CHAPTER 6

WIRE ROPE AND E.M. CABLE LUBRICATION

Etienne Grignard

1.0 INTRODUCTION

One of the major causes of wire or cable deterioration and the reduction of its serviceable life is a lack of proper field lubrication techniques. The lack of proper re-lubrication of an operational wire is roughly equivalent to the purchase of a new automobile and then ignoring the need to add more oil as the vehicle is used; ultimately the engine lubricant is consumed and the moving metal parts begin to abrade each other until the engine fails. However, with proper re-lubrication, that engine, like a rope or cable, will last for an indefinite period of time. It is important to realize that any rope or cable is a complex mechanical system that operates in a hostile environment. Not only is it subject to both internal and external abrasion during use, but it is also prone to the corrosive effects of the sea water. Without proper re-lubrication techniques in the field, both the abrasion of the strands and corrosive effect of the sea water combine to reduce both the wire’s load-carrying capacity and serviceable life.

Corrective Maintenance Vs Preventative Maintenance.
Questions to determine:

Corrective Maintenance:

- Cost to replace is relatively low
- Product is easily and readily available
- Product is replaced utilizing minimal man hours without significant shut downs
- Cost to replace is less expensive that cost to maintain
- Man hours to replace is less than man hours to maintain
- Safety is not jeopardized by lack of maintenance
- A replacement schedule is enforced
- Company can not commit to a follow a preventative maintenance program
- Maintenance materials distort research findings

Preventive Maintenance:

- Cost to replace is (relatively) high
- Product is not readily available
- Product replacement utilizes excessive man hours
- Product replacement stops production / research
- Cost to maintain is less expensive that cost to replace / install
- Man hours to maintain is less than man hours to install
- Safety may be jeopardized by lack of inspection
- Maintenance materials do not distort research findings
- Company commitment is to make preventative maintenance programs work

2.O WIRE LUBRICATION THEORY

The lubricants applied to working ropes and cables provide a dual form of protection in that individual wires are protected from one another and the whole wire is preserved against the corrosive action of sea water. In order to understand the importance of wire and cable lubrication, it is necessary to realize that a wire, when in use, is a dynamically complex mechanical tool which is composed of numerous moving parts. As the wire passes over the sheave train, it is subjected to corrosion, bending, tension, and compressional stresses as it attempts to equalize the effects of the load it is carrying. The lubricant added to the wire during manufacturing permits this equalization to occur with a minimum of abrasion to the individual wires within each strand.

2.1 Wire Re-lubrication

The reapplication of a lubricant in the field cannot be stressed too strongly since it ensures that the friction between individual wires is reduced to minimum; remember, each wire within a rope or cable is in constant contact with other wire along its entire length. If the user neglects to follow a program of field lubrication, the manufacturer supplied lubricant is soon dissipated and direct metal to metal contact established between the individual wires of the rope. As the “dry” rope is used, the abrading of the individual wires reduces their metallic area and subsequently, the total load carrying capability of the wire itself. The effects of operating a dry rope versus a lubricated rope are best illustrated in the following chart taken from the Roebling Wire Rope Handbook which shows the results of cyclic testing of non-lubricated versus lubricated wire rope.

	10" Tread Dia Sheave Sheave/Rope Dia Ratio = 18	24" Tread Dia Sheave Sheave/Rope Dia Ratio = 43
Dry Rope	16,000 Bends	74,000 Bends
Lubricated	38,700 Bends	386,000 Bends

During this test series a 9/16" dia 6 x19 wire rope was used. The results indicated that based on sheave size and lubrication, a lubricated wire will operate 2.4 times as long as a dry rope in the case of the 10" tread dia and 5.2 times as long when the tread dia is increased to 24". The results of such tests clearly indicate the benefits and the need for continued field lubrication of working wires and cables, as well as the importance of utilizing properly sized sheaves. The success of the 24" diameter sheave is due to the reduction in wire stresses due to the larger contact area the wire is exposed to and the reduction in individual wire movement within the rope.

Definition of Corrosion

"Corrosion is the deterioration of a substance (usually a metal) or its properties because of a reaction with its environment."

Basic Forms of Corrosion

There are many forms of corrosion. Some are frequently encountered in everyday life and on the job. Others require specific combinations of materials and environments that are rarely encountered. Gaining an understanding of the mechanisms at work in these forms of corrosion and how the mechanism results in the specific forms of corrosion is an important first step in controlling corrosion. What we understand, we can more easily control.

In this course, we will find that all forms of corrosion, with the exception of some forms of high-temperature corrosion, occur through th action of the electrochemical cell. We will find that this electrochemical cell can act in many ways, but that it's general principles, once understood, can be applied to the understanding of most forms of corrosion. We will find that many of the methods that are used to control corrosion involve intentional interruption of the action of the electrochemical cells responsible for corrosion

2.2 Corrosion Protection

Corrosion Occurs Through Electrochemical Reactions

- Except for high temperature corrosion, all corrosion reactions are electromechanical reactions occurring in electrolyte. –NACE

- Electrochemical reactions:

Occur in electrolytes, which are liquids that can carry and electrical current

Occur through the exchange of electrons

-The exchange of electrons in electrochemical reactions occur at separate sites

-The electrons flow through the metal from one of these separate sites to another

- Electrolyte:

  An electrolyte is a liquid that contains ions. An electrolyte can conduct electricity through the flow of ions. Anions flow towards the anode, cations flow towards the cathode.

Protecting a wire from the corrosive effects of the salt water environment may well be the most important aspect of increased wire life. As discussed, the wire is usually delivered with some type of lubricant already in place on the wire, which acts as a corrosion prevention device as well as a lubricant. If renewed in the field, a rust preventative/lubricant can extend the useful life of the rope or cable by as much as five times the working life currently being experienced.

The full effect of corrosion damage to an unlubricated wire is virtually impossible to assess fully due to the complexity of the problem. Simultaneously a corroding wire is affected by a loss of metallic area in the individual wires due to chemical and electrochemical action on the bare steel, the bare metallic contact areas between wires are pitted and toughened causing an uneven surface which forms stress points in individual wires, and finally the corroded contact surface inhibits the normal, smooth movement of the wires relative to one another generating high stress concentrations, speeding corrosion fatigue and crack propagation. All of these factors operate internally within the wire and may not be visible during a casual inspection other than the presence of surface or leaking rust.

2.3 Splash Zone Corrosion

The marine environment represents what is perhaps the most hostile climate a wire or cable may be required to operate in during its working life. At sea the wire is alternately subjected to the corrosive effects of the marine atmosphere and short immersions in seawater during lowerings. Combine this with frequent exposure to salt spray blowing aboard and a set of circumstances equivalent to splash zone conditions is produced.

When the wire in use is allowed to lose its factory-applied lubrication through a lack of re-lubrication at sea, it quickly loses its protective coating and becomes subject to the full corrosive effects of its environment. Figure 6-1 represents the typical corrosion rates which can be expected of bare steel in the marine environment. Based on the data presented in this figure, it is obvious that metals used in marine atmospheric conditions are subject to the highest rate of corrosion and therefore, require proper field lubrication techniques to be practiced if maximum wire life is to be achieved.

2.4 Marine Atmospheric Corrosion

Of secondary importance to the possible mechanisms for at-sea wire degradation are the affects of the marine atmosphere on unprotected steel. Based on the data presented in Figure 6-1, atmospheric corrosion has a lesser affect upon a wire than one in the splash zone. Nonetheless, its continuing effects will be realized over time. Given the circumstances of a reel of wire stored on a vessel without adequate protection or a covering, it can be expected that at least the upper layers of the wire will be rendered useless in a relatively short period of time.

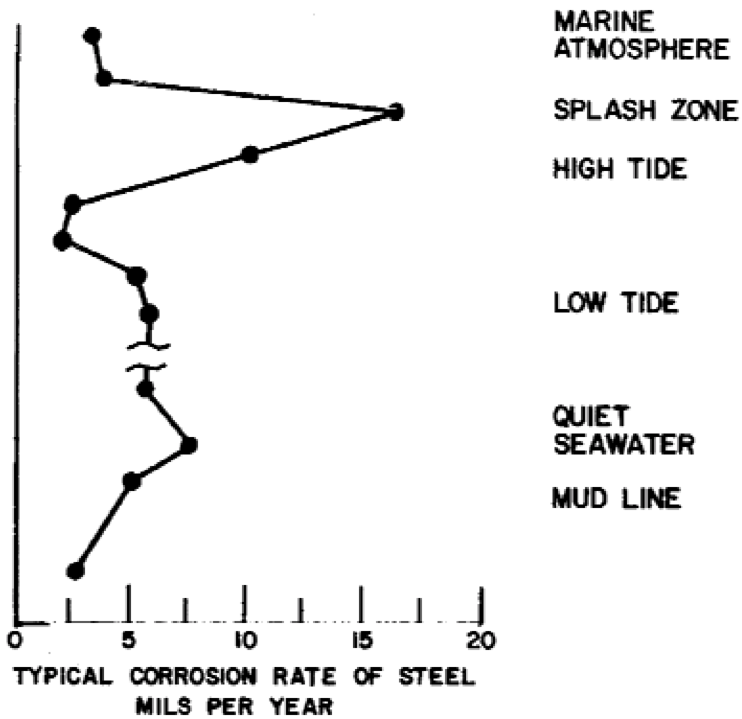
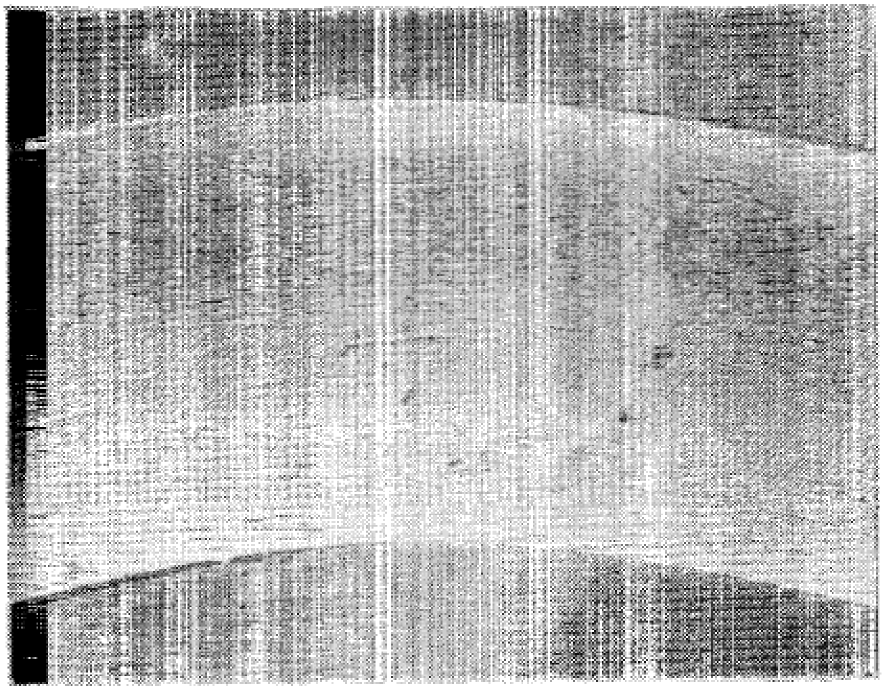
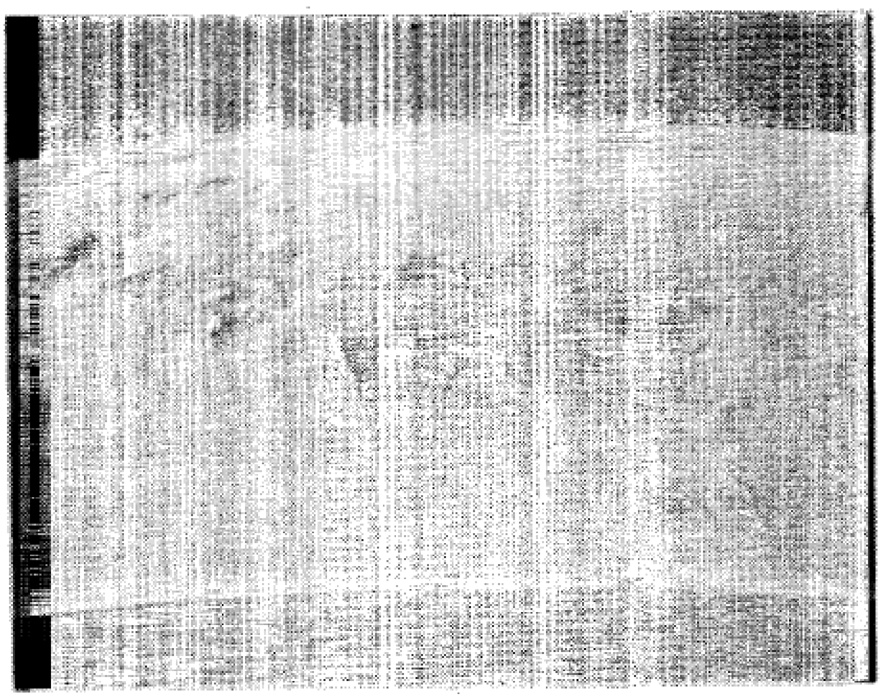


FIGURE 6-1

One prime example of the affects of atmospheric corrosion resulted from an experiment conducted by U S Steel of Trenton, NJ in 1969. In this experiment samples of unprotected steel were exposed to the salt air environment at distances up to 800 feet from the water edge. Although corrosion was present on all samples, it was determined that samples 80 feet from the water corroded at a rate of 10% to 15% faster than the 800 foot sample. Translate this to a research vessel whose wires are never more than 20 feet from the water and this potential for rapid atmospheric corrosion is obvious.



WIRE PROTECTED WITH LUBRICANT/RUST PREVENTATIVE
PHOTOGRAPH 1 (100x)



UNPROTECTED WIRE
PHOTOGRAPH 2 (100x)

2.5 Corrosion During Wire Immersion

The corrosive effects of sea water on wires that are immersed for long periods of time, such as buoy moorings, etc., has been an area of interest for some time. It has been observed that the rates of corrosion vary from location to location in the ocean when the wire in use is unprotected by either a lubricant or a rust preventive. Accelerated rates of corrosion have been observed, which were ultimately traced to a combined effect of chemical levels in the water and the temperature of the seawater.

This problem was fist addressed by the Grignard Chemical Company in 1969 when advanced states of corrosion were first noticed on bright steel samples from the Antigua area. With the assistance of the Woods Hole Oceanographic Institution, Oregon State University, the Halan Company and U.S. Steel, a series of experiments were conducted to determine the causes of the accelerated corrosion rate observed in the Antigua sample. Test specimens of bright steel wire, galvanized wire and electromechanical cable, supplied by U.S. Steel, were submerged in sea water for half their length at three widely spaced locations, i.e., Massachusetts, Oregon, and Antigua, W.I. for a period of three months. At the conclusion of the test, all specimens were removed from the sea water and the corrosion level present in each wire was evaluated.

The analysis performed jointly by the Woods Hole Oceanographic Institution and Grignard Chemical Company indicated that water temperature was the prime factors involved in the accelerated corrosion rate that had been observed. Water analysis from the three test sites were as follows.

Location	Solids (Sodium Chloride)	Temperature
Oregon	3.71% Total Solids	44^0 F
Massachusetts	3.61% Total Solids	40^0 F
Antigua	3.98% Total Solids	84^0 F

3.0 WIRE LUBRICANTS AND CORROSION PREVENTION

Essentially the function of any wire dressing is two-fold in that it must act as a lubricant between individual wires to prevent premature wear and it must also prevent corrosion of the wire in the long term. Of these two functions, corrosion prevention is probably the most important as more wires fail or are discarded due to the effects of corrosion than service wear. It is a sad but true statement that oceanographic wires tend to rust out before they wear out.

Corrosion is basically a chloride reaction process where rate is increased by temperature, i.e., sodium chloride, and pollutants in the air and water. Corrosion of an unmaintained wire or cable is not restricted to only its outer surface, but instead, attacks all of the wires individually. The result is a steady reduction of the metallic area of each wire and the susceptibility of the wire to corrosion fatigue during bending over a sheave.

A corroded surface, Photograph 2, is made up of a myriad of microscopic pits and craters that under loading establish failure planes in the wire strands. The bending stresses involved in working wires are a factor in fatigue failure of a wire, but when this condition is combined with active corrosion, the failure point of the wire becomes totally unpredictable. The longevity of any wire or cable can be substantially lengthened through a program of re-lubrication in the field and in the specification of wire dressings at the time of manufacture.

3.1 Incorporation of Rust Preventative During Manufacture

Present day manufacturing practices of applying either an asphaltic or petrolatum compound to the wire is not wholly satisfactory. Given current concerns over the longevity of ropes and cables in oceanographic service, perhaps the time is right to address new techniques for these ropes and cables at the time of their production and to develop testing procedures for the ropes. Even though most ropes and cables used in oceanographic applications are purchased on a competitive price basis, it would seem, that the additional cost of including an effective rust preventative would be outweighed by the greater length of service that would be obtained.

Desired Characteristics:

- Water Displacement
- Corrosion Protection
- Penetrate All Voids of the Cable
- Lubrication
- Regulatory Compliance(Environmentally Safe/Non Toxic)
- Easy to Apply ***
- Can Not Camouflage the Cable (McDermott)

3.2 Testing

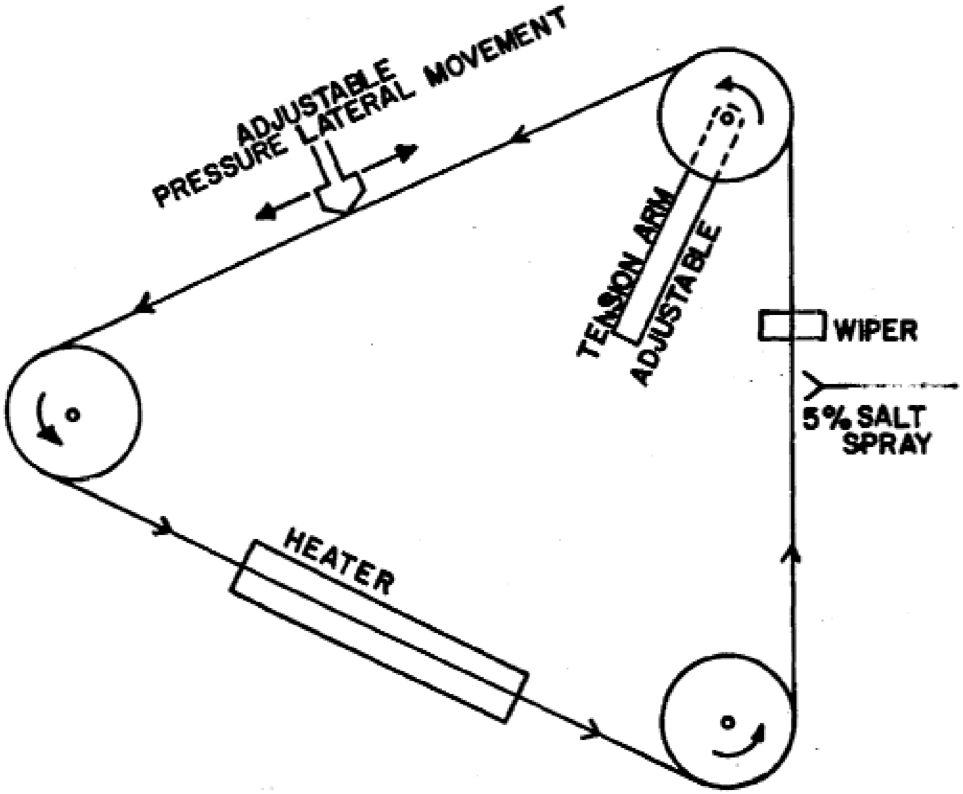
In addition, it would appear that a standard corrosion test for oceanographic ropes and cables should be developed. The current ASTM Salt Spray Panel Test is of little value where ropes and cables are concerned. In effect, the ASTM test achieves its results from monitoring the corrosion of a single steel panel in a static condition. The results of these tests confirm only that a static, high viscosity compound such as cosmoline or a shellac based product will provide good protection form corrosion. Since the hard surfaced rust preventatives are subject to cracking and flaking when the specimen is flexed, it is impossible to compare them or the ASTM test to a wire rope that is bent, stressed, and cavities during use.

Figure 6.2 illustrates a potential test bed for oceanographic ropes and cables that could be developed to assess not only the lubricating value of compounds, but also rust preventatives. In this diagram the wire would be subjected to equivalent corrosive conditions and stresses that are present in the field. This or a similar test method would certainly provide more relevant data than the simplified panel test.

3.3 Rust Preventatives

The largest problem in the effective applications of rust preventatives is being able to successfully coat the inner wire of a rope or cable. In the manufacture of electro-mechanical cables a cotton or synthetic braid is often used between the insulated conductor and the armor which provides an ideal reservoir for a medium viscosity rust preventative. Although the practice of incorporating a preventative is not, at present, commonly practiced by cable manufacturers, it is a concept worthy of evaluation.

Inspections of new electro-mechanical cable that had been coated with a rust preventative after the armor was installed revealed no penetration of the preventative to the cotton braid. In use, the type of cable construction is subject to water impregnation of the braid and progressive deterioration. In a section of cable, only one and a half years old, inspection revealed that the inner armor wires were badly corroded and the braid disintegrated.



3x19 WIRE ROPE
RPM 100 M/MIN.
HEATER TEMPERATURE

PROPOSED LUBRICATION AND CORROSION TEST FOR WIRE ROPE

FIGURE 6-2

The use of an unlubricated or untreated cotton or synthetic braid can result in abrasion between the braid and the inner armor wires. In a report by the Roebling Wire Rope Company it was stated that if during manufacture the amount of lubricant is reduced too low, or is non-existent, an abrasive action between the dry fibers and the armor wires occurs as the cable is worked. This results in a form of fretting corrosion which wears extremely fine particles of steel from the armor wires which oxidize rapidly and can usually be noticed by wire discoloration. This process also results in the reduction of the ultimate strength of the cable over time.

It should be realized that a requirement, by the user, for the addition of a lubricated cotton or synthetic braid would raise the final cost of the cable by some percentage. However, this author feels that if an adequate lubricant/rust preventative is incorporated in the braid, it would be possible to extend the working life of the cable by as much as a factor of five (5) over present experience. Given this type of cable longevity, the additional cost of a lubricated braid is truly insignificant.

CABLE LIFE LONGEVITY CAN INCREASE WITH A PROPER COATING

EXAMPLE: EM Cable Lube #2 manufactured by Grignard Company is a transparent material with excellent penetrating abilities (does not setup, dry or form a tacky film). EM Cable Lube #2 provides twice the lubricity of petroleum based materials, compatible with synthetic and natural rubber, does not readily pick up dust and grime.

ADVANTAGES:

- Environmentally Safe
- 100% Synthetic Base
- Displaces Moisture/Remains Stable
- Effective in Sub-Zero Temperatures

TECHNICAL DATA:

Property	Test Method	Typical Value
Appearance	Visual	Clear
API Gravity	ASTM D 287-39	25.9
Density	ASTM D 1217	7.486
Flash Point	ASTM D-92-52	350^{o} F
Fire Point	ASTM D-92-52	420^{0} F
Viscosity 100^{0}F	ASTM D-4127	390-410 SUS
Four Ball Ware	ASTM D-4127	.31 mm
Water Displacement & Stability	FTM 3007	Pass

REMEMBER: The use of solvent cutbacks should be avoided due to their low flash points and high evaporation rates which result in only partial penetration of the wire leaving the base strands open to corrosion.

4.0 COMPATIBILITY OF LUBRICANT AND RUST PREVENTATIVES

With the identified need to re-lubricate ropes and cables, it is appropriate to mention a few items that are of importance in achieving this process. Principally, the compatibility of the selected lubricant/rust preventative with the wire dressing provided by the manufacturer. Problems that can result from the use of incompatible materials include partial penetration of the wire, a leaching out of the components of the original compound or flaking area of the reapplied dressing due to exposure to ultraviolet light. Since these effects are not readily apparent, careful selection and evaluation of the product to be used is advised.

4.1 Selection of a Field Dressing

The solvents that are commonly used in field dressing include petroleum distillates, chlorinated hydrocarbons, diesters, glycols, and alcohols. The major problem with inexpensive petroleum solvents is their low flash point which presents a serious fire hazard when used in confined spaces or in areas where motor sparking, etc., is likely to occur. Prior to the selection of field dressing, it is advisable to contact the manufacturer and explain the intended use of the product. The fact that it is an oceanographic cable and not an elevator hoist, machinery, or automotive application may be of prime importance in obtaining an effective field dressing.

Oceanographic cable manufactured or dressed with a lubricant should not form a sheen or be iridescent on the water.

The manufacturers of available field dressings are numerous and it would be impractical to list them fully in this chapter. *The wire rope compound used in manufacture and dressing must be inhibited to meet the Water Displacement and* Stability Test FTM 3007. A product developed by Grignard Company, EM CableLube #2 properties can be used as a guide line when selecting a cable lubricant.

4.2 Galvanizing of Ropes and Cables

It has been a standard practice in oceanographic ropes and cables to galvanize the wires prior to laying them up in final form. Zinc, used in the galvanizing process, has good resistance to seawater and usually corrodes at a rate of about 1/1000 of an inch per year, as long as the zinc cladding is intact. However, in a working oceanographic wire internal abrasion and sheave wear can rapidly reduce or pierce the zinc on the wire.

Once the galvanized surface is broken and “white rust” is seen to form, it is indicative that degradation process has begun. In this case, the two dissimilar metals, zinc and steel, are acting against each other in the common electrolyte formed by the seawater causing an electrical flow between the two metals. One metal, the zinc coating, will become the anode while the steel act as the cathode resulting in a steady deterioration of the galvanized coating.

It is important to remember that when the “white rust,” zinc oxide, is seen, there is an abrading action taking place in the wire which, if left alone will result in the piercing of the galvanized coating.

The use of a lubricant/rust preventative on galvanized wire will provide the lubrication necessary to eliminate any oxide formation resulting in longer service life of the wire.

5.0 FIELD APPLICATION OF LUBRICANTS/RUST PREVENTATIVES

Considering the hostile environment in which oceanographic ropes and cables are expected to perform, it is obvious that a program should be developed to perform regularly scheduled re-lubrication of wires in service. Given the current and escalating costs of ropes and cables, the small investment in time and materials required to re-lubricate a wire are certainly outweighed by the greater wire life which can be obtained. The majority of major wire producers recommend a re-lubrication procedure and fully realize the benefits to the users in the reliability of their product.

Due to the variety of conditions and use rates that exist between oceanographic organizations, it is impossible to set down a firm schedule for re-lubrication of working cables. The frequency of this procedure is best determined by the individual user, based on his own experience and on the wire documentation he maintains, At a minimum, the wire should be dressed before being placed in storage ashore or every six months where actual use is on a limited basis.

For organizations with high use rates, this redressing should probably occur at two month intervals and should be applied beginning at the greatest deployment length occurring during this period. Again, the wire documentation will prove highly useful in determining where the redressing should begin. One additional consideration would be a redressing of the entire wire length prior to long periods of disuse aboard the vessel and the covering of the winch reel, where exposed to the elements, with a tarp or similar covering.

What should be remembered is that the wire or cable is an investment upon which many people depend to perform their work. Without proper care and maintenance the wire rapidly becomes unreliable and failures are subject to occur with little or no warning.

6.0 FIELD APPLICATION TECHNIQUES

In the use of field dressings it is important to remember that the majority of products on the market have a specific gravity of less than one. What this translates to in reality is that the dressing will replace moisture in and on the wire, but it will have no effect on entrained water. This brings us to the first concern in the field application of a wire dressing; the removal of excess seawater.

6.1 Cable Drying

The primary concern in preparing a rope or cable to receive a field dressing compound is that it be free from entrained water. This excess water can be removed by using a series of spaced flexible wipers constructed of either rubber, Teflon or leather. It is inadvisable to use rags or other porous materials as a wiper since they quickly saturate and become ineffective. Their purpose is to scrape off the entrained water that is carried along by the moving wire. Due to the construction of 3 x 19 wire rope, a larger number of wipes are required to remove the excess water than are needed with a more concentric electro-mechanical cable.

The placement of any wiping device is relatively crucial to the success of the re-lubrication process. Conceptually, the wiper should be located at a point midway between the outboard sheave and the point at which the field dressing is applied. In this way some of the entrained water will naturally be shed by the wire due to vibration before reaching the wiper and the wire will have a brief opportunity to air dry before being dressed.

Under ideal circumstances it would be preferable to incorporate a compressed air dryer immediately after the wiper to further reduce the moisture level of the wire. It is realized, however, that some vessels have limitations on the availability of service air supplies which can preclude this approach. This lack of an air supply can be partially overcome by reducing the speed at which the wire is recovered during a re-lubrication operation.

6.2 Field Dressing Application

As stated in the first edition of the Handbook of Oceanography Winch, Wire and Cable Technology, extensive work has been done on the investigation of preparing the rope prior to dressing it.

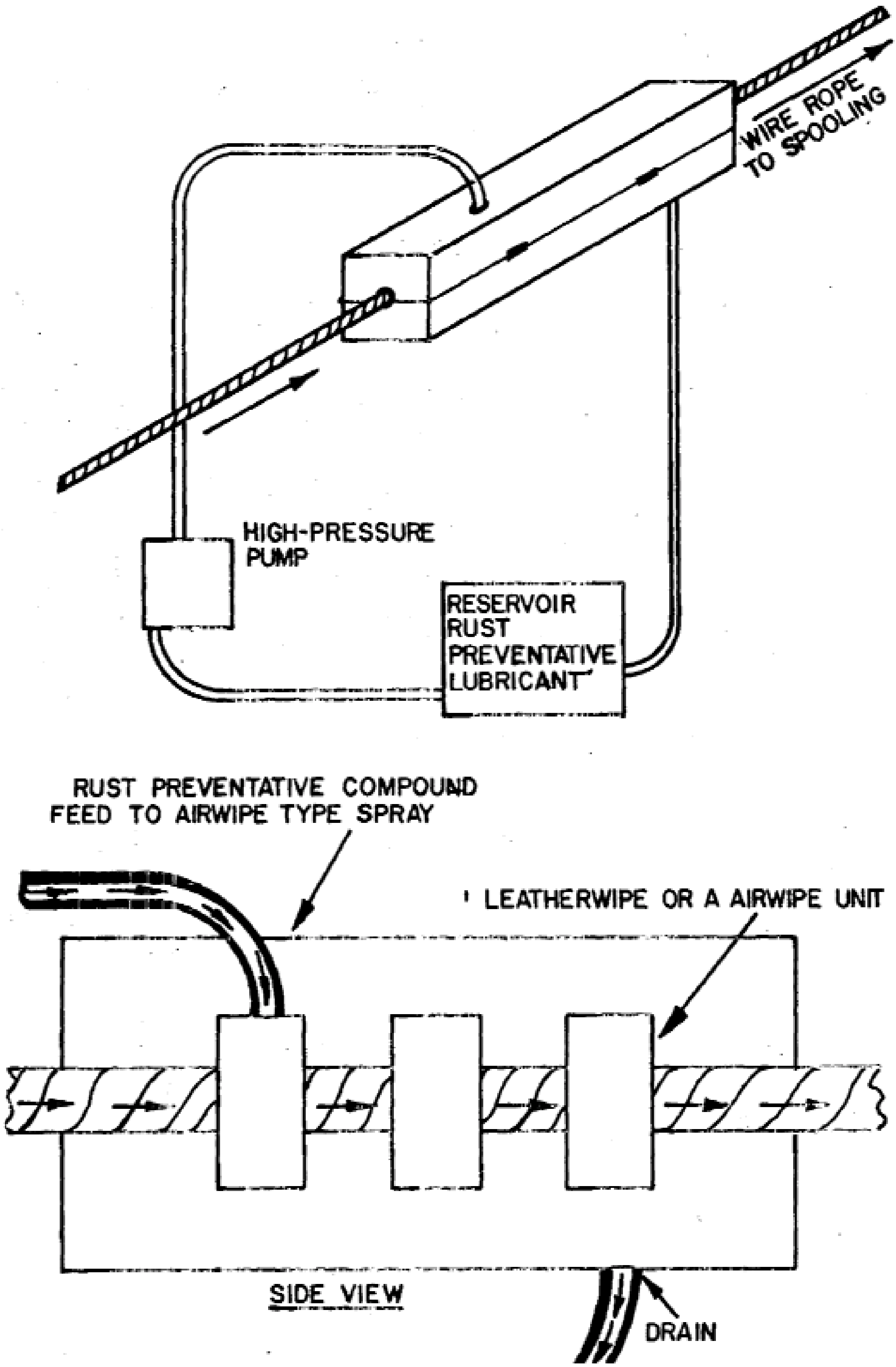
Four objectives must be obtained or the protective coating is worthless.

(1) Cleaning the rope of scale, dirt, salts, oxides and etc.
(2) High pressure water wash.
(3) Air Dry the rope of any water prior to dressing it in the lubricator.
(4) A light weight lubricator that will permit the lubricant to penetrate the wires in the strand and allow little leakage.

The first objective as shown in Figure 6-3 is the most important because if the valleys between the wires are not cleaned of solid debris and old wire rope compound, the dressing material even under pressure will not penetrate and if it does it can carry the abrasive debris between the wires an shorten their life by wear. Many lubricators are being marketed but no mention is being made for preparing used dirty rope prior to its lubrication or dressing. Investigation unveiled a wire rope cleaning unit for ski lift lines than can be adapted to small oceanographic 3 x 19 or 6 x 12 mechanical cable.

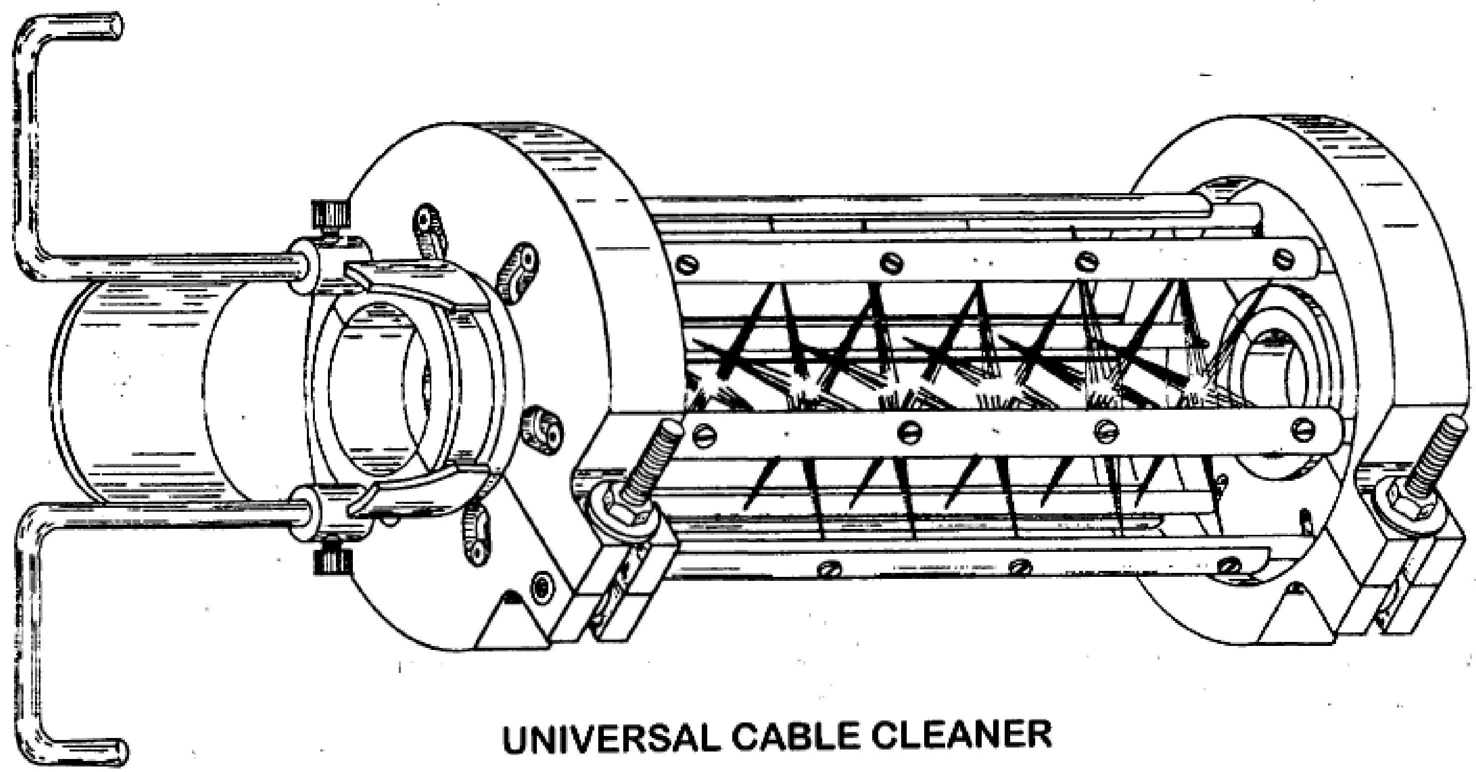
As shown in Figure 6-4, this unit is made of wire brushes that revolve with the lay of the rope as it passes through it. The worn steel wire brushes can be easily replaced in minutes and the same unit can be used for different size ropes.

The spiral wire brush unit designed by Brooke Ocean Technology shown in Figure 6-5 is excellent for cleaning the surfaces of electromechanical or strand cable.



CONCEPTUAL AUTOMATIC SPRAY UNIT

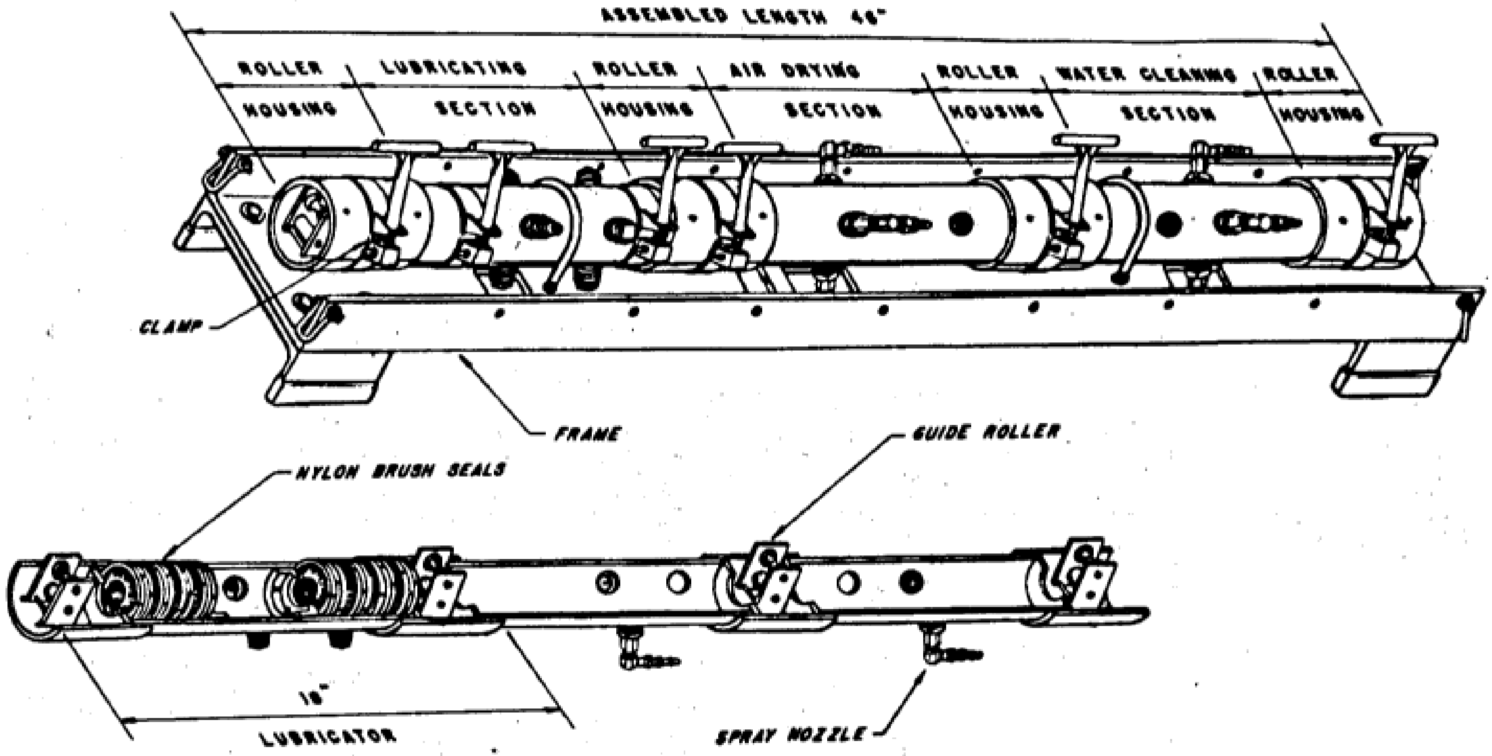
FIGURE 6-3



UNIVERSAL CABLE CLEANER

FIGURE 6-4

Courtesy --- Grignard Company



WIRE ROPE CLEANER LUBRICATOR

COURTESY BROOKE OCEAN TECHNOLOGY, LTD.

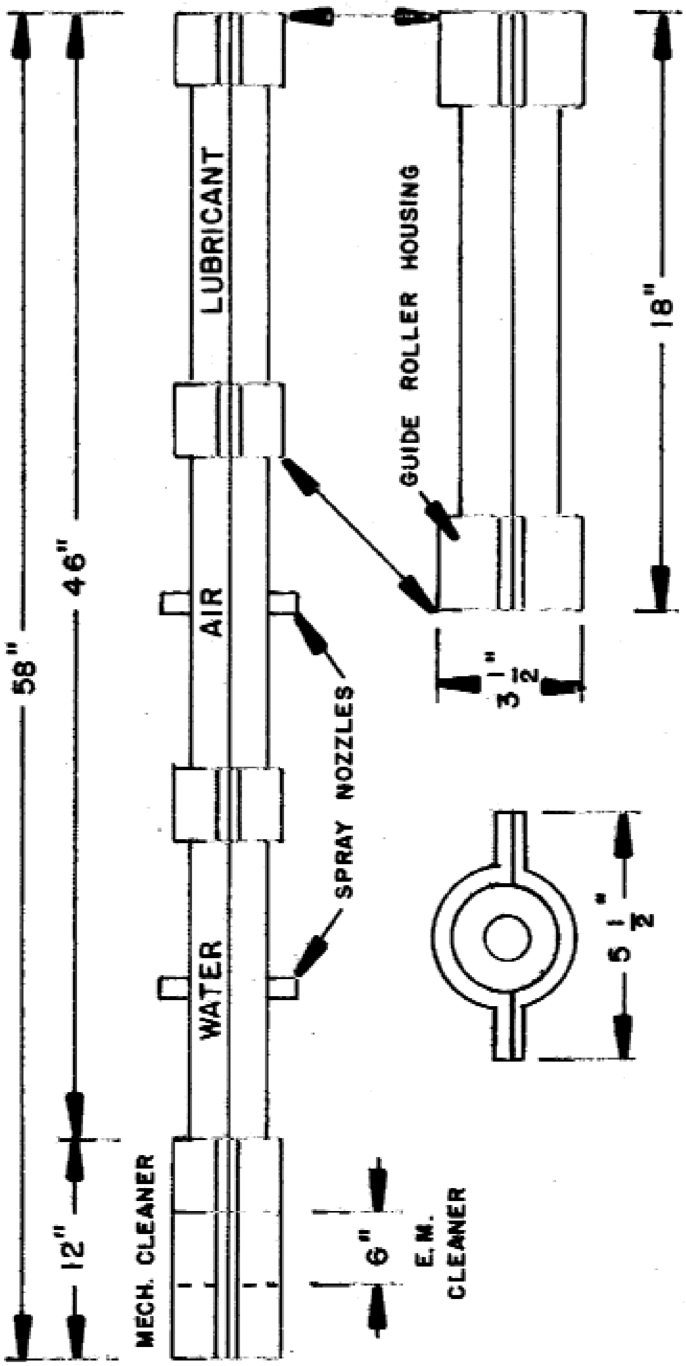
FIGURE 6-5

After examining different lubricators available, we highly recommend the combination of Brooke Ocean Technology's cleaner and lubricator with the rotating wire brush cleaner manufactured by Grignard Company (Figure 6-4). This combination as shown in Figure 6-6 of cleaner, water wash, air dry and lubricator is sectional and therefore only the required sections need be used depending on the condition of the rope. The combination of all the units are made of aluminum and weighs approximately 55 pounds (lubricator-8lbs.).

7.0 WIRE PRESERVATION DURING LONG TERM STORAGE

Wire rope or cable that will be stored for long periods in marine atmospheric conditions should be treated somewhat differently than the wires maintained at sea. This process involves three steps which, in actuality, occur simultaneously and involve a fresh water spray, air drying, and the applications of a lubricant/rust preventative. The process can be accomplished as the wire is removed form the ship's winch to the storage reel.

The fresh water spray acts to dissolve and remove any salts that may have remained on the wire after its last use. It is preferable that the freshwater be heated prior to spraying so that a maximum dissolution of salts, etc., can be achieved. The use of a spray rather than a washing with a hose allows for a maximum effect with a minimal water volume thereby increasing the efficiency of the air drying step.



COMBINATION UNIT

FIGURE 6-6

Air drying can be accomplished using a shoreside compressor and moderate pressure of approximately 80 psi. This, as in the field technique, serves to reduce the entrained moisture level and allow proper penetration of the lubricant. The lubricant/rust preventative can be applied utilizing the same unit as described in the field technique above.

Once the preservation process is completed, the reel should, ideally, be stored inside a building out of the weather as further protection. If this in not possible, a second alternative of covering the reel with a tarp is suggested. A periodic inspection and rotation of the stored reel is suggested as a means of keeping the lubricant/rust preventative evenly distributed throughout the spooled wire.

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