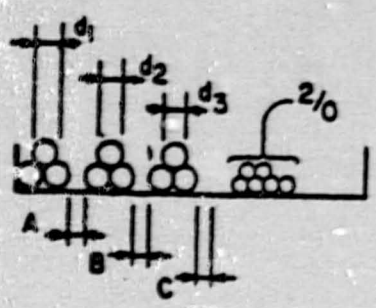
ATTACHMENT 1

SYSTEM	DIVISION OF SEPARATION	BACKGROUND COLOR	CABLE OR RACEWAY SUFFIX
Engineered safety features (ESF), essential supporting auxiliary systems (ESAS) and Class IE diesel generator power systems	Train A Train B	Orange Brown	A B
For safety-related equipment which requires or supplies redundant power sources	Special	Gold	S
(Post accident monitoring)			
PAM 1 PAM 2	1 2	Purple Green	J K
Reactor protection system (RPS), and Class IE vital AC and DC distribution systems	Channel I Channel II Channel III Channel IV	Red Black Blue Yellow	D E F G
Normal offsite pwr sypply Alt offsite pwr supply		White White	P R
Nondivisional		White	

ATTACHMENT 2

MINIMUM CABLE SPACING



A = $\frac{d_1}{2}$ or $\frac{d_2}{2}$, whichever is larger.

B = $\frac{d_2}{2}$ or $\frac{d_3}{2}$, whichever is larger.

C = $\frac{d_3}{2}$

ATTACHMENT 3

PULL TENSION BREAK-LINK (ROPES) SIZES AND TENSION TABLE

Size of Conductor	Max Tension per Conductor	Manila++ Rope Dia	Tensile Strength
1000 MCM	8000 lbs	7/8 in.	7700
750 MCM	6000 lbs	3/4 in.	5400
500 MCM	4000 lbs	9/16 in.	3450
450 MCM	3600 lbs	9/16 in.	3450
400 MCM	3200 lbs	1/2 in.	2650
350 MCM	2800 lbs	1/2 in.	2650
0000 AWG	1693 lbs	7/16 in.	1550
000	1342 lbs	5/16 in.	1000
00	1064 lbs	5/16 in.	1000
0	885 lbs	1/4 in.	600
1	670 lbs	1/4 in.	600
2	531 lbs	3/16 in.	450
4	334 lbs	+	
6	210 lbs	+	
8	133 lbs	+	
10	83 lbs	+	
12	52 lbs	+	
14	33 lbs	+	
16	20 lbs	+	
18	13 lbs	+	

+Use fish line or twine with known pull test less than maximum tension given.

++Reliable break-links of known break strength may be used in place of the break ropes.

NOTE: Break ropes shall be tested in accordance with MGL-E1.

ATTACHMENT 6

INSTALLATION FACTOR FOR CABLE BENDING RADII

CABLE USE	COMMERCIAL OR TVA TYPE LETTERS	INSTALLATION FACTOR		
		OD 1.0" AND LESS	OD ABOVE 1.0" AND UP TO 2.0"	OD OVER 2.0"
POWER, CONTROL (UNSHIELDED)	PX PN CPJJ SROJJ PXJ PNJ CPJ SROAJ PXOAJ PJ CPJJ SROAJH THHN PJJ CPMJ XHHW AF SROJ TW	4	5	6
POWER, CONTROL (SHIELDED)	EPSJ EPSU CPSJ SRSJ	12	12	12
SWITCHBOARD (UNSHIELDED)	SIS HTS S	4	-	-
SIGNAL, COAXIAL, TRIAXIAL, TELEPHONE, THERMOCOUPLE (SHIELDED)	MS YPS RG/U MXPS YMPS MXPSJ YMPOS MAUS YMPJ YMPSS	12	12	12

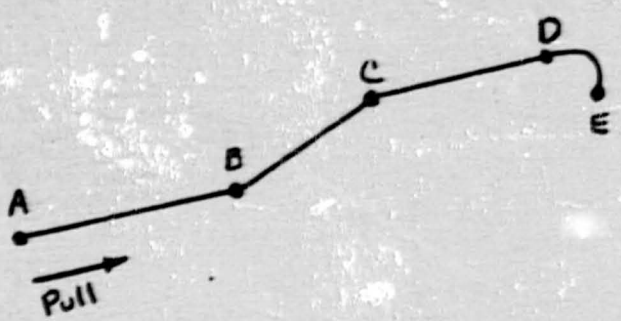
The minimum bend radii are based on ICEA Standards S-19-81, S-66-524, and S-68-516.

ATTACHMENT 5

TYPICAL EXAMPLE FOR CALCULATING THE EXPECTED PULLING FORCE (T) AND EXPECTED SIDEWALL PRESSURE (SWP)

This figure shows the conduit configuration on which the calculations are based. A figure or sketch is not required for the calculations provided the conduit data such as lengths and bends are presented in a form that will convey the configuration of the conduit. It is assumed the pull is to begin at point A and terminate at point E (no intermediate pull points).

Typical Conduit Configuration



3-inch conduit located at A7N/713

A to B - Straight section, 75 feet long
B to C - Inclined section, 35 feet long, 30° angle
C to D - Straight section, 40 feet long
D to E - 90° horizontal bend

*

ATTACHMENT 7

SHIELDED MEDIUM VOLTAGE POWER CABLES

Cable Manufacturer	Minimum Training Radius (inches)						
Cable Size	6 AWG(3/C)	2/0 AWG	4/0 AWG	300 MCM	400 MCM	500 MCM	750 MCM
Okonite Company (4.4 x cable OD)	3.6[1]	4.91	5.89	5.76	6.64	6.68	7.59
Collyer Insulated Wire (8.0 x cable OD)	N/A	9.10	N/A	N/A	11.48	12.00	N/A
Anaconda-Ericsson, Incorporated (8.4 x cable OD)	N/A	8.39	N/A	N/A	N/A	11.75	N/A
Rome Cable Corp. (10.9 x cable OD)	N/A	12.00	N/A	N/A	N/A	N/A	N/A
Essex Group (7 x cable OD)	N/A	N/A	N/A	N/A	10.77	N/A	N/A
General Cable (7 x cable OD)	N/A	N/A	N/A	10.24	N/A	N/A	N/A
Triangle-Plastic Wire and Cable (7 x cable OD)	N/A	7.21	8.05	N/A	9.45	10.00	11.97

[1]Includes section 4.4 criteria for multiconductor cable.

Page 5 of 5

DATA SHEET 1
CABLE INSTALLATION SHEET

5.1 Cable No.: _-____-____-____-__ Revision: _____ CONTRACT # _____

☐ Associated Cable ☐ Power or Control Cable ☐ Shielded Cable
☐ CSSC Cable ☐ Instrumentation Cable ☐ Non-Shield Cable
☐ Non-CSSC

Mark No.:_____ Size:_____ AWG/MCM Conds: _____ Routed Lgth: _____ ft

"FROM" Equip ID: _____ Location: _____
"TO" Equip ID: _____ Location: _____
FOR: _____ ECN: _____

Conduit: _____
Tray: _____

CABLE INSTALLATION

Reel No.: _____ Contract No: _____
Cable O.D.: _____ inches
Minimum Pulling Radius: _____ inches Minimum Training Radius: _____ inches
Start ft. mark: _____ Stop ft. mark: _____ Installed Lgth: _____
Rope Pull Device ID: _____ Dynamometer ID: _____ Cal Due Date: _____
Cable Installed By: _____ / _____
Craft Foreman Date

Pulling Force and SWP Calculations Performed By: _____ / _____
Cognizant Engineer Date

QC INSPECTIONS

6.1.2 Material: _____ / _____
QC Inspector Date

6.1.3 Lubricant: _____ / _____
QC Inspector Date

6.1.4 Routing: _____ / _____
QC Inspector Date

6.1.5 Bending Radius: _____ / _____
QC Inspector Date

6.1.6 Pull Force: _____ / _____
QC Inspector Date

6.1.7 Separation: _____ / _____
QC Inspector Date

6.1.8 Cable Support: _____ / _____
QC Inspector Date

6.1.9 Penetration: _____ / _____
QC Inspector Date

6.1.10 Identification: _____ / _____
QC Inspector Date

Remarks: _____

DATA SHEET 1
CABLE INSTALLATION SHEET

5.1 Cable No.: __-____-___-____-__ Revision: ____.____

☐ Associated Cable ☐ Power or Control Cable ☐ Shielded Cable
☐ CSSC Cable ☐ Instrumentation Cable ☐ Non-Shield Cable
☐ Non-CSSC

Mark No.:_____ Size:_____ AWG/MCM Conds: _____ Routed Lgth: _____ ft

"FROM" Equip ID: _____ Location: _____
"TO" Equip ID: _____ Location: _____
FOR: _____ ECN: _____

Conduit: _____
Tray: _____
_____
_____

CABLE INSTALLATION

Reel No.: _____ Contract No: _____
Cable O.D.: _____ inches
Minimum Pulling Radius: _____ inches Minimum Training Radius: _____ inches
Start ft. mark: _____ Stop ft. mark: _____ Installed Lgth: _____
Rope Pull Device ID:_____ Dynamometer ID:_____ Cal Due Date _____
Cable Installed By: _____/_____
Craft Foreman Date
Pulling Force and SWP Calculations Performed By: _____/_____
Cognizant Engineer Date

QC INSPECTIONS

6.1.2 Material: _____/_____
QC Inspector Date

6.1.3 Lubricant: _____/_____
QC Inspector Date

6.1.4 Routing: _____/_____
QC Inspector Date

6.1.5 Bending Radius: _____/_____
QC Inspector Date

6.1.6 Pull Force: _____/_____
QC Inspector Date

6.1.7 Separation: _____/_____
QC Inspector Date

6.1.8 Cable Support: _____/_____
QC Inspector Date

6.1.9 Penetration: _____/_____
QC Inspector Date

6.1.10 Identification: _____/_____
QC Inspector Date

Remarks: _____
_____
_____

DATA SHEET 2
SINGLE CABLE PULLING FORCE CALCULATION SHEET

Cable No.: __-____-___-____-__

(1) Single Conductor Cable

☐ Shielded
☐ Unshielded

Conductor cmil area = _____

Vendor supplied pull force = _____ pounds

Calculated pull force = (0.008) (cmil)

= _____ pounds

The maximum allowable pull force is _____ lbs.

(2) Multiconductor Cable

☐ Shielded
☐ Unshielded

Smallest conductor cmil area = _____

Number of conductors (N) = _____

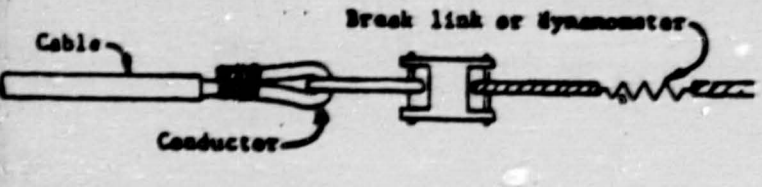
Vendor supplied pull force = _____ pounds

Calculated pull force = (0.008) (N) (cmil)

The maximum allowable pull force is _____ lbs.

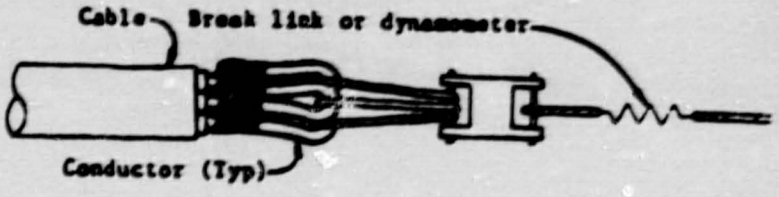
Single Conductor Cable

Loop on the End of the Conductor

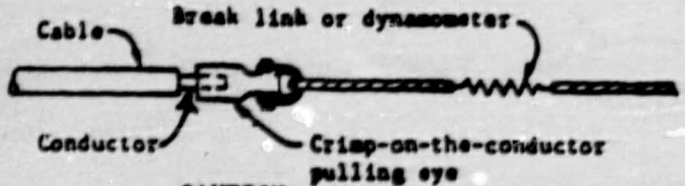


Multiconductor Cable

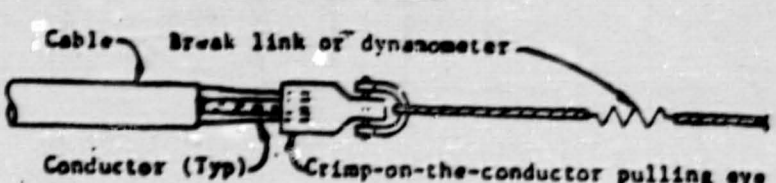
Loop on the End of the Conductor



Crimp-on-the-Conductor Pulling Eye

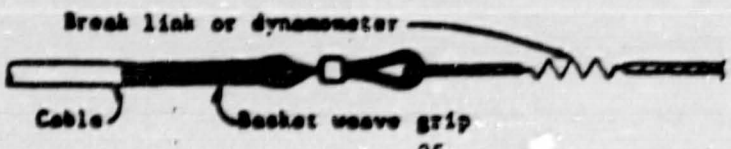


Crimp-on-the-Conductor Pulling Eye



CAUTION: When a basket weave grip is used, revise maximum allowable pull forces as outlined in section 4.5.2.

Basket Weave Grip



DATA SHEET 3
GROUP CABLE PULLING FORCE CALCULATION SHEET

Cable Number	Type of Cable Pwr or Cont	Instr	Single Cable Pull Force (lbs)
			Total

(1) Power or Control Cables

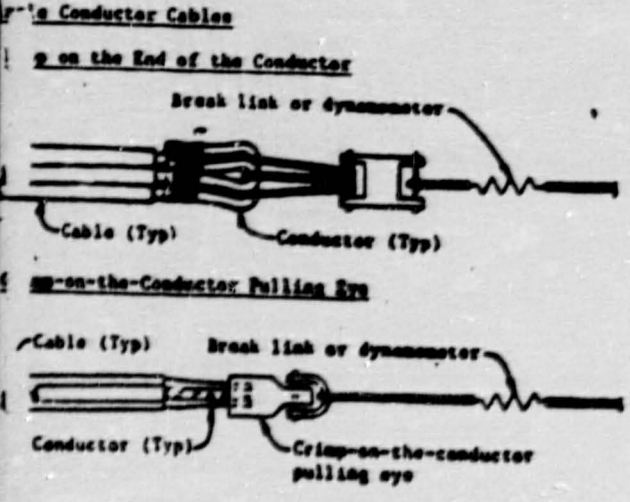
Maximum allowable pull force = 80% of total single cable pull forces

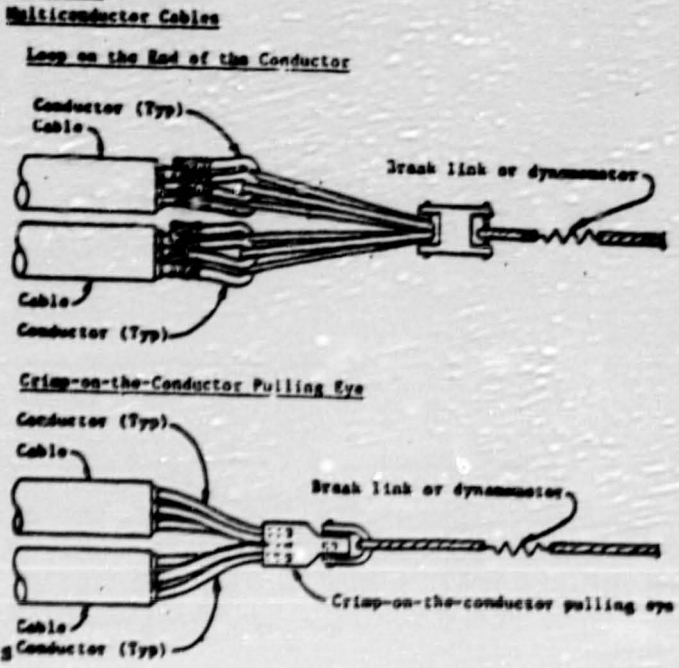
= _____ pounds

(2) Instrument Cables

Maximum allowable pull force = 60% of total single cable pull forces

= _____ pounds





CAUTION: When a basket weave grip is used, revise maximum allowable pull forces as outlines in section 4.5.2.

DATA SHEET 4

SIDEWALL PRESSURE AND EXPECTED PULLING FORCE CALCULATION SHEET

Cable No.: ___-____-___-____-__

Field configuration for conduit ____-____-____-____-___

SINGLE CABLE PULL ☐ PULLBY ☐

GROUP CABLE PULL ☐ PULLBACK ☐

DATA SHEET 5
CABLE PULLBACK SHEET

Cable No.: __-____-___-____-__ Revision: _____

☐ Associated Cable ☐ Power or Control Cable ☐ Shielded Cable
☐ CSSC Cable ☐ Instrumentation Cable ☐ Non-Shield Cable
☐ Non-CSSC

Mark No.: _____ Size: _____ AWG/MCM Conds: _____

"Pullback" Equip ID: _____ Location: _____

"Pullback" Conduit: _____

"Pullback" Tray: _____

_____

Reason for "pullback": _____

_____

CABLE PULLBACK

Cable O.D.: _____ inches Measuring Device ID: _____ Cal Due Date _____

Minimum Pulling Radius: _____ inches Minimum Training Radius: _____ inches

Rope Pull Device ID: _____ Dynamometer ID: _____ Cal Due Date _____

Cable "Pullback" By: _____ / _____
Craft Foreman Date

Pulling Force and SWP Calculations Performed By: _____ / _____
Cognizant Engineer Date

QC INSPECTIONS

6.1.3 Lubricant: _____ / _____
QC Inspector Date

6.1.4 Routing: _____ / _____
QC Inspector Date

6.1.5 Bending Radius: _____ / _____
QC Inspector Date

6.1.6 Pull Force: _____ / _____
QC Inspector Date

6.1.10 Identification: _____ / _____
QC Inspector Date

Remarks: _____

_____

_____

DATA SHEET 6
CABLE REPULL SHEET

Cable No.: __-____-___-____-__ Revision: _____

☐ Associated Cable ☐ Power or Control Cable ☐ Shielded Cable
☐ CSSC Cable ☐ Instrumentation Cable ☐ Non-Shield Cable
☐ Non-CSSC

Mark No.:_____ Size:_____ AWG/MCM Conds: _____

"Repull" Equip ID: _____ Location: _____

"Repull" Conduit: _____

"Repull" Tray: _____

_____

Reason for "Repull": _____

_____

CABLE REPULL

Cable O.D.: _____ inches

Minimum Pulling Radius: _____ inches Minimum Training Radius: _____ inches

Rope Pull Device ID:_____ Dynamometer ID:_____ Cal Due Date _____

Cable "Repull" By: _____ / _____
Craft Foreman Date

Pulling Force and SWP Calculations Performed By: _____ / _____
Cognizant Engineer Date

QC INSPECTIONS

6.1.3 Lubricant: _____ / _____
QC Inspector Date

6.1.4 Routing: _____ / _____
QC Inspector Date

6.1.5 Bending Radius: _____ / _____
QC Inspector Date

6.1.6 Pull Force: _____ / _____
QC Inspector Date

6.1.7 Separation _____ / _____
QC Inspector Date

6.1.8 Cable Support _____ / _____
QC Inspector Date

6.1.9 Penetration _____ / _____
QC Inspector Date

6.1.10 Identification: _____ / _____
QC Inspector Date

Remarks: _____

_____

_____

DATA SHEET 7

CABLE TRAY NODE NUMBERS		COVER REMOVED			COVER REINSTALLED		
FROM	TO	CRAFTSMAN	FOREMAN	DATE	CRAFTSMAN	FOREMAN	DATE

DATA SHEET 8

CABLE/WIRE REPAIR SHEET

Cable No.: ___-_____-_____-_____-___ MR: _____

Conductor No./Color: _____

Location: _____

Description and Reason for Damage: _____

_____

_____

_____

Repair Damage per Section _____

Engineer: _____ / _____
Signature Date

Work Performed by: _____
Craftsmen

Inspected by: _____ / _____
QC Inspector Date

DATA SHEET 9

SPARE CABLE INSTALLATION SHEET

Spare Cable No.: 0 - SP-285-_____-___ Revision: _____

Mark No.: _____ Size: _____AWG/MCM Conds: _____ Installed Lgth: _____ft

"From" Equip ID: _____ Location: _____

"To" Equip ID: _____ Location: _____

For: Cable originally pulled as ___-____-____-____-___, Rev. _____

Conduit: _____

Tray: _____

_____

_____

Reason for sparing cable: _____

_____

_____

Spare Cable Authorized By: _____ / _____
Cognizant Engineer Date

Spare Cable Installed By: _____ / _____
Craft Foreman Date

APPENDIX A

1.0 CABLE/WIRE REPAIRS

1.1 Precautions shall be taken to protect cables from damage. However, should damage occur, the cable shall be spliced per section 3.2.4 or replaced, or it may be repaired, depending on the extent of the damage. Repairs may be made to the jacket, shield, and insulation of low-voltage cables with the following restrictions:

a. If the conductor has been damaged, the cable shall be spliced (see section 3.2.4) or replaced.

b. Where the damage involves multiple components of low voltage cable (i.e., jacket, shield, and/or insulation), each component shall be repaired individually.

c. Repairs of coaxial and triaxial cable are limited to non-Class 1E applications only. Damaged Class 1E coaxial and triaxial cables shall be replaced.

1.2 For medium-voltage power cables, repairs may be made to the jacket only. If the damage extends beyond the jacket, the cable shall likewise be spliced (see section 3.2.4) or replaced. Unless otherwise indicated, repairs may be made on both Class 1E and non-Class 1E low-voltage and medium-voltage power cables.

1.3 Should damage occur during installation, the craft foreman shall document on the cable installation sheet where any repair has been made for Class 1E cables. Also, a cable tag containing the cable's unique identification shall be installed adjacent to the repaired area.

EXCEPTION

Cable tags are not required where minor repairs (see section 2.5 Appendix A) have been made on cables having a braided-type covering.

2.0 Cables Having Thermoplastic, Thermosetting, Rubber, or Rubber-Like Jackets and Insulations

2.1 General Requirements

In addition to the specific requirements associated with the use of a particulr cable repair option, the general requirements below shall be followed in making cable repairs:

a. Remove any foreign material or loosely attached portions of the damaged cable. Reposition and/or carefully trim any jagged edges which protrude above the surface contour of the area being repaired.

b. Clean the damaged area using denatured alcohol.

c. After completion, a cable tag, in accordance with section 1.3 shall be installed adjacent to the repair area.

2.2 Jacket Repairs

If a jacket repair is to be made, it shall be accomplished using one of the following options:

2.2.1 Option 1. Subject to the following conditions, AMP's Cold Shrink Tape may be used for jacket repairs of low-voltage cables to non-Class 1E applications. Jacket repairs for Class 1E cables shall be made using option 2 or option 3.

a. The tape shall not be used inside primary containment and other areas classified as having a harsh environment.

b. Use of the tape is restricted to repairing jacket damage which is discovered after the cable has been installed.

c. The tape shall not be used to repair the cable's jacket if the shield and/or insulation has also been damaged.

The following procedure shall be adhered to when repairing cable jackets using option 1:

Step 1 - See general requirements (section 2.1 of Appendix A).

Step 2 - Peel off the backing from the tape.

Step 3 - Stretch the tape to approximately three times its length and wrap under tension with approximately a 50 percent overlap.

Step 4 - The tape shall be applied to the cable for a minimum of 2-1/2 inches beyond the outermost bounds of the damaged area.

2.2.2 Option 2. A piece of Raychem heat shrinkable sleeving may be used to repair the outer jacket of both low-voltage and medium-voltage power cables. Slip the sleeving over one end and slide it along the cable to the area needing repair. Type N heat-shrinkable sleeving shall be used in all Class 1E applications and may be used in all non-Class 1E applications. Industrial grade heat-shrinkable sleeving may be used in all non-Class 1E applications.

The procedure outlined below shall be followed when using option 2 to repair cable jackets:

Step 1 - See general requirements (section 2.1 of Appendix A).

Step 2 - Select and install a piece of Raychem heat-shrinkable sleeving over the damaged jacket. Prior to shrinking, the sleeving shall be long enough to extend a minimum of 2-1/2 inches for Class 1E cables and 1-1/2 inches for non-Class 1E cables beyond the outermost bounds of the damaged area.

2.2.3 Option 3. Raychem type JRS, MRS, WRS, AND NJRS cable repair sleeves may be used to repair the outer jacket of low-voltage and medium-voltage power cables. Use of the JRS, MRS, and WRS cable repair sleeves is limited to non-Class 1E applications. NJRS cable repair sleeves shall be used on Class 1E cables when option 3 is selected to make cable repairs.

Step 1 - See general requirements (section 2.1 of Appendix A).

Step 2 - Apply a layer of Raychem Type N mastic in ribbon form, Raychem S-1024 or S-1119 red adhesive tape (approximately half-lapped) for a minimum of 2-1/2 inches for Class 1E cables and 1-1/2 inches for non-Class 1E cables beyond the outermost bounds of the damaged area.

EXCEPTION

Step 2 is not required when the repair is being made in a mild environment or if an NJRS cable repair sleeve is being used.

Step 3 - Select a properly sized Raychem type JRS, MRS, WRS, or NJRS cable repair sleeve and install according to the manufacturer's instructions, except that an electric heat gun shall be used instead of a torch with an open flame.

It shall be long enough to cover the Type N mastic applied in step 2.

2.2.4 Option 4. Although the least desirable method, the outer jacket of medium-voltage power cables may be repaired in the following manner to non-Class 1E applications.

Jacket repairs for Class 1E cables should be made using option 2 or option 3 only.

Step 1 - See general requirements (section 2.1 of Appendix A).

Step 2 - Cover damage areas with 3M Company Scotch 70 tape.

Step 3 - Cover Scotch 70 tape with Scotch 33+ tape.

Step 4 - Apply friction tape over Scotch 33+ tape.

Step 5 - Cover Friction tape with layer of Scotch 33+ tape.

Step 6 - To prevent the tape from unwinding, coat with a sealand and bonding compound, such as Scotchkote (available from 3M Company).

2.3 Shield Repairs

Repairing the shield of shielded low-voltage cables shall be accomplished in the following manner:

Step 1 - See general requirements (section 2.1 of Appendix A).

Step 2 - Remove the cable jacket and any binding tapes a minimum of 2 inches in each direction from the outermost bounds of the damaged shield area. Remove damaged section of shield and inspect insulation for damage. If the insulation has been damaged, make repairs as indicated in section 2.4 of Appendix A prior to repairing the shield.

Step 3 - Wrap the damaged shield area with a new shield (shield shall be the same type material as the damaged shield) 1-1/2 inches in each direction from the outermost bounds of the damaged area. Where applicable, splice the drain wire if it has been damaged or broken.

Step 4 - Apply 3M Company Scotch 33+ tape to each end of the shield to hold firmly in place.

Step 5 - Measure the dc resistance of the shield. A reading of 0.01 ohms per foot is acceptable. If the reading is above 0.01 ohms per foot, recheck step 4 to ensure that the new shield has good electrical contact with the existing shield. Remeasure the dc resistance. Refer to OE for evaluation if the value is still above 0.01 ohms per foot.

Step 6 - Complete by repairing the jacket in accordance with section 2.2 of Appendix A.

2.4 Insulation Repairs

Insulation repairs for low-voltage cables shall be accomplished by following the same procedure described in option 2 for jacket repairs (section 2.2 of Appendix A). Prior to making the repair, the damaged area shall be carefully inspected for conductor damage. If the conductor is damaged or the use of option 2 is not feasible,

the cable shall be spliced or replaced. After repairing the insulation, complete by repairing the shield (where applicable) and jacket in accordance with sections 2.2 and 2.3 of Appendix A, respectively.

2.5 Cables Having Braided-Type Coverings Over the Insulation

Minor scuffs or abrasions to braided-type coverings of cables shall be repaired by recoating. A modified silicon saturate (Compound No. 178-918-XMT, black, available from the Standard T Chemical Company, 2600 Rickman Terrace, Staten Island, New York 10303) may be applied to the abraded area of asbestos-covered cables. Other types of braided coverings such as aramid fiber o fiberglass may also be repaired using the same techniques and a compound recommended by the respective cable vendor and approved by OE. Tagging the cable with its unique identifier is not required for repairs of this type.

Where damage to the braided jacket is severe enough to expose the insulation, the cable shall be replaced or repaired in accordance with sections 1.0, 2.1, and 2.2.

3.0 The QC inspector shall inspect the cable repair to ensure the repair is performed as indicated on data sheet 8. Raychem inspection shall be made in accordance with the following:

3.1 Verify that the sleeves have not been underheated. Adhesive-coated sleeves shall show good adhesive flow at the ends of the shrunk sleeves. Adhesive flow indicates complete shrinking and satisfactory contact with the cable, ensuring a positive environmental seal. The sleeves should show a smooth and glossy appearance following the contour of the termination.

3.2 Verify that the sleeves are not overheated. Evidence of burning or blistering on the surface of the shrinkable sleeve indicates overheating. Any minor surface scorching that can be removed by solvent cleaning is acceptable. Tubing with deep blistering must be replaced.

3.3 Verify that the correct size sleeves as specified on the data sheets are applied.

APPENDIX B

SPARE CABLE PROGRAM

1.0 When a cable has been deleted by OE, or abandoned due to cable failure, or repulled with a new cable, the old cable should be removed as much as possible. If the cable cannot be removed it should be identified as a spare cable and the ends taped or capped off with a heat shrinkable cap.

1.1 Spared cables shall be tagged in the same manner as permanent cables with a cable number issued by the Modifications cable coordinator.

1.2 System 285 in the cable status master report contains all the spared cables that cannot be removed. OE uses this information to evaluate raceway loading requirements.

1.3 All spare cables shall be documented on data sheet 9. The Modifications cable coordinator will use the information furnished on this data sheet to update the cable status master report.

WATTS BAR NUCLEAR PLANT

MODIFICATIONS AND ADDITIONS INSTRUCTION

MAI-4

INSTALLATION AND INSPECTION OF CABLE TERMINATIONS

UNITS 1 AND 2

CURRENT REVISION LEVEL: 4

Responsible Section: Modifications

Prepared By: James E. Hoffert

Revised By: Behrouz Ahmadi

Submitted By: _____ Supervisor

PORC Review Date: 6/27/86

Approved By: _____ for Plant Manager

Date Approved: 6/27/86

Last page of this instruction: 51

1C	Doc Control Unit, LP4S 160D-C
	NRC
1C	NMRG, 710E, EB-C
1C	Plant Master File
	Plant Manager
	Supt (O&E)
	Supt (Maint)
	Plant Adm Svs Supv
	ASE Duty Station
	Building Services Supv
	Chem Lab
	Chem Engg Unit Supv
	Chief, Nuclear Safety Staff
	Chief, Nuclear Training Branch
	Chief, Quality Audits Branch
	Compliance Unit
	Component Engg & Svs Group
	DPSO-WBN
1C	Dwg & Vendor Manual Supv
1C	Elect Maint Supv
	Engg Section Supv
	Health Physics Supv
	Health Physics Lab
	Industrial Safety Supv
	Instr Maint Supv
	Instr Shop
	Materials Unit Supv
1C	Mech Maint Supv
	Mech Engg Unit Supv
1C	Modifications Manager
	Operating Instruction Coordinator
	Operations Supv
	Operations Training Sect Supv
	Operator Training Classroom
	P&S Supv
2C	Plant QA Supv
	Training Support Supv
	Power Stores Unit Supv
	Preop Test Supv
	Public Safety
	Reactor Engg Unit Supv
	Shift Engr's Office
	Staff Reference Copy
	Support Svs Supv
	Tech Support Center
	Unit 1 Control Rm
	Unit 2 Control Rm
1C	John Raulston, NEB, W10A63 C-K
	Site Director
	Watts Bar Tech Svs
	Design Svs Manager
1C	DCU 24-hour Station
1C	NSB - OC - Robert McKinney
2C	Modif. - Kent Fountain
1C	DCU - B - CC

HISTORY OF REVISION/REVIEW

REV. NO.	DATE	REVISED PAGES	REASON FOR CURRENT REVISION (INCLUDE ALL INSTRUCTION CHANGE NUMBERS)
0	02/14/84	All	Initial instruction
1	06/12/84	Cover Sheet	Revised cover sheet to include Field Quality Engineering review.
2	02/23/85	All	General revision
3	1/23/86	All	Incorporate TC-84-38. Delete reference Program Procedure TS.05.04.04 per approved waiver request (L65 850222 234) minor changes and clarification of terminal lug material allowed and added sections 6.1.1 and 6.1.2. Revised figure 6.1.1 to include plastic grip. Added changes per Const Spec G-38, Rev. 6 and SRN-G-38-6.
4	6/27/86	13, 35, 51	Clarify inspection requirements for momentary wire lifts made during modification.

1.0 PURPOSE

The purpose of this instruction is to outline the general criteria and inspection requirements for the termination of CSSC control, signal, and power cables.

2.0 SCOPE

This instruction applies to all Office of Engineering (OE) routed CSSC and non-CSSC electrical cables used in control, signal, and power circuits. For non-CSSC cables, QC inspections shall be performed by the craft foreman or cognizant engineer.

3.0 REFERENCES

3.1 Source Documents

3.1.1 General Construction Specification G-38, "Installing Insulated Cables Rated up to 15,000 Volts"

3.2 Other Documents

3.2.1 MAI-3, "Installation and Inspection of Insulated Control, Signal, and Power Cables"

3.2.2 MAI-9, "Bolting of Structural Steel and Electrical Connections"

3.2.3 MGL-E4, "Termination"

3.2.4 MGL-E3, "Medium-Voltage Cable Insulation Testing"

3.2.5 MIL-STD-454, Requirement 5, "Soldering"

3.2.6 AI-2.15, "Temporary Alteration"

4.0 GENERAL CRITERIA

4.1 Cable terminations shall generally be accomplished by means of ring tongue terminal lugs crimped onto the wires with tools that contain die stops to prevent overcrimping and a ratchet-type feature (where applicable) to prevent undercrimping. Vinyl, nylon, or Kynar (polyvinylidene fluoride, PVF_2) preinsulated or uninsulated ring tongue terminal lugs shall be used for wire size 10 AWG and smaller. Terminal lugs for wire size 8 AWG and larger shall be of the uninsulated type. Unless otherwise specified on design drawings, only the Kynar preinsulated or uninsulated terminal lugs shall be installed inside the primary containment. Parallel or butt splices may also be used in lieu of ring tongue terminals. Thomas and Betts Company, AMP Product Corporation, and Burndy Corporation are currently approved suppliers of terminal lugs and butt splices. Other suppliers may also be acceptable, but must likewise be approved by OE. Manufacturer's instructions are to be followed in the installation of cable accessories except where it conflicts with this instruction, then this instruction applies.

4.1.1 With the following exceptions, 2-hole copper compression-type terminal lugs shall be used to terminate No. 2 AWG and larger size field installed cables and may be used on smaller size cables. One-hole compression type terminal lugs may be used if the cable size is smaller than a No. 2 AWG and on larger size cables when:

(1) Space inside the termination compartment is not sufficient to permit the use of 2-hole lugs,

(2) Equipment is supplied with pigtails having vendor installed 1-hole lugs,

(3) Two-hole lugs are not available from the vendor, or

(4) Vendor equipment is supplied with contacts intended for use with 1-hole lugs.

4.1.2 Enlarging holes in terminal lugs or mismatching stud and terminal lug hole size is no longer permissible unless terminal lugs with the proper size holes are not available from the vendor. Terminal lugs shall be selected with holes which are compatible with the size of fastners or stud size required by the terminals on the device. Requests for deviations from this policy should be submitted to OE for evaluation on a case-by-base basis. To minimize the corrosion potential due to the protective coating being removed when holes are enlarged, a liberal application of Thomas and Betts (T&B) Kopr-Shield (or equivalent) shall be applied to the mating surfaces and bolts of terminal lugs or the terminal lug shall be retinned.

Where initial crimping is questionable recrimping of terminal lugs is acceptable (unless otherwise prohibited by the vendor of the lug) if the following conditions are met:

(1) The orientation of the recrimp shall be the same as that of the original crimp.

(2) The recrimping shall be done with a crimping tool which is properly calibrated.

(3) Each recrimped terminal shall be compared with a sample which has been installed with a properly calibrated tool. If the terminal lug installation compares favorably, then the recrimped terminal lug is considered acceptable. If the comparison is unfavorable, then the recrimped terminal shall be cut off and a new terminal lug shall be installed.

4.1.3 Exceptions to the preferred method of terminating conductors as described above are permissible in certain applications. These applications and the associated alternative methods of terminating cables are described below. Where applicable, torquing shall be accomplished in accordance with MAI-9.

(1) Communication Systems, provided the conductor size is no larger than No. 18 AWG, terminating may be accomplished by one of the following:

(a) By soldering when done in accordance with OE-approved procedures, manufacturer's soldering procedure, or MIL-STD-454, Requirement 5.

(b) By use of studs or terminal blocks on devices provided the conductor is coiled a minimum of 180 degrees around the stud or screw of the terminal block

(c) By use of any other industry accepted terminating method (such as quick connect and wire wrap terminals) provided the manufacturer's instructions are followed and appropriate tooling is used.

(2) Lighting System Branch Circuit Terminations
One-piece, self-insulated, screw-on electrical connectors in different sizes, UL approved for various wire combinations of 2 single-conductor No. 8 AWG and smaller shall be required for all splices and terminations. No terminating materials shall be required for terminals having pressure connectors on connections of No.10 AWG or smaller conductors to wiring devices or lighting fixtures having wire binding screws or studs and nuts having upturned lugs or equivalent.

(3) Low Voltage (600-Volt or Less) Equipment Having Solderless Pressure-Type Connectors. Terminations of conductors at equipment of this type shall be accomplished by removing the insulation and fillers, as required, from the end of the conductor and inserting the conductor into the connector.

(4) Components Having Termination Compartments Too Small to Permit the Use of Terminal Lugs (Such As Certain Types of Limit Switches). Termination of cables shall be made by coiling the conductors a minimum of 180 degrees around the terminal screw or stud.

4.2 Use of fasteners (bolts, nuts, washers, etc.) which meet a specific ASTM specification or have a particular thread type or size to connect the conductors to the component is not required as long as the fasteners used will permit torquing, where applicable.

All fasteners used on a particular termination shall be of the same material and shall be compatible with the material of the device terminals. This may be accomplished, for example, by using brass fasteners on copper or copper-alloy terminals. Unless otherwise prohibited or contrary to good construction practices, the same connection may be made using steel fasteners which have been plated or suitably treated to be corrosion resistant.

4.3 Wire strippers or electrician knives shall be used to prepare the cable for its termination. Care shall be exercised to ensure that all insulation layers or fillers are removed from the metallic conductors and that no conductor strands are clipped or nicked.

4.3.1 For cables with wire sizes No. 24 through No. 10 AWG the following wire strippers are recommended:

(1) Thomas and Betts Company catalog ABMK-1 for wire sizes No. 24 to No. 12 AWG and catalog ABMK-3 for wire sizes No. 18 to No. 10 AWG.

(2) Ideal Industries, Incorporated, Stripmaster model 45-series for wire sizes No. 22 to No. 10 AWG.

4.3.2 For cables with wire sizes No. 8 AWG or larger, electrican or skinning knives, Klein, or equivalent, are recommended.

4.4 Identification tags for cables shall be color-coded and lettered in accordance with the Division of Cable Separation, Attachment 3. Each cable termination shall be tagged similiar to attachment 2. The following materials are suitable for cable identification:

4.4.1 Self-sticking Mylar cable markers (available from AMP Special Industries or LEM Products, Incorporated).

4.4.2 Self-adhesive polyester cable markers (type B-361 available from W. H. Brady Company and type WA-1000-R available from Electromark Co., Division of PER-MAR Systems, Inc.).

4.4.3 Raychem's Thermofit Marker Sleeve (types NTMS and TW-TMS, Polyolefin heat shrinkable tubing cable markers and cable tags type NTMS-CM2).

4.4.4 Thomas and Betts Corporation (TY-RAP identification plates and self-locking ties).

4.5 The termination of medium-voltage (5-15Kv) cables at switchgear bus-bars, terminal blocks or other vendor supplied terminal equipment shall be made with terminating kits from attachment 1, table 9 as specified in the remarks section on data sheet 1. For cables less than 1000 MCM cable shields shall be grounded at both the switchgear end and at the equipment end with a flexible copper braid, unless design drawings specifically state otherwise. Shields of all conductors 1000 MCM or larger shall not be grounded at both ends. The design drawings will show the location of the grounds. Raychem's Ground Clamp Acessory Kits (attachment 1, table 9 may be used to connect the cable shields to ground).

4.5.1 Where a shielded power cable is terminated through a ground sensor current transformer, the shield ground lead shall be installed in accordance with attachment 6, Figure A, B, or C, in order that the current transformer senses only the phase currents and to avoid the ground connections constituting a shorted turn in the current transformer primary.

4.5.2 On long cable runs, shields shall be grounded at intermediate points in accordance with the table below. The locations of points of access, such as pull boxes, handholes, and manholes, will determine the interval. In making the intermediate grounds, remove only an amount of the jacket sufficient to permit connection of the ground lead to the shielding tape and then replace the jacket with Raychem heat shrinkable cable repair sleeve, using Raychem red adhesive tape type S-1024 or S-1119. Installation shall be documented on data sheet 15.

SHIELD GROUND INTERVAL TABLE

CABLE SIZE AWG or MCM	THREE CABLES PER CONDUIT (ft)
1/0	4500
2/0	3970
4/0	3000
250	2730
300	2260
400	2110
500	1870
750	1500
1000	----

4.6 When terminating cables to equipment (such as motors, instruments, electrical penetrations, etc.) furnished with pigtail leads instead of terminal blocks, the termination shall be insulated by one of the following methods as applicable:

4.6.1 Termination of low voltage cables (600V or less) shall be insulated using Raychem type-N materials (sleeves, end caps, breakouts, etc.) from attachment 1, Tables 4 through 8, as specified on the data sheets. If the termination is located inside an enclosure or piece of equipment which has been qualified for its installed environment, preinsulated parallel or butt splices may be used inside primary containment and areas subject to high energy line breaks or flooding.

4.6.2 Termination of medium-voltage (5-15-kV) cables shall be made with terminating kits from attachment 1, table 9, and insulated per Raychem NMCK8 kits or attachment 7. Cable shields shall be grounded at the equipment end with a flexible copper braid, unless design drawings specifically state otherwise. Raychem's Ground Clamp Accessory Kits (attachment 1, table 9) may be used to connect the cable shields to ground.

4.7 In non-CSSC applications outside of areas defined as harsh environments, the cognizant engineer may specify taping methods or other standard termination kits which are commercially available using the data sheets of this instruction.

4.8 Coaxial, triaxial, or multipin connector signal cables shall be terminated with the appropriate tools and supplemental materials (such as solder and sleeving) as specified on OE drawings or furnished with the instrumentation equipment.

4.9 The minimum training radius is the smallest radius to which a cable may be bent after all pulling operations have been completed.

4.9.1 Unless relaxed values are approved by OE prior to implementation, the minimum cable training radius for a single conductor cable is the appropriate installation factor from attachment 8 times the O.D. of the cable. For multiconductor cables not having an overall shield, the minimum training radius is equal to the appropriate installation factor from attachment 8 times the O.D. of the largest conductor in the multiconductor cable. The training radius for coaxial cable may be relaxed to a value equal to the outside diameter of the cable multiplied by a factor of 4; triaxial may likewise be relaxed except by a factor of 8. For medium voltage shielded power cables the training radius is the value listed on attachment 9.

4.9.2 At termination points and when limited space is available inside enclosures, such as junction boxes or cabinets, the outer jacket of unshielded cables may be removed. For shielded cables the cable should be run as close as practical to the termination point before the outer jacket is removed. After removal of the cable outer jacket, the minimum bending radius of the insulated conductor shall be determined by multiplying the installation factor from attachment 8 by the O.D. of the insulated conductor. The resultant O.D., now smaller since only a single insulated conductor is being considered, allows a smaller training radius to be implemented.

5.0 INSTRUCTIONS

5.1 Cable terminations shall be made by the craftsman using an OE-approved TVA or vendor drawing to the revision level specified on the Cable Termination Sheet, Data Sheet 1.

5.2 When terminating cables to equipment (such as motors, valve solenoids, etc.) furnished with pigtail leads, the cognizant engineer shall initiate the appropriate data sheets using MGL-E4 (reference 3.2.3) and note on the cable termination sheet where this data sheet is to be used. After the craftsman has obtained the cable and conductor O.D.'s he shall contact the cognizant engineer to complete the information on the data sheets. These data sheets shall specify the material to be used to insulate the cable terminations.

5.3 The craftsman shall terminate the cable using attachment 1 as a guideline to select the appropriate sized terminal lugs and tools. In applications where the use of Raychem heat shrinkable sleeving is a requirement, uninsulated terminal lugs and butt splices shall be used. For all other applications, terminal lugs and butt splices may be preinsulated unless prohibited by design documents. The AMP PIDG terminals shown on attachment 1 are for stranded conductors only. For solid or stranded conductors, use AMP solistrand or equal. He shall record the crimp tool identification number on the cable termination sheet and verify the tool is checked with go and no-go gauges when issued and returned to the tool room. He shall also identify the cable with permanent identification tags similiar to attachment 2.

5.4 In order to minimize output errors, selection of terminals and butt splices for terminations at thermocouple extension wires shall be based upon the following

(1) For iron-constantan and copper-constantan thermocouples, tin-plated copper terminal lugs and butt splice connectors shall be used. However, in order to ensure that both legs remain at approximately the same temperature, the legs of the thermocouple shall be lashed together after insulating the terminations. This may be accomplished by the use of a cable tie, a short piece of heat shrinkable sleeving, or by taping. (If the legs of the thermocouple do not remain at approximately the same temperature, an error may result in the output.) CAUTION: For terminations insulated with Raychem sleeves, allow the sleeves to cool before lashing by the use of a cable tie. Otherwise, the termination may push through the hot insulating sleeves and short together.

(2) For chromel-alumel thermocouples, chromel and alumel terminals lugs and butt splice connectors are preferred and shall be installed with the appropriate crimping tool. The chromel lug or connector shall be installed on the chromel extension wire and the alumel lug or connector on the alumel extension wire. (These types of materials tend to be brittle and are subject to fracture. After installation, immediately verify that the lug or connector has not been fractured.) Tin-plated copper terminals lugs and butt splice connectors may also be used as long as both legs of the thermocouple are lashed together after insulating the terminations as discussed in section 5.4 (1) above.

5.5 After the wires have been crimped and tagged, the QC inspector shall be notified to inspect and test the cable per section 6.0. For medium voltage cables the stress cone shall be installed prior to testing but QC inspection of the crimp is necessary before the stress cone is installed.

5.6 For cables that are required to be insulated, the craftsman shall obtain the insulation materials specified on the data sheet. QC inspection of each piece of heat shrinkable material applied and torquing the connection is required per section 6.0. Heat shrinks shall be applied in accordance with the manufactures instructions and/or attachment 4.

5.7 The cables shall be terminated by the craftsman after testing. QC inspector shall verify that the cable is terminated correctly according to the drawing specified on the cable termination sheet.

6.0 INSPECTION, TESTING AND ACCEPTANCE CRITERIA

The QC inspector shall perform the following inspections and verify that all tests meet the acceptance criteria. The QC inspector shall sign the cable termination sheet to indicate that all inspections and tests are satisfactory.

6.1 After the terminal lugs have been installed the QC inspector shall inspect the crimps using the figure 6.1.1, 6.1.2, or 6.1.3 as applicable with the following exceptions listed below.

6.1.1 For multiconductor cables that have a filler conductor insulation too large to fit into the insulation barrel of a properly sized preinsulated lug correctly, the following options are available for the craftsman:

(1) Use an uninsulated lug or
(2) Pencil down the insulation to fit or,
(3) Butt the conductor insulation up against the barrel as far as possible.

6.1.2 For single conductor SROAJ type cables that will not fit into the insulation barrel of a preinsulated lug, the above options in section 6.1.1 apply.

6.1.3 For solid conductor cable terminations, the terminal lug shall be an AMP Solistrand lug or equal.

6.1.4 Uninsulated terminal lugs and butt splices shall be used in applications where the use of Raychem heat shrinkable sleeving is a requirement.

Modifications and Additions Instruction

FIGURE 6.1.1

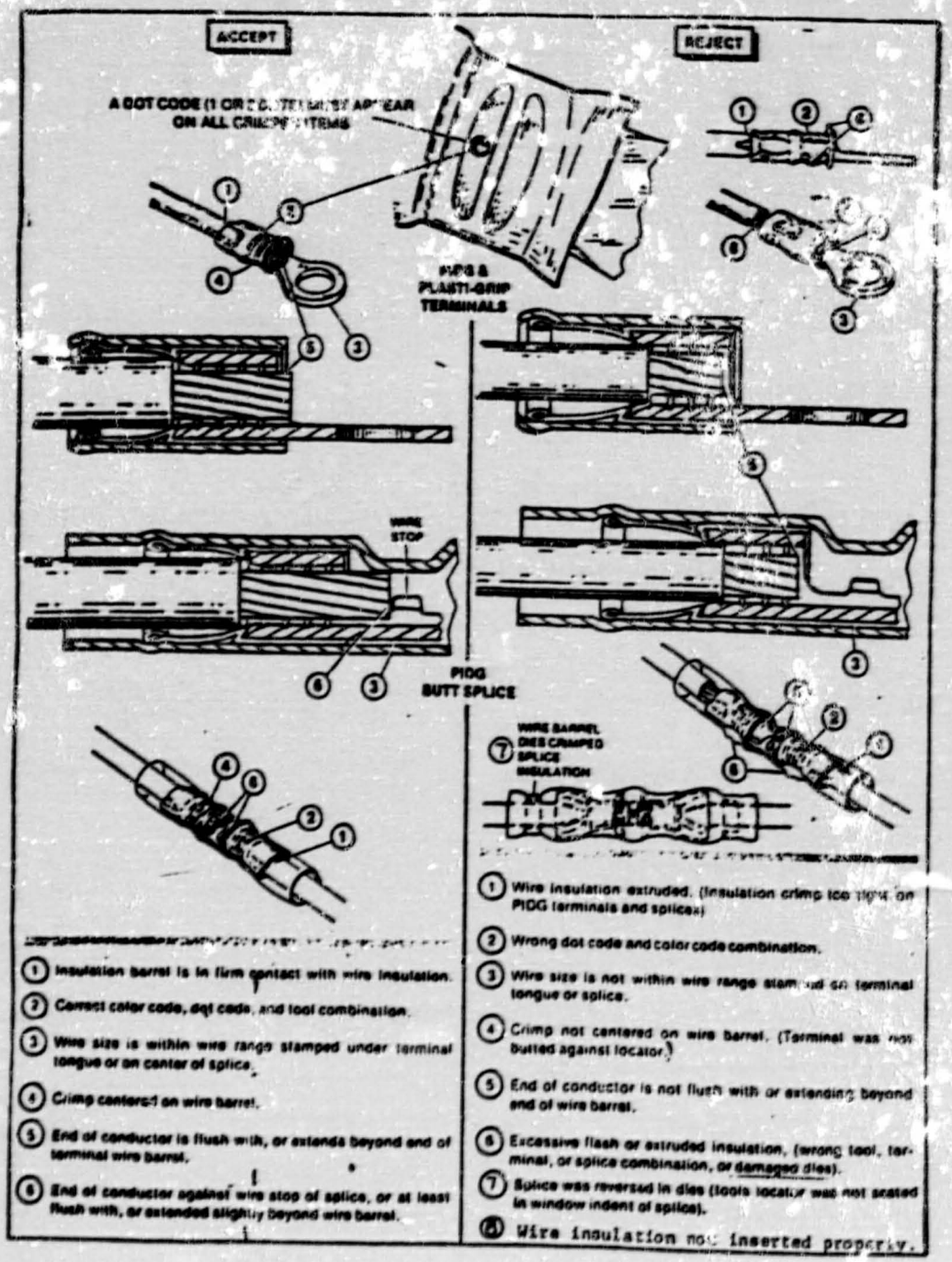
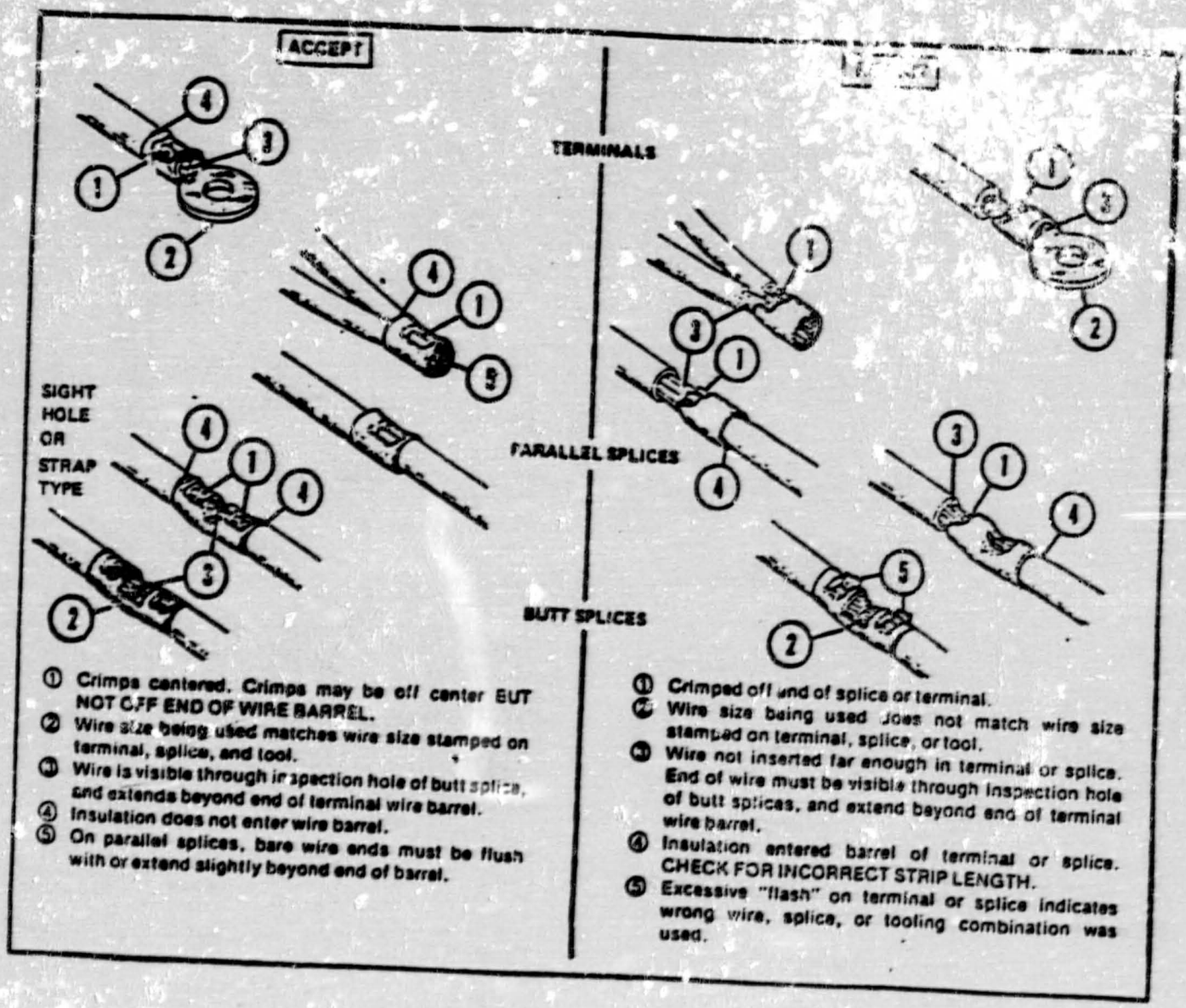


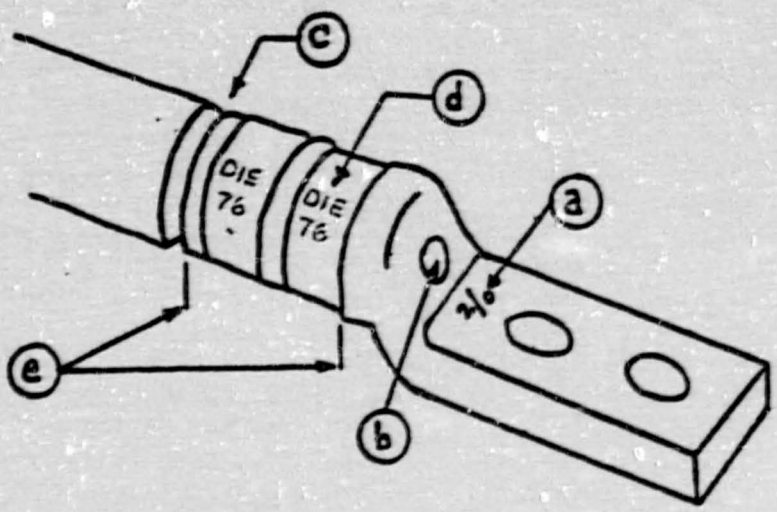
FIGURE 5.1.2


ACCEPT
TERMINALS
PARALLEL SPLICES
BUTT SPLICES
SIGHT HOLE OR STRAP TYPE
① Crimps centered. Crimps may be off center BUT NOT OFF END OF WIRE BARREL.
② Wire size being used matches wire size stamped on terminal, splice, and tool.
③ Wire is visible through inspection hole of butt splice, and extends beyond end of terminal wire barrel.
④ Insulation does not enter wire barrel.
⑤ On parallel splices, bare wire ends must be flush with or extend slightly beyond end of barrel.
① Crimped off end of splice or terminal.
② Wire size being used does not match wire size stamped on terminal, splice, or tool.
③ Wire not inserted far enough in terminal or splice. End of wire must be visible through inspection hole of butt splices, and extend beyond end of terminal wire barrel.
④ Insulation entered barrel of terminal or splice. CHECK FOR INCORRECT STRIP LENGTH.
⑤ Excessive "flash" on terminal or splice indicates wrong wire, splice, or tooling combination was used.

Modifications and Additions Instruction

FIGURE 6.1.3

The following acceptance criteria pertains to both CSSC and non-CSSC inspection on cable and/or conductor terminations for wire sizes No. 8 and larger:



(a) Correct crimper tool, die and lug is used for particular size cable and/or conductor termination.

(b) Conductor bottomed out in terminal (not applicable on cast lugs).

(c) The minimum distance between the insulation and connector shall be sufficient to determine that the insulation has not been crimped in the connector.

(d) Correct die number(s) embossed on hex crimps (not applicable when the TBM5S tool is used).

(e) Crimp properly placed within crimp boundaries.

THOMAS AND BETTS DIE SUFFIX DEFINITIONS

- No suffix letter after die number denotes 1 crimp.

H - Suffix denotes half die, required 2 crimps - first crimp on barrel end second crimp on tongue end, both within crimp boundaries.

R - Suffix denotes where space allows, make first crimp at taper end of terminal. Make second crimp at tongue end, both within crimp boundaries. Crimp in overlapping steps from second crimp toward tapered end of terminal, rotate 90 degrees and repeat above crimping operation to make terminal round.

6.2 Prior to terminating or insulating the cables (except for stress cones) the following tests shall be performed by the craftsmen and verified by the QC inspector.

6.2.1 Continuity Test--Using a continuity tester (ohmmeter, buzzer, battery-powered telephones, etc.) verify that each conductor has continuity from each terminated end of the cable. On multiconductor cables verify that there is no "cross-talk" between the conductors. Each conductor shall be checked separately for continuity, not as a group.

6.2.2 Insulation Test--For low voltage cables, use a 500-volt megger, or for medium voltage cables, use a 2500-volt megger, to check the conductor insulation to ground and for multiconductor cables between each conductor also. Each megger reading shall be taken for a minumum of 15 seconds for low voltage cables and one minute for medium voltage cables. The craftsman shall record the megger identification number, calibration due date of the megger, and the megger reading on the cable termination sheet. For multiconductor cables, record the lowest reading. The minimum acceptable reading shall be 1000 ohms per volt with a minimum of 1 meghohm for any voltage less that 1000 volts.

6.2.3 Hi-Pot Test--For medium-voltage cables only, the insulation shall be tested with a high potential test set after a satisfactory insulation test. The test shall be performed in accordance with the instructions in MGL-E3 (reference 3.6). The craftsman shall record the test instrument identification numbers, calibration due dates, and the steady state leakage current after 15 minutes. In general, the cognizant engineer must analyze the results in order to determine the acceptability of the results; however, the cable test is acceptable if the current remains steady and does not rise or become erratic.

6.3 The QC inspector shall inspect the application of insulating materials to the the terminations as follows:

6.3.1 Verify that the sleeves have not been underheated. Adhesive-coated sleeves shall show good adhesive flow at the ends of the shrunk sleeves. Adhesive flow indicates complete shrinking and satisfactory contact with the cable, ensuring a positive environmental seal. The sleeves should show a smooth and glossy appearance following the contour of the termination.

Modifications and Additions Instruction

6.3 The QC inspector shall inspect the application of insulating materials to the terminations as follows: (continued)

6.3.2 Verify that the sleeves are not overheated. Evidence of burning or blistering on the surface of the shrinkable sleeve indicates overheating. Any minor surface scorching that can be removed by cleaning with denatured alcohol is acceptable. Tubing with deep blistering must be replaced.

6.3.3 Verify that the correct size sleeves as specified on the data sheets are applied.

6.4 The QC inspector shall verify that the electrical bolted connections are tightened to the values shown in MAI-9 (reference 3.4). A separate data sheet from MAI-9 will not be required. The craftsman shall record the torque value and torque wrench identification number on data sheet 1.

6.5 The QC inspector shall verify that the minimum training radius specified on data sheet 1 has not been violated.

6.6 The QC inspector shall verify that the cable is terminated correctly according to the drawing specified on the cable termination sheet. He shall inspect all points affected by the modification.

* 6.7 Temporary wire lifts, which are described in appendix A, do not apply to momentary wire lifts made during modification. The QC inspector shall verify and document on data sheet 1 that the previously terminated cables which were momentary lifted in order to install a new cable are laid back down per applicable drawings.

Modifications and Additions Instruction

ATTACHMENT 1

TABLE 1

TERMINALS, BUTT SPLICES, AND TOOLS AVAILABLE
FROM AMP PRODUCT CORPORATON

Copper Wire Range, AWG	Noninsulated Terminal Series[1] and Butt Splice Series	Tool No.
22-16	Solistrand	49900
16-14	Solistrand	49900
12-10	Solistrand	49900

Copper Wire Range, AWG	Self-Insulated Terminal Series[1] and Butt Splice Series	Tool No.
22-16	PIDG (Vinyl or Nylon)	59170
16-14	PIDG (Vinyl or Nylon)	59170
12-10	PIDG (Vinyl or Nylon)	59239-4
22-16	Nuclear[2] PIDG (Kynar)	59170
16-14	Nuclear[2] PIDG (Kynar)	59170
12-10	Nuclear[2] PIDG (Kynar)	59239-4

1. Only enclosed (ring or rectangular type) tongue terminals shall be used. Terminals with NEMA drilling and spacing shall be used when available.

2. For self-insulated applications within the primary containment.

Modifications and Additions Instruction

ATTACHMENT 1

TABLE 2

THOMAS AND BETTS COMPANY TERMINALS, SPLICES, AND TOOLS FOR SEQUOYAH AND WATTS BAR NUCLEAR PLANTS ONLY

Thomas and Betts Company's cast copper compression series 53000 terminals and splices that are furnished with vendor-supplied equipment shall be used for field installations. The installation of these terminals and splices shall be made using tools purchased from Thomas and Betts Company as follows:

Size of Conductor, AWG	Terminal Catalog No.	Die Catalog No. TBM15 Tool†	Die Catalog No. 40-Ton Head Tool	Die Code	Butt Splice Catalog No.
8	53104 or 53204	15527	11401	29	53504
6	53105 or 53205	15527	11401	29	53505
4	53106 or 53206	15527	11401	29	53506
2	53107 or 53207	15526	11405	45	53507
1/0	53109 or 53209	15526	11405	45	53509
2/0	53110 or 53210	15534	11409	66	53510
4/0	53112 or 53212	15534	11409	66	53512
250 MCM	53113 or 53213	15512	11410	76	53513
300 MCM	53114 or 53214	15512	11410	76	53514
400 MCM	53116 or 53216	††	11424	99	53516
400 MCM	53116 or 53216	15505	††	99H	53516
500 MCM	53118 or 53218	††	11424	99	53518
500 MCM	53118 or 53218	15505	††	99H	53518
750 MCM	53123 or 53223	††	11426	112	53523
750 MCM	53123 or 53223	15609	††	112H	53523

†TBM15 head when using 15500 die series catalog numbers required a die adapter No. 15500.

††Not available

NOTE

The cast lugs listed above are factory marked for use with the 40-ton hydraulic head; therefore, the use of TBM15 hydraulic head would require twice the number of compression operations on large size lugs for proper termination due to the smaller compression area of the 15-ton dies. Lugs for the 350- to 500-MCM and 600-to 750-MCM copper wire ranges employ die codes for 99H and 112H, respectively, for the 15-ton head which are half-size. Whenever possible all Thomas Betts Company's series 53000 cast copper terminals above 300 MCM should be compressed with a 40-ton head.

Modifications and Additions Instruction

ATTACHMENT 1

TABLE 3

TERMINALS, BUTT SPLICES, AND TOOLS AVAILABLE
FROM THOMAS AND BETTS COMPANY

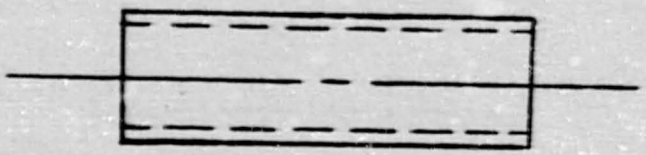
Copper Wire Range, AWG	Terminal[1] Catalog Series	Butt Splice Series (AWG)	Tool No.	600V and Below Applications		601-15,000V Applications
				Die[2] Catalog No.	Die Code No.	Die[2] Catalog No.
8	54000	54000	TBM5S	13454	None	Not Applicable
6	54000	54000	TBM5S	13454	None	Not Applicable
4	54000	54000	TBM5S	13454	None	Not Applicable
2	54000	54000	TBM5S	13454	None	Not Applicable
8	54000	54000	TBM15	15520	21	Not Applicable
6	54000	54000	TBM15	15522	24	Not Applicable
4	54000	54000	TBM15	15527	29	Not Applicable
2	54000	54000	TBM15	15528	33	Not Applicable
1/0	54000	54000	TBM15	15508	42H	Not Applicable
2/0	54000	54000	TBM15	15526	45	15C-45R
4/0	54000	54000	TBM15	15511	54H	15C-54R
250 MCM	54000	54000	TBM15	15510	62	15C-60R
300 MCM	54000	54000	TBM15	15534	66	15C-66R
400 MCM	54000	54000	TBM15	15512	76	15C-76R
500 MCM	54000	54000	TBM15	15506	87H	15C-87R
750 MCM	54000	54000	TBM15	15515	106	15C-106R
1000 MCM	54000	54000	TBM15	15603	125H	15C-125R

1. Only enclosed (ring or rectangular type) tongue terminals shall be used. Terminal with NEMA drilling and spacing shall be used when available.

2. The TBM15 hydraulic head (15 tons) when using 15500 die series catalog numbers requires a die adapter, Thomas and Betts Company catalog No. 15500.

Modifications and Additions Instruction

ATTACHMENT 1
TABLE 4
SELECTION GUIDE
RAYCHEM NUCLEAR CABLE SLEEVES



RAYCHEM CORP. PART NUMBER †	USE RANGE INSIDE CONTAINMENT, HELB		USE RANGE OUTSIDE CONTAINMENT		K-FACTOR	BOLT PAD ††	
	MIN (IN.)	MAX (IN.)	MIN (IN.)	MAX (IN.)		MAX. BOLT SIZE	MAX. CONN. TANG WIDTH
WCSF-050-	0.05	0.10	0.05	0.10	0.009		
WCSF-070-	0.07	0.14	0.07	0.19	0.048		
WCSF-115-	0.11	0.23	0.11	0.31	0.075		
WCSF-200-	0.20	0.40	0.20	0.54	0.13	#10 x 5/16	0.40
WCSF-300-	0.31	0.60	0.31	0.81	0.31	1/4 x 3/8	0.60
WCSF-500-	0.53	1.0	0.53	1.35	0.49	3/8 x 5/8	0.87
WCSF-650-	0.70	1.3	0.70	1.75	0.62	1/2 x 3/4	1.0
WCSF-1000-	1.10	2.0	1.10	2.7	0.91	1/2 x 1-1/4	1.9
WCSF-1500-	1.65	3.0	1.65	4.0	1.3		
WCSF-2500-	2.75	5.0	2.75	6.5	1.9		

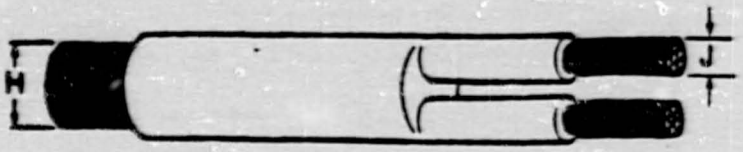
† WCSF - XXXX - L - N

- N - Nuclear Adhesive
- U - Uncoated
- Length (inches)
- Size
- Part Number

††The bolt pad shall be applied over the bolts when the overall bolt length is greater than .87" (3/8 x 5/8 long). Below this, the use of a bolt pad is optional. Bolt pads should be uncoated sleeves.

Modifications and Additions Instruction

ATTACHMENT 1
TABLE 5
SELECTION GUIDE
RAYCHEM NUCLEAR CABLE BREAKOUTS



H - BREAKOUT BODY DIAMETER (CABLE JACKET O.D.)
J - BREAKOUT LEG DIAMETER (CONDUCTOR O.D.)

RAYCHEM CORP PART NUMBER	H-CABLE BREAKOUT BODY USE RANGES MIN. (IN.)	MAX. (IN.)	K-FACTOR	NO LEGS	J-CABLE BREAKOUT LEGS USE RANGES MIN. (IN.)	MAX IN.)	K-FACTOR
302A812-52/144	0.42	0.78	0.084	2	0.10	0.20	0.030
302A823-52/144	0.63	1.16	0.179	2	0.18	0.34	0.064
302A834-52/144	1.00	1.84	0.404	2	0.30	0.56	0.152
302A845-52/144	1.60	2.90	0.749	2	0.54	1.00	0.293
302W068-52/144	1.97	3.08	1.152	2	1.07	1.96	0.657
403A112-52/144	0.38	0.70	0.134	3	0.12	0.22	0.061
403A123-52/144	0.73	1.34	0.270	3	0.19	0.36	0.094
403A134-52/144	0.95	1.74	0.427	3	0.27	0.50	0.154
403A145-52/144	1.48	2.50	0.700	3	0.53	0.98	0.288
403A211-52/144	0.36	0.66	0.111	3	0.10	0.20	0.046
403A222-52/144	0.60	1.10	0.194	3	0.18	0.34	0.074
402R439-52/144	2.38	4.37	1.094	3	1.10	1.84	0.378
502A812-52/144	0.50	0.92	0.100	4	0.10	0.20	0.0[illegible]
502A823-52/144	0.75	1.26	0.210	4	0.18	0.34	0.[illegible]64
502A834-52/144	1.15	1.90	0.456	4	0.29	0.54	0.144
502A845-52/144	1.83	2.95	0.854	4	0.53	0.98	0.288
602A114-52/144	0.98	1.62	0.272	5	0.16	0.30	0.040
602A212-52/144	0.42	0.78	0.147	N=2, 3, 4, & 5	0.06	0.12	0.054
602A312-52/144	0.54	1.00	0.159	5	0.10	0.20	0.046
703A155-52/144	1.53	2.80	0.596	6	0.31	0.58	0.152
803A155-52/144	1.53	2.80	0.596	7	0.31	0.58	0.152
902A014-52/144	1.19	1.71	0.266	8	0.19	0.36	0.034

Modifications and Additions Instruction

ATTACHMENT 1

TABLE 6

SELECTION GUIDE
RAYCHEM NUCLEAR CABLE END CAPS

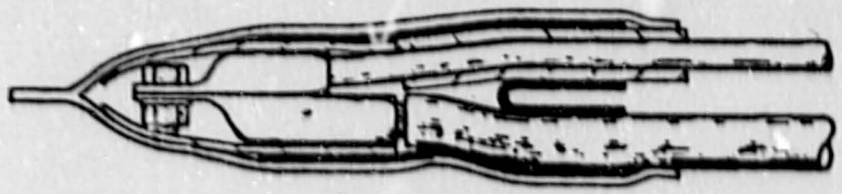
RAYCHEM CORP PART NUMBER	USE RANGES	
	MIN. (IN.)	MAX. (IN.)
101A011-52/144	0.08	0.16
101A021-52/144	0.13	0.26
101A031-52/144	0.18	0.36
101A041-52/144	0.25	0.55
101A052-52/144	0.37	0.78
101A062-52/144	0.45	0.95
101A073-52/144	0.71	1.50
101A083-52/144	0.90	1.90
101A094-52/144	1.50	3.20

Modifications and Additions Instruction

ATTACHMENT 1

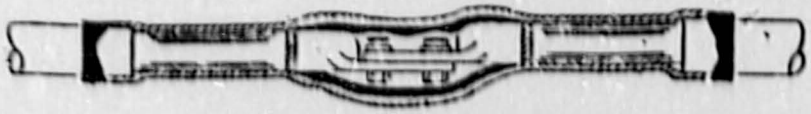
TABLE 7

SELECTION GUIDE
RAYCHEM NUCLEAR MOTOR CONNECTION KIT



STUB TYPE - 3 PHASE

RAYCHEM CORP KIT NUMBER	FEEDER CABLE O.D. RANGE	MOTOR LEAD MIN. O.D.	MAXIMUM LUG (W×L)	MAX. BOLT (DIA×L)	COMPLETED KIT NOM. LENGTH	COMPLETED KIT NOM. DIA.
NMCK-1V-35-00	0.10" - 0.20"	0.10"	0.38" x 2.0"	#10 x 5/16"	4" - 6"	3/4"
NMCK-2V-35-00	0.18" - 0.34"	0.11"	0.60" x 3.0"	5/16" x 1/2"	5" - 7"	1"
NMCK-3V-35-00	0.30" - 0.60"	0.20"	0.95" x 4.8"	1/2" x 7/8"	5-1/2" - 8"	1-1/2"
NMCK-4V-35-00	0.55" - 1.04"	0.31"	1.60" x 6.5"	5/8" x 1-1/4"	8" - 10"	2"



IN-LINE TYPE-3 PHASE

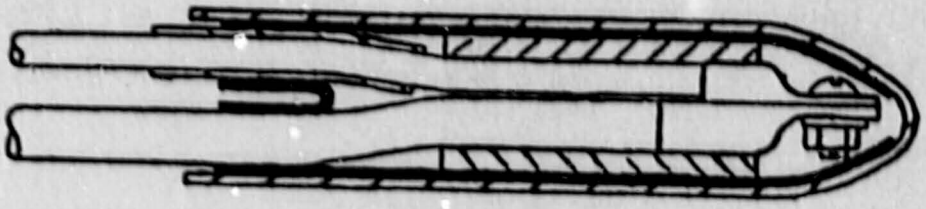
RAYCHEM CORP KIT NUMBER	FEEDER CABLE/MOTOR LEAD CABLE O.D. RANGE	MAX. LUG (W×L)	MAX. BOLT (DIA×L)	KIT NOM. LENGTH
NMCK-0L-35-00	0.11" - 0.40"	0.40" x 2.0"	#10 x 5/16"	9"
NMCK-1L-35-00	0.20" - 0.60"	0.71" x 2.7"	1/4" x 1/2"	12"
NMCK-2L-35-00	0.31" - 1.00"	0.95" x 5.0"	1/2" x 7/8"	15"
NMCK-3L-35-00	0.77" - 2.00"	1.6" x 6.5"	5/8" x 1-1/4"	21"

Modifications and Additions Instruction

ATTACHMENT 1

TABLE 8

SELECTION GUIDE
RAYCHEM TYPE "V"-STUB CONNECTION KIT



RAYCHEM CORP KIT NUMBER	NUMBER OF WIRES	WIRE O.D. RANGE	NOMINAL WIRE SIZE	MAX. BOLT SIZE (DIA x LGTH)	RECOMMENDED MAX. LUG TAVG WDTH	COMPLETED SPLICE (NOMINAL)
NPKV-2-16	2	.06" - .12"	#16 - #10 Kapton	#10 x 1/2"	.36"	3/4" x 3"
NPKV-2-14	2	.10" - .20"	#16 - #12 AWG	1/4" x 1/2"	.45"	3/4" x 3"
NPKV-2-10	2	.11" - .34"@	#16 - #6 AWG	5/16" x 3/4"	.60"	1" x 4"
NPKV-2-08	2	.18" - .34"	#12 - #6 AWG	5/16" x 3/4"	.60"	1" x 4"
NPKV-3-16	3	.06" - .12"	#16 - #10 Kapton	#10 x 1/2"	.36"	3/4" x 3"
NPKV-3-14	3	.10" - .20"	#16 - #12 AWG	1/4" x 1/2"	.45"	3/4" x 3"

@A shim is provided for one wire from .11" - .18". The wire O.D. range for the second wire is .18" - .34."

Modifications and Additions Instruction

ATTACHMENT 1

TABLE 9

SELECTION GUIDE FOR RAYCHEM MEDIUM VOLTAGE STRESS, GROUNDING KITS, AND REPAIR SLEEVES

Maximum Voltage	Non-Class 1E Raychem Corp. Indoor Kit No.	Non-Class 1E Raychem Corp. Outdoor Kit No	Class 1E Raychem Corp. Indoor Kit No	APPLICATION DIAMETER RANGE		
				Minimum Dia Over Primary Insulation (Inches)	Max Dia Over Cable Jacket (Inches)	Minimum Terminal Lug Barrel Dia (Inches)
8kV	HVT-I-A-1-00	HVT-0-A-1-00	NHVT-I-A-1-00	0.59	1.10	0.50
	HVT-I-A-2-00	HVT-0-A-2-00	NHVT-I-A-2-00	0.80	1.40	0.65
	HVT-I-A-3-00	HVT-0-A-3-00	NHVT-I-A-3-00	1.15	1.75	0.90

RAYCHEM PART NUMBERS		CABLE DIAMETER OVER SHIELD INCHES
24-inch braid	60-inch braid	
GCA-824	GCA-860	.40 - 1.35
GCA-424	GCA-460	1.1 - 2.25

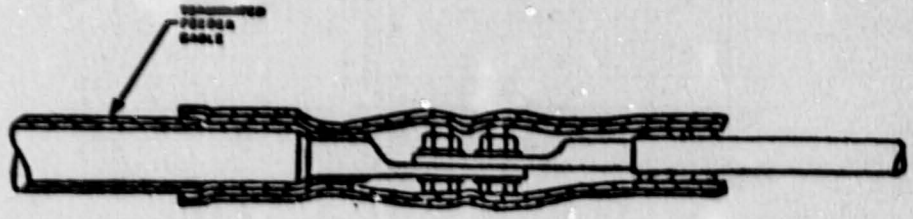
RAYCHEM PART NUMBER	CABLE DIASMETER RANGE (INCHES)
NJRS-1-12	0.25 to 0.8
NJRS-2-12	0.7 to 1.5

Modifications and Additions Instruction

ATTACHMENT 1

TABLE 10

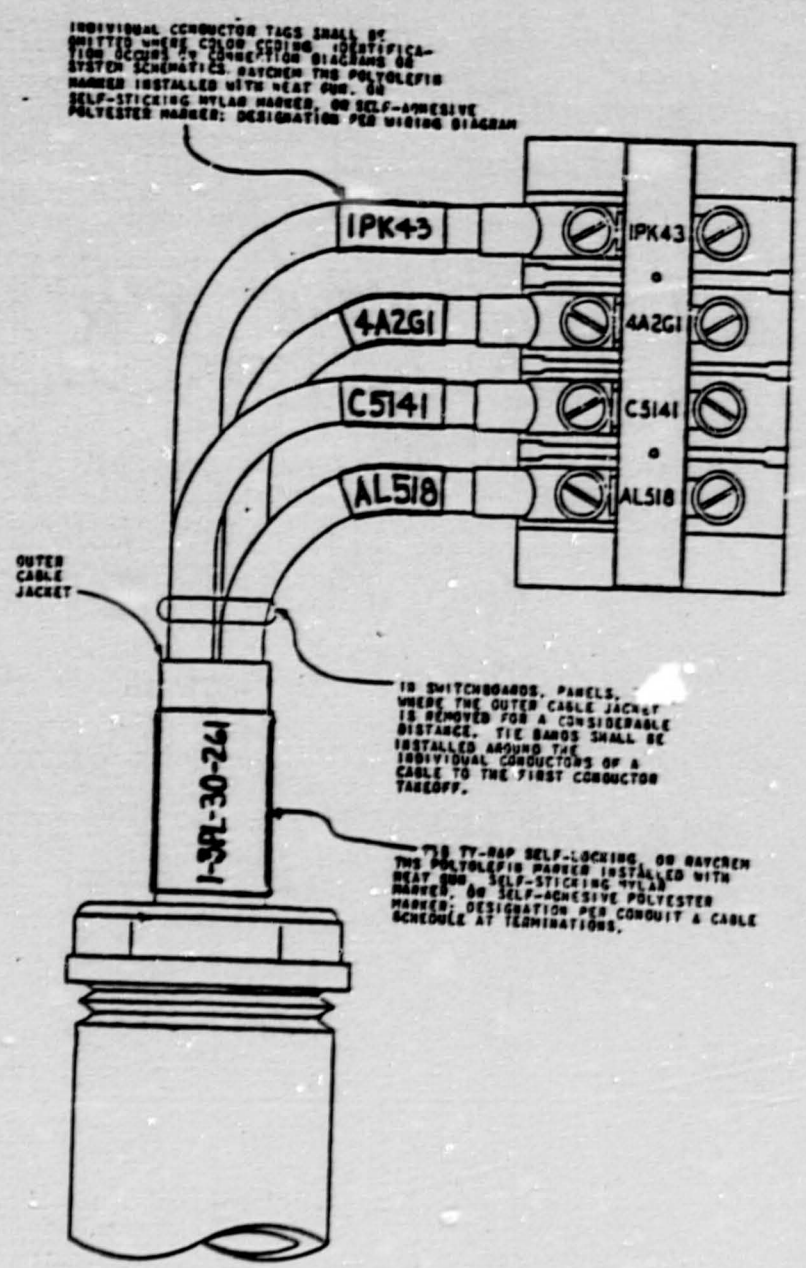
SELECTION GUIDE FOR RAYCHEM MEDIUM VOLTAGE MOTOR CONNECTION KIT



RAYCHEM KIT NO.	FEEDER CABLE SIZE	FEEDER CABLE SHIELDED CABLE (od over insulation)	DIAMETER UNSHIELD CABLE (od over jacket)	MOTOR LEAD DIA	MAX BOLT (Dia x Lgth)	MAX LUG WIDTH	MAX CONN LGTH
NMCK8-1L	2/0-250 MCM	0.53" - 1.1"	0.70" - 1.26"	0.41" - 1.26"	1/2" x 1.0	1.26"	9.0"
NMCK8-2L	350-500 MCM	0.87" - 1.5"	1.06" - 1.6"	0.79" - 1.6"	1/2" x 1.25	1.8"	9.0"

Modifications and Additions Instruction

ATTACHMENT 2



LOCATION OF TAGS

Modifications and Additions Instruction

ATTACHMENT 3

DIVISION OF CABLE SEPARATION

SYSTEM	DIVISION OF SEPARATION	BACKGROUND COLOR	LETTERING #	CABLE OR RACEWAY SUFFIX
Engineered safety features (ESF), essential supporting auxiliary systems (ESAS) and Class IE diesel generator power systems.	Train A	Orange	White	A
	Train B	Brown	White	B
For safety-related equipment which requires or supplies redundant power sources	Special	Gold	Black	S
(Post accident monitoring)				
PAM 1	1	Purple	White	J
PAM 2	2	Green	Black	K
Reactor protection system (RPS), and Class IE vital AC and DC distribution systems	Channel I	Red	White	D
	Channel II	Black	White	E
	Channel III	Blue	White	F
	Channel IV	Yellow	Black	G
Normal offsite power supply		White	Black	P
Alt offsite power supply		White	Black	R
Nondivisional		White	Black	

#It is permissible to use black lettering on conductor and cable labels for all but black backgrounds; white lettering shall be used on black background labels.

Modifications and Additions Instruction

ATTACHMENT 4

GENERAL RAYCHEM INSTALLATION INSTRUCTIONS

STEP 1 - Remove all nonqualified or braided jacketing material from the seal area. For multiconductor cables, remove the cable jacket, tapes, fillers, etc., for the distance required. This does not apply to ASCO solenoid valves with a bonded woven jacket wiring.

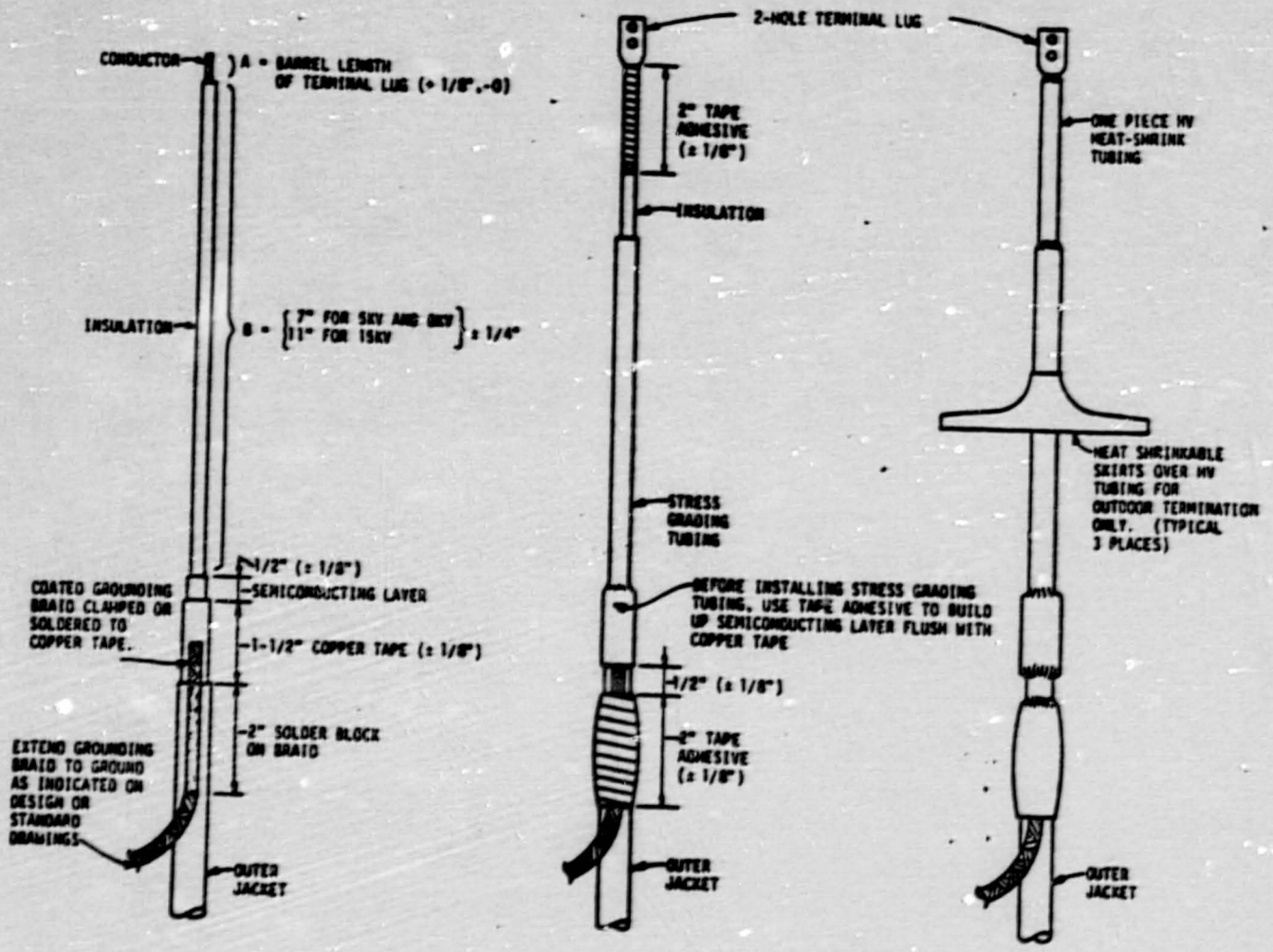
STEP 2 - Clean the cable jacket and wire insulation prior to installing the sleeving using 240 grit aluminum oxide coated abrasive cloth and denatured alcohol. Abrade the insulation (except for Kapton and other insulation types where abrasion is prohibited by the cable vendor).

STEP 3 - Where the conductor itself presents a large heat sink (i.e., #4/0 AWG or larger), preheat the termination area until too hot to touch (about 20-30 seconds) prior to the installation of any tubing.

STEP 4 - Install sleeves as illustrated on the data sheets. Begin shrinking WCSF sleeves at the center of the tubing. Heat uniformly around the circumference. When tubing stops shrinking in the center, move first towards one end, then the other. For shrinking end caps, begin at the closed end and shrink to the open end. For shrinking cable breakouts, begin at the junction and shrink toward the legs first and the body last. Continue shrinking until the sleeves are smoothly shrunk onto the cable surface and the sleeve outer surface has a glossy appearance. Also, a visible flow of adhesive is evident from each end of the sleeve.

STEP 5 - Do not flex the termination until comfortable to touch.

Modifications and Additions Instruction
ATTACHMENT 5
MEDIUM-VOLTAGE STRESS CONE INSTALLATION



The terminations of medium-voltage power cables shall be insulated with Raychem cable insulation termination kits. (See Attachment 1, Table 9, for selection of kit size)

STEP 1 - Prepare the cable for termination in accordance with instructions furnished with the termination kit.

STEP 2 - Select the appropriate size terminal lug from Attachment 1, Table 2. Install the terminal to the conductor with properly matched tools.

STEP 3 - Complete the kit installation in accordance with manufacturer's instructions using an electric heat gun. (Do not use torch with open flame) as the heat source.

STEP 4 - Cable shield ground connections are made according to design drawings or section 4.5.3. (Where shielded power cable is terminated through a ground sensor current transformer, the shield ground lead shall be installed in accordance with Attachment 6, Figures A, B, or C.)

Modifications and Additions Instruction

ATTACHMENT 6

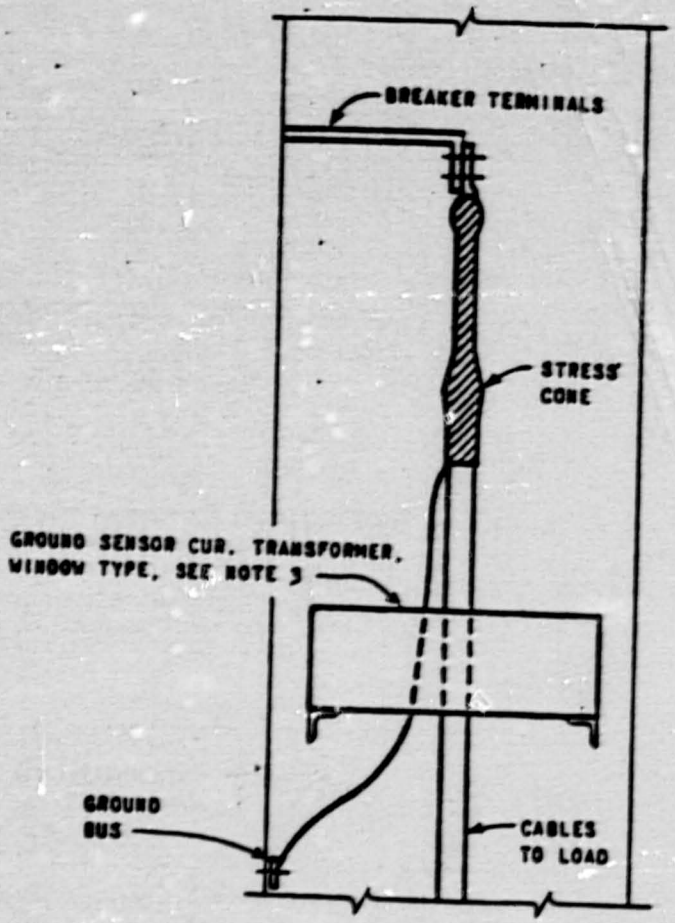


FIGURE A

LOAD CABLES LEAVING EITHER TOP OR BOTTOM OF SWITCHGEAR (CABLES LEAVING BOTTOM SHOWN)

NOTES:

1. ALL LOAD CABLES MUST PASS THROUGH THE WINDOW OF THE CURRENT TRANSFORMER.
2. WHEN CURRENT TRANSFORMER IS MOUNTED AS IN CASE A, TERMINATE CABLES PER SECTION 4.5
3. WHEN CABLES LEAVE TOP OF SWITCHGEAR, CURRENT TRANSFORMER WILL BE ABOVE BREAKER TERMINALS.

Modifications and Additions Instruction

ATTACHMENT 6 (CONTINUED)

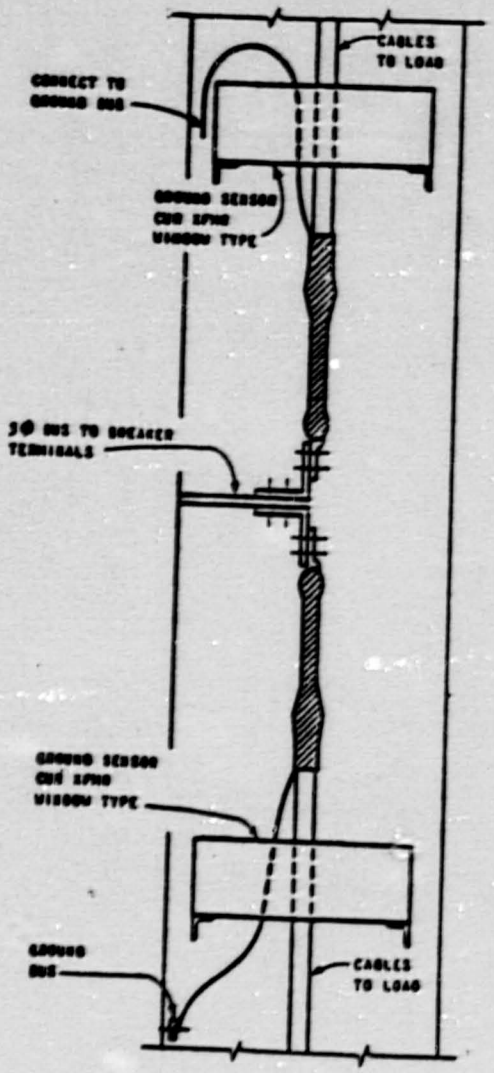


FIGURE C

LOAD CABLES LEAVING BOTH TOP
AND BOTTOM OF SWITCHGEAR

NOTES:

1. WHEN LOAD CABLES LEAVE FROM BOTH TOP AND BOTTOM OF SWITCHGEAR. THE GROUND SENSOR CURRENT TRANSFORMERS WILL BE INSTALLED AS SHOWN.
2. TERMINATE CABLES THE SAME AS CASE A.

Medium Voltage (5-15Kv) Installation Procedure
ATTACHMENT 7

Medium voltage (5-15Kv) cable terminations to equipment furnished with pigtails shall be made using the data sheet 13 or 14 and the following instructions:

Step 1 Use clean cloth to remove cable pulling lubricant, dust or dirt from cable in area of connection.

Step 2 Remove Cable jacket and prepare cable insulation as indicated.

Step 3 Clean insulation, jacket, and portion of stress cone involved using denatured alcohol or equivalent by wiping away from the splice area. A cleaner shall be considered equivalent if approved by the cable vendor for use on his products. If abrasive is required, use 120 GRIT ALUMINUM OXIDE or other as recommended by the cable vendor.

Step 4 Install terminal lugs and bolt assembly together. (Where required for moisture proofing purposes, cable breakout and heat shrinkable sleeving must be in place prior to bolting terminal lugs together.)

Step 5 Wrap half-lapped layers of Scotch 24 electrical shielding tape over lugs and bare portion of conductor. Form a smooth concentric buildup.

Step 6 When specified on data sheet 13 or 14, position cable breakout and shrink into place.

Step 7 Wrap half-lapped layers of Scotch 130C linerless hi-voltage splicing tape beginning in smallest diameter area. Build up to a thickness of 3/8" over the Scotch 24 tape. Wrap 2" beyond the penciled (tapered) area on the equipment lead side and 1-1/2" beyond the exposed portion of the terminal lug barrel on the stress cone side. Wrap with tacky side out and stretch to 3/4 of original width for best results.

Step 8 Wrap two half-lapped layers of Scotch 33+ vinyl plastic electrical tape over entire connection area extending 1/2" beyond previously applied Scotch 130C tape.

Step 9 If specified on data sheet 13 or 14, complete the connection by moisture proofing in the following manner. Using Raychem Heat Shrinkable Sleeving, shim the ends of the insulated connection as required to accomodate the application diameter range of the overall sleeve to be used.

ATTACHMENT 8

INSTALLATION FACTOR FOR CABLE BENDING RADII

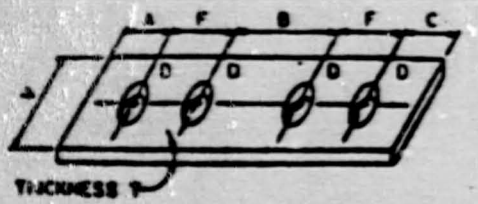
CABLE USE	COMMERCIAL OR TVA TYPE LETTERS	INSTALLATION FACTOR		
		OD 1.0" AND LESS	OD ABOVE 1.0" AND UP TO 2.0"	OD OVER 2.0"
POWER, CONTROL (UNSHIELDED)	PX PXJ PXMJ THHN XHHW TW PN PNJ PJ PJJ AF CP CPJ CPJJ CPMJ SROJ SROJJ SROAJ SROAJH	4	5	6
POWER, CONTROL (SHIELDED)	EPSJ EPSU CPSJ SRSJ	12	12	12
SWITCHBOARD (UNSHIELDED)	SIS HTS E	4	-	-
SIGNAL, COAXIAL, TRIAXIAL, TELEPHONE, THERMOCOUPLE (SHIELDED)	MX MXPS MXPSJ MAGS YPS YMPS YMPOS YMPSJ YMPSS RG/U	12	12	12

ATTACHMENT 9

SHIELDED MEDIUM VOLTAGE POWER CABLES

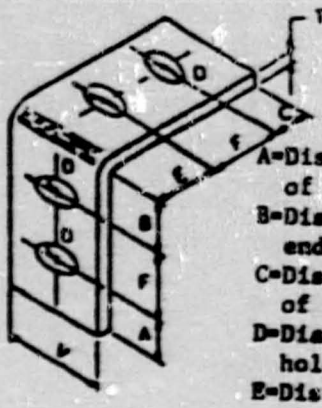
Cable Manufacturer	Minimum Training Radius (inches)						
Cable Size	6 AWG(3/C)	2/0 AWG	4/0 AWG	300 MCM	400 MCM	500 MCM	750 MCM
Okonite Company (4.4 x cable OD)	3.6	4.91	5.89	5.76	6.64	6.68	7.59
Collyer Insulated Wire (8.0 x cable OD)	N/A	9.10	N/A	N/A	11.48	12.00	N/A
Anaconda-Ericsson, Incorporated (8.4 x cable OD)	N/A	8.39	N/A	N/A	N/A	11.75	N/A
Rome Cable Corp. 10.9 x cable OD)	N/A	12.00	N/A	N/A	N/A	N/A	N/A
Essex Group (7 x cable OD)	N/A	N/A	N/A	N/A	10.77	N/A	N/A
General Cable (7 x cable OD)	N/A	N/A	N/A	10.24	N/A	N/A	N/A
Triangel-Plastic Wire and Cable (7 x cable OD)	N/A	7.21	8.05	N/A	9.45	10.00	11.97

ATTACHMENT 10



A=Distance from ℄ hole to barrel of larger LUG-1/16"
B=Distance from ℄ last hole to end of spade for both LUGS+1/8"
C=Distance from ℄ hole to barrel of smaller LUG-1/16"
D= Diameter of hole is same as hole in respective lug.
V=Width of larger LUG-1/32"
F=Distance between ℄ of holes in spade of lug
T=Thickness of larger lug spade (minimum) for 600V terminations, or;
=N x thickness of lug spade on field cable +1/16" where N is the number of equipment pigtail leads per phase for medium voltage (5-15KV) terminations.

STRAIGHT CONNECTION (MINIMUM SIZE)



A=Distance from ℄ hole to barrel of larger LUG-1/16"
B=Distance from ℄ last hole to end of spade of larger LUG+3/4"
C=Distance from ℄ hole to barrel of smaller LUG-1/16"
D=Diameter of hole is same as hole in respective LUG
E=Distance from ℄ last hole to end of spade of smaller LUG+7/16"
V=Width of larger LUG-1/32"
F=Distance between ℄ of holes in spade of lug
T=Thickness of larger lug spade (minimum) for 600V terminations, or;
=N x thickness of lug spade on field cable +1/16" where N is the number of equipment pigtail leads per phase for medium voltage (5-15KV) terminations.

ANGLE CONNECTION
(MINIMUM SIZE)

NOTE: Two-hole copper compression-type terminal lugs (in lieu of one-hole terminal lugs) shall be used when available from vendor and when space is available in the terminal box. Remove all burrs, sharp edges, and sharp corners from the adapter plate.

Y-MAX DIMENSION

CONDUCTOR SIZE AWG OR MCM	Y-MAX ALLOWABLE DISTANCE BETWEEN INSULATION AND CONNECTOR (SEE NOTE 1)
22-10	3/16" (+1/16" - SEE NOTE 2)
8-4/0	3/8" (+1/8" - SEE NOTE 2)
250-1000	1/2" (+1/4" - SEE NOTE 2)

NOTE 1: The minimum distance between the insulation and connector shall be sufficient to determine that the insulation has not been crimped in the connector.

NOTE 2: Where conductors must be bent to accommodate design configurations, such as at certain terminations or inside small conduit boxes, the maximum allowable distances specified in the table above may be exceeded by the amount specified.