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EVALUATION OF THE KERIE CABLE THERMAL ARC CUTTING EQUIPMENT

SUSAN J. TRUKKEN

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Submitted by:

S.J. TRUKKEN
LT, USN
Project Officer

Reviewed by:

J.R. MIDDLETON
GM-13
Senior Projects Officer

Reviewed and
Approved by:

FRANK E. EISSING
CDR, USN
Commanding Officer

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From 16-26 April 1984, the Navy Experimental Diving Unit (NEDU) conducted testing on the CLUCAS Underwater Kerie Cable thermal cutting equipment at 'A' dock, Pearl Harbor, Hawaii. The purpose of this testing was to verify Navy procedures for set up, use and maintenance, evaluate diver and equipment hazards, identify proper procedural corrections for identified hazards and provide a recommendation for training procedures.

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Glossary

B.S.P.	British standard pipe
D.C.	direct current
FSW	feet of seawater
mm	millimeter
psi	pounds per square inch
OB	overbottom
OD	outside diameter
O_2	oxygen
°F	degrees fahrenheit
FADS	fly away diving system

Abstract

From 16-26 April 1984, the Navy Experimental Diving Unit (NEDU) conducted testing on the CLUCAS Underwater Kerie Cable thermal cutting equipment at 'A' dock, Pearl Harbor, Hawaii. The purpose of this testing was to verify Navy procedures for set up, use and maintenance, evaluate diver and equipment hazards, identify proper procedural corrections for identified hazards and provide a recommendation for training procedures.

The Kerie Cable has similar hazards as other cutting equipment with acceptable safety margins. The procedures established proved to be effective and safe. The fleet will require only minimal training for safe and effective cutting. The CLUCAS Underwater Kerie Cable thermal cutting equipment is considered to be reliable, safe and an effective means of underwater thermal cutting.

KEY WORDS: Kerie Cable
Diver Tools
Underwater Cutting
Salvage Torch
Cutting Torch
Ultrathermic Torch

I. INTRODUCTION

In 1972, the Naval Diving and Salvage Unit tested Kerie Cable with the Thermo-jet cutting torch manufactured and marketed by Taylor Diving and Salvage Company. The test (reference 1) found the Thermo-jet cutting torch to be unsuitable for Navy use. Subsequent to this test, Kerie Cable was incorporated into the "CLUCAS Underwater Kerie Cable Thermal Arc Cutting Equipment" marketed by Seeler Enterprises, Napa, California.

In April 1984, manned testing was conducted on the CLUCAS underwater Kerie Cable Thermal Arc Cutting Equipment at Mobile Diving and Salvage Unit One (MOBDIVSALVU ONE), Pearl Harbor, Hawaii under the direction of NEDU. Testing was conducted in response to Naval Sea Systems Command (NAVSEA) Task 84-3 and in accordance with NEDU Test Plan 83-59 to determine the system's acceptability for U.S. Navy use. Testing was conducted to verify diver and equipment safety, and validate Navy procedures for set up, use and possible training evolutions.

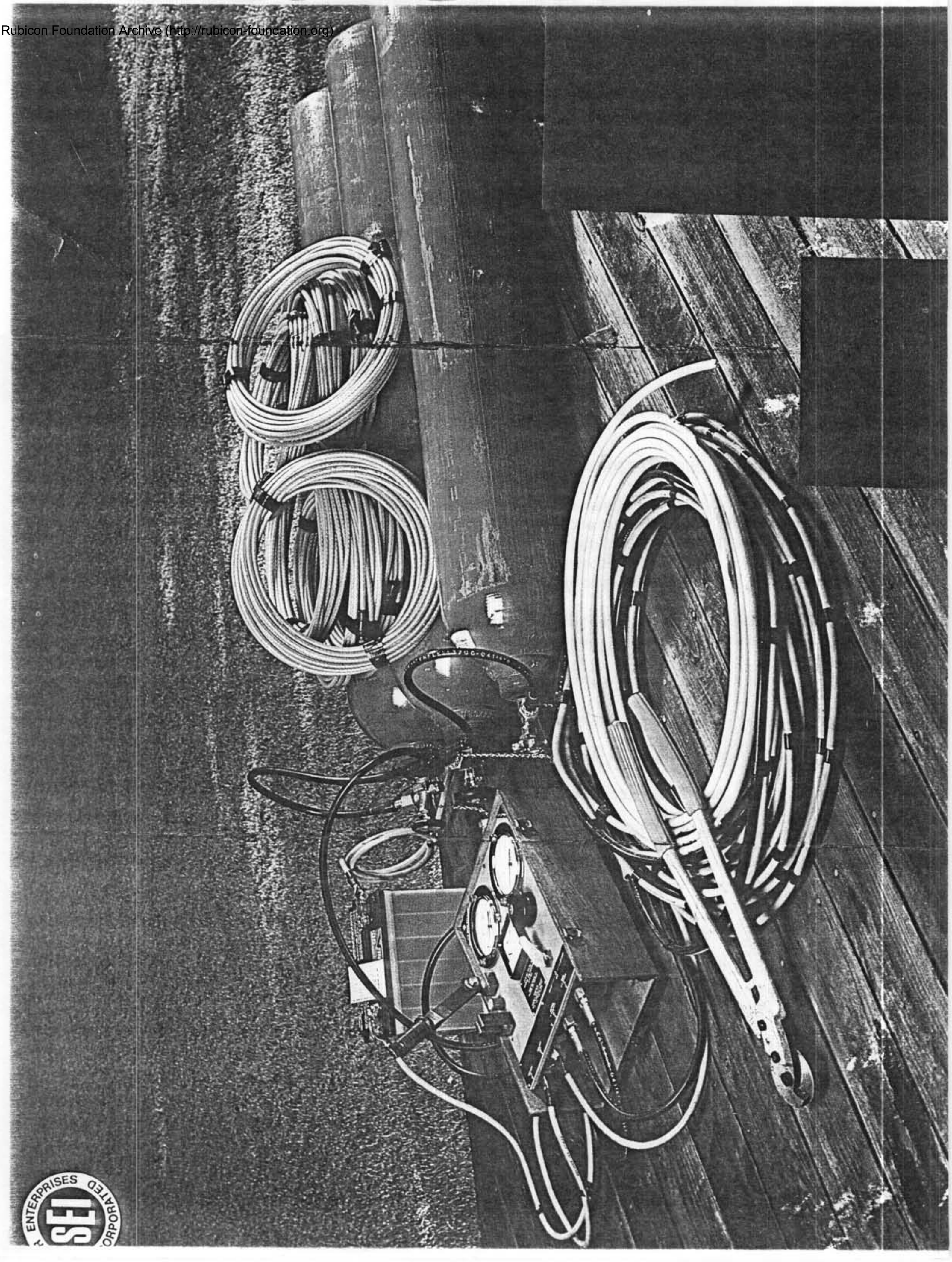
II. EQUIPMENT DESCRIPTION

A. The CLUCAS Underwater Kerie Cable Thermal Arc Cutting Equipment is an ultrathermic cable manufactured by CLUCAS Diving and Marine Engineering Limited in England and exclusively distributed by Seeler Enterprises, 2046 Waverly Street, Napa, California 94558. It is designed for quick, lightweight, continuous cutting of any ferrous metals.

B. The CLUCAS Underwater Kerie Cable Thermal Arc Cutting Equipment tested consists of the following items (see Figure 1).

1. One control panel.
2. One 10 ft. high pressure (HP) manifold.
3. One 100, 200 or 250 ft. extension lead.
4. One insulation sleeve.
5. One 1/4 in. x 1/4 in. British standard pipe (B.S.P.) double male adapter.
6. One 1/4 in. x 1/8 in. B.S.P. double male adapter.
7. One pair of heavy duty wire cutters.
8. 6, 9 or 12 mm Kerie Cable.
9. Two 12 volt batteries.

The Kerie Cable is a flexible spiral cable of 6 wire x 9 strand coreless high tensile steel wire with a rough inhibitor finish enclosed in an extruded ultraviolet inhibited polypropolene plastic sheathe. This cable is connected to the extension lead by an oxygen (O_2) adapter. The extension lead is in turn connected to the console. The console supplies negative amperage from the two 12 volt batteries and low pressure O_2 from the HP manifold via a hand loader. The cable is ignited by closing the knife switch on the console and



touching the tip of the cable to a striker plate. The striker plate is connected to the positive side of the battery opening. A HOKE valve on the console allows oxygen to flow down the center of the cable to feed the heated wire thus allowing the cable to ignite. Once the cable is ignited the knife switch is reopened. The cable continues to burn until it is completely consumed or until the oxygen is secured at the console. The burning of the cable can be stopped almost instantly by opening the oxygen vent valve on the console which vents the oxygen to the atmosphere instead of supplying it to the cable.

III. TEST PROCEDURE

All testing was conducted in accordance with the procedure in APPENDIX A and the Underwater Cutting and Welding Manual (Reference 2). Test Plan:

A. Orientation training was conducted on the surface, with each designated diver familiarized in the following manner:

1. Each diver read the manufacturers pamphlets.

2. Each diver read the procedure in NEDU Test Plan 83-59.

3. Each diver performed topside hands-on training utilizing the Kerie Cable Console, proper phone procedures, ignition techniques and making surface cuts with the cable.

B. Testing was conducted using 6, 9 and 12 mm cable to cut 1 inch thick HY 80 steel plate, 4 inch square 4340 steel bar, 3 inch OD copper nickel shaft, 2 inch 4340 steel plate, 1/4 inch 4340 steel plate, 1/4 inch brass plate and 4.5 inch OD aluminum round stock.

C. All divers wore the MK 12 SSDS in the air configuration with boots, dry suit, coverall and weights. A FADS I system provided air. No divers wore welding shields as the shields made it too dark to cut effectively underwater.

D. The power source was two 12 volt automobile batteries connected in series.

E. The depth of the project was 15 feet of seawater (FSW), visibility between 3-5 FSW, current from 0 to 0.5 knot, water temperature approximately 80°F and the bottom configuration was sandy silt.

F. A safety observer was at the work site at all times and a standby diver was dressed on deck.

G. The cable was marked every foot and the length of cable was recorded before and after each project.

H. Oxygen pressures were taken before and after each project.

I. Ignition time was recorded including re-starts underwater.

J. To record the amount of time, cable and oxygen used for which project, APPENDIX B was completed for every dive. After the testing was complete each diver was debriefed and asked to provide a written answer to the following questions.

1. Was the training provided in this procedure sufficient? If not, what would you do to improve training?

2. Were the procedures for cutting provided in this procedure correct? What changes to the bottom cutting procedures did you make when cutting different metals?

3. Were any safety hazards noted?

IV. RESULTS AND DISCUSSION

All training and underwater cutting was conducted following the procedure set forth in APPENDIX A and the Underwater Cutting and Welding Manual (Reference 2). All dives were uneventful from a safety standpoint. The procedures outlined in APPENDIX A proved to be very effective and the "emergency off" procedure proved satisfactory. The oxygen overbottom pressures (APPENDIX A, Table A1) provided the proper oxygen pressure to the diver at all times and prevented problems with burn back in the cable. The procedure for blowing down the cable prevented oxidation (rust) in the cable. The lack of rust and the quality of the cable prevented any spiral burning from occurring.

Various size cutting cables and techniques were tested for cutting different thicknesses and types of metal. A Navy procedure for cutting non-ferrous metals was also tested and is included in APPENDIX A. One quarter inch thick brass and 4.5 inch OD aluminum round stock were the non-ferrous metals tested. The 6 mm cable would not cut the brass and the 9 mm cable provided marginal results. The 12 mm cable could punch holes and then melt the brass. However, the heat dissipated so rapidly that when the cable was lifted from the metal for just a moment, the metal would cool enough to touch with a bare hand. Consequently, since Kerie Cable has a low burning temperature, it is not recommended for use on brass. Aluminum was easily cut by the Kerie cable. The 4.5 inch OD aluminum round stock was cut using the smaller 6 mm cable. No blow backs occurred with either the brass or the aluminum.

Thick ferrous metal was cut using the 12 mm cable. No blow backs occurred and the metal was easily burned through. The only problem when using the Kerie cable with the thicker metals was that slag would build up that had to be removed either by remelting or by chipping it out. APPENDIX A, Table A2 provides recommended cable sizes for use with various thicknesses of metal plate.

The testing showed that a diver using common sense, the procedures provided in APPENDIX A, the manufacturers pamphlets and reference 2 could work safely. Electrical shock hazard to diver is practically non-existent (i.e. the diver would have to burn himself by trying to touch the metal inside the cable before he could complete the circuit and shock himself). If the diver remains cognizant of which side his umbilical is on and places the cable on the opposite side and is concientious about using his "O_2 off" and "emergency off" procedures he will not be able to damage any of his vital life support equipment. If the diver waives the ignited cable about or loses control of it, there is little chance of it seriously burning him since the cable must be held close to an object for a period of time to burn it. Table 1 provides a synopsis of the problem areas identified in reference 1 and the results of current testing. All deficiencies were found to have been resolved as discussed above.

Training of the CLUCAS Kerie cable is simple. The cable is easy to learn to use both on the surface and in the water. For rough cuts a diver needs no more than a one day orientation. He should read the manufacturers pamphlets, read and understand the Navy procedure and set up and then practice with the unit topside before he tries in-water cutting. This topside, hands-on experience will not necessarily help his in-water technique, but it will familiarize him with the proper verbage, the layout and will provide practice with the topside support crew. This team training is actually more beneficial than the topside cutting experience. Test results show that it takes only a few minutes of in-water cutting to get accustomed to the sound and the sight of the cutting. With a few minutes in-water practice a diver inexperienced with Kerie cable can make adequate underwater cuts using this equipment.

The data taken during the testing to determine the average cable length and O_2 consumed is displayed in Table 2. It is important to note that the divers experienced in underwater cutting averaged the same amount of O_2 and cable consumption as the inexperienced divers.

V. CONCLUSIONS

The CLUCAS Underwater Kerie Cable Thermal Arc Cutting Equipment is a lightweight, mobile and easily manipulated cutting utensil. The lengths of cable available (50 ft. of 6 and 9 mm and 100 ft. of 12 mm) allow the diver to set up a project and then not have to change his position for over 30 minutes if required. This is an obvious aid to the maximum utilization of bottom time.

The Kerie cable itself is relatively expensive and does require oxygen to be available (6 mm is $3.00 a ft., 9 mm is $3.15 a ft. and 12 mm is $3.25 a ft.). When compared to other ultrathermic cutting equipment the shock hazard involved with this cable is minimal due to the 12 volt battery source vice a welding unit. Training is easy for both topside and the diver. This testing verifies that the CLUCAS Underwater Kerie Cable Thermal Arc Cutting Equipment is safe and satisfactory for Navy use when manufacturers instructions and the procedure described in APPENDIX A are followed.

VI. REFERENCES

1. NEDU Report 24-72, "Evaluation of the Thermo-Jet Cutting Torch" by LTJG B. Lebenson, USNR and HT1 J. Schlegel, USN

2. Naval Sea Systems Command Technical Manual, Underwater Cutting and Welding, NAVSEA 0929-LP-000-8010 of 1979.

TABLE 1

PROBLEM	MANUFACTURER REMEDY	NEDU	RESULTS
Kerie Cable would not ignite when connected to two 12 volt batteries.	Claims that Kerie Cable needs only two 12 volt batteries to ignite cable.	NEDU tested manufacturer procedures to ignite with two 12 volt batteries.	Satisfactory.
After ignition the cable burned in a spiral manner with the inside burning and the sheath not burning.	Cable of better quality; has written specific instructions for ignition procedures to preclude spotty burning.	NEDU tested manufacturer suggested procedures for ignition and cutting.	Only one failure to ignite and it was due to operator error.
Excessive oxidation of cable occurred after :30 in water and 1 hr on the surface.	Blow down cable before; maintain at least 70 OB psi upon entering water and blow down cable after use.	NEDU tested manufacturer suggested procedures.	Works very satisfactorily; no rust was discovered.
The equipment tender was required to reach over knife switch to reach hand loader creating an unsafe condition for the tender and diver.	Console is constructed to keep the knife switch and hand loader separate.	NEDU tested the manufacturers console configuration.	No safety problems.
Blow back when cutting thick ferrous and non-ferrous metal.	Recommend not using Kerie cable with thick ferrous and non-ferrous metals.	NEDU tested Navy procedures for cutting non-ferrous metals.	If procedures in Appendix A are used alum. and other low temp. melting point metals can be cut.

TABLE 2

Cable Use and O_2 Consumption

	Total Cable Consumed	Total Oxygen Consumed	Average Cable/Min	Average O2/Min
12 mm	365 ft	5425 psi	2.4 ft/min	40.6 psi/min
9 mm	90 ft	1025 psi	2.2 ft/min	35.5 psi/min
6 mm	223.5 ft	1875 psi	2.1 ft/min	13.9 psi/min
Total	678.5 ft	8325 psi	2.2 ft/min	30 psi/min

APPENDIX A

KERIE CABLE OPERATING PROCEDURE

1. Diver Training

   a. Read and understand manufacturers operational manual provided.

   b. Brief divers on safety precautions.

   (1) Keep equipment free of oil or grease.

   (2) When cutting underwater in confined or poorly vented spaces, use only approved methods of preparation and venting procedures for underwater cutting.

   (3) Do not attempt to cut any explosive materials, i.e. concrete, etc.

   c. Conduct topside cutting training using this procedure.

2. Equipment Set-up

   a. Connect three O_2 bottles together with the 10 foot high pressure (HP) hose manifold. Check HP gauge for bottle pressure. Turn OFF/ON valve to OFF. Turn regulator OFF.

   b. Connect HP hose manifold of the control unit to the fitting marked "high pressure O_2 in".

   c. Connect 100, 200 or 250 foot extension hose and electric lead to the control unit fittings marked "LP cutting O_2 out" and "Neg. amps out" in that order.

   d. Connect two 12 volt car batteries in series. (Place batteries on wooden pallet.)

   e. Connect negative side of batteries to "Neg amps in" on control unit.

   f. Open the knife switch.

3. Prepare Kerie Cable:

   a. Cut open Kerie Cutting Cable and inspect for cracks or cuts in plastic coating.

   b. Recoil in large loops.

   c. Connect cable to extension leads with the appropriate reducer.

   d. Blow down hose thoroughly with O_2 for approximately 20 seconds.

   e. Slide red plastic insulating sleeve along the Kerie Cable until it covers the joint between the cable and extension leads.

NOTE: Ensure red insulating sleeve is reinstalled when changing cable.

4. Prepare Work Site:

a. Install platform, hogging line as necessary.

b. Secure striker plate to convenient spot.

5. Bottom Procedures:

a. Pressurize Kerie Cable to 70 psi (if deeper than 60 FSW use 10 psi overbottom (OB) pressure).

b. Diver leaves surface with cable and positions himself at work site.

c. Diver requests "Gas on" (topside increase O_2 to proper overbottom pressure for at least 20 seconds). (See Table A1 for proper OB pressure and formula.)

d. When diver sees an increase in the bubbles he requests "SWITCH ON" (topside will respond when knife switch is closed). Kerie Cable burns at about two feet per minute until oxygen is secured.

e. Diver will touch the tip of the Kerie Cable to striker plate. The cable should ignite immediately.

f. Diver will announce "I have ignition" (topside will respond by opening knife switch).

NOTES:

(1) The equipment tender will check the amp meter on the control console to ensure a good ground and to check when diver tries ignition. The amp meter will read 0 when the cable is ignited.

(2) The equipment tender will ensure that the Kerie Cable is flushed with oxygen for 20 seconds before the knife switch is closed for ignition.

6. Cutting Procedures:

a. To cut, touch the ignited tip of the Kerie Cable to the spot to be cut.

b. Point the cutting tip into the cut at 90° angle from the work.

c. Keep the tip in constant contact with the material.

d. The divers hands should be at least 6 inches from the cut.

e. Keep tip moving into the cut. DO NOT force or poke the cable into the material being cut.

f. When cutting steel plate, use a brushing motion and several passes to eliminate molten metal from the cut.

g. When cutting thicker metal (2 1/2 in. and up) use a light, brushing motion to allow the metal surrounding the cut to cool enough to prevent molten metal. DO NOT speed process by creating a fire or inferno in the metal. Do not cut straight through.

h. When cutting nonferrrous metal, use a light, brushing motion. The brushing motion allows the metal surrounding the cut to cool enough to prevent molten metal and trapped oxygen from causing oxygen "pops." An oxygen "pop" is a trapped pocket of oxygen that pops molten metal, a definite operator hazard.

7. "Emergency off" safety procedures:

a. Diver indicates emergency action required by:

(1) Calling out "emergency off."

(2) Sending one hand pull signal on the communication cable.

b. Equipment tender turns HOKE valve to vent. The cable will flood and the oxidation will stop immediately.

8. Safety Rules and Precautions. All diving will be conducted in accordance with the U.S. Navy Diving Manual. All cutting will be conducted in accordance with the Underwater Cutting and Welding Manual, NAVSEA 0929-LP-000-8010, this procedure and the manufacturers (Seeler Enterprises Inc.) instructions.

a. Equipment Tender. The phone talker may be assigned the task of equipment tender.

(1) The tender will not close the circuit unless specifically directed by the diver. When so directed he will confirm each change with the diver.

(2) The equipment tender will ensure the diver has the proper oxygen overbottom pressure in accordance with Table A1.

(3) Equipment tender will remain within reach of the console at all times.

b. Ground/Cables. All connections should be tight and insulated with tape or other non-conductive material (i.e., red plastic insulating sleeve).

c. Diver Cutting Precautions

(1) Be aware of hazards involved with handling explosive gases and electrical circuits.

(2) Ensure gloves are secured at the wrist to prevent slag from getting in the glove.

TABLE A1

OVERBOTTOM PRESSURE

Size of Cable	Formula
6 mm	D + (250 to 300 psi)* = OB psi
9 mm	D + (300 to 340 psi)* = OB psi
12 mm	D + (340 to 380 psi)* = OB psi

NOTE: D = depth in FSW = psi or 60 FSW = 60 psi

* 40-50 psi range is allowed for divers preference.

EXAMPLE: At 60 FSW using 6 mm cable, overbottom psi is: 60 + 275 psi = 335 psi

TABLE A2

CABLE vs METAL

Size of Cable	Thickness of Metal
6 mm	up to 1 inch plate
9 mm	1 to 2 1/2 inch plate
12 mm	over 2 1/2 inches thick

8. Maintenance

TABLE A3

TROUBLE SHOOTING GUIDE

Component	Symptom	Cause	Remedy
Cable	Dark spots in cable	Rust - dirt	a. Always blow the hose/ cable through with O_2 to remove water before storing. b. Always blow the hose/ cable through with O_2 to remove water dirt before connecting to panel.
HOKE Valve	O_2 leak	Gland nut	a. Remove handle with a small screwdriver. b. Gently tighten gland nut until leak stops. c. Replace handle.
Regulator	LP gauge releases at 500 lbs. psi	O_2 leak by the nylon valve seat	a. Unscrew the panel. b. Turn panel over in the box. c. Remove hexagon cap nut from O_2 regulator with spanner wrench. d. Remove spring and piston. e. Replace seat with new one; the recessed brass ring is on top. f. Replace piston, spring, and hexagon cap nut.

APPENDIX B

DIVE DATA SHEET - KERIE CABLE

DIVER: ______________________ DATE: ______________________

PROJECTS:

A. HY 80 STEEL PLATE

B. 4"X4" STEEL INGOT

C. 3" OD SHAFT

D. 2" PLATE

E. 1/4 INCH PLATE

F. NON-FERROUS METAL

LIST OF POTENTIAL SAFETY HAZARDS

___ BLOW BACK

___ SPOTTY BURNING INSIDE CABLE

___ OXIDATION OF CABLE (BLACK CABLE)

METHOD OF IGNITION:

A. KNIFE SWITCH

B. OTHER ______________________

BEFORE EACH DIVE RECORD THE FOLLOWING:

A. LENGTH OF KERIE CABLE ______________________

B. PSI OF O_2 FLASKS ______________________

LEFT SURFACE ______________________

REACH BOTTOM ______________________

TIME OF IGNITION ______________________

STOP WORK ______________________

LEFT BOTTOM ______________________

REACH SURFACE ______________________

AFTER EACH DIVE RECORD THE FOLLOWING:

A. LENGTH OF KERIE CABLE ______________________

B. PSI OF O_2 FLASKS ______________________

COMMENTS:

A. GENERAL ______________________

B. SAFETY PROBLEMS ______________________