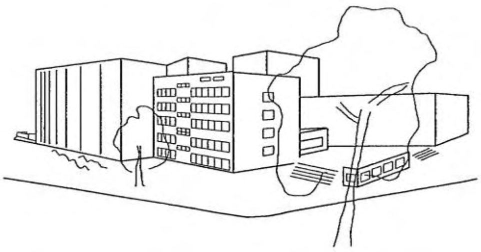
Bereich Hochspannungsprüftechnik
Institut für Elektroenergiesysteme und Hochspannungstechnik



Universität Fridericiana (TH) Karlsruhe
76128 Karlsruhe - Kaiserstraße 12
Telefon (0721) 608 2520 Telefax (0721) 69 52 24

Test Report No 2008-102

Type Test of a 11 kV Three Core Inline Coldshrink Transition Joints Type 92-AV 620-3

Customer: 3M Deutschland GmbH
Carl-Schurz-Str. 1

41453 Neuss

Reporter: Dr.-Ing. R. Badent
Dr.-Ing. B. Hoferer

This report includes 49 numbered pages and is only valid with the original signature. Copying of extracts is subject to the written authorization of the test laboratory. The test results concern exclusively to the tested objects.

1 Purpose of Test

2 resp. 1 joints type 92-AV 620-3 from 3M Deutschland GmbH for V_0 / V_n / V_m = 6,35/11/12 kV were subjected to a type test according to CENELEC HD 629.1 S2 02/2006 table 5 test sequence B1 resp. B2.

2 Miscellaneous Data

Test object: – 3 *Joints type 92-AV 620-3*
V_m = 12 kV,
Installation Instruction XE 0091 2412 6 A4 from 07.12.2007, Figure 2.1 - 2.26
KIT Table of Content, Figure 2.27
Type of the cable: The test object was assembled on a three-core XLPE-cable, 3x185, Figure 2.28
Cable length termination - joint: 3,5 m
Connector: Mechanical Connectors were used for the test

Manufacturer: 3M Deutschland GmbH
Carl-Schurz-Str. 1 – 41453 Neuss

Place of test: *Institute of Electric Energy Systems and High Voltage Technology* – University of Karlsruhe
Kaiserstraße 12 – 76128 Karlsruhe

Testing dates:
Delivery: 08.04.2008
Assembly: 08.04. - 11.04.2008
Test period: 15.04. - 14.06.2008

Atmospheric conditions:
Temperature: 19°C – 25°C
Air pressure: 980 - 1025 mbar
rel. humidity: 35 % – 60 %

Representatives: *Customer´s representatives*:
Dipl.-Ing. J. Weichold
Representatives responsible for the tests:
Dr.-Ing. R. Badent
Dr.-Ing. B. Hoferer
Mr. O. Müller

3M QUICK SPLICE 1000

11 kV INLINE COLDSHRINK TRANSITION JOINT
FOR PAPER OR POLYMERIC 3 CORE CABLE WITH
COPPER TAPE SCREEN AND LEAD SHEATH AND SWA
50 – 400 mm.² 92 AV (UK)

SELECTION CHART					
KIT No.	DIAMETER OVER INSULATION [E] (mm.)	CROSS SECTION (mm.²)		DIAMETER OVER CONNECTOR (mm.)	CONNECTOR LENGTH MAX. (mm.)
		MECHANICAL CONNECTORS	COMPRESSION CONNECTORS		
92-AV610-3	17.7 – 26.0	50 – 95	50 – 120	14.2 – 26.0	135
92-AV620-3	22.3 – 33.2	120 – 240	150 – 185	18.0 – 33.2	145
92-AV630-3	28.4 – 42.0	300 – 400	240 – 400	23.3 – 42.0	220

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung
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NOTE:-

1. FOR SCREENED PAPER CABLES A SCREENED PAPER MODULE (SPM2) IS REQUIRED.
2. IN SOME INSTANCES WHEN USING COMPRESSION CONNECTORS ON SMALL CROSS SECTIONAL CABLES, i.e. 50mm², THE DIAMETER OF THE CONNECTOR MAY FALL BELOW THE MINIMUM REQUIREMENT. IN THESE CASES PLEASE FOLLOW THE INSTRUCTIONS FOR THE 92-PG (SERIES) BUILD UP KITS FOR POLYMERIC CABLES.

ISSUE	DESCRIPTION / ECO	BY	DATE
12	LATEST REQUIREMENT.	ERH	07.12.07
11	LATEST REQUIREMENT.	ERH	22.03.07
10	LATEST REQUIREMENT.	ERH	15.12.06
9	LATEST REQUIREMENT.	ERH	10.08.06

MOD ENG :	DES.ENG. : A.RUSSELL
DRAWN : A. PARKER 17.07.02	CHECKED :
CAD FILE : XE-0091-2412-6	RELEASED :

11kV INLINE COLDSHRINK TRANSITION JOINT FOR PAPER OR POLYMERIC 3 CORE CABLE WITH COPPER TAPE SCREEN INSTALLATION INSTRUCTIONS

3M ELECTRICAL PRODUCTS — XE 0091 2412 6 — SHEET 1 OF 26 — A4

Figure 2.1: Installation Instruction

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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INDEX – JOINT CONFIGURATIONS

3M ELECTRICAL PRODUCTS	XE 0091 2412 6	SHEET 2 OF 26	ISS.12

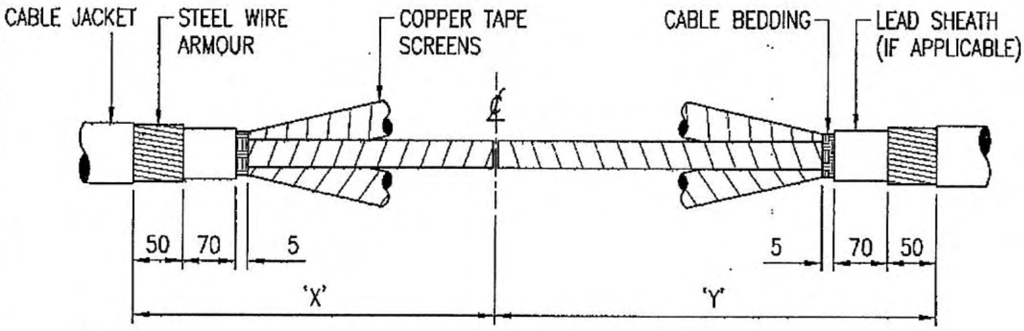
Figure 2.2: Installation Instruction

POLYMERIC INLINE JOINT

NOTE :- THE SMALLEST CROSS SECTIONAL AREA CABLE MUST BE ON THE LONG SIDE

FIG.1

KIT No.	DIM 'X'	DIM 'Y'
92-AV-610-3	460	650
92-AV-620-3	460	650
92-AV-630-3	470	740



1.1 SET CORES INTO REQUIRED POSITION, IF REQUIRED CROSS ON THE LONG SIDE.
1.2 *** IF XLPE CABLE HAS NO LEAD SHEATH, REMOVE THE BEDDING 5mm IN FRONT OF ARMOUR. ***

FIG.2

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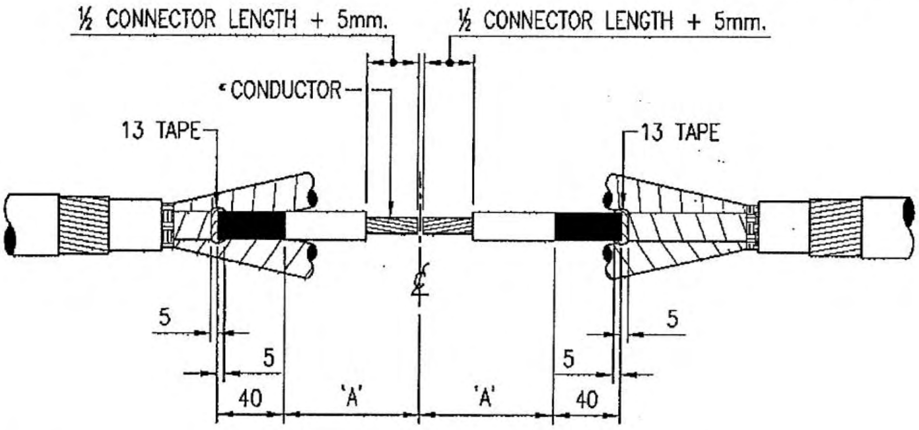
KIT No.	'A' DIM
92-AV-610-3	130
92-AV-620-3	130
92-AV-630-3	180



2.1 PREPARE CABLE AS PER DIMENSIONS SHOWN. SET CORES AND ALLOW FOR CROSS WHERE APPLICABLE.
2.2 FIX THE COPPER TAPE SCREEN WITH HIGHLY STRETCHED BINDER OF SCOTCH 13 TAPE AS SHOWN.

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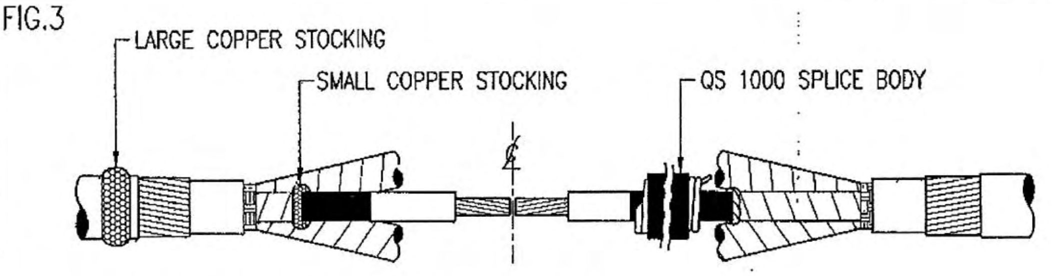
Figure 2.3: Installation Instruction

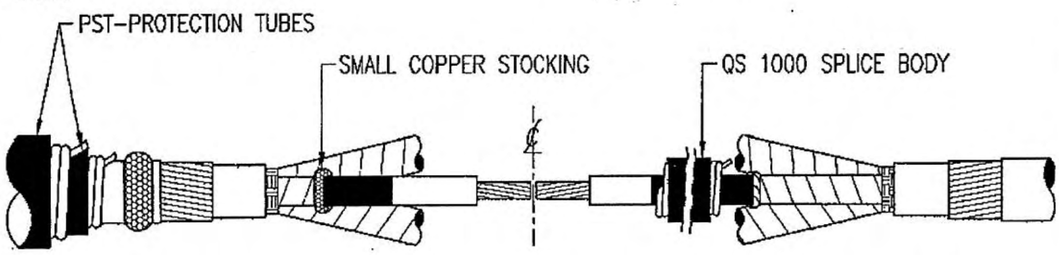
FIG.3



3.1 PARK LARGE COPPER STOCKING ON ONE SIDE OF JOINT.
3.2 WORKING ON ONE PHASE AT A TIME COMPLETE THE FOLLOWING :-
3.3 PARK THE QS 1000 SPLICE BODY.
3.4 PARK SMALL INDIVIDUAL STOCKING ON THE CORE.

*** COLDSHRINK OUTER PROTECTION ONLY *** — POLYMERIC TO POLYMERIC CABLES ONLY

FIG.3b



3b.1 PARK THE PST-PROTECTION TUBES ON THE CABLE ENSURING THAT THE PULL CORDS OF THE SUPPORT CORES OF THE PST'S ARE POSITIONED TOWARDS THE CENTRE OF THE JOINT, ON THE LONG-CORES.
3b.2 CARRY ON WITH STANDARD INSTALLATION FROM FIG.4 ONWARDS TO FIG.9.

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung
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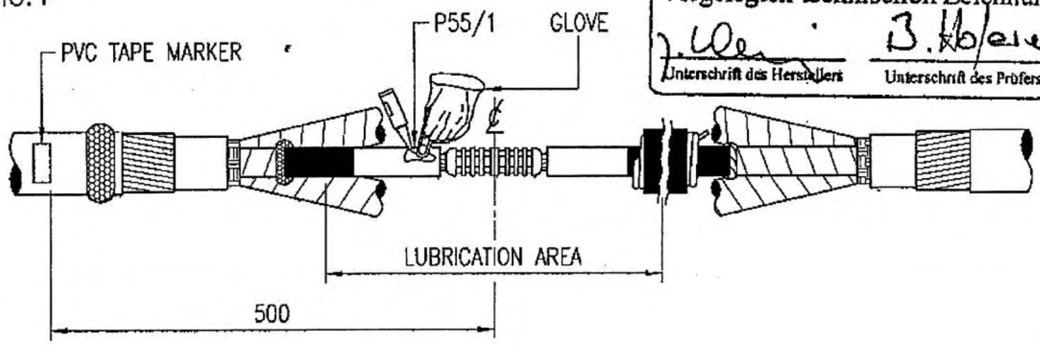
FIG.4



4.1 CONNECT CORE USING APPROPRIATE CONNECTOR.
4.2 APPLY A LIBERAL AMOUNT OF P55/1 OVER THE END OF THE SEMI-CONDUCTIVE LAYER, ON TO THE EXPOSED PRIMARY INSULATION AND CONNECTOR USING THE PROVIDED PLASTIC GLOVE.
4.3 PLACE A PVC TAPE MARKER ON THE CABLE SHEATH AT A DISTANCE OF 500mm FROM THE CONNECTOR CENTRE.

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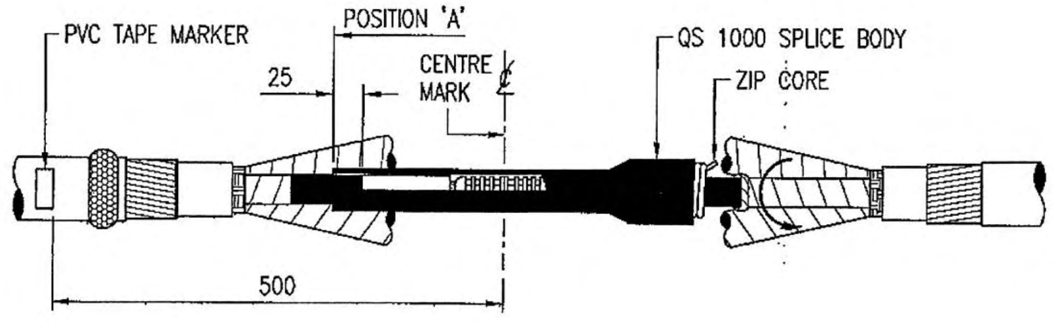
Figure 2.4: Installation Instruction

FIG.5



5.1 SLIDE THE QS 1000 BODY OVER THE CONNECTOR UP TO POSITION 'A'.

5.2 USING POSITION 'A' AS A STARTING POINT, SHRINK THE BODY ON TO THE CORE BY UNWINDING THE SPIRAL.

5.3 ONCE THE BODY HAS BEEN SHRUNK PAST ITS CENTRE MARK, AND BEFORE IT HAS BEEN SHRUNK FULLY ACROSS THE CONNECTOR, ENSURE THAT THE BODY IS IN POSITION USING THE PVC TAPE AND CENTRE MARKERS. IF NOT CORRECTLY POSITIONED, MAKE CORRECTION BY DISPLACEMENT.

*** PLEASE NOTE THAT THE SYMMETRICAL POSITION OF THE SPLICE BODY IS CRITICAL. ***

5.4 COMPLETE OTHER PHASES.

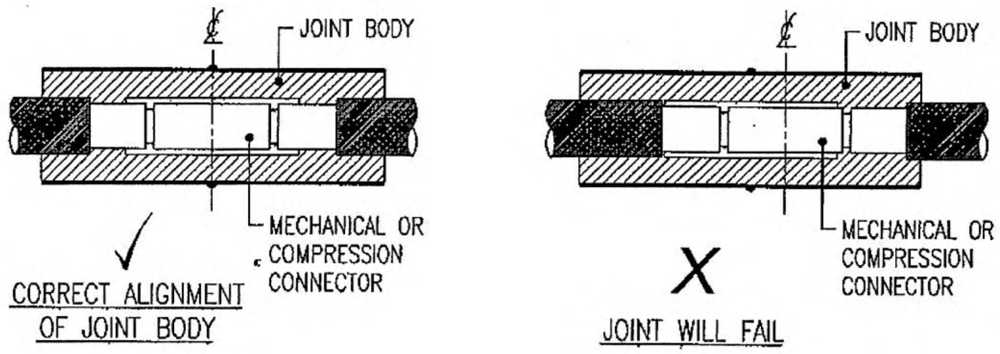


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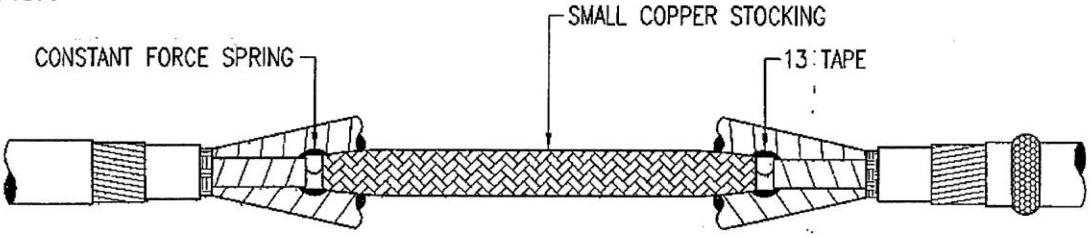
Figure 2.5: Installation Instruction

SHORT SIDE

LONG SIDE

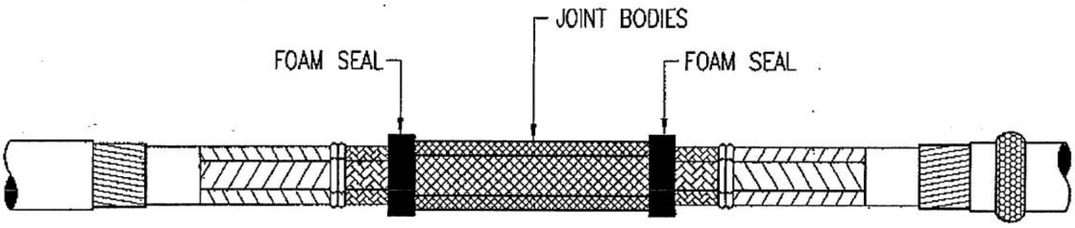
FIG.6



6.1 SLIDE THE SMALL COPPER STOCKING ACROSS EACH CORE.
6.2 CONNECT THE STOCKING TO THE COPPER TAPE SCREEN ON EACH SIDE OF THE JOINT USING CONSTANT FORCE SPRINGS.
6.3 COVER THE SPRINGS WITH SCOTCH 13 TAPE, APPLY IN THE SAME DIRECTION AS THE SPRINGS.

N.B:– ONLY FOR JOINTS INSTALLED IN A MOULD AND RESIN.

FIG.7



7.1 FIT A FOAM SEAL AT BOTH ENDS OF THE SPLICE BODIES.

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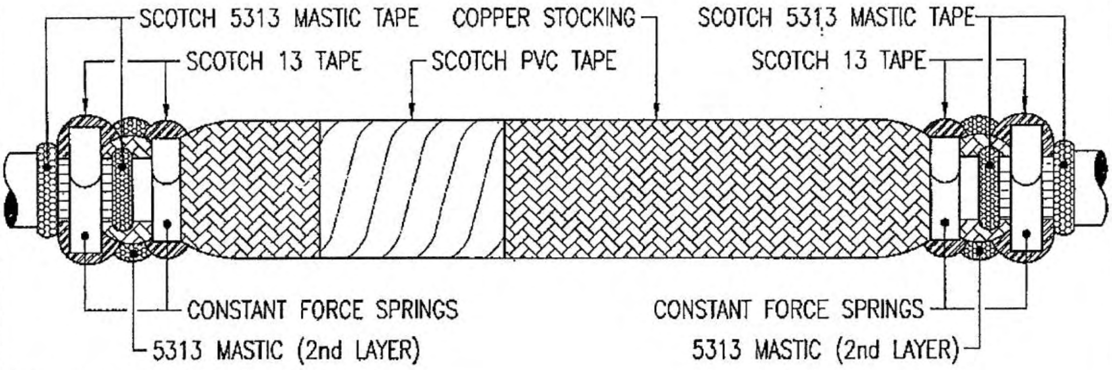
Figure 2.6: Installation Instruction

FIG.8 SHORT SIDE LONG SIDE



XLPE CABLE WITHOUT LEAD SHEATH

SHORT SIDE

8.1 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOUR AND AT THE END OF CABLE JACKET.
8.2 SLIDE THE COPPER STOCKING ACROSS THE JOINT AND CONNECT TO THE ARMOUR USING CONSTANT FORCE SPRINGS.
8.3 PULL THE COPPER STOCKING ACROSS THE JOINT AND TAPE THE AREA OF THE JOINT BODIES WITH THE WIDE PVC TAPE. (TAPE BETWEEN FOAM SEALS.)

LONG SIDE

8.4 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOUR AND AT THE END OF CABLE JACKET.
8.5 CONNECT THE COPPER STOCKING TO THE ARMOUR USING A CONSTANT FORCE SPRING.

BOTH SIDES

8.6 COVER THE CONSTANT FORCE SPRINGS WITH SCOTCH 13 TAPE, APPLY IN THE SAME DIRECTION AS THE SPRINGS.
8.7 APPLY A LAYER OF MASTIC AT BOTH ENDS OF THE JOINT BETWEEN THE SHEATH AND THE ARMOUR AND A SECOND LAYER OVER THE 5313 MASTIC, SANDWICHING THE COPPER STOCKING.

XLPE CABLE WITH LEAD SHEATH

SHORT SIDE

8.8 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOUR, LEAD SHEATH AND AT THE END OF THE CABLE JACKET.
8.9 SLIDE THE COPPER STOCKING ACROSS THE JOINT AND CONNECT TO THE ARMOUR AND LEAD SHEATH USING THE CONSTANT FORCE SPRINGS.
8.10 PULL THE COPPER STOCKING ACROSS THE JOINT AND TAPE THE AREA OF THE JOINT BODIES WITH THE WIDE PVC TAPE, (TAPE BETWEEN FOAM SEALS).

LONG SIDE

8.11 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOUR, LEAD SHEATH AND AT THE END OF THE CABLE JACKET.
8.12 CONNECT THE COPPER STOCKING TO THE ARMOUR AND LEAD SHEATH USING CONSTANT FORCE SPRINGS.

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BOTH SIDES

8.13 COVER THE CONSTANT FORCE SPRINGS WITH SCOTCH 13 TAPE, APPLY IN THE SAME DIRECTION AS THE SPRINGS.
8.14 APPLY A LAYER OF THE MASTIC AT BOTH ENDS OF THE JOINT BETWEEN THE SHEATH AND ARMOUR AND A SECOND LAYER OVER THE 5313 MASTIC, SANDWICHING THE COPPER STOCKING.

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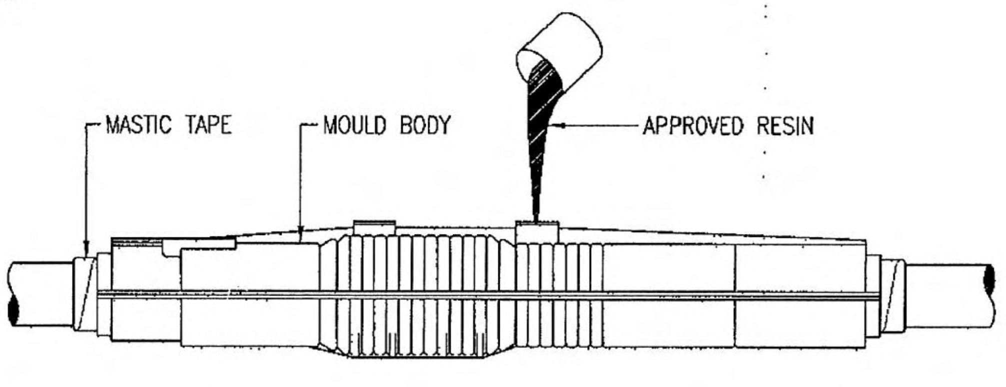
Figure 2.7: Installation Instruction

FIG.9



9.1 ABRADE CABLE SHEATH FOR 100mm BEYOND SHEATH OFF POSITION.
9.2 INSTALL THE MOULD CENTRALLY AROUND THE JOINT AND CLIP BOTH HALVES TOGETHER.
9.3 SEAL THE ENDS OF THE MOULD WITH MASTIC TAPE.
9.4 SUPPORT THE JOINT, MIX THE RESIN AND POUR INTO THE MOULD BODY.
9.5 DO NOT MOVE THE JOINT FOR AT LEAST TWO HOURS.

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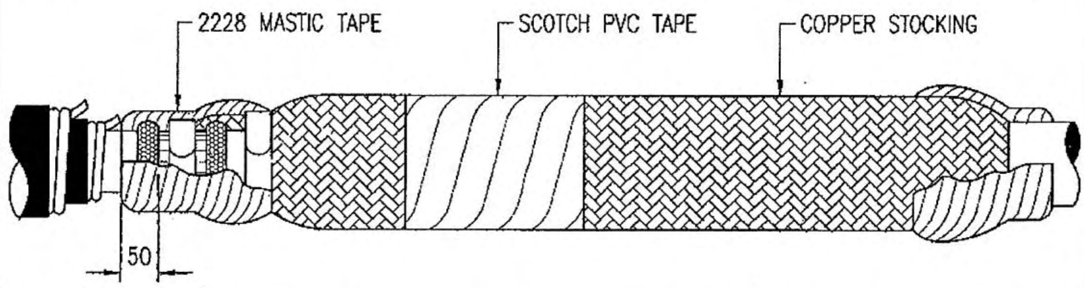
Figure 2.8: Installation Instruction

POLYMERIC INLINE JOINT – COLDSHRINK OUTER PROTECTION OPTION

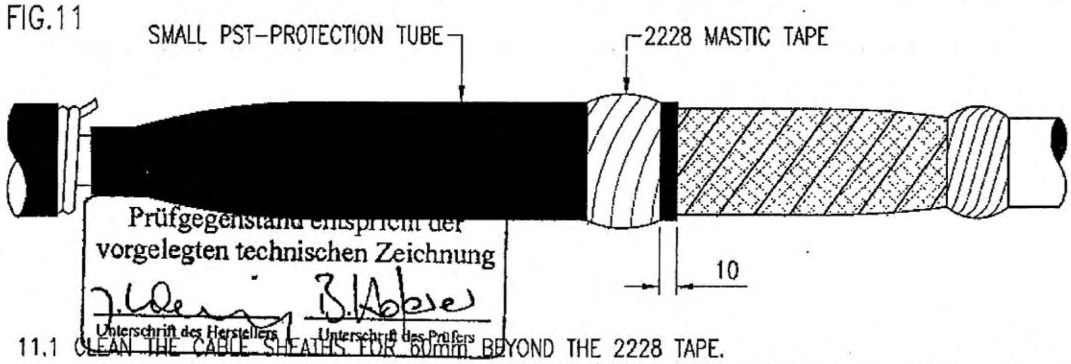
FIG.10

POLYMERIC TO POLYMERIC CABLES ONLY



10.1 APPLY TWO LAYERS OF 2228 TAPE, REACHING 50mm ON TO THE CABLE SHEATH, COVERING THE CONSTANT FORCE SPRINGS, 5313 MASTIC AND SEALING THE ARMOUR, LEAD SHEATH AND/OR BEDDING. ENSURE A MINIMUM DIAMETER OF 65mm.

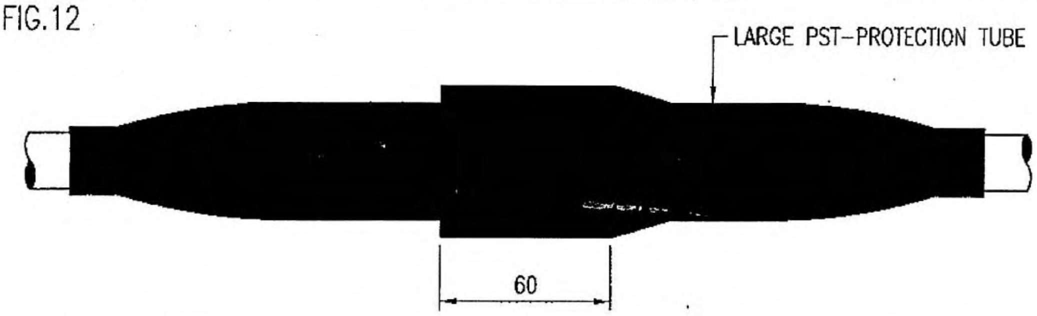
FIG.11



11.1 CLEAN THE CABLE SHEATHS FOR 60mm BEYOND THE 2228 TAPE.
11.2 SHRINK DOWN THE SMALLER PST-PROTECTION TUBE/TUBES FIRST. STARTING APPROX. 10mm PAST THE 2228 TAPE ON THE CABLE SHEATH.
11.3 APPLY THREE LAYERS OF 2228 MASTIC TAPE APPROX. 10mm FROM THE END OF THE PROTECTION TUBE.

NOTE:- FOR KIT No. 92-AV630-3 POSITION 2 SMALL PST-PROTECTION TUBES, ONE ON EITHER SIDE OF THE JOINT.

FIG.12



12.1 SHRINK DOWN LARGE PST-PROTECTION TUBE, STARTING 60mm ON THE FIRST PROTECTION TUBE.

NOTE:- FOR KIT No. 92-AV630-3 POSITION LARGE PST-PROTECTION TUBE OVER THE SMALLER PST-PROTECTION ON EITHER SIDE OF THE JOINT.

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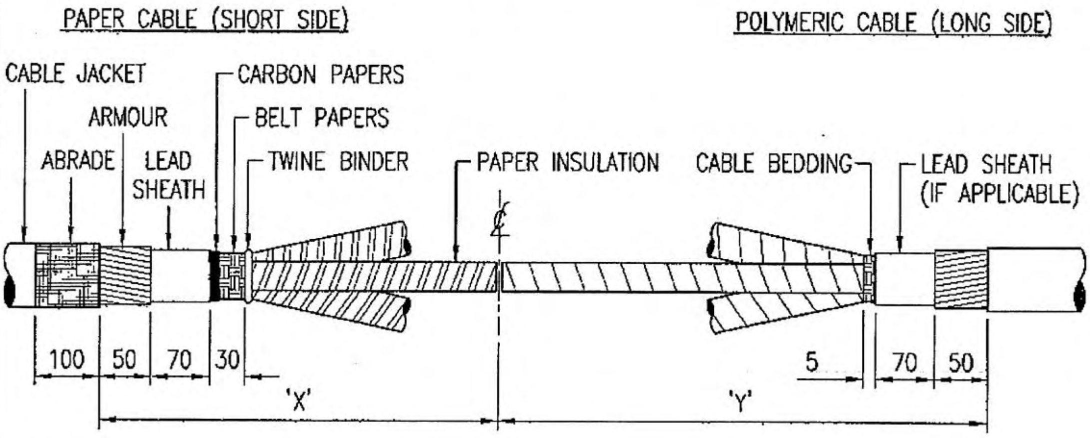
Figure 2.9: Installation Instruction

TRANSITION INLINE JOINT

KIT No:	DIM 'X'	DIM 'Y'
92-AV 610-3	460	650
92-AV 620-3	460	650
92-AV 630-3	510	740

NOTE:- FOR TRANSITION JOINTS A BLOCKED CONNECTOR MUST BE USED AND THE DIMENSION OF THE BLOCK IN THE CONNECTOR MUST BE TAKEN INTO ACCOUNT. DIMENSIONS ARE TO THE "CENTRE OF THE JOINT".

FIG.13



PAPER CABLE

13.1 SET CORES INTO REQUIRED POSITION, IF REQUIRED CROSS ON THE POLYMERIC SIDE.

*** IF XLPE CABLE HAS NO LEAD SHEATH, REMOVE THE BEDDING 5mm IN FRONT OF ARMOUR. ***

13.2 REMOVE CARBON PAPER 5mm FROM THE END OF THE LEAD SHEATH.

13.3 *** FOR PICAS CABLES CLEAN & ABRAID 120mm OF ALUMINIUM SHEATH. ***

PAPER CABLE PREPARATION

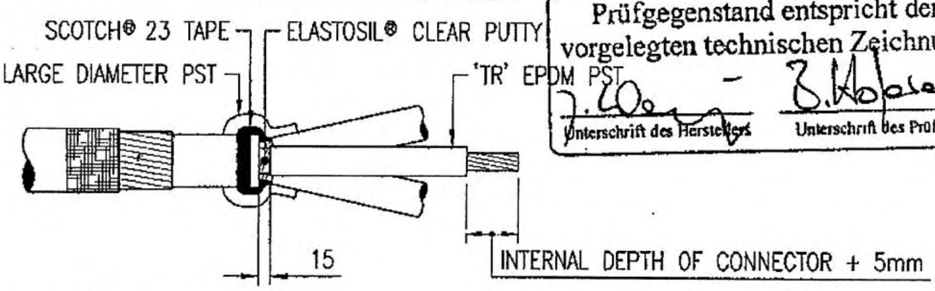


FIG.14

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USING COMPONENTS FROM THE PILCL KIT :-

14.1 SHRINK A LONG PST ON EACH CORE, START SHRINKIING 15mm IN FRONT OF THE BELT PAPERS.

14.2 INSERT A WEDGE OF ELASTOSIL CLEAR PUTTY INTO THE CROTCH, ENSURE ALL VOIDS IN THE CROTCH ARE FILLED. USE APPROX 1/4 OF THE PACK.

14.3 FLATTEN THE REMAINING ELASTOSIL INTO A PAD AND WRAP AROUND THE BELT PAPERS, EXTENDING 5mm ON THE LEAD/ALUMINIUM SHEATH TO THE CORE PSTS.

14.4 APPLY A LAYER OF 23 TAPE OVER THE PUTTY STARTING 5mm ON THE LEAD/ALUMINIUM SHEATH. APPLY WITH LOW TENSION, NO STRETCH. APPLY A SECOND LAYER OF 23 TAPE WITH HIGH TENSION, HIGH STRETCH WORKING BACK TOWARDS THE LEAD/ALUMINIUM SHEATH.

14.5 SHRINK DOWN THE REMAINING PST OVER THE CROTCH AREA, COVERING THE 23 TAPE. ENSURE APPROX. 40mm OF LEAD IS LEFT EXPOSED, (90mm FOR ALUMINIUM SHEATH).

14.6 CUT THE PRIMARY INSULATION AND CORE PST TO THE DIMENSIONS ABOVE.

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Figure 2.10: Installation Instruction

POLYMERIC CABLE LONG SIDE PREPARATION

KIT No.	'A' DIM
92-AV-610-3	130
92-AV-620-3	130
92-AV-630-3	180

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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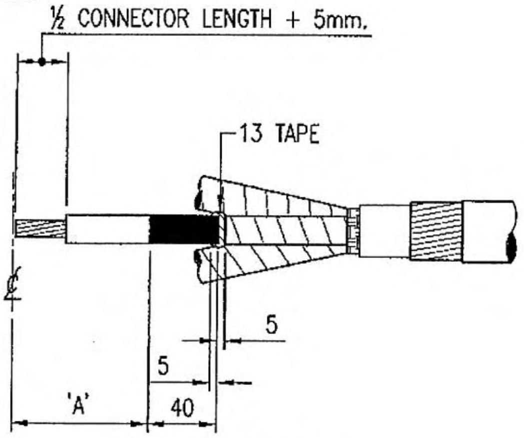
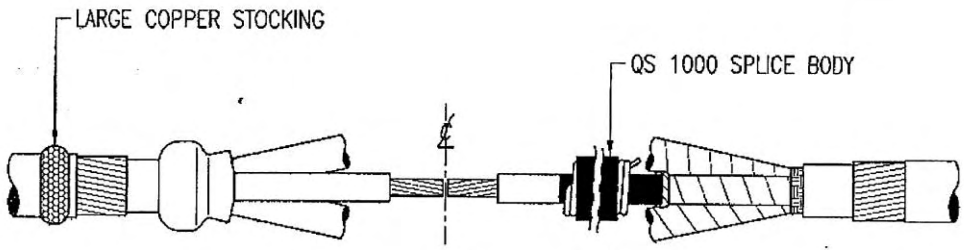
FIG.15



15.1 PREPARE CABLE AS PER DIMENSIONS SHOWN. SET CORES AND ALLOW FOR CROSS WHERE APPLICABLE.
15.2 FIX THE COPPER TAPE SCREEN WITH HIGHLY STRETCHED BINDER OF SCOTCH 13 TAPE AS SHOWN.

FIG.16



16.1 PARK LARGE COPPER STOCKING ON ONE SIDE OF JOINT.
16.2 WORKING ON ONE PHASE AT A TIME COMPLETE THE FOLLOWING :-
16.3 PARK THE QS 1000 SPLICE BODY.

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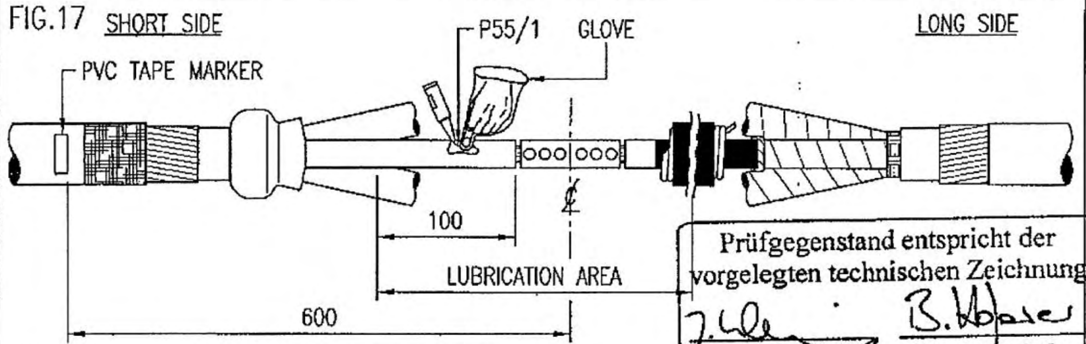
Figure 2.11: Installation Instruction

FIG.17



Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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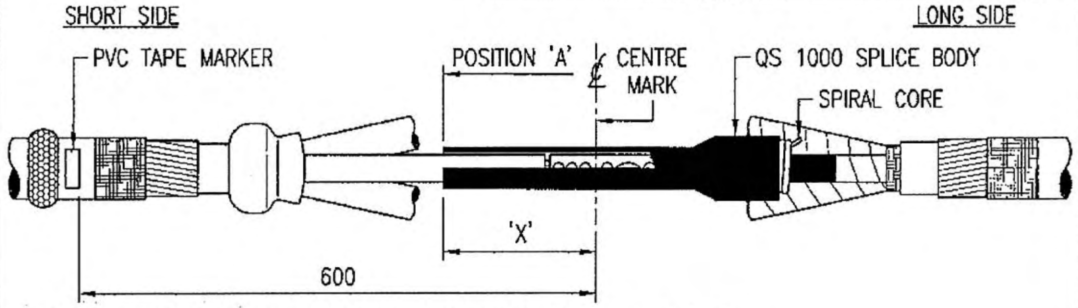
17.1 CONNECT CORE USING APPROPRIATE CONNECTOR.

17.2 APPLY A LIBERAL AMOUNT OF P55/1 OVER THE END OF THE SEMI-CONDUCTIVE LAYER, ON TO THE EXPOSED PRIMARY INSULATION AND CONNECTOR USING THE PROVIDED PLASTIC GLOVE.

17.3 PLACE A PVC TAPE MARKER ON THE CABLE SHEATH AT A DISTANCE OF 600mm FROM THE CONNECTOR CENTRE.

FIG.18

mm^2	50	70	95	120	150	185	240	300	400
'X' mm	155	155	155	160	160	160	210	210	210



18.1 SLIDE THE JOINT BODY OVER THE CONNECTOR, UP TO POSITION 'A'.

18.2 USING POSITION 'A' AS A STARTING POINT, SHRINK THE BODY ON TO THE CORE BY UNWINDING THE SPIRAL.

18.3 ONCE THE BODY HAS BEEN SHRUNK PAST ITS CENTRE MARK, AND BEFORE IT HAS BEEN SHRUNK FULLY ACROSS THE CONNECTOR, ENSURE THAT THE BODY IS IN POSITION USING THE PVC TAPE AND CENTRE MARKERS. IF NOT CORRECTLY POSITIONED, MAKE CORRECTION BY DISPLACEMENT.

*** PLEASE NOTE THAT THE SYMMETRICAL POSITION OF THE SPLICE BODY IS CRITICAL ***

18.4 COMPLETE OTHER PHASES.

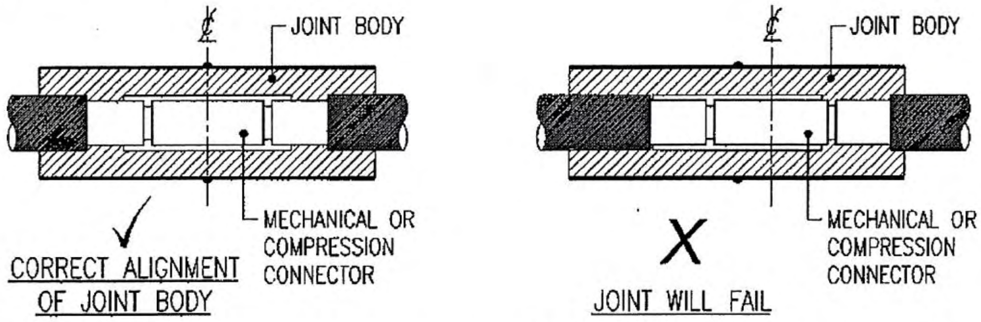


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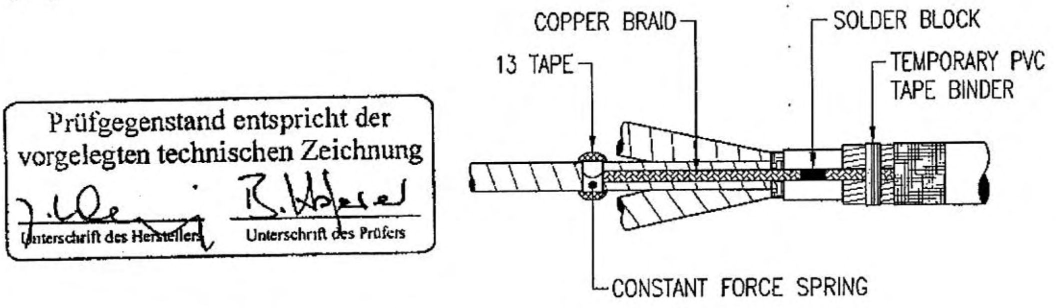
Figure 2.12: Installation Instruction

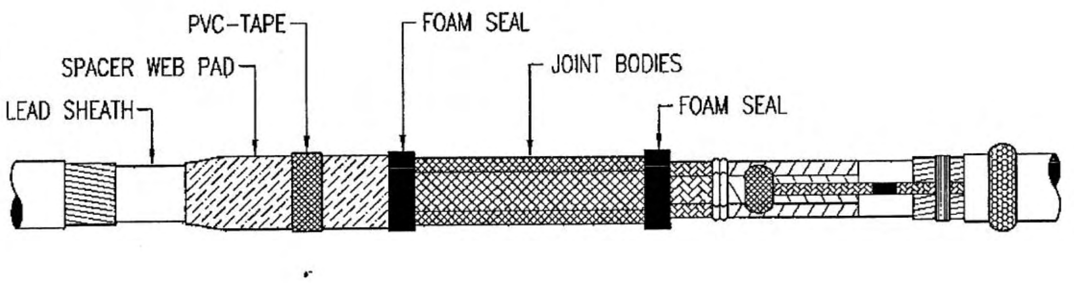
FIG.19



19.1 ATTACH 3 COPPER BRAIDS TO COPPER TAPE SCREENS WITH CONSTANT FORCE SPRINGS AND WITH A TEMPORARY PVC TAPE BINDER TO THE WIRE ARMOURS. ENSURE SOLDER BLOCK IS POSITIONED BEYOND THE ARMOURS, (TRIM OFF ANY EXCESS BRAID).
19.2 OVERTAPE CONSTANT FORCE SPRINGS WITH HIGHLY STRETCHED 13 TAPE APPLIED IN THE SAME DIRECTION AS THE SPRINGS.

PAPER CABLE XLPE CABLE

FIG.20



20.1 FIT A FOAM SEAL AT BOTH ENDS OF THE SPLICE BODIES.
20.2 APPLY THE SPACER WEB PAD, BETWEEN THE LEAD/ALUMINIUM SHEATH OF THE PAPER CABLE AND THE FOAM SEAL AND HOLD IN PLACE WITH TAPE OR STRING.

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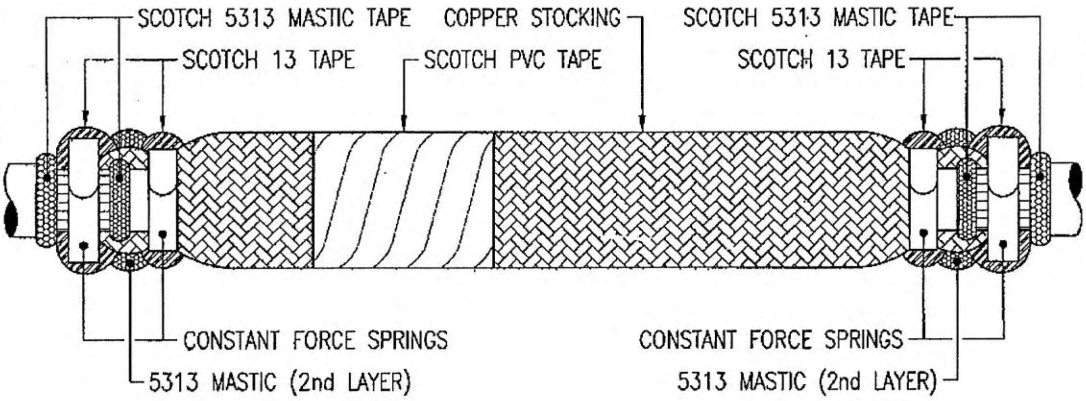
Figure 2.13: Installation Instruction

SHORT SIDE LONG SIDE

FIG.21



FOR TRANSITION JOINTS

PAPER CABLE

21.1 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOURS AND AT THE END OF THE CABLE JACKET. (FOR PICAS CABLES APPLY AT THE END OF THE CABLE JACKET ONLY.)

21.2 SLIDE THE OVERALL COPPER STOCKING ACROSS THE JOINT. CONNECT THE COPPER STOCKING TO THE LEAD/ALUMINIUM SHEATH USING THE SMALLER CONSTANT FORCE SPRING. CONNECT THE COPPER STOCKING TO THE ARMOUR USING THE LARGER CONSTANT FORCE SPRING.

21.3 PULL THE COPPER STOCKING ACROSS THE JOINT AND TAPE THE AREA OF THE JOINT BODIES WITH THE WIDE PVC TAPE. (TAPE BETWEEN FOAM SEALS.) DO NOT COVER THE AREA OF THE PAPER CABLE CROTCH.

XLPE CABLE WITHOUT LEAD SHEATH

21.4 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOURS AND AT THE END OF CABLE JACKET.

21.5 CONNECT THE COPPER STOCKING TO THE ARMOUR USING CONSTANT FORCE SPRING.

XLPE CABLE WITH LEAD SHEATH

21.6 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOURS, LEAD SHEATH AND AT THE END OF THE CABLE JACKET.

21.7 CONNECT THE COPPER STOCKING TO THE ARMOUR AND LEAD SHEATH USING CONSTANT FORCE SPRINGS.

BOTH SIDES

21.8 COVER THE CONSTANT FORCE SPRINGS WITH SCOTCH 13 TAPE, APPLY IN THE SAME DIRECTION AS THE SPRINGS.

21.9 APPLY A LAYER OF MASTIC AT BOTH ENDS OF THE JOINT BETWEEN THE SHEATH AND THE ARMOUR, AND A SECOND LAYER OF 5313 MASTIC, SANDWICHING THE COPPER STOCKING.

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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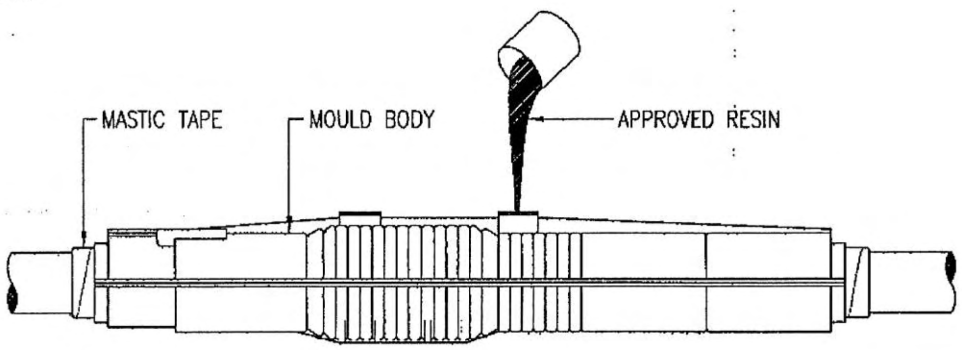
Figure 2.14: Installation Instruction

FIG.22



22.1 ABRADE CABLE SHEATH FOR 100mm BEYOND SHEATH OFF POSITION.
22.2 INSTALL THE MOULD CENTRALLY AROUND THE JOINT AND CLIP BOTH HALVES TOGETHER.
22.3 SEAL THE ENDS OF THE MOULD WITH MASTIC TAPE.
22.4 SUPPORT THE JOINT, MIX THE RESIN AND POUR INTO THE MOULD BODY.
22.5 DO NOT MOVE THE JOINT FOR AT LEAST TWO HOURS.

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Figure 2.15: Installation Instruction

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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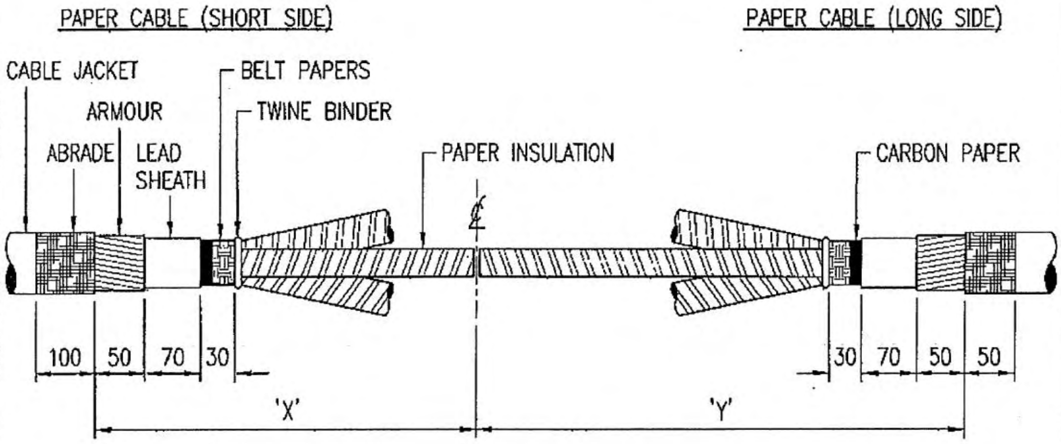
PAPER INLINE JOINT

FIG.23

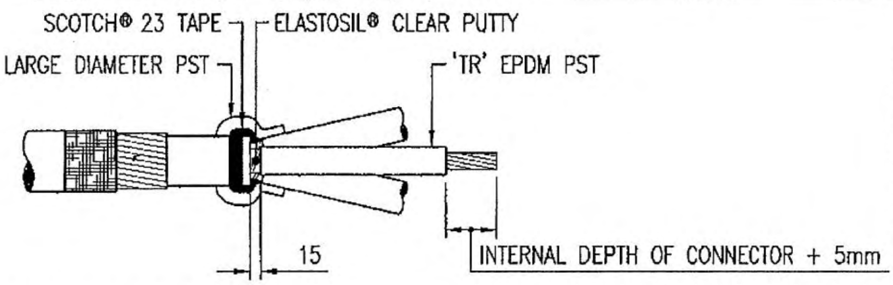
KIT No.	DIM 'X'	DIM 'Y'
92-AV 610-3	460	670
92-AV 620-3	460	670
92-AV 630-3	510	740



PAPER CABLE

23.1 REMOVE CARBON PAPER 5mm FROM THE END OF THE LEAD SHEATH.
23.2 *** FOR PICAS CABLES CLEAN & ABRADE 120mm OF ALUMINIUM SHEATH. ***
23.3 SET CORES INTO POSITION, IF REQUIRED CROSS ON THE LONG SIDE.

FIG.24



USING COMPONENTS FROM THE PILCL KITS :-

24.1 SHRINK A LONG PST ON EACH CORE, START SHRINKING 15mm IN FRONT OF THE BELT PAPERS.
24.2 INSERT A WEDGE OF ELASTOSIL CLEAR PUTTY INTO THE CROTCH, ENSURE ALL VOIDS IN THE CROTCH ARE FILLED. USE APPROXIMATELY 1/4 OF THE PACK.
24.3 FLATTEN THE REMAINING ELASTOSIL INTO A PAD AND WRAP AROUND THE BELT PAPERS, EXTENDING 5mm ON THE LEAD/ALUMINIUM SHEATH TO THE CORE PST'S.
24.4 APPLY A LAYER OF 23 TAPE OVER THE PUTTY STARTING 5mm ON THE LEAD/ALUMINIUM SHEATH. APPLY WITH LOW TENSION, NO STRETCH.. APPLY A SECOND LAYER OF 23 TAPE WITH HIGH TENSION, HIGH STRETCH WORKING BACK TOWARDS THE LEAD/ALUMINIUM SHEATH.
24.5 SHRINK DOWN THE REMAINING PST OVER THE CROTCH AREA. COVERING THE 23 TAPE. ENSURE APPROXIMATELY 40mm OF LEAD IS LEFT EXPOSED, (90mm FOR ALUMINIUM SHEATH).
24.6 CUT THE PRIMARY INSULATION AND CORE PST TO THE DIMENSIONS ABOVE.

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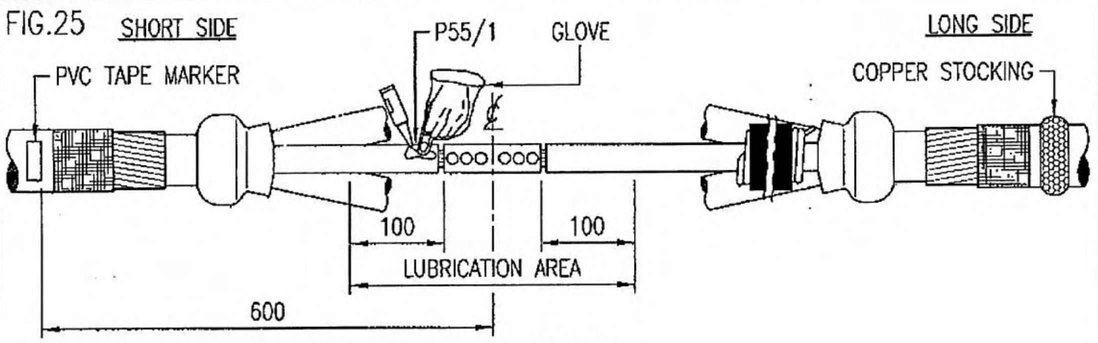
Figure 2.16: Installation Instruction

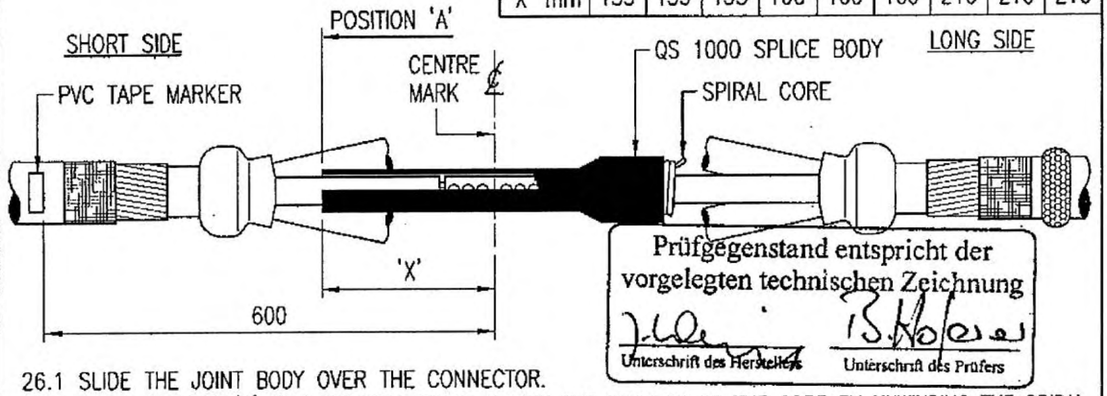
FIG.25



25.1 PARK COPPER STOCKING ON ONE SIDE OF THE JOINT.
25.2 CONNECT CORE USING THE APPROPRIATE CONNECTOR.
25.3 APPLY A LIBERAL AMOUNT OF P55/1 GREASE OVER THE LUBRICATION AREA AND CONNECTOR USING THE PROVIDED PLASTIC GLOVE.
25.4 PLACE A PVC TAPE MARKER ON THE CABLE SHEATH AT A DISTANCE OF 600mm FROM EACH CONNECTOR CENTRE.

FIG.26

mm²	50	70	95	120	150	185	240	300	400
'X' mm	155	155	155	160	160	160	210	210	210



26.1 SLIDE THE JOINT BODY OVER THE CONNECTOR.
26.2 USING POSITION 'A' AS A STARTING POINT, SHRINK THE BODY ON TO THE CORE BY UNWINDING THE SPIRAL.
26.3 ONCE THE BODY HAS BEEN SHRUNK PAST ITS CENTRE MARK, AND BEFORE IT HAS BEEN SHRUNK FULLY ACROSS THE CONNECTOR, ENSURE THAT THE BODY IS IN POSITION USING THE PVC TAPE AND CENTRE MARKERS. IF NOT CORRECTLY POSITIONED, MAKE CORRECTION BY DISPLACEMENT.

** PLEASE NOTE THAT THE SYMMETRICAL POSITION OF THE SPLICE BODY IS CRITICAL **

26.4 COMPLETE OTHER PHASES.

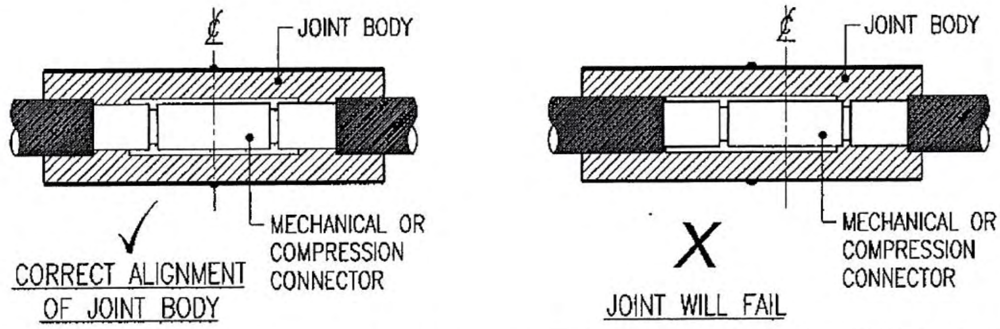


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Figure 2.17: Installation Instruction

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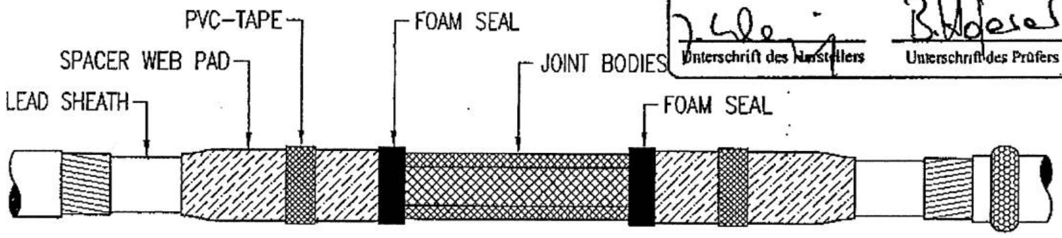
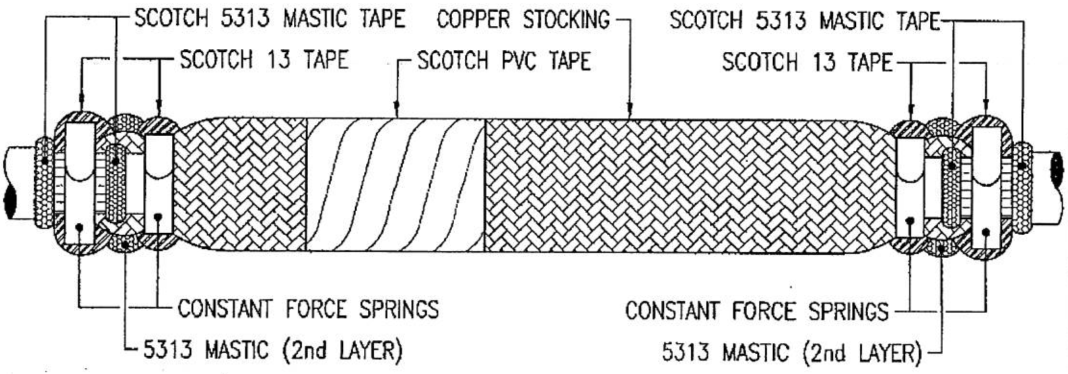
FIG.27 PAPER CABLE



27.1 FIT A FOAM SEAL AT BOTH ENDS OF THE SPLICE BODIES.

27.2 APPLY THE SPACER WEB PAD, BETWEEN THE LEAD SHEATH OF THE PAPER CABLE AND THE FOAM SEAL AND HOLD IN PLACE WITH TAPE OR STRING.

FIG.28 SHORT SIDE LONG SIDE



FOR PAPER TO PAPER JOINTS

SHORT SIDE

28.1 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOUR AND AT THE END OF THE CABLE JACKET. (FOR PICAS CABLES APPLY AT THE END OF THE CABLE JACKET ONLY.)

28.2 SLIDE THE COPPER STOCKING ACROSS THE JOINT AND CONNECT TO THE ARMOUR AND LEAD/ALUMINIUM SHEATH USING THE CONSTANT FORCE SPRINGS. USE THE SMALLER SPRING FOR THE LEAD/ALUMINIUM SHEATH.

28.3 PULL THE COPPER STOCKING ACROSS THE JOINT AND TAPE THE AREA OF THE JOINT BODIES WITH THE WIDE PVC TAPE. (TAPE BETWEEN FOAM SEALS.) DO NOT COVER THE AREA OF THE PAPER CABLE CROTCH.

LONG SIDE

28.4 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOUR AND AT THE END OF THE CABLE JACKET. (FOR PICAS CABLES APPLY AT THE END OF THE CABLE JACKET ONLY.)

28.5 CONNECT THE COPPER STOCKING TO THE ARMOUR AND LEAD/ALUMINIUM SHEATH USING CONSTANT FORCE SPRINGS. USE THE SMALLER SPRING FOR THE LEAD/ALUMINIUM SHEATH.

BOTH SIDES

28.6 COVER THE CONSTANT FORCE SPRINGS WITH SCOTCH 13 TAPE, APPLY IN THE SAME DIRECTION AS THE SPRINGS.

28.7 APPLY A LAYER OF THE MASTIC AT BOTH ENDS OF THE JOINT BETWEEN THE SHEATH AND ARMOUR, AND A SECOND LAYER OF 5313 MASTIC, SANDWICHING THE COPPER STOCKING.

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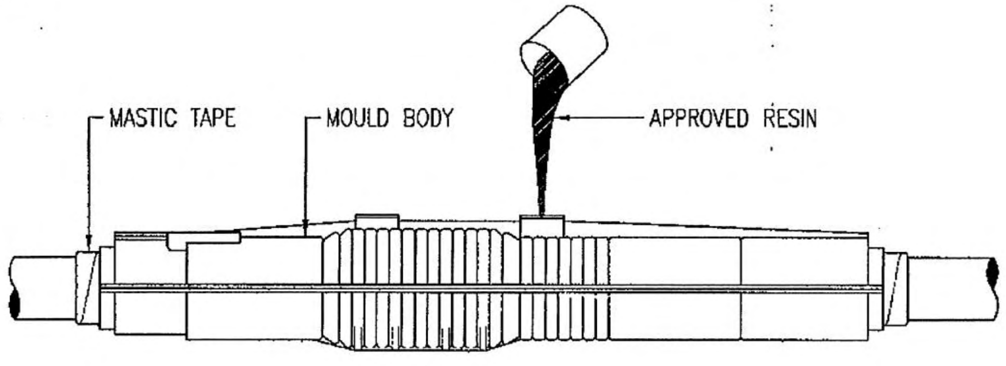
Figure 2.18: Installation Instruction

FIG.29



29.1 ABRADE CABLE SHEATH FOR 100mm BEYOND SHEATH OFF POSITION.
29.2 INSTALL THE MOULD CENTRALLY AROUND THE JOINT AND CLIP BOTH HALVES TOGETHER.
29.3 SEAL THE ENDS OF THE MOULD WITH MASTIC TAPE.
29.4 SUPPORT THE JOINT, MIX THE RESIN AND POUR INTO THE MOULD BODY.
29.5 DO NOT MOVE THE JOINT FOR AT LEAST TWO HOURS.

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Figure 2.19: Installation Instruction

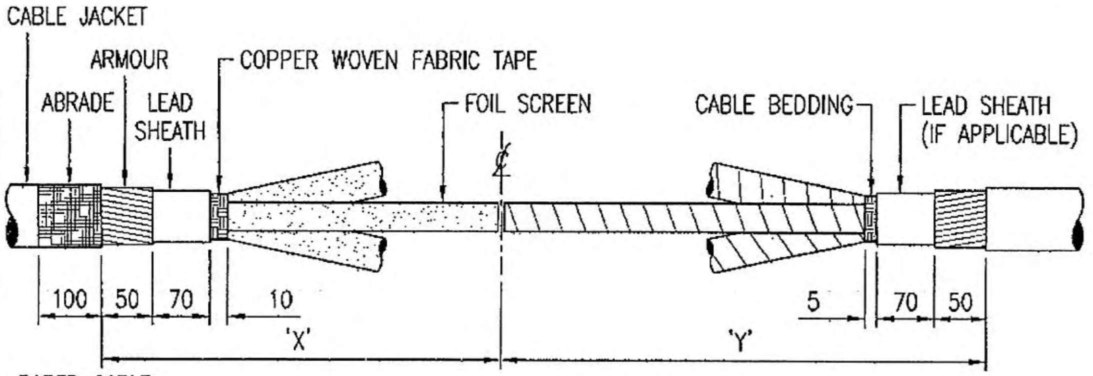
TRANSITION INLINE JOINT - SCREENED PAPER

NOTE:- *** A SCREENED PAPER MODULE IS REQUIRED ***
FOR TRANSITION JOINTS A BLOCKED CONNECTOR MUST BE USED AND THE DIMENSION OF THE BLOCK IN THE CONNECTOR MUST BE TAKEN INTO ACCOUNT. DIMENSIONS ARE TO THE "CENTRE OF THE JOINT".

KIT No.	DIM 'X'	DIM 'Y'
92-AV 610-3	460	650
92-AV 620-3	460	650
92-AV 630-3	510	740

FIG.30

PAPER CABLE (SHORT SIDE) POLYMERIC CABLE (LONG SIDE)



PAPER CABLE

30.1 SET CORES INTO REQUIRED POSITION, IF REQUIRED CROSS ON THE POLYMERIC SIDE.
*** IF XLPE CABLE HAS NO LEAD SHEATH, REMOVE THE BEDDING 5mm IN FRONT OF ARMOUR. ***

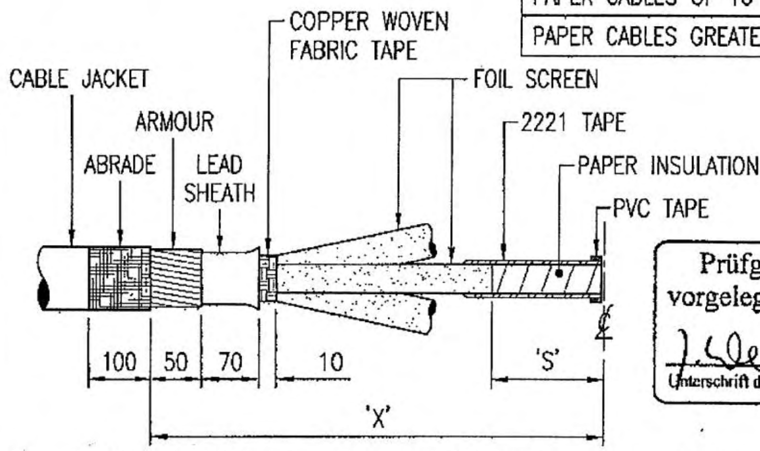
30.2 REMOVE COPPER WOVEN FABRIC TAPE AND WRAP BACK AGAINST LEAD/ALUMINIUM SHEATH FOR A MAXIMUM OF 10mm.

30.3 *** FOR PICAS CABLES CLEAN & ABRAID 120mm OF ALUMINIUM SHEATH. ***

FIG.31

PAPER CABLE (SHORT SIDE)

CABLE SIZE	'S'
	FOIL SCREEN
PAPER CABLES UP TO 185mm²	140
PAPER CABLES GREATER THAN 185mm²	190



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31.1 REMOVE FOIL SCREEN TO DIMENSION 'S'. ENSURE SMOOTH FINISH.

31.2 COMMENCING 10mm ON TO THE FOIL SCREEN APPLY 1 x ½ LAPPED LAYER OF LIGHTLY STRETCHED 2221 TAPE OVER THE EXPOSED PRIMARY INSULATION. (SECURE END WITH PVC TAPE.)

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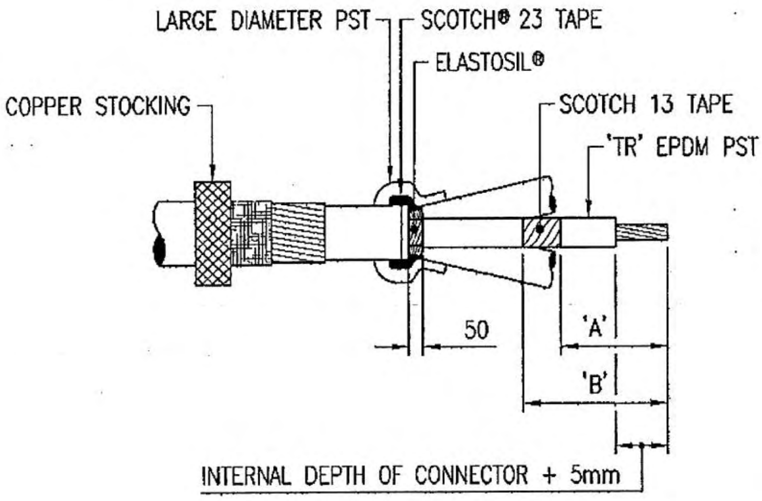
Figure 2.20: Installation Instruction

FIG.32

13 TAPE LENGTH		
	DIM 'A'	DIM 'B'
PAPER CABLES UP TO 185mm²	130	180
PAPER CABLES GREATER THAN 185mm²	180	230

PAPER CABLE (SHORT SIDE)



32.1 SHRINK THE LONGER EPDM PST TUBES ON EACH CORE. COMMENCE SHRINKING 50mm IN FRONT OF THE LEAD/ALUMINIUM SHEATH.
32.2 INSERT A WEDGE OF ELASTOSIL CLEAR PUTTY INTO THE CROTCH AS WELL AS IN BETWEEN THE CORES USING ONE QUARTER OF THE PACK.
32.3 FLATTEN THE REMAINING ELASTOSIL TO FORM A PAD AND WRAP IT AROUND THE CABLE CROTCH, EXTENDING FROM THE LEAD/PICAS SHEATH TO CORE PST'S, (5mm ON TO EACH).
32.4 WRAP 2 LAYERS OF SCOTCH 23 TAPE OVER THE ELASTOSIL, FIRST LAYER WITH LOW TENSION, SECOND LAYER WITH HIGHER TENSION, STARTING 5mm ON THE LEAD/PICAS SHEATH.
32.5 SHRINK DOWN THE LARGER DIAMETER PST. COMMENCE SHRINKING 10mm ON THE LEAD/PICAS SHEATH.
32.6 CUT THE PRIMARY INSULATION AND CORE PST TO GIVEN DIMENSION (ALLOWING FOR BLOCK IN CONNECTOR).
32.7 WRAP TWO HALF LAPPED LAYERS OF 13 TAPE, STARTING AT DIMENSION 'B' UP TO DIMENSION 'A' AND BACK AGAIN. ENSURE TAPE IS HIGHLY STRETCHED WHEN APPLIED AND THAT THE WRITING IS 'FACE UP'.
32.8 COMPLETE ON OTHER 2 CORES.
32.9 PARK THE COPPER STOCKING ON THE PAPER CABLE.

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Figure 2.21: Installation Instruction

POLYMERIC CABLE LONG SIDE PREPARATION

KIT No.	'A' DIM
92-AV-610-3	130
92-AV-620-3	130
92-AV-630-3	180

FIG.33

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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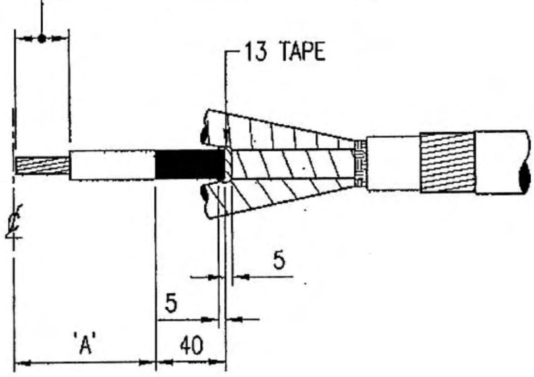
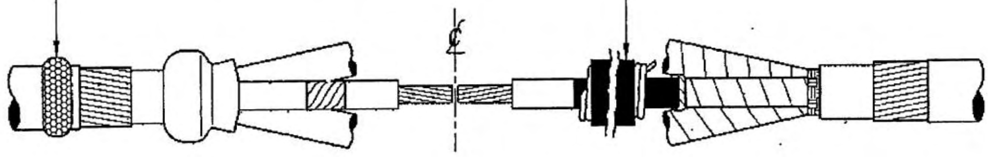


33.1 PREPARE CABLE AS PER DIMENSIONS SHOWN. SET CORES AND ALLOW FOR CROSS WHERE APPLICABLE.
33.2 FIX THE COPPER TAPE SCREEN WITH HIGHLY STRETCHED BINDER OF SCOTCH 13 TAPE AS SHOWN.

FIG.34



34.1 WORKING ON ONE PHASE AT A TIME COMPLETE THE FOLLOWING :-
34.2 PARK THE QS 1000 SPLICE BODY.

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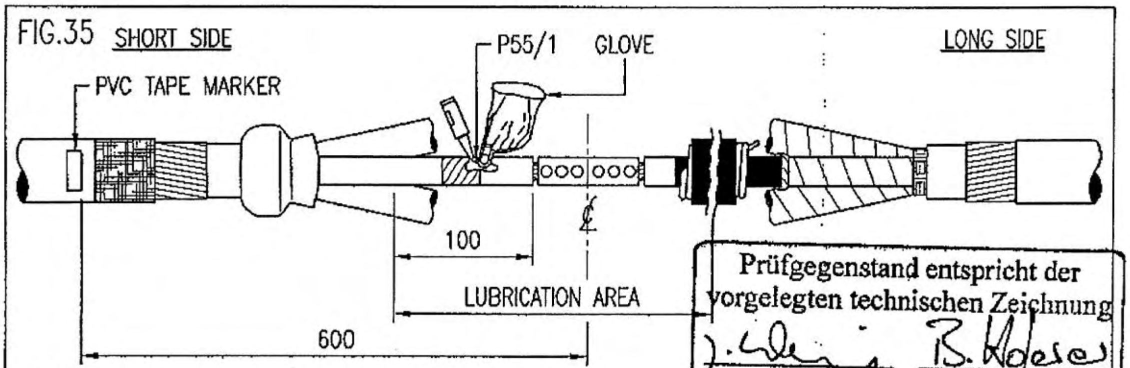
Figure 2.22: Installation Instruction

FIG.35



Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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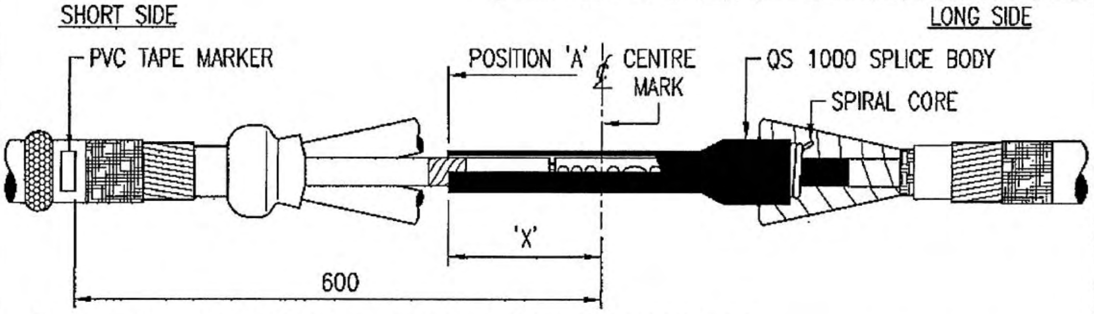
35.1 CONNECT CORE USING APPROPRIATE CONNECTOR.
35.2 APPLY A LIBERAL AMOUNT OF P55/1 OVER THE END OF THE SEMI-CONDUCTIVE LAYER, ON TO THE EXPOSED PRIMARY INSULATION AND CONNECTOR USING THE PROVIDED PLASTIC GLOVE.
35.3 PLACE A PVC TAPE MARKER ON THE CABLE SHEATH AT A DISTANCE OF 600mm FROM THE CONNECTOR CENTRE.

FIG.36

mm^2	50	70	95	120	150	185	240	300	400
'X' mm	155	155	155	160	160	160	210	210	210



36.1 SLIDE THE JOINT BODY OVER THE CONNECTOR, UP TO POSITION 'A'.
36.2 USING POSITION 'A' AS A STARTING POINT, SHRINK THE BODY ON TO THE CORE BY UNWINDING THE SPIRAL.
36.3 ONCE THE BODY HAS BEEN SHRUNK PAST ITS CENTRE MARK, AND BEFORE IT HAS BEEN SHRUNK FULLY ACROSS THE CONNECTOR, ENSURE THAT THE BODY IS IN POSITION USING THE PVC TAPE AND CENTRE MARKERS. IF NOT CORRECTLY POSITIONED, MAKE CORRECTION BY DISPLACEMENT.

*** PLEASE NOTE THAT THE SYMMETRICAL POSITION OF THE SPLICE BODY IS CRITICAL ***

36.4 COMPLETE OTHER PHASES.

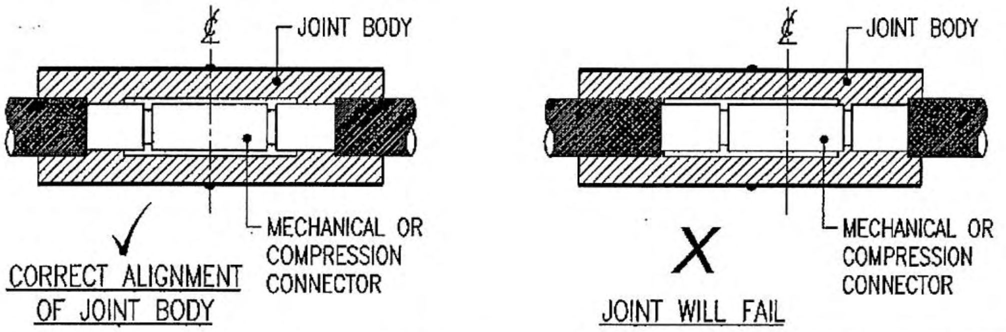


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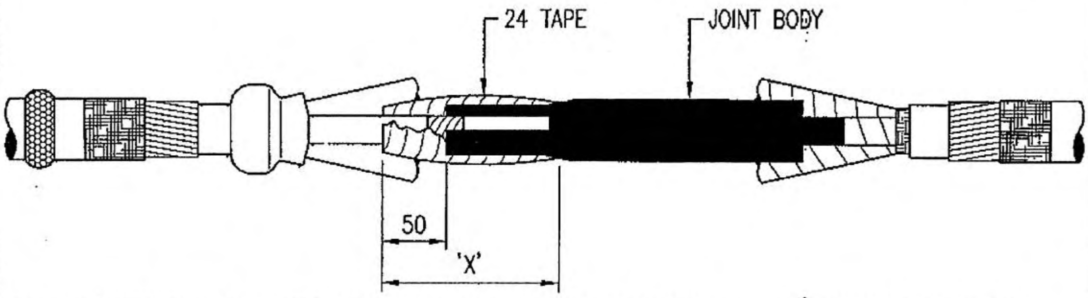
Figure 2.23: Installation Instruction

FIG.37

CABLE SIZE	DIM 'X'
PAPER CABLES UP TO 185mm²	130
PAPER CABLES GREATER THAN 185mm²	180



37.1 COMMENCING 50mm FROM THE EDGE OF THE JOINT BODY WRAP 1 x HALF LAPPED LAYER OF 24 TAPE FOR A LENGTH 'X' mm UP ON TO THE JOINT BODY AND TIE OFF.
37.2 COMPLETE FOR OTHER PHASES.

FIG.38

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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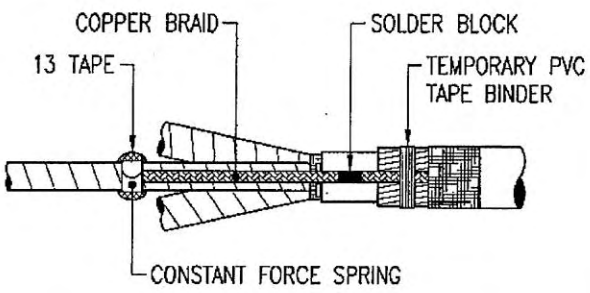
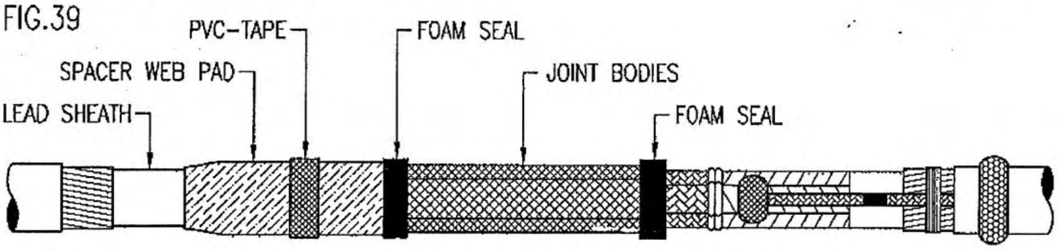


38.1 ATTACH 3 COPPER BRAIDS TO COPPER TAPE SCREENS WITH CONSTANT FORCE SPRINGS AND WITH A TEMPORARY PVC TAPE BINDER TO THE WIRE ARMOURS. ENSURE SOLDER BLOCK IS POSITIONED BEYOND THE ARMOURS, (TRIM OFF ANY EXCESS BRAID).
38.2 OVERTAPE CONSTANT FORCE SPRINGS WITH HIGHLY STRETCHED 13 TAPE APPLIED IN THE SAME DIRECTION AS THE SPRINGS.

FIG.39



39.1 FIT A FOAM SEAL AT BOTH ENDS OF THE SPLICE BODIES.
39.2 APPLY THE SPACER WEB PAD, BETWEEN THE LEAD/ALUMINIUM SHEATH OF THE PAPER CABLE AND THE FOAM SEAL AND HOLD IN PLACE WITH TAPE OR STRING.

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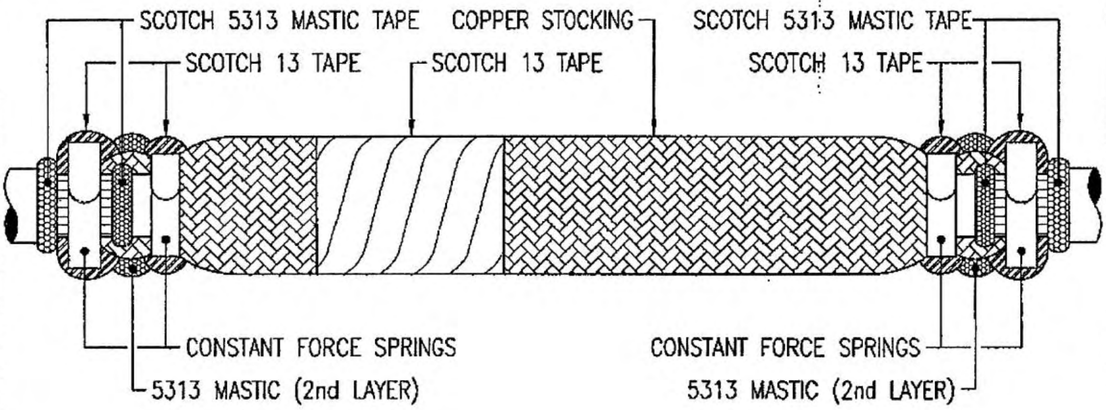
Figure 2.24 Installation Instruction

SHORT SIDE LONG SIDE

FIG.40



FOR TRANSITION JOINTS

PAPER CABLE

40.1 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOURS AND AT THE END OF THE CABLE JACKET. (FOR PICAS CABLES APPLY AT THE END OF THE CABLE JACKET ONLY.)

40.2 SLIDE THE OVERALL COPPER STOCKING ACROSS THE JOINT. CONNECT THE COPPER STOCKING TO THE LEAD/ALUMINIUM SHEATH USING THE SMALLER CONSTANT FORCE SPRING. CONNECT THE COPPER STOCKING TO THE ARMOUR USING THE LARGER CONSTANT FORCE SPRING.

40.3 PULL THE COPPER STOCKING ACROSS THE JOINT AND TAPE THE AREA OF THE JOINT BODIES WITH THE 13 TAPE, TO SECURE COPPER STOCKING TO 24 TAPE ON THE JOINT BODIES (TAPE BETWEEN FOAM SEALS.) DO NOT COVER THE AREA OF THE PAPER CABLE CROTCH.

XLPE CABLE WITHOUT LEAD SHEATH

40.4 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOURS AND AT THE END OF CABLE JACKET.

40.5 CONNECT THE COPPER STOCKING TO THE ARMOUR USING CONSTANT FORCE SPRING.

XLPE CABLE WITH LEAD SHEATH

40.6 APPLY A LAYER OF 5313 MASTIC AT THE END OF THE ARMOURS, LEAD SHEATH AND AT THE END OF THE CABLE JACKET.

40.7 CONNECT THE COPPER STOCKING TO THE ARMOUR AND LEAD SHEATH USING CONSTANT FORCE SPRINGS.

BOTH SIDES

40.8 COVER THE CONSTANT FORCE SPRINGS WITH SCOTCH 13 TAPE, APPLY IN THE SAME DIRECTION AS THE SPRINGS.

40.9 APPLY A LAYER OF MASTIC AT BOTH ENDS OF THE JOINT BETWEEN THE SHEATH AND THE ARMOUR, AND A SECOND LAYER OF 5313 MASTIC, SANDWICHING THE COPPER STOCKING.

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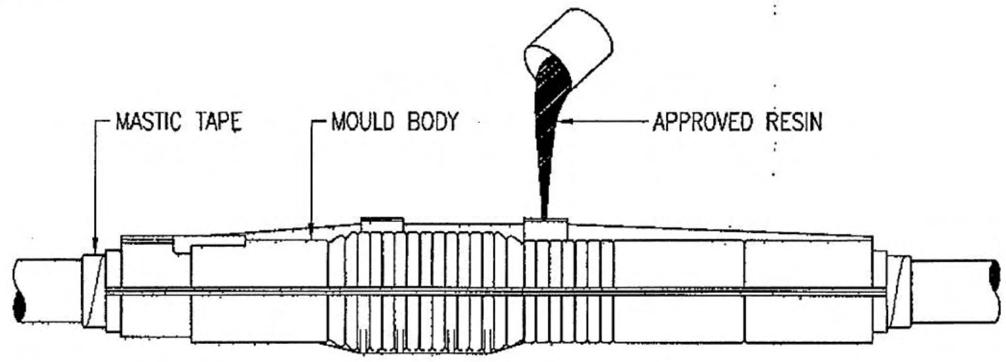
Figure 2.25: Installation Instruction

FIG.41



41.1 ABRADE CABLE SHEATH FOR 100mm BEYOND SHEATH OFF POSITION.
41.2 INSTALL THE MOULD CENTRALLY AROUND THE JOINT AND CLIP BOTH HALVES TOGETHER.
41.3 SEAL THE ENDS OF THE MOULD WITH MASTIC TAPE.
41.4 SUPPORT THE JOINT, MIX THE RESIN AND POUR INTO THE MOULD BODY.
41.5 DO NOT MOVE THE JOINT FOR AT LEAST TWO HOURS.

Prüfgegenstand entspricht der vorgelegten technischen Zeichnung

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Figure 2.26: Installation Instruction

3M Electrical Markets Division — **Kit Contents List**

Component Description	Kit Reference 92-AV610-3	92-AV620-3	92-AV630-3
Installation Drawing	1	1	1
Contents List	1	1	1
QS1000 Splice Body AP11	3		
QS1000 Splice Body AP12		3	
QS1000 Splice Body AP13			3
25mm2 Copper Stocking 600mm pieces	3	3	3
Copper Stocking 50mm2 x 1400mm	1	1	
Copper Stocking 50mm2 x 1600mm			1
Constant Force Spring P62	6		
Constant Force Spring P63		6	
Constant Force Spring P64			6
Constant Force Spring P65	4	4	
Constant Force Spring P66			4
Foam Seals	2	2	2
13 Tape 19mm Roll	1	1	1
Plastic Gloves	3	3	3
5313 Mastic 2m Piece	1	1	1
P55/1 Lubricant	3	3	3
1700P Temflex Tape	1	1	1
White Plastic Rubbish Bag	1	1	1

Connector

Mechanical Type
50-240 Pfisterer

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Figure 2.27: KIT Content

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HD 629.1 S2:2006

Annex A
(informative)

Identification of test cable
(see 5.1)

Rated voltage U_0/U (U_m): kV 6,35/11 (12)

Construction: ☐ 1-core ☒ 3-core ☒ Individually screened ☐ Overall screen

Conductors: ☐ Al ☒ Cu

☒ Stranded ☐ Solid

☒ Circular ☐ Shaped

☐ 120 mm² ☐ 150 mm² ☒ 185 mm²

Other cross-section: mm²

Insulation: ☒ XLPE

☐ EPR ☐ HEPR

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Insulation screen: ☐ Bonded ☒ Strippable

Metallic screen: ☐ Wire ☒ Tape ☐ Extruded

Armour: ☒ Wire ☐ Tape

Oversheath: ☒ PVC ☐ PE (state type)

Water blocking, if any: ☐ Within conductor ☐ Under oversheath

Diameters:

- Conductor 16,6 mm
- Insulation 24,5 mm
- Insulation screen 26,4 mm
- Oversheath 69 mm

Cable marking: CABLE L0317 2007
ELECTRIC CABLE 11000 V BS 6622

Figure 2.28: Cable data sheet

Tests: Test volume, chronological order and requirements conform to CENELEC HD 629.1 S2 02/2006 test sequence B1 and B2, table 5. The PD-test was performed at 2 V_0. The tests were carried out in accordance with the test methods described in IEC 61442 03/2005.

Test sequence B1:

Pos. 1. *DC voltage withstand test*
$V = 6\ V_0 = -38$ kV ; t =15 min

Pos. 2. *AC voltage withstand test*
$\hat{v}/\sqrt{2} = 4{,}5\ V_0 = 28.5$ kV; t = 5 min

Pos. 3. *Partial discharge test*
$\hat{v}/\sqrt{2} = 2{,}0\ V_0 = 12.5$ kV ; PD $\leq$ 10 pC

Pos. 4. *Impact test at ambient temperature*

Pos . 5. *Impulse voltage withstand test at elevated temperature*
lightning impulse voltage, $\hat{v} = 95$ kV;
positive and negative polarity each 10 impulses

Pos. 6. *Electrical heat cycling in air*
each loading cycle had a 5 hour heating period and a 3 hour no-load cooling period;
Continuous AC-test voltage: $\hat{v}/\sqrt{2} = 16$ kV
number of cycles: 63

Pos. 7 *Electrical heat cycling in water*
each loading cycle had a 5 hour heating period and a 3 hour no-load cooling period;
Continuous AC-test voltage: $\hat{v}/\sqrt{2} = 16$ kV
number of cycles: 63

Pos. 8 *Partial discharge test at ambient temperature and elevated temperature*
$\hat{v}/\sqrt{2} = 2{,}0\ V_0 = 12.5$ kV ; PD $\leq$ 10 pC

Pos .12 *Impulse voltage withstand test,*
lightning impulse voltage; $\hat{v} = 95$ kV; positive and negative polarity each 10 impulses

Pos. 13 *AC voltage withstand test*
$\hat{v}/\sqrt{2} = 2{,}5\ V_0 = 16$ kV; t = 15 min

Test sequence B2:

Pos. 1. *DC voltage withstand test*
$V = 6\ V_0 = -38$ kV ; t =15 min

Pos. 2. *AC voltage withstand test*
$\hat{v}/\sqrt{2} = 4{,}5\ V_0 = 28.5$ kV; t = 5 min

Pos. 9. *Thermal short circuit test, screen*
$I_{Sc} = 1.7$ kA; 2 shots

Pos. 10. *Thermal short circuit test, conductor*
$\theta_{Sc} = 250°C$; 2 shots

Pos. 11. *Dynamic short circuit test*
$I_d = 80$ kA; 1 shot

Pos .12. *Impulse voltage withstand test*
lightning impulse voltage, $\hat{v} = 95$ kV;
positive and negative polarity each 10 impulses

Pos. 13 *AC voltage withstand test*
$\hat{v}/\sqrt{2} = 2{,}5\ V_0 = 16$ kV; t = 15 min

3 Assembly

Final assembling of the joints was executed in the high-voltage laboratory of the IEH by technicians of 3M Deutschland GmbH.

Figure 3.1: Joint.

4 Test Setups

4.1 DC Voltage Withstand Test

The DC-voltage was generated according to Figure 4.1. The voltage measurement was carried out with an ohmic-capacitive divider (ratio 2000:1). The measurement uncertainty was 3%.

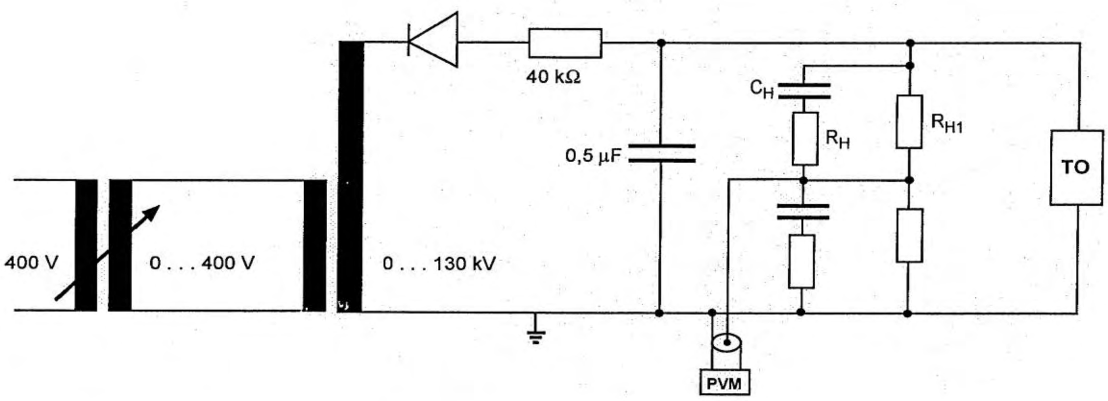

Figure 4.1: Scheme of DC voltage test circuit.
R_H = 3,6 kΩ, R_{H1} = 360 MΩ, C_H = 180 pF, ratio 2.000:1, PVM: Peak Voltmeter TO: Test object, measurement uncertainty 3%

4.2 AC Voltage Withstand Test

The test voltage was generated by an 18-kVA transformer. The voltage measurement was carried out with a capacitive divider (C_H = 180 pF; ratio = 2.000) and a peak voltmeter calibration $\hat{v} / \sqrt{2}$.

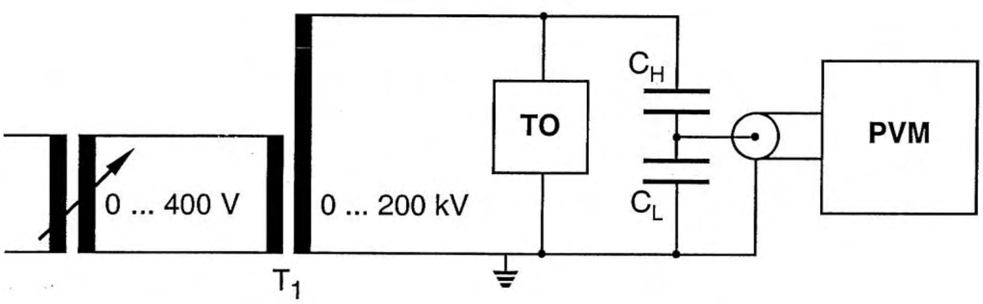

Figure 4.2: Scheme of AC test circuit
T_1 : transformer 400V / 200000V ; 18 kVA ; v_K = 3,5 % ; 50 Hz
C_H: 180 pF ; ratio 2000:1 ; PVM : Peak-Voltmeter
TO: Test object; measurement uncertainty 3 %

4.3 Partial-Discharge Test

The PD-measurement was performed with an analog bridge according to *Kreuger*, Figure 4.3. External PDs producing common mode signals at the detector are rejected by the differential amplifier. Internal PDs represent differential mode signals and are amplified. The background noise level at 12.5 kV_{rms} was 1.0 pC.

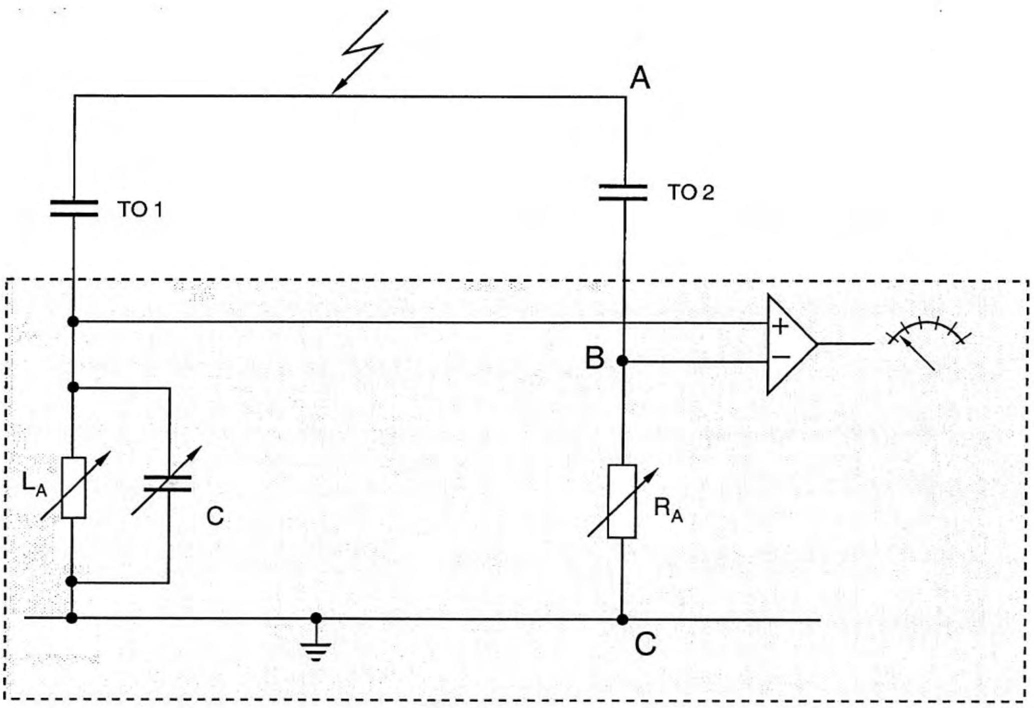

Figure 4.3: Scheme of PD test circuit
TO1: Test object 1
TO2: Test object 2

For balancing the bridge a calibrating impulse with q_A = 10.000 pC is applied between the terminals A (high-voltage) and C (ground) and the amplifier output is minimized. A pulse between the terminals A and C corresponds to an external PD. For the calibration a PD pulse, q_A = 10 pC, is applied between A and B. Subsequently, the amplifier output of the PD measuring unit is adapted to the applied pulse.

Starting from zero the AC-voltage was steadily raised up to 14.1 kV and kept constant for 60 s, then slowly reduced to 12.5 kV including pd-reading.

4.4 Impact Test at ambient temperature

For impact testing the joint was put into a box which was filled with sand to the horizontal centre of the joint. A mass of 4 kg with a fin consisting of a radius of 2mm and an angle of 90° was falling down from a height of 1,0 m striking to the joint horizontal and a right angular to the axis of the joint.

One impact each was placed to the ends of the joints and the connector.

Prior to the impact test the insulation resistance between the conductor and the metal screen was measured by means of a current-voltage measurement. The current was measured by means of a series resistor (100.000 Ω) and a digital multimeter. For the test a dc voltage of 500 V was applied.
Measurement uncertainties: current measurement: 1%
voltage measurement: 1%.

After the impact test the joints were placed in a tank of water for 24 h and the insulation resistance was measured once again.

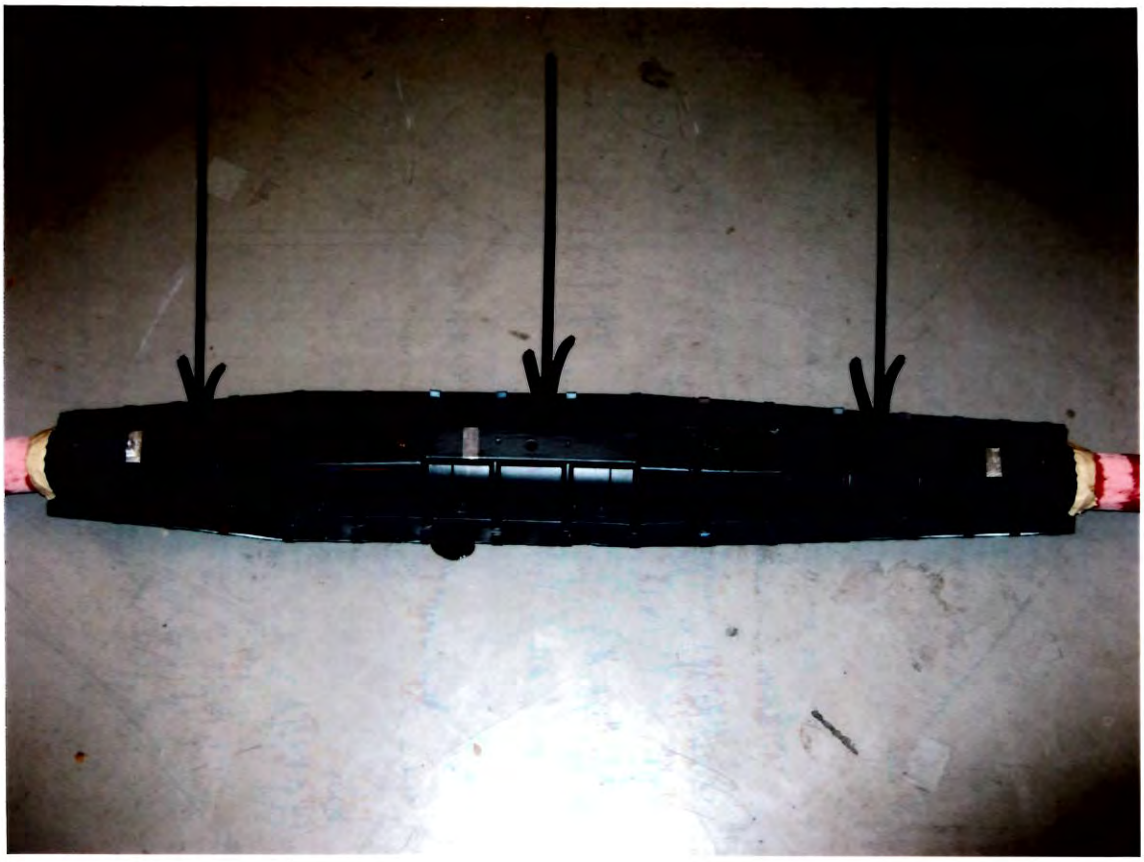

Figure 4.4: Placement of the strikes

4.5 Impulse Voltage Withstand Test

For impulse testing was used a two-stage Marx generator (Haefely) with a maximum cumulative charging voltage of V = 400 kV and a maximum impulse energy of E_{max} = 20 kWs. At this test, the capacity of the energy storage capacitor was C_S = 0.25 µF. The crest value of the impulse voltage was measured by a damped capacitive divider and a subsequent impulse peak voltmeter (Haefely). The front time and the time to half value were evaluated from the oscillographs.

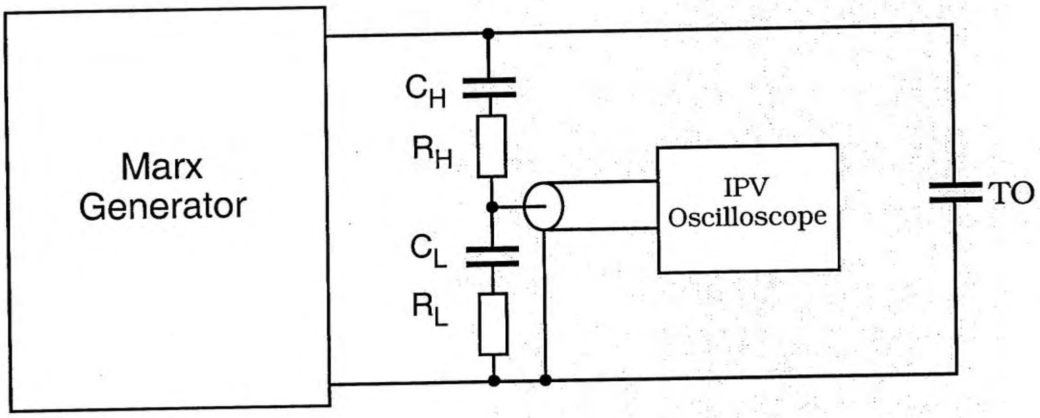

Figure 4.5: Scheme of impulse voltage test circuit
C_H: 1200 pF ; R_H = 70 Ω ; ratio: 3225;
IPV: impulse-peak-voltmeter (Haefely) – measurement uncertainty 3%
Oscilloscope: Tektronix TDS 3044 B – measurement uncertainty 2%

The waveform parameters were determined at reduced charging voltage.

Positive impulse, phase 1:	T_1 = 3.17 µs	T_2 = 48.8 µs
Negative impulse, phase 1:	T_1 = 2.97µs	T_2 = 49.8 µs
Positive impulse, phase 2:	T_1 = 2.87 µs	T_2 = 48.2 µs
Negative impulse, phase 2:	T_1 = 3.07 µs	T_2 = 48.4 µs
Positive impulse, phase 3:	T_1 = 2.97 µs	T_2 = 49.8 µs
Negative impulse, phase 3:	T_1 = 3.03 µs	T_2 = 49.0 µs

4.6 Electrical Heat Cycling in Air

The test objects must be heated by a current which provides the permitted service temperature of the tested cable plus 5 K - 10 K, that means 95°C - 100°C, for XLPE-cable. The heating current I was determined with a dummy cable. The same cable as used for the test, with a length of 3 m, was drilled with a diameter of 0.8 mm up to the conductor. The temperature was measured with a thermo couple NiCr-Ni. The measurement uncertainty was ± 2 K.

The heating current was 530 A. Current inception was accomplished by a transformer (V_1 = 400 V; V_2 = 20 V) which used the cable as secondary winding. The current was measured by an current transformer, 1500/5, and a digital multimeter. The measurement uncertainty was 1%.

4.7 Electrical Heat Cycling in Water

The test objects were placed in a tank and filled with water. The height of the water was 1000 mm above the test object. The conductivity of the water at 20°C was 63 mS/m.

4.8 Thermal Short Circuit Test, Conductor

According IEC 986 for Cu with q = 185 mm^2 $I^2t = 1091.4 \cdot 10^6$ A^{2}s with θ_{sc} = 250°C and θ_i = 25°C. That means $I_K(1s)$ = 33.04 kA. The short-circuit during test was I_K = 17.35 kA, resulting in a short-circuit duration of t_K = 3.65 s.The test object was tested with two three-phase thermal short-circuit currents. Between two tests the specimen cooled down to ambient temperature. The current was measured by means of a current transformer 50000:2 A burdened with an 1 Ω-Manganin resistor. The output signal of the current transformer was recorded by a digital storage oscilloscope (Tektronix 2430 A). The measurement uncertainty was 2%.

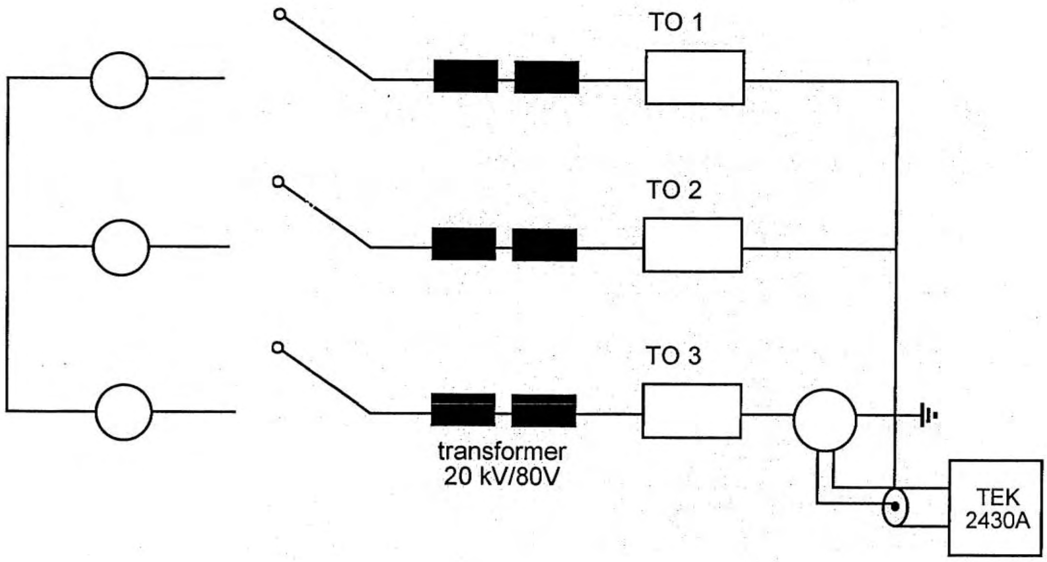

Figure 4.8.1: Scheme of short-circuit test.

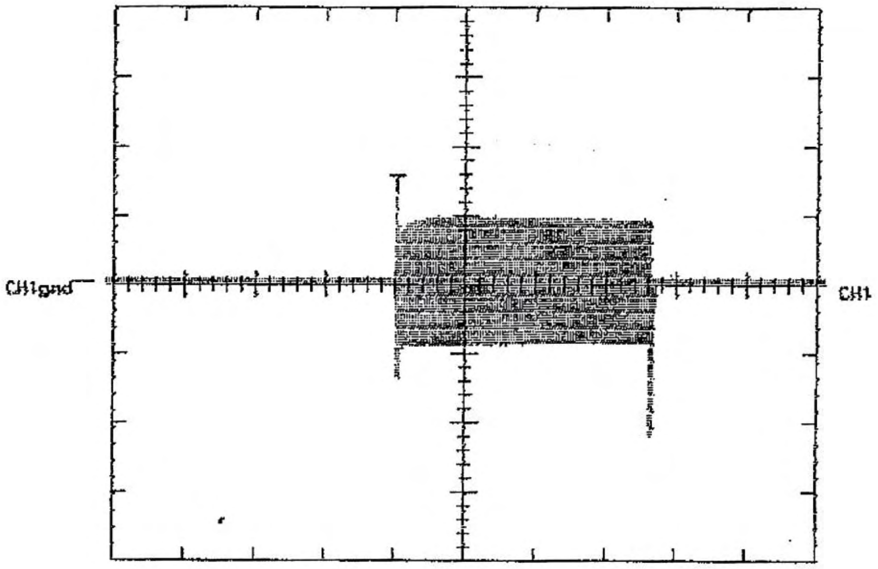

Figure 4.8.2: Short circuit current.
Hor: 1 s/Div; Vert: 25kA/Div

4.9 Thermal Short Circuit Test, screen

The test circuit was the same already described in 4.8 with reduced voltage for the high-current transformer and in single-phase operation. Before starting the short circuit test, the cable was heated by means of current inception of the conductor up to 95°C - 100°C conductor temperature. The short circuit current was I_K = 1.73 kA; t_K = 1.00 s.

4.10 Dynamic Short-Circuit Test

The test was performed at accredited Test Lab FGH at Mannheim. Figure 4.10.1 shows the test setup, Figure 4.10.2 the currents in all phases.

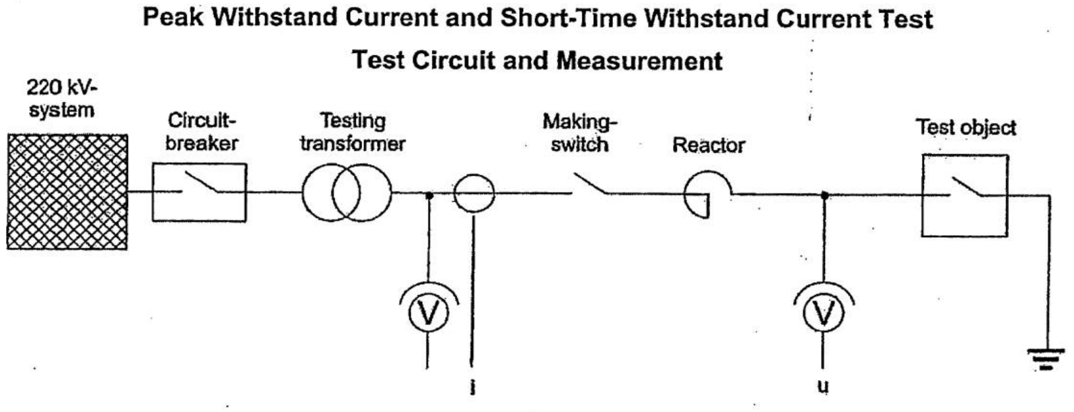

Figure 4.10.1: Dynamic short circuit current

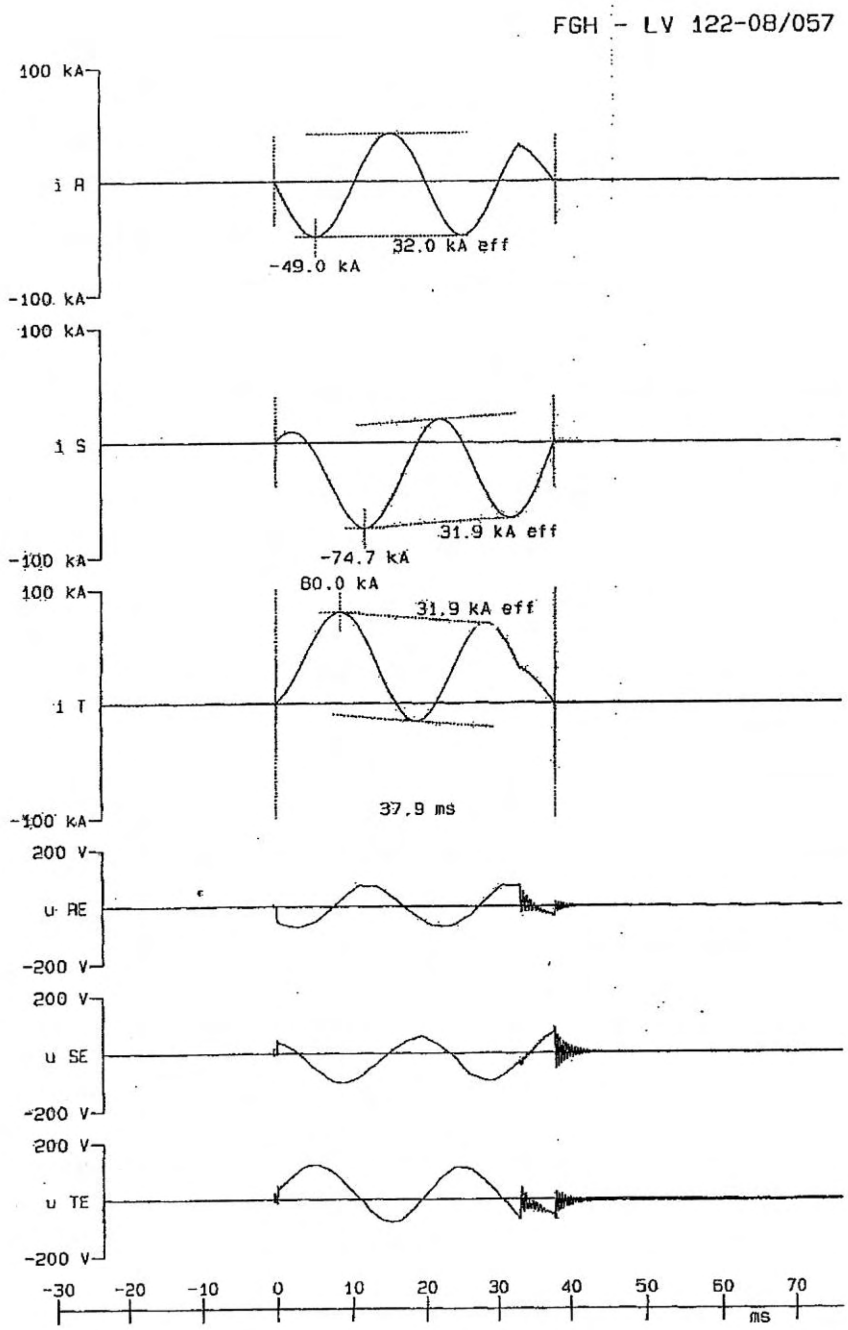

Figure 4.10.2: Currents in all phases

5 Results

5.1 Test Sequence B1

5.1.1 DC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 15.04.2008

Test voltage: V = - 38 kV ; t = 15 min

With each test object neither flashover nor breakdown occurred at the test objects during the DC voltage withstand test.

The test was passed successfully.

5.1.2 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 15.04.2008

Test voltage: $\hat{v}/\sqrt{2}$ = 28.5 kV , t = 5 min

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

The test was passed successfully.

5.1.3 Partial Discharge Test

This test was carried out as described in 4.

Test date: 15.04.2008

Voltage: $\hat{v}/\sqrt{2}$ = 14.1 kV ; t = 60 s thereafter
$\hat{v}/\sqrt{2}$ = 12.5 kV with pd reading

PD magnitude (12.5 kV): < 10 pC

The test was passed successfully.

5.1.4 Impact Test at Ambient Temperature

This test was carried out as described in 4.

Test date: 16.04. - 17.04.2008

Insulation resistance: before impact test: > 1000 MΩ
after impact test: > 1000 MΩ

The test was passed successfully.

5.1.5 Impulse Voltage Withstand Test at elevated temperature

This test was carried out as described in 4.

Test date:	23.04.2008
Test voltage:	$\hat{v} = 95$ kV
Heating current:	I = 530 A; t = 5 h
Number of tests:	10 positive polarity, 10 negative polarity, each phase

Neither flashover nor breakdown occurred at the test objects during all lightning impulse voltage withstand tests.

The test was passed successfully.

5.1.6 Electrical Heat Cycling in Air

This test was carried out as described in 4.

Test date:	25.04. - 16.05.2008
Test voltage:	$\hat{v}/\sqrt{2} = 16$ kV
Heating current:	I = 530 A
Cycle:	5 h heating; 3 h cooling
Number of cycles:	63

Neither flashover nor breakdown occurred.

The test was passed successfully.

5.1.7 Electrical Heat Cycling in Water

This test was carried out as described in 4.

Test date:	17.05.-07.06.2008
conductivity:	63 mS/m
Test voltage:	$\hat{v}/\sqrt{2} = 16$ kV
Heating current:	I = 530 A
Cycle:	5 h heating; 3 h cooling
Number of cycles:	63
Heath of water:	1000 mm

The test was passed successfully.

5.1.8 Partial Discharge Test

5.1.8.1 Partial Discharge Test at ambient temperature

This test was carried out as described in 4.

Test date:	14.06.2008
Voltage:	$\hat{V}/\sqrt{2}$ = 14.1 kV; t = 60 s thereafter $\hat{V}/\sqrt{2}$ = 12.5 kV with pd reading
PD magnitude (12.5 kV):	< 10 pC

The test was passed successfully.

5.1.8.2 Partial Discharge Test at elevated temperature

This test was carried out as described in 4.

Test date:	14.06.2008
Heating current:	I = 530 A, t = 5 h
Voltage:	$\hat{V}/\sqrt{2}$ =14.1 kV; t = 60 s thereafter $\hat{V}/\sqrt{2}$ = 12.5 kV with pd reading
PD magnitude (12.5 kV):	< 10 pC

The test was passed successfully.

5.1.9 Impulse Voltage Withstand Test

This test was carried out as described in 4.

Test date:	14.06.2008
Test voltage:	$\hat{V}$ = 95 kV
Number of tests:	10 positive polarity, 10 negative polarity, each phase

Neither flashover nor breakdown occurred at the test objects during all lightning impulse voltage withstand tests.

The test was passed successfully.

5.1.10 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 14.06.2008

Test voltage: $\hat{v}/\sqrt{2} = 16$ kV , t = 5 min

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

The test was passed successfully.

5.2 Test Sequence B2

5.2.1 DC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 15.04.2008

Test voltage: V = - 38 kV ; t = 15 min

With each test object neither flashover nor breakdown occurred at the test objects during the DC voltage withstand test.

The test was passed successfully.

5.2.2 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date: 15.04.2008

Test voltage: $\hat{v}/\sqrt{2} = 28.5$ kV , t = 5 min

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

The test was passed successfully.

5.2.3 Thermal Short Circuit, Screen

This test was carried out as described in 4.

Test date:	26.05.2008
current:	I_K = 1.73 kA
	t_K = 1.00 s
heating current	I = 530 A
number of stresses:	2

The test was passed successfully.

5.2.4 Thermal Short Circuit, Conductor

This test was carried out as described in 4.

Test date:	27.05.2008
current:	I_K = 17.35 kA
	t_K = 3.65 s
number of stresses:	2
time between stresses:	2h

The test was passed successfully.

5.2.5 Dynamic Short Circuit

This test was carried out as described in 4.

Test date:	02.06.2008
current:	I_d = 80.0 kA
	t_d = 37.9 ms

The test was passed successfully.

5.2.6 Impulse Voltage Withstand Test

This test was carried out as described in 4.

Test date:	12.06.2008
Test voltage	$\hat{v} = 95$ kV
number of tests:	10 positive polarity, 10 negative polarity, each phase

Neither flashover nor breakdown occurred at the test objects during all lightning impulse voltage withstand tests.

The test was passed successfully.

5.2.7 AC Voltage Withstand Test

This test was carried out as described in 4.

Test date:	12.06.2008
Test voltage:	$\hat{v}/\sqrt{2} = 16$ kV , t = 15 min

With each test object neither flashover nor breakdown occurred at the test objects during the AC voltage withstand test.

The test was passed successfully

6 Conclusion

The joints, type 92-AV 620-3 for three core cables from 3M Deutschland GmbH passed all tests described in clause 2 successfully. The test objects fulfilled the requirements according CENELEC HD 629.1 S2 02/2006, Table 5, test sequences B1 and B2.

Karlsruhe, 22.07.2008

Dr.-Ing. R. Badent
Bereichsleiter HPT

Dr.-Ing. B. Hoferer
stellv. Bereichsleiter HPT