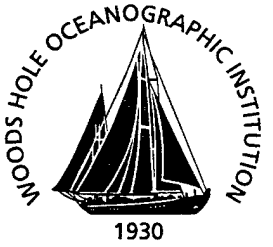
WHOI-2001-05

Woods Hole Oceanographic Institution



Loose-Tube Neutral Tether Fiber Optic Termination Procedure

by

Martin F. Bowen

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

June 2001

Technical Report

Funding was provided by the Woods Hole Oceanographic Institution.

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Approved for Distribution:

Timothy K. Stanton, Chair

Department of Applied Ocean Physics and Engineering

INTRODUCTION

NOTE 1:

THIS PROCEDURE IS THE SECOND OF TWO OPERATIONS THAT MUST BE PERFORMED AT EACH END OF A PRE-CUT LENGTH OF NEUTRALLY-BUOYANT TETHER.

THIS SECOND PROCEDURE ASSUMES THAT THE TETHER'S OUTER YELLOW JACKET AND SPECTRUM-FIBER, STRAIN RELIEF LAYER HAVE ALREADY PASSED THROUGH AND BEEN TERMINATED WITHIN A PMI INDUSTRIES® (OR SIMILAR) METAL, LOAD-BEARING TERMINATION ASSEMBLY.

AT LEAST EIGHT FEET OF INNER, BLACK-JACKETED TETHER CORE (CONTAINING SIX COPPER CONDUCTORS AND A STAINLESS STEEL LOOSE-TUBE, CONTAINING THREE SINGLE-MODE OPTICAL FIBERS) SHOULD BE EXPOSED TO BE OPTICALLY TERMINATED AS BELOW.

AFTER BELOW PROCEDURE IS COMPLETED, THE DUAL-TERMINATED TETHER CAN BE MECHANICALLY FASTENED TO THE VEHICLE'S FRAME, AND THE TERMINATED ELECTRO-OPTICAL ASSEMBLY CAN BE PASSED INTO AND MOUNTED ONTO THE VEHICLE'S OIL-FILLED JUNCTION BOX.

THE PROCEDURE BELOW ALONE WILL NOT RESULT IN A LOAD-BEARING ASSEMBLY. IF THIS PROCEDURE IS PERFORMED PRIOR TO MECHANICAL, LOAD-BEARING TERMINATION OF THE TETHER, IT MAY BE DIFFICULT OR IMPOSSIBLE TO PASS THE OPTICAL TERMINATION ASSEMBLY THROUGH THE LOAD-BEARING TERMINATION ASSEMBLY.

PARTS ARE REFERENCED BY NUMBERS IN [BRACKETS] AND TOOLS ARE REFERENCED BY LETTERS IN [BRACKETS].

NOTE 2:

TO DATE (03/18/01), THE AUTHOR KNOWS OF NO COMMERCIALLY AVAILABLE SYSTEMS OR KITS TO SUBSTITUTE FOR THE FOLLOWING METHOD TO TERMINATE ELECTRO-OPTICAL, LOOSE-TUBE ASSEMBLIES WHEN USED IN OIL-COMPENSATED UNDERWATER APPLICATIONS.

NOTE 3:

ONE WILL NEED A LARGE, CLEAN WORKBENCH, PLENTY OF LIGHT AND A VARIETY OF TOOLS, MOST OF WHICH ARE LISTED SEPARATELY. THE ENTIRE PROCEDURE CAN TAKE UP TO FOUR HOURS PER TETHER END.

CAUTION!: EXPOSED OR STRIPPED OPTICAL FIBERS CAN PENETRATE SKIN IF NOT HANDLED CAREFULLY. ALSO, THE CUT-OFF END OF THE STAINLESS STEEL LOOSE-TUBE CONTAINING OPTICAL FIBERS CAN BE HYPODERMICALLY SHARP! IF YOU DO NOT NORMALLY WEAR SAFETY GLASSES, LEARN TO NOW!

PROCEDURE

1. PLACE BLACK PLATEN BLOCK [E] INTO HEATER [F]
2. PLACE THERMOMETER [HH] INTO CENTER OF BLOCK
3. PLUG HEATER INTO ENABLED POWER STRIP [S]

CAUTION!: DO NOT ENABLE BLOCK HEATER WITHOUT THE BLOCK IN PLACE.

4. TURN HEATER ON
5. ADJUST TEMPERATURE CONTROL TO MAINTAIN 90°C (MARKED)

CAUTION!: ENABLED BLOCK HEATER CAN CAUSE BURNS AND MELT PLASTIC.

6. SET BLOCK HEATER ASIDE
7. SECURE THE LOAD-BEARING TERMINATION TO THE WORKBENCH'S LEG

CAUTION!: THE MINIMUM BEND DIAMETER OF TETHER IS 24 INCHES.

8. SLIP A DORN® NUMBER 2 NEOPRENE STUFFING GLAND [5] ONTO THE TETHER CORE [11] AND OUT OF THE WAY AGAINST THE MECHANICAL TERMINATION, ORIENTATION IS NOT KEY
9. LIKEWISE SLIP ON A LENGTH OF 1/2 IN ID x 3 IN L HEATSHRINK [6]
10. LIKEWISE SLIP ON A LENGTH OF 1 IN ID x 2 FT L URETHANE TUBING [12]
11. USING A SINGLE-EDGED RAZOR BLADE [T] OR A SHARP X-ACTO KNIFE [K], AND WITHOUT NICKING THE INSULATION OF THE COPPER CONDUCTORS WITHIN, STRIP OFF THREE FEET OF THE TETHER'S BLACK JACKET
12. THIS ACTION SHOULD LEAVE ABOUT FIVE FEET OF TETHER CORE EXPOSED

CAUTION!: AGAIN, THE MINIMUM BEND DIAMETER OF TETHER IS 24 INCHES. IF THE LOOSE-TUBE IS KINKED AT ANY TIME, IT IS LIKELY THAT THE OPTICAL FIBERS ARE BROKEN AND THE PROCEDURE MUST RESTART.

13. REMOVE THE MYLAR TAPE LAYER, ONE END OR THE OTHER UNWINDS EASIER BECAUSE OF IT'S OVERLAPPING WRAP
14. CAREFULLY REMOVE THE BROWN, WATER-BLOCKING RUBBER MATERIAL BY FRICTION WITH DRY FINGERTIPS, DO NOT APPLY SOLVENTS
15. GENTLY SEPARATE THE SIX COPPER CONDUCTORS FROM THE CENTRALLY LOCATED LOOSE-TUBE WITHOUT BENDING THE LOOSE-TUBE

16. FOLD THE COPPER CONDUCTORS BACK 180° AND SECURE (OUT OF THE WAY) TO THE TETHER WITH A TYRAP [MM]

CAUTION!: THE CUT-OFF END OF THE STAINLESS STEEL LOOSE-TUBE CONTAINING OPTICAL FIBERS CAN BE HYPODERMICALLY SHARP!

17. AT THIS POINT, IT HELPS TO SECURE THE PORTION OF TETHER ONE IS WORKING ON INTO A SOFT-JAWED VISE [JJ] MOUNTED TO THE BENCH EDGE
18. CHECK THAT THE BLOCK HEATER'S THERMOMETER HAS APPROACHED AND PERHAPS STABILIZED AT 90°C, DO NOT TOUCH THE BLOCK OR THE THERMOMETER
19. MAKE AN INK MARK ON THE LOOSE-TUBE AT A POINT FOUR INCHES FROM WHERE THE COPPER CONDUCTORS ARE FOLDED BACK
20. LIGHTY SCORE THE OD OF THE LOOSE-TUBE USING A MINIATURE HACKSAW [U] OR EQUIVALENT
21. THE NEXT STEP DEPENDS ON SUSTAINED METAL FATIGUE WITH HEAT BUILD-UP, THIS IS A SUBTLE OPERATION, TAKE YOUR TIME
22. USE MAGNIFYING GLASSES [L]
23. HOLDING THE SCORED POINT ABOUT 1/4 IN BETWEEN THUMBS AND INDEX FINGERS
24. SLOWLY AND STEADILY WORRY/BEND THE SCORE JUST SLIGHTLY OFF AXIS AND IN ALL QUADRANTS UNTIL THE TUBE WEAKENS AND PARTS—YOU WILL FEEL SOME HEAT BUILD-UP, BUT IT WILL NOT BURN (THE OLD MELTING SPOON TRICK)
25. WHEN THE TUBE FINALLY PARTS, USUALLY IN LESS THAN A MINUTE, TRY NOT TO STRESS/BREAK/BEND THE ENCLOSED OPTICAL FIBERS

CAUTION!: EXPOSED FIBERS ARE DELICATE AND DANGEROUS TO YOUR VISION. BE CERTAIN THAT NO LASERS ARE CONNECTED TO THE TETHER AS WORK IS PERFORMED.

26. ON AXIS WITH THE TETHER CORE, REMOVE THE SEPARATED TUBE SLOWLY FROM THE THREE OPTICAL FIBERS, AND DISPOSE OF THE TUBE PIECE PROPERLY
27. THE THREE OPTICAL FIBERS ARE COATED IN A WAXY BLOCKING MATERIAL AND EACH FIBER'S CLADDING IS COLOR-CODED
28. REMOVE THE WAXY COATING USING A PRECISION WIPE COATED [LL] WITH ACETONE [A], ALWAYS DRAWING GENTLY AWAY FROM THE CUT-OFF TUBE WITH MINIMAL CLEANING FRICTION AND DELICATE MOVEMENTS
29. **DRILL TWO 4-40 SCREW BODY CLEARANCE HOLES INTO THE SMALLER SPIDER BASE [10] TO MOUNT THE CLAMP HALVES PERPENDICULAR TO THE LOOSE-TUBE AXIS.**
30. LOOSELY ASSEMBLE THE LOOSE-TUBE CLAMP PAIR [1] ONTO THE MODIFIED SPIDER BASE [10] USING TWO SS FH SCREWS [8]

31. **CUT A SMALL DORN GLAND [14] IN HALF AT THE TAPER LINE**

32. **PLACE THE SMALLER HALF OF THE DORN INTO THE END OF THE SPIDER**

NOTE 4:

PARTS FROM TWO DIFFERENT SPIDER ASSEMBLIES [9] AND [10] ARE MIXED TO MAKE ONE MODIFIED ASSEMBLY.

33. CAREFULLY FEED THE THREE EXPOSED FIBERS AND THE CUT-OFF END OF THE LOOSE-TUBE THROUGH THE MODIFIED DORN, THE MODIFIED SPIDER BASE AND THE CLAMP HALVES
34. USING A SMALL FH SCREWDRIVER [W], TIGHTEN THE CLAMP HALVES AROUND THE BITTER END OF THE LOOSE TUBE ABOUT 1/4 IN FROM THE EDGE OR LESS, THIS WILL SECURE THE ASSEMBLY FROM ROTATIONAL INFLUENCES
35. MEASURE THE LENGTH OF THE FIBERS EXPOSED BEYOND THE SPIDER BASE
36. SUBTRACT FROM THAT MEASUREMENT THREE INCHES
37. GO TO THE 900 MICRON SPIDER BREAKOUT ASSEMBLY (ORANGE) [9]
38. USING KEVLAR® SCISSORS [BB], CUT OFF ALL SIX ORANGE SPIDER BREAKOUT CHANNELS SO THAT AT LEAST THREE INCHES OF CLADDED FIBER WILL EXTEND BEYOND THE CHANNELS' EDGES

CAUTION!: EXPOSED OR STRIPPED OPTICAL FIBERS CAN PENETRATE SKIN IF NOT HANDLED CAREFULLY.

NOTE 5:

THE 900-MICRON ID BREAKOUT CHANNELS ARE OF LARGE ENOUGH ID TO ACCOMMODATE EACH CLEANED, CLADDED SINGLE-MODE FIBER. IN TERMS OF SOURCING AND MANUFACTURING, THE TWO ARE NOT MATCHED, HOWEVER, IF THE FIBERS ARE CLEAN AND FREE OF WAX, THEY CAN BE SUCCESSFULLY INSERTED THROUGH THE TEFLON-LINED CHANNELS.

39. BEGIN TO INSERT THE THREE INDIVIDUAL FIBERS INTO THREE OF THE SIX SEPARATE AVAILABLE BREAKOUT CHANNELS, THOSE AWAY FROM YOU ARE RECOMMENDED
40. AS ONE PROGRESSES, URGE ALL THREE FIBERS TO PENETRATE THEIR INDIVIDUAL CHANNELS AT THE SAME RATE
41. AVOID STRESSING THE FIBERS OFF AXIS
42. IF EXCESSIVE RESISTANCE IN ANY ONE CHANNEL IS ENCOUNTERED, SLOWLY REMOVE ALL THREE FIBERS AND BEGIN AGAIN
43. PATIENCE IS KEY, YOU ARE THREADING THREE NEEDLES AT ONCE

CAUTION!: IF THE OPTICAL FIBERS ARE BROKEN, THE PROCEDURE MAY LIKELY HAVE TO RESTART.

44. WITHOUT STRESSING THE NOW OVER-JACKETED AND PROTECTED FIBERS, AND AVOIDING TORQUE TO THE ENTIRE ASSEMBLY, EASE THE 6-SPIDER BREAKOUT [9] INTO THE SPIDER BASE'S FORKS [10] AND SNAP THE TWO PARTS TOGETHER
45. ONCE ASSEMBLED, THE AREA BETWEEN WHERE THE THREE FIBERS EXIT THE LOOSE-TUBE TO WHERE THEY ENTER THE BREAKOUT CHANNELS SHOULD BECOME RELAXED PATHWAYS FOR LIGHT TRANSMISSION
46. THE TERMINATION OF INDIVIDUAL FIBERS BEGINS HERE
47. ONLY CERTAIN PORTIONS OF COMMERCIAL TERMINATION KITS ARE ACTUALLY USED, THE REST IS CACHED OR DISPOSED
48. NO METAL, CRIMP-TYPE FERRULES ARE INVOLVED IN THIS PROCEDURE
49. WITHOUT BREAKING OFF THE EXPOSED FIBERS, SLIP A LENGTH OF 1/4 IN ID x 1.5 IN L HEATSHRINK [6] ONTO EACH ORANGE-JACKETED BREAKOUT
50. THE HEATSHRINK WILL EVENTUALLY BE THE OVERALL F/O CONNECTOR'S STRAIN RELIEF AND PRIMARY AXIAL SUPPORT
51. ADJUST THE CLADDING STRIPPER TOOL [FF] FOR 126 TO 127 MICRON USE

NOTE 6:

THE FIBER CLADDING STRIPPER IS CRUCIAL TO THE SUCCESS OF THIS PROCEDURE. IT HAS A SCREW ADJUSTMENT THAT CAN TUNE THE DIAMETER OF ITS CUT OR SCORE DOWN TO A SPECIFIC SINGLE-MODE FIBER DIAMETER—USUALLY 125 TO 127 MICRONS. IF ONE HOLDS THE TOOL UP TO A LIGHT SOURCE, THE DIAMETER CAN BE SCRUTINIZED. AFTER THE TOOL IS PROPERLY TUNED, STRIPPING CAN BE ACCOMPLISHED EASILY WITHOUT THE POPULAR USE OF SOLVENTS (ACETONE) TO SOFTEN THE CLADDING. IN OTHER WORDS, IT IS RECOMMENDED THAT ONE PRACTICE MECHANICALLY STRIPPING THE CLADDING OFF A 'DRY' FIBER BEFORE THIS ALTERNATE PROCEDURE IS ATTEMPTED. ACETONE-SOFTENED CLADDING AROUND A FIBER STRETCHES A GREAT DEAL, CAN BREAK THE FIBER WHEN IT RETRACTS, AND OVERALL DOES NOT BENEFIT THE TERMINATION PROCESS AS SOME HAVE PUBLISHED. A WELL-TUNED STRIPPER IS WORTH THE SETUP TIME.

CAUTION!: THE MORE FIBER LENGTH LOST IN ATTEMPTS TO TERMINATE, THE MORE LIKELY THE PROCEDURE MUST RESTART.

52. CHECK THAT THE BLOCK HEATER'S THERMOMETER HAS CONTINUED TO STABILIZE AT 90°C, DO NOT TOUCH THE BLOCK OR THE THERMOMETER
53. THE THREE COLOR-CODED AND CLADDED FIBERS SHOULD BE EXTENDING FROM THE ENDS OF THREE OF THE SIX TOTAL BREAKOUT CHANNELS

54. THE THREE UNUSED BREAKOUT CHANNELS COULD BE CUT OFF NEAR THE BREAKOUT BASE USING KEVLAR® SCISSORS, BUT SAVE THEM FOR NOW

55. THE CONNECTORIZING OF EACH FIBER BEGINS HERE

CAUTION!: EXPOSED OR STRIPPED OPTICAL FIBERS CAN PENETRATE SKIN IF NOT HANDLED CAREFULLY.

56. SLIP A 1/4 IN x 1 IN L HEATSHRINK [6] OVER EACH FIBER ASSEMBLY

57. THERE ARE THREE FIBERS TO TERMINATE, TREAT EACH DELICATELY THOUGHOUT THE FOLLOWING STEPS

CAUTION!: INDIVIDUAL FIBERS ARE NOT AXIALLY SUPPORTED BY ADHESION TO THE WALLS OF THE BREAKOUT CHANNELS. THEY FLOAT WITHIN THE LOOSE-TUBE AND THE WAX BLOCKING MATERIAL. ANY ON-AXIS TORQUE STRESSES THAT ARE INTRODUCED TO THE OPTICAL FIBERS ARE TRANSFERRED INTO THE LOOSE-TUBE AND FURTHER INTO THE TETHER BODY WITHOUT BENEFIT. IT IS CRUCIAL THAT THE ASSEMBLY DOES NOT BECOME UNCONSTRAINED AT THIS TIME, CAUSING FIBERS TO BREAK.

58. USING A RAZOR BLADE [T], SCORE THE ORANGE JACKET OF THE BREAKOUT CHANNEL ABOUT 1/2 IN FROM THE EDGE, AVOID CUTTING THE UNDERLYING KEVLAR FIBERS

59. REMOVE THE 1/2 IN PIECE OF JACKET AND DISPOSE

60. FOLD BACK THE 1/2 IN LONG EXPOSED KEVLAR STRANDS AND ONE WILL SEE THE 900 MICRON ID, SEMI-TRANSPARENT FURCATION TUBE INSIDE, WHICH IS MADE OF TEFLON AND SUPPORTS THE FIBER SOMEWHAT

61. INSIDE THE FURCATION TUBE ONE SHOULD STILL SEE THE FIBER INTACT

62. AT A POINT 1/8 IN OUT FROM THE FOLDED KEVLAR STRANDS, AND USING A RAZOR BLADE, CAREFULLY SCORE THE FURCATION TUBE

63. THE PRIMARY GOAL IS TO REMOVE EXCESS FURCATION TUBE WITHOUT BREAKING THE LONGER FIBER WITHIN, TAKE YOUR TIME

64. TAKING ABOUT 1/4 TO 1/2 IN BITES, STRIP THE COLORED CLADDING OFF THE RAW FIBER, THIS MAY TAKE SOME PRACTICE ON A SACRIFICIAL LENGTH OF CLADDED FIBER

65. STRIP THE CLADDING DOWN TO A POINT 1/8 IN FROM THE EDGE OF THE FURCATION TUBE

66. CAREFULLY CLEAN THE NAKED FIBER WITH ACETONE ON A PRECISION WIPE OR ACETONE DIRECTLY ON ONE'S FINGERTIPS

67. PICK UP A NEW ST CONNECTOR [2] AND REMOVE THE DUSTCAP FROM THE CERAMIC FERRULE

68. HOLD THE CONNECTOR UP TO A LIGHT ON AXIS, YOU SHOULD SEE A PINPOINT OF LIGHT IN THE CENTER OF THE FERRULE
69. IF YOU DO NOT SEE LIGHT, THE FERRULE MAY BE PLUGGED OR FAULTY (ABOUT 1 IN 20 TO 30 CONNECTORS), DISPOSE OF THE UNIT NOW
70. CHECK THE CLEANLINESS OF THE NAKED FIBER BY INSERTING (SNAKING) IT INTO THE DRY CONNECTOR FROM THE METAL END, A 125 MICRON OD FIBER SHOULD FIT SMOOTHLY INTO A 126 OR 127 MICRON ID FERRULE

NOTE 7:

A PAINFUL LEARNING CURVE WAS EXPERIENCED BY THE AUTHOR WHEN 126-MICRON OD FIBERS BUILT INTO AN UNFAMILIAR AT&T® TETHER WERE INNOCENTLY, SUCCESSFULLY INSERTED AND EPOXIED INTO 125 MICRON ID FERRULES BY TRIAL AND ERROR AND FORGIVING TOLERANCES. HOWEVER, THE FIBERS FRACTURED INSIDE THE CONNECTOR FERRULES AS THE ASSEMBLIES COOLED. THE LESSON IS, ENSURE THAT TETHER FIBERS ARE SMALLER IN DIAMETER THAN THE CONNECTORS TO BE JOINED.

71. IF THE FIBER DOES NOT SNAKE THROUGH THE FERRULE, RECLEAN THE FIBER, CHECK FOR BITS OF CLADDING ADHERING TO THE FIBER, AND AGAIN HOLD THE FERRULE CHANNEL UPWARDS TO CHECK VISUALLY FOR LIGHT BEING ABLE TO PASS THROUGH IT
72. WHEN ONE IS CONFIDENT THAT THE NAKED FIBER WILL JOIN TO/THROUGH THE CONNECTOR, TAKE THE NEXT STEPS
73. PICK UP A TWO-PART EPOXY PACK [4] AND REMOVE THE SEPARATING CLAMP (BLUE) AND ROD (WHITE)
74. THE TWO-PART EPOXY IS NOW ACTIVATED AND HAS A 15 MINUTE 'POT LIFE'
75. 'POT LIFE' IS THE AMOUNT OF TIME ONE HAS TO MANIPULATE THE EPOXY BEFORE IT BEGINS TO SET UP/SOLIDIFY/CURE
76. GRAB EACH END OF THE EPOXY PACKET AND RUB/SAW IT BACK AND FORTH OVER A TABLE EDGE TO THOROUGHLY MIX THE TWO ENVELOPED CHEMICAL PARTS
77. THE TWO PARTS OF THE EPOXY KIT MUST BE THOROUGHLY MIXED IN ORDER TO CURE PROPERLY AND EVENTUALLY SIEZE/STABILIZE THE OPTICAL FIBER WITHIN THE FERRULE OF THE CONNECTOR
78. IF THE PACKET BREAKS, START AGAIN WITH ANOTHER, DO NOT TRY TO RECOVER THE CHEMICALS

CAUTION!: IF THE EPOXY COMES IN CONTACT WITH SKIN, WASH IMMEDIATELY AND FOLLOW THE MANUFACTURER'S SAFETY INSTRUCTIONS.

79. USING SCISSORS [AA], SNIP OFF A SMALL CORNER OF THE ENABLED EPOXY PACKET
80. SQUEEZE A SINGLE DROP OF MIXED EPOXY ONTO A DISPOSABLE SURFACE, SUCH AS A PLASTIC KIT BAG FROM A USED F/O CONNECTOR
81. THE MIXED EPOXY PRODUCT WILL APPEAR SEMI-TRANSPARENT / YELLOWISH
82. TOUCH THE METAL END OF THE F/O CONNECTOR TO THE EPOXY DROP
83. THE LIQUID EPOXY 'DAB' WILL WICK SLIGHTLY INTO THE BACK OF THE CONNECTOR
84. REINSERT THE NAKED FIBER THROUGH THE EPOXY DAB AND THROUGH THE CONNECTOR FERRULE AS PRACTICED, NICE AND EASY
85. ONCE THE TIP OF THE FIBER APPEARS BEYOND THE CONNECTOR FERRULE, GENTLY SNAKE THE FIBER BACK AND FORTH UNTIL YOU ARE CERTAIN THAT EPOXY HAS COATED THE FIBER THROUGHOUT THE FERRULE
86. THIS SNAKING/COATING EXERCISE PREVENTS FAILURE OF THE FIBER WITHIN THE FERRULE BY REDUCING AIR POCKETS WITHIN THE ASSEMBLY, WHICH COULD BE STRESSED AT HIGH PRESSURES BY CHANGING AMBIENT FLUID PRESSURES
87. BEST CASE: THE FIBER IS COATED WITH EPOXY AND EXTENDS ABOUT 1/4 IN FROM THE END OF THE CONNECTOR FERRULE
88. THE KEVLAR FIBERS OF THE CHANNEL ARE PARALLEL TO THE METAL END OF THE CONNECTOR
89. WHILE THE EPOXY IS 'LIVE', SLIDE THE PREVIOUSLY-MOUNTED PIECE OF 1 IN L HEATSHRINK OVER THE EXPOSED KEVLAR FIBERS AND THE BACK BARREL (METAL) OF THE F/O CONNECTOR
90. OBSERVING AXIAL PROTOCOL AND USING A HEATGUN [I], SHRINK THE MASTIC-LINED SHRINK TUBING SLOWLY AND EVENLY AROUND THE ASSEMBLY SO THAT IT CAPTURES THE ORANGE CHANNEL JACKET, THE KEVLAR FIBERS, AND THE SERRATED METAL BASE BARREL OF THE F/O CONNECTOR (TAKE CARE BECAUSE THE HEATGUN IS CAPABLE OF MELTING THE ORANGE JACKET)
91. AFTER COOLING, THIS WILL BE THE ONLY LONG-TERM SUPPORT FOR THE CONNECTOR ASSEMBLY
92. THE THREE SHRINK TUBES BECOME THE ONLY AXIAL AND LONGITUDINAL SUPPORT FOR EACH INDIVIDUAL FIBER WHERE THEY ENTER THE ST CONNECTORS
93. CHECK THAT ONLY 1/4 IN OF NAKED FIBER EXTENDS BEYOND THE CONNECTOR FERRULE
94. IF MORE THAN 1/4 IN EXTENDS, TRIM THE EXCESS CARFULLY, THE SHOCK OF CUTTING THE NAKED FIBER CAN SHATTER THE FIBER REMAINING
95. SUPPORT THE ASSEMBLY IN YOUR FINGERTIPS UNTIL COOLED
96. IN THE BEST OF CASES, A SMALL DIMPLE OF EPOXY WILL ADHERE BETWEEN THE FIBER AND THE FERRULE AT THE DISTAL END OF THE ASSEMBLY
97. THE FIRMED ASSEMBLY IS READY FOR CURING IN THE BLOCK HEATER

98. ARRANGE THE HOT, BLOCK HEATER SO THAT THE CONNECTOR CAN BE INSERTED AND CURED WITHOUT UNDO STRAIN ON THE FURCATION TUBE AND OVERALL ASSEMBLY
99. LOWER THE CONNECTOR AND THE 1/4 IN EXCESS FIBER STRAIGHT DOWN INTO A FREE CAVITY IN THE BLOCK HEATER
100. IF THE EXCESS FIBER IS BROKEN ON ITS WAY INTO THE BLOCK, THE PROCESS MUST START AGAIN
101. USING A LUX® TIMER [II], ALLOW THE ASSEMBLY TO CURE AT 90°C FOR AT LEAST 15 MINUTES (OR OVERNIGHT AT ROOM TEMPERATURE)
102. WHEN THE CLEAR EPOXY HAS CURED, IT WILL APPEAR RED IN COLOR, WHICH CAN BE SEEN AT THE JOINT BETWEEN THE EXCESS FIBER AND THE FERRULE
103. REMOVE ASSEMBLY STRAIGHT UP OUT OF THE BLOCK WITHOUT BREAKING THE EXCESS FIBER
104. ALLOW THIS ASSEMBLY TO COOL TO ROOM TEMPERATURE WITHOUT INFLUENCE
105. LIGHTLY SCRIBE [X] THE BASE OF THE FIBER WHERE IT MEETS THE CONNECTOR FERRULE
106. TOUCH THE TIP OF THE FIBER, IF IT HAS BEEN SCORED IT WILL TIP OVER AND BREAK AT THE POINT OF SCORING, IF IT HAS NOT BEEN SCORED THE FIBER WILL JUST BEND
107. MAKE CERTAIN TO DISPOSE OF THE BROKEN FIBER
108. LIGHTY RUN A DRY PIECE OF 30 MIL POLISHING PAPER (GREEN) [O] ACROSS THE BROKEN FIBER
109. DRIP A COUPLE OF DROPS OF WATER [KK] ONTO THE GLASS POLISHING PLATE [N]
110. PLACE A 1/4 SHEET OF 30 MIL PAPER ONTO THE DROPS AND THE PLATE, 'ROUGH' SIDE UP
111. THE PAPER SHOULD ADHERE FLATLY TO THE PLATE
112. DRIP MORE DROPS ONTO THE SHEET
113. PLACE THE ST POLISHING DISK [NN] ONTO THE PAPER
114. SLOWLY LOWER THE ST FERRULE INTO THE DISK AND WATER DROPS
115. POLISH IN SMOOTH FIGURE EIGHT MOVEMENTS UNTIL THE RED EPOXY DOT ON THE END OF THE FERRULE DISAPPEARS, DO NOT POLISH FURTHER USING 30MIL PAPER
116. CLEAN THE PLATE
117. POLISH ABOUT 20 FIGURE EIGHT STROKES WITH 12 MIL PAPER (YELLOW) [P] AND CLEAN WATER
118. REPEAT WITH 5 MIL PAPER (BROWN) [Q] AND WATER
119. REPEAT WITH 0.3 MIL PAPER (WHITE) [R] AND WATER
120. WIPE OFF THE FERRULE WITH A PRECISION WIPE AND ALCOHOL [B]
121. INSPECT WORK WITH A FIBER INSPECTION SCOPE [V], THE TIP SHOULD BE MIRROR SMOOTH
122. ATTACH VISIBLE LIGHT SOURCE [DD] TO THE TERMINATED FIBER AND ST CONNECTOR AND CHECK OTHER END OF TETHER FOR LIGHT CONTINUITY, EVEN AN UNTERMINATED FIBER WILL GLOW WITH RED LIGHT IF ONE END IS PROPERLY TERMINATED

123. TERMINATE THE OTHER TWO FIBERS AS ABOVE, IT MAY BE THAT THE SAME EPOXY DROP MAY STILL BE WET OR 'LIVE'

124. TERMINATE THE OTHER END OF THE TETHER AS ABOVE

125. USING THE LASER LIGHT SOURCE [EE] AT 1300 AND 1550 NANOMETER WAVELENGTHS CHECK ALL THREE FIBERS FROM TETHER END TO TETHER END FOR NO MORE THAN 3 DB LOSS BY READINGS ON THE POWER METER [M]

CAUTION!: THE LASER LIGHT SOURCE CAN DAMAGE YOUR VISION!

126. PLACE DUST CAPS OVER THE TERMINATED CONNECTOR ASSEMBLIES

127. RELEASE THE COPPER CONDUCTORS BY CUTTING THE TYRAPS WITH SIDECUTTERS [Y], DO NOT USE A KNIFE OR RAZOR BLADE

128. SOLDER TOGETHER LIKE COLORED CONDUCTORS AND EXTEND THE THREE CONDUCTORS BEYOND THE END OF THE LONGEST FIBER ASSEMBLY USING COLOR-CODED 18 AWG TEFLON JACKETED WIRE

129. COVER THE SOLDER JOINTS WITH THE APPROPRIATE HEATSHRINK

130. SLIDE THE URETHANE TUBING CAREFULLY DOWN OVER THE WIRES AND THE MODIFIED SPIDER ASSEMBLY

131. SLIDE THE GLAND [5] DOWN AND OFF THE BLACK JACKET OF THE TETHER CORE

132. SLIDE THE LOOSE PIECE OF HEATSHRINK DOWN THE MEET THE BLACK EDGE OF THE TETHER CORE

133. SHRINK INTO PLACE WITH LARGER HEATGUN [G]

134. WORK GLAND BACK OVER THE CENTER OF THE COOLED HEATSHRINK

135. WORK THE END OF THE URETHANE TUBING OVER THE GLAND

136. SECURE WITH TWO SMALL HOSECLAMPS [13]

137. PROTECT ENTIRE ASSEMBLY INSIDE A RIGID TUBE IF VEHICLES ARE NOT AVAILABLE FOR IMMEDIATE HOOKUP

********** END OF PROCEDURE **********

LOOSE-TUBE NEUTRAL TETHER FIBER OPTIC TERMINATION
PARTS & TOOLS

03/21/01

	ITEM	DESCRIPTION	SOURCE	PART NO	MAINTAIN: QTY	MAINTAIN: UNITS
PARTS						
1	CLAMP	SS LOOSE TUBE CLAMP PAIR	MACHINE DRAWING		6	PAIRS
2	CONNECTOR	26-27 MICRON ST CONNECTOR	AMP	502579-2	50	EA
3	COUPLER	ST CONNECTOR COUPLER	FIBERTRON	105-271-142	20	EA
4	EPOXY	EPO-TEK 353ND 2-PART PACK	NEWARK 88F2388	AMP 504035-1	30	PACKS
5	GLAND	NEOPRENE STUFFING GLAND KIT	DORN MS16174-111	NUMBER 2	10	KITS
6	HEATSHRINK	1/8 TO 1 INCH UNSHRUNK ID W/ MASTIC LINING	NEWARK	1/8 INCH ID STEPS, BLACK	20	EA 6" LENGTHS
7	MODIFICATION	SPIDER MODIFICATION	MACHINE DRAWING		6	EA
8	SCREW	4-40 X 1/4" SS FH SCREW	STOCKROOM		1	BOX
9	SPIDER	SPIDER FAN-OUT KIT PLUS 900 MICRON	FIBER INSTRUMENT SALES	SIECOR SFK-P-06-900-M	6	EA
10	SPIDER	SPIDER FAN-OUT KIT PLUS 250 MICRON	FIBER INSTRUMENT SALES	SIECOR SFK-P-06-250-M	6	EA
11	TETHER	6-CONDUCTOR 3-FIBER LOOSE TUBE NEUTRAL	SOUTHBAY CABLE	QUOTE 69216	2	EA 100' LENGTHS
12	TUBING	ETHER-BASED POLYURETHANE 1" ID X 1/8" WALL	MCMASTER-CARR	5184K83 (??)	25	FEET
13	CLAMPS	STAINLESS STEEL HOSE CLAMPS	STOCKROOM	1-1/2 INCH DIA	10	EA
14	GLAND	NEOPRENE STUFFING GLAND KIT	MODIFIED DORN	NUMBER 1	10	KITS
OTHER						
	CASE	IMPACT RESISTANT SUITCASE CASE FOR F/O KIT	PELICAN	1600	2	EA

LOOSE-TUBE NEUTRAL TETHER FIBER OPTIC TERMINATION
PARTS & TOOLS

03/21/01

	ITEM	DESCRIPTION	SOURCE	PART NO	MAINTAIN: QTY	MAINTAIN: UNITS
TOOLS						
A	ACETONE	FINGERNAIL POLISH REMOVER	PHARMACY		1	BOTTLE
B	ALCOHOL	ISOPROPYL RUBBING OR STOVE ALCOHOL	PHARMACY OR STOCKROOM		1	BOTTLE
C	BATTERY		ALKALINE	AA	4	EA
D	BATTERY		ALKALINE	9 VOLT	4	EA
E	BLOCK	ST STYLE PLATEN FOR 20 ASSEMBLIES	FIBERTRON	9050 ST/D4/FC	1	EA
F	HEATER	PLATEN HEATER W/ TEMP CONTROL	FIBERTRON	9550		
G	HEAT GUN	BIG RED			1	EA
H	DVM	DIGITAL VOLT-OHM TEST METER	FLUKE		1	EA
I	HEAT GUN	SMALL BIEGE		PRINCESS	1	EA
J	IRON	VARIABLE TEMP SOLDERING IRON		UNGAR	1	EA
K	KNIFE	XACTO STRAIGHT EDGE BLADE	STOCKROOM		1	EA
L	MAGNIFIER	4X MAGNIFYING SAFETY GLASSES			1	EA
M	METER	FIBER OPTIC (LASER) POWER METER	NOYES	OPM 4	1	EA
N	PLATE	1/4" THICK POLISHING PLATEGLASS			1	EA
O	POLISH SHEET	30 MIL GRIT GREEN	FIBERTRON		20	SHEETS
P	POLISH SHEET	12 MIL GRIT YELLOW	FIBERTRON		20	SHEETS
Q	POLISH SHEET	5 MIL GRIT BROWN	FIBERTRON		20	SHEETS
R	POLISH SHEET	0.3 MIL GRIT WHITE	FIBERTRON		20	SHEETS
S	POWER	6-OUTLET POWER STRIP	STOCKROOM		1	EA
T	RAZOR	SINGLE-EDGED RAZOR BLADES	STOCKROOM		10	EA
U	SAW	MINIATURE SMALL-TOOTHED HACKSAW			1	EA
V	SCOPE	ST CONNECTOR INSPECTION SCOPE			1	EA
W	SCREWDRIVER	FLATHEAD SMALL	STOCKROOM		1	EA
X	SCRIBE	SAPPHIRE TIPPED FIBER SCRIBE			2	EA
Y	SIDECUTTER			SMALL GREEN HANDLE	2	EA
Z	SIDECUTTER			LARGE RED HANDLE	2	EA
AA	SCISSORS	GENERIC	STOCKROOM		1	EA
BB	SCISSORS	KEVLAR-RATED	FIBERTRON	FAL INDUSTRIES	1	EA
CC	SOLDER	RESIN-CORE MULTI-CORE	STOCKROOM		1	ROLL
DD	SOURCE	FIBER OPTIC VISIBLE (LED) LIGHT SOURCE	ANICOM AN-FOLS-1	EXFO FLS-235B	1	EA
EE	SOURCE	FIBER OPTIC INVISIBLE (LASER) LIGHT SOURCE	NOYES	OLS1-2 ST	1	EA
FF	STRIPPER	CLADDING	FIBERTRON	MILLER FO 103-S	2	EA
GG	STRIPPER	MULTI-PURPOSE	STOCKROOM	MILLER 101-S	2	EA
HH	THERMOMETER	50-150 DEGREES CENTIGRADE RANGE	FIBERTRON		1	EA
II	TIMER	EGG TIMER	GROCERY	LUX CP2428	1	EA
JJ	VISE	SOFT-JAWED TABLE-CLAMPED VISE		PANAVISE	2	EA
KK	WATER	FRESH WATER FOR POLISHING			1	BOTTLE
LL	WIPES	LINT-FREE PRECISION WIPES OR KIMWIPES	STOCKROOM		2	BOXES
MM	TYRAP	6 AND 11 IN BLACK	STOCKROOM	PANDUIT CABLE TIES	100	EA
NN	DISK	ST TYPE FERRULE POLISHING DISK	FIBERTRON	ST	2	EA

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16. Abstract (Limit: 200 words)

Neutral tethers for unmanned underwater vehicles may contain a bundle of single-mode, optical fibers that are protected inside flexible stainless steel tubing. To date the author knows of no commercially available systems or kits that substitute for the following procedure, which is a step-by-step method for terminating electro-optical, loose-tube tether assemblies when used in oil-compensated, underwater applications. This procedure alone will not result in a load-bearing assembly. It assumes that the tether's outer jacket and synthetic strain-relief layer have already passed through and been terminated to an unspecified, customized, load-bearing assembly. The procedure addresses in detail the preparation of three optical fibers and three copper conductors for repeated make-and-break installations into a vehicle's primary junction box. The user will need a large, clean workbench, plenty of light and a variety of specialized tools, most of which are listed. A spreadsheet is provided that describes the parts required and suggests appropriate vendors or other sources. The entire procedure can take up to four hours to complete per tether end.

17. Document Analysis **a. Descriptors**

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tether
procedure

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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