1. SCOPE

This document provides information and guidance on the application of polymeric cables on the PowerSystems 11kV network. It is produced to support the change within PowerSystems to the use of both three core and single core polymeric cables.

The rationale for the change is outlined in CAB-05-019 'Recommendation for Change from Paper Insulated to Polymeric Insulated Cable at 11kV'.

Throughout this document, references to 11kV shall by inference also relate to 6kV and 6.6kV networks and equipment.

2. ISSUE RECORD

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Issue Date	Issue No	Author	Amendment Details
Aug 2003	1	D.W. Naylor	New Issue
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3. ISSUE AUTHORITY

Author	Owner	Issue Authority
David Naylor Senior Project Eng, Engineering Support	Alastair Ferguson Section Head, Engineering Support	Alastair Ferguson Section Head, Engineering Support .....

4. REVIEW

This document shall be subject to review as more of the technical details are finalised, and as required by changes in policy or technology.

5. CONTENTS

6. DETAILS RELATING TO THE MIGRATION TO POLYMERIC CABLES

These notes indicate the situation as it stands at 1st November 2003. This document will require frequent updating and revision.

Within PowerSystems and Core (for work in the PowerSystems areas) the migration to using polymeric cable commenced in October 2003. PICAS will continue to be available in reducing quantities. Where it is possible to use polymeric cables on a project or fault – they must be used.

At the time of writing, cables have been selected and approved, and switchgear terminations, overhead terminations and three core and single core joints and trifurcating joints (for jointing 3 core cables to single core cables) have been developed and are available on stock.

Most SP jointers, CORE jointers and some contractors have been trained on the new techniques and materials.

To coincide with the migration, most types of switchgear will start to be available with gland plates and other modifications required suiting single core cables. Spare three core gland plates are being purchased to ensure that any initial complications can be minimised. Power Systems South X type development is now complete. This document contains detailed information on changes to switchgear.

Cable connected transformers are still only available suitable for 3 core PICAS cable. Development of suitable transformer cable box terminations and earthing for single core cables is nearing completion. This applies both to the short box and long box versions. Therefore until further notice, in PS South, X type substations shall continue to use 3 core PICAS. Indoor Y type substation shall use single core polymeric cables for the ring switch connections and PICAS for the transformer loop.

Both polymeric cables and PICAS exist in the PowerSystems Approved Equipment Registers. Third party connectors will need to be advised at the initial contact stage that it is now PowerSystems preferred policy to use polymeric cable and single core switchgear and transformer terminations.

Spiking guns will require modification to spike polymeric cables. This is due to the insulation gripping the spike so tightly that the spike cannot easily be removed from the cable. Instructions on the approved supplier of the modification will be released by Engineering Support during November 2003.

7. POLICY

PowerSystems policy is for the exclusive use of polymeric cables in new construction, diversion and repair works. Single core and three core polymeric cables shall be used in accordance with the policies outlined in this section. Connections to legacy switchgear and transformers may require different approaches – these are dealt with in later sections. During the phase of migration to polymeric cables certain current switchgear applications will require alternative approaches which are outlined in the appropriate section of this document.

Terminations onto switchgear and transformers shall use single core polymeric cables.

Main cable runs shall be laid using three core polymeric cables. This includes sections of cable inserted into existing lengths of pilc or picas cable for reasons such as fault repair or cable route deviation.

The transition between single core polymeric and three core cables shall be achieved by the use of trifurcating joints. These joints will also enable correct cable phasing to be achieved at switchgear and transformer terminations.

Terminations onto overhead lines shall normally be three core polymeric. Single core overhead terminations are also permitted in accordance with the requirements of the next paragraph.

To avoid using two joints (a trifurcating joint and a straight joint) in close proximity on a short length of cable, **in the following situations only** it is permissible to lay three single core cables for the entire length of a cable connection:

- cable less than 25m length between switchgear and overhead line
- cable less than 25m length between transformer and overhead line
- cable less than 25m length between switchgear and switchgear
- cable less than 25m length between switchgear and transformer
- cable less than 25m length between switchgear and cable section
- cable less than 25m length between cable section and overhead line

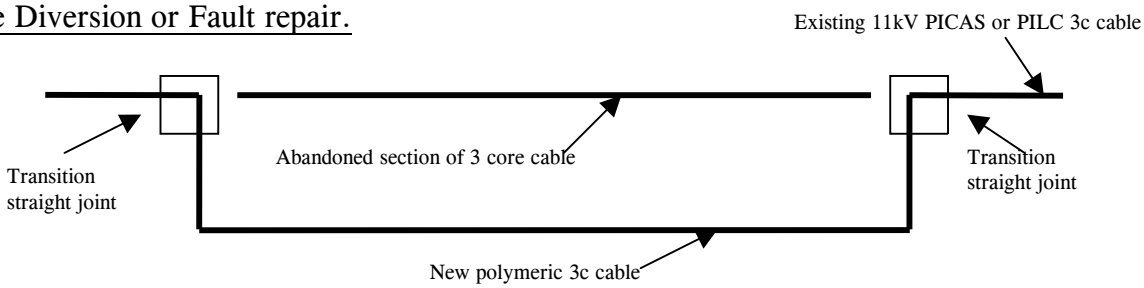
It should be noted that the 25m rule ***does not apply*** to 11kV single core runs between a Primary Transformer and the associated 11kV switchboard because it is not uncommon for these to be in excess of 25m. The earthing arrangements are also different.

In all other situations, three-core cable shall be laid for the majority of the cable route connection with short lengths of single core cables being used for terminations as defined in the paragraphs above.

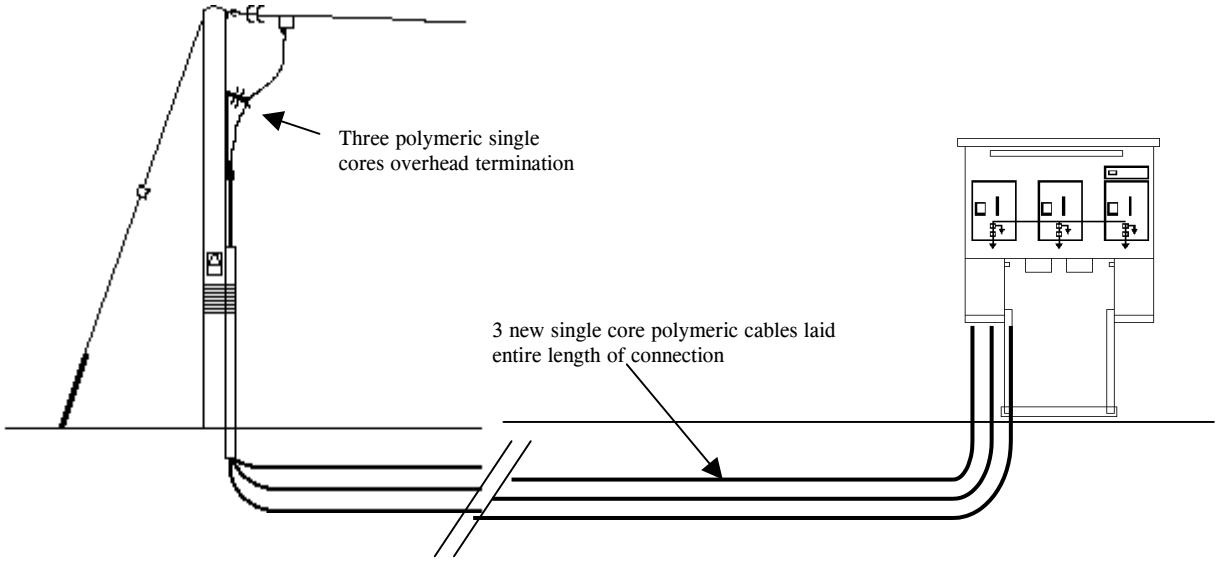
When laying single core cables, three cables shall always be laid – even if the application is only planned to be single phase.

Examples of certain applications of this policy are shown on the following pages.

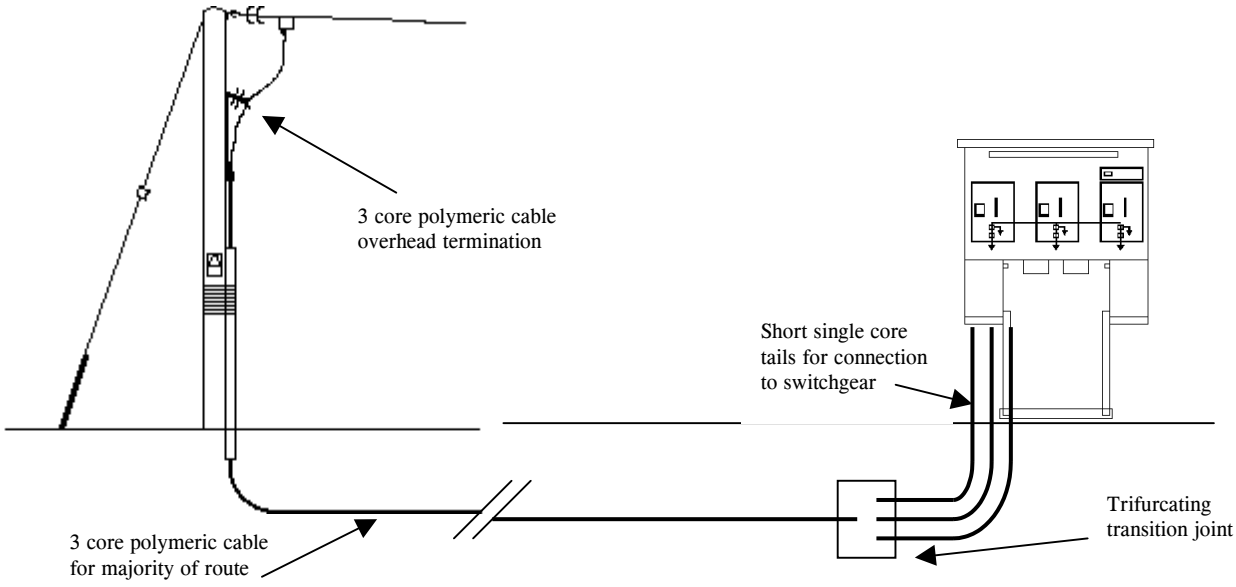
Cable Diversion or Fault repair.



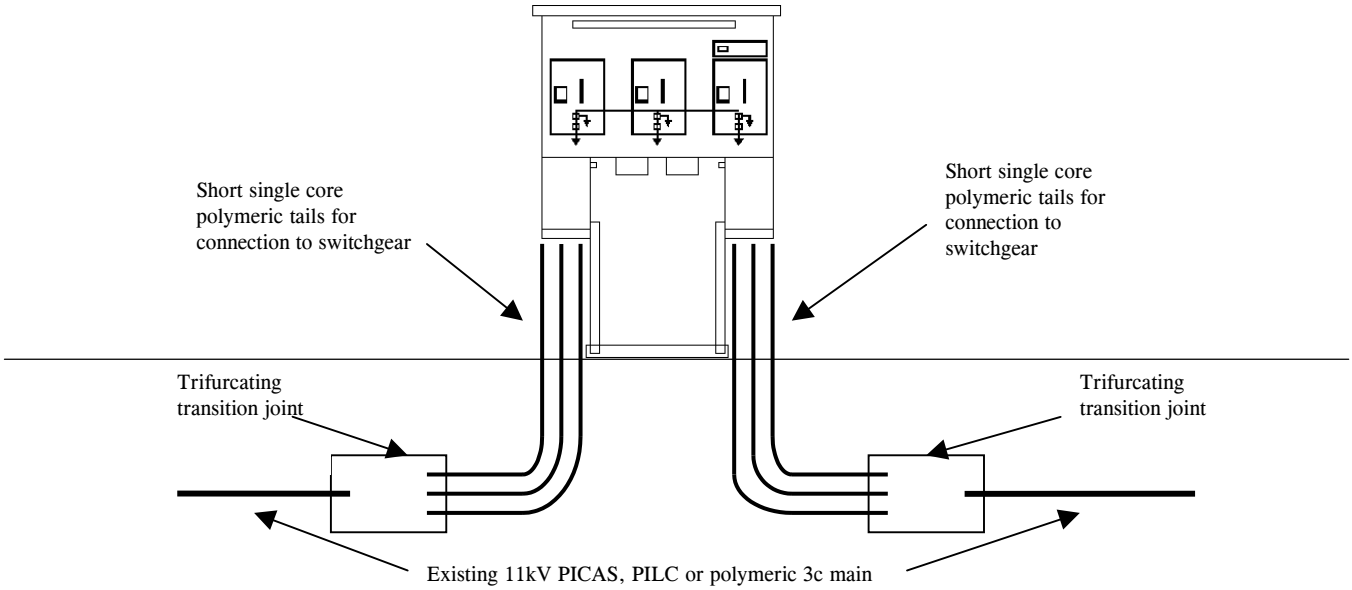
Cable connection between overhead line and switchgear **(less than 25m length).**



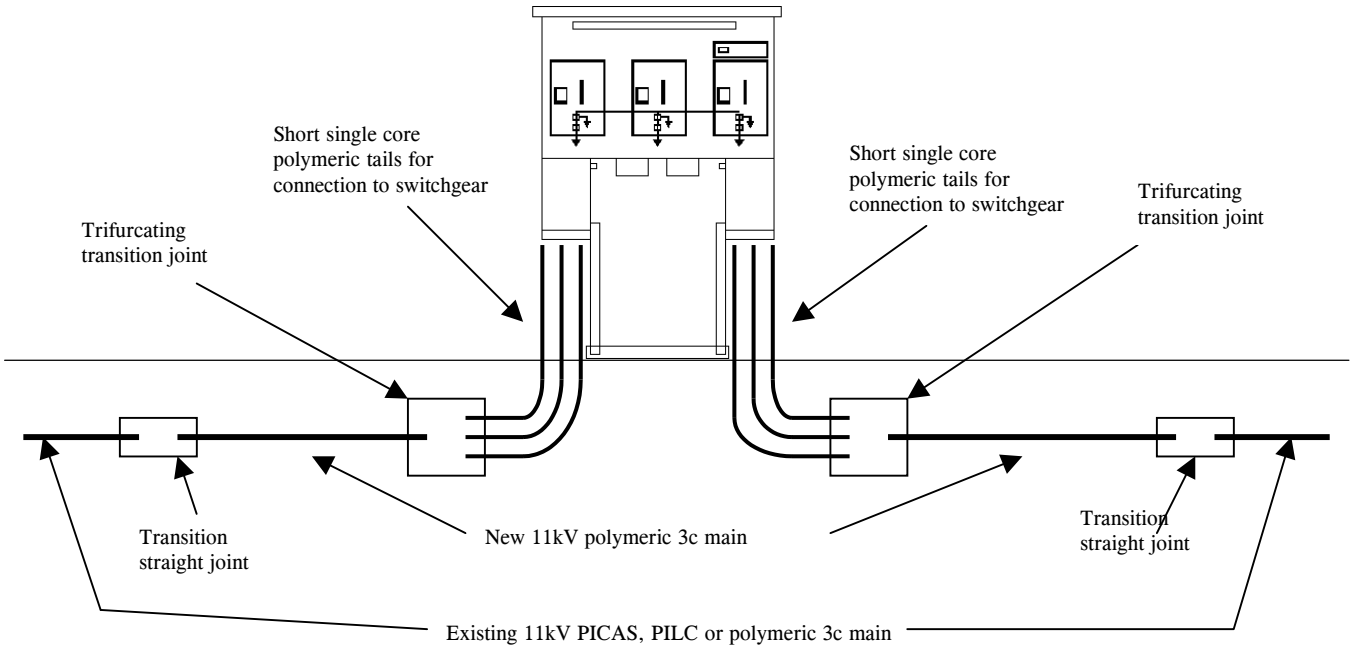
Cable connection between overhead line and switchgear **(greater than 25m length).**



New Substation to be connected **(less than 25m from existing main)**.



New Substation to be connected **(more than 25m from existing main).**



8. COMPONENTS AND COMMODITY CODES

Cable	
95mm^2 1 core xlpe cable	C09550955
185mm^2 1 core xlpe cable	C09550956
300mm^2 1 core xlpe cable	C09550957
95mm^2 3 core xlpe cable	C09463200
185mm^2 3 core xlpe cable	C09463201
300mm^2 3 core xlpe cable	C09463202
Cable terminations (each including compression lug)	
95mm^2 coldshrink switchgear termination for xlpe singles	C12051506
185mm^2 coldshrink switchgear termination for xlpe singles	C12051507
300mm^2 coldshrink switchgear termination for xlpe singles	C12051508
Transformer elbow connectors	C12051634
95mm Outdoor Termination for 3-core c/w compression lugs	C12051621
185mm Outdoor Termination for 3-core c/w compression lugs	C12051622
300mm Outdoor Termination for 3-core c/w compression lugs	C12051623
95mm Outdoor Termination for 1-core c/w compression lugs	C12051625
185mm Outdoor Termination for 1-core c/w compression lugs	C12051626
300mm Outdoor Termination for 1-core c/w compression lugs	C12051627
Polymeric to Polymeric Joints	
Straight joint up to 185mm c/w mechanical connectors	C12051600
Breech Joint up to 185mm c/w mechanical connectors	C12051601
Stop End up to 185mm c/w mechanical connector	C12051602
Loop Joint up to 185mm c/w mechanical connectors	C12051603
Straight joint up to 300mm c/w mechanical connectors	C12051604
Breech Joint up to 300mm c/w mechanical connectors	C12051605
Stop End up to 300mm c/w mechanical connectors	C12051606
Loop Joint up to 300mm c/w mechanical connectors	C12051607
Screen Termination Kit	C12051640
Trif. Joint 3-core poly to 3 x 1-core poly up to 185mm c/w mechanical connectors	C12051608
Trif. Joint 3-core poly to 3 x 1-core poly up to 300mm c/w mechanical connectors	C12051609
Polymeric – PILC/PICAS Transition Joints	
Trif joint 3 core PILC/PICAS to 3 x 1c poly up to 95mm c/w mechanical connectors	C12051628
Trif joint 3 core PILC/PICAS to 3 x 1c poly up to 185mm c/w mechanical connectors	C12051610
Trif joint 3 core PILC/PICAS to 3 x 1c poly up to 300mm c/w mechanical connectors	C12051613
Build up kit for small conductors	C12051650
Earthing Kit for 50mm² to 95mm² 11kV PILC cable	C12051619
Earthing Kit for 120mm² to 300mm² 11kV PILC cable	C12051620
Earthing Kit for 95mm² 11kV PICAS cable	C12051617
Earthing Kit for 120mm² to 300mm² 11kV PICAS cable	C12051618
Straight joint up to 185mm c/w mechanical connectors	C12051610
Breech Joint up to 185mm c/w mechanical connectors	C12051611
Loop Joint up to 185mm c/w mechanical connectors	C12051612
Straight joint up to 300mm c/w mechanical connectors	C12051613
Breech Joint up to 300mm c/w mechanical connectors	C12051614
Loop Joint up to 300mm c/w mechanical connectors	C12051615

Tools	Commodity Code
MDPE Sheath Stripper – KMS type	C26252100
PG3 stripping pliers 2.8mm cutting wheels – 30 –55mm dia cables	C26252101
Spare Blade for PG pliers – circular cut – Blade 20C	C26252103
Spare Blade for PG pliers – Longitudinal cut – Blade 20L	C26252104
Fully bonded screen stripping tool FBS 1714-1 10 – 50mm dia cables	C26253000
Spare Blade - Fully bonded screen stripping tool FBS 1714-1 10 – 50mm dia cables	C26253001
Adjustable screen scoring tool LHM1R – 14 – 40mm dia cables	C26253002
Spare Blade - Adjustable screen scoring tool LHM1R – 14 – 40mm dia cables	C26253003
Adjustable insulation stripping tool - BRMrd 1 14 – 40mm	C26253004
Spare Blade - Adjustable insulation stripping tool - BRMrd 1 14 – 40mm	C26253005
EP1 Compression Tool (aluminium single core XLPE terminations)	C26253006
Die 18 ALU19 (95mm^2 solid aluminium cable)	C26253007
Die 25 ALU19 (185mm^2 solid aluminium cable)	C26253008
Die 32 ALU19 (300mm^2 solid aluminium cable)	C26253009
Miscellaneous Items	
CES4 Heat Shrink Gland	C12050970

9. CABLE CHARACTERISTICS

9.1 Cable Ratings

9.1.1 Three Core 11kV XLPE

Conductor CSA mm^2	Cyclic Rating Factor	Cable Rating (Amps)			
		Laid Direct		Ducted	
		Continuous	Cyclic	Continuous	Cyclic
95	1.11	235	261	200	222
185	1.12	335	375	290	325
300	1.12	435	487	380	426

9.1.2 One Core 11kV XLPE

Conductor CSA mm^2	Cyclic Rating Factor	Cable Rating (Amps)			
		Laid Direct		Ducted	
		Continuous	Cyclic	Continuous	Cyclic
95	1.11	245	272	208	231
185	1.12	353	395	300	336
300	1.12	461	516	392	439

* Ratings are based on the following conditions (single core cables laid in trefoil and bonded at both ends)	
Depth of cover (m)	0.6
Ambient ground temperature (°C)	15
Soil thermal resistivity (°Km/W)	1.2

** Ratings are based on the following conditions (single core cables laid in trefoil and bonded at both ends)	
No. Of Cables	Derating Factor
1	1
2	0.89
3	0.8
4	0.77

** Based on spacing between cables = 300mm

9.2 Cable Impedance

9.2.1 Three Core 11kV XLPE

Cable Impedance Ohms/km			Capacitance (uF/km)
Max DC resistance per phase @ 20°C	Max AC resistance per phase @ 65° C & 50Hz	Reactance @ 50Hz	
0.320	0.408	0.099	0.310
0.164	0.210	0.088	0.420
0.100	0.129	0.082	0.480

9.2.2 One Core 11kV XLPE

Cable Impedance Ohms/km			Capacitance (uF/km)
Max DC resistance per phase @ 20°C	Max AC resistance per phase @ 65° C & 50Hz	Reactance @ 50Hz	
0.320	0.413	0.110	0.290
0.164	0.215	0.086	0.370
0.100	0.133	0.071	0.450

10. PHOTOGRAPHS

The photos below show a selection of polymeric cables, joints and terminations.

3 core polymeric to polymeric straight joint

3 CORE POLYMERIC TO 3 SINGLE CORE TRIFURCATING JOINT

3 core overhead termination

single core switchgear termination

11. INSTALLATION PARAMETERS

	Single core polymeric cables			Three core polymeric cables		
	95mm^2	185mm^2	300mm^2	95mm^2	185mm^2	300mm^2
Maximum pulling tension (kN)	2.85	5.55	9.0	3.91	6.36	9.79
Minimum bending radius (mm) **dynamic** *i.e. during pulling-in*	560	650	750	600	750	900
Minimum bending radius (mm) **static** *i.e. bent in situ adjacent to joints or terminations*	420	490	560	500	600	750

The minimum installation temperature for all polymeric cable is -10°C.

When laying more than one circuit in the same trench single the cables shall be laid with 300mm separation to avoid de-rating effects. If the circuits are closer than 300mm then careful consideration will be required to determine whether a larger cross section conductor will be required to offset the de-rating effect of closer conductors.

As defined in the previous section the policy is to use only short lengths of single core cables for short connections, between terminals or between terminals and existing three core mains. There are some particular installation requirements relating to polymeric cables which at present are not included in the specification 'Handling and Installation of Cables up to and Including 33kV' CAB-15-003 (formerly known as LC2).

Drum lengths will in general be a standard 250m whether the drum contains three core or single core cable. The cable will be marked at 1m intervals to indicate the length of cable left on the drum.

There is a variation in the terms of the contract that allows drum lengths of more than 250m to accommodate situations where intermediate cable joints are not reasonably practicable. Should drum lengths of more than 250m be required then these should be ordered through procurement at an early date.

Marking of Cores for Correct Connection to Switchgear

It is vital that single core cables are correctly marked when installing cables into a substation. For example when connecting three circuits to a ring main unit there will be nine identical single core cables. Care shall be taken to mark the three cables associated with each particular circuit to ensure that all the cables are terminated onto the correct set of terminals. Further marking will be required to identify the correct phase within each set of three single cores.

Three core cables have core numbers printed on the outer screen.

There have been situations in other DNOs that use single core cables where switchgear has been terminated with two phases of one circuit and one phase of another circuit connected to the same terminals.

Configuration

Where single core 11kV cables are laid direct in the ground to form one three phase circuit they shall be laid in touching trefoil. They shall be bound together using nylon cable ties at intervals of one metre. The nylon cable ties shall have a smooth internal surface and have a minimum loop tensile strength of 54kg.

Single core cables shall, wherever practicable be arranged neatly in close trefoil and bound with cable ties at intervals of one metre. When approaching terminations, the cores must remain in close trefoil for as long as possible, keeping the splayed length to the minimum that practical considerations will permit, having paid particular regard to minimum bending radii.

Ducted installations

The outside diameter of three core polymeric cables is approximately 5% larger than 3 core PICAS cables. Three single core cables in trefoil are a further 5% larger in diameter than the equivalent 3 core polymeric cable. 95mm^2 and 185mm^2 cables (both three single core and 3 core) will still fit in 100mm ducts. Note that three 300mm^2 single cores are unlikely to fit in a 100mm duct due to the minimal clearance available – a 150mm duct shall be used.

Where single core 11kV cables are to be installed in ducts to form one three phase circuit, it is acceptable to install all three cores in a single 100mm or 150mm duct. This is only permissible because of the policy of using only short lengths of singles (i.e. up to 25 metres).

If a pilot cable is to be laid in the same track as high voltage cable(s) and it has to be installed in a duct then it should be installed in a separate duct from the high voltage cables.

Installation of short lengths of single core cables for connection to switchgear or transformers.

There are two methods for the installation of single cores in these situations. The choice of method depends upon site conditions, switchgear type, time available etc.

The first method, which is applicable to all switchgear and transformers, involves laying the unterminated single cores from the joint hole into the substation and up through the gland towards the bushings. In most cases the gland plate can be removed from the switchgear to enable the cores to be threaded through. Each core is then made off in conventional fashion

and connected to the terminal bushings. This offers the advantage of easy handling of the cables and the correct orientation of the cable lugs can be correctly achieved. Of the two methods this is the more time consuming and restrictive to other work in the substation.

The second method is only applicable to terminations that enable the palm contacts on the terminal bushings to be rotated to meet the cable lugs at the correct angle - the Ringmaster extensible range for example. This method involves using pre-prepared cable 'tails' i.e. lugs and stress control terminations already fitted. The tails are installed from the switchgear outwards by passing the unterminated end of the tail down through the gland, into the trench or duct and on to the joint hole. This method offers the speed advantage of using pre-prepared tails, but can introduce difficulties man-handling the tails. Because there can be no control of the angle at which the cable lugs will lie once installed, this method can only be used where the switchgear lugs can be rotated as required.

Bonding and Earthing

Feeder cables.
It is vital that the copper earth screen wires are bonded together and connected to the substation HV earth. The copper wires of each single core shall be gathered into a single brass shear bolt lug. Most gland plates will incorporate a parking bar suitable for bolting the three lugs onto. A further connection is required from this parking bar to the substation HV earth.

Cables between switchgear and transformer.
Alternating current in single core cables results in voltages being induced in the cable sheaths, the magnitude of the induced voltage depends upon the cable length, current magnitude and spacing of conductors. It is possible to keep these voltages within tolerable limits by bonding and earthing at both ends, unfortunately this gives rise to circulating currents in the cable sheaths which has the effect of de-rating the cables. Accordingly it has been practice normally only to bond and earth the screens of single core cables between switchgear and transformer at one end – normally at the switchgear.

This practice has normally only been applied to the 11kV tails of Primary transformers (the only previous application of 11kV single core cables) which carry high currents.

For the application to cable connection loops between secondary switchgear and transformers it is thought that the rating of the cable will remain adequate for the required duty.

It is therefore acceptable to bond and earth the copper screen wires at both the switchgear and transformer.

Cable Spiking for Identification

Conventional spiking guns will spike 3 core polymeric cables in normal fashion, although a jacking attachment is required to facilitate removal of the spike from the cable. The jack attachment is available as a modification, from the approved manufacturer, to more modern spiking guns.

Spiking guns will not satisfactorily spike three single core cables simultaneously. A special insert is required for spiking guns to accommodate three single cores plus a packer. Until these inserts are approved, each single core shall be spiked individually. Alternatively since single cores are only to be used for short lengths it may be more practical to excavate to a suitable termination where the cables may be positively identified.

More guidance on spiking guns will be issued by Engineering Support during November 2003.

Temporary Bonding of Cable Screens

A screen bonding kit has been approved that will be used to bond the screens of cables which are to be jointed. This has a series of screw fastenings that can be fitted to the bunched screen wires to keep them at the same potential during jointing.

Insulation Testing of Polymeric Cables, and circuits comprising a mixture of cable types.

Cables shall be tested in accordance with the PowerSystems document SUB-02-613, Electrical Insulation Testing of HV Equipment up to 33kV.

12. CONNECTIONS TO NEWLY PURCHASED SWITCHGEAR

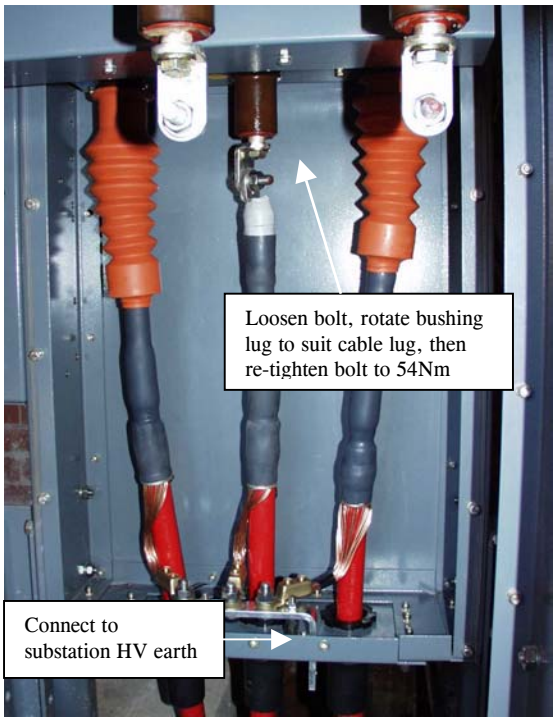
The primary consideration is that the bending and crossing of cores within cable boxes is not permitted. For this reason, single core terminations are to be used and angled cable glands are not appropriate to most types of switchgear. Revised termination arrangements have been made (or are in progress) for most types of switchgear.

Primary switchboards:
Hawker Siddeley Eclipse is immediately suitable for single core connection. Angled cable boxes are used for switchboards housed in buildings, horizontal gland plates are used for containerised switchgear.

Schneider Genie is immediately suitable for single core connection.

Schneider 11kV secondary switchgear. Detailed notes follow on the next pages.

Ringmaster Extensible switchgear. A new gland plate has been developed and approved for use on this switchgear. This plate has each separate single core passing through a heat shrinkable Sigmaform CES 4 gland (supplied with the switchgear). There is a copper earth bar attached to the gland plate for termination of the copper cable screen wires. It is essential that this copper bar be connected to the main switchgear earth bar and to the main substation earth. See photo showing a gland plate fitted to a Ringmaster extensible unit. One of the stress control boots has been removed for the purpose of clarity.



Depending how the cables are installed, the cable lugs will not always fall at the right angle to meet the bushing lug.

In the photo, the bushing lug has been rotated to match the orientation of the cable lug. This is acceptable providing the bushing end bolt is re-tightened to a torque of 54Nm.

The copper screen wires of each core are bunched into a separate brass shear-bolt lug.

Each brass lug is connected to the earth bar by an individual M12 nut and bolt.

Schneider RN2c ring main unit. The same single core gland plate developed for the Ringmaster extensible switchgear (see above) shall be used for the ring switch cable boxes of this unit. A slightly larger plate of the same style is used in the tee-off circuit breaker cable box (when the RMU is not directly coupled to a transformer).

Certain RMU types are currently supplied with angled gland plates so that they may be installed in substations without cable trenches. When using single core cables, these units will now use horizontal gland plates. To ensure that the singles are able to bend completely from a horizontal to a vertical orientation before passing through the plate, the unit is to be installed on a 150mm platform, which will be supplied with the unit. The photograph shows a type B unit mounted on a stand, with one single core cable fitted.

The following notes provide complete detail on all variants of Schneider equipment.

All the Schneider switchgear types shall be supplied with suitable gland plates and glands to accept three separate single-core, polymeric insulated 11kV cables. The gland plates shall be constructed from non-magnetic material and drilled with three 52 mm diameter holes to accept Sigmaform Type CES4 heat shrinkable gland or similar. A copper earth bar shall be provided with three separate M12 holes to allow connection of the copper screening wires.

Schneider's gland plate design (Schneider Drawing 2C82722 Revision O, "RN2c 3x1c CES4 GLD-PLT (R/S)) is used with Ringmaster extensible range and RN2c ring switch cable boxes.

Schneider's gland plate design (Schneider Drawing 2C82723 Revision A, "RN2c 3 x 1c CES4 GLD-PLT (T-OFF)) is used with RN2c circuit-breaker cable boxes.

To ease the introduction of Ringmaster range of switchgear for use with single core cables, PowerSystems will purchase a number of 3-core gland plates. This will allow standardisation of the range whereby all new switchgear will be suitable for use with single core cables, but will also allow PowerSystems to fit 3-core gland plates where it is necessary to use 3-core cable.

Switchgear Types Involved

The following switchgear types, as supplied to PowerSystems will require to be modified to accept single core 11kV cables.

Ringmaster RN2c non-extensible 200A ring main unit
Ringmaster RN6c non-extensible 630A ring main unit (PowerSystems South X-type)
Ringmaster CE2 200A extensible circuit-breaker
Ringmaster CE6 630A extensible circuit-breaker
Ringmaster SE6 630A extensible switch

Type A ring main unit (Power Systems Part Nos. C39880321 and C35310597)
This is a free standing RN2c–T1/16 (with TLFs) ring main unit presently supplied complete with tee-off cable box, three 3-core cable gland plates and Sigmaform CES-5 heat shrinkable glands.

This unit shall be supplied with the standard RN2c support without the need for any customised stand arrangement.

Type A ring main units shall now be supplied with three “RN2c 3x1c CES4” single-core gland plates and 9 Type CES-4 glands.

Type B ring main unit (PowerSystems Part No. 5310599)
This is a free standing RN2c-T1/16 (with TLFs) ring main unit, identical to a Type A unit except that it is presently supplied with angled cable boxes for 3-core cables complete with Sigmaform CES-5 heat shrinkable glands.

This RMU is primarily utilised in PowerSystems South in indoor substations without cable ducts or trenches. To facilitate easy installation of the single core cables, and to ensure their minimum bending radii is not exceeded, the gland plate requires to be positioned at a minimum height of 700mm above the substation floor.

Since the height of the ring switch cable box gland plates on the standard RN2c is only 538 mm, a stand base will be required to raise the height of the ring switches approximately 150 mm. Schneider’s stand base design (Schneider Drawing SKMC13203) is used with Type B RMUs for this purpose.

Type B ring main units shall now be supplied with three horizontally mounted “RN2c 3x1c CES4” gland plates, 9 Type CES-4 glands and an additional stand base.

Type C ring main unit (PowerSystems Part Nos. C39880072 and C35310599)
This is a RN2c-T1/16 (with TLFs) ring main unit for direct transformer mounting presently supplied complete with 3-core cable gland plates and Sigmaform CES-5 heat shrinkable glands on the ring switch cable boxes only.

This unit shall be supplied with the standard RN2c support without the need for any customised stand arrangement to facilitate direct coupling to a unit transformer.

Type C units shall now be supplied with two "RN2c 3x1c CES4" single core gland plates and 6 Type CES-4 glands.

Type D ring main unit (PowerSystems Part No. C35310672)
This is a free-standing RN2c-T2/16 ring main unit with 200/1A CTs, VIP 300 relay and VIP shunt trip coil, which is utilised to supply high voltage customers in PowerSystems South. The unit is supplied with angled gland plates and tee-off cable box (a separate free-standing metering unit is used by PowerSystems in this case). It is presently supplied complete with three 3-core cable gland plates and Sigmaform CES-5 heat shrinkable glands.

A stand base will be required to allow Type D units to be used in substations without cable trenches.

All Type D ring main units shall now be supplied with three horizontally mounted "RN2c 3x1c CES4" gland plates, 9 Type CES-4 glands and with an additional stand base. Although note at present the free-standing Lucy metering unit still requires PICAS cable. Therefore the tee-off gland plate needs to be changed to a 3 core cable plate to enable PICAS to be used for the cable loop between RMU and metering unit.

Type D1 ring main unit including MU2 metering unit (PowerSystems Part No. C39880325)
This is a RN2c-T2/16 ring main unit with 200/1A CTs, VIP 300 relay and VIP shunt trip coil for direct coupling to a high voltage metering unit which is utilised to supply high voltage customers in PowerSystems North. The unit is presently supplied complete with 3-core cable gland plates and Sigmaform CES-5 heat shrinkable glands. All Type D1 ring main units are supplied with an MU2-M3/16 directly coupled metering unit and fitting kit. There are no proposed changes to the design of cable boxes on the MU2.

This unit shall be supplied with the standard RN2c support without the need for any customised stand arrangement.

Type D1 ring main units shall now be supplied with two "RN2c 3x1c CES4" single-core gland plates and 6 Type CES-4 glands. The MU2 metering unit shall continue to be supplied with the existing 3-core gland plate and CES-5 gland.

Type D2 ring main unit including MU2 metering unit (PowerSystems Part No. C39880322)
This is a RN2c-T1/16 ring main unit with 100/50/5A CTs, Time Limit Fuses, and TLF shunt trip coil for direct coupling to a high voltage metering unit which is utilised to supply high voltage customers, up to 1.6MVA only, in PowerSystems North. This unit is presently supplied complete with 3-core cable gland plates and Sigmaform CES-5 heat shrinkable glands. All Type D2 ring main units are supplied with an MU2-M2/16 directly coupled metering unit and fitting kit.

This unit shall be supplied with the standard RN2c support without the need for any customised stand arrangement.

All Type D2 ring main units shall now be supplied with two "RN2c 3x1c CES4" single core gland plates and 6 Type CES-4 glands. The MU2 metering unit shall continue to be supplied with the existing 3-core gland plate and CES-5 gland.

SE6-S2/21 extensible switches (Power Systems Part No. C39880065)
This is an extensible switch utilised by the Automation Team in PowerSystems. In some cases angled gland plates suitable for 3-core PICAS have been specified, but generally horizontal gland plates are used.

The height of the gland plate is only 223 mm, however it is considered that it is not practicable to install the switchgear on an additional stand to achieve the required height of 700m for substations without trenches. Therefore, in such cases, additional excavation will be carried out and extensible units shall be supplied with the standard support without the need for any customised stand arrangement.

All Type SE6 switches shall now be supplied with a horizontally mounted "RN2c 3x1c CES4" gland plates and 3 Type CES-4 glands

CE2-T1/16 and CE6-T6/16 extensible circuit-breakers (Power Systems Part Nos. C39880324 and C39880054)
These extensible circuit-breakers are used in conjunction with SE6 switches by the Automation Team in PowerSystems. The CE2 is supplied with 100/5/5 CTs and Time Limit Fuses. The CE6 is supplied with 800/1 CTs and a VIP 300 relay.

As for SE6 units, the CE2 and CE6 circuit-breakers shall be supplied with the standard support without the need for any customised stand arrangement.

All Type CE2 and CE6 circuit-breakers shall now be supplied with a horizontally mounted "RN2c 3x1c CES4" gland plates and 3 Type CES-4 glands.

Type X ring main unit

This is a free standing RN6c ring main unit that has been modified for use in Solkor protected networks, or for HV generator customers. Additional CTs have been supplied and these are installed within a compartment above the circuit-breaker cable box. The RMU is supplied with a special support stand to provide adequate bending radii for the cables. The unit is presently supplied with angled cable boxes for 3-core cables complete with Sigmaform CES-5 heat shrinkable glands.

The ring switches of this unit shall use the standard single core gland plate used for ring switches on standard RN2C. The tee-off circuit breaker requires a different mode of connection due to the CT chamber reducing the height of the gland plate below the minimum-bending radius for the single core cables. The tee off cable box uses a special gland plate that is reversible for the cable to approach from either the left or right and has the glands slightly offset.

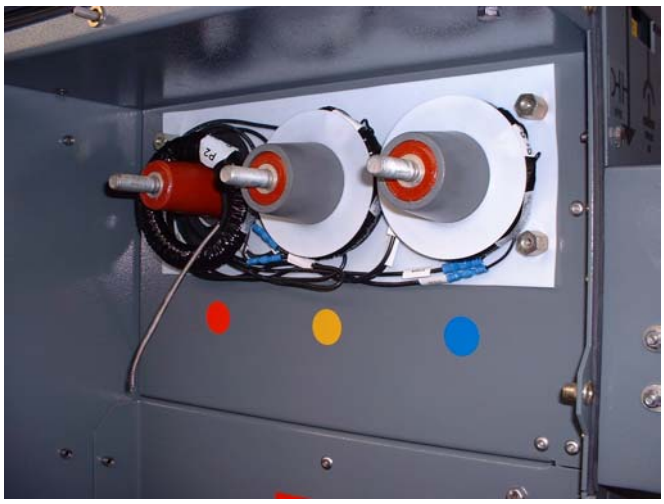
Earth Fault Indicators

With the introduction of single core cables, the existing "core-balance EFI CT" arrangement be discontinued.

At present all RN2c ring main units supplied to PowerSystems are fitted with 500/1A Talus CTs for use with an Earth Fault Indicator on the left-hand ring switch cable box bushings. These are shorted out within the LV Pilot Cable Box. PowerSystems intend to use Nortech's FIND EFI on all RMUs. The Nortech FIND EFI will be supplied and fitted to all RN2c RMUs supplied to PowerSystems by Schneider.

At present all SE6-S2/21 switches supplied to PowerSystems are fitted with 500/1 Talus CTs. These are shorted out within the LV Pilot Cable Box. PowerSystems intend to fit the Nortech SPi themselves to these units and there are no plans to have the EFI fitted pre-delivery by Schneider.

To coincide with the introduction of single core cables, Schneider shall supply the all RN2c ring main unit types complete with a Nortech FIND earth fault indicator utilising to Talus CTs.



The bushing cover panel and the red phase bushing neoprene sleeve have been removed to show the Talus CT's on a Ringmaster RMU.

This is the Nortech FIND EFI, which will be fitted by Schneider to the Ringmaster RMU.

These EFI's will be fully wired from the CT to the EFI, which will be fitted in a prominent position on the left-hand leg.

Bushing shrouds

The RN2c range of RMUs are presently supplied to PowerSystems complete with three Econ boots (bushing shrouds) per cable box. There is no proposed change to this practice and the RMUs will continue to be supplied with the appropriate number of bushing shrouds as required.

The extensible range requires the use of "straight boots". These will continue to be supplied by PowerSystems.

Table showing requirements

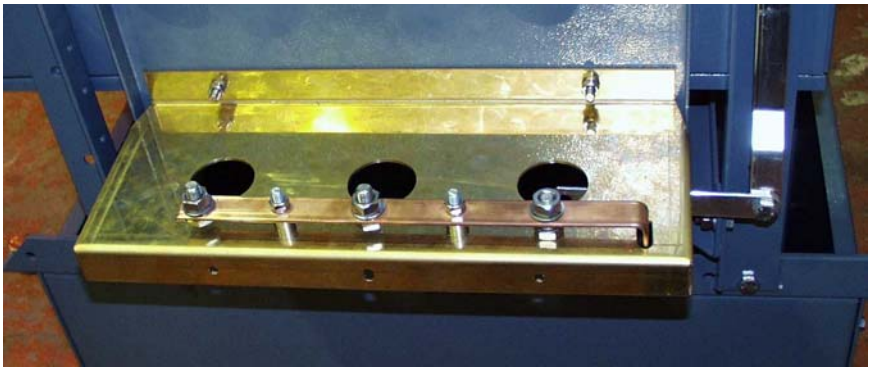
Switchgear Type	CES-4 Gland Plate	CES-4 Gland	Stand Base	Nortech FIND EFI	Econ Boots
Type A ring main unit	3	9	No	Yes	9
Type B ring main unit	3	9	Yes	Yes	9
Type C ring main unit	2	6	No	Yes	6
Type D ring main unit	3	9	Yes	Yes	9
Type D1 ring main unit	2	6	No	Yes	6
Type D2 ring main unit	2	6	No	Yes	6
Type SE6 Switch	1	3	No	No	0
Type CE2 circuit-breaker	1	3	No	No	0
Type CE6 circuit-breaker	1	3	No	No	0
Type X ring main unit	2 Tee off gland plate	9	Special	No	6 *

* Three Tyco boots also required

Lucy Sabre ring main unit. These units were originally suitable only for 3 core cable connection. A new gland plate suitable for single cores has been developed and is in the process of gaining approval. The plate is similar to the Schneider equivalent and is shown in the photograph below.

The copper screen wires are each terminated in a separate brass shear-bolt lug, which is bolted to the earth-parking bar. It is essential that this parking bar be connected to the switchgear HV earth and to the substation HV earth conductor.

In all three cable boxes on this unit the cable lugs are bolted to the palm of a lug protruding from the bushings. There is no means of rotating the bushing lug so it is important that the cable lug is correctly positioned so that no undue twisting force is applied to the single core cable or bushing lug.



The Lucy RMU is designed with the gland plates very low down for siting over trenchwork. For use in PowerSystems South substations where cables are laid along the floor, the unit is supplied with a stand which raises the unit to a height where the single core cables s can be safely bent into a vertical position.

The photograph shows the unit mounted on the stand.

13. CONNECTIONS TO NEWLY PURCHASED GROUND MOUNTED CABLE CONNECTED TRANSFORMERS

Since the commencement in 2002 of the procurement contract for transformers, all cable-connected transformers have been delivered from the manufacturer with HV terminations suitable for single core cables. To suit three core PICAS cables, these transformers have been retro-fitted with an appropriate three core cable box.

Currently there are two variants of HV cable box used – the 'long box' containing two sets of 300/5 CTs (for connection in X type solkor protected substations), and the 'short box' without CTs for non unit protected installations.

Developments are in progress for unit protected transformers to be supplied with the CTs installed inside the tank and a secondary wiring termination box on the outside of the transformer. This solution is still being engineered. In the meantime, connections to transformers in Solkor substations shall use three core PICAS and the traditional long cable box.

For single core cable connection, there will be a common cable box for both the short box and long box transformer. The cable box will use ANSI style cable terminations, requiring

'elbow' connectors on the single core cables which plug onto the protruding terminals in the right-hand photograph. Note that the left-hand picture shows an early, incorrect, means of

earthing via a single stud. That design is being modified to include an earth parking bar similar to that developed for switchgear.

14. REPLACEMENT TRANSFORMER CABLE BOXES FOR EXISTING TRANSFORMERS

Once the cable screen earthing bar described in the above section is designed, a quantity of replacement boxes suitable for terminating single cores and for connection to existing transformers will be available. In the meantime, where it is necessary to change a connection to an existing transformer, existing methods shall be used to replace the termination using PICAS cable. In accordance with the usage policy outlined earlier, the majority of any new circuits shall use 3 core polymeric cable, with only the final connection to the transformer being made using PICAS.

15. FREE-STANDING METERING UNIT

The Lucy free-standing metering unit used in PowerSystems South is being re-engineered. At present it uses two compound filled boxes for terminating three core PICAS cable. When approved, the new version will accommodate three single core polymeric cables on the PowerSystems side, with an air insulated box on the customer side for terminating the usual range of customer cables. In the meantime 3 core PICAS shall continue to be used.

16. SOLUTIONS FOR CONNECTIONS TO LEGACY SWITCHGEAR

Work is progressing to engineer solutions that will enable polymeric cables to be terminated in a reasonable range of older switchgear that currently require a compound filled box and a PICAS termination. Until specific details are announced, a short length of 3 core PICAS shall to be used for the final connection onto this switchgear. Immediately outside the substation at a suitable position, a transition joint shall be made for the rest of the new cable connection to be made with 3 core polymeric cable in accordance with the policy laid out in this document.

17. OVERHEAD LINE TERMINATIONS

Two terminations will be available – for one three core cable, or three single core cables. The choice of which termination to use depends upon the policy outlined in an earlier section of this guide.

Many of the components are common between the terminations including the crucifix and surge divertor / insulators. Different cable cleats are required when used with single cores, which are specially shaped to hold the cores. Standard cable guards are still appropriate for use with polymeric cables, despite outside diameters being slightly different.

18. QUESTIONS AND ANSWERS FROM ROADSHOW

The questions and answers in this section (where appropriate) are those which were asked at the various road shows. Some of the questions raised issues that have been included in the main body of the document. Other questions and answers appear below.

Q. Do all three single core cables require to be spiked even although only one is faulty?

A. PSSI 5 states in Appendix 1 Section 3.2.9; every single core to be worked on shall be spiked.

This will allow for:
1. Fault Work - Spiking of only damaged cores (may be 1,2 or 3)
2. Other Work - All cores to be spiked.

The wording in PSSI 5 will be amended for fault conditions to take into account the need to observe a definite change in insulation conditions before and after spiking on the single core to be worked on, otherwise additional single cores will require to be spiked.

Q. Does the temporary earth bonding kit that is used when jointing 11kV cable with plastic sheaths require to be in the DOM earth register, colour tagged and visually inspected at regular intervals.

A Business *Risk and Safety have stated that this will not be required.*

Q. What method is used to cap cables and what action should a store-man take if a drum is returned uncapped?

A. Standard heat shrink caps can be used to cap polymeric cables. However since the outer sheath is not the same material as the CORAL cable it requires a slightly different technique. The MDP sheath should be abraded in the same manner as other cables but this area should then be heated gently before application of the heat shrink cap.

It is important that all cables are capped immediately after cutting off a section. This is especially so in the case of a three core polymeric 11kV cable as it is non-water blocking. Should a drum be returned uncapped then the cable end should be held on the ground and the drum rolled back one revolution and if no water runs out from the cable on the drum then it can be capped in the normal manner. For single core cables cut off 0.5m and cap.

Q. Can cables be jointed routinely in substations?

A The much preferred option is that the cable jointing will be outside the substation unless it is not reasonably practicable. Where joints have to be made in substations there must be adequate separation between cables and joints. In outdoor substations all joints must be buried. In indoor substations they should be located such that there is no risk of tripping.

Q. Are all the tools and spare parts associated with the tools required in stock?

A Tools and spare parts for tools have been commodity coded. Spare parts will be stock items but the tools themselves will be held in very small quantities for replacement purposes only (Power Systems staff only – not third parties).

Q. How are single cores zip tied when they go through ducts?

A. This is difficult to achieve in practice and is one of the reasons for keeping lengths of single cores to a minimum. The most practical method is to zip tie the cables together then push them through the duct. The difficulty of this increases with the length and with any curve in the duct run. Use of 150mm ducts may assist.

Q. Can the X/R ratios figures be provided?
A See section 9

Q. What gasses are given off from faulted polymeric cables (PVC gives off hydrochloric gasses)?
A This will be addressed in a later issue.

Q. Are insulating boots required for Genie and Eclipse cable boxes?

A. Eclipse switchgear is type tested without boots and therefore none are required.

Genie terminations should use the cold shrink Tyco boot.

Q. Should the three core cable be sheath tested before commissioning?

A This is being debated at present and the outcome will be published when appropriate. Until this happens it will not be necessary to carry out a sheath test prior to commissioning.

Q. Have contractors been advised of the installation and capping of polymeric cables?

A. The November 2002 issue of Handling and Installation of Cables up to and Including 33kV (formerly known as LC2) includes all the installation parameters for polymerics – pulling tensions, bending radii and the requirement and guidance on capping, although the advice on heating the oversheath is not mentioned.

Q. Do we need to dig a trench for Ringmaster SE6, CE6 and CE2?

A. Yes. There are no angled gland plates available for this swiutchgear. To satisfy the minimum bending radii of the single core cables it will be necessary to mount the switchgear over a trench.

Q. If a solution cannot be engineered in either polymeric or picas is it acceptable to replace all the substation plant?

A. Yes – but this is not expected to arise for several years by which time it is anticipated that there will be alternative solutions.

Q. Will Debut for windows be updated?

A. Yes if it is found to be required.

Q. How do cable locators perform on single cores?

A. Cable locators have been proven to work on single core cables.

Q. Will EFI's be stock items?

A. Yes – in due course

Q. What class of cable is polymeric with regard to mechanical protection?

A. This will be addressed in a later issue

Q. What temperature are joints and terminations rated?

A To the maximum operating temperature of the conductors – 90°C

Q. Can trifurcating joints be made off in substations particularly transformer cable loops? This is current practice.
A Joints on cable loops should be avoided and the transformer loop replaced unless there are very special factors to take into consideration and these should be justified in each case. The trifurcating joint again should preferably be outside the substation.
Similarly remaking PILC cables into a box within 3m should also not be considered.

Q. What are the velocity of propagation values for fault location?
A This has still to be determined

Q. How will cable be recorded on GIS?
A. Both GIS and UDB are set up to record polymeric cables, both single core and three core. The pick lists within both systems include all the types and sizes of cable.

Q. Will the application guide be part of the Construction manual?
A. No, the guide is seen to be document to assist in the transition period. All technical issues will be incorporated into the relevant 'Standards Document'.

Q. Will 300mm^2 polymeric cable go through the 125mm duct used by trenchless?
A. Yes.

Q. Are contractor labour and jointers being trained?
A. Some contractor jointers have already been trained and further courses will be arranged, as the contractor needs merit.

Q. Can we get battery operated crimping tools for awkward switchgear?
A. 3M have been asked to see whether this is possible.

Q. Can we get trefoil clamps for single core cables on poles?
A There are cleats available at present however ELLIS have been requested to consider a modified design to remove the sharp edges.

Q. Will 95mm^2 cable need to specially protected to ensure it is within bursting limits?

A The cable has been designed to operate at a fault level of 250MVA and therefore no special consideration should need to be given relative to the other cable sizes. However this will be confirmed in a later issue.

Q. Will there need to be any changes to fault location methods? Do we have any experience of the difficulty / ease of fault location?

A. The experience picked up to date is that fault location can be more difficult because the xlpe simply vapourises (compared to papers reducing to carbon which is low resistance). It is possible to gain a location (i.e. distance) for the fault, but locating it using shock discharge can be less effective due to the higher resistance of the fault.

Q. What stance has been taken for advising third party connectors about this policy change?

A. It is the responsibility of Connections staff to advise 3rd party connectors of Company policy when discussing connections at an initial stage. However it is anticipated that a revised copy of the original Technical Bulletin will be made available for Third Party connectors.

Q. How exactly will strategic stocks be managed - where will they be, who will manage it and how is cable obtained from this stock?

Q. Why are the cores solid and not stranded?

A Solid cores when set into cable boxes maintain the bending radius better that stranded cores. Solid cores are also preferable because stranded cores allow water penetration between the strands.

Q. What about cable ratings (in ground, air and ducts) and voltage drop figures ?

A These are provided in section 9.

Q. Fitting cables through ducts - is it possible to fit a 3 core pilot cable in a 100mm duct as well as 3 185m single cores?

A It is not good practice to install the cable providing the protection circuit in the same duct with the cable it is protecting. The pilot cable should always be laid in a separate duct.

Q. Will there be a technical bulletin about the spiking gun jack and modifications?

A Yes in due course.

Q. What about joints for jointing onto polymeric triplex cables (Core need these when connecting to the United Utilities network.

A This is purely an issue between Core and United Utilities. Power Systems cannot advise Core on this matter.

Q. Will there be an earth parking bar in the transformer cable boxes.

A Yes. The manufacturer's proposal has been submitted for approval.

Q What is the preferred attachment to the cable for pulling purposes.

A The manufacturers have stated that a stocking or eye bolt are both acceptable for single and three core cables.