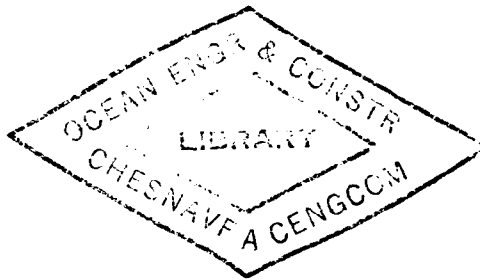


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**NAVAL AIR STATION BERMUDA
FLEET MOORINGS
UNDERWATER INSPECTION REPORT
8-15 JULY 1981**

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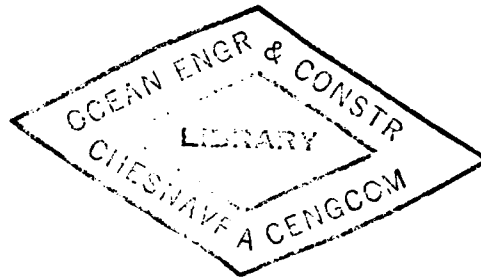
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**NAVAL AIR STATION BERMUDA
FLEET MOORINGS
UNDERWATER INSPECTION REPORT
8-15 JULY 1981**

**FPO-1-81(18)
DECEMBER 1981**

**OCEAN ENGINEERING
AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, DC 20374**

ABSTRACT

This report provides an evaluation of ten fleet moorings located inshore at the island of Bermuda and is based on the underwater inspection of these moorings conducted by UCT-1 divers and CHESDIV engineering support personnel during the period 8-15 July 1981.

The results of this investigation revealed that only one of the ten moorings inspected is considered safe for utilization by fleet units within the constraints of rated moorings loads. Comments concerning the specific condition of each mooring inspected are included as well as recommendations for mooring overhaul or replacement.



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TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	i
TABLE OF CONTENTS	ii
LIST OF FIGURES	iii
LIST OF TABLES	iii
1.0 INTRODUCTION	1
1.1 Background	1
1.2 Mooring Historical Data	1
2.0 INSPECTION PROCEDURES	5
2.1 Underwater Inspection Limitations	5
2.2 Procedures	6
3.0 INSPECTION SUMMARY	7
3.1 Findings	7
3.2 Proposed Corrective Actions	8
4.0 MOORING INSPECTION COMMENTS/RECOMMENDATIONS	8
 <u>Appendix</u>	
A MOORING INSPECTION REPORTS AND SCHEMATICS	A-1
Mooring E-1 Inspection Results.	A-2
Mooring E-2 Inspection Results.	A-7
Mooring E-3 Inspection Results.	A-10
Mooring E-4 Inspection Results.	A-14
Mooring E-5 Inspection Results.	A-17
Mooring F-1 Inspection Results.	A-21
Mooring F-2 Inspection Results.	A-25
Mooring F-3 Inspection Results.	A-29
Mooring F-4 Inspection Results.	A-33
Mooring F-6 Inspection Results.	A-37
B CLASS E AND CLASS F MOORING COSTS	B-1
C INSPECTION PHOTOGRAPHS	C-1
D CORRESPONDENCE UCT ONE MESSAGE 301100Z JUN 81	D-1
CHESDIV MESSAGE 041228Z Aug 81	D-2

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Bermuda Fleet Mooring Locations	2
2. Class E Mooring Locations	3
3. Class F Mooring Locations	4
B-1. Class "E" Mooring With In-Line Link Anodes	B-5
B-2. Class "F" Mooring With In-Line Link Anodes	B-6
C-1. Worn Section of Mooring E-3 Riser Chain	C-2
C-2. Worn Section of Mooring E-5 Riser Chain	C-2
C-3. Buoy F-3 Riding with 8 - 10° Trim Angle	C-3
C-4. Buoy F-4 - A Sample of the Typical Buoy Condition	C-3

LIST OF TABLES

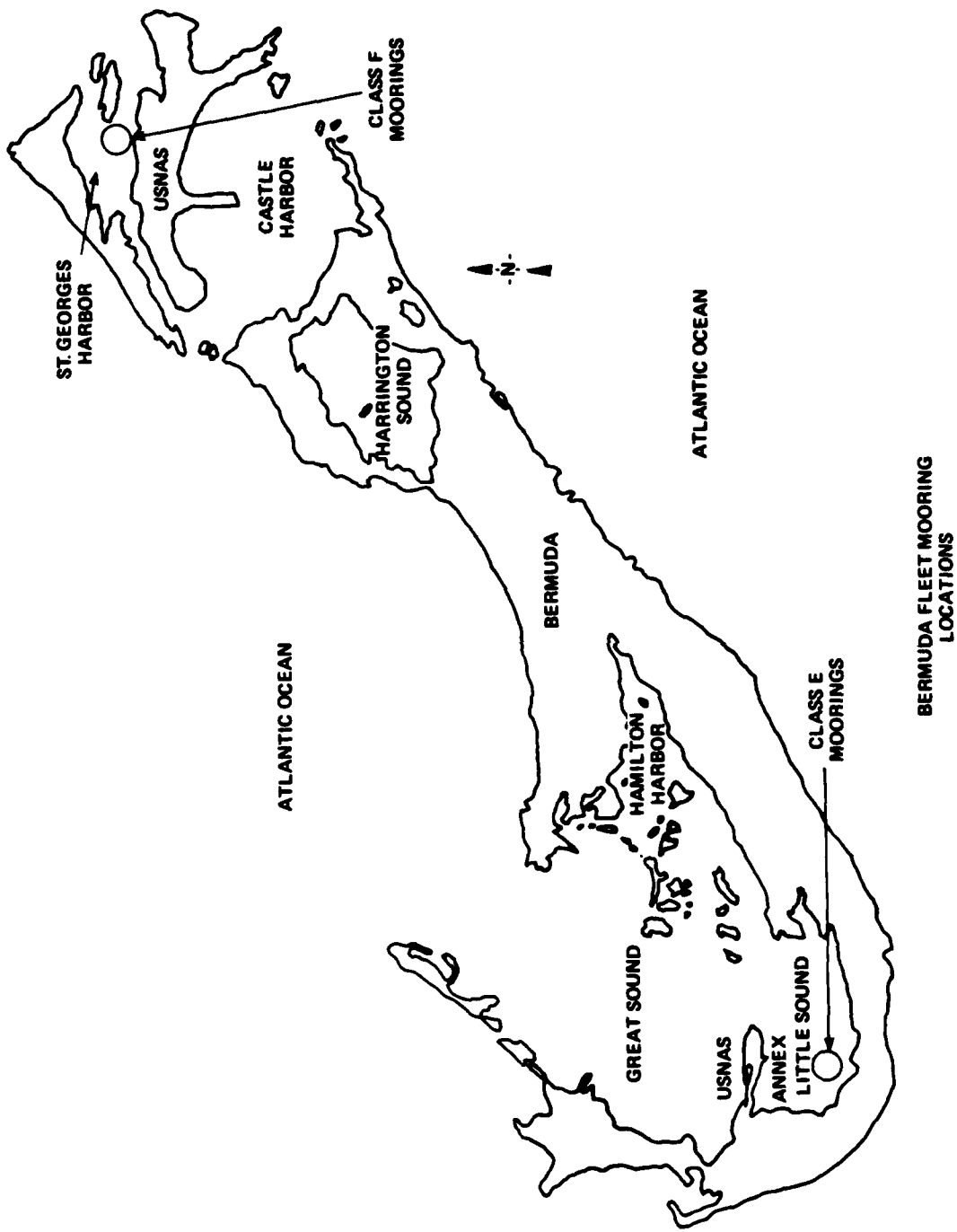
<u>Table</u>	<u>Page</u>
1. Bermuda Fleet Mooring Status	9
B-1. Class "E" Mooring Parts List and Estimated Costs	B-3
B-2. Class "F" Mooring Parts List and Estimated Costs	B-4
B-3. Estimated Installation Costs for Class E or F Moorings at Bermuda	B-7

NAS BERMUDA FLEET MOORINGS
UNDERWATER INSPECTION REPORT

1.0 INTRODUCTION

1.1 Background. By message, on 30 June 1981, Underwater Construction Team One (UCT-1) requested CHESNAVFACENGCOM to provide on-site engineering support during the scheduled inspection of fleet moorings at Bermuda. A total of ten moorings were inspected, five "E" class located in Port Royal Bay in the Little Sound south of the Naval Air Station Annex (see Figures 1 and 2) and five "F" class in St. George's Harbor north of the Naval Air Station (see Figures 1 and 3). CHESNAVFACENGCOM was requested to provide inspection planning and on-site engineering support, to collect the raw data gathered by UCT-1 divers, to analyze this data, and to prepare the inspection report.

1.2 Mooring Historical Data. The underwater inspections of these moorings were conducted during the period 8-15 July 1981. Upon arrival on island, a meeting was held with personnel of the NAS Public Works Department (PWD) to obtain and review all available data concerning the usage and maintenance of these moorings. Copies of reports of two previous underwater mooring inspections, conducted by local contractors during 1978 and 1980, were made available to CHESNAVFACENGCOM personnel. It was determined by UCT-1 divers that the wire diameters of the mooring material detailed in these reports did not reflect the sizes of the material actually in the water, and these reports were subsequently disregarded as being erroneous.



BERMUDA FLEET MOORING LOCATIONS

Figure 1. Bermuda Fleet Mooring Locations

**LOCATION OF CLASS "E" FLEET MOORINGS
NEAR THE N.A.S. ANNEX BERMUDA**

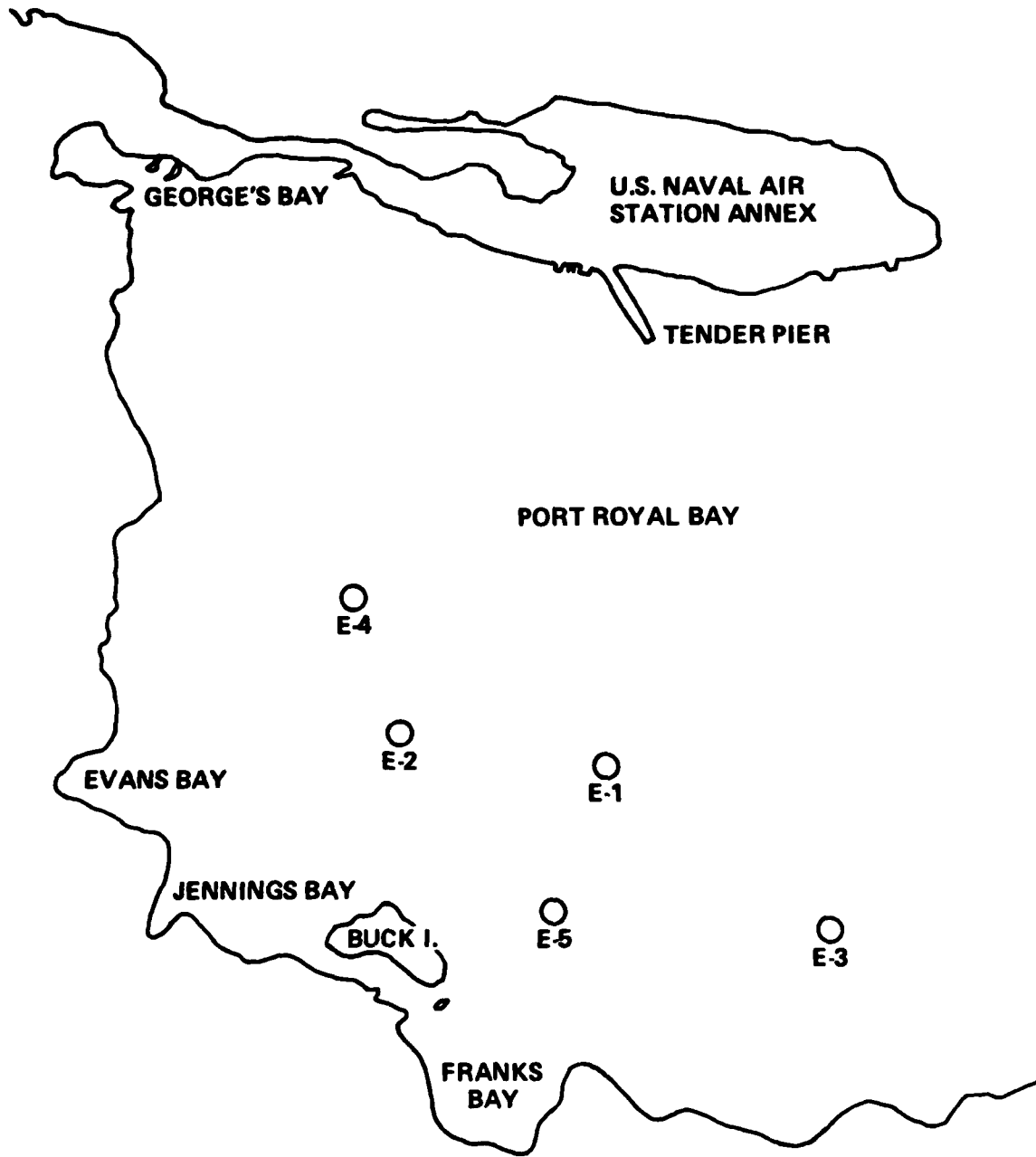


Figure 2. Class E Mooring Locations

**LOCATION OF CLASS "F" FLEET MOORINGS
NEAR N.A.S. BERMUDA**

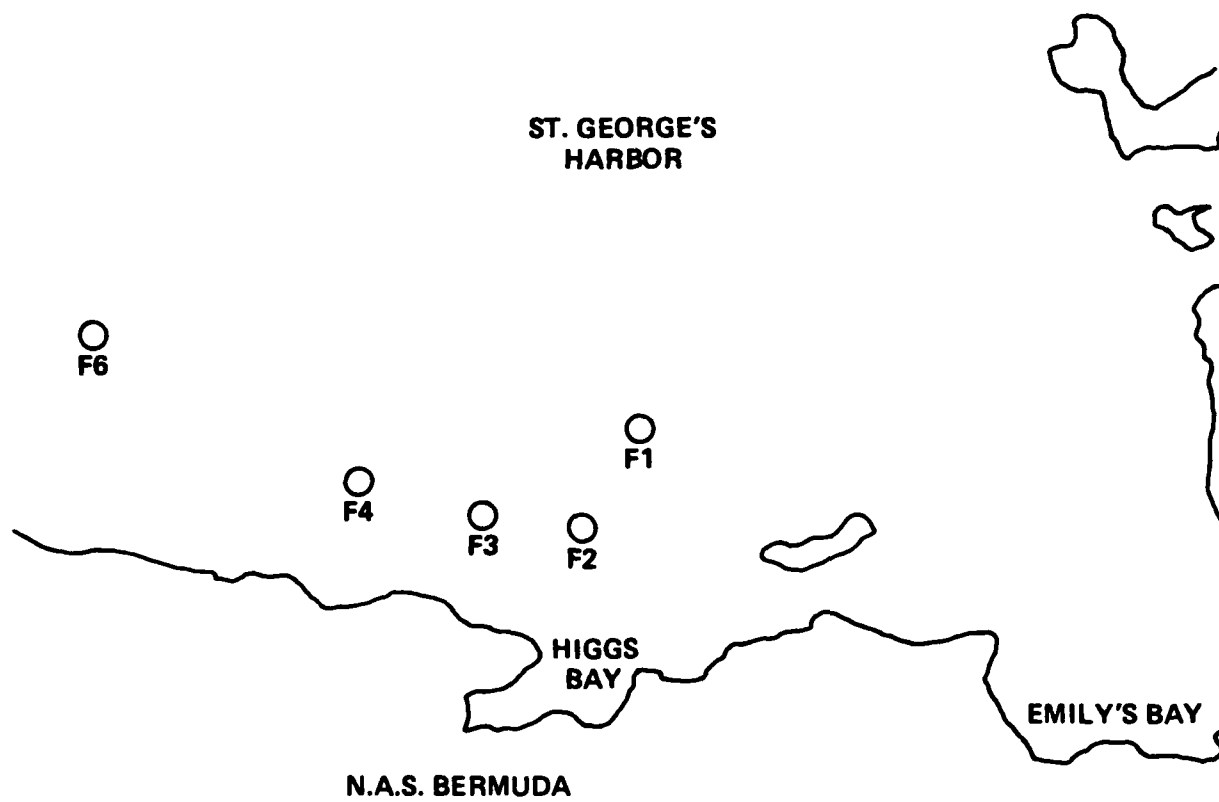


Figure 3. Class F Mooring Locations

For the most part, both classes of moorings are presently utilized by harbor craft of less than 325 tons and occasionally by a smaller 120 ton research vessel operated by the NUSC Tudor Hill Laboratory. Each mooring consists of a tension bar type cylindrical buoy, riser, ground ring, three ground legs, and three Navy stockless anchors. Both the E and F classes of moorings were initially installed during the mid 1940's, but available Navy records of these moorings only go back to 1971. PWD records indicate that all ten buoys were refurbished in 1978 and coated with fiberglass. Buoy height above the sea floor is affected only by tidal current flow.

Records indicate that during the period 1972-1977 limited amounts of mooring material were received. There is no indication into which moorings this material was installed. Additional documentation indicates that the "F" class moorings were overhauled at the same time that the ten buoys were refurbished in 1978. The extent of the overhaul could not be determined.

2.0 INSPECTION PROCEDURES

2.1 Underwater Inspection Limitations. While conducting an underwater mooring inspection, divers clean and measure only a small sample of the existing chain links and jewelry. The purpose of the inspection is to obtain a general perception of the condition of the mooring material and to verify existing maintenance records. When accurate maintenance records are not available and the original wire diameter and/or age of the installed material is unknown or questionable, the sample measurements made by divers may not detect badly deteriorated or undersized mooring components (which could lead to a mooring failure at considerably less than its rated load). Although

underwater inspections supplement accurate maintenance records and provide a "quick look" report on the condition of a sample of a mooring, the effective method of determining the true condition of a mooring is to remove it from the water, inspect and measure the material to ascertain its actual condition, and to evaluate its suitability for future use. Underwater mooring inspections provide only limited information concerning the true material condition of mooring components.

2.2 Procedures. The following inspection procedures were established:

- o The buoy is inspected by noting fender condition, fouling, wear and corrosion on connecting links, need for cleaning and recoating, and collision damage.

- o The selective sampling approach during the inspection of the chain and connecting hardware is taken to determine the amount of corrosion and wear. Using pre-cut gauges, double link measurements of the in-tension riser chain are taken just under the buoy, approximately midway down the riser chain, and just above the ground ring. Caliper measurements of the ground ring and single link measurements of the slack ground legs are taken just below the ground ring and at the wearpoint (where the chain is picked up and put down on the bottom by tides or wave action on the buoy). A third set of measurements is taken near the anchor when the chain was not buried. Single link wire diameter measurements detect corrosion loss while double link measurements, where the two links contact, detect a combination of wear and corrosion.

- Chain links and other hardware measuring greater than 90% of the original wire diameter is considered satisfactory; those measuring less than 90% of original diameter is cause for the mooring classification to be downgraded; and any mooring material measuring less than 80% of original wire diameter is cause for the mooring to be considered unsatisfactory for fleet use. The controlling station is responsible for ensuring that, until overhauled, downgraded moorings are only used within the load constraints of the lower classification (see DM-26*) and that those moorings considered unsatisfactory are not utilized by fleet units and are recommended for immediate overhaul or replacement.
- Since most anchors are normally buried in the bottom, no attempts are made to inspect them. Divers would observe the ground legs to the point they are buried in the seafloor.

3.0 INSPECTION SUMMARY

3.1 Findings. During the underwater inspection of these moorings, 11-15 July 1981, UCT-1 divers logged approximately 28 hours in the water. The data these divers accumulated indicate that only one (F-1) of the ten moorings meets the safety and design criteria for "E" and "F" class moorings. The condition of the remaining moorings were found to be unsatisfactory for fleet use. None of the ten moorings are equipped with cathodic protection; none of the buoys have guard rails; all buoy rubbing plates and hatches are fiberglass

*NAVFAC Design Manual 26, "Harbor and Coastal Facilities", July 1968.

coated (precluding ready access for maintenance); and four of the ten moorings (E-1/F-1/F-2/F-6) do not have swivels in the risers. Table 1 depicts the current status of the Bermuda fleet moorings. Specific data and detailed sketches of the findings observed during this inspection are contained in Appendix A.

3.2 Proposed Corrective Action. Due to the poor condition of the Bermuda moorings and the lack of as-builts and complete maintenance records, it is recommended that all ten moorings be removed and thoroughly inspected. Salvageable and reusable material should be sandblasted to bare metal and recoated, and worn and deteriorated components surveyed. The estimated costs (in FY 81 dollars) for new procurement and installation of both "E" and "F" class moorings are contained in Appendix B.

4.0 MOORING INSPECTION COMMENTS/RECOMMENDATIONS

As a result of the analysis of the data gathered during the inspection, the following comments/recommendations are pertinent:

General

- In view of the small number of harbor craft that regularly use these moorings, the requirement for maintaining ten fleet moorings should be reviewed. Those in unsatisfactory maintenance condition should be removed without replacement.
- The positions of the moorings are uncertain. It is recommended that they be re-surveyed and the charts corrected.

Table 1. Bermuda Fleet Mooring Status

Mooring Number	Current Status			Deficiencies
	SAT	UNSAT	UNK	
E-1		X		Legs entwined, unsatisfactory ground ring; one anchor facing wrong direction; no swivel in riser
E-2		X		Unsatisfactory riser chain, ground ring and legs buried - condition unknown
E-3		X		Unsatisfactory riser chain and buoy bottom jewelry; ground legs too short; buoy numbered "E-5"
E-4			X	Ground ring and legs buried - condition unknown
E-5		X		Unsatisfactory riser chain; one leg not attached to ground ring; two lengths of chain pass through ground ring; ground legs too short
F-1	X			No swivel in riser chain
F-2		X		One ground leg missing; no swivel in riser; two attached legs buried - condition unknown
F-3			X	Buoy has 8-10° list; buoy bottom jewelry non standard; legs buried - condition unknown
F-4			X	Buoy bottom jewelry non standard; ground legs buried - condition unknown
F-6		X		Ground legs in unsatisfactory condition; no swivel in riser; riser too short

- There is no cathodic protection on any of the ten Bermuda fleet moorings. The continuity cable observed was badly deteriorated and broken in numerous places. The 5/8-inch wire continuity cable utilized has a fiber rope core. A plastic core type wire rope is recommended for use as a continuity cable.
- Accurate as-built documentation of each mooring to be reinstalled should be prepared and maintained.
- All fleet moorings should be scheduled for continuing periodic underwater inspections. Preventative maintenance should be performed as soon as possible after the results of these inspections are known. Overhauled or new NAS Bermuda moorings should be inspected by divers immediately after installation to verify that anchors are properly set, orientation of the ground legs is as designed, and that the cathodic protection system is intact.

Buoy

- Buoy bottom jewelry above the riser chain in several moorings do not comply with sound chain joining practices.
- Rubbing railing (fender assembly) should be installed on buoy tops to protect buoy and fiberglass coating from damage due to chain movement.

Riser

- Only one of the ten moorings inspected conditionally meets design criteria and appears safe for usage by fleet units within rated load constraints. However, a swivel should be inserted in its riser chain as soon as possible. The inclusion of at least one swivel in the riser of a free-swinging mooring is standard practice (DM-26).
- The design length of the combined buoy bottom jewelry and riser chain should approximate the depth of the water from high tide to the bottom less ten feet (DM-26). Excess length of the riser results in piling of chain on the bottom or the burying of the ground ring and lower end of the riser. Shortness of the riser causes the ground ring to ride high above the sea floor and results in the buoy supporting additional ground leg weight in the water column.

APPENDIX A
MOORING INSPECTION REPORTS AND SCHEMATICS

The following sections contains the inspection data and a schematic drawing of each of the ten Bermuda fleet moorings inspected. The data outlined in each Appendix are a summary of the information obtained by the UCT-1 divers and on-site CHESNAVFACENGCOM support personnel.

1.0 MOORING E-1 INSPECTION RESULTS.

1.1 Findings. All components of this mooring installation were visible to UCT-1 divers. The buoy was found to be in satisfactory condition, and measurements of the wire diameter at three locations along the riser chain proved to be better than 90% of the specified 1 3/4" size (DM-26). The only shortfall in the riser assembly was the lack of a swivel.

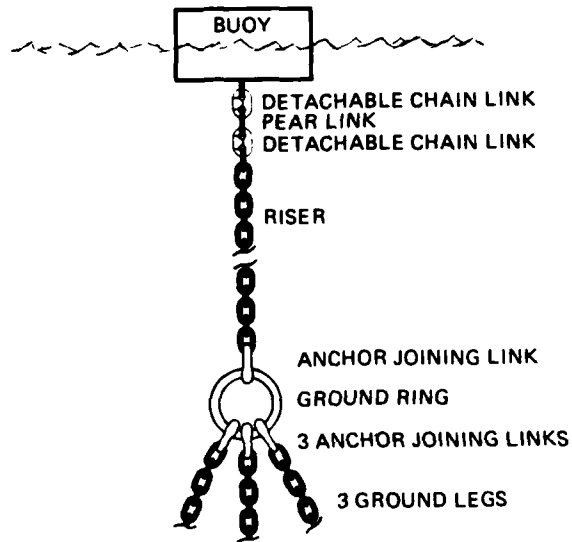
The ground ring was located on the bottom (water depth 36') and was determined to be of substandard size (14" outer diameter and 2 3/4" wire diameter). The break load of a ground ring of this size does not meet DM-26 specifications and, therefore, this ring is unsatisfactory for use in a Class E mooring. Each of the three legs consisted of approximately four shots (360') of chain between the ground ring and anchor, and the sampled wire diameters of each of these legs were satisfactory (> 90%).

Although the material condition of the ground legs appear to be satisfactory (> 90%), all three legs were intertwined for the first 60 feet from the ground ring, and below this point, all three legs were within a 190° sector of the bottom (see Plan View, page A-1-2). Three 3' x 4' x 5' unattached concrete clumps were located on the bottom between legs B and C, and the anchor for leg B was observed to be backwards (the fluke pointing away from the buoy). Assuming the mooring was correctly installed, it is probable that it was moved under load and apparently dragged legs A and C across leg B.

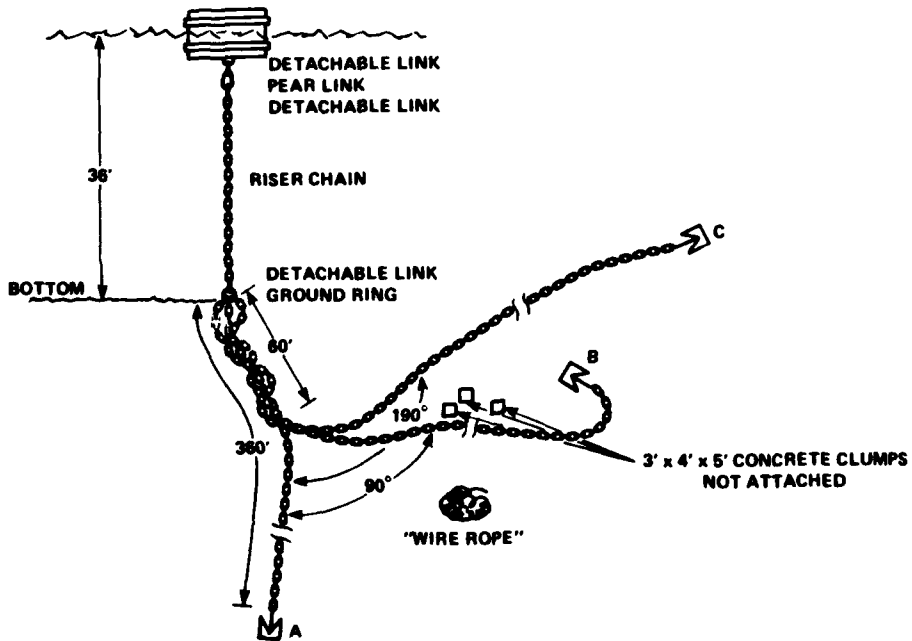
1.2 Conclusion/Recommendation. This mooring is not safe to use and is, therefore, unsatisfactory for fleet utilization. Recommend that the mooring be recovered, inspected, and overhauled as required.

E-1

SCHEMATIC
(NOT TO SCALE)



GROUND LEGS
PLAN VIEW



NOTE: ONE SWIVEL ON EACH OF LEGS A AND B FIVE FEET BELOW THE GROUND RING

TWISTED LEGS DUE TO NO SWIVEL IN RISER AND/OR DRAGGING.
LEGS NEED TO BE RE-POSITIONED. GROUND RING UNDERSIZED.

MOORING INSPECTION REPORT

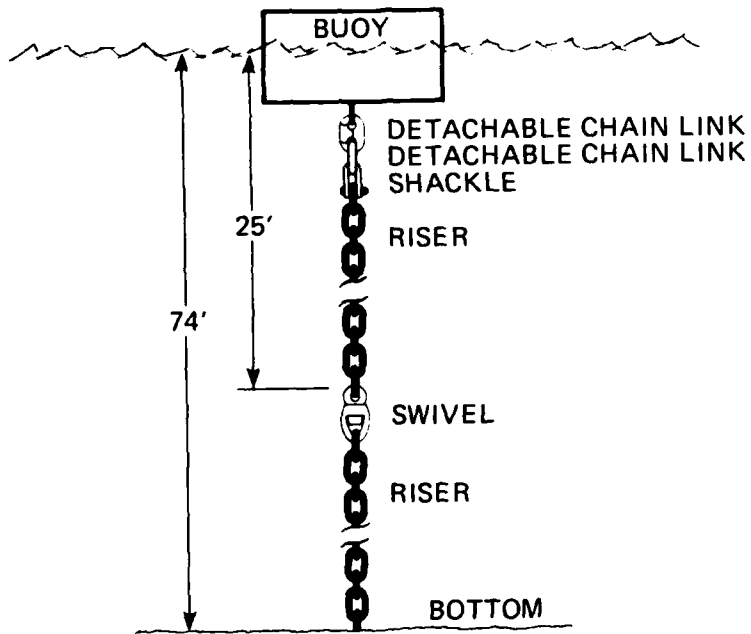
1. FACILITY NAS BERMUDA ANNEX		2. MOORING NO. E-1	3. TYPE/CLASS MOORING Riser/E	4. LAT: LON: PORT ROYAL BAY	
5. INSPECTION	DATE 11 July 81 14 July 81	DIVERS Osborn/Calvert Hubler/Woodruff		WATER DEPTH 36'	SUPERVISOR C.A. Hubler (CHESDIV)
ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6"x5"	-	✓		Cylindrical Riser type with tension bar
Coating	-	-	✓		Fiberglass; medium fouling
Deck Plate	-	-	✓		Fiberglass covered steel
Fenders	-	-	✓		Rubber
Riser Chain	1 3/4"	Below buoy	✓		> 90% (double link)
	1 3/4"	Middle	✓		> 90% (double link) } approximately 30 ft. length
	1 3/4"	Above G.R.	✓		> 90% (double link)
Ground Ring	2 3/4"	-		✓	ID - 11 1/4" (sub standard); on bottom
Ground Leg A Chain	1 3/4"	Below G.R.	✓		> 90% (single link) } forged 360 ft.
	1 3/4"	Toward Anchor	✓		> 90% (single link)
Ground Leg B Chain	1 3/4"	Below G.R.	✓		> 90% (single link) } forged 360 ft.
	1 3/4"	Toward Anchor	✓		> 90% (single link)
(Continued on next page)					

1.0 MOORING E-2 INSPECTION RESULTS.

1.1 Findings. This mooring is located in 72 feet of water, and only the buoy and riser chain were visible to the divers. The ground ring, ground legs, and anchors were all buried in the silt/mud bottom, and their material condition and the orientation of the three legs could not be determined. Although the buoy was in satisfactory condition, the riser chain was in unsatisfactory condition. Single link measurements near the tidal wear point revealed that some links were worn down to 7/8 of an inch, 50% of their initially designed wire diameter (1 3/4"). Although the orientation of the legs and anchors could not be determined, PWD personnel advised that this mooring may have been dragged off location by a ship.

1.2 Conclusion/Recommendation. Due to the unsatisfactory wire diameter of some links in the riser, this mooring is unsafe for fleet use. Recommend that the mooring be completely overhauled.

E-2
SCHEMATIC
(NOT TO SCALE)



RISER WORN TO 7/8" (50% REQUIRED DIAMETER)

RECORDS INDICATE MOORING HAS BEEN DRAGGED FROM ORIGINAL LOCATION AND THAT ANCHORS ARE PROBABLY CLUMPED TOGETHER.

MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA ANNEX	2. MOORING NO. E-2	3. TYPE/CLASS MOORING Riser/E	4. LAT: LON: PORT ROYAL BAY
5. INSPECTION	DATE 11 July 81	DIVERS Deems/Watson	WATER DEPTH 74'
SUPERVISOR C.A. Hubler (CHESDIV)			INITIALS

ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	JNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6" x 5'		✓		Cylindrical Riser type with tension bar
Coating	-	-	✓		Fiberglass, medium fouling
Deck Plate	-	-	✓		Fiberglass covered
Fenders	-	-	✓		Rubber
Riser Chain	1 3/4"	-		✓	Single link measurement 7/8" about 50% of original wire diameter
Ground Ring	-	-			Buried
Ground Legs	-	-			Buried
SUMMARY: Unsatisfactory condition due to worn/deteriorated riser chain. Condition of ground ring, ground legs unknown.					

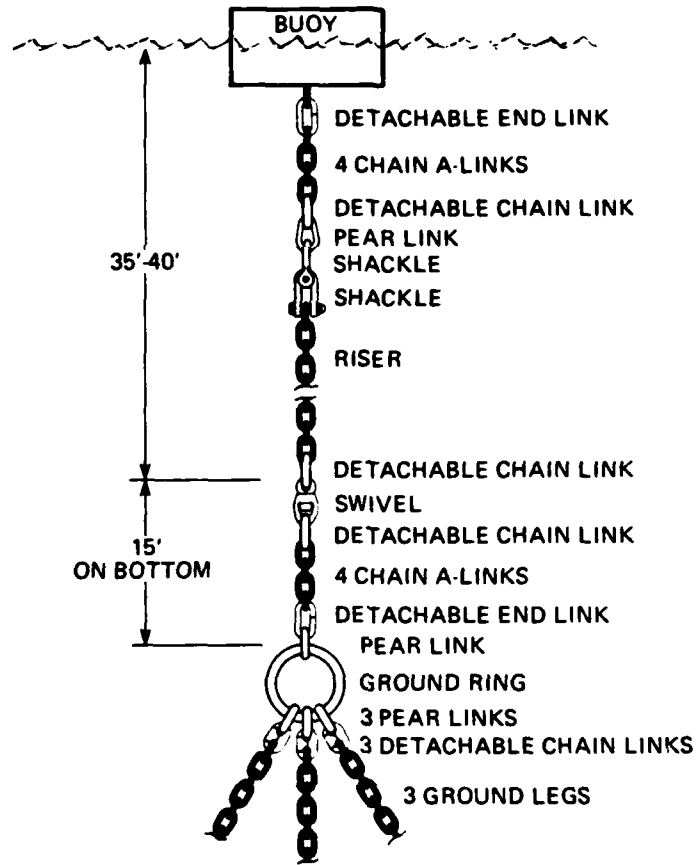
1.0 MOORING E-3 INSPECTION RESULTS

1.1 Findings. This mooring is in 40 feet of water. The buoy is in satisfactory condition except for being numbered "E-5". The riser is in unsatisfactory condition and badly worn with the wire diameter of some links measuring $\frac{3}{4}$ of an inch, about 43% of their original $1 \frac{3}{4}$ inch diameter. Approximately 15-20 feet of riser chain rests on the bottom with an oversized ($5 \frac{1}{16}$ " wire diameter) ground ring. Between 90' and 120' of the ground legs were visible before they disappeared into the bottom near their anchors, which were visible to the divers. The orientation of these relatively short legs is shown on page A-III-2. The wire diameter of each of the legs was measured to be greater than 90% of its designed diameter of $1 \frac{3}{4}$ inches.

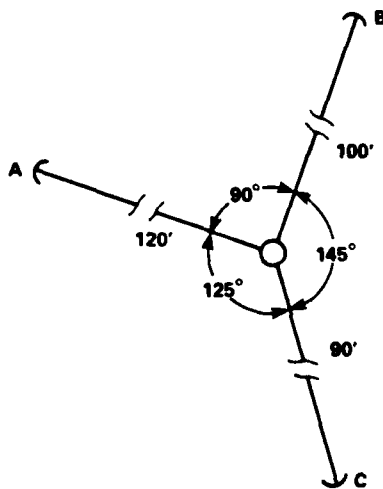
The hardware used to attach the buoy to the riser chain is unsatisfactory. A detachable end link is connected to the buoy and four links of chain which are followed by a detachable chain link, a pear link and two back-to-back shackles, the second of which is connected to the riser chain.

1.2 Conclusion/Recommendation. This mooring is unsafe for fleet use and is recommended for complete overhaul.

E-3
 SCHEMATIC
 (NOT TO SCALE)



LEG ORIENTATION



RISER WORN TO 3/4" OR 43% ORIG DIAM, 1 1/4" CHAIN WHEN NEW

MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA ANNEX	2. MOORING NO. E-3	3. TYPE/CLASS MOORING Riser/E	4. LAT: LON: PORT ROYAL BAY
5. INSPECTION	DATE 11 July 81 14 July 81	DIVERS Johnston/Reynolds Oliver/Woodruff	WATER DEPTH 40'
		SUPERVISOR C.A. Hubler (CHESDIV)	INITIALS

ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"	-	✓		
Shackle	2"	-	✓		
Buoy	9'6"x5'		✓		Cylindrical Riser type with tension bar. Numbered "E-5"
Coating	-	-	✓		Fiberglass, medium fouling
Deck Plate	-	-	✓		Fiberglass covered
Fenders	-	-	✓		Rubber
Buoy Bottom Hardware	-	-		✓	Non-standard material
Riser Chain	1 3/4"	-		✓	Single link measurement 3/4", about 43% of original wire diameter
Ground Ring	5 1/16"	-	✓		Oversized
Ground Leg A Chain	1 3/4"	Below G.R.	✓		> 90% (single link) } forged; 120 ft.
	1 3/4"	Towards Anchor	✓		> 90% (single link)
Ground B Chain	1 3/4"	Below G.R.	✓		> 90% (single link) } forged; 100 ft.
	1 3/4"	Towards Anchor	✓		> 90% (single link)
(Continued on next page)					

1.0 MOORING E-4 INSPECTION RESULTS

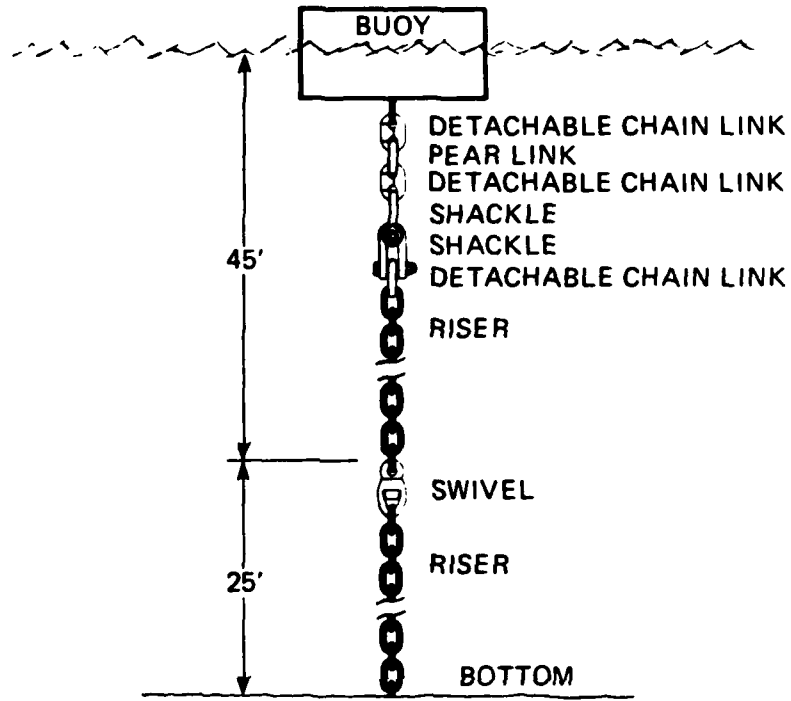
1.1 Findings. This mooring was originally installed as a Class C mooring and subsequently downgraded twice to a Class E. The buoy's condition is satisfactory, but the connecting jewelry between the buoy and the riser chain is unsatisfactory. Below the buoy, there exists a detachable chain link, a pear link, a detachable chain link, two back-to-back shackles, and a third detachable chain link attached to the riser.

The riser chain wire diameter is greater than 90% of the original oversized 2 1/4 inch diameter chain installed. The riser chain enters the bottom at 70 feet of water depth, and the ground ring, ground legs, and anchors are buried. An attempt was made to raise the ground ring and expose a portion of the ground legs using two one-ton lift bags, but this attempt failed. The condition and orientation of the ground legs were not observed.

1.2 Conclusion/Recommendation. Although the exposed portion of the riser chain shows little sign of corrosion or wear, the condition of the buried portion of the mooring is unknown. This mooring should be removed, inspected, and overhauled as required. Until this is accomplished, the degree of safety available to fleet units utilizing this mooring is uncertain.

E-4

SCHEMATIC
(NOT TO SCALE)



CONDITION OF BURIED RING AND LEGS UNKNOWN. LIFT BAGS COULD NOT LIFT
GROUND RING AND LEGS FROM MUD BOTTOM.

MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA ANNEX	2. MOORING NO. E-4	3. TYPE/CLASS MOORING Riser/E	4. LAT: LON: PORT ROYAL BAY
5. INSPECTION	DATE 14 July 81	DIVERS Johnston/Reynolds Deems/Watson	WATER DEPTH 70'
SUPERVISOR C.A. Hubler (CHESDIV)			INITIALS

ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6"x5'	-	✓		Cylindrical Riser type with tension bar
Coating	-	-	✓		Fiberglass, medium fouling
Deck Plate	-	-	✓		Fiberglass covered
Fenders	-	-	✓		Rubber
Buoy Bottom Hardware	-	-		✓	Non-standard material
Riser Chain	2 1/4"	Below Buoy	✓		> 90% (double link)
	2 1/4"	Middle	✓		> 90% (double link) } oversized, requires only 1 3/4"
	2 1/4"	Above mudline	✓		> 90% (double link)
Ground Ring	-	-			Buried
Ground Legs	-	-			Buried
SUMMARY:					
Mooring condition unknown. Ground ring and ground legs buried in mud.					

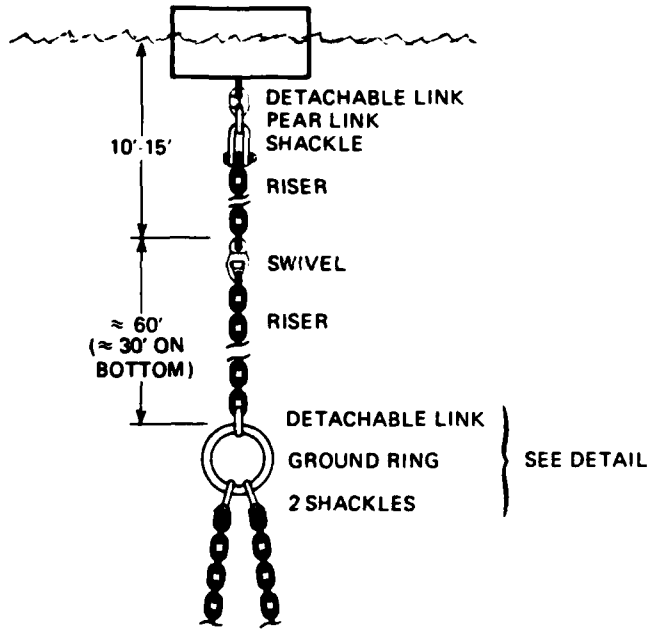
1.0 MOORING E-5 INSPECTION RESULTS

1.1 Findings. This mooring is installed in 35 feet of water depth. The condition of the buoy is satisfactory, but the riser chain is excessively worn with wire diameter sizes as small as 7/8 of an inch, about 50% of the original wire diameter (1 3/4"). The riser is also too long. Approximately 30' of riser chain is stretched out on the bottom leading to the ground ring. The ground ring was on the bottom and was determined to be in satisfactory condition. However, shackles connect only two ground legs to it, and two lengths of chain run through the ground ring (see sketch on page A-18). These two lengths of chain and the two identified ground legs lead to a nearby mound of entwined chain atop and alongside a large concrete clump. From this entwined chain, three legs were observed to run out approximately 100 feet each to their anchors. The bitter end of the leg not connected to the ground ring was not observed nor was it determined whether the concrete clump was attached to one or more of the ground legs. The reason for the chain lengths passing through the ground ring is unknown. In addition, the wire diameters of all three ground legs are less than 90% of original diameter.

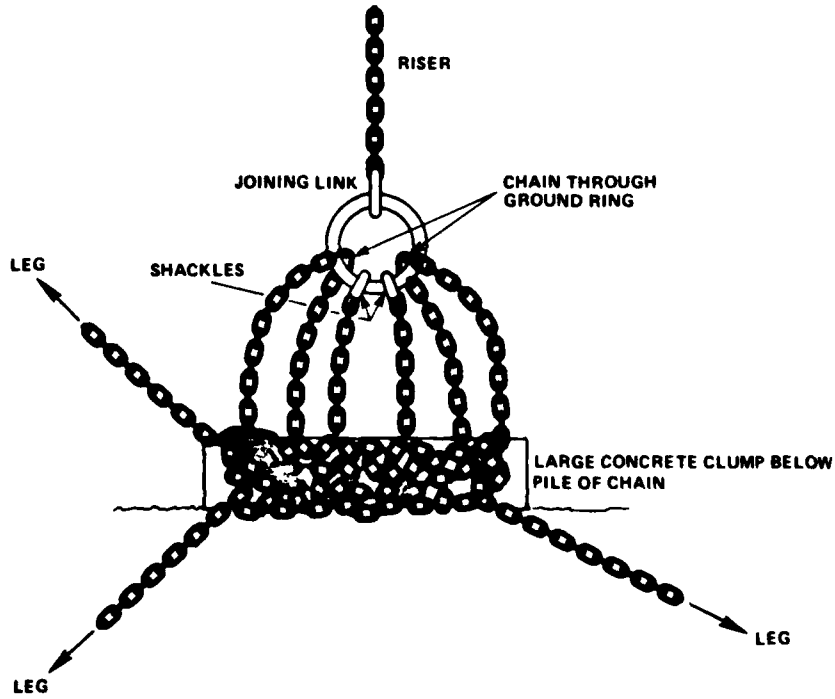
1.2 Conclusion/Recommendation. This mooring is unsafe for use and is recommended for overhaul.

E-5

CONNECTION OF BUOY
AND GROUND ASSEMBLY
(NOT TO SCALE)



GROUND RING CONNECTIONS



MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA ANNEX	2. MOORING NO. E-5	3. TYPE/CLASS MOORING Riser/E	4. LAT: LON: PORT ROYAL BAY
5. INSPECTION	DATE 11 July 81 14 July 81	DIVERS Deem/Watson Johnston/Reynolds	WATER DEPTH 35'
		SUPERVISOR C.A. Hubler (CHESDIV)	INITIALS

ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6"x5'		✓		Cylindrical Riser type with tension bar
Coating			✓		Fiberglass; medium fouling
Deck Plate			✓		Fiberglass coated
Fenders			✓		Rubber
Riser Chain	1 3/4"			✓	Single link measurement 7/8" about 50% original wire diameter
Ground Ring	3 1/4"		✓		On bottom
Ground Leg A Chain	1 3/4"	Below G.R.		✓	} approx. 100'
Ground Leg B Chain	1 3/4"	Towards Anchor		✓	} approx. 100'
Ground Leg C Chain	1 3/4"	Below G.R.		✓	Missing
(Continued on next page)	1 3/4"	Towards Anchor		✓	> 90% (double link) approx. 100'

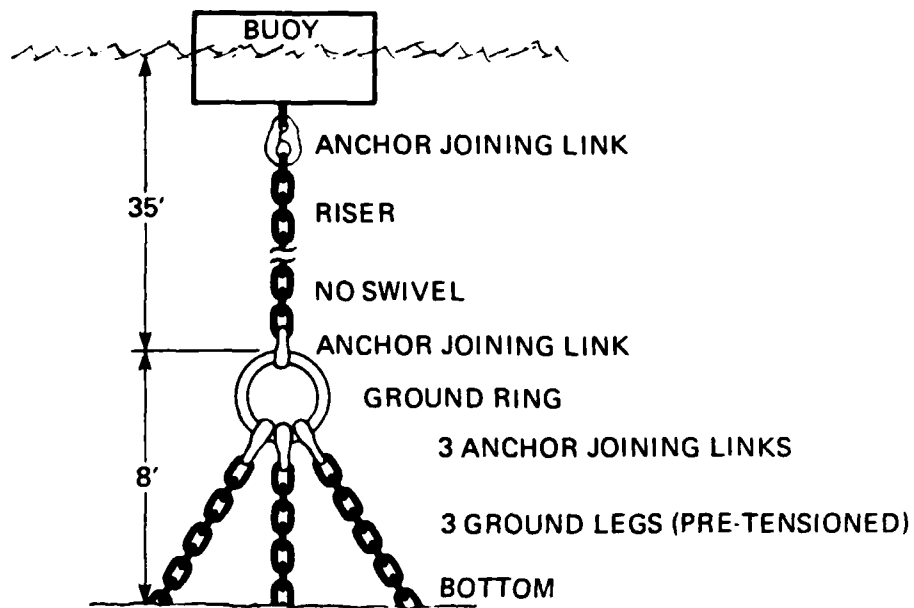
1.0 MOORING F-1 INSPECTION RESULTS

1.1 Findings. Although DM-26 requires only 1 1/4 inch chain for a Class F mooring, the riser and legs of this mooring consist of 1 3/4 inch chain. The condition of the buoy and riser is satisfactory and the ground ring is about 8-10 feet above the bottom. The ground ring was fabricated locally and is of non-standard size (8" inner diameter). Although smaller than the design requirements of DM-26, records indicate that this ring was pull tested to 50K pounds prior to installation and is, therefore, considered satisfactory for an "F" class mooring. This ground ring is made of tempered steel, and (although none was observed during this inspection) corrosion should be anticipated due to the differences in the relative galvanic potential of steels of different compositions. The condition of the 20-35 feet of pre-tensioned ground legs exposed appears to be satisfactory as is the leg orientation. The only deficiency noted was the lack of a swivel in the riser chain.

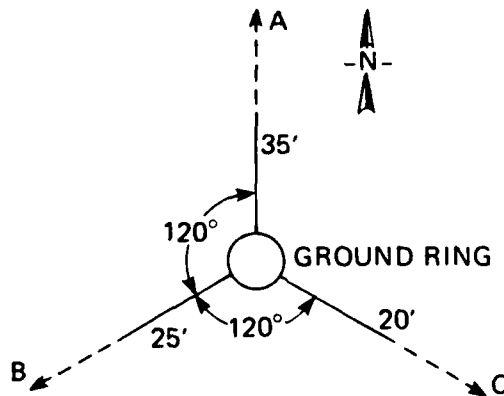
1.2 Conclusion/Recommendation. This mooring conditionally meets the required criteria for a Class F mooring, but a swivel should be inserted in the riser chain.

F-1

SCHEMATIC (NOT TO SCALE)



LEG ORIENTATION



NOTE: SWIVEL IN LEG B, 12'
OUT FROM GROUND
RING

SATISFACTORY BUT NEED SWIVEL IN RISER WHEN OVERHAULED

MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA	2. MOORING NO. F-1	3. TYPE/CLASS MOORING Riser/F	4. LAT: LON: ST. GEORGE'S HARBOR
5. INSPECTION	DATE 11 July 81 15 July 81	DIVERS Reynolds/Osborn Hubler/Woodruff	WATER DEPTH 45'
		SUPERVISOR C.A. Hubler (CHESDIV)	INITIALS

ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6"x5		✓		Cylindrical Riser type with tension bar
Coating	-		✓		Fiberglass; medium fouling
Deck Plate	-		✓		Fiberglass covered
Fenders	-		✓		Rubber
Riser Chain	1 3/4"	Below Buoy	✓		> 90% (double link) approx. 35' length, over sized chain
	1 3/4"	Middle	✓		req. only 1 1/4"
	1 3/4"	Above G.R.	✓		> 90% (double link) for class F; no riser
Ground Ring	2 1/2"		✓		8-10" off bottom; non standard size (8" ID-tempered steel)
Ground Leg A Chain	1 3/4"	Below G.R.	✓		> 90% (single link) 25' exposed oversized chain
	1 3/4"	Towards Anchor	✓		> 90% (single link)
Ground Leg B Chain	1 3/4"	Below G.R.	✓		> 90% (single link) 20' exposed oversized chain
	1 3/4"	Toward Anchor	✓		> 90% (single link)
(Continued on next page)					

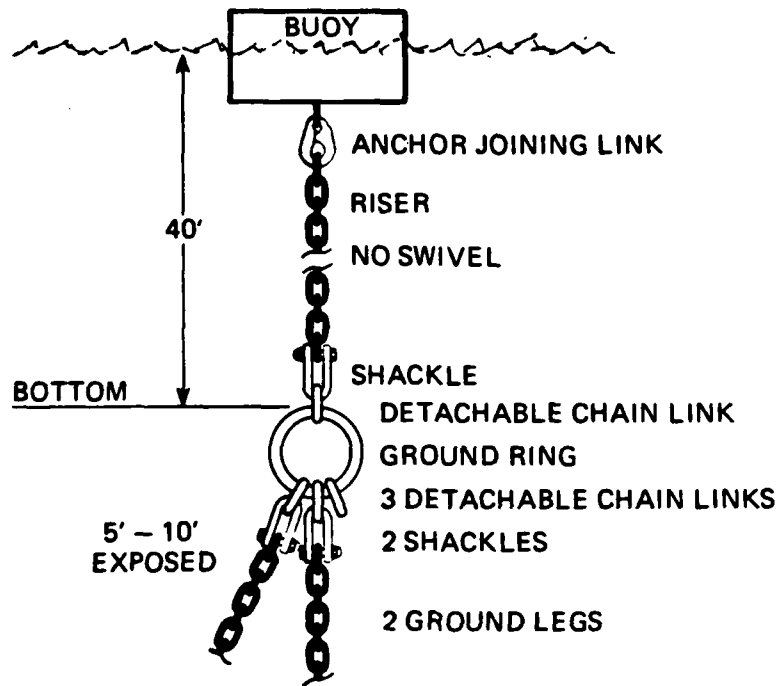
1.0 MOORING F-2 INSPECTION RESULTS

1.1 Findings. This mooring is installed in 40 feet of water. The condition of the buoy is satisfactory, but the riser chain shows signs of wear and corrosion. The wire diameter of the riser is less than 90% of its original diameter (1 3/4"), but since a Class F mooring only requires 1 1/4 inch chain, the condition of the riser is satisfactory. No swivel exists within the riser chain.

The ground ring is on the bottom attached to two ground legs by shackles. The third ground leg was not located and assumed to be buried in the bottom. Although the wire diameters of the two observed 1 1/4 inch ground legs were satisfactory, only 5-10 feet of these legs were exposed prior to entering the bottom. The length and orientation of these legs are unknown.

1.2 Conclusion/Recommendation. This mooring is unsatisfactory for fleet use and is recommended for overhaul.

F-2
SCHEMATIC (NOT TO SCALE)



MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA	2. MOORING NO. F-2	3. TYPE/CLASS MOORING Riser/F	4. LAT: LON: ST. GEORGE'S HARBOR
5. INSPECTION	DATE 12 July 81 15 July 81	DIVERS Deems/McClairy Hubler/Woodruff	WATER DEPTH 40'
		SUPERVISOR C.A. Hubler (CHESDIV)	INITIALS

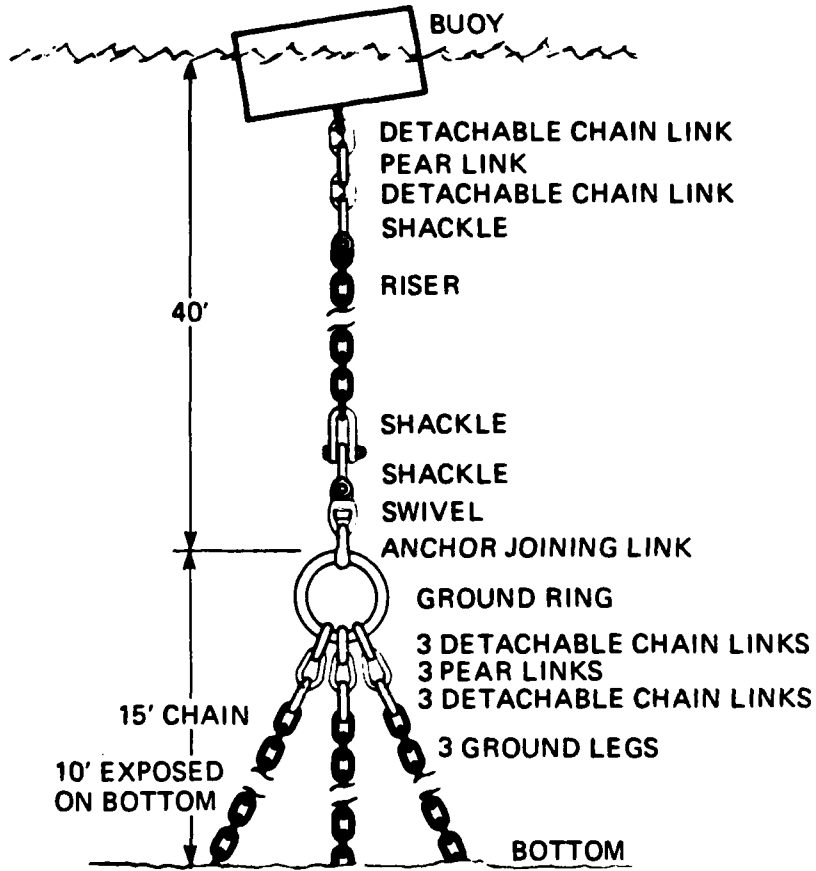
ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6"x5'		✓		Cylindrical Riser type with tension bar
Coating	-		✓		Fiberglass; medium fouling
Deck Plate	-		✓		Fiberglass covered
Fenders	-		✓		Rubber
Riser Chain	1 3/4"	Below Buoy	✓		> 80% (double link) approx. 35' length; over-
	1 3/4"	Middle	✓		> 80% (double link) sized chain (only requires
	1 3/4"	Above G.R.	✓		> 80% (double link) 1 1/4"; no swivel
Ground Ring	2 5/8"				On bottom
Ground Leg A Chain	1 1/4"	Below G.R.	✓		> 90% (single link) } 5-10' exposed
	1 1/4"	Toward Anchor	✓		> 90% (single link)
Ground Leg B Chain	1 1/4"	Below G.R.	✓		> 90% (single link) } 5-10' exposed
	1 1/4"	Toward Anchor	✓		> 90% (single link)
(Continued on next page)					

1.0 MOORING F-3 INSPECTION RESULTS

1.1 Findings. This mooring is in 45 feet of water and was initially installed using 1 1/2 inch chain in the riser and its three legs. Although the exterior condition of the buoy appears satisfactory, its internal integrity is questionable since the buoy has an 8-10 degree trim angle. The condition of the bottom jewelry is non standard, but the condition of the riser appears to be satisfactory. The ground ring is about five feet above the bottom, and about 10-15 feet of each of the three ground legs attached to it are piled on the sea floor beneath it. The wire diameter of each of the three legs measure less than 90%, but greater than 80%, of its original 1 1/2 inch diameter. The remainder of each of the legs are buried and their lengths and orientation are unknown.

1.2 Conclusion/Recommendation. From a safety standpoint, the use of this mooring by fleet units is questionable. The mooring should be removed, the buoy should be thoroughly inspected in order to determine the cause of its list, and the condition of the ground legs should be determined. The mooring should be overhauled as required prior to reinstallation.

F-3
SCHEMATIC (NOT TO SCALE)



8° TO 10° TRIM ANGLE ON BUOY
CONDITION OF BURIED LEGS UNKNOWN

MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA	2. MOORING NO. F-3	3. TYPE/CLASS MOORING Riser/F	4. LAT: LON: ST. GEORGE'S HARBOR
5. INSPECTION	DATE 12 July 81 15 July 81	DRIVERS Deems/McClairy Johnston/McClairy	WATER DEPTH 45'
		SUPERVISOR C.A. Hubler (CHESDI)	INITIALS

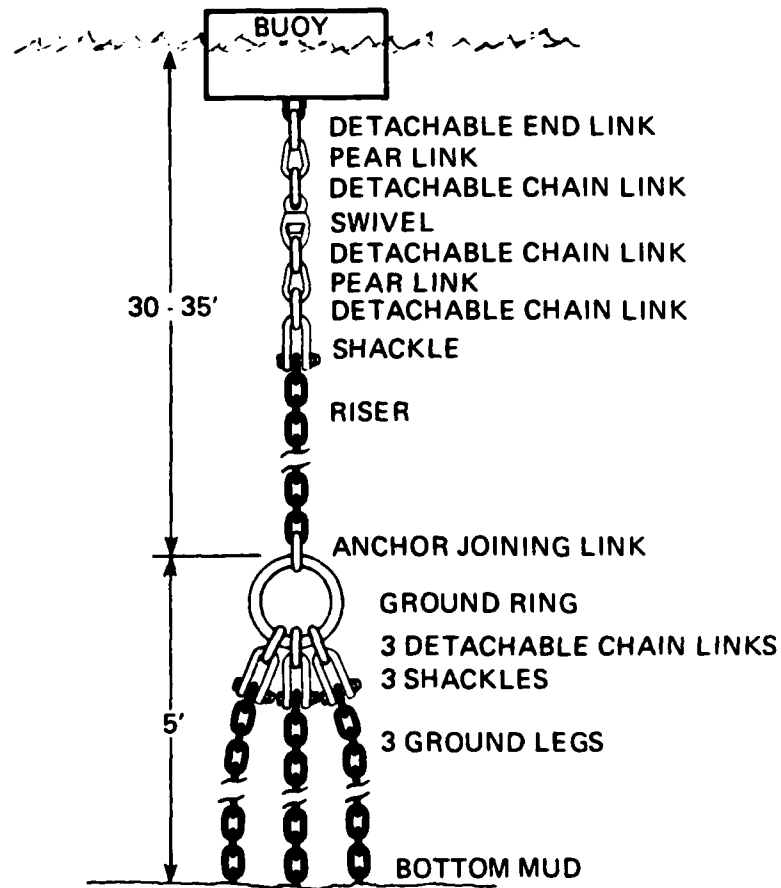
ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6"x5'			✓	Cylindrical Riser type with tension bar; 8-10° list
Coating	-		✓		Fiberglass; medium fouling
Deck Plate	-		✓		Fiberglass covered
Fenders	-		✓		Rubber
Buoy (Bottom Hardware)	-			✓	Non standard jewelry
Riser Chain	1 1/2"	Below Buoy	✓		> 90% (double link)
	1 1/2"	Middle	✓		> 90% (double link) } 35' length; oversized chain
	1 1/2"	Above G.R.	✓		> 90% (double link)
Ground Ring	2 3/4"		✓		5' above bottom
Ground Leg A Chain	1 1/2"	Below G.R.	✓		> 80% (single link) } oversized chain forged; 5-10' exposed
	1 1/2"	Toward Anchor	✓		> 90% (single link)
Ground Leg B Chain	1 1/2"	Below G.R.	✓		> 80% (single link) } oversized chain forged; 5-10' exposed
	1 1/2"	Toward Anchor	✓		> 90% (single link)
(Continued on next page)					

1.0 MOORING F-4 INSPECTION RESULTS

1.1 Findings. A water depth of 40 feet exists at the mooring site. The buoy's condition is satisfactory, but its bottom jewelry is non standard, consisting of two end links, a swivel, three detachable links and a shackle. The wire diameter of the riser chain is greater than 90% of its original 1 3/4 inch diameter. The ground ring is suspended by the riser about five feet above the sea floor. The three ground legs attached to the ground ring drop parallel into the bottom. The wire diameters of the few feet of each 1 1/2" diameter ground leg observed satisfactorily met the over 90% criteria, but the lengths and orientation of these legs, and the positions of their anchors are unknown.

1.2 Conclusion/Recommendation. This mooring should be used with caution due to the uncertainty concerning the positions and conditions of its ground legs. Recommend that this mooring be recovered, inspected, and overhauled as required.

F-4
SCHEMATIC
(NOT TO SCALE)



LEG ORIENTATION AND CONDITION BELOW BOTTOM UNKNOWN

MOORING INSPECTION REPORT

1. FACILITY NAS BERMUDA	2. MOORING NO. F-4	3. TYPE/CLASS MOORING Riser/F	4. LAT: LON: ST. GEORGE'S HARBOR
5. INSPECTION	DATE 12 July 81 15 July 81	DIVERS Watson/Oliver Hubler/Woodruff	WATER DEPTH 40'
		SUPERVISOR C.A. Hubler (CHESDIV)	INITIALS

ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6"x5"		✓		Cylindrical Riser type with tension bar
Coating	—		✓		Fiberglass; medium fouling
Deck Plate	—		✓		Fiberglass coated
Fenders	—		✓		Rubber
Buoy Bottom Hardware	—			✓	Non standard jewelry
Riser Chain	1 3/4"	Below Buoy	✓		> 90% (double link)
	1 3/4"	Middle	✓		> 90% (double link) } about 30'; oversized chain (only 1 1/4" required)
	1 3/4"	Above G.R.	✓		> 90% (double link)
Ground Ring	2 3/4"		✓		5' off bottom
Ground Leg A Chain	1 1/2"	Below G.R.	✓		> 90% (single link) } 5-10' exposed; oversized chain
	1 1/2"	Toward Anchor	✓		> 90% (single link)
Ground Leg B Chain	1 1/2"	Below G.R.	✓		> 90% (single link) } 5-10' exposed; oversized chain
	1 1/2"	Toward Anchor	✓		> 90% (single link)
(Continued on next page)					

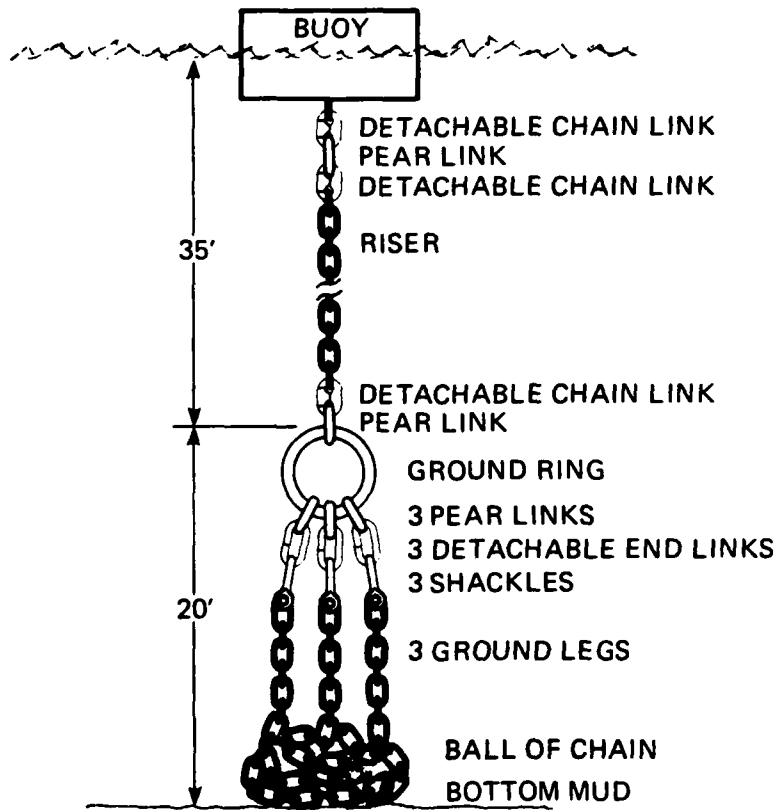
1. MOORING F-6 INSPECTION RESULTS

1.1 Findings. As with most other moorings, the condition of this buoy is satisfactory. The riser chain wire diameter meets acceptable standards, but the riser does not contain a swivel. In addition, the riser is too short. The water depth at the site is 55 feet. The ground ring is approximately 20 feet above the bottom. The three ground legs attached to the ground ring drop parallel to the bottom where a pile of intertwined chain exists. The three chain legs apparently enter the mud bottom from under this pile of chain.

The twenty plus feet of each ground leg exposed below the ground ring are heavily corroded and pitted. Two of the three ground legs failed the 80% wire diameter measurement test.

1.2 Conclusion/Recommendation. This mooring is unsatisfactory for fleet use and is recommended for complete overhaul.

F-6
SCHEMATIC
(NOT TO SCALE)



NOTE: 5' OF EACH LEG IN BALL AT FLOOR

GROUND LEGS WORN TO BELOW 80% OF REQUIRED 1 1/4" WIRE DIAMETER
AREA LESS THAN 65% OF THAT REQUIRED

MOORING INSPECTION REPORT

1. FACILITY AS BERMUDA	2. MOORING NO. F-6	3. TYPE/CLASS MOORING Riser/F	4. LAT: LON: ST. GEORGE'S HARBOR
5. INSPECTION	DATE 12 July 81 15 July 81	DIVERS Woodruff/Sutton Johnston/McClairy	WATER DEPTH 55'
SUPERVISOR C.A. Hubler (CHESDIV)			INITIALS

ITEM	SIZE	LOCATION OF MEASUREMENT	CONDITION		REMARKS
			SAT	UNSAT	
Buoy (Top Hardware)					
Pear Link	2"		✓		
Shackle	2"		✓		
Buoy	9'6" x 5'		✓		Cylindrical Riser type with tension bar
Coating	—		✓		Fiberglass; medium fouling
Deck Plate	—		✓		Fiberglass coated
Fenders	—		✓		Rubber
Riser Chain	1 1/2"	Below Buoy	✓		approx. 30' lengths; oversized chain; no swivel } } }
	1 1/2"	Middle	✓		
	1 1/2"	Above G.R.	✓		
Ground Ring	2 3/4"		✓		20' above bottom
Ground Leg A Chain	1 1/2"	Below G.R.	✓		20' exposed; oversized chain } } } heavy corrosion
	1 1/2"	Toward Anchor	✓		
Ground Leg B Chain	1 1/2"	Below G.R.	✓		20' exposed; oversized chain } } } heavy corrosion
	1 1/2"	Toward Anchor	✓	✓	
(Continued on next page)					

APPENDIX B
CLASS "E" AND "F" MOORINGS

1.0 ESTIMATED PROCUREMENT/INSTALLATIONS COST PER MOORING

1.1 Material Cost. This Appendix contains estimated costs, in FY 81 dollars, for the procurement of new material for both a Class E and a Class F mooring and for the installation of either type mooring by a local contractor. Since it was assumed that the buoys and anchors currently installed in the Bermuda fleet moorings are reusable, their procurement costs are not included. The unit costs identified in Tables B-1 and B-2 are based on recent quotes by CONUS based vendors and reflect the costs of the material required for each class of mooring, as depicted in Figures B-1 and B-2.

1.2 Installation Cost. With the exception of different wire diameters of component materials, the composition of each of these moorings are basically the same. Therefore, the cost of installing either class should be approximately equal at an estimated cost of \$13,713 (FY 81\$) per mooring. In addition, an estimated cost of \$9,000 (FY 81\$) per MOB/DEMOB is required separately for work required at the Air Station or the Annex. Therefore, the total cost estimate for recovery and installation of three moorings at one facility would be approximately \$50,000 (FY 81\$). This cost breakdown, based on Bermudian local rates is shown in Table B-3.

The above cost estimate is based on local labor rates and equipment rental cost data obtained from qualified Bermudian contractors and includes the cost

of an installation platform and crew, required cranes, riggers, divers, surveyors, and other required support personnel and equipment. This estimate also includes 25% contingency funds to cover additional installation costs that could accrue in the event of inclement weather, equipment malfunctions, or other unexpected occurrences.

Table B-1. Class "E" Mooring Parts List and Estimated Costs

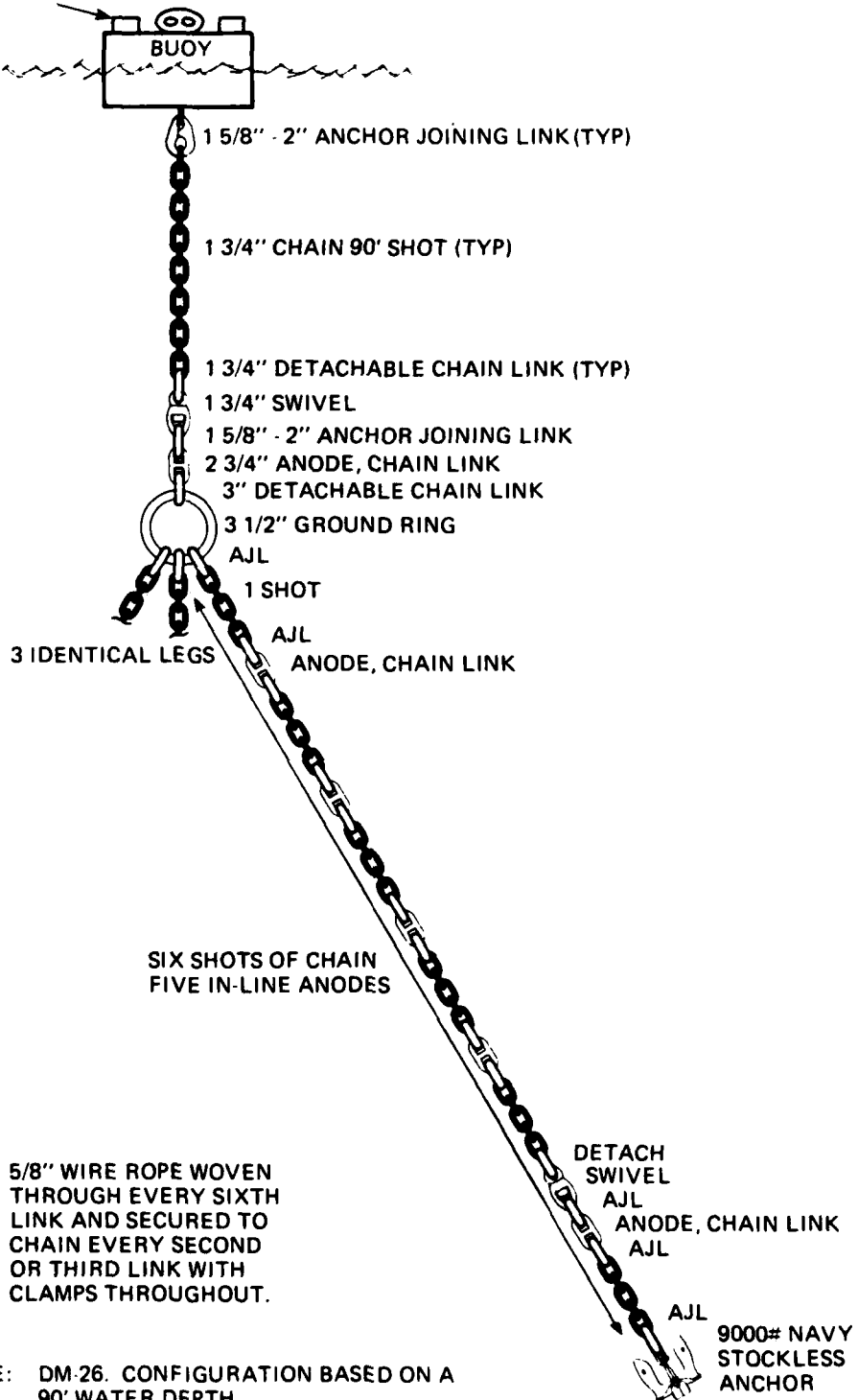
	Item	Size	Quantity			Cost (FY-81\$)	
			Req'd	Spares	Total	Unit	Total
Riser Assembly	Chain, 90' Shots	1 3/4"	1	-	1	3647	3647
	Link, Anchor Joining	1 5/8"-2"	2	1	3	289	867
	Link, Detachable Chain	1 3/4"	1	-	1	137	137
	Link, Detachable Chain	3"	1	-	1	525	525
	Swivel, Chain	1 3/4"	1	-	1	213	213
	Ring, Ground	3 1/2"	1	-	1	436	436
Subtotal							5825
Ground Leg Assembly	Chain, 90' Shots	1 3/4"	18	-	18	3647	65646
	Link, Anchor Joining	1 5/8"-2"	36	9	45	289	13005
	Link, Detachable Chain	1 3/4"	3	1	4	137	548
	Swivel, Chain	1 3/4"	3	1	4	213	852
Subtotal							80051
Cathodic Protection Assembly	Anode, Chain Link	2 3/4"	16	-	16	850	13600
	Wire Rope, Continuity	5/8"	2090'	190'	2280'	2/ft	4560
	Clips, Wire Rope	2 1/2"	590	60	650	1	650
Subtotal							18810
Total							104686

Table B-2. Class "F" Mooring Parts List and Estimated Costs

	Item	Size	Quantity			Cost (FY-81\$)	
			Req'd	Spares	Total	Unit	Total
Riser Assembly	Chain, 90' Shot	1 1/4"	1	-	1	2518	2518
	Link, Anchor joining	1 1/4-1 9/16"	2	1	3	224	672
	Link, Detachable Chain	1 1/4"	1	-	1	107	107
	Link, Detachable Chain	2 3/4"	1	-	1	283	283
	Swivel, Chain	1 1/4"	1	-	1	169	169
	Ring, Ground	2 3/4"	1	-	1	229	229
Subtotal							3978
Ground Leg Assembly	Chain, 90' Shot	1 1/4"	18	-	18	2518	45324
	Link, Anchor Joining	1 1/4-1 9/16"	36	9	45	224	10080
	Link, Detachable Chain	1 1/4"	3	1	4	107	428
	Swivel, Chain	1 1/4"	3	1	4	169	676
Subtotal							56508
Cathodic Protection Assembly	Anode, Chain Link (500 lb)	2 3/4"	16	-	16	850	13600
	Wire Rope, Continuity	5/8"	2090'	190'	2280'	2/ft	4560
	Clips, Wire Rope	2"	705	70	775	1	775
	Subtotal						
Total							79421

**SCHEMATIC
(NOT TO SCALE)**

RUBBING RAILING
(FENDER ASSEMBLY)



NOTE: 5/8" WIRE ROPE WOVEN THROUGH EVERY SIXTH LINK AND SECURED TO CHAIN EVERY SECOND OR THIRD LINK WITH CLAMPS THROUGHOUT.

SOURCE: DM-26. CONFIGURATION BASED ON A 90' WATER DEPTH.

Figure B-1. Class "E" Mooring With in-line Link Anodes

**SCHEMATIC
(NOT TO SCALE)**

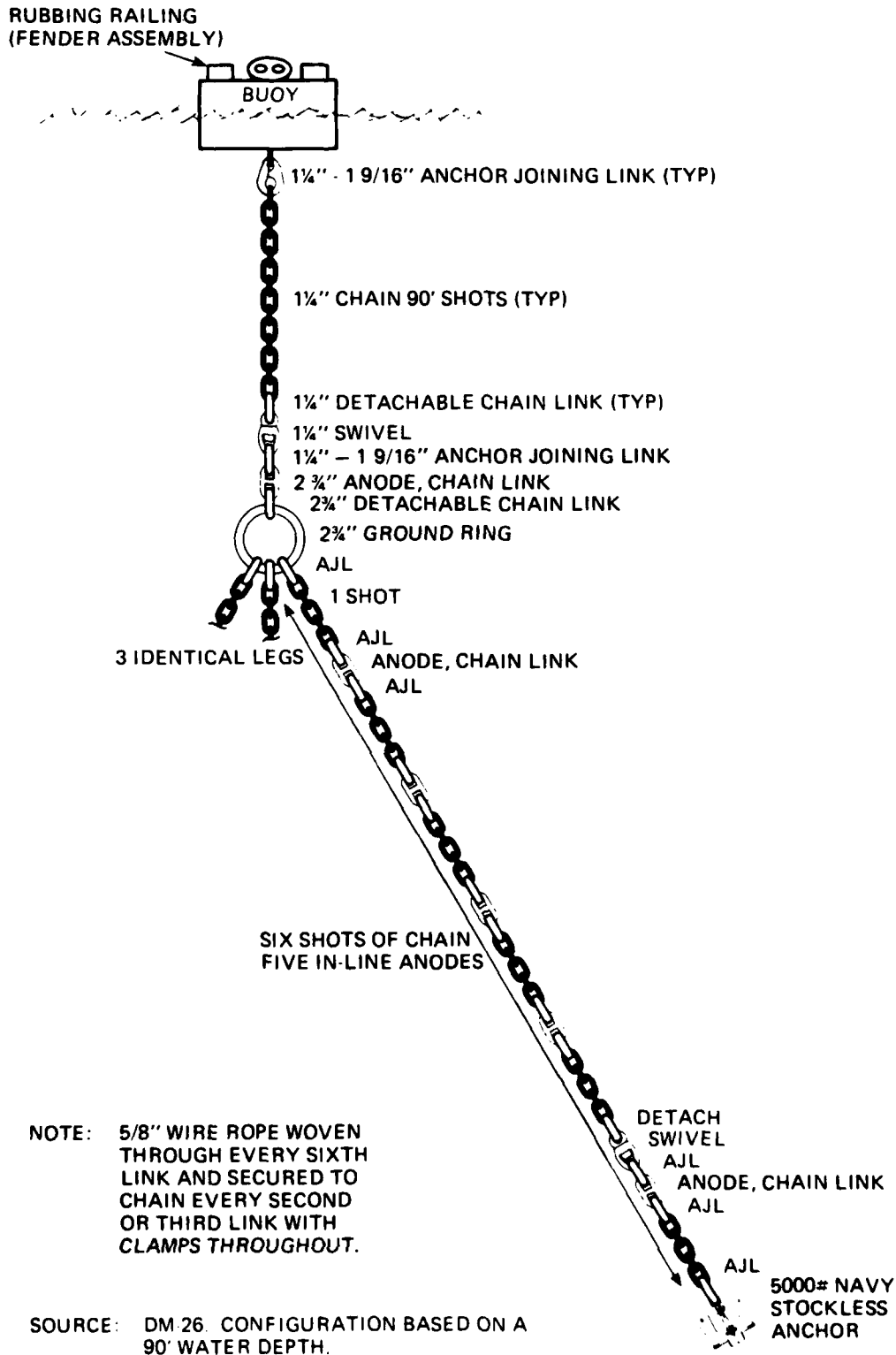


Figure B-2. Class "F" Mooring With in-line Link Anodes

Table B-3. Estimated Installation Costs for Class E or F Moorings at Bermuda

Item	Time (hrs)	Rate (\$/hr)	Cost (\$)
I. Costs per mooring			
A. Removal of Old Mooring			
● Crane Barge, Crew, Tug	1 day	1600/day	1600
● Land Crane	4	75	300
● Divers (4 men @ 8 hrs)	32	30	960
● Riggers (4 men @ 8 hrs)	32	20	640
● Truck and Driver	4	25	100
Removal and Subtotal			3600
B. Old Mooring Disposal			
● Land Crane	4	75	300
● Riggers (2 men @ 4 hrs)	8	20	160
● Truck and Driver	4	25	100
Disposal Subtotal			560
C. Survey Site and Mark Location			
● 2 Surveyors @ 5 hrs	10	25	250
● 1 Boat and Skipper	1 day	300	300
Survey Subtotal			550
D. Assembly and Installation			
● Crane Barge, Crew, Tug	2 days	1600/day	3200
● Riggers (4 men @ 16 hrs)	64	20	1280
● Land Crane	8	75	600
● Truck and Driver	8	25	200
Installation Subtotal			5280
E. Post-Installation Quality Assurance Inspection			
● 1 Boat and Skipper	1 day	300/day	300
● 2 Divers @ 8 hrs	16	30	480
● 2 Surveyors @ 4 hrs	8	25	200
Q. A. Subtotal			980
Cost per Mooring Subtotal			10970
Per Mooring Contingency 25%			2743
Per Mooring Total			13713
II. Costs per MOB/DEMOB			
● Crane Barge, Crew, Tug	5 days	1600/day	3200
● Land Crane	40	75	3000
● Truck and Driver	40	25	1000
MOB/DEMOB Subtotal			7200
Contingency 25%			1500
Per MOB/DEMOB Total			9000

NOTE: All rates are in FY 81\$.

APPENDIX C

PHOTOGRAPHS

This Appendix contains photographs taken above and below the surface of the water, which depict the condition of some of the Bermuda fleet mooring components.

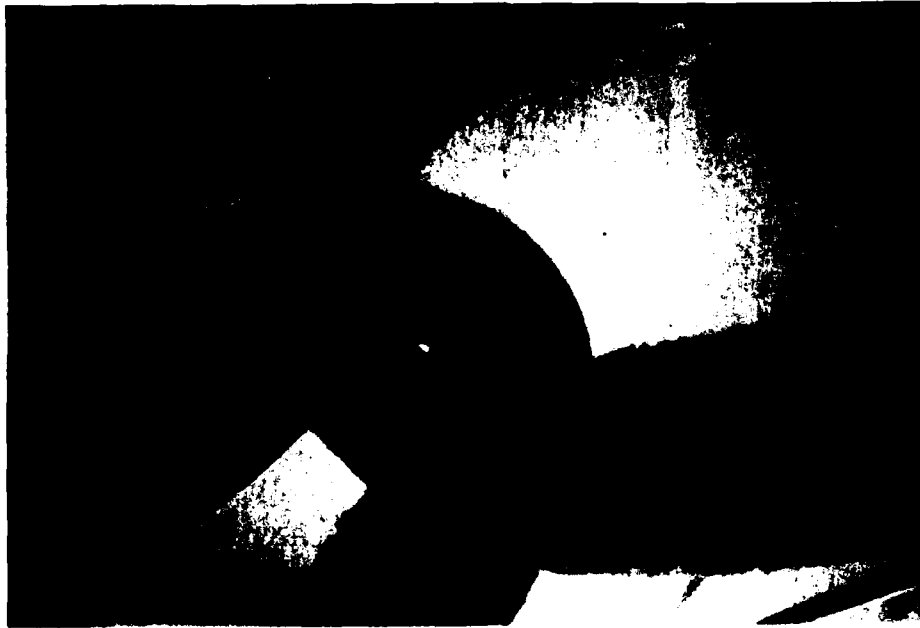


Figure C-1. Deteriorated Section of Mooring E-3 Riser Chain



Figure C-2. Deteriorated Section of Mooring E-5 Riser Chain



Figure C-3. Buoy F-3 Riding with 8-10° Trim Angle



Figure C-4. Buoy F-4 - A Sample of the Typical Buoy Condition

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