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DEVELOPMENT OF INSPECTION PROCEDURES AND REPLACEMENT CRITERIA F--ETC(U)
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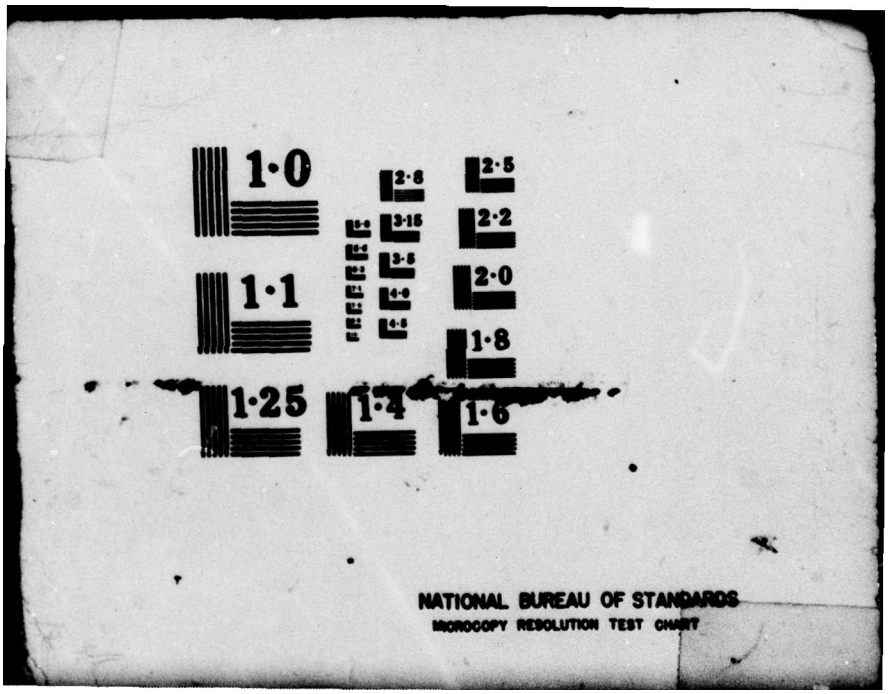
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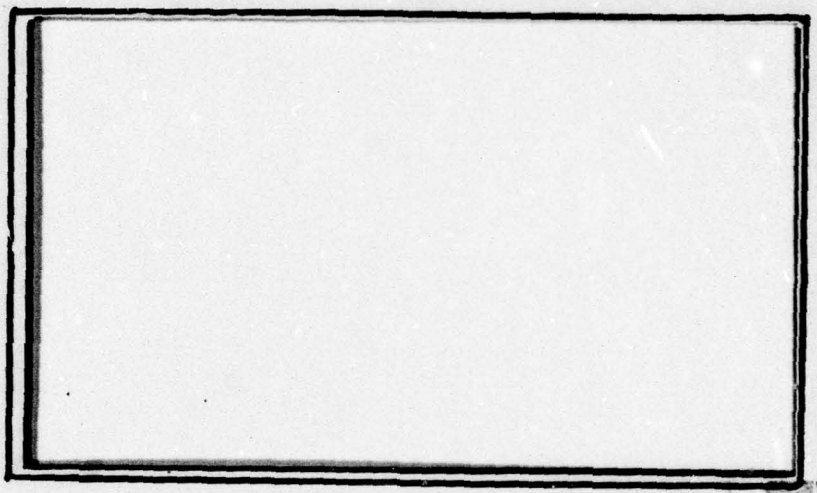

TECHNICAL MEMORANDUM

U.S. NAVAL APPLIED SCIENCE LABORATORY
FLUSHING & WASHINGTON AVES.
BROOKLYN, NEW YORK 11251

USNASL-9110-P-1J(REV. 10-64)

(14) NASL-9400-97-TM-11

(6) DEVELOPMENT
OF
INSPECTION PROCEDURES AND REPLACEMENT CRITERIA
FOR
AN/SQA-10 VDS TOWCABLES.

Lab. Project 9400-97, Technical Memorandum #11

~~(S2780) Task 11509~~)

(11) 19 SEP 66

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MATERIAL SCIENCES DIVISION

(9) Technical memo.

Approved: D. H. Kallas

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SUMMARY

An investigation was conducted on corroded AN/SQA-10 VDS towcables to obtain information for determining the adequacy of the Naval Applied Science Laboratory developed monthly towcable inspection procedures and replacement criteria, which are currently being used in the Fleet. The results obtained indicate that corrosion is a maximum at the towpoint and decreases with distance from the towpoint, and that for cables with up to two years of service the deleterious effects of corrosion become negligible at a distance of ten to fifteen feet from the towpoint. The results also indicate that cable corrosion is, in general, related to total time in service regardless of the amount of towing time. These results are not significantly different from those obtained during the initial phase of this work and which were used as the basis for developing the monthly towcable inspection procedures and replacement criteria. Recommendations are made for continuing monthly inspections of AN/SQA-10 VDS towcables in accordance with the procedures and criteria developed at NASL.

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ADMINISTRATIVE INFORMATION

Ref: (a) NASL Program Summary dated 1 May 1966; S2720, Task 11309.
(b) NASL Project 9300-24, Tech. Memo #1 of 12 May 1965
(c) Fed. Spec. RR-W-410a; Amend 2 of 1 Dec 1961; Wire Rope and Strand
(d) BuShips ltr 9670, Ser 1633D-661 of 3 June 1965.

1. The U.S. Naval Applied Science Laboratory is conducting an investigation, in accordance with reference (a), on AN/SQA-10 VDS electro-mechanical towcables. A report covering the results of evaluations conducted on eleven sample towcables, and the development of monthly towcable inspection procedures and replacement criteria, was forwarded under reference (b). This report covers the work of evaluations on sixteen additional sample towcables.

OBJECT

2. The object of the investigation was to obtain additional information on AN/SQA-10 VDS towcables regarding deterioration due to corrosion and to review and revise, if necessary, the monthly towcable inspection procedures and/or replacement criteria developed under reference (b).

DESCRIPTION

3. Sample AN/SQA-10 VDS electro-mechanical towcables were furnished for the investigation by the sixteen ships listed on Table 1. The cable has an insulated electrical core surrounded by two layers of preformed, improved plow steel, galvanized armor wires. Each layer has 24 armor wires of the following nominal diameters; 0.112 inch for the inner wires and 0.141 inch for the outer wires. The nominal overall diameter of the cables is from 1.33 to 1.36 inches.

PROCEDURE

4. The individual armor wires of the sample cables were examined to determine the extent of corrosion as defined by the three general categories indicated below:

a. Severe Corrosion - entire surface corroded with considerable pitting.

b. Medium Corrosion - entire surface corroded with little or no evidence of pitting.

c. Light Corrosion - zinc coating still visible over most of wire.

11. Data on the results of bend tests conducted on samples of individual armor wires from various cables are shown on Table 5. The table gives the number of double bends to failure for severely corroded and medium to lightly corroded armor wires. The overall average number of bends to failure for corresponding wires evaluated under reference (b) are also shown for comparison.

ANALYSIS

12. The data from Tables 2 and 3 show that the reduction of wire diameter as a result of corrosion, is a maximum at the towpoint end and decreases along the cable with distance from the towpoint. The data also indicate that the extent of cable corrosion is, in general, related to total time in service, regardless of the amount of towing time. As seen from Tables 2 and 3 the first six cables listed, which had a total time in service of from 1 1/2 to 4 years, showed the most severe corrosion. On the other hand the towcable from the Laffey with 2633 hours of towing time showed less corrosion than the first six cables listed which had towing times of 423 hours or less. Similar observations from corresponding data were also made in reference (b).

13. The data of Tables 2 and 3 for all cables with up to two years of total time in service are shown plotted on Figure 1 to show variation of corrosion along the cable as reflected by wire diameter. A curve is faired in through the lowest points plotted in order to reflect the worst conditions. It is seen that wire diameter reduction due to corrosion is a maximum of about 0.010 inch at the towpoint end and drops off gradually to about 0.004 inch at ten feet from the towpoint end. There does not appear to be any significant difference in corrosion of inner and outer wires as measured by reduction in wire diameter. The dotted curves, representing corresponding data reported in reference (b), indicate that the two sets of data have approximately the same trend.

14. The data of Table 4 for all cables with up to two years of total time in service are shown plotted in Figure 2 to show variation of tensile strength of wires with distance from towpoint. A curve is faired in through the lowest points plotted in order to reflect the worst conditions. It is seen from these curves that although tensile strengths at the towpoints are far below the minima specified for the wires, they increase rapidly with distance from the towpoint to the specified minima at a distance of approximately 10 to 15 feet. Here again, the dotted curves representing corresponding data from reference (b) indicate that the two sets of data have approximately the same trend.

15. The results of the bend test shown on Table 5 are not significantly different from the results reported in reference (b) for corresponding wires. It may be seen that the overall average number of bends to failure for both sets of data is appreciably less for severely corroded wires than for medium to lightly corroded wires. These results support the observation made in reference (b), that the bend test data are a fairly sensitive measure of the degree of corrosion of towcable armor wires.

5. Diametral measurements of the individual armor wires were taken with a micrometer to determine the reduction in wire diameter due to corrosion. These measurements were made at 1 inch increments over a 5 inch length near the towpoint end, at 2,4,6 and 8 foot increments thereafter, and at the reel end of each sample.

6. Tensile and torsional ductility tests were conducted on inner and outer armor wires from the towpoint and reel ends of each sample, to determine the reduction in strength and ductility due to corrosion.

7. Bend tests were conducted on one-foot samples of severely corroded and medium to lightly corroded armor wires. These tests were conducted in the fixture specially designed for the investigation reported in reference (b). The fixture consists of a steel plate with two 1-inch diameter steel pins protruding 1/2 inch beyond one of the surfaces. The pins were spaced a distance apart equal to the diameter of the test wire. Each wire was placed between the pins with a sufficient length extending below the pins to permit clamping both the wire and fixture in a vise. The free end of the wire was then held with vise grip pliers and slowly bent back and forth, without twisting through 90 degrees on each side of the vertical, making a double bend. This procedure was repeated until the wire broke. A complete back and forth movement of the wire on each side of the vertical was counted as one double bend and the number of double bends to failure was recorded for each sample.

RESULTS

8. The identities of the sample AN/SQA-10 VDS towcables furnished by various ships for this investigation, together with pertinent information from the ship's records, are given in Table 1. It may be seen from the table that the cables were on board the ships for a period of time varying from 2/3 of a year to 4 years and that the towing time varied from 96 to 2633 hours. It may also be seen that four of the samples were removed from towcables which had previously been reterminated.

9. Data obtained on the extent of cable corrosion, as determined by reduction in diameter of the individual armor wires, are shown on Tables 2 and 3 for outer and inner armor wires, respectively. Each table gives the average wire diameter for each cable at various locations from the towpoint end. The years on board ship and the towing hours for each cable are also given for comparison.

10. Data on the results of tensile and torsional ductility tests conducted on the individual armor wires are shown on Table 4, together with the corresponding requirements of specification, reference (c). The table gives the average breaking load and the average number of revolutions to failure for wires of each cable at the towpoint end and at the end of the samples opposite the towpoint. The years on board ship and the towing hours for each cable are also given for comparison.

16. A review of the data for the four towcables which had previously been reterminated reveals that these cables were sufficiently corroded after from 9 to 14 months of additional service use to warrant replacement. This substantiates the conclusion made in reference (b) which indicates that the service use of reterminated cables should be limited to a maximum of one year.

17. It appears from paragraphs 12 through 16, that there is no essential difference between the results reported herein and those reported in reference (b). Accordingly, it is not considered necessary to revise the monthly towcable inspection procedures or replacement criteria developed under reference (b).

CONCLUSIONS

18. The following conclusions, similar to those made in reference (b), may be drawn from the results reported herein:

a. Corrosion of AN/SQA-10VDS towcables is a maximum at the towpoint and decreases with distance from the towpoint.

b. Towcable corrosion is evidenced by a decrease in diameter, reduction in tensile strength, and loss of ductility of the armor wires.

c. For towcables with up to two years of total time in service the deleterious effects of corrosion become negligible at a distance of 10 to 15 feet from the towpoint.

d. The service use of reterminated cables should be limited to a maximum of one year.

19. The monthly towcable inspection procedures and replacement criteria, as developed under reference (b), will adequately provide for early detection of cable corrosion and timely removal or retermination of severely corroded AN/SQA-10 VDS towcables.

RECOMMENDATIONS

20. It is recommended that monthly inspection of AN/SQA-10 VDS towcables be continued in accordance with the procedures and criteria developed at NASL and issued as Fleet instructions, by the Naval Ship Systems Command, under enclosure (1) of reference (d).

21. It is also recommended that the instructions given in enclosure (1) of reference (d), for forwarding sections of replaced or reterminated cables to NASL, be cancelled since no further work is anticipated in connection with this investigation.

FUTURE WORK

22. No further work is contemplated since the work planned for this phase of the program, in accordance with reference (a), is completed with this report.

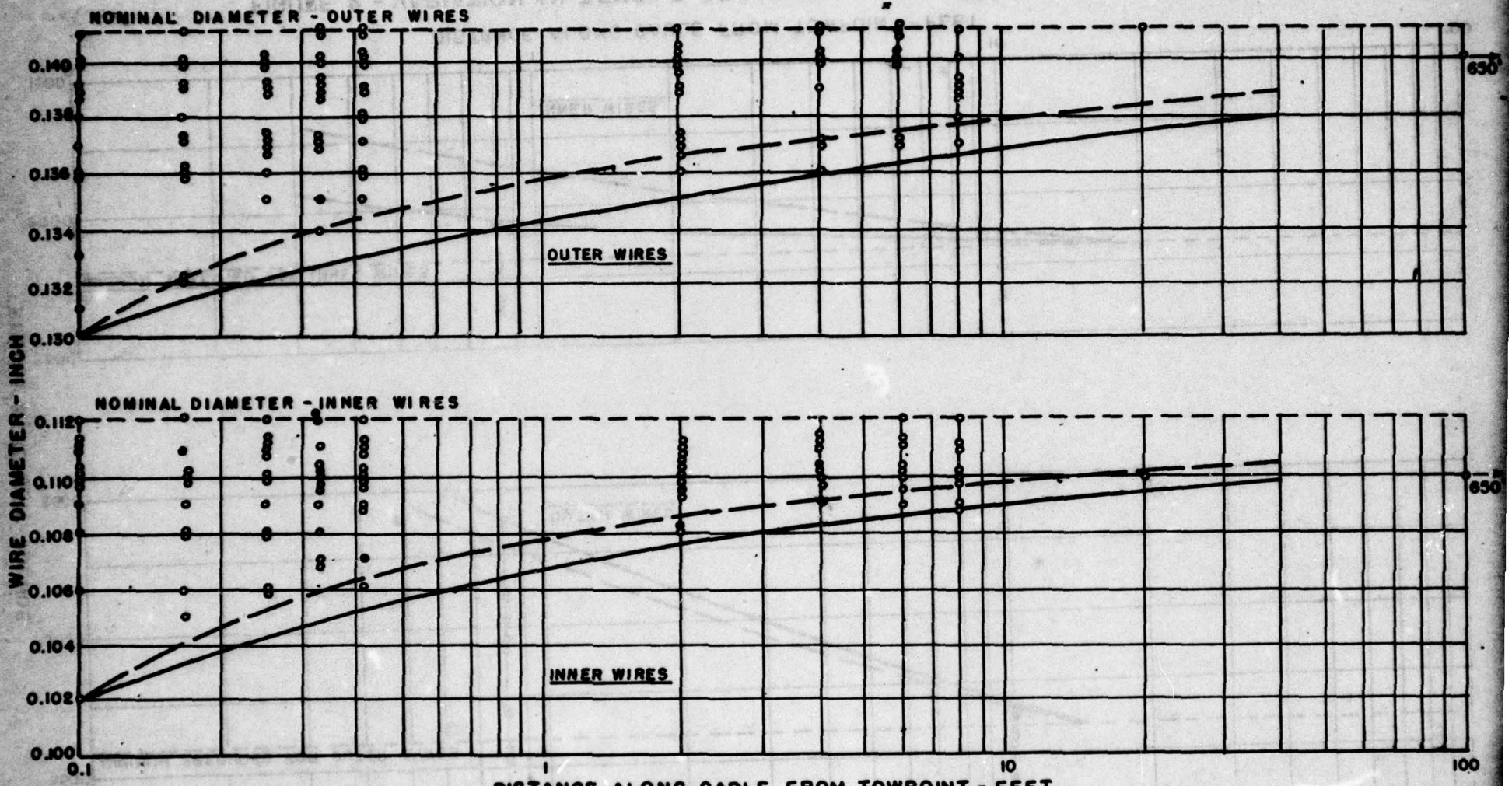

FIGURE 1 - VARIATION IN WIRE DIAMETER WITH DISTANCE FROM TOWPOINT FOR CABLES WITH UP TO 2 YEARS OF SERVICE

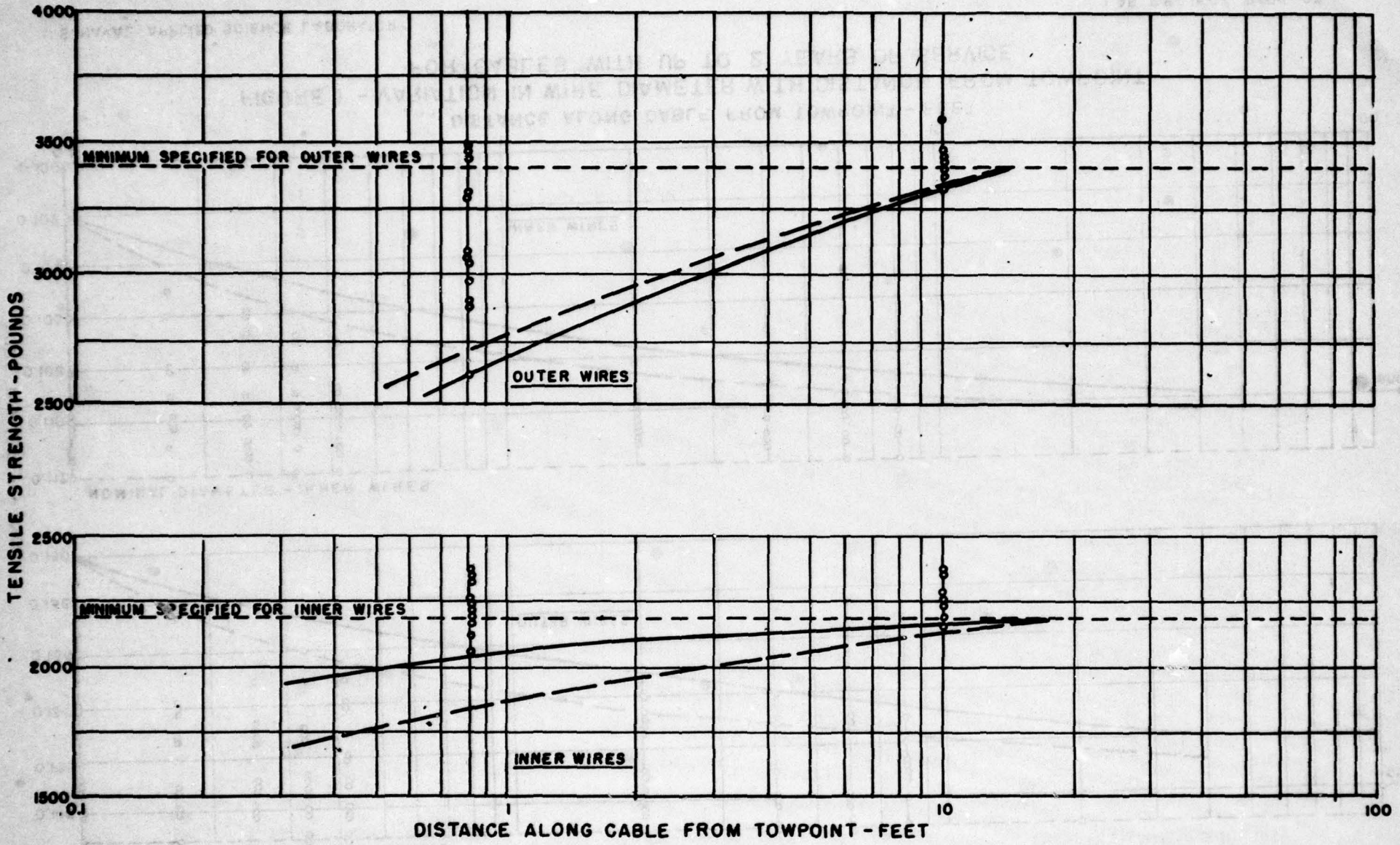

FIGURE 2 - VARIATION IN TENSILE STRENGTH WITH DISTANCE FROM TOWPOINT FOR CABLES WITH UP TO 2 YEARS OF SERVICE

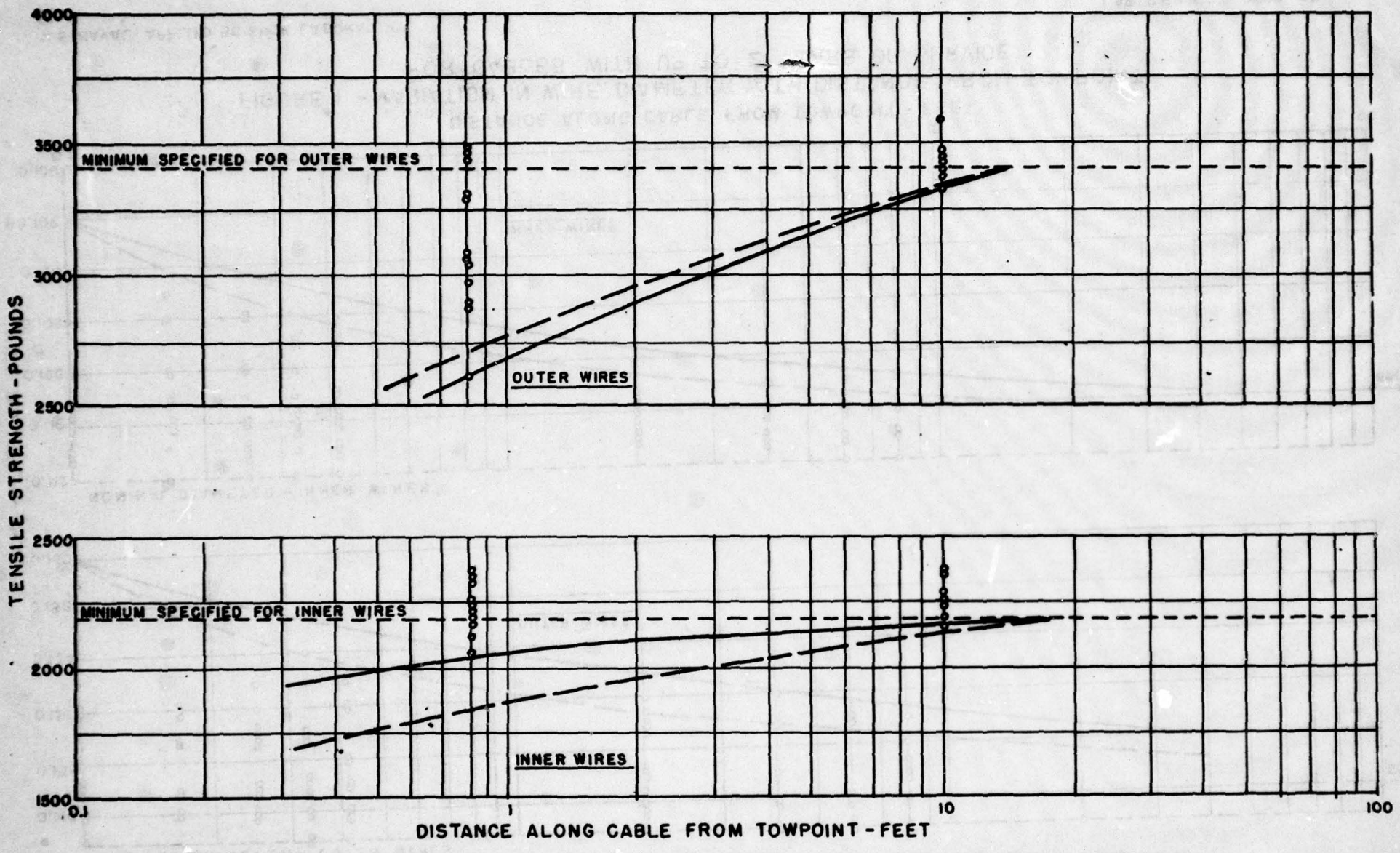

FIGURE 2 - VARIATION IN TENSILE STRENGTH WITH DISTANCE FROM TOWPOINT FOR CABLES WITH UP TO 2 YEARS OF SERVICE

TABLE 1

IDENTITY OF SAMPLE AN/SQA-10 TOW CABLES SUBMITTED FOR INVESTIGATION

Ship		INFORMATION FROM SHIP'S RECORDS				
		Date Cable Installed	Date Sample Removed	Years on Board	Estimated Hours of Towing	Condition of Cable
MANSFIELD	DD-728	Sep 1960(1)	Nov 1964	4	400	Badly corroded and pitted in some areas
TATTNALL	DD-746	Sep 1962(2)	Nov 1964	2 1/4	423	Armor wires failed to meet bend test
WILLIS	DD-1027	Dec 1962	May 1965	2 1/2	289	———
BOLE	DD-755	Aug 1962(3)	Dec 1964	2 1/2	300	2nd determination unsuccessful due to brittle strands
SMALL	DD-838	Oct 1963	Apr 1966	1 1/2	300	Slight rust near towpoint
RADFORD	DD-446	Mar 1963	Dec 1964	1 2/3	410	Armor wires found to be brittle with reduced tensile strength and diameter
BAILEY	DD-713	Sep 1963(4)	Jun 1965	1 3/4	500	Cable replaced due to electrical failure
ZELLARS	DD-777	Apr 1963	Mar 1965	2	250	Cable rusted more toward towed body end than near reel end
COLLETT	DD-730	Apr 1964	Apr 1965	1	170	Covered with rust
CUNNINGHAM	DD-752	Feb 1964	Feb 1965	1	179	Corroded and pitted near towpoint
FOX	DD-779	Nov 1964	Jul 1965	2/3	96	Very good-cable reterminated because armor unlayed when towed body went out of control
O'BRIEN	DD-727	Feb 1964	Jan 1965	1	185	Good
LAFFEY	DD-724	Oct 1962	Oct 1964	2	2633	Cable completely covered with rust
OWENS	DD-776	Jan 1964	Jan 1965	1	200	———
LOWREY	DD-770	Sep 1963	Jul 1964	2/3	450	Replaced due to short in electrical cable
DEHAVEN	DD-725	Feb 1964	Jun 1965	1 1/2	-	———

NOTES: (1) Cable reterminated Sep 1963
(2) " " Oct 1963
(3) " " Apr 1964
(4) " " Sep 1964

TABLE 2

DATA ON THE EXTENT OF CORROSION AND ON THE DIAMETER OF OUTER ARMOR WIRES

NOMINAL WIRE DIAMETER -0.141 INCH

SHIP	YEARS ON BOARD	EST. HOURS OF TOWING	CORRODED COND-ITION OF WIRE	AVERAGE DIAMETER OF WIRE - INCH (10 SAMPLES) AT INDICATED DISTANCE FROM TOWPOINT									AT END OPPOSITE TOWPOINT	
				1"	2"	3"	4"	5"	2'	4'	6'	8'	DIA.	DISTANCE FEET
MANSFIELD	4	400	SEVERE	0.117	0.121	0.124	0.127	0.129	0.130	0.130	0.133	0.134	0.139	650
TAUSSIG	2 1/4	423	SEVERE	0.128	0.130	0.130	0.134	0.135	0.135	0.133	0.133	0.135	0.134	10
WILLIS	2 1/2	289	SEVERE	0.120	0.122	0.125	0.130	0.133	0.133	0.130	0.131	0.134	0.134	10
BOLE	2 1/2	200	SEVERE	0.132	0.131	0.132	0.133	0.133	0.132	0.133	—	—	—	—
SMALL	1 1/2	300	SEVERE	0.130	0.132	0.133	0.134	0.135	0.136	0.136	0.137	0.138	0.138	10
RADFORD	1 2/3	410	SEVERE	0.133	0.136	0.137	0.135	0.136	0.137	—	—	—	—	—
BAILEY	1 3/4	500	SEVERE	0.131	0.132	0.135	0.139	0.138	0.137	0.137	—	—	—	—
ZELLARS	2	250	MEDIUM	0.139	0.140	0.140	0.141	0.141	0.140	—	—	—	—	—
COLLETT	1	170	MEDIUM	0.138	0.136	0.137	0.139	0.139	0.140	0.140	0.140	0.139	0.140	10
CUNNINGHAM	1	179	MEDIUM	0.140	0.138	0.139	0.139	0.140	0.140	0.141	0.141	0.139	0.140	650
FOX	2/3	96	MEDIUM	0.136	0.136	0.137	0.137	0.137	0.137	—	—	—	—	—
O'BRIEN	1	185	MEDIUM	0.139	0.139	0.139	0.139	0.139	0.140	0.140	0.140	0.139	0.139	10
LAFFEY	2	2633	MEDIUM	0.137	0.137	0.136	0.137	0.136	0.137	0.137	0.138	0.139	0.141	10
OWENS	1	200	MEDIUM	0.136	0.137	0.137	0.137	0.138	0.139	0.140	0.141	0.140	0.141	20
LOWREY	2/3	450	LIGHT	0.140	0.140	0.141	0.141	0.141	0.140	—	—	—	—	—
DE HAVEN	1 1/2	-	LIGHT	0.139	0.139	0.140	0.140	0.140	0.139	0.139	0.140	0.139	0.140	10

TABLE 3

DATA ON THE EXTENT OF CORROSION AND ON THE DIAMETER OF INNER ARMOR WIRES

NOMINAL WIRE DIAMETER - 0.112 INCH

SHIP	Years on Board	Est. Hours of Towing	Corroded Condition of Wire	AVERAGE DIAMETER OF WIRE - INCH (10 SAMPLES) At indicated distance from towpoint									At end opposite Towpoint	
				1"	2"	3"	4"	5"	2'	4'	6'	8'	Dia.	Distance Feet
MANSFIELD	4	400	severe	0.102	0.103	0.104	0.105	0.105	0.107	0.108	0.108	0.108	0.110	650
TAUSSIG	2 1/4	423	severe	0.105	0.105	0.106	0.106	0.105	0.105	0.105	0.106	0.105	0.106	10
WILLIS	2 1/2	289	severe	0.096	0.097	0.097	0.100	0.101	0.102	0.103	0.101	0.103	0.105	10
BOLE	2 1/2	200	severe	0.106	0.106	0.106	0.105	0.106	0.106	0.105	—	—	—	—
SMALL	1 1/2	300	severe	0.106	0.106	0.106	0.107	0.107	0.108	0.109	0.109	0.110	0.110	10
RADFORD	1 2/3	410	severe	0.102	0.105	0.106	0.107	0.106	0.108	—	—	—	—	—
ZELLARS	2	250	medium	0.110	0.110	0.110	0.110	0.110	0.110	—	—	—	—	—
COLLETT	1	170	medium	0.110	0.109	0.109	0.110	0.110	0.110	0.110	0.110	0.109	0.110	10
CUNNINGHAM	1	179	medium	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.109	0.110	650
FOX	2/3	96	medium	0.108	0.108	1.108	0.109	0.109	0.110	—	—	—	—	—
O'BRIEN	1	185	light	0.111	0.111	0.111	0.112	0.111	0.111	0.111	0.111	0.111	0.111	10
LAFFEY	2	2633	light	0.110	0.110	0.111	0.110	0.111	0.111	0.111	0.111	0.111	0.111	10
OWENS	1	200	light	0.109	0.108	0.108	0.108	0.109	0.110	0.110	0.110	0.110	0.110	20
LOWRY	2/3	450	light	0.111	0.111	0.111	0.111	0.111	0.111	—	—	—	—	—
DEHAVEN	1 1/2	-	light	0.111	0.111	0.111	0.110	0.110	0.110	0.110	0.110	0.110	0.110	10

TABLE 4

RESULTS OF TENSILE AND TORSIONAL DUCTILITY TESTS ON INDIVIDUAL ARMOR WIRES

SHIP	YEARS ON BOARD	ESTIMATED HOURS OF TOWING	DISTANCE OF TEST WIRE FROM TOWPOINT FEET	CORRODED CONDITION OF WIRE	AVERAGE BREAKING LOAD-LBS. (5 SAMPLES)				AVERAGE NO. OF REVOLUTIONS TO FAILURE IN 8-INCH TEST LENGTH (5 SAMPLES)			
					OUTER WIRES (0.141 IN DIA)		INNER WIRES (0.112 IN DIA)		OUTER WIRES (0.141 IN DIA)		INNER WIRES (0.112 IN DIA)	
					T	O	T	O	T	O	T	O
MANSFIELD	4	400	0.8	SEVERE	2310		1710		1		2	
			650	MEDIUM		3340		2220		7		19
TAUSSIG	2 1/4	423	0.8	SEVERE	2745		1917		1		3	
			10	SEVERE		2850		2210		5		6
WILLIS	2 1/2	289	0.8	SEVERE	2403		1636		1		2	
			10	SEVERE		3310		2173		3		6
BOLE	2 1/2	200	0.8[1]	SEVERE	2620		2035		1		2	
SMALL	1 1/2	300	0.8	SEVERE	2608		2060		1		3	
			10	SEVERE		3420		2190		2		5
RADFORD	1 2/3	410	0.8[1]	SEVERE	2980		2220		1		2	
BAILEY	1 3/4	500	0.8[1]	SEVERE	2893				1			
ZELLARS	2	250	0.8[1]	MEDIUM	3040		2380		2		16	
COLLETT	1	170	0.8	MEDIUM	3065		2285		1		17	
			10	MEDIUM		3320		2280		6		17
CUNNINGHAM	1	179	0.8	MEDIUM	3180		2174		3		14	
			325	MEDIUM		3370		2237		4		17
			650	MEDIUM		3377		2265		7		18
MINIMUM SPECIFIED REQUIREMENTS, REFERENCE (c)					3400		2180		15		20	

TABLE 4 CONT'D

SHIP	YEARS ON BOARD	ESTIMATED HOURS OF TOWING	DISTANCE OF TEST WIRE FROM TOWPOINT FEET	CORRODED CONDITION OF WIRE	AVERAGE BREAKING LOAD - LBS (5 SAMPLES)				AVERAGE NO. OF REVOLUTIONS TO FAILURE IN 8-INCH TEST LENGTH (5 SAMPLES)			
					OUTER WIRES (0.141 IN DIA)		INNER WIRES (0.112 IN DIA)		OUTER WIRES (0.141 IN DIA)		INNER WIRES 0.112 IN DIA)	
					T	O	T	O	T	O	T	O
FOX	2/3	96	0.8(1)	MEDIUM	3290		2190		2		16	
O'BRIEN	1	185	0.8	M-L	3080		2220		5		13	
			10	M-L		3320		2230		6		15
LAFFEY	2	2633	0.8	M-L	3310		2220		8		16	
			10	M-L		3410		2190		9		17
OWENS	1	200	0.8	M-L	3430		2340		9		15	
			20	M-L		3580		2343		11		17
LOWREY	2/3	450	0.8(1)	LIGHT	3490		2240		9		13	
DEHAVEN	1 1/2	-	0.8	LIGHT	3441		2382		10		16	
			10	LIGHT		3366		2350		14		19
MINIMUM SPECIFIED REQUIREMENTS, REFERENCE (c)					3400		2180		15		20	

NOTES: (1) Sample cable too short to provide sample wires from each end without overlapping.

(2) M-L indicates that outer wires had medium corrosion and inner wires had light corrosion.

(3) T-Towpoint end of sample; O-End of sample opposite towpoint.

TABLE 5

RESULTS OF BEND TESTS ON ARMOR WIRES
HAVING VARIOUS CONDITIONS OF CORROSION

Condition of Wire	SHIP	Years on Board	NUMBER OF DOUBLE BENDS TO FAILURE (1)											
			Outer Wires (0.141 inch dia.)						Inner Wires (0.112 inch dia.)					
			Sample No.					Overall Average	Sample No.					Overall Average
			1	2	3	4	5		1	2	3	4	5	
Severely Corroded	MANSFIELD	4	2.5	2	3	1.5	3	3.0 (2.3)	6.5	3.5	4	4	3.5	5.5 (4.2)
	TAUSSIG	2 1/4	3	2.5	3.5	3	2.5		6	7.5	6	7	5	
	WILLIS	2 1/2	4	4	4	2	2.5		5.5	2.5	5.5	3	3.5	
	BOLE	2 1/2	3	3.5	3	4	2.5		8	7	7	6	5	
	SMALL	2 1/2	2.5	3	4	3	3.5		6.5	6	7	7.5	6.5	
Medium to Lightly Corroded	ZELLARS	2	4.5	5	4	7	4.5	5.1 (5.3)	17	17.5	18	17	16	14.1 (12.0)
	COLLETT	1	6	3	4	4	5		14	14	13	15	16	
	CUNNINGHAM	1	6	5	5	6	5		17	16	12	13	14	
	OWENS	1	5	6	6	5	4.5		11	11	10	10	10	
	LOWREY	2/3	5	6	5	6	5		17	14	12	13	15	

NOTE: (1) A double bend consisted of a complete back and forth movement of a wire through 90 degrees on each side of the vertical.

(2) The values in parenthesis are for corresponding wires evaluated under reference (b) and are shown for comparison.