AMERICAN CONSULTING ENGINEERS COUNCIL'S

HEAVY MOVABLE STRUCTURES MOVABLE BRIDGES AFFILIATE

3RD BIENNIAL SYMPOSIUM

NOVEMBER 12TH - 15TH, 1990

ST. PETERSBURG HILTON & TOWERS
ST. PETERSBURG, FLORIDA

SESSION WORKSHOP NOTES

Session (1-5)
"Electrical Cable of the Submarine Type..", Ken Charboneau,
Marine Industrial Cable Co., La.

ABSTRACT

By using existing cable design specifications coupled with field experience in installation techniques, we can address some of the do's and don'ts of matching cable design characteristics to any given installation.

Cable manufacturers have been routinely asked design questions that have purely electrical and electronic origins, such as how to eliminate cross-talk and 60 cycle hum when combining control conductors with adjacent power conductors.

We would like to discuss here not only the electrical reasons for a cable's design but what influence should the installation circumstances have on that design.

DISCUSSION

In attachment #1, you have a basic cable design that is state-of-the-art.

This paper is meant to integrate the more science of cable design to the more art of cable installation. The best designed cable in the world is not good if it's not installed properly. A badly designed cable is still bad even if installed properly.

The hope of this paper is to stimulate from the professionals in this room how to best address this integration of science and art of manufacturing and installing of Submarine Cables.

Let's address some of the basic points, first from a cable manufacturers standpoint.

MANUFACTURING

1) COPPER - In the back of attachment #1 is a two page simplistic form that the customer is to fill out so that the cable manufacturer will know how many of what size conductors are to be put in their Submarine Cable. Generally this is not a controversial issue as long as the copper meets section 2 of ICEA Standards.

2) INSULATION - Cross-linked polyethylene is the ideal insulation for Submarine Cables when one considers all electrical, physical and dimensional aspects.
Insulation thicknesses in excess of column A, Table 3-1 as recommended in ICEA Standards can be counter-productive.
Generally speaking, you will have a more reliable Insulation system when you use a thicker layer of insulation. Before one decides to arbitrarily increase insulation wall thickness, be aware of what this will do to the cable O.D. and its resultant minimum bend radius.

3) CABLING - A simplistic explanation of a complex subject would be that cabling allows for a reasonable bend radius to occur. Adjustments made to the length-of-lay during cabling will also affect cross-talk and 60 cycle hum.

4) CABLE JACKET - High density polyethylene has a very low moisture absorption rate and is inert to most solvents and chemicals.
Jacket thicknesses for movable bridge applications are recommended by this manufacturer to be 30% thicker than those recommended in the ICEA Standards.

5) ARMOR - Steel armor is used principally for physical protection against lateral damage. The steel in turn has to be protected against corrosion. This is accomplished in two layers, the steel is galvanized and then a thin layer of polyethylene is extruded over each wire. With this insulator and separator over each wire, if any damage is incurred then only those wires affected will act as a sacrificial anode and the rest of the cable will be unaffected.

6) OVERALL JACKET - High density polyethylene is physically very tough.

Again, we recommend a thickness 30% more than the minimum stated in the ICEA Standards.

Now we will address some of the basic points of installing a Submarine Cable.

INSTALLERS

1) LENGTH & WEIGHT - Installers are sometimes quite surprised when they see just how big and heavy a short (250 ft.) piece of Submarine Cable is when it arrives at the job site. A simple pay-out system envisioned before seeing the cable is usually inadequate. A reel 9 ft. high and 6 ft. wide weighing 2 1/2 tons requires a longer and heavier than normal reel shaft. The jacks used to lift the reel are almost never high enough or heavy enough. The reel wobbles when turned.

The pulling line, winch and associated equipment have to be adequate not only for the dead weight but the drag load which can be substantial.

2) END SEALS AND PULLING EYES - Kellum Grips have a history of success, they work well.

Some customers have asked the cable manufacturer to use the steel armor of the cable as a pulling eye, formed at the factory. This usually is not very practical.

End seals are a must, due to the very nature of a Submarine Cable. Adhesive type heat shrinkable end seals are readily available from electrical wholesale outlets. It takes a great deal of abuse to rupture one of these end seals, but it happens.

An effective means of protecting against this problem is to force a tube of regular construction grade silicone in and on the end of the cable prior to shrinking the end seal in place. The shrinkage of the end seal further forces the silicone into the interstices of the cable.

3) BENDING RADIUS - Most installations require the cable to make two or more 90° Bends.

It is imperative that the cable is never bent at a tighter radius than 12 times the cable diameter. The cable manufacturer should be consulted if the installer feels that this bend radius will have to be smaller. <u>Some</u> Submarine cables can be safely bent around a radius of 10X or even an 8X cable diameter.

4) ENTRANCE CONDUIT OR STAND-PIPE - This area of a bridge can be very congested. Without proper planning, it is not uncommon to see the use of crow-bars and cranes being used to clear the area of other cables and/or debris.

This is the time when one can appreciate the extra design and care given during the cable's manufacture. The redundant, oversized cable jackets and redundant sealing of ends protect against these unknown and varying conditions encountered in the field.

SUMMARY

The interrelationship between Submarine Cable design and the reality of the unpredictable conditions of installation is profound.

This relationship dictates a need for a better understanding between the cable manufacturer and the contractor who installs the cable.

This better understanding will reduce the cost of both manufacturing and installation.

This understanding will optimize the installed product and will insure that the cable has less chance of superficial damage which could result in shorter than expected cable life.

1. SCOPE

1.1 This specification covers multiconductor, cross-linked polyolefin insulated, polyethylene jacketed, helically served steel armored power communication and control cable with an overall jacket of polyethylene for underwater installation.

2. CONSTRUCTION

2.1 The construction of this cable is in accordance with the requirements of good commercial practices and appropriate specifications.

2.2 Insulated Conductors

2.2.1 Uncoated copper conductors are to be in accordance with ASTM B-3. Concentric stranded conductors in accordance with ASTM B-8. Class "B" concentric stranding.

2.2.2 Conductor insulation shall be cross-linked polyethylene (XLPE) compound, meeting the requirements of ICEA publication #S-66-524 (2nd edition)/NEMA Publication WC7-1982.

2.2.3 The insulation must meet the following physical and thermal requirements:

Unaged	
Tensile Strength - pounds force per square inch (lbf/in^2), min.	1800
Elongation - percent, min.	250
Aged	
Air oven (168 hours at 136°C)	
Tensile strength - percent of unaged, min.	80
Elongation - percent, min.	80

2.2.4 Dimensional Tolerances

The insulation thickness and wire overall diameter are nominal dimensions. The dimensional tolerances for the conductors shall meet the requirements of ICEA Publication #S-66-524 (2nd edition) Para. 3.1. The insulation thicknesses shall meet the requirements of ICEA Publication #S-66-524 (2nd edition) Para. 3.3.

2.2.5 Number Code

Conductor coding shall be accomplished by the use of printed coding consisting of the appropriate color number followed by the corresponding spelled-out word or words. The legend shall be legible after handling incident to installation and maintenance.

2.2.6 Strippability - The insulation shall be readily removable from the conductor. A separator is required between the conductor and the insulation, to enhance the strippabilty. The separator shall be colored black or shall be opaque to make clearly distinguishable from the conductor once the insulation is removed.

2.3 Cabling

2.3.1 The conductors shall be cabled in a tight and concentric configuration. The direction of lay for adjacent layers shall be reversed. Maximum length of lay shall be in accordance with ICEA Publication #S-66-524 (2nd edition) Para. 5.2.

2.3.2 The various cable components shall be cabled together and filled if necessary to give the completed cable a substantially circular cross section.

2.3.3 The cabled assembly shall be covered with a 0.002 in. corrugated polyester film separator applied helically with minimum of 25% overlap.

2.4 Cable Jacket

2.4.1 The cable shall be provided with a high-density polyethylene jacket according to ICEA Pub. #S-66-524 Para. 4.4.2.

2.4.2 The jacket thickness shall be in accordance with ICEA Pub. #S-66-524 Para. 4.4.3.

2.4.3 Optional jacket materials (PVC-TPR-PU) are available to meet specific functional requirements.

2.5 Steel Armor

2.5.1 Cable armor shall consist of a single layer of strands of galvanized plow steel wire, which is covered with a layer of polyethylene.

2.5.2 The size and number of strands shall provide a percent coverage of 91 to 97%.

2.5.3 Cable armor shall be applied at a nominal lay angle of 18° - 25° in a preformed helix.

2.6 Armor Jacket

2.6.1 The cable shall be provided with a high-density polyethylene jacket according to ICEA Pub. #S-66-524 Para. 4.4.2.

2.6.2 The jacket thickness shall be in accordance with ICEA Pub. #S-66-524 Para. 4.4.3.

2.6.3 Optional jacket materials (PVC-TPR-PU) are available to meet specific functional requirements.

3. TESTING

3.1 The following tests shall be conducted on the completed cable.

3.1.1 Voltage Test - The cable shall withstand between conductors and ground and between conductors a RMS test voltage as defined in the following table. The duration of the test shall be one minute.

TEST VOLTAGE (KV)

CONDUCTOR SIZE AWG	300V	600V
20	0.5	
18	1.0	1.5
16	1.0	1.5
14 - 9		3.5
8 - 2		5.5
1 - 4/0		7.0
250 & LARGER		8.0

3.1.2 Insulation Resistance Test

The Insulation Resistance shall be measured after the AC voltage test and the measured values shall be in accordance with the requirements of ASTM D2655 & D470.

WIRE SIZE (XLP-USE)	MEGOHMS/MFT. @ 60°F
#12 - #10 AWG	1,750
# 8 - # 2 AWG	1,600
# 1 - 4/0 AWG	1,075
250 - 500 MCM	725
600 - 1000 MCM	550

4. ASSEMBLY

4.1 Specific assemblies shall be designed, sized and manufactured based on:

4.1.1 Power Conductors

Size________________ Qty________________

Comments:____

____

____

4.1.2 Control Conductors

Size________________ Qty________________

Size________________ Qty________________

Comments:____

____

____

4.1.3 Communications Conductors

Size________________ Qty________________

Size________________ Qty________________

Comments:____

____

____

4.2 Cabled Core

4.2.1 Geometric Description________________________________

____

____

4.2.2 Diameter________________

4.3 Finished Cable

4.3.1 Overall Diameter____________________

4.3.2 Weight/1000ft.____________________

4.3.3 Marking____

5. REQUEST FOR QUOTE

5.1 Footage Required____________________

5.1.1 Length tolerance; -____%, +____%

5.1.2 Lengths____________________

5.2 Required Delivery

5.1.1 Days A.R.O.____________________

5.2.2 Gross Weight____________________

5.2.3 Shipping Instructions____

____

____