawing No. O14-304 which depicts a Left Hand Crossover.

To compensate for any cross over trolley wire sag and to maintain the two converging trolley wires and the frog at the same height both trolley wires shall be supported 2m from the point of convergence of these wires on the frog. This is to provide for smooth trolley pole and pantograph running. These supports shall be provided by forming a 'cross over support square' as shown in Drawing No. O14-304.

The frogs shall be installed as specified in the Section of this Specification dealing with frogs.

The frog shall be sized to suit the trolley wire and of the correct direction for the given crossover.

2.6.2 PANTOGRAPH ONLY

To accommodate pantograph transition at the point of converging tracks the converging trolley wires above them are crossed.

At the intersection point of the trolley wires a contact bar type 1 Assembly to Drawing No. O14-572 shall be used.

The Crossing trolley wire shall run centrally over the curved track within the limits of the pantograph pan running surface.

At the point of intersection the crossing trolley wire shall cross above the main wire.

The intersecting trolley wires shall be adjusted to ensure smooth pick up of incoming trolley wire by the pantograph.

About 1200mm from the point of intersection of the trolley wires forming the contact bar cross spans shall be provided. The trolley wire shall be supported from the cross span with feeder ears.

The straight and intersecting trolley wires shall be connected electrically utilising a jumper wire assembly as per the Trolley wire Equaliser at both intersections.

The Crossing trolley wire shall extend past the reach of a pantograph pan and then it shall be terminated on adjacent poles utilising 11mm, 6X25(12/6+6/1) RHOL 1 WRC G2070 galvanised 'Tirfor' wire rope.
A preformed helical termination threaded through a GY2 insulator shall be attached to the end of the trolley wire.

The wire rope shall be attached to the pole as described below:

An anchor band to Drawing No. O923 shall be attached to the pole. A 300mm long piece of 13mm galvanised steel chain shall connect the anchor band to a 200mm glass disc insulator to Drawing No. D3771. A clevis thimble to Drawing No. D3121 shall be used to attach the wire rope to the disc insulator. A GY2 strain insulator shall be incorporated at approximately 1.75m from the attachment point of the disc insulator.

The wire rope shall be terminated with galvanised steel preformed helical terminations using galvanised steel thimbles where necessary.

2.7 TURNOUTS

In some locations, at the terminus, the two tracks merge into one.

This is called a turn out and could be described as a single ended crossover.

The converging wire shall be broken into a series of short chords to closely follow the track curve, supported and located on a network.

2.7.1 DUAL RUNNING

At the intersecting point a frog assembly shall be installed as per crossover detail.

2.7.2 PANTOGRAPH ONLY.

At the intersecting point a contact bar Type 1 assembly shall be installed as per crossover detail. The curved wire shall cross over the straight wire. See Drawing No. O14-544 Detail B for a typical pantograph-only turnout.

2.8 FROGS

Above track points a frog shall be utilised to guide the trolley pole in the desired
direction.

The frog shall be right or left hand to suit the application. The tips shall be sized to suit the size of the trolley wire being used.

2.8.1 INSTALLATION REQUIREMENTS

The frog shall be adjusted to sit centrally between the rails using a mirror gauge and shall be levelled in both the longitudinal and transverse directions. The frog shall also be adjusted to provide a smooth interface with the trolley wire.

The frog shall be located and supported at adjacent poles by additional wire rope restraints (frog legs).

To compensate for any cross over trolley wire sag and to maintain the two converging trolley wires and the frog at the same height, for smooth pantograph running, a span wire shall be installed across both wires at 2m from the point of convergence of these wires on the frog.

The frog shall be provided with guard bars, located between the legs of the frog, to ensure the trolley pole shoe does not become entangled in the frog.

Initially, the centre of the frog shall be located 4115mm beyond the toe of the points. This distance may have to be adjusted for each individual location to ensure correct trolley pole shoe tracking without loss of contact. (Toe of the points is the location where the single end of the point switch casting is welded to the rail). It is important to note that the position of the frog relative to the track switch is critical to the correct operation of the frog in service.

The frog shall be attached to the trolley wire via a frog back as per Drawing No.O14-405. The frog back shall be attached to the trolley wire with 'U' bolts.

The converging wire shall be threaded through the frog back opening provided and a 400mm tail shall be left to allow adjustment of the frog location. This tail shall be bent upwards.

The frog shall be restrained and supported by 'frog legs' as shown on Drawing No.O14-304.

2.9 CROSSING PANS

Where tracks intersect, crossing pans are required to facilitate crossing over of trolley wires.
The angle of the crossing pan shall correspond correctly to the angle of intersection of the tracks. The angles of crossing pans ranges from 15 degrees to 90 degrees generally in 5 degree steps.
Crossing pans from 15 degrees to 35 degrees are the P.T.C. standard crossing pan. Crossings from 40 degrees to 89 degrees are manufactured to Fandstan Drawing No. FE3089-1-AE.
(AE signifies the specified angle).
Crossing pans that are 90 degree are to Fandstan Drawing No. FE3109-1.

2.9.1 GENERAL INSTALLATION REQUIREMENTS FOR CROSSING PANS.

The intersecting wires cross above the crossing pan and shall be bent ('crowded') correctly to ensure the crossing pan does not distort during the installation process.

The crossing pan shall be adjusted to sit level in both the longitudinal and transverse directions.

The crossings shall be located centrally to the track crossings (using a mirror gauge).

The crossing shall be installed and adjusted to provide a smooth interface with the trolley wire and shall provide a smooth passage for pantographs without loss of contact. The crossing shall provide correct trolley pole tracking without loss of contact.

2.9.2 INSTALLATION FOR 15 DEG. TO 35 DEG. CROSSINGS

A 'U' bolt shall be used to hold the two trolley wires together at the point of intersection for registration. The crossing shall be placed below the intersecting trolley wires. The crossing pan shall be attached to the trolley wire by the clamping plate provided at each end of the crossing assembly. The downward force exerted by the clamping plate shall bring the trolley wire lower surface in line with the running surface of the crossing for smooth transition of trolley poles and pantographs.

For crossing pans from 15 degrees to 35 degrees, cross span wires shall not be attached directly to the crossing. The crossing shall be located between cross spans. To compensate for any cross over trolley wire sag and to maintain the two intersecting trolley wires and the crossing pan at the same height, for smooth pantograph running, a span wire shall be installed across both wires at 2m from the intersection point of the wires on the crossing pan.
2.9.3 INSTALLATION FOR 45 DEG. TO 90 DEG. CROSSINGS.

Fandstan type crossings 45 degrees to 90 degrees shall be fitted with crossing backs. The crossing back shall be supplied with 3 links of chain which is connected to a bullring that sits horizontal. The crossing back is suspended centrally above the track crossings from 3-4 pull-offs (legs) spanning radially from the bull ring to support and locate the crossing back from adjacent poles. A 'U' bolt shall be used to hold the crossing trolley wires and the crossing back together to provide trolley wire registration. The crossing shall be attached to the installed crossing back via 8 No. socket screws. The trolley wire jacking screws located at each end of the crossing back shall be used to bring the running surface of the trolley wire to the same level or slightly below the running surface of the crossing. This should be done to ensure smooth transition of trolley poles and pantographs from the trolley wire to the crossing and vice versa in all directions of travel.

The pull offs (legs) shall be made using 6mm galvanised wire rope. The pull off legs shall be attached to the pole, terminated and insulated in the manner described for the curve network. A GY1 insulator shall be inserted at a distance of 1500mm away from the bull ring used to support the crossing back.

2.10 TROLLEY WIRE

2.10.1 INSTALLATION REQUIREMENTS

The trolley wire installed shall be straight, free of kinks, twists and other defects and the cross section profile shall not be deformed along the entire length of the wire.

2.10.2 TROLLEY WIRE SPECIFICATION

The trolley wire shall conform in all aspects with Specification No. 17/OH/04/96.
The profile of the trolley wire shall be as per Drawing No. 06887.

2.10.3 TROLLEY WIRE SIZES

There are two standard trolley wire sizes utilised by the PTC. They are:
81 sq.mm.
129 sq.mm.

For each location, the size of the trolley wire to be used shall be specified by the PTC. In general, 129 sq.mm. trolley wire is to be used as the standard.

2.10.4 TROLLEY WIRE TERMINATION

Copper Preformed Helical Terminations shall be utilised for the termination of trolley wire.

The termination shall be matched to the trolley wire correctly. Terminations to be used shall be as per table below:

<table>
<thead>
<tr>
<th>TROLLEY WIRE X-SECTION</th>
<th>TROLLEY WIRE O.D.</th>
<th>STRANDED EQUIVALENT CONDUCTOR</th>
<th>MANUFACTURER</th>
<th>PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>129 sq.mm.</td>
<td>13.4 mm</td>
<td>19/2.75mm 13.75mm DIA.</td>
<td>FANNER PLP</td>
<td>CFG-138</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ALM DULMISON</td>
<td>CDE1375</td>
<td></td>
</tr>
<tr>
<td>81 sq.mm.</td>
<td>10.77 mm</td>
<td>7/3.5mm 10.5mm DIA</td>
<td>FANNER PLP</td>
<td>CFG-105</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ALM DULMISON</td>
<td>CDE1000D</td>
<td></td>
</tr>
</tbody>
</table>

The trolley wire shall be terminated to the designated pole/s or structure/s using, 11mm, 6x25(12/6+6/1) RHOL 1 WRC G2070 galvanised 'Tirfor' wire rope, as described below:

1) An anchor band to Drawing No. O923 shall be attached to the pole.

2) A 300mm long piece of 13mm proof coil regular link galvanised steel chain shall connect the anchor band to a 200mm glass disc insulator to Drawing No. D3771.

3) A clevis thimble to Drawing No. D3121 shall be used to attach the wire rope to the disc insulator.

4) In each leg anchoring the trolley wire a GY2 strain insulator shall be incorporated at approximately 1.75m from the attachment point to the disc insulator.
5) The preformed helical termination attached to the trolley wire shall be threaded through a GY2 insulator. The Tirfor wire of the anchoring leg shall be attached to the trolley wire via the GY2 insulator.

6) The wire rope shall be terminated with galvanised steel preformed helical terminations using galvanised thimbles where applicable.

Standard trolley wire termination arrangements are shown on Drawing Nos O14-579 and O14-580.

2.11 TROLLEY WIRE SPICING (JOINING)

The trolley wire shall be run with the minimum number of joints.
To join two lengths of trolley wire the splice ears utilised shall be of a proven design, comply with Specification TMO/02/06/92 and shall be approved by the Corporation.
The transition from trolley wire to the splice shall be smooth in both directions.
The surface where pantographs and trolley poles run shall be smooth and flat.

The Fandstan or South Eastern Transit in-line 5 screw splice ear (or approved equivalent), sized correctly for the trolley wire being joined, shall be used.

2.12 TROLLEY WIRE CURRENT EQUALISER

A trolley wire equaliser shall be installed every five poles/bays to bridge the up and down trolley wires.

The jumper shall comprise a feeder ear attached to each trolley wire and connected via a length of 185 sq.mm. double insulated flexible cable (specified in the Clause "Feeder tap to trolley wire cable") which is supported on an independent paraffil cross span located above the standard cross span. The arrangement is shown on Drawing No. O14-606.
The flexible cable shall be supported on the cross span by wrapping, in a spiral form, 1.5 sq.mm., 7/0.50mm insulated copper building wire over the entire supported length.

Where there are section insulators supported on the span where the current equaliser is to be installed the cable of the current equaliser is electrically connected to the trolley wire by being attached to the section insulator main casting thus eliminating the need for a feeder ear.
2.13 TROLLEY WIRE ANCHORING FOR SHARP RADIUS CURVES

Straight runs of trolley wire are tensioned to a higher tension than that for trolley wire on curves.

To compensate for this differential in tension, a trolley wire anchor shall be installed to transfer the tension imbalance to adjacent poles. For the lower tension of trolley wire applied in this instance the 6mm steel wire rope utilised for the cross spans should be used.

Each trolley wire anchor assembly shall consist of two separate legs anchored to poles on either side of the track. Typical legs assembly is shown on Drawing No. O14-599. The wire rope tension members shall be attached to the pole in the same manner as the standard cross spans via a standard pole band to Drawing No. O6897 and a shackle insulator assembly to Drawing No. O7364.

In each trolley wire anchor leg GY1 strain insulators shall be incorporated at approximately 1.5m from attachment points of the trolley wire anchor bar and the reel type insulator at the pole.

A tie, similar to a network centre, shall be used to locate the anchor bars relative to each other and minimise the possibility of side kinking the trolley wire.

The wire rope shall be terminated with aluminium or copper swaged ferrules or galvanised steel preformed helical terminations, using galvanised steel thimbles where applicable.

The tensioner installation shall be provided with guard bars, located between the legs of the anchoring arrangement, to ensure the trolley pole shoe does not become entangled.

2.13.1 TROLLEY WIRE ANCHOR ASSEMBLY (HANGER & EAR SUSPENSION)

Each anchor assembly comprises a galvanised steel anchor bar to Drawing No. O7466, two standard 10" line ears, a hanger to Drawing No. O13-983, an 8mm alloy Dee shackle, quality grade S and a 12mm bull ring. The male line ears are attached to the anchor bar with 3/4" brass nuts each fitted with a spring washer. The hanger shall be attached to the ear closest to the bent end of the anchor bar via the 3/4" screw. The shackle shall be threaded through the bull ring and attached to the 7/16" diameter hole of the anchor bar. The legs (pull offs) transferring the tension to adjacent poles shall attach to the bull ring.
2.13.2 TROLLEY WIRE ANCHOR ASSEMBLY (PENDULUM/PULL OFF ARM SUSPENSION).

Trolley wire supported by pendulum is tensioned to a higher tension than that for trolley wire supported by fixed cross span system or by curved cantilever with ear and hanger system.

To compensate for this differential in tension, a dual running trolley wire tensioner shall be installed to transfer the tension imbalance to adjacent poles utilising 11mm, 6X25(12/6+6/1) RHOL 1 WRC G2070 galvanised 'Tirfor' wire rope.

Each tensioner assembly shall consist of two separate legs anchored to poles on either side of the roadway. Typical legs assembly is shown on Drawing O14-315.

The wire rope tension members shall be attached to the pole as described below:

An anchor band to Drawing No. O923 shall be attached to the pole.
A 300mm long piece of 13mm galvanised steel chain shall connect the anchor band to a 200mm glass disc insulator to Drawing No. D3771.
A clevis thimble to Drawing No. D3121 shall be used to attach the wire rope to the disc insulator.

In each trolley wire tensioner leg GY2 strain insulators shall be incorporated at approximately 1.5m from attachment points of the trolley wire tensioner and of the disc insulator.
The wire rope shall be terminated with galvanised steel preformed helical terminations using galvanised steel thimbles where necessary.

The dual running trolley wire tensioner shall be manufactured to Fandstan Drawing No. FE 3084-3 or approved equivalent.

Trolley wire supported by standard hanger and ear suspension is tensioned to a lesser tension than for pendulum suspension and the anchorage detensioning system employed is to be in accordance with PTC Drawing No. O14 - 599.

2.14 TROLLEY WIRE AND BOOM TUBE ANCHORING (PENDULUM/PULL OFF ARM)

With pendulum installations the trolley wire and the boom tubes shall be anchored
to adjacent poles at 400m intervals so as to minimise the adverse effects of possible trolley wire breaks. (See Drawing No. O14-546.)

2.14.1 BOOM TUBE ANCHORING

At the point of anchoring, the boom tubes of two consecutive poles shall each be anchored to the adjacent poles thus preventing excessive movement of the tubes towards the space between the two consecutive poles. (Boom Anchor Leg)

A steel wire rope tie shall be strung between the boom tubes of the consecutive poles preventing excessive movement of the boom tubes away from each other thus forming an 'Anchoring Catenary'.

The Boom Anchor Legs and Anchoring Catenary shall be made from 11mm, 6X25(12/6+6/1) RHOL 1 WRC G2070 galvanised 'Tirfor' wire rope.

Insulators shall be inserted in line with the Tirfor wire as per Drawing O14-546.

The boom anchor legs shall be attached to the pole as described below:

An anchor band to Drawing No. O923 shall be attached to the pole.

A 300mm long piece of 13mm galvanised steel chain shall connect the anchor band to a 200mm glass disc insulator to Drawing D3771.

A clevis thimble to Drawing No. D3121 shall be used to attach the wire rope to the disc insulator.

In each boom anchor leg a GY2 strain insulator shall be incorporated at approximately 1.75m from the attachment point of the disc insulator.

The boom anchor legs and anchoring catenary shall be attached to the boom tube as described below:

Two boom connector brackets, to Drawing No. D4953, shall be attached back to back to the boom tube.

A clevis thimble shall be attached to each boom connector bracket.

A GY2 insulator shall be incorporated in the Tirfor wire 1.75m from the boom connector bracket.

The wire rope shall be terminated with galvanised steel preformed helical terminations using galvanised steel thimbles where necessary.

At a distance of 1m on either side from the mid point of the anchoring catenary a GY2 insulator shall be inserted.

At a distance of 2m from the centre of the GY2 insulator a 16mm bull ring, to Drawing No. D3885 Reference D3885/2, shall be included in line with
the wire rope. A Rebosio tension type insulator to Drawing No, D3677 shall be connected between the bull ring and the wire rope of the anchoring catenary.

Should an adjacent pole, to which boom tubes are anchored, have inadequate load capacity in the event of wire failure, the pole shall be stabilised by the provision of a back anchor to the next external adjacent pole.

2.14.2 TROLLEY WIRE ANCHORING

The trolley wire shall be anchored mid-bay below the Anchoring Catenary. An Arthur Flury splice Part No. 635.012.000 (or approved equivalent) shall be placed on top of the trolley wire mid-way between the consecutive poles where anchoring is to occur.
The short piece of trolley wire utilised to provide the reaction point of the splice shall be replaced with a piece of trolley wire 2m long.
The splice shall be located centrally on the 2m trolley wire length.
A preformed helical termination which has been threaded through a GY2 strain type insulator shall be attached on each end of the 2m trolley wire length.
The 2m trolley wire length shall be bent upwards to enable it to be suspended from the bull ring incorporated in the Anchoring Catenary above via 11mm Tirfor wire.

2.15 BULL RINGS

Galvanised steel bull rings shall be utilised where two or more wire rope members in tension (such as pull-offs, lacing or cross spans) act radially through a common point.
There are three sizes currently utilised and they shall be correctly chosen for each application with consideration given to the number of fittings and the magnitude of forces acting at the point where the bull ring is used.

D3885/1 12.7 mm thickness, would be used for lacing.
D3885/2 15.9 mm thickness, would be used for holding 2 to 3 legs.
D3885/3 12.7 mm (heavy duty) thickness, would be used for network spine applications.

They shall be manufactured in accordance with Drawing No. D3885.
2.16 CURVES AND JUNCTIONS - FIXED SYSTEM

Span networks shall be erected to provide support and restraint for the trolley wire and all the associated components required to make up the curve or junction.

2.16.1 SPAN NETWORK

Drawing No.O14-315 shows a typical curve network arrangement. The drawing pertaining to each individual curve and/or crossing shall be consulted to work out the requirements for the specific curve.

All networks including the 'pull-offs' (legs) and the 'lacing' shall be constructed using 6mm steel wire rope to Specification TMO/04/07/92.

Insulators, GY1 type, to Specification TMO/03/07/92 shall be used for centre, primary and secondary insulation.

The attachment structure or pole shall be insulated from the cross spans by using a reel and shackle type insulator as per Drawing No. O7364. The reel insulator shall be attached to the pole or supporting structure in the same manner as for the straight cross spans.

More than one pull-off span can be attached to the reel insulator. This arrangement shall consist of a 16mm bullring attached to the insulator using 6mm steel wire rope (320mm from the centre of the insulator to the centre of the bull ring). The distance between the centre of the reel insulator and the centre of the secondary insulators, of all the pull offs attached to the bullring, shall be 1500mm.

The number of pull off spans to be attached on each bullring and reel insulator assembly shall be determined by the loads applied in each specific situation and shall not exceed three.

Spans extending straight across two poles shall be attached to the poles independently from other pull-off spans.

The primary insulators on the inner side of the curve shall follow the rail and they shall be offset towards the centre of the curve by a distance equal to the trolley wire offset which is specified in Table D.

A bull ring, with its centre at a distance of 300mm from the centre of the primary insulator shall be attached to the primary insulator using 6mm steel wire rope on both sides of the curve. The pull-offs and the lacing shall be attached to the bull ring. The primary insulators shall insulate the
lacings and pull off spans from the trolley wire and the fittings supporting it.

All wire rope parts of the network shall be terminated using corrosion resistant aluminium alloy or copper swaged fittings or preformed helical terminations to Specification TMO/05/07/92.

With the exception of wire rope sections of the network which are shorter than 700mm at least one end of every wire rope section shall be fitted with a preformed helical termination to provide adjustment. The distance between centre spans on curves shall be in accordance with Table D.

2.17 SECTION INSULATOR ASSEMBLY

2.17.1 GENERAL

Section insulators shall be used to enable electric isolation of sections of the overhead system from adjoining sections. The section insulator shall be supported from a standard steel cross span in a manner that enables the section insulator to 'float'.

2.17.2 INSTALLATION OF THE STANDARD P.T.C. SECTION INSULATOR

The section insulator shall be supported using a standard steel cross span and an adjustable hanger as per Drawing No. O14-305 for pole to pole support.

The cross span shall be constructed as per the detailed construction of the steel cross span of this Specification with the line ear being replaced with the nominated section insulator.

The P.T.C. section insulators shall be selected as follows:

a) for 81sq.mm. trolley wire to Drawing No. O12-332
b) for 129sq.mm. trolley wire to Drawing No. O12-354
c) for 129sq.mm. to 81sq.mm. trolley wire use of Composite Section Insulator to Drawing No. O13-356

The section insulator shall be adjusted to provide a smooth passage to trolley pole and pantograph current collectors.
A cut off disc to Drawing No. O13-446A shall be installed on the steel cross span midway between the section insulators

2.18 AERIAL SWITCH (ISOLATOR)

The aerial switch shall be utilised to enable:

- The bridging and isolation between underground feeder cables and overhead cables.
- The bridging and isolation between two sides of a section insulator.
- The bridging and isolation between two aerial feed cable termination points.
- A bypass feed around an Automatic Sectionalising Switch in case of failure of the Automatic Switch.
The pole on which the aerial switch is mounted shall be bonded to the tracks as per Drawing No. E14-555.

2.18.1 AERIAL SWITCH

The standard switch installed shall be a 1500 Ampere 1000V d.c. Panel Mounted Isolator (switch).

The Manufacturer's Part No. is Multicontact P552-A3-001.

2.18.2 AERIAL SWITCH OPERATING GEAR

The aerial switch operating gear shall comprise:

- An operating handle to Drawing No. O14-312, Items 4, 7 and 9. It shall include a length of 1/2" pipe to suit the height of mounting the switch box at each location.
- The locking band to Drawing No. O14-312 Item 6 (diam. to suit pole)
- The guide band to Drawing No. O14-312 Item 3 (diam. to suit pole)
- The fibreglass upper operating insulated rod to Drawing No. O14-312, Item 2 which shall be sealed with a suitable adhesive at the interface of the fibreglass tube to the steel tongue at the ends to prevent water ingress.
- A locking clamp to Drawing No. O14-312 Item 5.

Assembly of the above components and the aerial switch box onto the pole will be required.

2.18.3 AERIAL SWITCH BOX.

The Aerial switch box comprises the backing plate and the front cover.

The backing plate shall incorporate a wooden 'V' block.

The switch assembly shall be attached to the backing plate of the switch box.

All the counter bored holes accommodating bolt heads or nuts shall be filled with electrical insulating material that will inhibit moisture ingress once the fasteners have been fully tightened.

The front cover shall be manufactured from fire retardant fibreglass and it shall incorporate a commercially available, corrosion resistant, adjustable type toggle latch.
The Switch box shall be mounted on the pole using two bands to Drawing No. O14-312 Item 1.

2.18.4 EXISTING AERIAL SWITCH BOXES CONTAINING ASBESTOS.

Where the existing aerial isolator switch box contains asbestos within its interior provision shall be made to exclude the presence of such material. This is achieved by removal of the existing aerial isolator switch and replacing it with the installation of a new fibreglass aerial isolator switch box within which the components of an existing asbestos lined box have been transferred.

With regard to the handling of asbestos, the Contractor is required to submit to the PTC a procedure for approval.

2.19 SURGE DIVERTER (ARRESTER)

2.19.1 SURGE DIVERTER CHARACTERISTICS.

The diverter shall have the following characteristics:

Rated Voltage 1kV dc / 2kV dc
Nominal Discharge Current 10kA
Permissible Short Circuit 20kA/0.2s
Pressure relief Class 4
Manufacturer's Part Number Siemens 3EC2010

OR Bowthorpe HE60MC07
With 3 No. 13mm dia. mounting holes on 162 P.C.D.

2.19.2 MOUNTING AND CONNECTING DETAILS

The Diverter shall be insulated to a level of 10kV from the pole or structure to which it is attached. The installation of the surge diverter on a wooden cross arm is shown on Drawing No. O14-312.
The earth terminal of the diverter shall be connected to a rail bond by a continuous length of single core, annealed, stranded copper cable. The cable shall have a cross sectional area of 70 sq.mm with no less than 19 strands. The level of insulation shall be 0.6/1 kV and the outer sheath shall be heavy duty, resistant to chemicals (petro-chemicals especially), shall not sustain combustion and shall be stabilised against Ultra-violet Radiation.

The cable shall comply with AS 3147 and its outer sheath shall be Black or Grey in colour.

One end of the cable is connected to the earth terminal of the surge diverter via a crimped type terminal lug having a stud hole to accept a 10mm screw.

The other end shall be connected by 'Cadweld' to the 91/2.14mm bare conductor of a standard track bond which has been welded to the rail (See Drawing No. E14-557). Where the cable emerges from the ground onto the pole it shall be enclosed in a 25mm hot dip galvanised steel conduit for protection. The conduit shall be extended to a minimum height of 3m above the ground level. The conduit shall be attached to the pole by a 19mm stainless steel strap in at least three positions. The cable extending above the conduit shall also be supported on the pole using 19mm stainless steel strap at intervals not exceeding 2m. However, to prevent the stainless steel band cutting into the cable sheathing and insulation at the point of attachment a rubber or PVC cover with a minimum thickness of 5mm shall be placed and secured between the band and the cable sheath. The cover shall extend a minimum of 30mm from either edge of the band.

The positive terminal of the surge diverter shall be connected via a single core, annealed, tinned, finely stranded copper cable to whatever is being protected e.g. feeder cable, trolley wire, etc. The cable shall have a cross sectional area of 16sq.mm and shall have no fewer than 224 strands. The level of insulation shall be 1.8/3 kV and the outer sheath shall be heavy duty, resistant to chemicals (petro-chemicals especially), shall not sustain combustion and shall be stabilised against Ultra-violet Radiation. The cable shall comply with Standard IEC 502 and its outer sheath shall be Black or Grey in colour.

If the Bowthorpe diverter is utilised its disconnector device shall be used for the positive connection and will indicate, by tail lead blow off when there has been a lightning strike, the operation of the diverter. The manufacturers installation instructions shall also be consulted for the arrester being used.

The pole on which surge diverters are mounted shall be bonded to the track as per Drawing No. E14-557.
2.20 SECTION INSULATOR BRIDGING VIA AN AERIAL SWITCH

To enable power feed from the adjacent electrical section, in case of power supply loss, quick electrical bridging across section insulators is provided via an aerial switch in certain locations. The aerial switch shall be installed onto one of the poles supporting the section insulator. Flexible, 185 sq.mm. feeder tap to trolley wire cable shall be used to make the necessary connections.

A cable shall connect one end of the switch to one side of the section insulator closest to the switch. A current equaliser shall connect this end of the section insulator closest to the aerial switch to the same end of the second section insulator.

Another cable shall connect the other end of the aerial switch to the other side of the section insulator closest to the aerial switch. Again, a current equaliser shall connect this end of the section insulator closest to the aerial switch to the same end of the second section insulator.

All the flexible cables shall be supported along their entire length onto a 2-tonne Parafil cross span located above the standard cross span in the same manner as the feeder tap to trolley wire. The flexible cable shall be supported from the Parafil by wrapping in a spiral form. 1.5mm5. 7/0.50mm insulated copper building wire over the entire supported length.

The flexible cables shall be kept clear from the pole or conductive fittings attached to the pole.

2.21 AERIAL FEEDER CABLES

2.21.1 AERIAL POWER FEEDER CONDUCTORS (CABLES)

Aerial Power Feeder Cables shall be 400 sq. mm., 91/2.36mm. hard drawn, bare, concentric, copper conductor.

Where the feeder is to be run beneath the existing bare conductor of another service authority, the cable shall be suitably protected by appropriate insulated sleeving for a distance of 5 metres each side beyond that crossing.

The feeder shall be supported on SLP/11/180 pin type porcelain insulators, to A.S. 2947.1-3, fitted to wooden cross-arms. The feeder cable shall be held onto the insulator by a cable tie made from a 3.15mm solid, annealed
copper wire.

The pins used to attach the insulators to the cross arm shall be to A.S. 1154 .2.

The wooden cross arms shall be manufactured to:

Drawing 014-427 for one or two feeder arrangement.

Drawing 014-428 for three or four feeder arrangement.

The cross arm shall be attached to the pole using a 'U' Band to Drawing O9563 and steadied by two galvanized cross arm braces manufactured to:

* Drawing O13-195 for the two feeder cross arm

* Drawing O13-196 for the four feeder cross arm.

* The braces shall be attached to the pole, below the cross arm by a pole band fitted with a 1/2" B.S.W. stud to Drawing O13-490.

In circumstances where the feeder misalignment at the pole exceeds 900mm, it is necessary to use turning insulators to Drawing No. D5508/2 and Z brackets

2.21.2 AERIAL POWER FEEDER CONDUCTOR TERMINATION.

The feeder conductor shall be terminated using copper preformed helical terminations.

A clevis thimble shall be inserted through the loop of the termination fitting. The clevis thimble shall be attached to two 200mm glass disc insulators to Drawing D3371.

A 300mm length of 13mm galvanised chain shall connect the insulators to the pole via:

1. A 4 Feeder Cable Anchor Cross Arm manufactured to Drawing No. D4938 where 3 or 4 conductors are to be terminated. The cross arm shall be assembled as per Drawing No. Q4135.

2. A 2 Feeder Cable Anchor Cross Arm manufactured to Drawing No. D4950 where 1 or 2 conductors are to be terminated. The cross arm shall be assembled in a similar way to Drawing No. Q4135.
An Anchor Band to Drawing No. O923 where a single feeder conductor has to be terminated and it is practical to use this arrangement.

If the cables terminated on either side of the pole need to be electrically connected a short length of 400mm5, annealed copper, double insulated cable shall be used. At each end a 400mm5 tinned copper crimp type lug which has a 20mm stud hole shall be fitted.

Also a 'tail' of each bare terminated conductor, protruding through the preformed helical termination, shall be fitted with the same lug.

The insulated cable shall sag under the cross arms to form a jumper between the cables being connected. A 3/4" galvanised steel bolt and Belville washers shall be used to connect the lugs.

Whether the pole requires back guying is a matter largely governed by the experience of the field personnel and by observation. Local ground conditions can play an important part in the stability of the pole. The following guidelines are offered:-

Where 2 or more feeders terminate on an anchor pole, the pole shall be back guyed to the next adjacent pole preferably at mid height or at a minimum greater height such that the installation does not interfere with vehicular traffic.

It is preferable that span poles not be used for feeder termination. However, for the termination of 1-2 feeders on a span pole, adequate restraint should be afforded by back guying to the next adjacent pole at mid height. Where more than 2 feeders are to be terminated, an anchor pole should be installed.

In circumstances where the end pole or feeder termination pole is not sufficiently strong to resist the anchoring loads, it will be necessary to run a back guy from the second last pole to the end pole and then anchor to the second last pole and slack span the feeders over the last pole bay.

In some instances it may be necessary to back guy over the last two pole bays, anchor to the third pole and slack span within the two bays.

When slack spanning, it is important that the feeders are not run so loose that they may rub together during high winds.

2.21.3 AERIAL POWER FEEDER CONDUCTOR JOINING

A crimped type full tension copper sleeve shall be used to join feeder cables.
A specially designed crimped type full tension copper sleeve shall be used to join 400 sq.mm. concentric feeder cables to existing feeder cables that have a cross section / configuration other than 400 sq.mm. concentric i.e. 323mm5 or 400 sq.mm. (equivalent) rope lay and 323 sq.mm. concentric.

The mechanical strength of the sleeves shall be in accordance with A.S. 1154.1.

The feeder cables shall be tensioned in accordance with table B.

2.21.4 FEEDER TAPS

2.21.4.1 Feeder Tap to Trolley Wire General Specification

Feeder taps shall be utilised to connect 600V d.c. power feeder cables to the trolley wire at predetermined locations.

The distance between successive feeder taps is dependent on the type and number of trams likely to be in the section at the same time, the location of tram stops and the pertaining terrain. This distance shall be specified for each location on system design drawings.

However, the distance between feeder taps shall not exceed 500m.

Feeder tap points shall be located in line with a pole.

The tap to trolley wire cable shall be supported along its entire length onto a 2-tonne Parafil cross span located above the standard cross span as per Drawing No. 14-605. The flexible cable shall be supported from the parafil by wrapping, in a spiral form, 1.5mm5, 7/0.50mm insulated copper building wire over the entire supported length.

The feeder tap to trolley wire cable shall be kept clear from the pole or conductive fittings attached to the pole.

A separate feeder tap shall be provided for each trolley wire.

2.21.4.2 Underground Feeder Cable Taps

Feeder taps connecting to an underground feeder cable shall be connected to the feeder using an electro-tinned crimp type
terminal lug designed for 185sq.mm. cable and provided with a 20mm. stud hole.

An aerial switch (isolator) shall be used to enable isolation of the feeder tap from the underground feeder and act as a terminal block for the feeder tap to trolley cable and the underground cables.

2.21.4.3 Feeder Tap Terminal (T Clamp) to Overhead Feeder Cable.

Feeder tap terminals shall be attached to the hard drawn bare aerial feeder conductor to provide termination for the feeder tap to trolley cable.

The terminal shall be attached close to the cross arm.

The tap terminal (clamp) shall be manufactured to Drawing No. O792 and sized correctly for the size of the feeder conductor it attaches to.

Surfaces in contact with conductors or fittings that provide current path shall be tin plated and a suitable jointing compound employed.

2.21.4.4 Feeder Ears

The Fandstan feeder ear Part Number 91211 or the South Eastern Transit feeder ear Part No. 12050 shall be used.

The feeder ear clamps onto the trolley wire.

The tap to trolley cable attaches to the feeder ear via a crimped lug at the connection tabs provided for this purpose.

Where the feeder tap to trolley wire is installed at a span supporting section insulators the feeder tap cables shall be electrically connected to the trolley wire by being attached to the section insulator main casting.

2.21.4.5 Feeder Tap to Trolley Wire Cable

The feeder tap to trolley cable shall be a single core, annealed, finely stranded, copper, double insulated, highly flexible cable.
It shall have a cross sectional area of 185 sq.mm. and shall have no fewer than 2590 strands.

The level of insulation shall be O.6/1 kV and the outer sheath shall be heavy duty, resistant to chemicals (petro-chemicals especially), shall not sustain combustion and shall be stabilised against Ultra-violet Radiation.

The cable shall comply with A.S. 3147 and its outer sheath shall be Black, Grey or Orange in colour.

2.21.5 CROSS ARM REPLACEMENT

Where timber cross arms have been installed on poles for a period of time, they are subject to rot, splitting, cracking and the results of fair wear and tear. Consequently, some in-service timber cross arms will need to be replaced with new. The installation of new cross arms on the pole shall be such that the its position is appropriate to the surrounding assets. Depending on the circumstances, it may not be possible or desirable to install the new arm in the same position as the existing which it is to replace but unless this is the situation, it is usual to place the new arm in a similar position to that of the arm which it is to replace.

Where the pole surface requires repainting, the Contractor shall follow the procedures outlined elsewhere within this specification.

2.22 ELECTROLYSIS FEEDER CONDUCTOR SUPPORT

The aerial electrolysis feeder conductor shall be supported on SLP/11/180 pin type porcelain insulators, to A.S. 2947.1-3, fitted to wooden cross - arms. The feeder cable shall be held onto the insulator by a cable tie made from a 3.15mm solid annealed copper wire.
The pins used to attach the insulators to the cross arm shall be to A.S. 1154.2.

2.23 SUPERVISING CABLE - AERIAL SUPPORT

2.23.1 SUPPORT OF SUPERVISING CABLE ON POLE

The supervisory cable shall be supported on poles utilising shackle porcelain insulators type SHLV8.
The insulator shall be attached to a 'Band-it' stainless steel sign mounting bracket by a 5/16" stainless steel set screw. The set screw is inserted through the back of the bracket and screwed all the way onto the bracket. The insulator shall be secured onto the bracket using a stainless steel washer and nut. The complete assembly is then attached to the pole using a 19mm stainless steel strap and buckle.

At the point of cable support the galvanised wire bearer (catenary), incorporated in the cable, shall be separated from the cable for a length of 150mm. Care shall be taken to ensure the cable or its insulation are not damaged. The separated bearer wire shall be suspended over the insulator. The cable and the bearer wire shall be secured to the insulator by a cable tie made from an 1.5mm3 insulated building wire. The building wire shall hold the bearer wire and the cable together in a manner that prevents the bearer parting from the cable further than the 150mm described above.

2.23.2 SUPPORT OF SUPERVISORY CABLE ON PARAFIL CROSS SPAN

The supervisory cable shall be supported on a two tonne parafil cross span located above the standard steel cross span. The supervisory cable shall be located no less than 2000mm from the primary insulator towards the pole or wall support.

At the point of cable support the galvanised wire bearer (catenary), incorporated in the cable, shall be separated from the cable for a length of 50mm. Care shall be taken to ensure the cable or its insulation are not damaged. A 'U' bolt to Drawing O13-983 shall be inserted between the separated bearer wire and the supervisory cable. The parafil cross span shall be also placed within the 'U' bolt. A 40x40x6mm galvanised plate, with 2No. 8mm diameter holes, centrally located at 20mm apart shall be used to clamp the bearer wire and parafil wire rope together. The cable and the bearer wire shall be secured to each other by a cable tie made from an 1.5mm3 insulated building wire in a manner that prevents the bearer parting from the cable further than the 50mm described above.

The supervisory cable height shall be kept to a maximum especially at road intersections.

2.23.3 UNDERGROUND SUPERVISORY CABLE INSTALLATION

The Supervisory cable shall be installed in 50mm conduits in the manner
specified for the underground feeder cables. A higher level of care shall be
exercised to prevent damage to the Supervisory cable given that its lower
mechanical strength and thinner insulation.

2.23.4 SUPERVISORY CABLE PROTECTION ON POLE

When the supervisory cable emerges from underground onto a pole it shall
be enclosed in a 25mm hot dip galvanised steel conduit for protection. The
conduit shall be extended up to the junction box. The conduit shall be
attached to the pole by a 19mm stainless steel strap in at least two positions
at intervals of not more than 2 metres.

2.23.5 SUPERVISORY CABLE CONNECTION

All connections of the supervisory cables shall be made in junction boxes
attached to a pole at a height 3-4 metres above ground level. Joints shall
not be made within the cable. The cable glands of the junction box shall be
sized to suit the supervisory cable used.
The junction box shall be manufactured to Drawing No. E13-355.
On the poles adequate spare cable shall be left to enable connections at the
predetermined locations. The cable ends shall be sealed against moisture
 ingress by a heat shrink type end cap.
The supervisory cable connections shall be effected by PTC staff.

At the substation, the supervisory cable shall be brought and secured onto
the pole nearest to the substation or into the substation pit allowing
adequate spare cable to enable connections inside each substation.

2.24 TESTING AND REINSTATEMENT OF POLE BONDS

HP For poles that carry sectionalising switches the pole bond cable shall not be
disconnected unless the sectionalising switch is isolated and the permission of
the Superintendent has been obtained.

To test the pole bond, the bond conductor shall be disconnected at the pole. The
conductor resistance shall be measured between the pole terminal lug and the rail.

The test shall be conducted by a qualified electrical trades person or Technical
Officer.
The equipment as well as the method utilised to perform the test shall be approved
by the Superintendent.
The results of the bond testing shall be submitted in writing to the Superintendent. The location, pole number, original cable resistance reading, final pole bond resistance reading after reinstatement shall be included in the test results.

Depending on the test results obtained one of the following procedures shall be undertaken.

If the cable resistance exceeds 1 (one) Ohm then:

- If the pole carries underground feeder cables, an aerial switch or a sectionalising switch then a new 70 sq.mm. double insulated conductor shall be run between the pole and the rail as per drawing E14-555. On completion of the cable installation the resistance between the pole and the rail shall be retested and shall not exceed 1 Ohm.

If the cable resistance does not exceed 1 (one) Ohm then:

- The cable bond connections shall be reinstated at the pole as per Drawing No. E14-555. On completion of the cable installation the resistance between the pole and the rail shall be retested and shall not exceed 1 Ohm.

Poles with surge diverter

If the pole carries a surge diverter an additional 70 sq.mm. double insulated cable shall be run between the pole and the rail as per Drawing No. E14-557 to connect the surge diverter earth directly to the rail. The installation shall be carried out as described in the section dealing with surge diverters.

On completion of the cable installation the resistance between the surge diverter earth cable and the rail shall be retested and shall not exceed 1 Ohm.

Any road opening permit and service proving that may be necessary for the installation of new pole bonds or Surge Diverter connections shall be obtained by the contractor. Any roadway or footpath excavated for new pole bond installation or Surge Diverter connection shall be reinstated to a standard that is acceptable to the local authorities and/or VicRoads as applicable.
3 ACCEPTANCE INSPECTION AND TESTING

A number of acceptance tests and inspections shall be arranged by the Contractor to be performed in the presence of the Superintendent or special groups delegated by him to observe the inspection and/or tests as outlined in this clause.

Any defects and/or non compliances shall be rectified by the Contractor at his expense.

The Contractor shall be present at all of these inspections/tests. All defects and/or non compliance with this Specification and/or the stated test standards shall be given to the Contractor in writing by the Superintendent to make correct at the Contractor's expense.

3.1 STATIC INSPECTION AND MEASURING

After installation, the following inspections shall be made by the Contractor in the presence of the Superintendent and the measurements specified herein shall be recorded.

The components of the system shall be checked to see if they have been installed in accordance with the Specification, drawings, written instructions and to the satisfaction of the Superintendent.

3.1.1 CROSS SPAN AND OTHER TROLLEY WIRE SUPPORT ASSEMBLIES

The Cross Span and other trolley wire support assemblies shall be checked to confirm that they have been installed to the specified drawings and Specification.

The slope of the cross span shall be checked.

3.1.2 TROLLEY WIRE HEIGHT, SAG, STAGGER AND OFFSET

The trolley wire parameters below, together with the temperature at the time of measurement, shall be checked by the Contractor in the presence of the Superintendent and the results shall be recorded to ensure conformance with the Specification. A copy of the results shall be given to the Superintendent.

The trolley wire height with respect to track shall be measured at each support point.
The Superintendent shall be the judge of acceptable performance in this regard.

3.1.4 ELECTRICAL CLEARANCES AND SEPARATIONS

The clearances and separations of the electrical conductors and fittings shall be checked.
The assembly shall be 2500V Megger tested with a minimum resistance of 1meg-ohm per kilometre.

HP The new system shall not be energised or connected to the existing electrical system and a test tram shall not be run without written approval from the Superintendent.

3.2 DYNAMIC TESTING - TEST TRAM

After completion of all works and before service trams can run on the new works, the following inspections and tests shall be carried out.

The Contractor shall make arrangements through the Superintendent for a test tram to be run through the section at normal operating speeds. The test shall be carried out when the ambient temperature is in the range 10 to 30 degrees Celsius.

3.2.1 LOSS OF CONTACT (ARCING)

Loss of contact shall not exceed 1%, otherwise the works shall be rejected (Measured at normal service speed).

3.2.2 STAGGER, OFFSET AND HEIGHT

Measurements recorded and or observed shall be in accordance with this Specification.

3.2.3 CARBON PANTOGRAPH PAN AND TROLLEY POLE OPERATION

Carbon pantograph pans and trolley pole current collectors shall pass through the sections, both directions, without impact damage.

3.2.4 SECTION INSULATORS, CROSSINGS, FROGS AND SPLICES

All the above fittings as well as incoming wires shall be 'picked' up
without undue impact as judged by the Superintendent.

3.3 ELECTRICAL TESTING.

The Superintendent may order Electrical testing of a section by the Electrical Testing Section of the Corporation.

**HP** Permanent power shall not be restored to the trolley wire until the consent to proceed is obtained from the Superintendent.

Permanent power shall not be restored to the trolley wire until all tests as specified above has been completed and approved by the Superintendent.
<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
<th>Section</th>
<th>PTC Drawing No.No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span Pole</td>
<td>11/OH/04/92</td>
<td>219.1x8.2CHS x5m</td>
<td>273.1x9.3CHS x6m</td>
</tr>
<tr>
<td>Anchor Pole</td>
<td>12/OH/04/92</td>
<td>273.1x9.3CHS x5m</td>
<td>323.9x9.5CHS x6m</td>
</tr>
<tr>
<td>Centrally Mounted Span &amp; Lighting Pole</td>
<td>13/OH/04/93</td>
<td>219.1x8.2CHS x6m</td>
<td>273.1x9.3CHS x8m</td>
</tr>
<tr>
<td>Anchor Pole with Dual Cantilever Capacity</td>
<td>14/OH/04/93</td>
<td>273.1x9.3CHS x6m</td>
<td>323.9x12.7CHS x8m</td>
</tr>
<tr>
<td>Anchor Pole for Tensioned Small Radius Curves</td>
<td>15/OH/04/93</td>
<td>273.1x9.3CHS x4m</td>
<td>323.9x12.7CHS x8m</td>
</tr>
<tr>
<td>Span Pole Base Mounted for Spread Footing</td>
<td>16/OH/04/93</td>
<td>219.1x8.2CHS x5m</td>
<td>273.1x9.3CHS x4m</td>
</tr>
</tbody>
</table>

Note: The 11m poles are for standard span and anchoring applications.
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>NOM CROSS-SECT AREA</th>
<th>CONDUCTOR MATERIAL</th>
<th>CONSTRUCTION No of strands/size</th>
<th>NOM O.D.</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AERIAL FEEDER CABLE</td>
<td>0.6.Try 400 EQV</td>
<td>HARD DRAWN COPPER</td>
<td>91/.093&quot; 91/2.36mm</td>
<td>25.96</td>
<td>BARE</td>
</tr>
<tr>
<td>AERIAL FEEDER CABLE</td>
<td>0.5.Try 300 EQV</td>
<td>HARD DRAWN COPPER</td>
<td>61/0.103&quot; 61/2.62mm</td>
<td>23.58</td>
<td>BARE</td>
</tr>
<tr>
<td>AERIAL ELECTROLYSIS CABLE</td>
<td>0.3.Try 200 EQV</td>
<td>HARD DRAWN COPPER</td>
<td>37/0.103&quot; 37/2.62mm</td>
<td>18.3</td>
<td>BARE</td>
</tr>
<tr>
<td>AERIAL ELECTROLYSIS CABLE (NEW)</td>
<td>0.28.Try 181</td>
<td>HARD DRAWN COPPER</td>
<td>37/2.5mm</td>
<td>17.5</td>
<td>RAIL OVERHEAD Catenary CONDUCTOR</td>
</tr>
<tr>
<td>TROLLEY WIRE</td>
<td>0.126.Try 81</td>
<td>CADMIUM COPPER</td>
<td>SOLID SOLID</td>
<td>10.76</td>
<td>TO DRG. 06887</td>
</tr>
<tr>
<td>TROLLEY WIRE</td>
<td>0.2.Try 129</td>
<td>COPPER TIN BEARING</td>
<td>SOLID SOLID</td>
<td>13.46</td>
<td>TO DRG. 06887 &amp; SPEC/DOH/01/91</td>
</tr>
<tr>
<td>AERIAL SWITCH AND BOLTED CONNECTION CABLE</td>
<td>0.6.Try 400 EQV</td>
<td>ANNEALED COPPER</td>
<td>61/2.85mm</td>
<td>35</td>
<td>PVC/RED/PVC BLACK 0.6/1kV INSUL</td>
</tr>
<tr>
<td>FEEDER TAP TO TROLLEY CABLE</td>
<td>0.3.Try 185</td>
<td>ANNEALED COPPER</td>
<td>2550/0.2m m</td>
<td>31.6</td>
<td>UV RESIST. RUBBER 0.6/1kV DOUBLE INSUL. GREY OR BLACK</td>
</tr>
<tr>
<td>EQUALIZER CABLE</td>
<td>0.3.Try 185</td>
<td>ANNEALED COPPER</td>
<td>2550/0.2m m</td>
<td>31.6</td>
<td>UV RESIST. RUBBER 0.6/1kV DOUBLE INSUL. GREY OR BLACK</td>
</tr>
<tr>
<td>UNDERGROUND ELECTROLYSIS FEEDER</td>
<td>120.Try 185</td>
<td>ANNEALED COPPER</td>
<td>37/2.03mm</td>
<td>20.4</td>
<td>PVC/PVC 0.6/1kV</td>
</tr>
<tr>
<td>ELECTROLYSIS POTENTIAL LEADS</td>
<td>2.5.Try 185</td>
<td>ANNEALED COPPER</td>
<td>71/0.067m m</td>
<td>10</td>
<td>2 CORE PVC/PVC 0.6/1kV</td>
</tr>
<tr>
<td>UNDERGROUND SCREENED FEEDER CABLE</td>
<td>0.6.Try 400EQV</td>
<td>ANNEALED COPPER</td>
<td>61/2.85mm</td>
<td>39</td>
<td>1 CORE, XLPE INSUL 37 WIRE SCREEN, PVC SHEATH</td>
</tr>
<tr>
<td>SUPERVISING CABLE</td>
<td>0.64.Try 185</td>
<td>ANNEALED COPPER</td>
<td>10 PAIR (0.9mm)</td>
<td>15.5</td>
<td>POLYETHYLENE ALUMINIUM FOIL SCREENED WITH GALV. BEARER WIRE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20 PAIR (0.9mm) 21.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30 PAIR (0.9mm) 25.6</td>
</tr>
</tbody>
</table>
TABLE C  TEMPERATURE - SAG - TENSION

FOR CADMIUM COPPER TROLLEY WIRE - 129 sq.mm. 10kN Max. TENSION

<table>
<thead>
<tr>
<th>WIRE TEMPERATURE Degrees C</th>
<th>15 m SPAN SAG mm</th>
<th>15 m SPAN TENSION kN</th>
<th>20 m SPAN SAG mm</th>
<th>20 m SPAN TENSION kN</th>
<th>25 m SPAN SAG mm</th>
<th>25 m SPAN TENSION kN</th>
<th>30 m SPAN SAG mm</th>
<th>30 m SPAN TENSION kN</th>
<th>35 m SPAN SAG mm</th>
<th>35 m SPAN TENSION kN</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>10.0</td>
<td>56</td>
<td>10.0</td>
<td>88</td>
<td>10.0</td>
<td>127</td>
<td>10.0</td>
<td>172</td>
<td>10.0</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>8.7</td>
<td>64</td>
<td>8.8</td>
<td>100</td>
<td>8.8</td>
<td>143</td>
<td>8.9</td>
<td>193</td>
<td>8.9</td>
</tr>
<tr>
<td>10</td>
<td>42</td>
<td>7.5</td>
<td>75</td>
<td>7.6</td>
<td>115</td>
<td>7.7</td>
<td>163</td>
<td>7.8</td>
<td>218</td>
<td>7.9</td>
</tr>
<tr>
<td>15</td>
<td>51</td>
<td>6.3</td>
<td>88</td>
<td>6.4</td>
<td>133</td>
<td>6.6</td>
<td>186</td>
<td>6.8</td>
<td>246</td>
<td>7.0</td>
</tr>
<tr>
<td>20</td>
<td>62</td>
<td>5.1</td>
<td>104</td>
<td>5.4</td>
<td>154</td>
<td>5.7</td>
<td>212</td>
<td>6.0</td>
<td>277</td>
<td>6.2</td>
</tr>
<tr>
<td>25</td>
<td>76</td>
<td>4.2</td>
<td>124</td>
<td>4.6</td>
<td>179</td>
<td>4.9</td>
<td>242</td>
<td>5.3</td>
<td>310</td>
<td>5.6</td>
</tr>
<tr>
<td>30</td>
<td>94</td>
<td>3.4</td>
<td>147</td>
<td>3.8</td>
<td>206</td>
<td>4.3</td>
<td>273</td>
<td>4.7</td>
<td>345</td>
<td>5.0</td>
</tr>
<tr>
<td>35</td>
<td>113</td>
<td>2.8</td>
<td>171</td>
<td>3.3</td>
<td>234</td>
<td>3.8</td>
<td>304</td>
<td>4.2</td>
<td>380</td>
<td>4.5</td>
</tr>
<tr>
<td>40</td>
<td>133</td>
<td>2.4</td>
<td>195</td>
<td>2.9</td>
<td>262</td>
<td>3.4</td>
<td>336</td>
<td>3.8</td>
<td>416</td>
<td>4.2</td>
</tr>
<tr>
<td>45</td>
<td>153</td>
<td>2.1</td>
<td>219</td>
<td>2.6</td>
<td>290</td>
<td>3.0</td>
<td>367</td>
<td>3.5</td>
<td>450</td>
<td>3.8</td>
</tr>
<tr>
<td>50</td>
<td>171</td>
<td>1.9</td>
<td>241</td>
<td>2.3</td>
<td>417</td>
<td>2.8</td>
<td>397</td>
<td>3.2</td>
<td>484</td>
<td>3.6</td>
</tr>
</tbody>
</table>
### TABLE D  OFFSET OF TROLLEY WIRE AND CENTRE SPAN DISTANCE

<table>
<thead>
<tr>
<th>RADIUS OF CURVE</th>
<th>OFFSET OF TROLLEY WIRE</th>
<th>DISTANCE BETWEEN CENTRE SPANS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ft</td>
<td>in</td>
</tr>
<tr>
<td>50</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>60</td>
<td>18</td>
<td>7.5</td>
</tr>
<tr>
<td>70</td>
<td>21</td>
<td>6.25</td>
</tr>
<tr>
<td>80</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>90</td>
<td>27</td>
<td>4.5</td>
</tr>
<tr>
<td>100</td>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>125</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>150</td>
<td>46</td>
<td>2.375</td>
</tr>
<tr>
<td>200-300</td>
<td>60-90</td>
<td>1.5-0.75</td>
</tr>
<tr>
<td>300-400</td>
<td>90-120</td>
<td>0.75-0.25</td>
</tr>
<tr>
<td>500</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>750</td>
<td>230</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>305</td>
<td>0</td>
</tr>
<tr>
<td>1500-2000</td>
<td>460-610</td>
<td>0</td>
</tr>
<tr>
<td>OVER 2000</td>
<td>OVER 610</td>
<td>0</td>
</tr>
</tbody>
</table>

**NOTE:**

i) Trolley wire Offset is towards the centre of curve.

ii) Equivalent conversions have been rationalised.
<table>
<thead>
<tr>
<th>TITLE</th>
<th>DRAWING NO.</th>
<th>REVISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLEVIS THIMBLE DETAILS</td>
<td>D 3121</td>
<td>C</td>
</tr>
<tr>
<td>INSULATOR POLYMERIC, TENSION (REBOSIO TYPE)</td>
<td>D 3677</td>
<td></td>
</tr>
<tr>
<td>DISC INSULATOR 200mm DIAMETER (GLASS)</td>
<td>D 3771</td>
<td></td>
</tr>
<tr>
<td>STRUT INSULATOR POLYMERIC</td>
<td>D 3773</td>
<td></td>
</tr>
<tr>
<td>BULL RINGS COMPONENT, STYLE VARIABLE</td>
<td>D 3885</td>
<td>A</td>
</tr>
<tr>
<td>'U' - BOLTS COMPONENTS, STYLE VARIABLE</td>
<td>D 3933</td>
<td>A</td>
</tr>
<tr>
<td>PARAFIL ROPE TERMINATION FITTINGS</td>
<td>D 4464</td>
<td></td>
</tr>
<tr>
<td>PARAFIL ROPE COMPONENT, STYLE VARIABLE</td>
<td>D 4465</td>
<td></td>
</tr>
<tr>
<td>2 TONNE PARAFIL TIE WITH CLEVIS TERMINATION FITTING ASSEMBLY, LENGTH VARIABLE</td>
<td>D 4466</td>
<td></td>
</tr>
<tr>
<td>ANCHOR CROSS ARM FOR (4) FEEDER CABLES ON CIRCULAR POLES COMPONENT, NON-VARIABLE</td>
<td>D 4938</td>
<td>A</td>
</tr>
<tr>
<td>ANCHOR CROSS ARM FOR (2) FEEDER CABLES ON CIRCULAR POLES COMPONENT, NON-VARIABLE</td>
<td>D 4950</td>
<td></td>
</tr>
<tr>
<td>BOOM CONNECTOR BRACKET CASTING, COMPONENT, NON-VARIABLE</td>
<td>D 4953</td>
<td>A</td>
</tr>
<tr>
<td>SINGLE PIVOT TYPE CANTILEVER ARM BRACKET ASSEMBLY, DIAMETER VARIABLE</td>
<td>D 5075</td>
<td>B</td>
</tr>
<tr>
<td>BACK TO BACK PIVOT TYPE CANTILEVER ARM BRACKET ASSEMBLY, DIAMETER VARIABLE</td>
<td>D 5076</td>
<td>B</td>
</tr>
<tr>
<td>POLE TO TRACK BONDING</td>
<td>E14-555</td>
<td>A</td>
</tr>
<tr>
<td>BOOM TUBE O.D. 60.3, WALL 5.4 COMPONENT, LENGTH VARIABLE</td>
<td>F 12075</td>
<td>H</td>
</tr>
<tr>
<td>FEEDER TAP TERMINAL CLAMP TO POLE</td>
<td>O 792</td>
<td>H</td>
</tr>
<tr>
<td>ANCHORING BANDS</td>
<td>O 923</td>
<td>B</td>
</tr>
<tr>
<td>TROLLEY WIRE CROSS SECTIONS</td>
<td>O 6887</td>
<td>D</td>
</tr>
<tr>
<td>129sq.mm./81sq.mm.</td>
<td>O 6897</td>
<td>B</td>
</tr>
<tr>
<td>POLE BANDS</td>
<td>O 7364</td>
<td>E</td>
</tr>
<tr>
<td>5&quot; REEL INSULATOR &amp; SHACKLE FOR SPANS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TITLE</td>
<td>DRAWING NO.</td>
<td>REVISION</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>DOUBLE ANCHOR BAR</td>
<td>O 7466</td>
<td>A</td>
</tr>
<tr>
<td>&quot;U&quot; BAND (FOR CROSS ARM)</td>
<td>O 9653</td>
<td>C</td>
</tr>
<tr>
<td>0.126 SECTION INSULATOR FOR USE WITH CARBON INSERT COLLECTOR SHOE - GENERAL ARRANGEMENT</td>
<td>O12-332</td>
<td>D</td>
</tr>
<tr>
<td>0.2 SECTION INSULATOR GENERAL ARRANGEMENT</td>
<td>O12-354</td>
<td>B</td>
</tr>
<tr>
<td>CROSS ARM BRACE - 2 FEEDER ARM</td>
<td>O13-195</td>
<td></td>
</tr>
<tr>
<td>CROSS ARM BRACE - 4 FEEDER ARM</td>
<td>O13-196</td>
<td></td>
</tr>
<tr>
<td>OVERHEAD DISC SIGN</td>
<td>O13-446</td>
<td>A</td>
</tr>
<tr>
<td>0.2 &amp; 0.126 COMBINATION SECTION INSULATOR FOR CARBON INSERT COLLECTOR SHOE GENERAL ARRANGEMENT</td>
<td>O13-356</td>
<td>D</td>
</tr>
<tr>
<td>POLE BAND, CROSS ARM BRACE</td>
<td>O13-490</td>
<td></td>
</tr>
<tr>
<td>LIMITS FOR DECORATIONS TRAMWAY POLES &amp; SPAN WIRES</td>
<td>O13-625</td>
<td>B</td>
</tr>
<tr>
<td>HANGER (FOR LINE EAR)</td>
<td>O13-983</td>
<td>F</td>
</tr>
<tr>
<td>STRAIGHT CROSS SPAN ASSEMBLY IN STEEL FROM POLE TO POLE</td>
<td>O14-292</td>
<td></td>
</tr>
<tr>
<td>STRAIGHT CROSS SPAN ASSEMBLY IN STEEL FROM WALL TO POLE</td>
<td>O14-293</td>
<td></td>
</tr>
<tr>
<td>STRAIGHT CROSS SPAN ASSEMBLY IN STEEL FROM WALL TO WALL</td>
<td>O14-294</td>
<td></td>
</tr>
<tr>
<td>OVERHEAD WIRING - TYPICAL ANCHORING - LAYOUT DETAILS FOR CROSS OVER</td>
<td>O14-304</td>
<td>B</td>
</tr>
<tr>
<td>SECTION INSULATOR ASSEMBLY CROSS SPAN FROM POLE TO POLE</td>
<td>O14-305</td>
<td></td>
</tr>
<tr>
<td>SECTION INSULATOR ASSEMBLY CROSS SPAN FROM WALL TO POLE</td>
<td>O14-306</td>
<td></td>
</tr>
<tr>
<td>SECTION INSULATOR ASSEMBLY CROSS SPAN FROM WALL TO WALL</td>
<td>O14-307</td>
<td></td>
</tr>
<tr>
<td>GENERAL ARRANGEMENT FEEDER TAP TO TROLLEY</td>
<td>O14-309</td>
<td></td>
</tr>
<tr>
<td>TROLLEY WIRE CURRENT EQUALIZER</td>
<td>O14-310</td>
<td></td>
</tr>
<tr>
<td>TITLE</td>
<td>DRAWING NO.</td>
<td>REVISION</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>AERIAL SWITCH OPERATING MECHANISM &amp; SURGE DIVERTER MOUNTING</td>
<td>O14-312</td>
<td></td>
</tr>
<tr>
<td>SURGE DIVERTER MOUNTING BRACKET</td>
<td>O14-314</td>
<td>A</td>
</tr>
<tr>
<td>OVERHEAD WIRING CURVE NETWORK</td>
<td>O14-315</td>
<td></td>
</tr>
<tr>
<td>CENTRALLY MOUNTED SPAN &amp; LIGHTING POLE 8kN/14m</td>
<td>O14-339</td>
<td>E</td>
</tr>
<tr>
<td>ANCHOR POLE WITH DUAL CANTILEVER ARM CAPACITY 17kN/14m</td>
<td>O14-346</td>
<td>E</td>
</tr>
<tr>
<td>STEEL SPAN POLE 6.5kN/11m</td>
<td>O14-349</td>
<td>E</td>
</tr>
<tr>
<td>STEEL ANCHOR POLE 12kN/11m</td>
<td>O14-350</td>
<td>E</td>
</tr>
<tr>
<td>FROG ERECTION DETAIL</td>
<td>O14-405</td>
<td></td>
</tr>
<tr>
<td>DUAL RUNNING TROLLEY WIRE TENSIONER</td>
<td>O14-406</td>
<td>B</td>
</tr>
<tr>
<td>2 FEEDER WOODEN CROSS ARMS</td>
<td>O14-427</td>
<td>B</td>
</tr>
<tr>
<td>4 FEEDER WOODEN CROSS ARMS</td>
<td>O14-428</td>
<td>B</td>
</tr>
<tr>
<td>SINGLE PENDULUM TROLLEY WIRE SUPPORT ASSEMBLY. STYLE VARIABLE</td>
<td>O14-500</td>
<td>B</td>
</tr>
<tr>
<td>SINGLE TRACK CANTILEVER SINGLE PENDULUM T.W. SUPPORT ASSEMBLY. STYLE VARIABLE</td>
<td>O14-531</td>
<td>B</td>
</tr>
<tr>
<td>KUMMLER &amp; MATTER SINGLE PENDULUM FITTINGS</td>
<td>O14-532</td>
<td>A</td>
</tr>
<tr>
<td>BACK-TO-BACK SINGLE TRACK CANTILEVERS SINGLE PENDULUM T.W. SUPPORT ASSEMBLY. STYLE VARIABLE</td>
<td>O14-545</td>
<td>A</td>
</tr>
<tr>
<td>STANDARD COMBINED TROLLEY WIRE BOOM TUBE ANCHORING</td>
<td>O14-546</td>
<td>A</td>
</tr>
<tr>
<td>BOOM CLAMP FOR 60.3 DIA. BOOM TUBE</td>
<td>O14-547</td>
<td></td>
</tr>
<tr>
<td>CURRENT EQUALIZER INSTALLATION ON BACK-TO-BACK CANTILEVER ASSEMBLY</td>
<td>O14-548</td>
<td>A</td>
</tr>
<tr>
<td>TAP TO TROLLEY INSTALLATION ON BACK TO BACK CANTILEVER ASSEMBLY</td>
<td>O14-549</td>
<td>A</td>
</tr>
<tr>
<td>SECTION INSULATOR SUPPORT ASSEMBLY ON BOOM TUBE</td>
<td>O14-550</td>
<td></td>
</tr>
<tr>
<td>CROSS CONTACT BAR - TYPE 1 ASSEMBLY</td>
<td>O14-572</td>
<td></td>
</tr>
<tr>
<td>STANDARD SINGLE TROLLEY WIRE TERMINATION</td>
<td>O14-579</td>
<td>A</td>
</tr>
<tr>
<td>TITLE</td>
<td>DRAWING NO.</td>
<td>REVISION</td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>STANDARD SINGLE TROLLEY WIRE TERMINATION V-PULL</td>
<td>O14-580</td>
<td>A</td>
</tr>
<tr>
<td>STANDARD DUAL TROLLEY WIRE TERMINATION</td>
<td>O14-581</td>
<td>A</td>
</tr>
<tr>
<td>TROLLEY WIRE ANCHOR - LOW TENSION</td>
<td>O14-599</td>
<td>A</td>
</tr>
<tr>
<td>FEEDER TAP TO TROLLEY WIRE CABLE SUPPORT ON INDEPENDENT PARAFIL CROSS SPAN</td>
<td>O14-605</td>
<td></td>
</tr>
<tr>
<td>CURRENT EQUALISER CABLE SUPPORT ON INDEPENDENT PARAFIL CROSS SPAN</td>
<td>O14-606</td>
<td></td>
</tr>
<tr>
<td>2 FEEDER WOODEN CROSS ARMS FOR TURNING INSULATORS</td>
<td>O14-673</td>
<td>A</td>
</tr>
<tr>
<td>4 FEEDER WOODEN CROSS ARMS FOR TURNING INSULATORS</td>
<td>O14-674</td>
<td>A</td>
</tr>
<tr>
<td>ANCHOR CROSS ARM 4 FEEDER CABLES FOR USE ON CIRCULAR POLES ASSEMBLY, STYLE VARIABLE</td>
<td>Q 4135</td>
<td></td>
</tr>
<tr>
<td>MINIMUM CLEARANCES TO STRUCTURES FOR TRAMWAYS</td>
<td>P15556</td>
<td></td>
</tr>
</tbody>
</table>
ATTACHMENT 'A' GENERAL CONDITIONS GOVERNING ATTACHMENTS TO THE CORPORATION'S POLES AND AERIAL CROSSINGS OF THE TRAMWAY OVERHEAD NETWORK.
ATTACHMENT 'B' CONDITIONS CONTROLLING THE ERECTION OF DECORATIONS AND/OR ILLUMINATIONS ON THE CORPORATION'S TRAMWAY OVERHEAD POLES AND EQUIPMENT.
ATTACHMENT 'C' TROLLEY WIRE STAGGER - DIAGRAMMATIC REPRESENTATION.

TROLLEY WIRE STAGGER
DIAGRAMMATIC REPRESENTATION ONLY