APPENDIX VIII

CONDUCTING CABLE WORKSHOP
REVIEW OF UNOLS CABLE POOL

OCEANOGRAPHIC CABLE POOLS
GENESIS

Before 1982:

- Each institution purchased cable to meet its own requirements.
- Characteristics varied through fleet (Electrical and mechanical)
- CTD became dominant user of E-M cable

Problems:

- User: unable to pick R/V of choice
- User: unpredictable cable performance (multiple designs/vendors)
- Many annual proposals for funds
- High cost per unit length
- Inefficient maintenance of reserve cables

Solutions:

- Standardize cable type/design/length
- Provide uniform winch capability
- Bulk-purchase cable
- Pool reserve cables

HISTORICAL REPLACEMENT OF CABLE

Too Short • 75-80%
Age/corrosion • 15-20%
Loss • 5-10%

Reason: Electrical failure - cut at sea

Causes: Crushing due to poor level-wind
Z-kinking (cyclical overloading)
Slack wire hockle (cyclical "0" load)

Solutions:

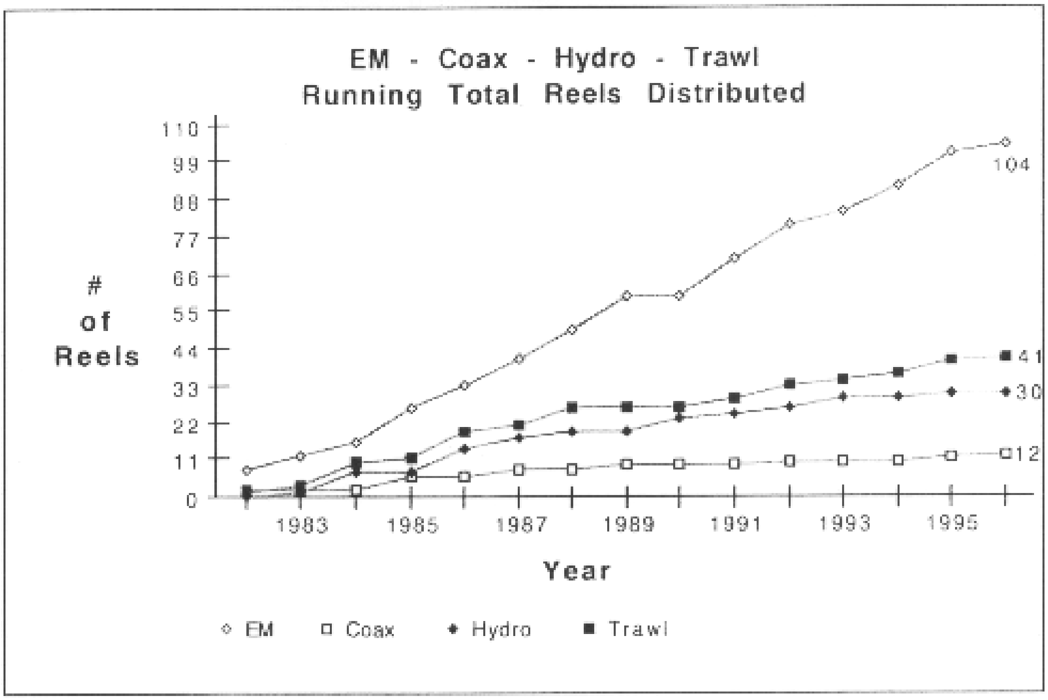
- Multiple conductor cable - redundancy
- Improve strength/weight ratio
- New winch/level-wind systems
- Improve payload characteristics
- Define operating limits:
  - Sea state
  - Vessel motion
  - Lowering speeds
  - Payload limits (weight/bulk)
- Education

UNOLS
Oceanographic Cable 'Pools'

Total Purchases since Inception

		No. of Reels	Total Length (x1000)	Total Cost (x1000)
EM-	.225"	18	457.1'	$ 132.7
	.303"	5	132.4'	91.7
	.322"	100	3,174.2'	1,853.3
	Total	123	3,764.0'	$2,077.7
Coaxial -	.68"	13	359.9'	$959.9
Hydro -	3/16"	9	271.2'	$ 73.4
(3x19)	1/4"	25	742.1'	340.7
	Total	34	1,013.3'	$414.1
Trawl -	1/2"	27	811.3'	$ 608.3
(3x19)	9/16"	22	845.6'	993.2
	Total	49	1,656.9'	$1,601.5
Grand Total		219	6,794.1'	$5,053.2

UNOLS Oceanographic Cable 'Pools'



D.Moller-11/1/96

UNOLS E-M CABLE

Requirement: A long cable with data transmission capability used to lower varied instrumentation from R/V on the High Seas

GENERAL SPECIFICATIONS

- Payload weight: >1000# (450kg.)
- Operating Depth: 6,000m.
- Lowering rates: >60m./min.

- Dynamic environment
- Continuous operation
- Intermediate sized winch systems
- "Well logging" cable design
- Multiple conductors
- Low powered telemetry
- Minimal power capacity

CHARACTERISTICS

- Nominal .322"(8.2mm) diameter
- 10,000 meter length
- Best weight to strength ratio
- Highest elastic limit
- Best abrasion resistance
- Best corrosion resistance
- High rotational stability
- Armor stress balance
- Well preformed (resist unlaying)
- Service life >3 years
- Survival: >40% RBS for 70% life
- Survival: Periodic loading >50% RBS
- Withstand cyclical loading
- Flexure: operate over sheaves 40X cable dia.
- Galvanized
- Storage under tension to 40 layers
- Lubricated

UNOLS E-M CABLE

PERFORMANCE SPECIFICATIONS

Diameter:	.322" (+/-.003") at 15% RBS <2% Change at 50% RBS Uniform over length
Length:	10,000 meters, w/o splices
Strength:	RBS >9,000# w/ one-end-free
Rotation:	<20°/ft. at 40% RBS
Flexure:	>50,000 cycles, sheave 40X O.D. at 40% RBS without failure
Tension cycling:	as above, 10% to 40% RBS
Min.Sheave size:	<15" tread diameter
Armor:	Strength ≥ XIPS Ductility ≤ XIPS Min. outer wire dia.=.032" (.81mm)
Electrical:	3 cond.,stranded copper wire >#20AWG Conductor: DC resist <10Ω/1000', <40pf/ft.@1kHz, Rated >600 VDC Primary circut: 1 conductor to armor Telemetry: optimize freq <20kHz (5kHz+10kHz) Copper yield >65% RBS of cable
Lubrication:	Low vicosity, water displacing During armoring

May '1986
SPECIFICATIONS
FOR
A UNOLS "CTD" CABLE

The academic oceanographic community, represented collectively by the University and National Oceanographic Laboratory System (UNOLS), has for many years used Electro-mechanical cables in general purpose applications to lower various scientific instruments over the side of oceangoing research vessels. The cables, which are handled with intermediate-sized hydrographic winches, support the instruments and provide the medium for electronic telemetry to the vessel. This type of cable has come to be known as "CTD wire".

Since 1982 a community wide effort has been made to "standardize" E-M cables to a single design to provide commonality on UNOLS vessels. A triple conductor .322" diameter cable of 33,000 ft. length has been selected for this application. In 1984,1985 and 1986 several reels of this cable were purchased. Winch systems have been replaced or upgraded to accommodate cables of this size.

The E-M cable is of the general type developed for the well logging industry. Although this type cable continues to be suitable for oceanographic applications, operating conditions and scientific applications aboard research vessels differ from those of the oil industry. These differences are significant enough to warrant the design of a cable that will specifically meet the needs of the UNOLS laboratories.

The following specifications describe in general terms the significant characteristics a UNOLS E-M cable design MUST have. No priority is implied by the order given.

GENERAL:

An Electro-mechanical cable is required to lower various scientific instruments over the side of oceangoing research vessels. The cable must be capable of safely lowering an instrument to a 20,000 foot water depth in the dynamic environment caused by ship and wave motion, and lowering/raising speeds of 300 ft./min. Multiple conductors are required for the real time transmission of electrical data and control signals and for redundancy. The cable must be capable of being stored under tension for long periods of time on single drum winches to a depth of 40 layers. Resistance to crushing, as occurs when level winding is faulty, is desirable. It is expected, that regardless of the Ultimate and Yield Strengths of the cable, payloads will evolve to a point that loading of the cable (static + dynamic) will frequently approach 50% of RBS.

CHARACTERISTICS:

1) Maximum strength attainable-- identified as the best possible ratio of strength to weight. The ability of a cable to "survive" under extreme conditions is a function of its Rated or Ultimate Breaking Strain.

2) Highest elastic limit attainable-- identified as the best possible ratio of elastic limit to weight. This characteristic controls the mix of payload size, wire out, wire speed and environmental conditions at which the cable can operate with safety. This applies to both strength and electrical components of the cable.

3) High rotational stability-- identified as a minimal amount of axial rotation under loads cyclically varying from 0% to 45% of RBS. Low rotation is considered necessary to avoid looping/hockling the cable on bottom contact or "Zero" tension conditions and to prevent excessive spinning of lowered instruments. (A 'trade off' with Item 15)

4) High degree of armor stress balance -- identified as the absence or near absence of variations to the relative loading on inner and outer armors that produce strength degradation when one end of the cable is free to rotate.

5) Minimum service life of 3 years-- the useful life in "normal" service assuming reasonable care and proper handling.

6) Cable must be capable of operating at:
   >30% RBS for 90% of expected life;
   >40% RBS for 70% of expected life.

7) Withstand occasional loading to 50% RBS without significant, if any, reduction in strength or change in electrical characteristics.

8) The cable must be galvanized.

9) The cable must have a finished O.D. of .322". This is to avoid modifications to existing winch/sheave train systems.

10) The cable must be in an unbroken length of 33,000' (without splices).

11) The cable must be capable of operation with single drum winch systems where the cable is stored under tension.

12) Operate continuously (useful life) over sheaves NLT 40X cable diameter without degradation in strength.

13) The cable must be capable of withstanding repeated flexures over sheaves at the nominal working loads given in Item 6 without degradation in strength or change in electrical characteristics.

14) The cable must be capable of withstanding cyclical loading in tension as results from ship motion without degradation in strength or change in electrical characteristics.

15) Exhibit the best possible resistance to abrasion, both internal and external, consistent with the need for high rotational stability. (A 'trade off' with Item 3)

16) Exhibit the best possible resistance to corrosion, particularly crevice corrosion and hydrogen imbrittlement.

17) The cable must not unlay when cut, i.e., it must be well preformed.

18) The cable should be lubricated for abrasion and corrosion protection. The lubricant should not extrude in use.

19) The cable must have multiple electrical conductors capable of efficient transmission of low power telemetry signals at frequencies <20kHz. Cable design should be optimized to permit simultaneous transmission of 5kHz and 10 kHz signals in a single conductor to armor circuit. There is no requirement for power transmission.

PERFORMANCE SPECIFICATIONS:

1) Finished Diameter: The finished diameter shall be .322" at a loading of 15% of RBS. The diameter shall be uniform over the length of the rope with tolerances of (±0.003"). This specification permits the use of existing winch/sheave train systems without modification.

2) Working Diameter: The change in cable diameter due to a change in cable loading shall not exceed 2% of the finish diameter. At a loading of 50% RBS the cable diameter shall not be less than .316". This specification is to assure the cable stays within limits necessary for proper level winding.

3) Rotation: The finished rope should not rotate about its axis more than 20° per foot at 40% of Rated Breaking Strength. It is recognized that this requirement may not be met given the specified outer armor wire size and minimum sheave diameter.

4) Rated Breaking Strength: >9000# with 1 end free to rotate.

5) Flexure Tolerance: Withstand ≥50,000 flexure cycles over sheaves 40X wire O.D. at 35-40% of RBS without failure of individual wires or degradation of electrical performance. Degradation in strength shall not exceed 5% of RBS. This is estimated to be 150% of flexures in a sheave train for 500 casts to oceanic depths including flexures at the overboarding sheave due to ship motion.

6) Tension Cycling: Withstand ≥50,000 cycles in tension from 10% to 40% of RBS at an 8 sec. period without failure of individual wires or degradation of electrical performance. Degradation in strength shall not exceed 5% of RBS. This value is considered to be representative of tension variations due to ship motion and pay-out/haul-in speeds for 500 casts to oceanic depths.

7) Sheave Size: The cable shall be capable of operation with sheaves of tread diameter ≤15".

8) Cable Length: The cable shall be of an unbroken length of 33,000 ft. without splices.

9) Armor Wires: The armor wires shall be galvanized and have the following characteristics:
   Tensile strength: ≥ xtra Improved Plow Steel
   Ductility: ≥ of XIPS
   Outer armor: wires to have a diameter ≥.032".

10) Electrical: The cable shall be constructed with 3 stranded copper wire conductors sized #20 AWG or larger, each of which shall have the following electrical characteristics:
   Resistance: <10 ohms/1000ft.
   Capacitance: <40 pf./ ft. at a freq. of 1 kHz.
   Voltage Rating: ≥ 600 VDC

11) Yield Strength: Construction shall be such that the conductors shall not yield at a cable loading equal to 70% of RBS.

12) Lubrication: The cable should be lubricated for abrasion and corrosion protection at the armor closing process during manufacture. The lubricant shall be of a low viscosity, water displacing type that does not extrude in use.