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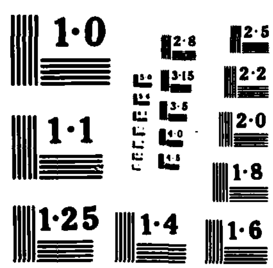
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PROJECT COMPLETION REPORT

FOR

PETROLEUM-OIL-LUBRICANT [POL] PIER

MOORING BUOY SYSTEM

DIEGO GARCIA B. I. O. T.

BY

BESIER, GIBBLE & QUIRIN

CONSULTING ENGINEERS

FPO - 1 - 80 [12]

JANUARY 1981

OCEAN ENGINEERING
AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
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The concept of using the two buoy moorings of the POL Pier Mooring Buoy System at Diego Garcia was adopted after considering an initial concept of a pier plus two mooring islands which proved to have constructural disadvantages that the present buoy moorings alleviated. (Con't)

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The initial concept of two mooring islands was studies from a constructional viewpoint by analyzing 6 concepts of construction methods and concluded the safest and cheapest method was the use of a construction jacket for driving the required piles. The use of floating equipment was necessary afor construction.

Upon further consideration and analysis the mooring-buoy system concept was adopted as being cheaper, easier and safer to construct with the available cranes than the mooring islands. This concept required two mooring buoys anchored in position each with 5 chain and anchor legs. Three of the legs were installed in shore as the main anchors to resist the ship forces. two of the legs were installed outshore as back stays to hold the buoys in place with a pretension load.

Design computations were performed and sizes selected from government sources. Anchors are 100 kip propellent embedment types, chains are 2-1/2" diameter from anchors to sinker, 2-1/4" diameter from sinker to ground ring and 3-1/2" diameter from ground ring through the buoy. The sinker on each leg consists of a 20,000 pound standard Navy Anchor. The buoys are standard Peg Top Type modified to obtain increased buoyancy.

The materials were procured from Government sources inspected and preassembled at Port Hueneme and shipped to Diego Garcia. At the site Naval Construction Forces, with the help of land cranes and a YC barge having a land crane on deck, placed embedment anchors in the bottom (5 each for two mooring buoys), laid chain and sinkers (20,000 lb. Navy anchors) for 5 legs for each of two buoys, connected the chain to the embedment anchors and connected 5 chain legs together to each of the 2 buoys. Connection sto the buoys were made by sinking the buoys and making the final system hookup underwater. The buoys were then refloated. With predetermined chain lengths, a pretention now existed in the chains. The interior of th buoys were filled with foam to enhance their survivability in case they are inadvertently punctured.

Measurements of chain links were made for future reference. Cathodic protection was provided for all chains, buoys and sinkers. Readings by voltmeter were taken of the cathodic protection system to prove its operation. Surveys were made of all sinker and embedment anchor locations. All this information is recorded on the as built drawings and in tables in this completion report.

Actual completion of all work was slightly ahead of the planned schedule.

DISCLAIMER NOTICE

EXECUTIVE SUMMARY

The concept of using the two buoy moorings of the POL Pier Mooring Buoy System at Diego Garcia was adopted after considering an initial concept of a pier plus two mooring islands which proved to have constructural disadvantages that the present buoy moorings alleviated.

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1.0 INTRODUCTION

This completion report pertains to the two mooring buoys which replaced the originally designed mooring islands of the POL Pier Project at Diego Garcia, Chagos Archipelago, B.I.O.T.

The main POL pier is a 40 feet wide platform (concrete deck on steel pilings) by 550 feet long with a 1,150 feet approach trestle connecting it to shore at its southeasterly end. The berthing face is aligned in a northwesterly-southeasterly direction located within the lagoon of Diego Garcia parallel to and 30 feet seaward from the toe of the existing dredged turning basin, and its trestle connects with an existing causeway. See Figure 1.

The two mooring buoys serve the purpose of securing bow and stern lines of maximum size ships and are located at the two ends of the pier approximately 175 feet from the edge of the pier and set back 60 feet (inshore) from the pier face. The two mooring buoys consist each of a single modified peg top buoy and 5 sets of anchor chains, sinkers and propellant embedment anchors. See Figure 2.

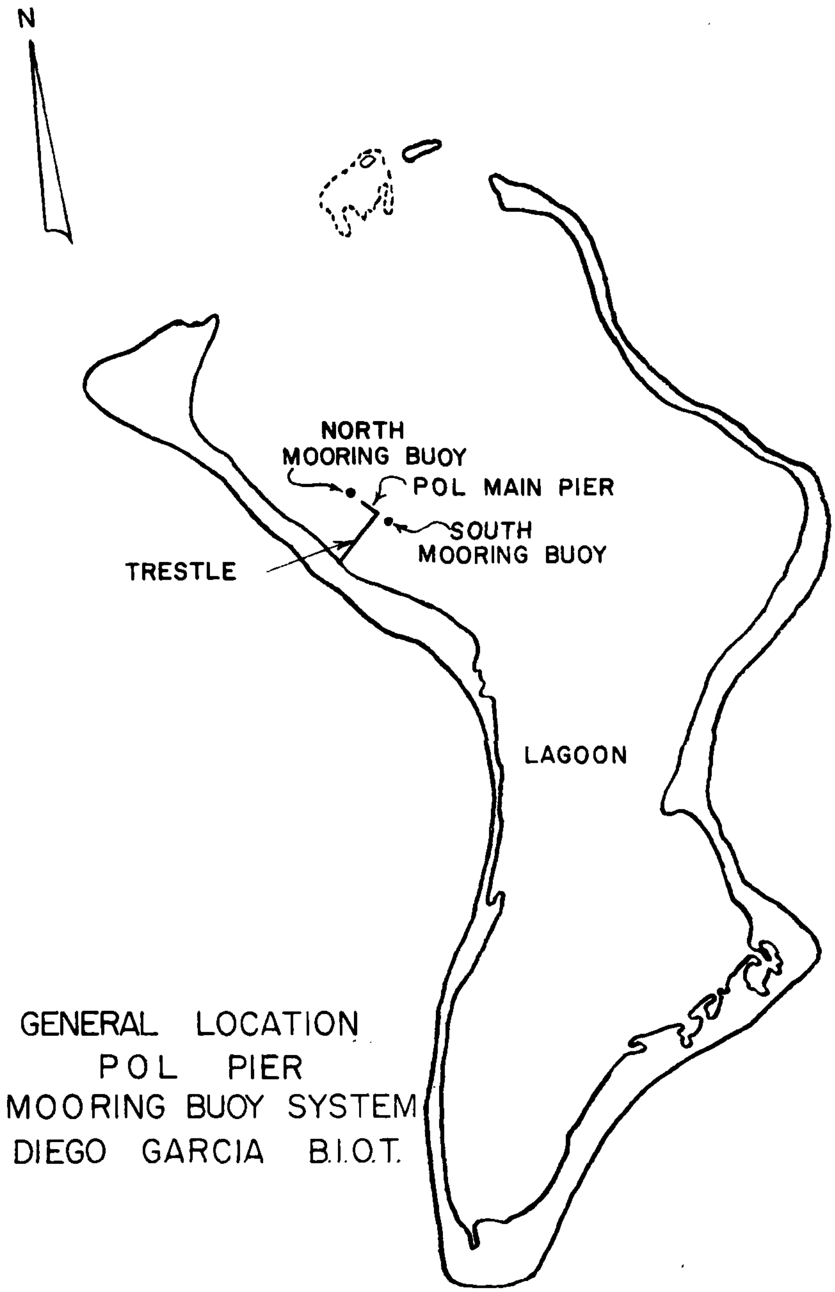
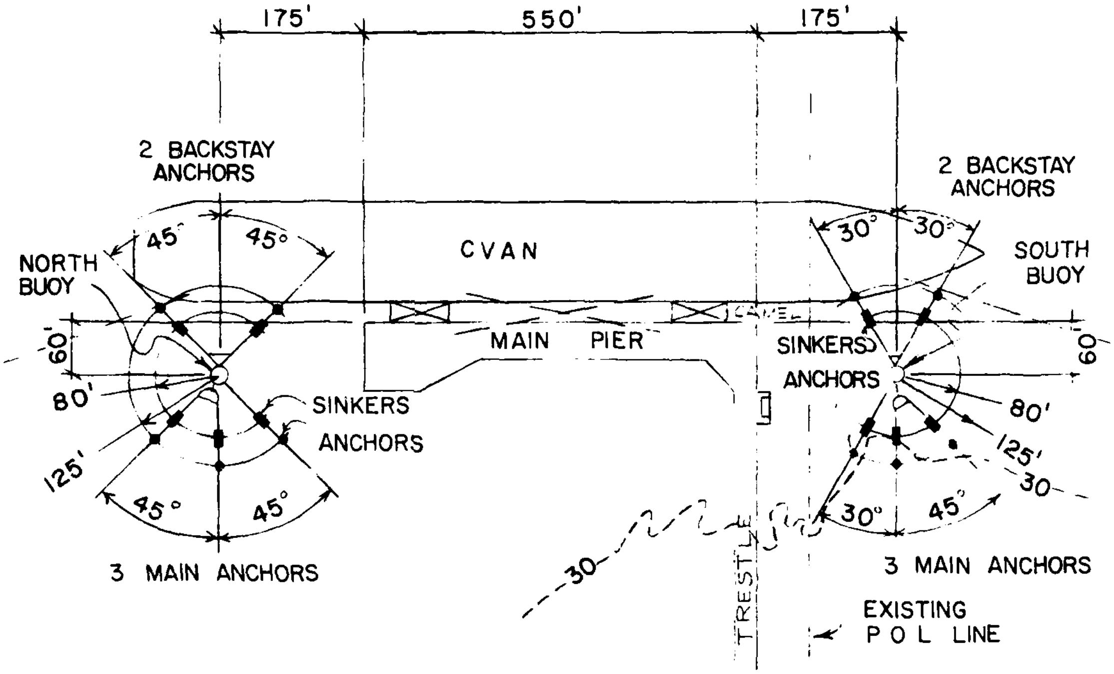


Figure 1
General Location



SITE LAYOUT
POL PIER - MOORING BUOY SYSTEM
DIEGO GARCIA B.I.O.T.

Note: ---30--- Indicates Contour Line, Waterdepth in Feet

Figure 2
Site Layout

2.0 OVERVIEW - HISTORY

2.1 Initial Design

The initial concept for this POL Pier was developed by Lyon Associates Inc., in a report dated February 1976, see reference 1. It proposed a main pier as mentioned above and two mooring islands consisting of concrete decks on steel pilings, instead of the buoy system described herein. NAVFAC Drawing No. 7,013,431 shows this design.

The Lyon Report gives a detailed analysis of climatic and oceanographic conditions, covering winds, sea elevations, waves and currents, salinity, temperature, sedimentation, soils, foundations and materials. It also covered pier layout, types of construction, orientation, utilities, POL facilities and port control office. Appendix A gives a summary of these climatic and oceanographic conditions. Appendix A is an excerpt from reference 1.

For design purposes the following selections were made:

Wind:	50 year return period having 49 knots sustained and 69 knots peak gusts
Still Water Level:	5.6 feet
Waves:	Significant wave height - 7.5 feet Maximum wave height - 12.2 feet Period - 8.0 seconds Approach Direction - Northwest to Southeast
Currents:	2 Knots maximum Southeast or Northwest

2.2 Mooring Island Construction

The Ocean Engineering and Construction Project Office (FPO-1) of Chesapeake Division Naval Facilities Engineering Command (CHESDIV) was tasked in October 1978 by Pacific Division Naval Facilities Engineering Command (PACDIV) to perform a study and analysis of six viable concepts for their relatively safe and economical constructability by Naval Construction Forces on the island. See reference 3. Construction of the main peir was to be carried out with land equipment working out from shore by driving piles ahead and platforming as work moved outshore. There was some concern as to the practicality of constructing the mooring islands by the same method, via temporary construction supports out to the mooring islands.

The six following concepts were analyzed.

a. Crawler crane with additional temporary construction bents

b. Direct pile driving from work barge

c. Jack-up AMMI Pontoon

d. Construction jacket

e. Semi-submersible templet

f. Flexifloats

The analysis concluded that the construction jacket would be the best one since it provided the highest constructability by the on island construction forces.

The construction jacket consisted of a pipe space frame, braced, measuring 24'-0 square at the top, elev. 10.0', and 44'-0" square at the bottom, elev. -45.0', having 13 pipes in a vertical or battered position. The jacket (43 tons weight estimated) was to be placed on the bottom and 13 piles driven through the open vertical and battered pipes in the frame. Following this 16 additional batter piles were to be driven.

It was estimated that the cost of the FPO-1 engineering efforts would be $66,053 including concept development, engineering analysis and design, drawings and specifications, and 3 weeks on-site consultation. The in-house design work would be completed in 8 (Earliest) to 16 weeks (latest). Construction cost was estimated to be approximately $133,000. The jacket was designed for an operating environment of 3 feet waves and 10 knots wind which is a common sea state at the site during the May - June period. Under these conditions the system would have had a factor of safety of 2.5 at the initial stage of driving the first pile. However, the jacket weight might have caused some difficulties in the weight handling process.

PACDIV and the Officer in Charge (OIC) of the Pier Team, Diego Garcia, concurred with this conclusion and requested continuation of CHESDIV's effort into final design, plans and specifications.

2.3 Mooring Island Replacement By Mooring-Buoy

However, after further consideration and analysis of the limitations of construction equipment and construciton forces available on the island a seventh concept was developed, namely, a mooring buoy system concept which was then discussed by telephone between Mr. C.E. Bodey (Code FPO-1E of CHESDIV) and Capt. L. Donovan, Project Officer - Diego Garcia (Code 09DG of PACDIV) on 20 April 1979, as a replacement for the original mooring island design. Subsequently,

C. Cher, K. Cooper and A. DelCollo all of CHESDIV prepared a report dated 26 April 1979 on the concept, including bill of material and cost estimate. See reference 4.

The proposed system included the installation of two mooring buoys with 5 sets of chains and anchors; one at 175 feet away from the north end of the main pier, one at 175 feet away from the south end of the pier, and both at 60 feet inshore from the berthing face of the main pier. Preliminary analysis of the proposed system indicated it would be able to restrain a CVAN aircraft carrier under design environmental loads of 44 MPH wind and 1 knot current at a 10° yaw angle. In addition, the proposed system potentially possessed the following advantages in ship operations by:

a. Providing approximately a 100-foot wide tug passageway at both ends of the pier for access to the carrier.
b. Minimizing impact damage to the ship hull under unusual ship departure maneuvers that would cause the ship to impact the buoy.

The buoy system at each end of the main pier consisted of the following major hardware components:

One 12 foot diameter buoy
Five 135 foot lengths of 2 1/4 inches diameter chain
Five sinkers each at 8,600 pounds air weight minimum
Five 100 kips propellant embedment anchors
Assembly connecting hardware

The propellant embedment anchors are those developed at the Civil Engineering Laboratory (CEL) at Pt. Hueneme, California.

Most of the other hardware components and miscellaneous attachments would be obtainable from the Government stock. The entire system could result in a considerable amount of cost saving.

Subsequently an installation plan was prepared by K. Cooper in January 1980. See reference 5. Following this a decision was made to proceed with the mooring buoy system.

2.4 Financial Summary

The total cost for the project in the areas of CHESDIV direct responsibility was $142,300. The final breakout of costs is as follows:

Project Management	$11,800	
Initial Fixed Dolphin		
Installation Concepts	4,400	
Templet Design	27,500	
Final Buoy Mooring Dolphin		
Design, coor. of procure.	36,600	
On-site FPO-1 Reps	30,000	
Completion Report	10,000	
Total FPO-1 efforts		$120,300
CEL - Emb. Anch. Mobilization Support and on-site support		22,000
Total CHES/CEL effort		$142,300

These monies did not cover cost of acquisition of mooring hardward from NAVFAC Fleet Inventory, transportation of hardware to the island, or cost of equipment and manpower supplied by the Navy Construction Forces.

3.0 DESIGN SUMMARY

3.1 Basic Considerations

The Diego Garcia mooring-buoy installation as conceived could not accommodate the large horizontal span of the anchor chains of the standard fleet mooring designs (DM-26) because of the constraints of water depth and close proximity to the main pier. The design however did attempt to maintain most of the design criteria and characteristics of the standard fleet moorings. Here a minimum chain "slack" must be provided and therefore any motion which cannot be accommodated by chain must be absorbed by the elasticity of the ships breasting lines to the buoy. Reference 5 gives a more detailed dissertation on chain moorings. Appendix B is an excerpt from reference 5.

3.2 Chain Layout

The horizontal span and the angular orientation of the legs of each mooring was determined by bathymetry, the proximity of the pier to the mooring buoys and by the location of the POL lines at the south end of the pier. See figure 2.

3.3 Mooring Design Loading

In the Lyon report, reference 1, the pier and mooring islands were designed for the berthing loads, under a sustained wind of 65 miles per hour, of an AOE type vessel having the following characteristics:

Displacement - Light	18,700 tons
Displacement - Full Load	53,600 tons
Length overall	793 feet
Beam at waterline	107 feet
Mean Draft - Full Load	39 feet

The orientation of the pier was set in a northwest - southeast direction. In Appendix A it is stated that maximum winds are likely to be westerly, northwesterly, or southeasterly all of which would then result in tension in the ships mooring lines to the mooring islands. Maximum current was taken for design purposes at 2 knots having a direction from southeast or northwest.

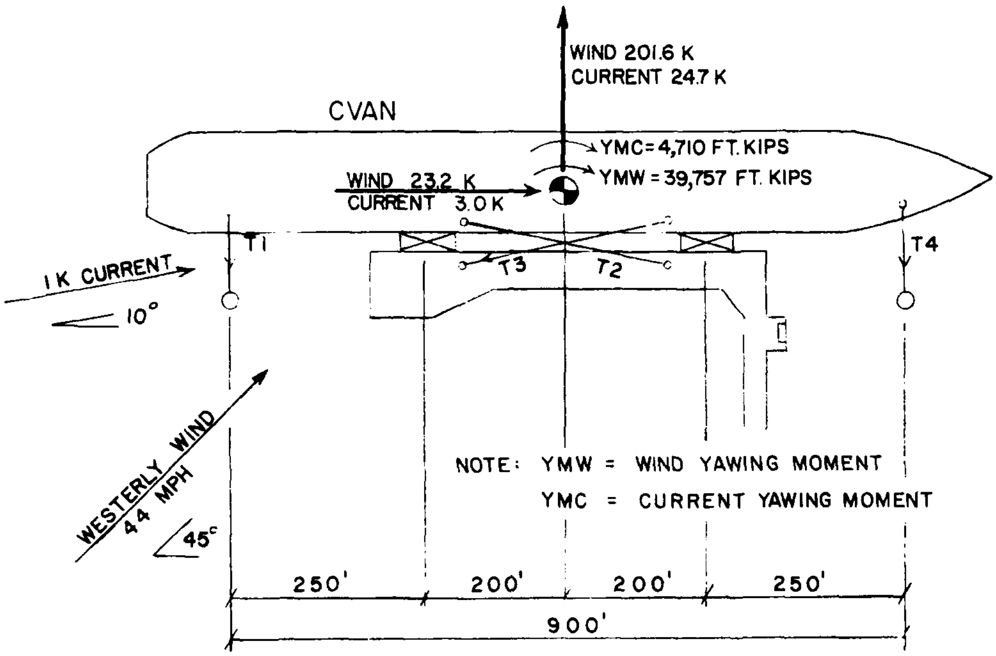
For the design of the mooring-buoy system it was ascertained that a greater line pull on the buoys would result from using an aircraft carrier of the CVAN class under more normal wind conditions than using the AOE type vessel under maximum wind conditions. Consequently, for design, wind was assumed to be 44 miles per hour and current was assumed to be 1 knot. To produce maximum line pull wind was assumed to come from a westerly direction combined with a 10° yaw angle for current.

Wind loads acting on a CVAN were computed on the basis of the formula given in reference 8. These formulas produced the following:

Angle of Yaw for wind direction	225°
Lateral Force on ship	201.6 kips
Longitudinal Force on ships	23.2 kips
Yawing moment of ship	39,757 ft.-kips

Current loads acting on a CVAN were computed on the basis of the formula given in reference 8. These formula produced the following:

Angle of yaw for current direction	10°
Lateral resistance of ship	24.7 kips

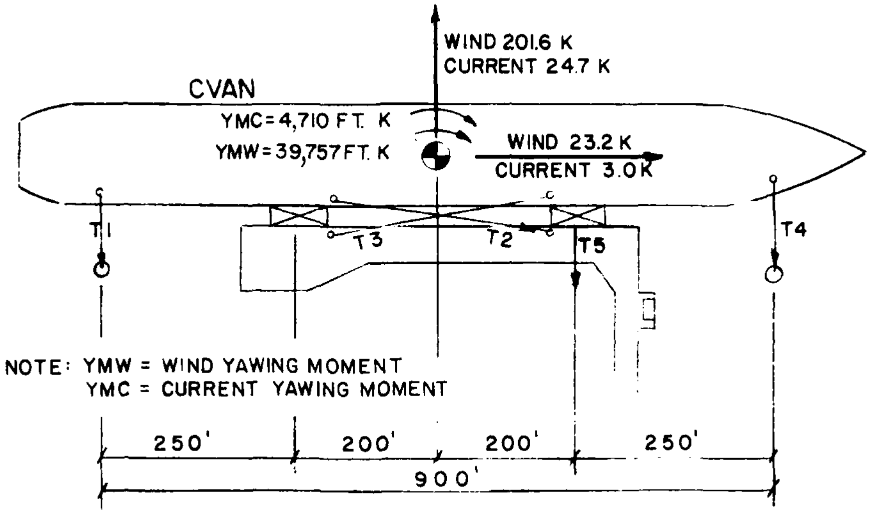


MOORING LOADS I

T1	-	165.4 K	HORIZ.	-	LINE PULL
T2	-	0	HORIZ.	-	LINE PULL
T3	-	26.2 K	HORIZ.	-	LINE PULL
T4	-	61.0 K	HORIZ.	-	LINE PULL

CVAN		CHARACTERISTICS		
LOA	1123'	SIDE AREA	76,000	SQ. FT.
LWL	1040'	END AREA	16,600	SQ. FT.
BEAM	133'	DISPLACEMENT	85,350	TONS

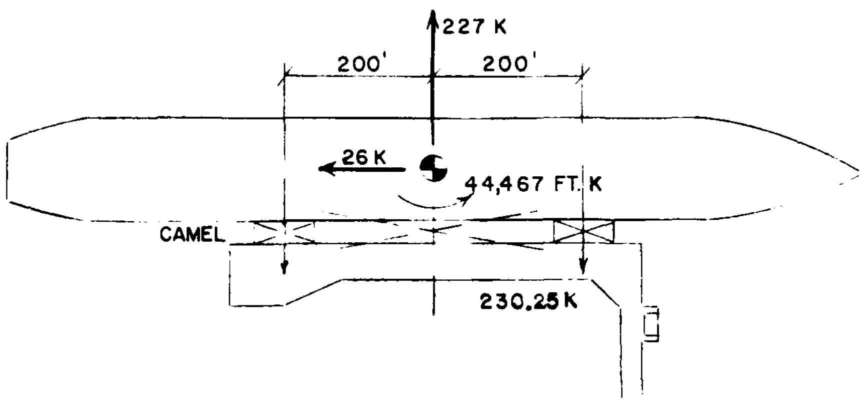
Figure 3
Pier & Mooring Loading I



MOORING LOADS II

T1	-	185.5 K	HORIZONTAL LINE PULL
T2	-	0	HORIZONTAL LINE PULL
T3	-	26.2 K	HORIZONTAL LINE PULL
T4	-	0	HORIZONTAL LINE PULL
T5	-	40.9 K	HORIZONTAL LINE PULL

Figure 4
Pier & Mooring Loading II



CVAN RESTRAINED BY PIER ONLY

Figure 5
Pier & Mooring Loading III

Longitudinal resistance of ship	3.0 kips
Yawing moment of ship	4,710 ft. kips

Figure 3 gives the summarization of CVAN characteristics and loading on the pier and buoy moorings under a westerly wind and a southeasterly current for the condition where the tension in the mooring lines is such that both mooring buoys are functioning.

Figure 4 gives loading on the pier and buoy moorings under the same wind and current for the condition where the tension in the breasting line (T5) connected to the pier is greater than the tension in one mooring buoy line (T4) so that this one mooring buoy does not function.

Figure 5 illustrates the loading on the pier when the bow and stern lines attached to the mooring buoys afford no restraint causing the pier to totally restrain the ship.

The maximum static loading on a buoy is therefore 135.5 kips, acting horizontally.

Since the line from the buoy to the ship will be approximately at an angle of fifteen degrees to the horizontal actual maximum line pull will be 193.2 kips.

The actual load on the mooring buoy exerted by the ships mooring lines will of course be a dynamic load due to wave action and current and wind surges. Consequently a factor of 33% is added to compensate. This makes the maximum load acting horizontally on the buoys equal to 247.3 kips.

Similarly the maximum tension on a bollard on the pier under Loading Condition III would be 230 kips. This would be in excess of the bollard capacities shown on Diego Garcia Drawing S-41.

3.4 Site Conditions

Site conditions, namely seafloor profile were assumed for design purposes to be as follows at the south buoy:

a. water depth at the buoy site of 60 feet

b. water depth of 30 feet at 125 feet inshore from buoy

c. bottom from buoy seaward - flat

d. bottom from buoy inshore to 30 feet depth - gradual slope; 1 vertical to 4.167 horizontal

e. bottom at 30 feet depth - flat

The seafloor profile at North buoy was assumed to be the same even though the bottom is somewhat flatter in general.

3.5 Chain and Anchor Loading

For purposes of chain and anchor design the system consists of a buoy with 3 sets of chains, sinkers and embedment anchors laid to resist the mooring forces of a berthed ship and 2 sets of chain, sinkers and embedment anchors to act as back stays. See Figure 2. A pre-load of 10,000 pounds was applied horizontally at the chain buoy junction point by pretensioning the two back stay chains.

The three sets of chains and anchors are provided to resist the maximum load (horizontal) of 247 kips. For simplicity of design analysis a single set of chains, sinker and anchor would be subjected to 100,000 pounds pull acting horizontally.

Two conditions were analyzed, namely a) Pre-load state and b) Design load state, all in accordance with the Design Manual NAVFAC DM26 July 1968, Chapter 6, Section 3 and 4.

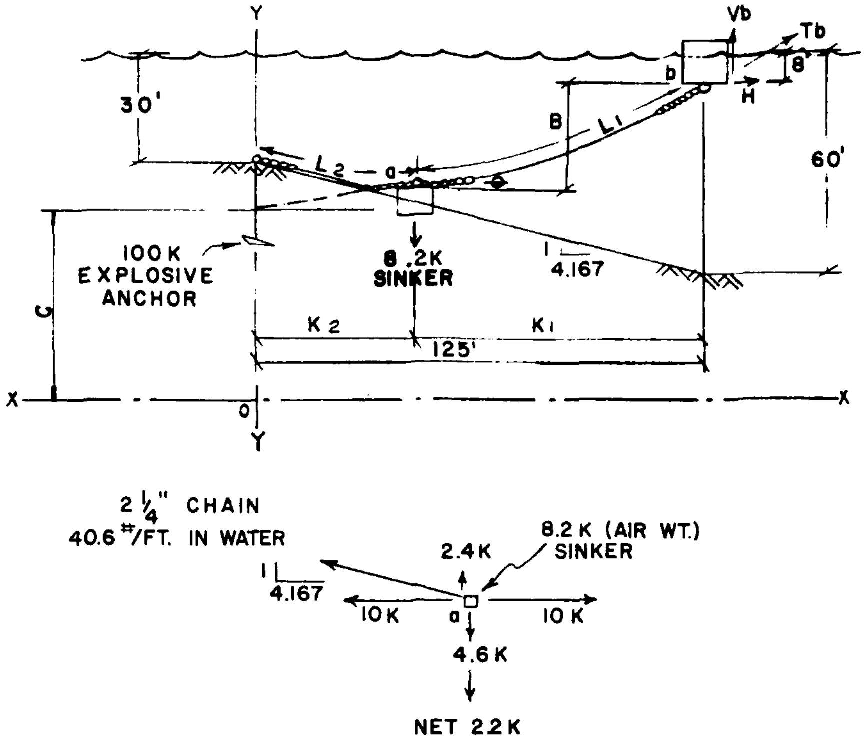
For a 100,000 pound horizontal load a 2-1/4" Die-Lock Chain having a breaking strength of 610,000 pounds was chosen based on availability from Government inventory.

A summary of the Pre-load state computations are shown in figure 6.

A summary of the Design-load state computations are shown in figure 7.

The above computations indicated the need for one 12 foot diameter buoy having a length of 3-1/2" diameter chain (riser chain) passing through its hawser pipe for all five sets of chains and anchors to be connected thereto; 5 - 1 shot lengths of 2-1/4 inches diameter chain from buoy to sinkers plus 5 - 1/2 shot lengths of 2-1/2" chain from sinkers to anchors; 5 - sinkers each at 20,000 pound air weight; 5 - 100 kips Embedment Anchors; and assembly connecting hardware, all of which were available from Government stock. Sinkers were to be placed 80 feet from center of buoy measured horizontally.

EQUILIBRIUM AT PRE-LOAD STATE



H	=	10,000#	PRETENSION FORCE
θ	=	12.4°	CHAIN ANGLE AT SINKER
K1	=	80'	HORIZONTAL
K2	=	45'	HORIZONTAL
B	=	32.8'	VERTICAL
C	=	246.3'	VERTICAL
L1	=	89.2'	CURVE LENGTH
L2	=	46.8'	CURVE LENGTH

Figure 6
Design Loading - Chain & Anchor - Preload State

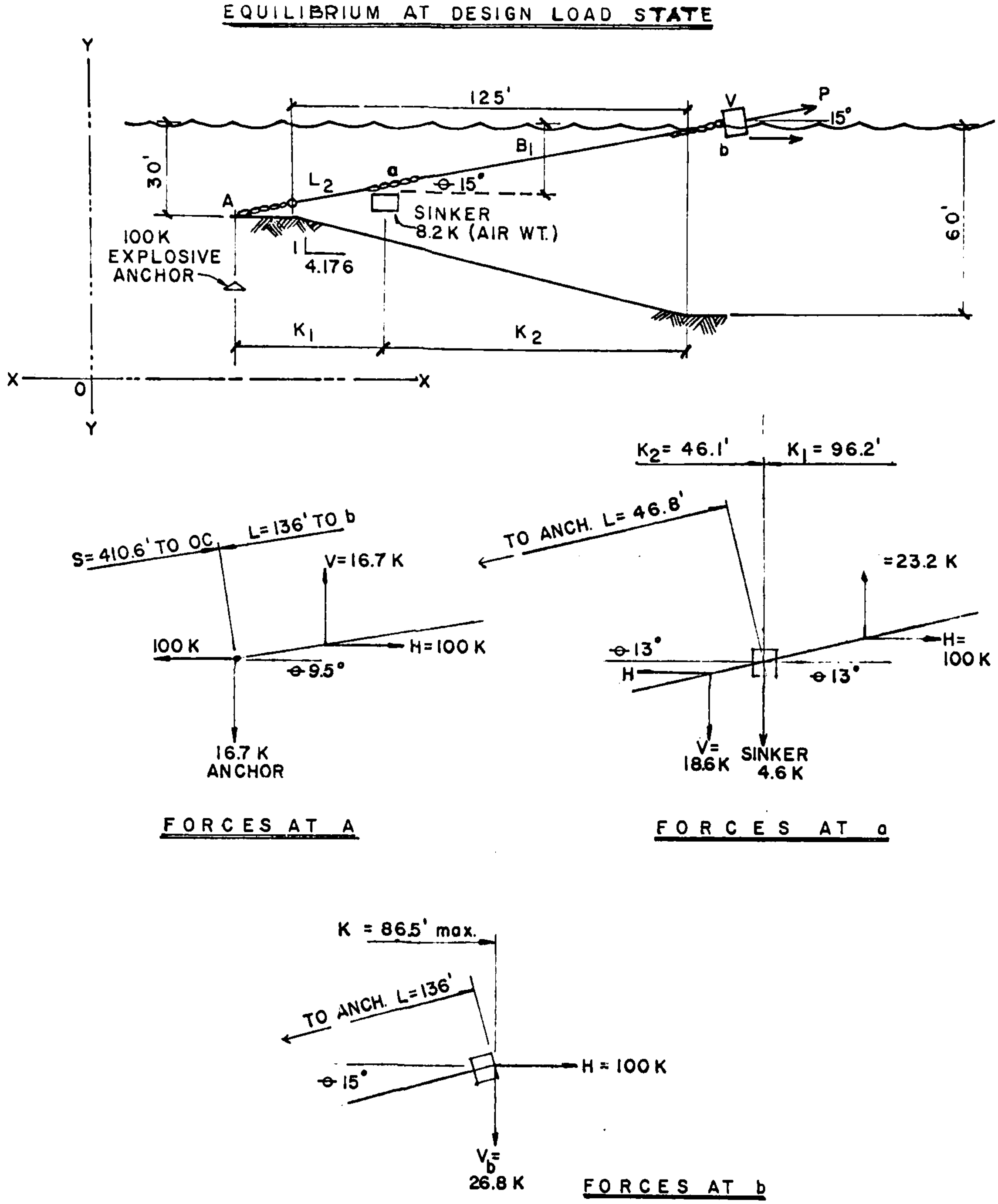


Figure 7
Design Loading - Chain & Anchor-Maximum Line Pull

4.0 PLANNING AND SCHEDULING SUMMARY

4.1 Constraints

Lift equipment on the island, being limited, imposed special handling requirements. Essentially by using a land crane mooring system components were placed on the sea floor at the pier to be picked up by a barge using lift lines through a bow sheave and winch, and transported to the site while still suspended in the water. Consequently chain leg sub-assemblies were palletized in the U.S. for ease and modular handling and shipment.

Since crane capacities did not permit lifting the mooring ground ring and chain legs for hook up to the buoy, an innovative approach was developed by flooding and sinking the buoy down a guide line attached to the riser chain. A keeper bar was then assembled to the riser chain by divers, the guide line removed and the buoy blown free of water raising the buoy and the suspended mooring chains to the surface. The air was supplied through air hoses attached to a compressor mounted on the construction barge.

A standard Peg Top Buoy was selected and modifications made to produce a cylinder having greater buoyancy than the standard buoy. See As Built NAVFAC Drawing No. 3017728, page 55. Furthermore the sink and float capability requirements for the buoys required flooding and blowing piping and valves, air compressor, hoses and underwater hook-ups. Foaming kits were provided to foam the interior as an insuracne to cover future possibilities of damage to the buoy by ships, recognizing that replacement and repair would be difficult at such a remote site.

4.2 Installation Plan

An installation plan for the Pier Buoy Mooring system was prepared by K. Cooper, in January 1980. See reference 4. The plan was prepared after a site visit, and was coordinated with LCDR P.W. Marshall, Officer in Charge, Underwater Construction Team Two (UCT-2). Primary labor and equipment for the project was provided by UCT-2. A summary of this plan is as follows:

1. Inspect and preassemble chain leg components (anchors, sinkers and chain) in the U.S.
2. Modify buoys in the U.S.
3. Prepare barge prior to UCT arrival on Diego Garcia
4. Mobilize construciton barge
5. Survey and place all marker buoys
6. Place 10-100K embedment anchors and pull test
7. Bring pallets to pier and offload to seafloor
8. Pick up pallet with barge lift wire, move to site, connect to embedment anchor wire - repeat for each leg of mooring
9. Connect legs of mooring to ground ring on bottom
10. Sink buoy to bottom and connect riser chain
11. Bring buoy to surface and complete buoy hardware assembly and cathodic protection attachment
12. Conduct mooring inspection including; survey location of buoys, photo and TV inspection
13. Demobilize and prepare equipment for return shipments.

4.3 Schedule

The installation plan included a schedule. See figures 8 and

9, which show the planned schedule. Also shown are the actual finishing dates which indicates work completed ahead of schedule.

PROJECT SCHEDULE

DIEGO GARCIA BUOY MOORING SYSTEM

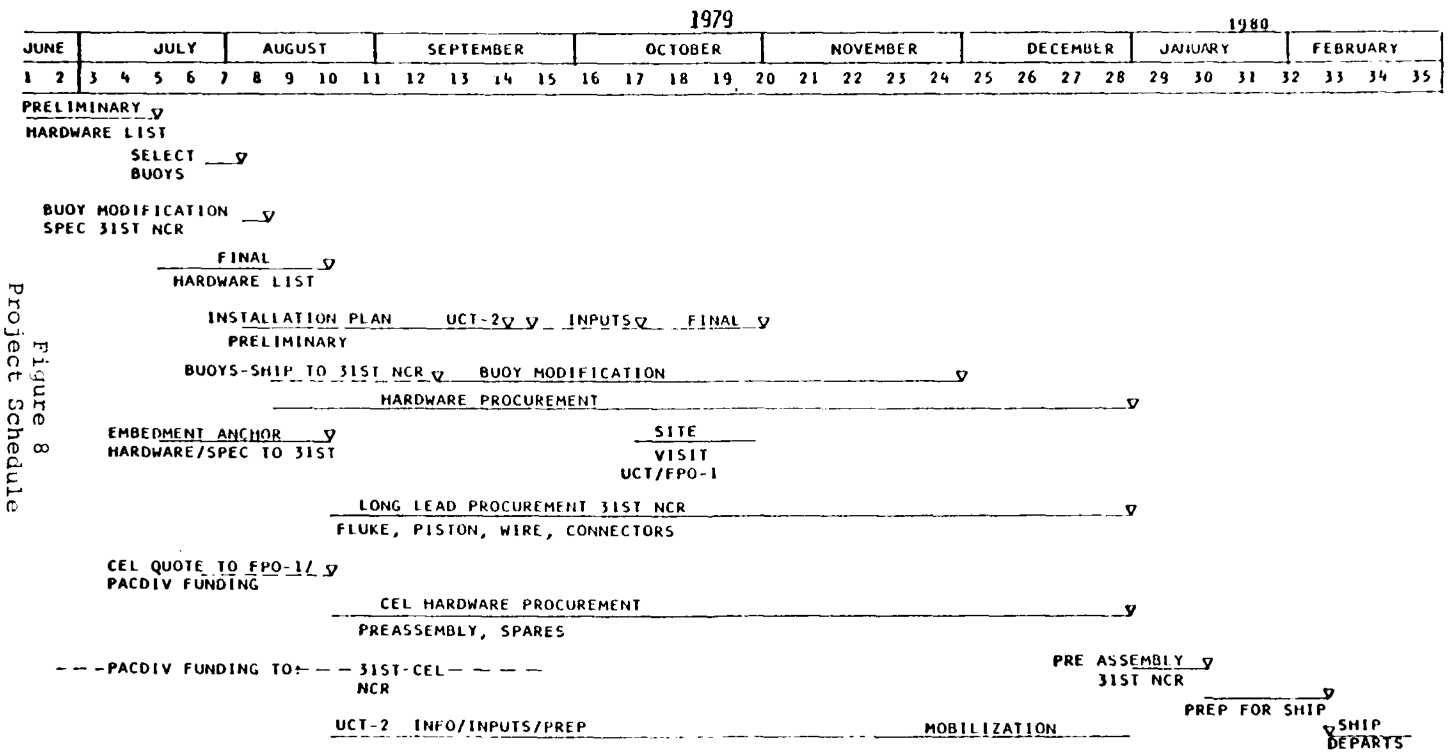


FIGURE 8
Project Schedule

Figure 8
Project Schedule

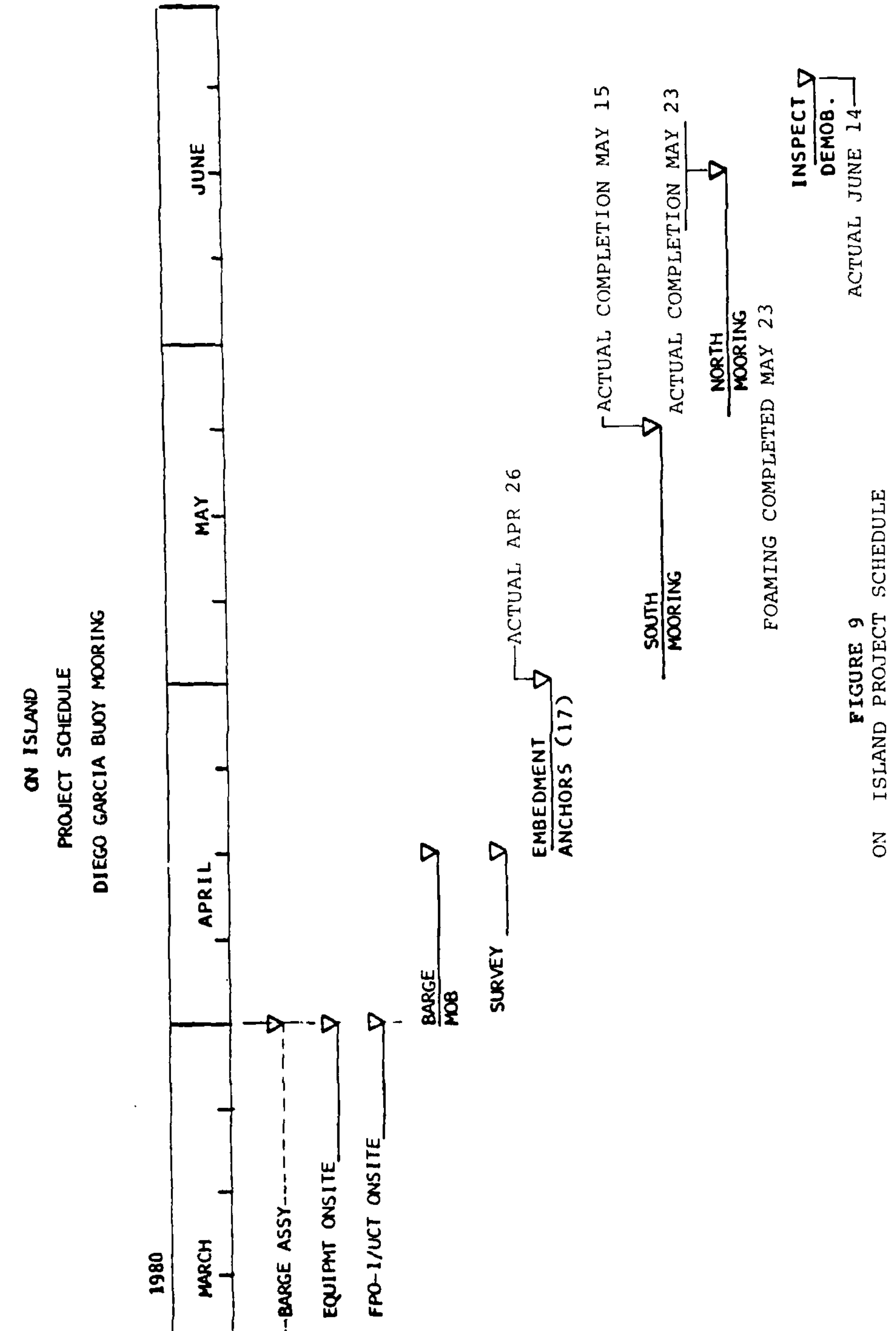


Figure 9
On Island Project Schedule

5.0 CONSTRUCTION AND INSTALLATION

5.1 Organization

The installation plan set up the organizational responsibilities for the design, mobilization and execution of the installation. Refer to Appendix C which is an excerpt from reference 4.

5.2 Procument and Shipment

31st Naval Construction Regiment (31st NCR), Pt. Hueneme, CA, provided all components of the required hardware. Each mooring leg was then packaged for shipment and installation on a single pallet as shown in Figure 10. Refer to Appendix D which is an excerpt from reference 4 for detailed preassembly and assembly plan. Since not all of the hardware required was available at Continental United States (CONUS) at time of preassembly, some components were shipped directly to Diego Garcia to be assembled on the pallet at the mooring site. 31st NCR completed its work by snipping all pallets, buoys, etc. to Diego Garcia.

5.3 Chain Work

Not all components were available as specified so that substitutions were made. Substitution of parts were made at the site. In order for some components to fit properly parts were modified or had to be cut apart with matching pieces of other parts. Refer to NAVFAC drawing No. 3017737, page 56, for complete detail of the actual installation, namely, its as-built condition. Also refer to Appendix E and reference 5 for "As-shipped to Diego Garcia" condition of each pallet.

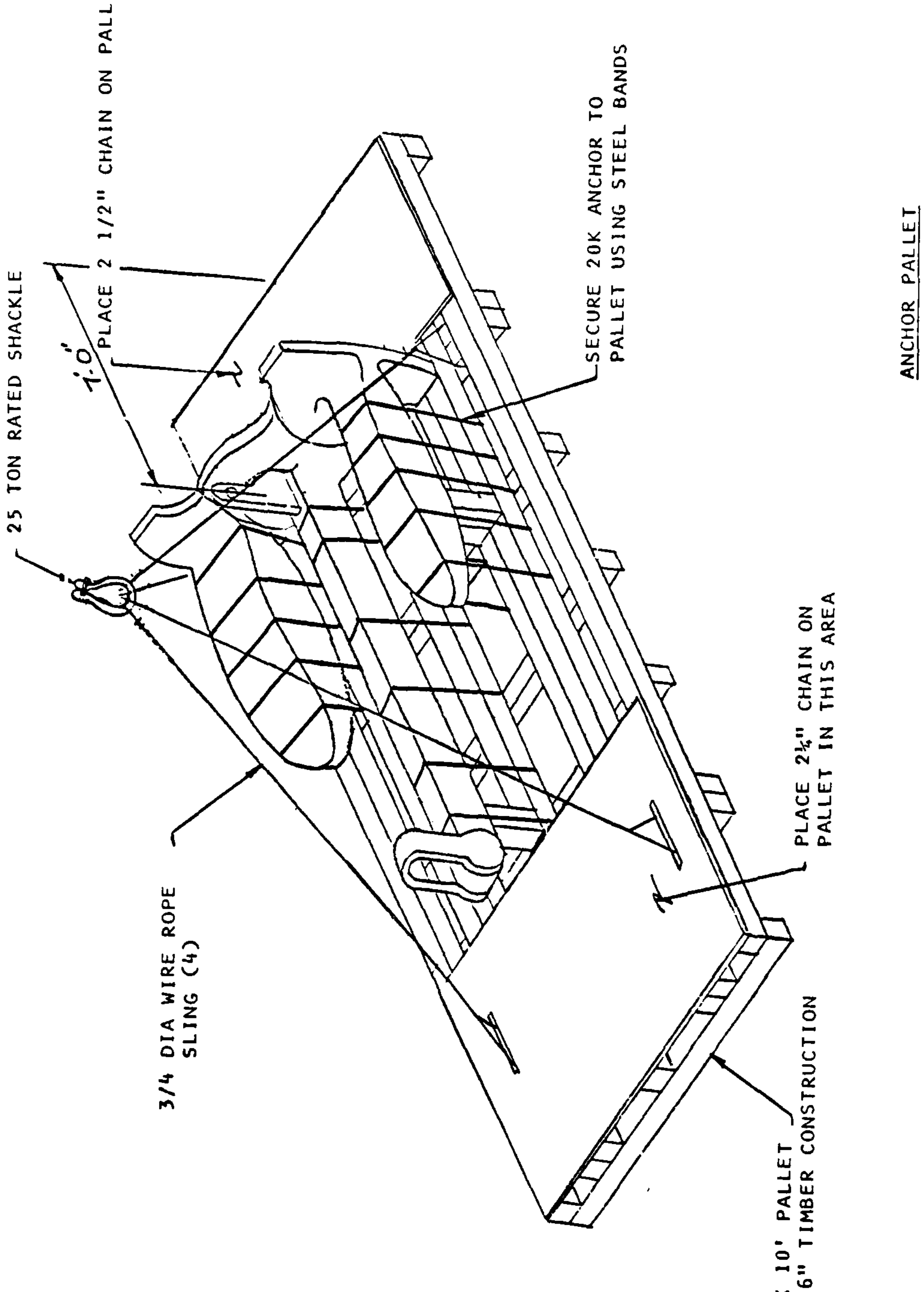


Figure 10
Anchor & Chain Pallet

5.4 Measurement of Components

In order to provide a future reference base for evaluation of corrosion data, measurements of components were required prior to installation of the mooring. Each measurement will document a particular gauge to be compared to a new component standard and to future measurements taken during underwater inspections. See reference F.

Measurements were made prior to shipping and are shown in the component data sheet enclosed with reference 5 and in Appendix C.

5.5 Mobilization at Site

Materials and equipment were assembled on Diego Garcia in an area between Air Ops and the pier road.

Barge Mobilization - The construction barge (YC 1497) was set up per NAVFAC Drawings No. 3017739 and 3017740. Major on island assets were installed on the barge:

a. Double drum mooring winch (2 each)

b. Truck crane (P&H 640), USN 42-02179

A single drum pulling winch shipped with project equipment was installed per drawing referenced above.

5.6 Survey

Establishing Stations A,B, and C

Stations A,B, and C were established on the approach trestle, as shown in figure 11. Stations A,B, and C are in a straight line and parallel to existing bench marks. Station A is set back 5 feet

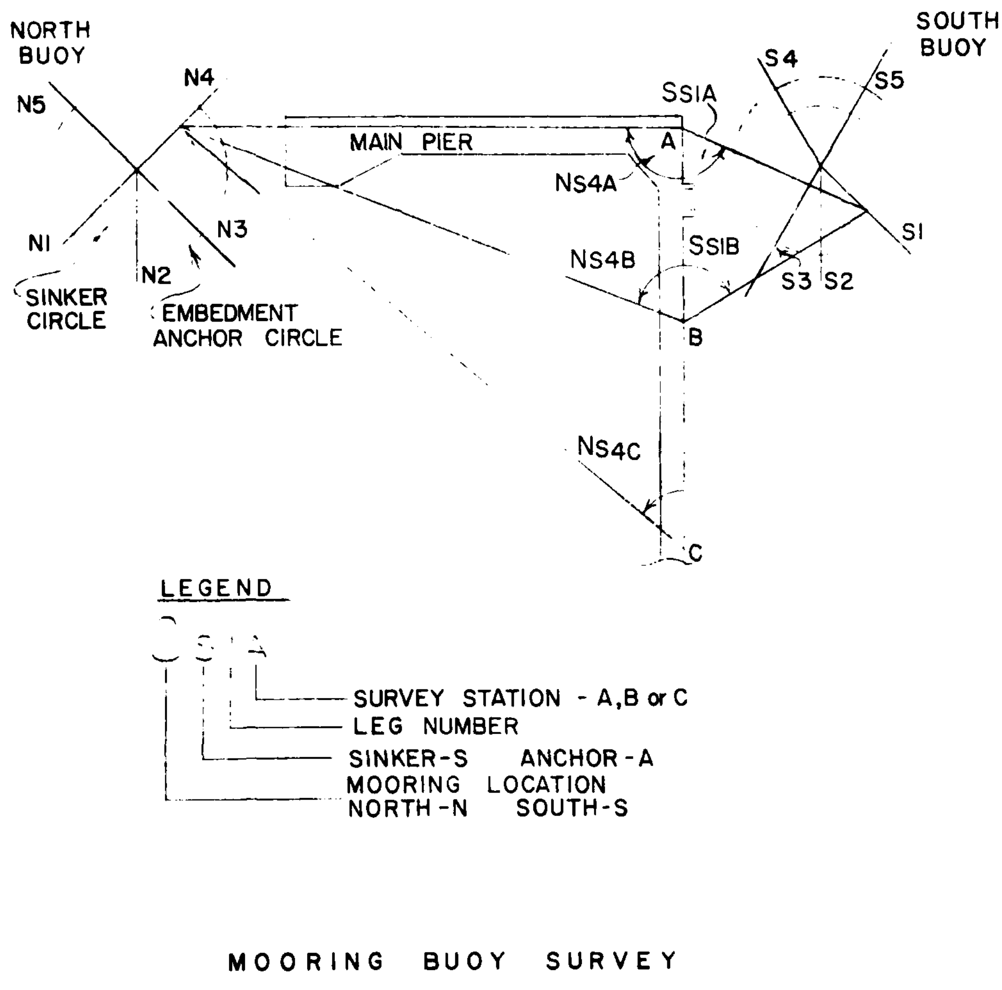


Figure 11
Mooring Buoy Survey

from south face of pier and set back 10 feet from east face of pier. Station B and Station C are 200 feet and 500 respectively from Station A.

South Mooring Buoy Survey

The south mooring buoy survey used Station A and B for all survey points. The bearings from Station A were read from line AB counterclockwise (CCW). The bearings from Station B were read from line BA clockwise (CW).

Table 1 tabulates all bearings for the anchors and the sinkers of the legs of the south mooring buoy and for the buoy itself.

North Mooring Buoy Survey

The north mooring buoy survey used Stations B and C to establish survey points for the legs of the mooring and for the construction mooring anchors. The bearings from Station A were read from Line AB clockwise (CW). The bearing from Station B and C were read from CB counterclockwise. (CCW).

Table 2 tabulates all bearings from Stations B and C for the anchors and Stations A and C for the sinkers of the legs of the north mooring buoy and for the buoy itself.

5.7 Propellent Embedment Anchors

A total of ten embedment anchors were installed at the designated marker buoys.

One SUPSAL launch vehicle (quadropad frame) was loaded onto the

Table 1

South Mooring Buoy Survey

	STATION A(CCW)		STATION B(CW)	
	Design	Actual	Design	Actual
BUOY	74°28'33.2"	76°00'00"	50°11'39.9"	50°11'
SA1	61°56'39.5"	62°06'	79°29'13.6"	79°33'
SA2	43°35'24.7"	43°35'	86°31'45.7"	86°17'
SA3	32°56'41.5"	32°41'	75°01'21.8"	75°04'
SA4	122°31'46.2"	122°00'	22°12'58.7"	21°30'
SA5	105°45'54.9"	105°55'	42°41'50.9"	43°13'
Ss1	65°01'51.5"		70°22'57.0"	
Ss2	52°13'27.5"		71°25'19.0"	
Ss3	46°41'14.7"		61°48'35.2"	
Ss4	101°29'48.8"		30°43'50.5"	
Ss5	96°58'41.7"		44°39'01.6"	

Table 2

North Mooring Buoy Survey

	STATION A(CW)		STATION B(CCW)		STATION C(CCW)	
	Design	Actual	Design	Actual	Design	Actual
BUOY	80°01'39"	78°51'			57°59'40.6"	58°30'
NA1	79°43'30.8"	79°43'			66°44'46.4"	66°42'
NA2	75°17'07.8"	75°21'			66°38'38.1"	66°55'
NA3	76°34'42.1"	76°32'			60°30'15.4"	60°35'
NA4	94°26'49.3"	93°51'			48°35'06.7"	49°48'
NA5	93°22'51.7"	93°24'			56°10'31.0"	56°22'
Ns1			83°40'58.0"	83°29'	63°43'26.8"	63°44'
Ns2			85°11'48.6"	85°06'	63°24'11.3"	63°27'
Ns3			82°28'41.0"	82°30'	59°30'28.0"	59°38'
Ns4			72°00'26.5"	71°47'	51°59'20.0"	51°57'
Ns5			74°46'04.3"	74°45'	56°45'47.7"	56°52'

construction barge together with the major components of the anchor system, including flukes, pistons and wires. One CHESDIV reaction vessel launch vehicle was retained in the staging area as a spare.

Installation of the embedment anchors was accomplished as follows:

1. Explosives and primer for the placement of embedment anchors were stored on the barge.
2. Assembly of the launch vehicle was performed by FPO-1/CEL together with 3 men of UCT-2 assisting in the assembly process.
3. The barge was positioned, using the LCM8 along side the barge and the LARK positioned astern of the LCM-8 while also moored with an upwind anchor. The launch vehicle was lowered by the crane, the firing circuit was checked a final time, and the embedment anchor fired into the bottom, after which the launch vehicle was recovered and prepared for the next placement.
4. Each embedment anchor was tested for holding power by use of the barge and beach gear pulling a wire attached to the embedment anchor cable. The applied load was approximately 100 kips measured by a load cell located near the fixed beach gear block. Divers connected the pulling wire to each anchor wire and also disconnected the wire after each test. Actual Test loads are given in Table 3.

Table 3

Embedment Anchor Holding
Power Test Loads

S1	115,000 pounds
2	100,000 pounds
3	100,000 pounds
4	145,000 pounds
5	105,000 pounds
N1	115,000 pounds
2	125,000 pounds
3	98,000 pounds
4	105,000 pounds
5	105,000 pounds

5.8 Installation Scenario - Chains and Buoy

After completing the following, the installation of chains and buoy was begun:

1. Pallets offloaded and inspected
2. Parts not available at CONUS mobilization were assembled as neeeded to complete each pallet
3. Crane barge mobilized
4. Survey completed and marker buoys installed
5. Embedment anchors placed and tested

5.8.1 Distance measurements by diver for each of the mooring legs were made a) from the point of impact of the embedment anchor (where the anchor wire comes out of the bottom) to the center of the sinker float marker weight, (shown as point An in Figure 12), b) from the bottom to the center of the pin in the open socket at the end of the embedment anchor wire, (given on the drawings as "B"). The resultant dimension "C" was determined by multiplying "B" by a factor of .9 and subtracting from "A". By adding 7 feet to "C" the length of chain to remain was determined. See Table 4. By

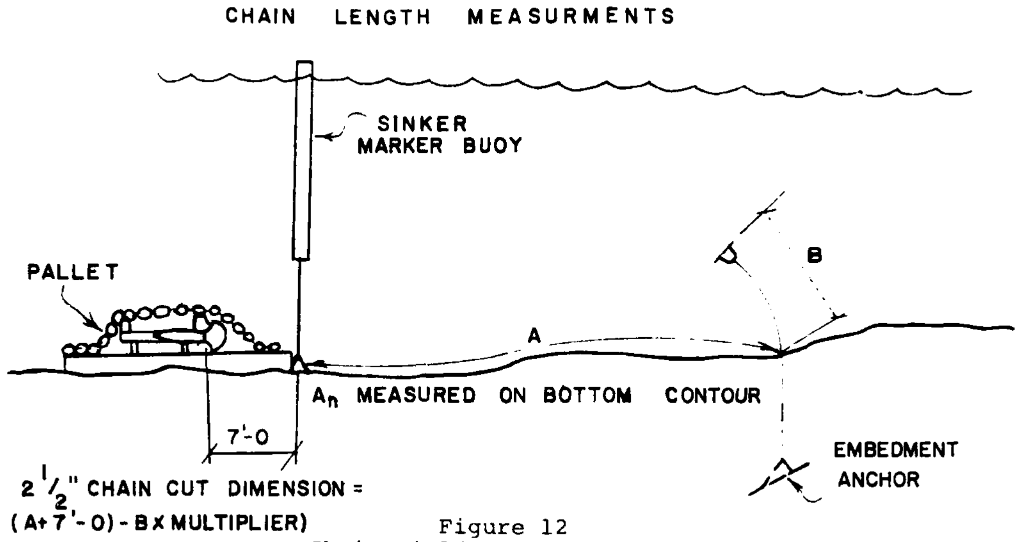


Figure 12
Chain Field Measurements

Table 4

Chain Field Measurements
(all figures in feet and inches)

	B	.9B	A	C= A-.9B	C+7'
S1	31'-0"	27'-10"	107'	79'-2"	86'-2"
2	34'-6"	31'-0"	56'	25'-0"	32'-0"
3	29'-0"	26'-1"	50'	23'-11"	30'-11"
4	36'-5"	32'-9"	55'	22'-3"	29'-3"
5	37'-0"	33'-3"	52'	18'-9"	25'-9"
N1	33'-0"	29'-8"	50'	20'-4"	27'-4"
2	35'-0"	31'-6"	46'	14'-6"	21'-6"
3	35'-0"	31'-6"	57'	25'-6"	32'-6"
4	30'-0"	27'-0"	33'-4"*	6'-4"	13'-3"
5	30'-0"	27'-0"	51'-0"	24'-0"	31'-0"

* Short distance of N4 is the result of the anchor being shot approximately 17'-0" from designed position. The marker buoy was probably moved by the anchor wire prior to placement.

measuring from the center line of the lifting eye near the (flukes) anchor the cut line was established and the excess chain cut off and removed from each pallet. The permanent end fitting was then connected. The 3/4" diameter galvanized wire for the cathodic protection system to the last 2-1/2" chain link was secured using a special clamp, after which the 2-1/2" chain was replaced on the pallet and secured in place. The same procedure was followed for each leg in succession.

5.8.2 Pallet Mobilization

Each pallet was lifted by a 30 ton crane onto a flatbed truck which transited to the outboard south corner of the pier, where the crane offloaded each pallet and placed them on the sea floor. Five pallets comprising one mooring were placed at a time, the south mooring being accomplished first. Divers disconnected the crane hook from the pallet sling.

5.8.3 Pallet Installation

Two tag lines were connected to the pallet slings near the 2-1/4" chain and the lift wire was passed through the 100 kip sheave on the barge. A pusher boat located the barge near the pier with its lift wire over the pallet and a diver secured the lift wire to the pallet shackle connecting 4 sling wires. Using the deck winch and beach gear the pallet was lifted near the surface and the tag lines secured to deck cleats near the crane end of the barge. The barge was moved to the proper buoy marker maintaining directional control of the pallet by use of the tag lines. With the barge at dead stop the pallet was properly aligned towards the center of the mooring and lowered to the bottom and the lift wire disconnected by diver.

Each pallet in turn was placed as described above.

5.8.4 Construction Mooring

For purposes of placing the mooring buoys and connecting the chain legs the crane barge was used. A four point mooring was utilized for position control. The barge was moored with the crane facing away from the shore. Mooring anchors (6,000 pound Navy Stockless) were placed by the barge. A small boat was used to attach the barge anchor wires to the wire pendents attached to the anchors.

5.8.5 Chain Connection - Leg No. 1

1. The barge was warped into position near the anchor pallet for Leg No. 1
2. Divers cut the wire bands securing the 2-1/2" chain
3. The end of the 2-1/2" chain was lifted by the crane and secured to a deck cleat at the side of the barge

5.8.6 Chain Connection - Leg No. 2

1. The barge was warped into position near the anchor pallet for Leg No. 2
2. Divers cut the wire bands securing the 2-1/2" chain
3. The end of the 2-1/2" chain was lifted to the deck and secured to a deck cleat approximately 15' from the end of the chain
4. The end of the chain from Leg 2 was passed through the

equalizer and connected to the chain of Leg No. 1. The equalizer, with Legs 1 and 2 connected, was lowered over the side of the barge and connected to the deck cleat.

5.8.7 Chain Connection - Leg No. 3

1. The barge was positioned near the pallet for Leg No. 3
2. Divers disconnected the bands securing the 2-1/2" chain and ground ring.
3. The ground ring was lifted to the side of the barge (with the main crane hook) and secured to the deck cleat. The secondary hook was used to iift the 3-1/2" chain, which was secured to the deck.
4. A shackle previously assembled to the ground ring was connected into the top of the equalizer.

The last link of the 3-1/2" chain was connected to the bow lift wire and the equalizer was lowered onto the water and disconnected from the crane hook. A marker buoy line was secured to the ground ring, thus suspending the three primary legs below the bow with each leg towards its proper anchor pallet.

The forward barge mooring lines were slackened and using the stern mooring winches, the assembled legs and ground ring were pulled towards the center of tne mooring until the ground ring was approximately over the center mooring marker. The slack in the bow mooring lines were taken up and the stern mooring lines eased until the 3-1/2" chain hung perpendicular to the bottom. The wire strap holding the 3-1/2" chain, and the ground ring was lowered to the bottom, where it was disconnected.

5.8.8 Chain Connection Leg No. 5

The procedure for Leg No. 1 was used for No. 5.

5.8.9 Chain Connection Leg No. 4

The procedure for Leg No. 1 was used except that by diver a wire was passed through the spider plate eye and connected to the crane hook. The leg was then lifted to the deck where the 2-1/4" joining link on the spider plate was connected to Leg No. 5.

The spider plate was lifted to its maximum height with the crane which was centered on the barge. By slacking the barge stern mooring wires and tension the forward mooring lines, the barge was warped toward the marker buoy locating the ground ring. The crane wire was lowered as the barge moved forward allowing the chains to be laid on the bottom towards the ground ring. The spider plate was laid close to the ground ring.

Divers connected the spider plate shackle to the spider plate with the help of a com-a-long, and taking care that the connection be made in the proper orientation. By connecting a line to the bitter end of the 3-1/2" chain and using the deck winch the assembly was lifted so the ground ring was approximately 5' off the bottom. All connections were inspected by divers to confirm all was in proper order.

5.8.10 Installation of Modified Peg Top Buoy

Upon delivery of the modified buoys to the island further modifications were made on the island of Diego Garcia:

1. Top plate was burned to fit the hawse pipe

2. Top plate slot was opened for the 3-1/2" chain
3. Upper and lower hawse pipe inside reinforcing rings were removed, and the lower replaced with new rolled plate.

Then the following were checked:

1. Buoyancy control piping - securely in place and all valves closed
2. Exterior surfaces for paint damage - repaired by sanding and repainting
3. Anodes - securely in place
4. Buoy openings and manholes - all secured

The buoy was then transited from the storage area to the outboard end of the pier. Using a four part sling connected to the side lifting eyes, the buoy was lifted into the water. The buoy was then secured to the LCM-8 and moved to the side of the crane barge, where the four part sling was connected to the crane hook.

Since the buoy is not stable while floating, control was achieved by the use of tag lines whereupon it was made secure to the side of the barge, and increasing tension on the crane hook.

The auxiliary crane lifting wire was passed through the center pipe of the buoy and divers connected the wire to the last link of the 3-1/2" chain.

The 2" plugs of the four stand pipes on the buoy manhole covers were removed and the buoyancy control hose attached to the buoy piping whereupon all vent valves were opened.

Water was pumped into the buoy and the buoy was slowly submerged. As the buoy went below the water surface depth control was maintained by the crane. When the buoy was lowered to below the barge bottom the auxiliary crane lifting was tensioned in order to lift the ground ring just off the bottom.

Using the auxiliary lift wire as a guide wire the buoy was lowered to the bottom while the 3-1/2" chain was passed up through the buoy.

A diver placed a keeper bar through the top of the second 3-1/2" chain link to hold the chain, whereupon the auxiliary lift wire was disconnected.

Since the hawse pipe in the buoy was too small, namely 14" inside diameter, the usual rubbing casting could not be placed into the hawse pipe in the buoy bottom.

Then the buoy center pipe cover plate was placed by diver over the upper link of the 3-1/2" chain with the 2" x 3" reinforcing plates on the cover facing down. A 3-1/2" anchor joining link was then installed into the upper link of the 3-1/2" chain. By reconnecting the auxiliary lifting wire and tensioning it the keeper bar was removed. The lift wire was then slacked to lower the cover plate to the center pipe at the buoy deck. Then the auxiliary wire was again disconnected and the cover plate holes aligned with the threaded holes in the buoy by using a pry bar to turn the chain. Whereupon divers secured the plate with six bolts. The main lift was disconnected.

By blowing air into the buoy, the buoy was slowly brought up to the surface until it was afloat and all water removed from the interior. An anchor joining link and a F-shackle were connected to the 3-1/2" riser chain at the top of the buoy. All buoyancy control piping was removed and the plugs secured. The manhole inspection plates and stand pipes were removed. The interior was dried after removing all residual water.

5.9 Installation of Foam

Urethane foam, a commercial product known as "Insta-Foam, Forth-Pak" (Insta-Foam Products, Inc., Joliet, Illinois 60435) in kit form was shipped to the site. Foam was then sprayed into the buoy interior following manufacturers instructions and observing all warnings and precautions and keeping nozzle approximately 18" to 24" away from the surface being sprayed. All manholes were then secured. The south buoy was filled to 75% of the interior space and stopped due to material shortage. The buoy was later completely filled by UCT-2 DET. Diego Garcia personnel.

5.10 Cathodic Protection

With buoy in a no load condition final assembly of the cathodic protection system was performed by divers as follows:

All clamps were checked by diver to confirm each was secure. See Figure 13.

5.11 Pallets

All timber pallets were removed by lifting with barge pulling winch (and beach gear) and pulling pallet with line connected to LARK.

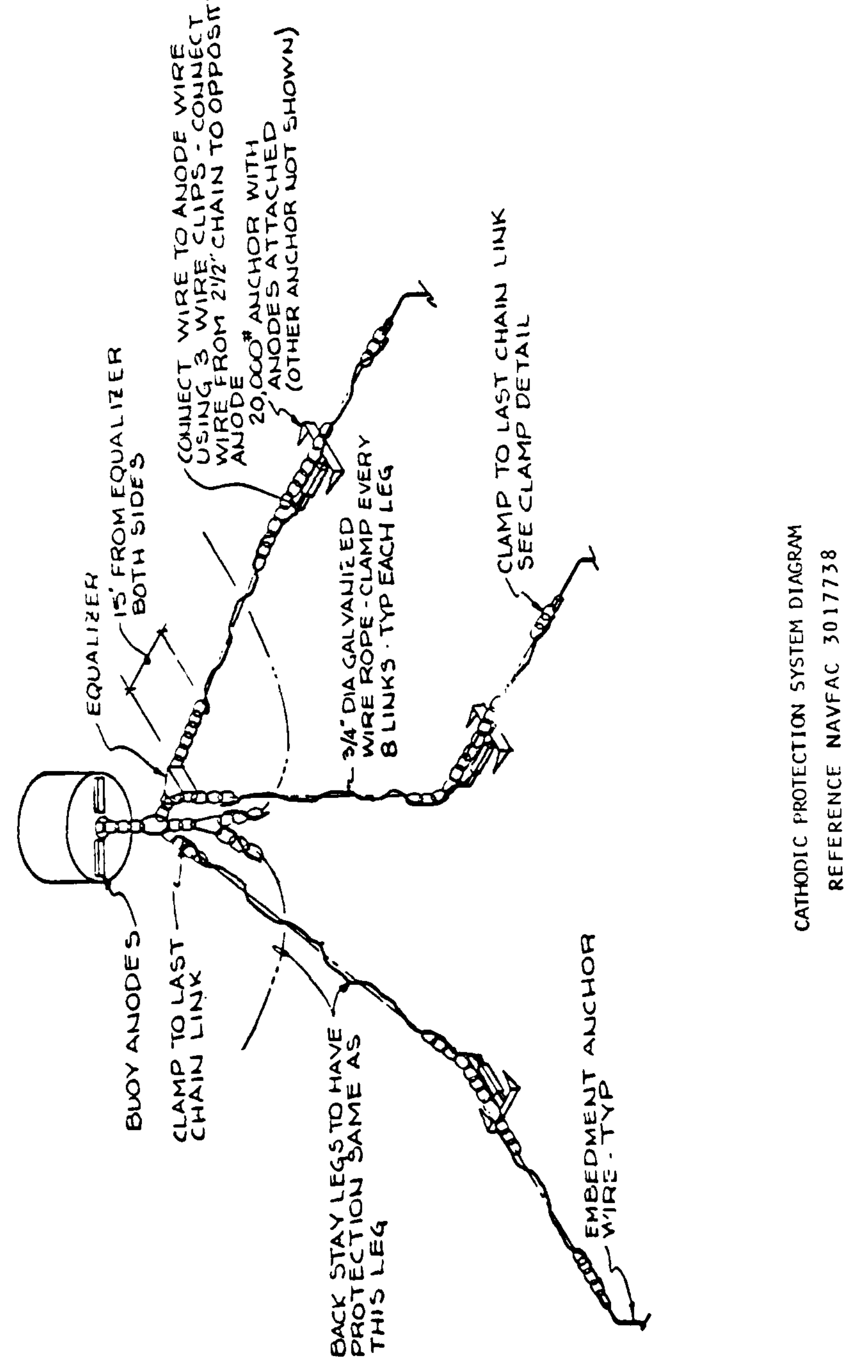


Figure 13 - Cathodic Protection

6.0 MOORING INSPECTION

6.1 Inspection

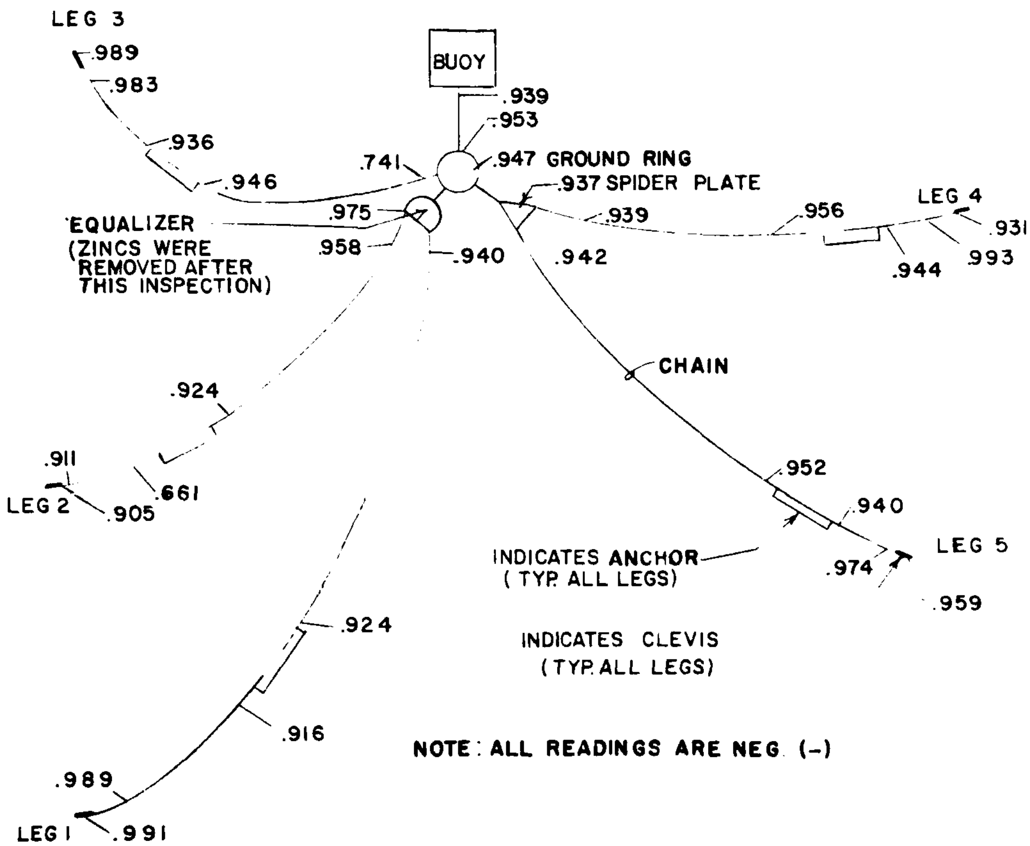
A mooring inspection was made to document the final placement and as-built construction of the mooring using manual measurement and photographs and including the following:

1. Survey of final buoy location - See Tables 1 and 2.
2. Electrical potential readings by use of underwater voltmeter of the cathodic protection system. See figures 14 and 15.
3. Still photographs of each major mooring component. See photographs, 1 to 5, pages 50 to 54.
4. Through visual inspection, all cotter pins and hardware pins

Some of the photographs, item 3 above, were made during progress of the installation.

6.2 Voltmeter

The underwater voltmeter mentioned in item 2 above was an instrument which measured the electrical potential readings of the various components of the chain moorings for purposes of determining corrosion potential. For steel, of which the chain and fittings were made, a potential reading of -0.800 volts is usually considered to indicate complete protection. Potentials above -0.800 (such as -0.700 volts) indicate underprotection and potentials under -0.800 (such as -0.900 volts) indicate overprotection. Actual readings, shown on figures 42 and 43, indicated adequate protection, and after the test the zincs on the equalizer were removed.



SOUTH BUOY MOORING

Figure 14
South Buoy - Voltmeter Readings

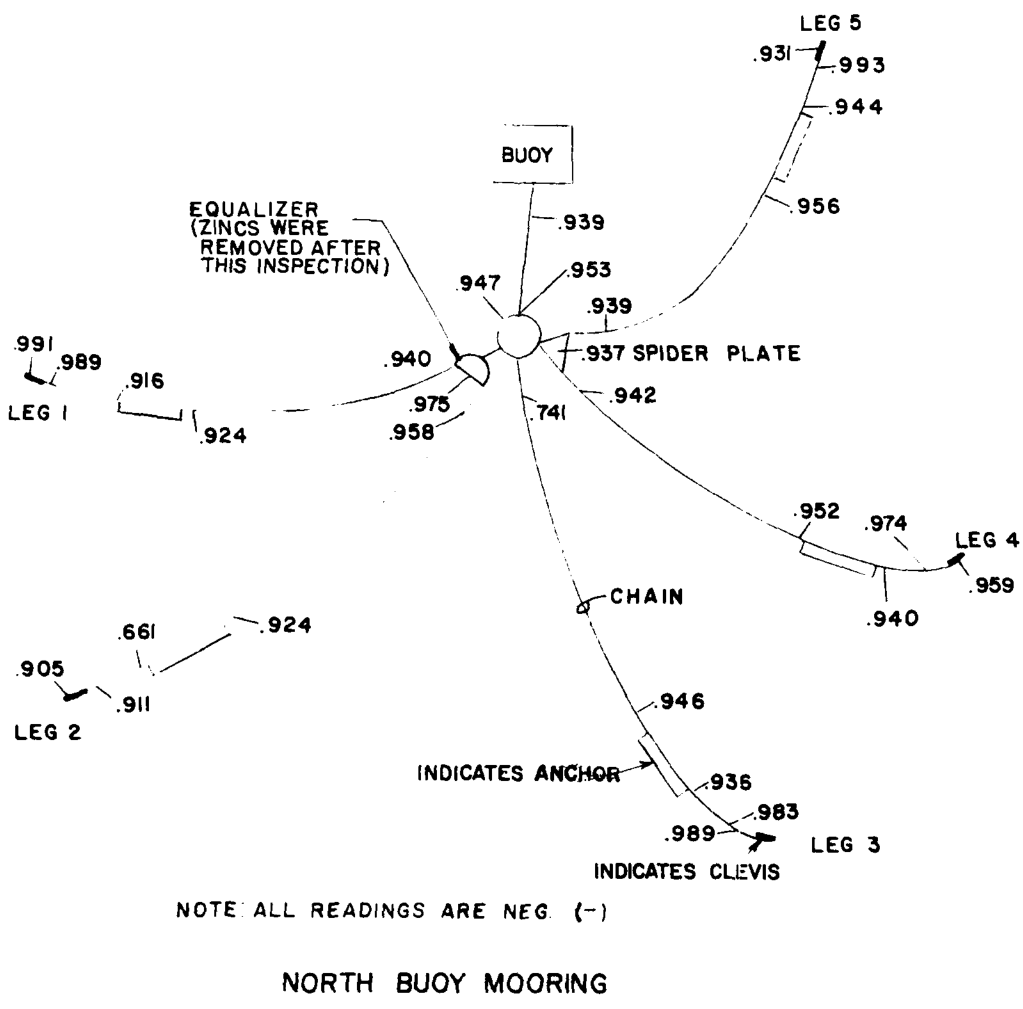


Figure 15
North Buoy - Voltmeter Readings

The probe used with the voltmeter was a titanium probe which had a silver/silver chloride reference electrode near the base of the probe in the probe holder. When the probe was brought into contact with the metal components of the chain mooring the readings measured the potential difference between the metal contacted by the titanium probe and the silver/silver chloride electrode. When the titanium probe was not touching the metal the readings indicated the potential difference of the titanium probe and the silver/silver chloride electrode. The silver/silver chloride electrode has a known potential in seawater so that the readings of potential difference could be converted to the potential of the metal of the components of the chain mooring. A titanium probe was used because of its polarization characteristics, namely, that the potential readings of the titanium probe changes so quickly (in less than one second) when making contact with the metal of the moorings that readings of the metal can be had almost instantaneously.

It should be noted that to insure getting good readings the metal contacted was cleaned of fouling or corrosion products and paint and the probe was such that it was used as a scraper. The probe was such that it could stand moderate abuse when used as a scraper. Lack of good contact was detected by noting the stability of the potential readings indicated on the voltmeter. If the indicated potential drifted more than 0.010 volts over a short period, particularly if it shifted rapidly between a high and low value then good contact between the probe and the metal was probably not being maintained.

7.0 LESSONS LEARNED

The remote location and limited equipment assets of Diego Garcia created a unique construction environment which imposed demand on personnel, equipment and the construction scenario. The lessons learned from the project are in many cases relative to these demands.

1. The involvement of the military construction force (Underwater Construction Team 2) in the early phase of project planning allowed direct input of detailed construction procedures, personnel capabilities, and the benefit of underwater construction expertise. This early interaction should be required on all construction projects at a remote site.

2. The use of the Design Manual, NAVFAC DM-26 proved not very useful in that it is outdated. For purposes of interchangeability many parts were not compatible. Many parts were not available. The market place now has new types of steel and products not reflected in the manual.

3. Thorough inspection of every component and/or total preassembly is suggested prior to deployment. Preassembly should include exact component identification in plain language including multi-pak items.

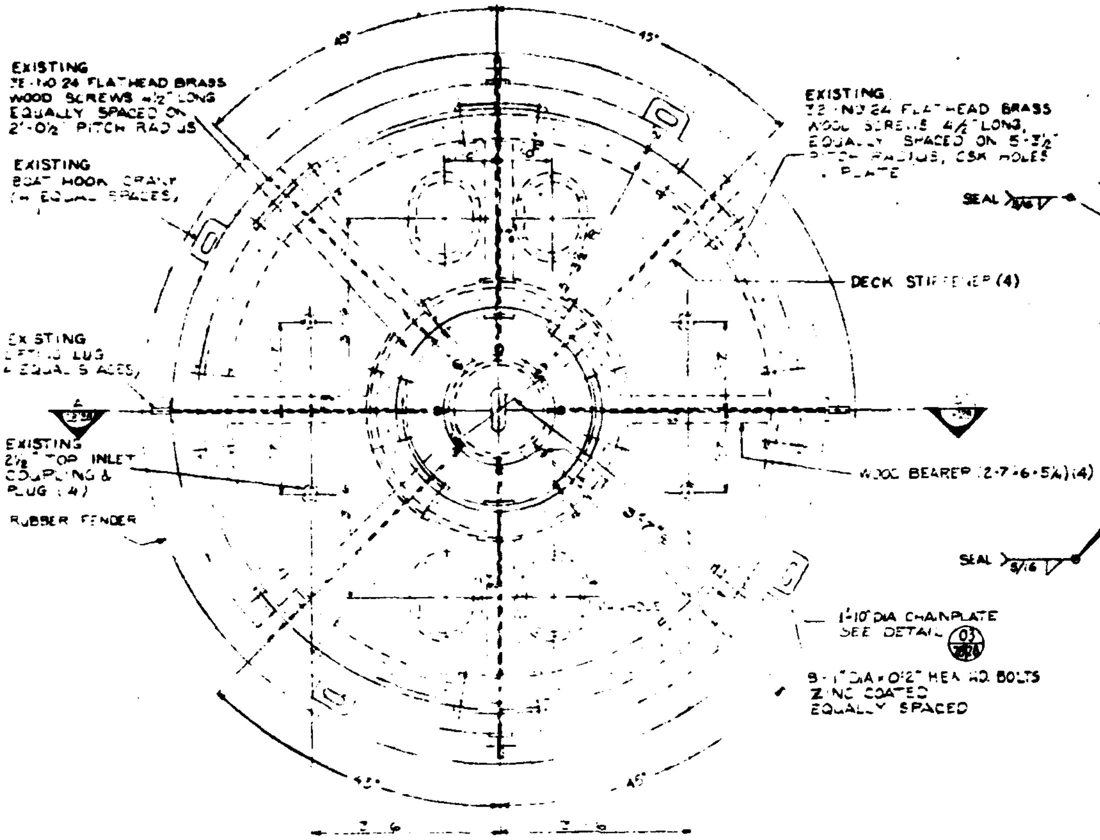
4. A site visit in the project planning phase allowed early identification of resource requirements, project support assets, site storage areas, organizational planning, and

direct communication with on-site personnel.

5. Direct communication between working level components of organization allowed direct access to schedule changes, design component alternatives and ready access to informational demands. Close working cooperation of all organizations and frequent planning meetings were most beneficial.

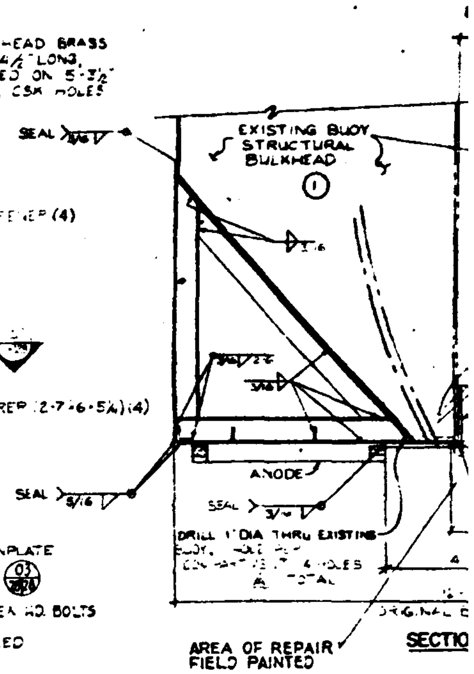
6. Construction work in an isolated location places a high demand on spare parts. Spares for all components and in-particular for all connecting links and assembly components for these links need to be procurred and shipped.

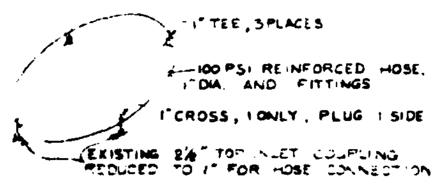
7. Environmental conditions require consideration when using mix chemical compounds relative to application techniques and yield rate/volumes. Any compounds that are subject to deterioration due to shelf life and/or temperature and humidity variability should be control shipped and redundancy in quantity ordered for possible inadvertent deterioration during shipping.



TOP VIEW

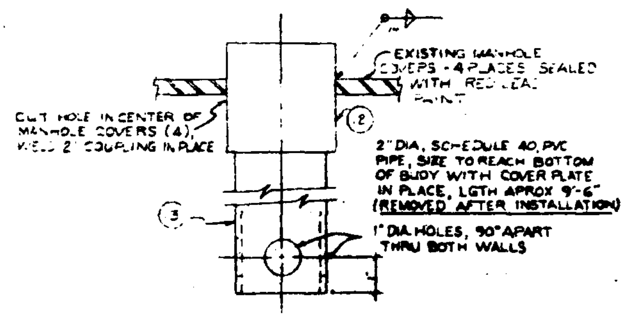
SCALE 3/4" = 1'-0





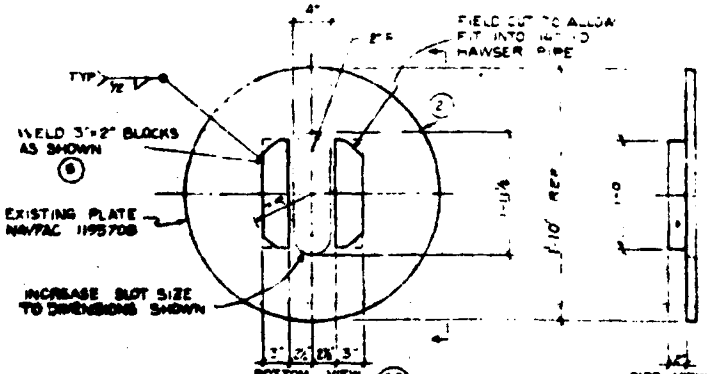
CONNECTION DIAGRAM
BUOYANCY CONTROL SYS.

CONTRACTOR TO SUPPLY & INSTALL
(REMOVED AFTER USE)



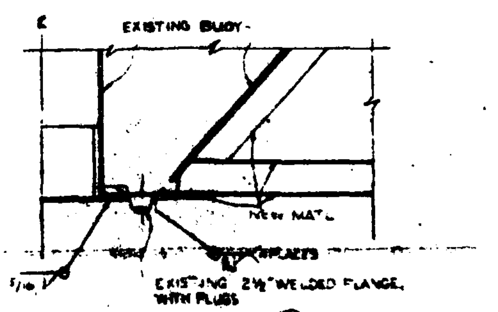
BUOYANCY CONTROL STANDPIPE (NTS) 04

4 REQ'D.



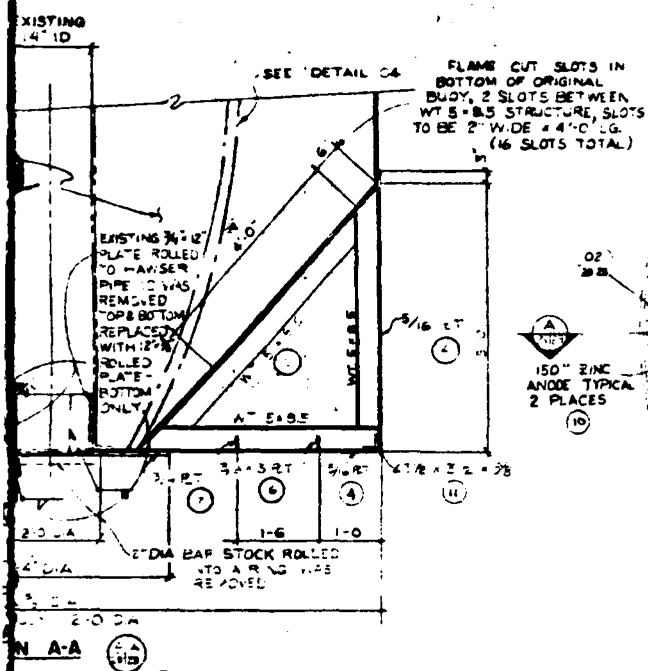
CHAIN PLATE

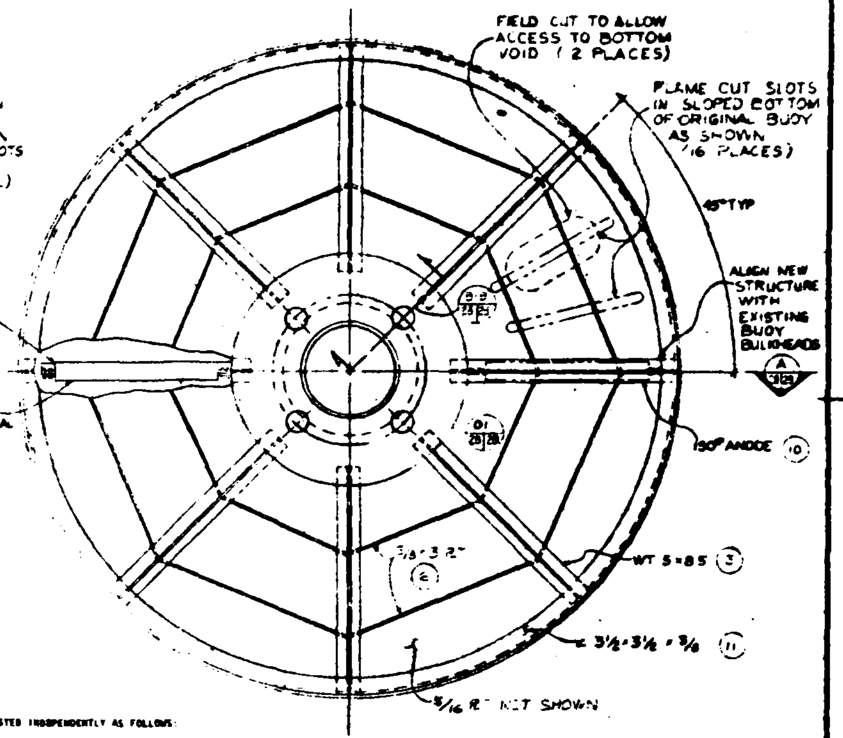
MODIFY EXISTING BUOY CHAIN PLATE TO DIMENSIONS SHOWN
SCALE 1 1/2" = 1'-0



SECTION B-B

SCALE 1" = 1'-0





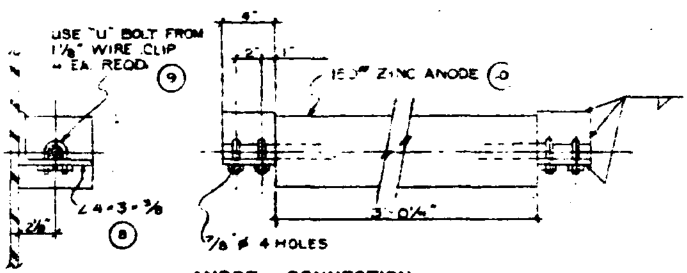
BUOY MODIFICATION

BOTTOM VIEW

SCALE 3/4"=1'-0

TESTING: BEFORE PAINTING, EACH COMPARTMENT OF THE EXISTING BUOY SHALL BE TESTED INDEPENDENTLY AS FOLLOWS:

1. INSTALL A STANDPIPE IN THE TOP 2-1/2" INLET SO THAT THE END OF THE PIPE IS 3 FEET ABOVE THE HIGHEST POINT OF THE BUOY WHEN THE BUOY IS SUPPORTED WITH ITS SHORT AXIS VERTICAL.
2. FILL COMPARTMENT WITH FRESH WATER BY MEANS OF FITTINGS ATTACHED TO THE BOTTOM 2-1/2" INLET UNTIL WATER OVERFLOWS AT THE TOP OF THE STANDPIPE.
3. EXAMINE ALL JOINTS FOR TIGHTNESS, REPAIR ALL LEAKS AND RETEST AS REQUIRED
4. EMPTY THE COMPARTMENT AND DRY THE INTERIOR THOROUGHLY.
5. WHEN MODIFICATION IS COMPLETED: FILL THE INTERIOR OF THE ADD-ON VOLUME WITH WATER AND CONFIRM ALL WELDS ARE WATERTIGHT. REPEAT STEP 4.



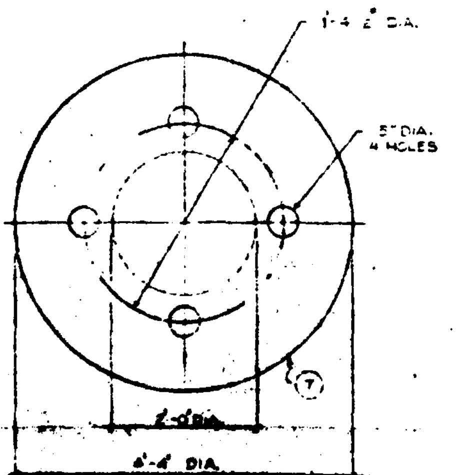
ANODE CONNECTION
TYPICAL 2 PLACES
SCALE 3/4"=1'-0

NOTES

1. WELDING - WELDING TO BE COMPLETED PER
   A. AMERICAN WELDING SOCIETY (AWS) CODE D1.0 (CODE FOR WELDING IN BUILDING CONSTRUCTION).
2. MATERIAL - STRUCTURAL STEEL SHALL BE ASTM A36.
3. CONTRACTOR SHALL CONFIRM ALL DIMENSIONS AND MATERIAL QUANTITIES REQUIRED. BUOY TO BE MODIFIED IS IN USED CONDITION.
4. TREATMENT AND PAINTING:
   A. CLEAN EXTERIOR SURFACES BY DRY ABRASIVE BLASTING TO WHITE METAL CONDITION AS DEFINED BY SSPC-SP5-63 (STEEL STRUCTURES PAINTING MANUAL, STEEL STRUCTURES PAINTING COUNCIL).
   B. PAINT EXTERIOR SURFACES USING NAVY EPOXY-POLYAMIDE SYSTEM PER MIL-P-24441, LATEST REVISION. FIRST COAT SHOULD BE GREEN PRIMER (FORMULA 150); THE SECOND HAZE GRAY (FORMULA 151); AND THE THIRD, WHITE (FORMULA 152). PAINT TO BE SUPPLIED FROM MANUFACTURER PER QUALIFIED VENDORS LIST.
   C. INTERIOR - THE CONTRACTOR SHALL THOROUGHLY INSPECT THE INTERIOR SURFACE OF THE BUOY. THE INTERIOR SHALL BE CLEANED AND DRIED. CORROSION SHALL BE REMOVED AND REPAINTED PER A AND B ABOVE, TO THE BEST EXTENT POSSIBLE DUE TO LIMITED ACCESS THROUGH INSPECTION MANHOLES.
   D. AREAS REQUIRING FIELD CUTTING WERE REPAINTED USING RED-LEAD PAINT.

LIST OF MATERIALS
(MATERIAL REQUIRED FOR ONE BUOY MODIFICATION)
(TWO BUOYS REQUIRED)

ITEM	QUANTITY	DESCRIPTION	SUPPLIER
1	1	BUOY, PEG TOP, NAVFAC DWG 1195707	[illegible]
2	1	CHAIN PLATE, NAVFAC DWG 1195708 (PART OF ITEM ONE)	
3	125 L.F.	STRUCTURAL TEE, WT 5 x 8.5	
4	315 S.F.	PLATE, ASTM A-36, 5/16" THICK	
5	2	BAR STOCK, 2 x 3 x 12"	
6	52 L.F.	PLATE, ASTM A-36, 3/8" THICK X 3"	
7	1	PLATE, ASTM A-36, 3/8" THICK x 4'-4" DIA.	
8	4 L.F.	STRUCTURAL ANGLE, 4 x 3 x 3/8"	
9	2	WIRE CLIP, 1-1/8" DIAMETER WIRE (GALVANIZED)	CROSBY OR EQUAL
10	2	ANODE ZINC, 150 POUNDS NATURAL PER MIL-A-18001 (ZINC)	[illegible] P/N [illegible]-150 OR EQUAL
11	1	STRUCTURAL ANGLE 3-1/2 x 3-1/2 x 3/8 ROLLED TO 12'-0" O.D.	
12	4	COUPLING, 2" PIPE, STEEL	
13	4	PIPE, 2" SCH 40 PVC, 10'-0" LG	



BOTTOM COLLAR
MATL. 3/8 PL
SCALE 1"=1'-0

AS BUILT DWG. BY [illegible]

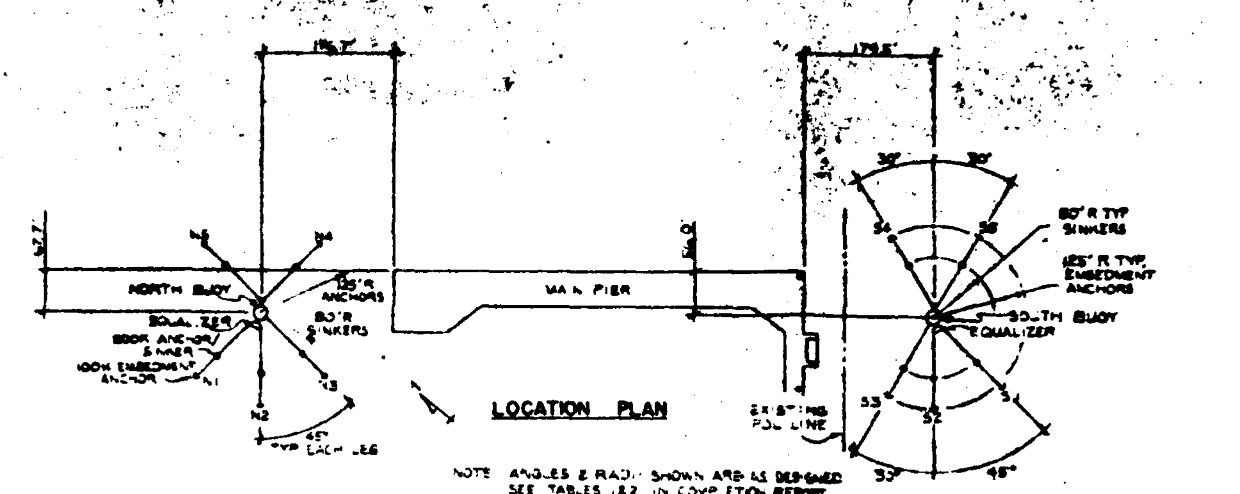
REVISIONS

A	REMOVE FOAM NOTE, ADD [illegible]
	ADD STANDPIPES AND [illegible] IN BUOY

CHESAPEAKE DIVISION

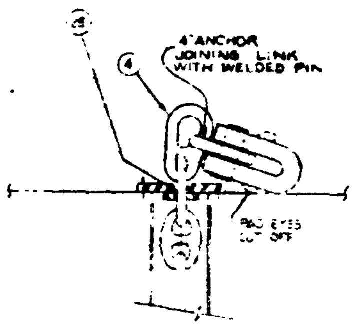
PEG TOP BUOY
AS BUILT DRAWING

F 80091 3017728

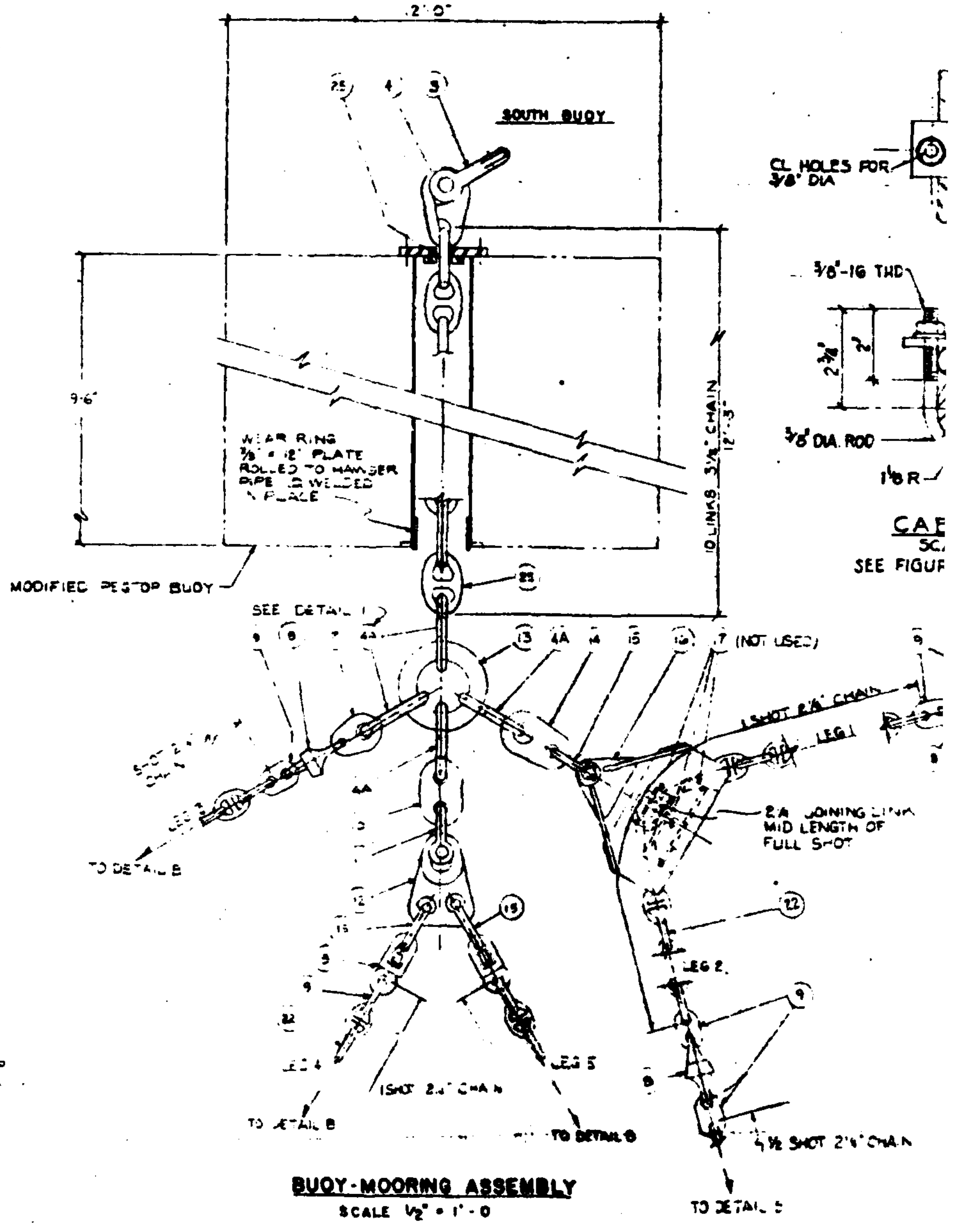


LOCATION PLAN

NOTE: ANGLES & RADII SHOWN ARE AS DESIGNED. SEE TABLES 1&2 IN COMPLETION REPORT DATED NOV 1980 FOR ACTUAL SURVEY OF ANCHORS & SINKERS AS PLACED.

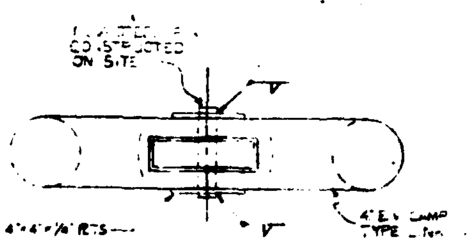


NORTH BUOY

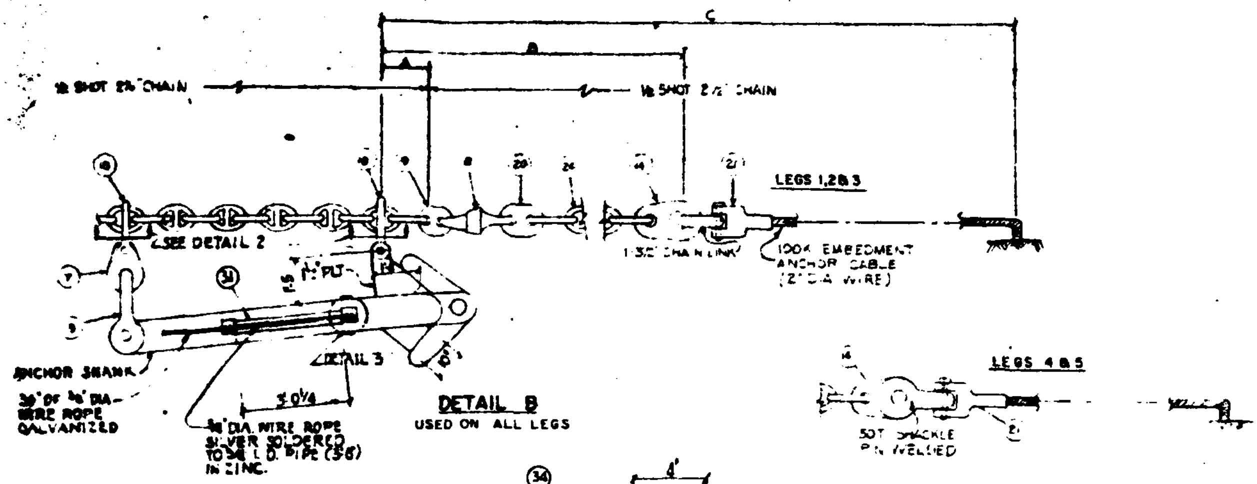


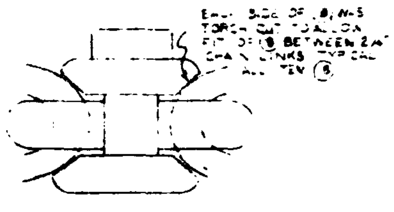
BUOY-MOORING ASSEMBLY

SCALE ½" = 1'-0

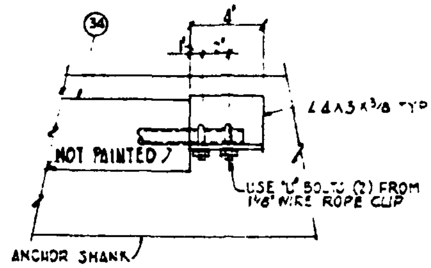


DETAIL 1
ITEM 4-A





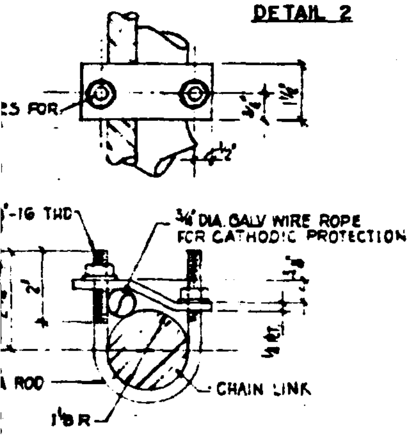
DETAIL 2



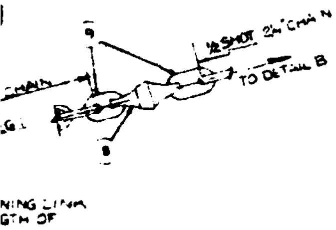
ANODE CONNECTION

TYPICAL 2 PLACES CENTER ANODE ON ANCHOR SHANK
SCALE 1/4

DETAIL 3



CABLE CLAMP
SCALE ½
SEE FIGURE 13 IN REPORT



LEG NO	DIMENSION A	DIMENSION B	DIMENSION C
SOUTH BUOY			
1	8'-1½"	88'-2"	107'-0"
2	8'-1½"	32'-0"	58'-0"
3	5'-1½"	30'-11"	50'-0"
4	5'-9"	29'-3"	58'-0"
5	5'-9"	29'-0"	52'-0"
NORTH BUOY			
1	3'-2½"	27'-4"	60'-0"
2	3'-2½"	21'-6"	46'-0"
3	0'-6"	32'-8"	57'-9"
4	0'-9"	13'-3"	33'-4"
5	0'-9"	31'-0"	51'-0"

	NORTH BUOY					SOUTH BUOY				
LEG	1	2	3	4	5	1	2	3	4	5
1										
2										
3			1-U					1-U		
4	1-U		2-U	1-U		1-U		2-U	1-U	
5										
6	NOT USED					NOT USED				
7	1-U	1-U	1-U 3½" 1-N			1-U	1-U	1-U 1-N		
8	2-N	2-N	2-N	2-N	2-N	2-N	2-N	2-N	2-N	2-N
9	3-N	3-N	2-N	2-N	2-N	BALT 3-N	3-N	2-N	2-N	2-N
10				NACO 1-N					1-N	
11				1-N					1-N	
12				1-N					1-N	
13			1-N					1-N		
14	2-N	1-N	1-N	1-N	1-N	1-N 1-N	1-N	1-N	1-N	1-N
15	1-N			1-U	1-N	1-N			1-U	1-N
16	1-N					1-N				
17	NOT USED					NOT USED				
18	2-NM	2-NM	1-N 1-NM	1-N 1-NM	1-N 1-NM	1-NM 1-N	2-NM	2-NM	2-NM	1-N 1-NM
19	1-U	1-U	1-U	1-U	1-U	1-U	1-U	1-U	1-U	1-U
20	1-U	1-U	1-U	1-U	1-U	BALT 1-U	1-U	1-U	1-U	1-U
21	1-U	1-U	1-U	1-U	1-U	1-U	1-U	1-U	1-U	1-U
22	NACO 1-N		NACO 1-N			NACO 4-N-LO		NACO 1-N	NACO-U ½AL-U	1-N AL MC
23	PW 1-AL	NACO 1-N				MC 1-AL	CSW-PW 1-AL			
24	1-U	CSW 1-U	SL 1-U	SL 1-U	SL 1-U	SL 1-U	SL 1-U	SL 1-U	AL 1-U	AL 1-U
25			1-N						1-N	

NOTES:
N - NEW
U - USED
AL - A-LINK
SL - STUD LINK
LO - LIGHT OIL COAT
NM - NEW MODIFIED
PW - PAINTED WHITE
MC - MASTIC COAT
CSW -
NACO -

*REQUIRED BURNING, HEATING & JACKHAMMERING TO OPEN

LIST OF MATERIALS

ITEM	QTY	DESCRIPTION	IDENT.
1	2	BUOY, MODIFIED PEGTOP	REF NAVFAC 3017728
2		NOT USED	
3	2	F SHACKLE	FSN 2C4030-640-9629
4	8	ANCHOR JOINING LINK 3½"	FSN 2C4010-809-6828 BALTS CAMP
5		NOT USED	
6	2	RUBBING CASTING 3½"	FSN KZ4030-640-9620
7	8	ANCHOR JOINING LINK 2¼"	FSN 2C4010-391-0534
8	20	SWIVEL 2¼"	FSN 2C4030-527-8864
9	24	JOINING LINK 2¼"	FSN 2C4010-391-0642
10	2	JOINING LINK 3½"	FSN 2C4010-809-6927
11	2	SHACKLE, ROUND PIN 3½"	BALT INC. OR EQUAL
12	2	SPIDER PLATE	
13	2	GROUND RING	FSN 2C2040-527-0617
14	12	ANCHOR JOINING LINK 2½"	FSN 2C4010-391-0636
15	6	SHACKLE, ROUND PIN 2½"	BALT INC. OR EQUAL
16	2	EQUALIZER	CIVENGLAB DWG 74-37-2F (SEU)
17	24	ZINC ANODE, TYPE ZHC, NOT USED	MIL-A-18001
18	20	SINKER SHACKLE	FSN 2C4030-267-7076
19	10	ANCHOR WITH SHACKLE 20,000LB MODIFIED BY NAVFAC DWG 3017737 WITH ANODES (2)	FSN H2040-388-4775
20	10	JOINING LINK 2½"	FSN 2C4010-391-0648
21	10	PROPELLENT EMBEDMENT ANCHOR SYS	REF NAVFAC MANUAL, 100K SYS
22	8	ANCHOR CHAIN - 90' OF 2¼"	FSN 2C4010-240-1030
23	4	" " - 45' OF 2¼"	FSN 2C4010-240-1036
24	10	" " - 45' OF 2½"	FSN 2C4010-240-1036
25	2	" " - 13' OF 3½"	FSN 2C4010-282-2886
26		NOT USED PER REV B	
27	4	BOLT, ¾" ø x 18"	FSN 5306-174-9561
28	4	NUT, ¾"	FSN 5310-260-7900
29	4	WASHER, ¾" LOCKING	FSN 5310-013-6906
30		NOT USED	
31	172	CLAMP, NAVFAC 3017738-02	
32	1800'	WIRE ROPE, ¾" DIA, GALVANIZED	
33	100	WIRE ROPE CLIPS - ¾" WIRE	
34	20	ANODE, 150#	HARCO P/N PZ150 OR EQUAL

	AS BUILT DWG BY BEGIER GIDDLE + QUIRIN	DEC 1980	
REVISIONS			
SYMBOL	DESCRIPTION	DATE	APPROVED
A	ADDED 10K ANCHOR TO LEGS 1,2,3 & 5-2	9-3-79	
B	USE 1-20K ANCHOR EACH LEG	10-3-79	

DESIGNED BY
DRAWN BY
CHECKED BY

DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
CHESAPEAKE DIVISION
WASHINGTON, D.C.

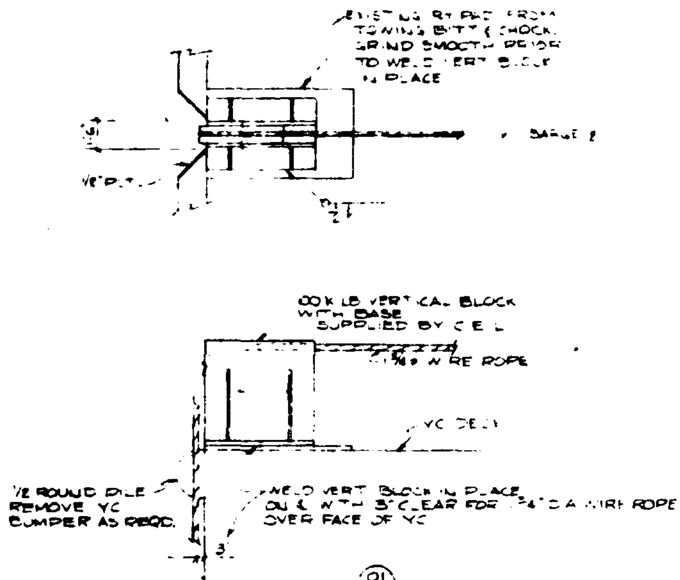
BUOY-MOORING ASSEMBLY
AS BUILT DRAWING
DIEGO GARCIA BIOT

APPROVED DATE
APPROVED DATE

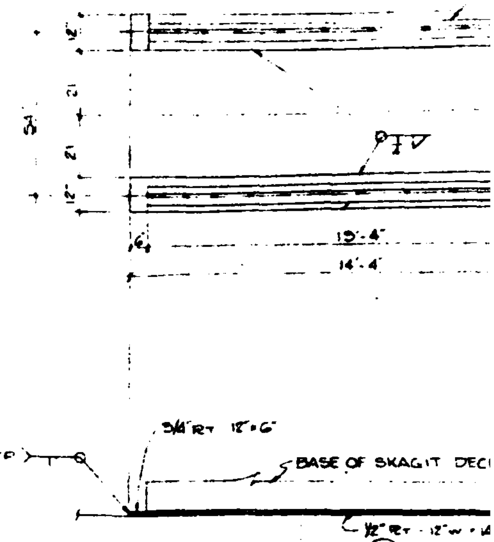
SIZE	CODE IDENT NO	NAVFAC DRAWING NO.
F	80091	3017737
		CONSTR. CONTR. NO
SCALE		SPEC	SHEET 1 OF 1

2¼" CHAIN

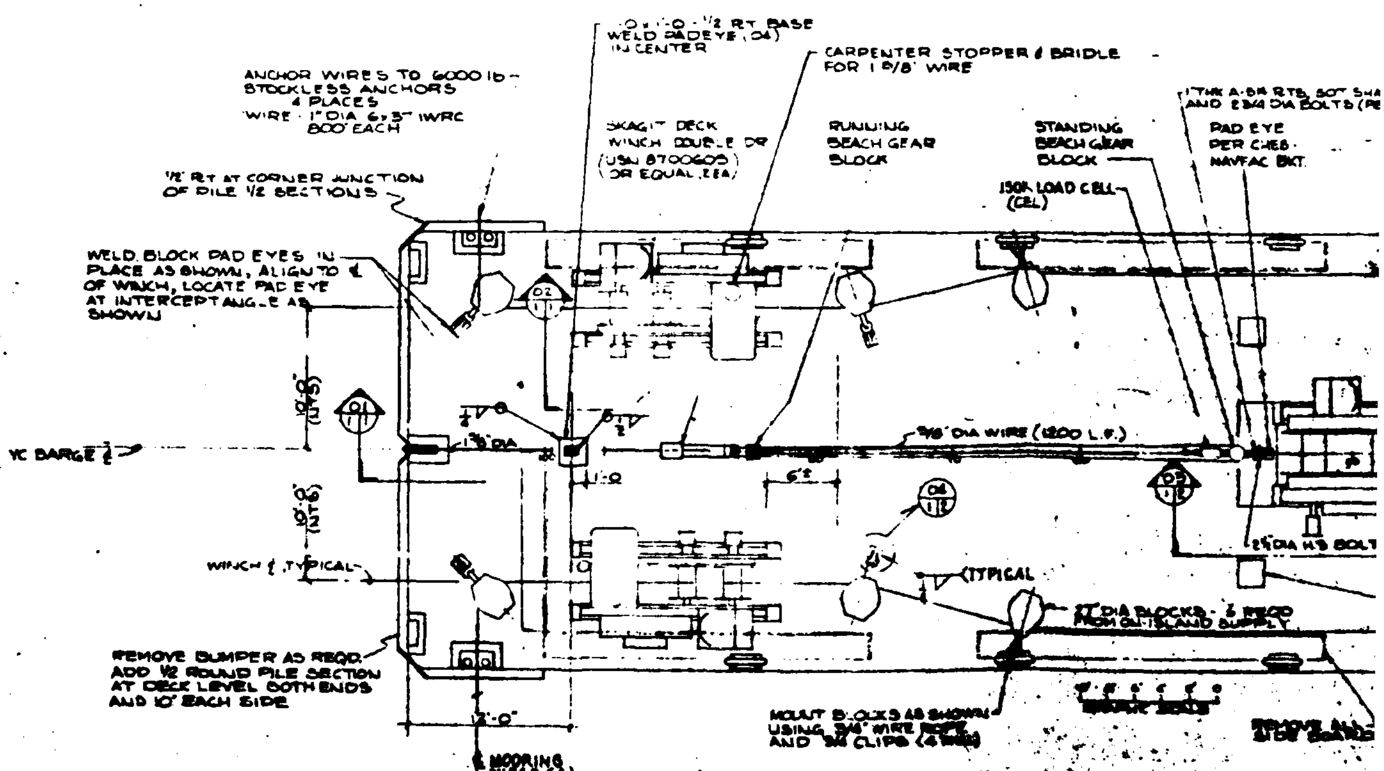
2



01
VERTICAL BLOCK DETAIL
SCALE: 1/2"=1'-0"

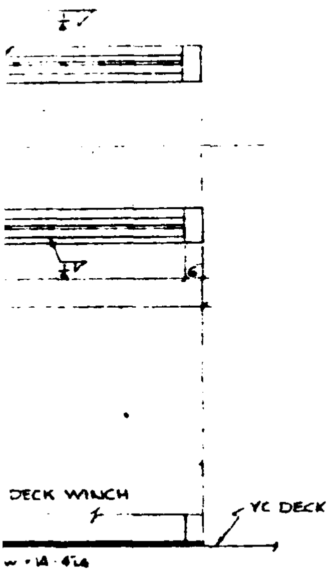


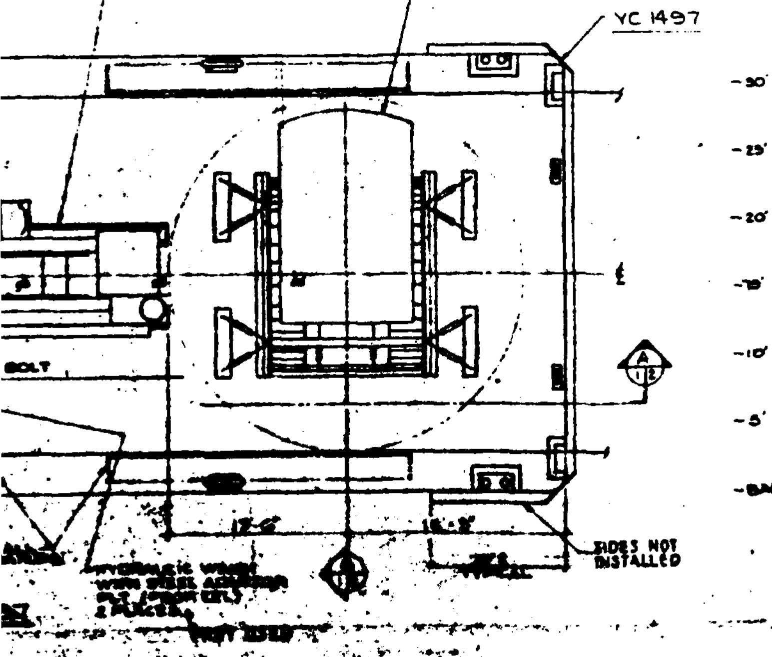
02
WINCH MOUNTING D
MOORING WINCH
TYPICAL 2 PLACE
SCALE 1/2"=1'-0"



DECK PLAN - YC 1497
SCALE 1/16"=1'-0"

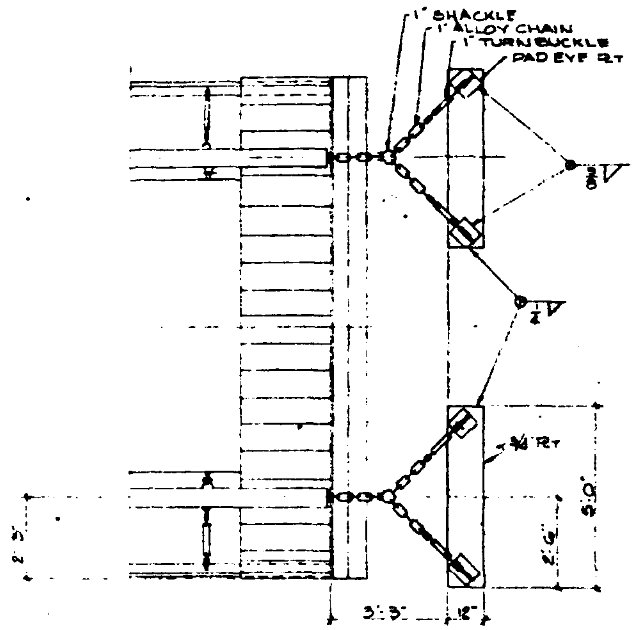
REVISIONS			
SYMBOL	DESCRIPTION	DATE	APPROVED





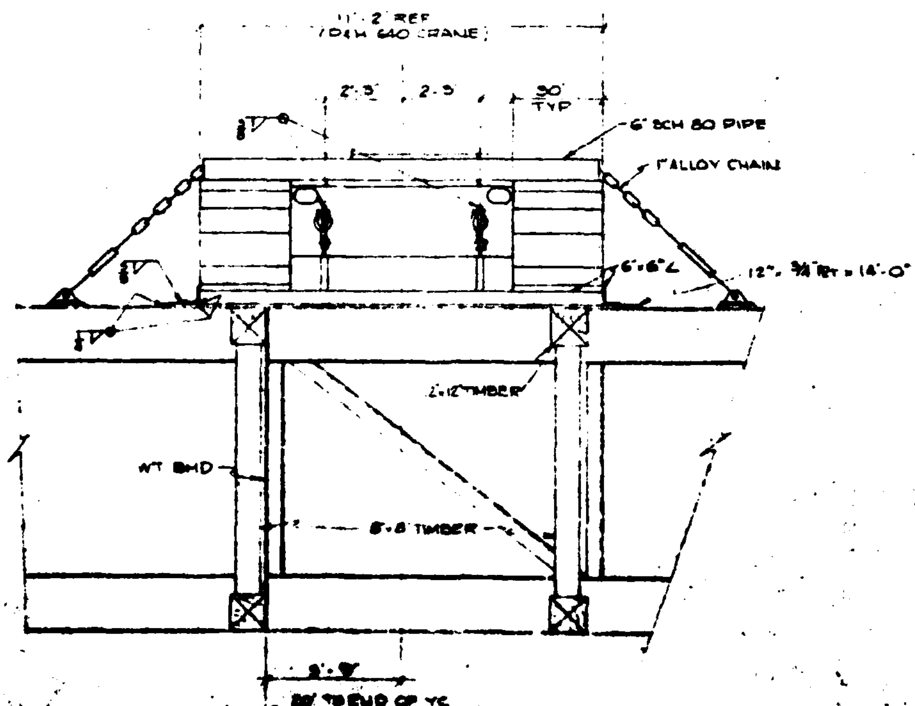
NOTES:

1. UNLESB OTHERWISE UOTED; ALL MATERIAL ASTM-A36 STEEL; ALL FIELD WELDS; ALL WELDS USE E70XX ELECTRODE
2. TOURCH HEAT AREA OF WELD TO 180°F MIN TO COMPLETELY DRY AREA. ELECTRODE MUST BE DRY.



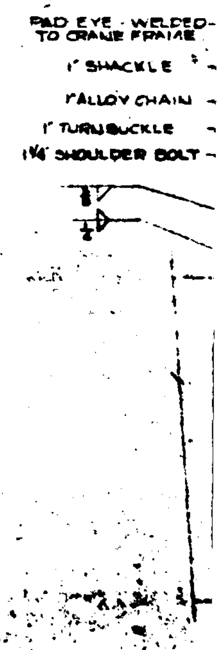
‡ - SYM ABOUT ℄

PLAN-DECK PLATES

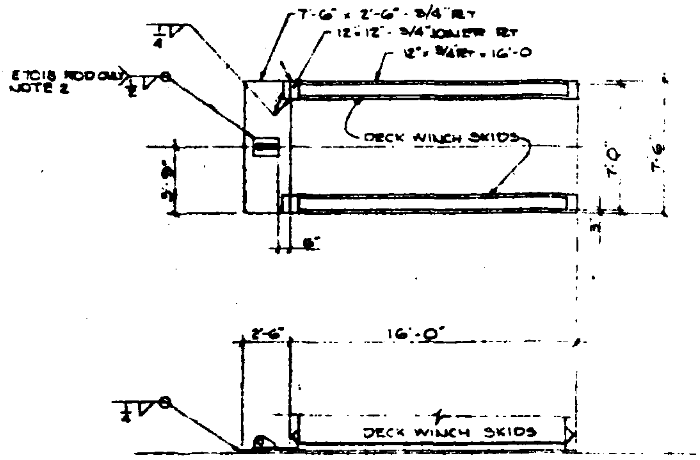


SECTION A
CRANE HOLD DET'L
SCALE 3/8"=1'-0"

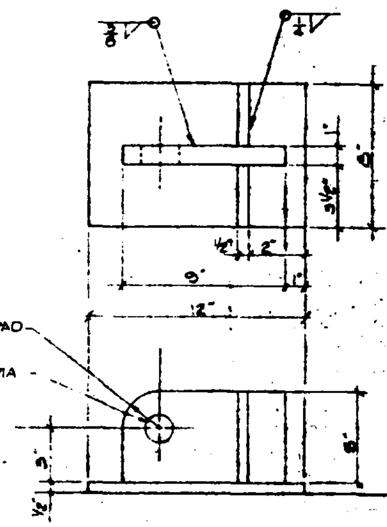
USE E70...
SEE NOT...



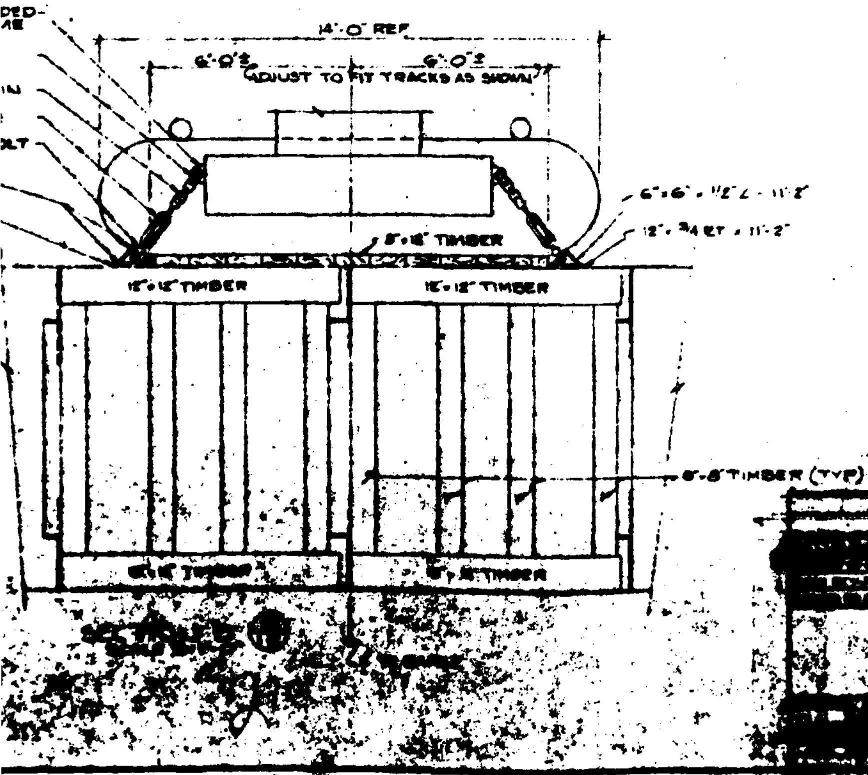
REVISIONS			
SYMBOL	DESCRIPTION	DATE	APPROVED

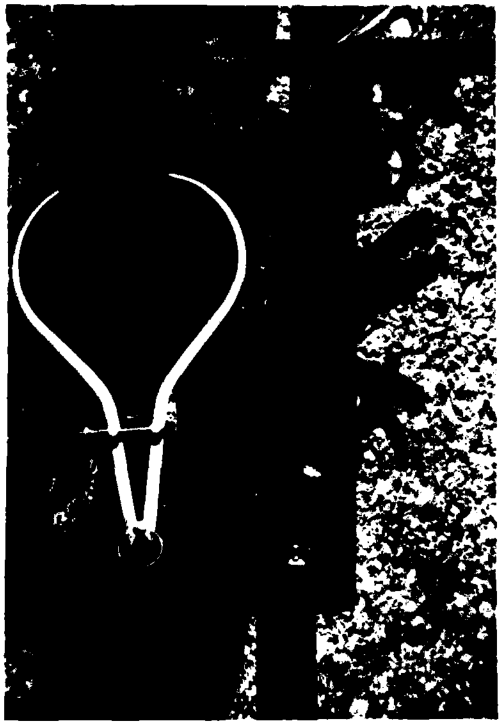


WINCH MOUNTING DETAIL
SCALE 1/4"=1'-0"

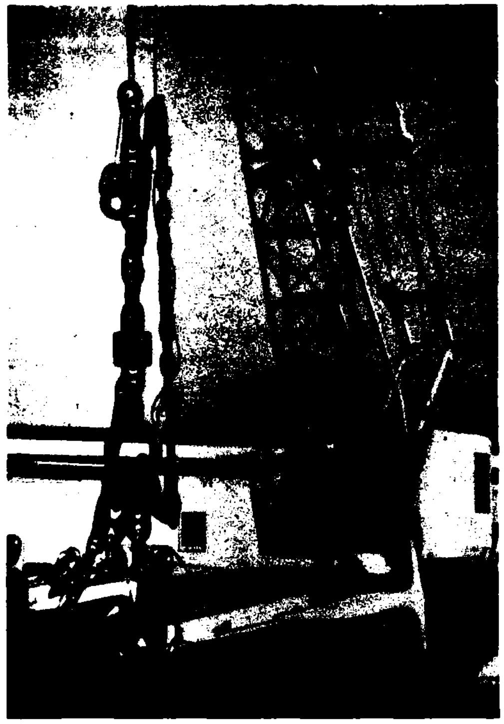


DECK PAD EYE
SCALE - 1/4"
5 REQD
MATL - A36 STL PLT
NOTE - BUILD 1 SPARE - 6 TOTAL

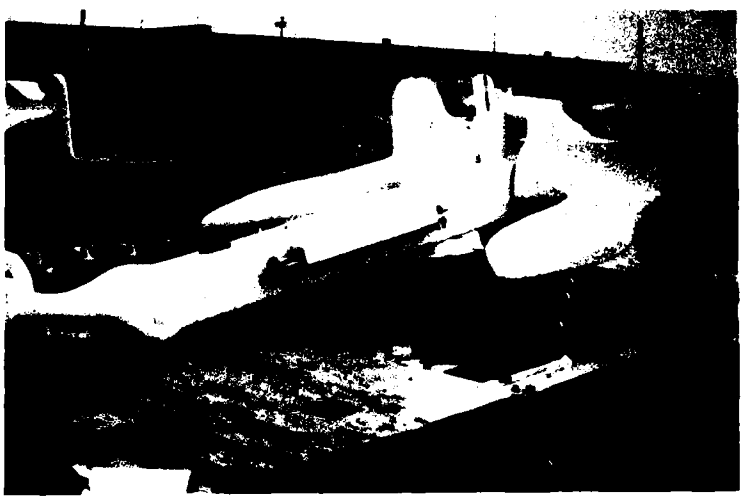




No. 1 Measurement of Chain

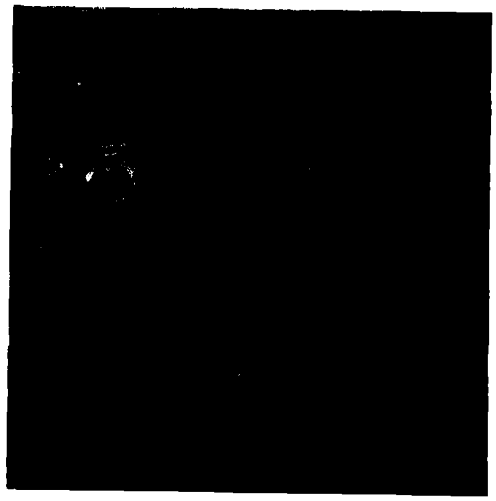


No. 3 Chain laid out on Pallet



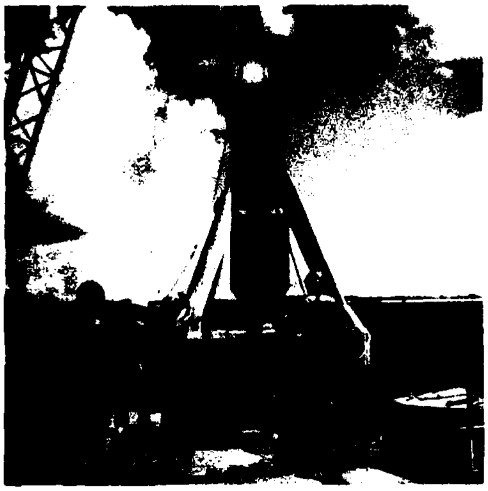
No. 2 Sinker (anchor) on Pallet

No. 4 Shackle connecting sinker to chain

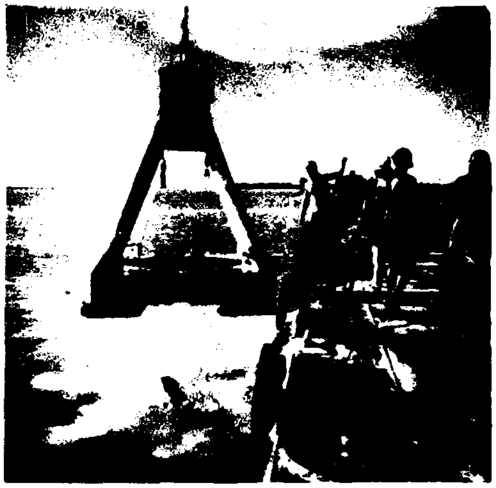


No. 6 Barge - bow sheave and beach gear

No. 5 Pallet on flat bed



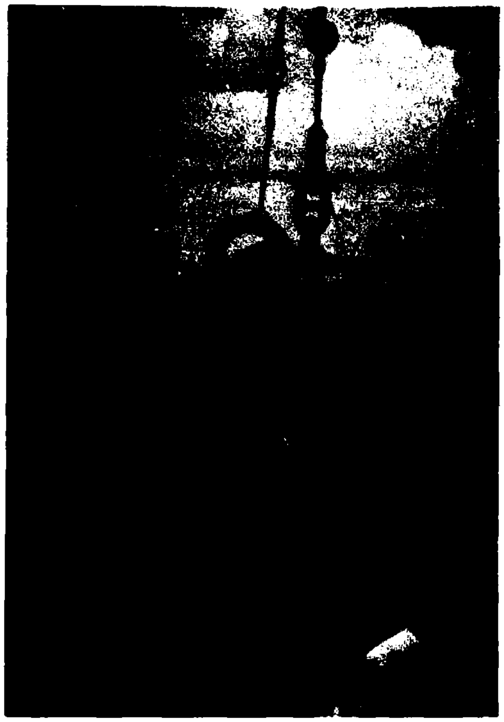
No. 7 Barge - lowering embedment anchor launch vehicle



No. 8 Barge - lifting launch vehicle after shot

No. 9 Barge - handling Equalizer and legs no. 1 and 2

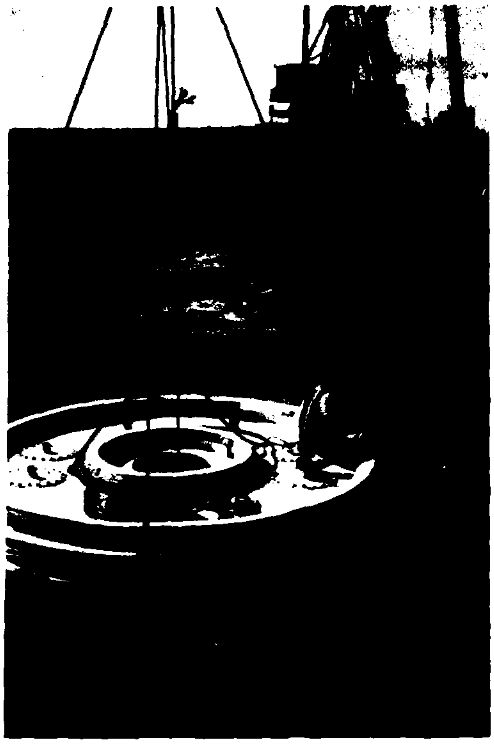
No. 10 Barge - ground ring and leg no. 3 and 3-1/2 inch chain



No. 11 Barge - ground ring, 3-1/2 inch chain and equalizer

No. 12 Barge

No. 16 Diver taking voltmeter readings



No. 13 Buoy - afloat ready to sink

No. 14 Buoy - raised - all chains connected underwater - mooring shackle attached

No. 15 Buoy - foam being applied

REFERENCES

1. Conceptual Design Recommendations for a Pier at Diego Garcia B.I.O.T., by Lyon Associates, Inc., February 1976, prepared under contract N62742-76 C-0004

2. NAVFAC Drawings No. 7013431 Mooring Island and Catwalk Pier Isometric.

3. Concept Development and Cost Estimate for POL Pier Mooring Island Installation, Diego Garcia, B.I.O.T., by C. Chern, January 1979

4. Concept Study, Bill of Materials and Cost Estimates for POL Pier Buoy-Mooring System, Diego Garcia, B.I.O.T., by C. Chern, K. Cooper and A. DelCollo, April 26, 1979

5. Installation Plan, Pier Buoy Mooring Project and Maintenance to Existing Mooring, Diego Garcia, B.I.O.T., by K. Cooper, January 1980

6. Memo from K. Cooper dated February 8, 1980 enclosing documents giving "as-shipped to Diego Garcia" condition of each pallet

7. Project Log Diego Garcia Buoy Mooring Project -- K. Cooper (3/26/80 thru 6/6/80)

8. NAVFAC DM-26

APPENDIX A

SUMMARY

OF

ENVIRONMENTAL CONDITIONS

Excerpt from Reference 1

APPENDIX A

A.1 WINDS

A.1.1 Typical Winds

Prevailing winds at Diego Garcia generally blow from the northwestern quadrant in the summer and early fall (June through September) and from the southeast during the winter (January through March). The April-May and October-December periods are transition periods during which winds are variable in speed and direction. Wind speeds average from 5 to 10 knots with the highest average speed occuring in the months of July and August.

A.1.2 Extreme Winds

Extreme winds may be generated by tropical cyclones or by gales associated with the prevailing wind systems. Most probable approach directions for such winds are westerly, northwesterly or southeasterly. For design purposes a sustained wind of 49 knots and peak gusts of 69 knots (a 50 year return period wind) was selected.

A.2 SEA LEVEL ELEVATION

A.2.1 Astronomical Tide

Astronomical tidal ranges at Diego Garcia vary from about 1.5 to 6.5 feet. The hydrographic datum in use is Indian Spring Low Water which is somewhat below Mean Low Water Springs. The datum for land surveys is Mean Sea Level which is officially 3.3 feet above the hydrographic datum. Recent studies indicate, however, that the true difference between these two datum levels may be 3.7 to 3.9 feet.

A.2.2 Design Still Water Level

A design still water level of 5.6 feet, having a return period of 64 years, was utilized in combination with the selected design storm wave in the design of pier structures. A maximum yearly tidal height of 6.5 feet was used in consideration of typical conditions in which the pier will be utilized.

A.3 WAVES

A.3.1 Typical Waves

Waves will be generated inside the lagoon on an everyday basis by the prevailing winds and will coincide with these winds in direction. The maximum wave height which might be expected during a typical year at the pier site will be about 2.0 feet and have a period of 2.0-2.5 seconds. In addition to these waves, swell entering the entrance to the lagoon may be expected at the site a high percentage of the time. This swell is not expected to exceed 1.0-2.0 feet, typically, and will have a period ranging from 4 to 10 seconds. It will approach the site from a northerly direction. Sea and swell may combine to form a wave reaching a maximum of 3 to 4 feet in height. Combined heights above 4.0 feet will be rare.

A.3.2 Design Waves

Maximum waves at the pier site will be generated by storm winds and will be a combination of waves entering the lagoon through its entrance and waves generated within the lagoon. The selected design wave characteristics, having a return period of 50 years, are: Significant Wave Height (H_s) 7.5 feet, Maximum Wave Height (Hmax) 12.2 feet, Period (T) 8.0 seconds, Approach Direction: Northwest to Southeast.

A.3.3 Seiche

Seiches, or standing waves, within the lagoon are not expected to be a problem in pier design, construction or operation.

A.3.4 Reflected Waves

Reflected waves are not expected to be a problem in pier design although operation of small craft adjacent to a closed pier may be hampered at times.

A.4 CURRENTS

A.4.1 Typical Currents

Currents in the lagoon are primarily tidal although surface currents may be affected by the wind. Currents at the pier site typically will be highest during periods of high tide range but are not expected to exceed 1/4 to 1/2 knot in speed. The primary directions will be northwesterly (ebb) and southeasterly (flood) and prevailing northwesterly or southeasterly winds will reinforce or retard these currents, depending on the coincidence or opposition of current and wind. Currents increase in strength progressively toward the lagoon entrance and speeds up to 1 to 2 knots can occur typically in the entrance and at the outer end of the channel.

A.4.2 Design Maximum Currents

A maximum current speed of 2.0 knots was selected for design and represents a coincidence of maximum wind current and maximum tidal current at the project site. The most probable directions are southeast or northwest.

A.5 SALINITY AND TEMPERATURE

The water temperature in the lagoon ranges from about 80 to 85 F and sea water conductivity should be based upon a salinity of 40.7 parts per million.

A.6 SEDIMENTATION

Sedimentation of harbor turning basin, channel and quay areas is expected to be negligilbe. The construction of the new pier-mooring buoys is not expected to significantly alter the sedimentation or sediment transport regime of the area.

A.7 SOILS, FOUNDATIONS AND MATERIALS

The submarine deposits consist of unconsolidated calcareous sand and silt composed of shell fragments and coralline debris of sand and silt-size particles, the relative density varies from "loose" to "very dense". There exist interbedded layers of cemented coral sands and other coral debris as well as numberous coral heads.

APPENDIX B

DM-26 FLEET MOORINGS

Escerpt from Reference 5

B.1 INTRODUCTION

Design of the buoy-dolphin mooring system for the Diego Garcia pier was driven by operational requirements, installation constraints and environmental considerations which make the moorings quite different from standard Navy Fleet Moorings. These differences make the installation of the moorings more critical in some respects than conventional fleet moorings; and they need to be understood by those responsible for the hardware acquisition and installation.

B.1.1 DM-26 FLEET-MOORINGS

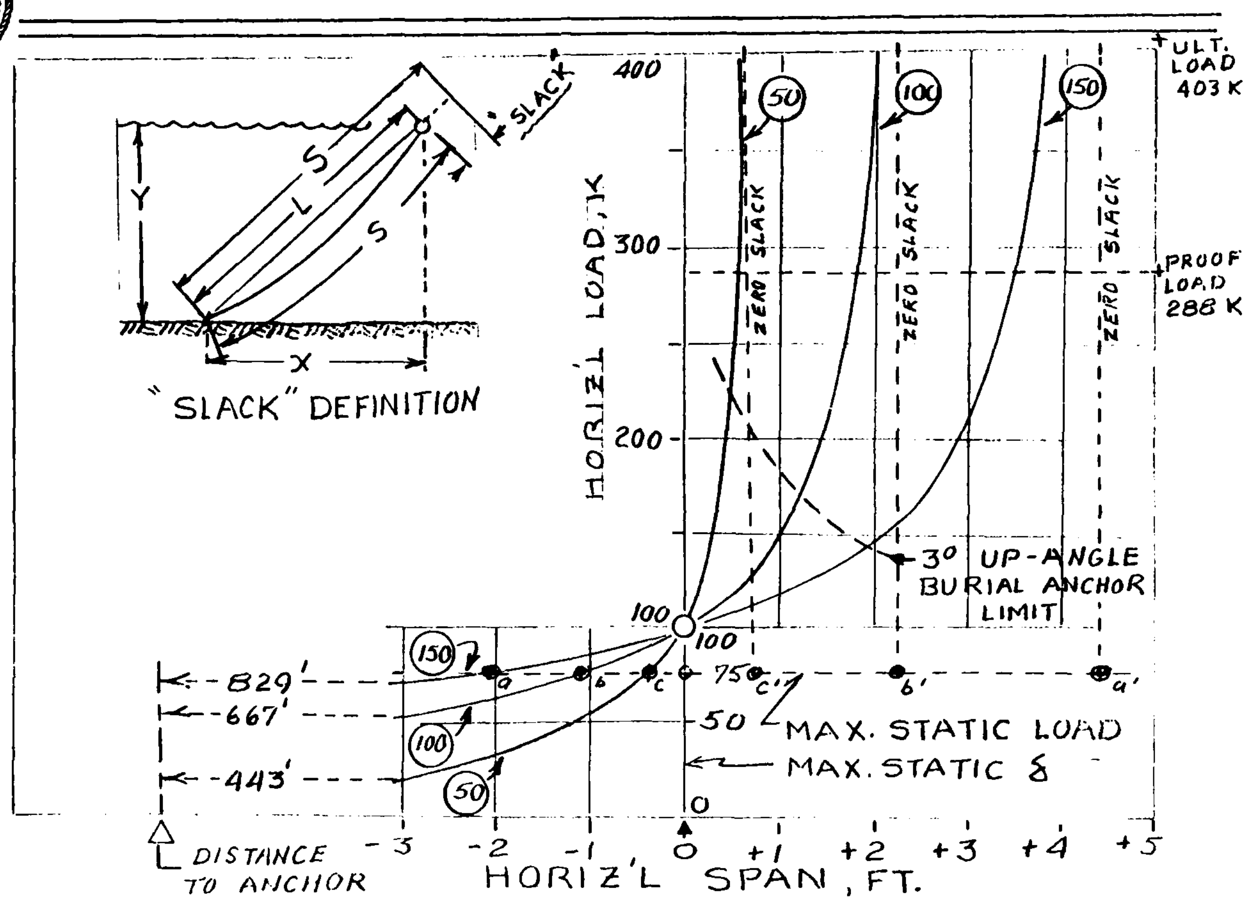
Figure 1 shows the operating characteristics catenary legs equivalent to those of a DM-26 CLASS C telephone-buoy type fleet mooring for 50 feet, 100 feet and 150 feet of water depth. CLASS C meets the Diego Garcia requirement of 100,000 pound horizontal load per leg. This load includes a factor of 1.33 for a dynamic load increment. The curves shown in Figure 1 are for a single leg of a free mooring (without sinkers).

The importance of Figure 1 is to show the critical aspects of shallow water moors compared to deeper water moors; and to show the magnitude of the horizontal span of the legs. The cross-over point of the three curves reflects a maximum dynamic loading criteria of 0° up-angle on the anchor shank, safety factor of 4:1 and a "Slack" of 0.6 feet minimum. "Slack" is defined here as the excess of total catenary leg and riser length over a "tautline" length from the anchor to the buoy. Slack is therefore a measure of the mooring's capability to absorb oscillatory motion of the ship mooring bitt around its maximum static load excursion. From Figure B1 it can be seen that the spring rate (stiffness) of a shallow water mooring is greater than for the deeper water moorings. Also, the spring rates of moorings in the "working quadrant," or zone, are much less than for those in the "overload quandrant," or zone. This shows the necessity of avoiding working the overload zone where small ship motions develop high loads very rapidly. Also, in the "working zone," it can be seen that the higher spring rate of the shallow water moors tolerates substantially less ship oscillatory motion, for the same dynamic load factor, than is the case for the deeper water moors.

Although the Diego Garcia installation cannot accommodate the large horizontal span of the DM-26 fleet mooring design, the necessity for maintaining most of the design criteria and characteristics of the standard fleet moorings is recognized. This is particularly true with regard to providing at least the minimum chain "slack" criteria for the shallow water moor. Motion which cannot be accommodated by the chain must be absorbed by the elasticity of the ships breast lines to the buoy.

B.1.2 EMBEDMENT ANCHORS

Embedment anchors are required for permanent moorings in the coral seafloor at Diego Garcia; and CEL 100K lb. anchors have been installed and utilized there successfully for several years. The shallow water in conjunction



OCEAN FACILITIES ENGINEERING AND CONSTRUCTION PROJECT OFFICE

CHARACTERISTICS OF DM26 CLASS C MOOR

FIGURE B1

with limited horizontal span, involves high up-angles of the chain at the anchor-point as shown in Figure B2. The embedment anchor is not limited by the 3 degree up-angle limitation for burial anchors that is shown by Figure B-1.

The high up-angles would have forced the system to work past the knee of the characteristic curve and up into the low-slack, chain snapping overload zone unless relatively large sinkers were used. Figure B3 shows the influence of sinker weight on slack for the final configuration. This accounts for the use of 20K pound anchors as sinker weights on the primary legs of the moorings.

Equally significant is the difference in failure mode between embedment anchors and burial anchors. The burial anchor may drag if overloaded but it may either dig in deeper, or it may rebury on future dragging. However, if the embedment anchor is overloaded, it starts to break-out of the soil and become less resistant to further overloading (if it does not break-out entirely). It cannot be depended on to recover such lost holding power. Thus, despite the established reliability and special merits of embedment anchors, they are less forgiving of design shortcomings and operational overloads than are burial anchor systems; and they can allow operation of chain and other components in a much less forgiving zone of the catenary load/defection curve.

Application of embedment anchors to this mooring design has reflected these design considerations in the emphasis placed on anchor load sharing provisions and tailoring the design to the bathymetry. In addition, methods for underwater measurement and adjustment of each leg assembly have been developed to assure load sharing balance and buoy location.

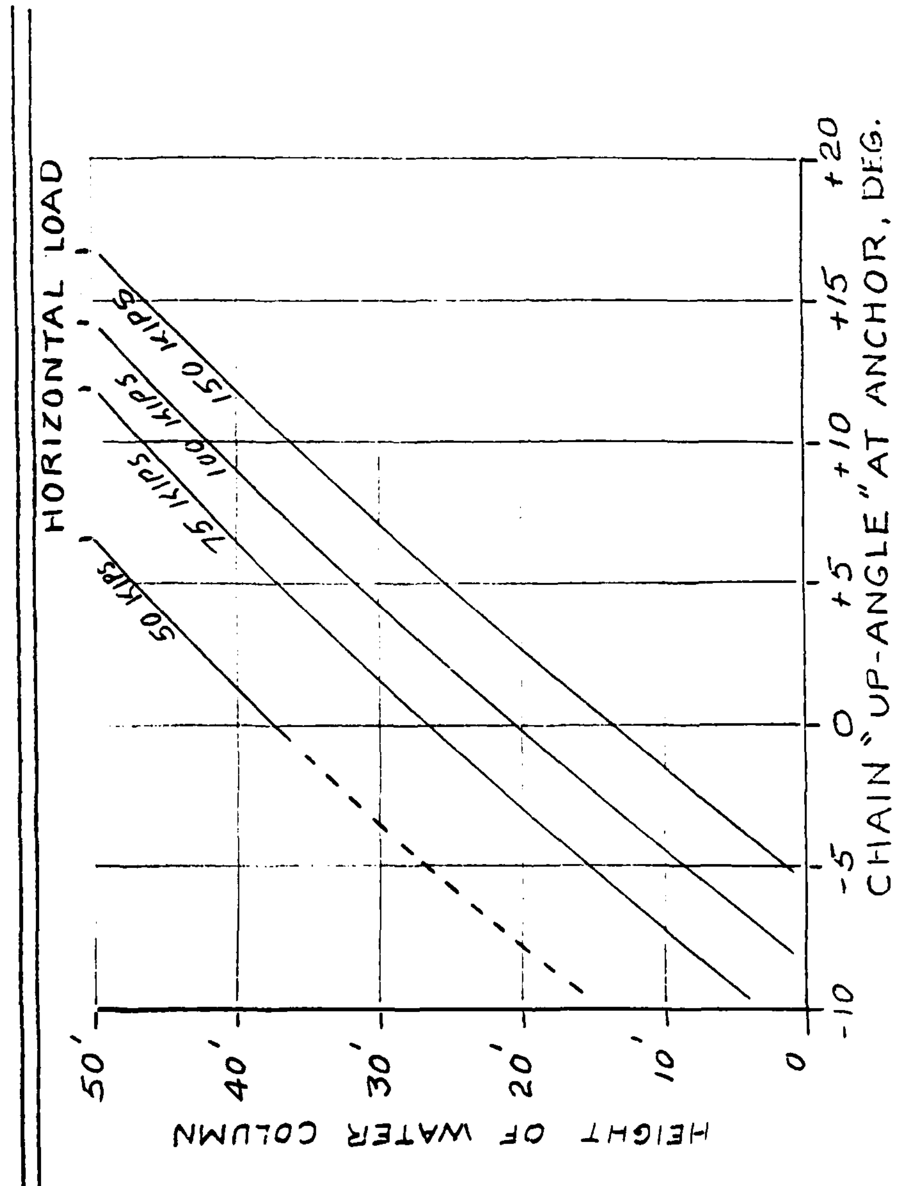
B.1.3 LEG SPAN AND ARRAY ANGLES

The horizontal span and the angular orientation of the legs of each mooring is determined by bathymetry, the proximity of the pier to the mooring buoys and by the location of the POL lines at the south end of the pier (as shown in Figure B-4.

The embedment anchors, when used at the minimum thirty feet of water depth, require the use of the heavy-mass launcher for firing. As shown by Figure 4, the bathymetry is such that the horizontal span of the primary legs for the south array is limited to approximately 130 feet. The angular orientation to these 30-foot contour pockets, and clearance around the POL lines is also shown in Figure B4. The north mooring is made identical in scope of chain and component selection to the south mooring for the purpose of commonality.

B.1.4 MOORING LEG DESIGN CHARACTERISTICS

The characteristics of the final mooring leg design are shown in Figure B5. The maximum static load (75K lb.) and the maximum dynamic load with 1.33 factor (100K lb.) are shown to fall below the knee of the operating curve.



WATER DEPTH VS "UP ANGLE"
FIGURE B2

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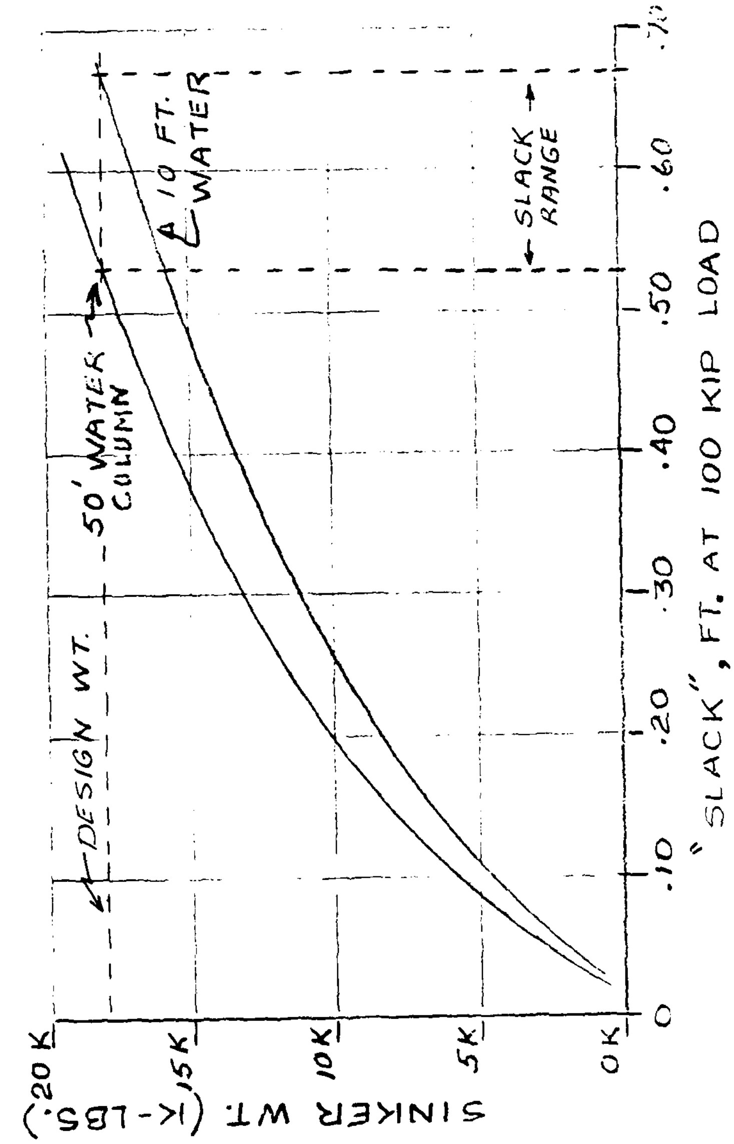
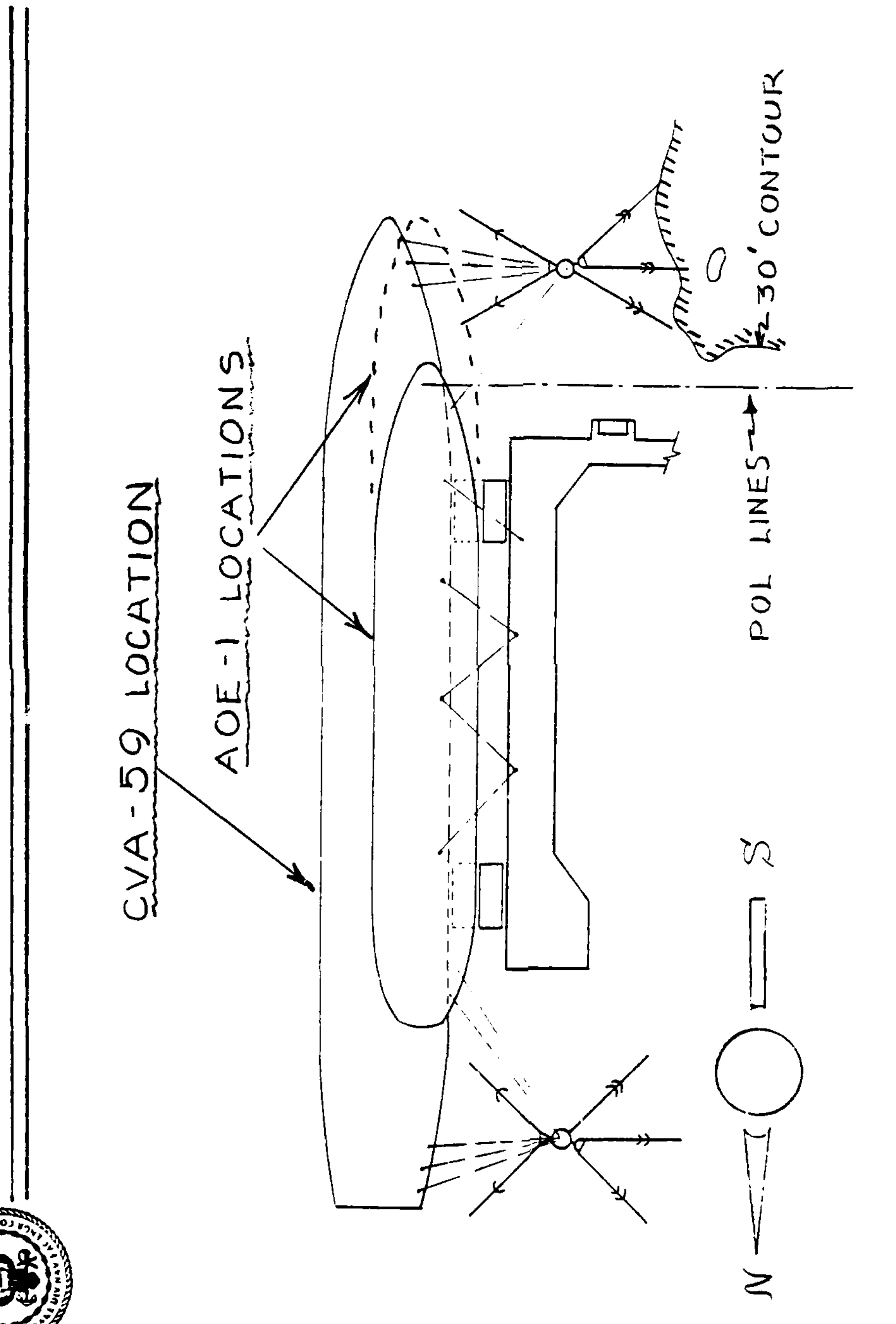
AND CONSTRUCTION PROJECT
OFFICE



SINKER WEIGHT VS "SLACK"
FIGURE B3

OCEAN FACILITIES ENGINEERING AND CONSTRUCTION PROJECT OFFICE



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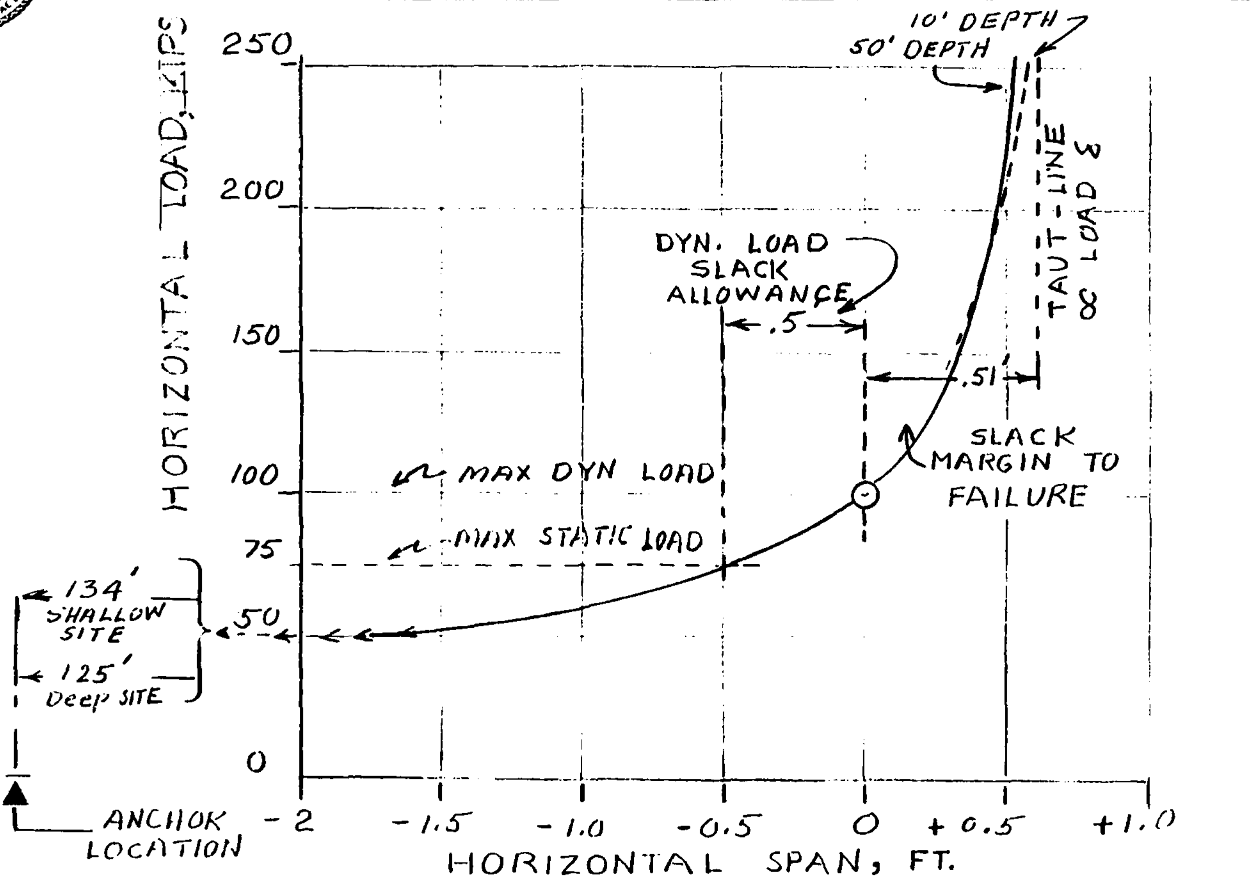
BUOY MOORING LAYOUT
FIGURE B4



OCEAN FACILITIES ENGINEERING AND CONSTRUCTION PROJECT OFFICE

MOORING LEG CHARACTERISTICS
FIGURE B5

The area between the 10-foot and the 50-foot water depth curves covers differences in bathymetry and tides. The sinker location meets the minimum slack criteria (0.5 feet) at maximum design static load; it maintains the free-buoy location, and it is within the free-buoy buoyancy capability to support the weight of the suspended chain-legs.

B. 1.5 INSTALLATION LIFT-CONSTRAINTS

On-island lift equipment limitations (lack of suitable floating crane) have imposed special handling requirements.

The need to transfer on-shore hardware to a barge and then transport and place it on-bottom is met by transferring the heavier components on pallets from the pier to the seafloor using cranes on the pier. The barge then lifts the load off-bottom and transports it to the site while it is still suspended in the water. The lifting and lowering is accomplished with the bow sheave on the barge and a deck winch.

The need to lift the mooring ground ring and chain legs for hook-up to the buoy is accomplished by flooding and sinking the buoy down a guide-line attached to the ground ring. The keeper plate on the buoy is assembled to the riser chain; and the buoy is blown free of water to raise the buoy and the suspended mooring chain to the surface.

These operations require palletizing of certain leg sub-assemblies and subsequent lowering to the seafloor. The sink-and-float capability requirement for the buoys requires on-site foaming kits and modification of the peg-top buoys. The flood-and-blow operations require buoy modifications, air compressors and hoses and underwater hook-ups by the UCT-2.

APPENDIX C

PROJECT ORGANIZATION

Excerpt from Reference 5

3.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The organizational responsibilities for the design, mobilization, and execution of the installations, as shown in Figure C-1 are as delegated in the following paragraphs:

C.1 PACNAVFACENGCOM

C.1.1 Project Management

1. Task Assignment
2. Program Review
3. Financial support
4. Requirements and criteria

C.2 CHESNAVFACENGCOM (FPO-1)

1. Develop design, and installation plan tasks
2. Designate hardware requirements of mooring components
3. Provide survey/location requirement data
4. Provide hardware assembly drawing
5. Provide mobilization plan for preassembly at 31st NCR
6. Support technical support on site
7. Maintain master installation log (as-built)
8. Brief all hands at site on installation scenarios
9. Process photographic data
10. Provide cathodic protection plan and equipment requirements
11. Assume quality control responsibility of mooring installation in conjunction with UCT-2.
12. Assume responsibility for the component assembly and ordnance loading for firing of the embedment anchors
13. Provide UDATS system (TV) for final mooring inspection.

Appendix C

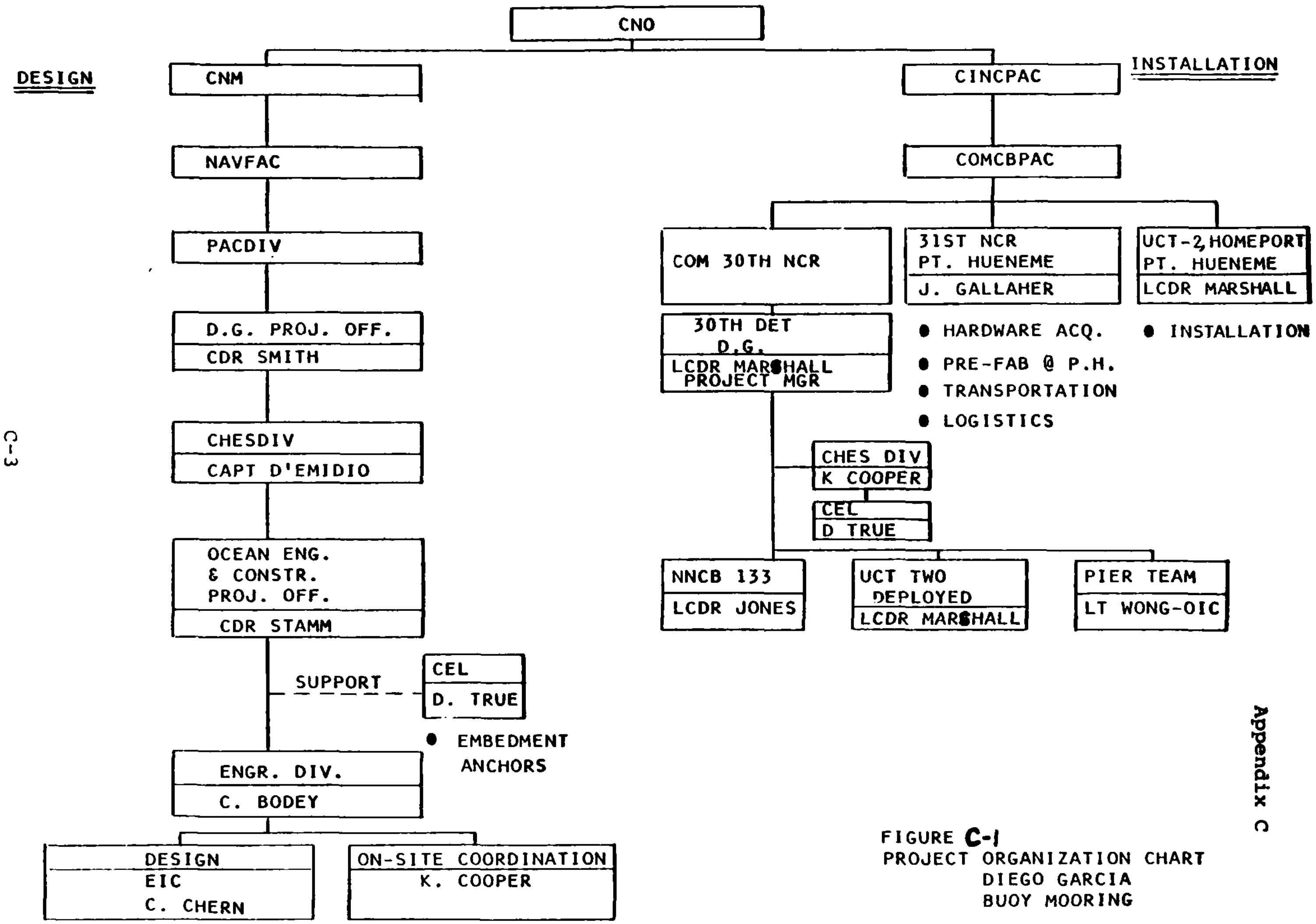


FIGURE C-1
PROJECT ORGANIZATION CHART
DIEGO GARCIA
BUOY MOORING

C .3 31ST NCR

1. Provide components of mooring system
2. Direct transportation required to site
3. Provide load out and preassembly site (CONUS)
4. Modify components as required
5. Interface directly with PACDIV concerning financial responsibility of mooring components cost
6. Provide lift capability (30,000# max) to preassemble mooring components at 31st NCDR, and labor to preassemble and palletize components
7. Provide components to support operations as required by UCT-2 and CHESDIV

C .4 30 NCR DET DIEGO GARCIA

1. Provide working/storage area. Provide lift capability (10,000*) to be used during pallet assembly.
2. Provide YC barge work platform
3. Provide crane with operator for work platform
4. Prepared barge for operations by placing preassembled components on deck as per CHESDIV drawings and UCT-2 coordination
5. Provide double drum mooring winch (USN 8700605) and double drum pulling winch (USN 8700721), in operational condition without cable on drums
6. Provide on site berthing, messing
7. Provide LCM-6 with operator and deck crew
8. Provide message traffic on site
9. Maintain security on site
10. Provide crane operator
11. Provide transport from storage area to pier for preassembled components and off loading to seafloor alongside pier

12. Provide on site ordnance handling/storage

13. Maintain on island assets provided to support OPS

14. Provide 120 CFM/75PSI compressor and 200 ft. hose

15. Provide oxygen and MAPP gas

16. Direct materials from support ship to the assigned stagging area near the pier road and Air Ops. Maintain security of material

C.5 UCT-TWO

1. Implement installation plan

2. Have representative available at preassembly and palletizing of mooring components at 31st NCR

3. Plan/direct diving operation

4. Assemble valving on modified buoy for buoyance control

5. Assure safety responsibility for operations

6. Interface with on island support requirements

7. Provide diving equipment with communication

8. Provide hydraulic tools and power supply

9. Provide survey equipment and perform survey. Assume quality control responsibility of installation in conjunction with CHESNAVFACENGCOM (FPO-1).

10. Provide DC welding equipment and welders

11. Provide generator (110 VAC/2KW Min)

12. Conduct detailed dive inspection of mooring after installation

13. Provide 35mm underwater camera, take U/W photographs

14. Provide deck handling labor in support of embedment anchors

15. Maintain all UCT diving and associated equipment

16. Provide auxiliary support tools, welding, hydraulic com-a-longs, pry bars, rigging tools, tag lines

17. Provide meter to measure cathodic protection potential during final inspection

18. Maintain on site communication between barge, support craft and survey team

19. Provide barge security, ordnance security on barge

C.6 CIVIL ENGINEERING LABORATORY (CEL)

1. Provide consultation concerning use of embedment anchors

2. Provide on site representative to assist in anchor assembly

3. Document long lead items for procurement by 31st NCR (i.e., flukes, pistons, connectors, anchor wires)

4. Mobilize (CONUS) CHESDIV and SUPSAL embedment anchor guns (2)

5. Provide sheave suitable for use in pull test of 100K/lbs

6. Provide two load cells @ 150K lbs capacity

7. Provide preassembled embedment anchor installation equipment package

8. Provide slings to handle pistons

9. Provide anchor wire (2") containment box

10. Provide battery (24-32V) to fire SUPSAL embedment anchor

11. Provide all required equipment to 31st NCR for transportation per schedule

12. Assume quality control responsibility of embedment anchor components designated to 31st NCR for construction

13. Procure ordnance, package for transportation and storage, and coordinate transportation to site

APPENDIX D

CONUS PREASSEMBLY

Excerpt from Reference 5

CONUS PREASSEMBLY

Mooring components secured CONUS will be preassembled at 31st NCR to packaging for shipment. The purpose of the preassembly hardware layout is to:

1. Familiarize personnel with the components
2. Establish procedures for handling
3. Guarantee hardware interface
4. Package anchor pallets
5. Conduct inventory of mooring components and support hardware prior to shipment
6. Inspect modification of buoy and preassemble valves and hose connectors for buoyancy control
7. Locate, mark, and measure links to be used as corrosion standards
8. Secure zinc anodes to equalizers, add protective packaging.

D .1 PACKAGING OF MOORING LEGS ON PALLETS

Each mooring leg will be shipped from CONUS on an individual pallet as shown in Figure 10 of the text. The pallet will contain all hardware available CONUS at the time of assembly. Hardware shipped directly to Diego Garcia will be assembled onto the pallet at Diego Garcia.

D.1.1 Pallets: Wooden pallets will be constructed and delivered to the preassembly site. Each pallet is 20 feet long and 10 feet wide and is constructed of 6"x6" timbers. Each pallet will have an individual sling which will remain on the pallet for use during transport.

D.1.2 Pallet Packaging: Each mooring leg chain will be laid out and visually inspected prior to assembly.

D.2 PALLET ASSEMBLY

There will be one pallet for each mooring leg. Each pallet will be designated by the number (i.e., N1, N2, ...) of the leg as shown on drawing 3017737.

D.2.2 Legs No. 1, 2

1. Place 20,000# anchor on pallet. Place stanchion blocks under anchor as shown in figure
2. Place steel bands around the anchor thus securing the anchor to the pallet
3. Connect hardware to chain as shown in Figure D-1, D-2, D-6 and D-7.

NOTE

2-1/4" chain may not be available at mobilization site. A quantity of 2-1/4" chain may be secured CONUS. All hardware should be assembled in place, however, no final assembly (i.e. forcing locating pins in place) of 2-1/4" chain connections should be made unless 2-1/4" chain is on location.

4. Lift the 2-1/2 in. chain over the centerline of the pallet. Lower the 2-1/2 in. chain and connect the chain to the anchor per the dimensions shown in Figure D-1, D-2, D-6 and D-7. Chain which is not on location will be assembled on Diego Garcia by this assembly process.
5. Beginning at the bitter end of the 2-1/2 in. chain, lay 3/4" diameter galvanized wire rope alongside the chain up to the area of the anchor anode.
6. Secure the end of the wire rope to the last 2-1/2 in. chain link using line.
7. Move up the 2-1/2 in. chain eight links and secure the cable to the chain using special clamps 3017738, item 31. Move up the chain four links and pass the cable through the chain. Continue to place clamps and pass the cable through the chain up to the area of the anchor. Reference Figure D-11 for cathodic protection detail.
8. Cut the cable to a length which will allow the cable to be secured to the anode having a wire facing the 2-1/2 in. chain. Secure the cable to the anode cable using three 3/4" wire clips.

9. Connect the 3/4" wire to the anchor anode facing the direction of the 2-1/4" chain using three 3/4" wire clips. Connect the cable to the chain, as described in 7 above, for a length of 75 feet.

10. Lift the bitter end of the 2-1/2" chain and place it on the pallet as shown in figure

11. Flake the 2-1/4" chain, with the 3/4" wire rope attached, on the pallet

12. Secure the chain and plywood to the pallet using wire bands

13. Place a lifting bail under the pallet and secure in place

14. Clearly label the pallet with the leg number.

D.2.3 Leg No. 3: This pallet is assembled in the same manner as legs 1 and 2, and will contain all components shown in Figure D-3 and D-8.

D.2.4 Leg No. 4: This pallet is assembled in the same manner as legs 1 and 2 and will contain all components shown in Figure D-4 and D-9.

D.2.5 Leg No. 5: This pallet is assembled in the same manner as legs 1 and 2, and will contain all components shown in Figure D-5 and D-10.

.3 MEASUREMENT OF COMPONENTS

In order to provide a future reference base for evaluation of corrosion data, measurements of components will be required prior to installation of the mooring. Each measurement will document a particular gauge to be compared to a new component standard and to future measurements taken during underwater inspections.

Each measurement shall be taken using measurement devices accurate to at least 1/32 inch. Each measurement will be taken after thoroughly cleaning the measurement area.

Document the measurement per the charts on the following pages. The measurements will become part of the master log and the "as-built" drawings.

APPENDIX E

CHAIN LEGS

AS SHIPPED TO DIEGO GARCIA

Excerpt from Reference 5 & 6

AD-A167 460 PROJECT COMPLETION REPORT FOR PETROLEUM-OIL-LUBRICANT (POL) PIER MOORING..(U) NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON DC CHESAPEAKE.. JAN 812 (02)0041 2/2

UNCLASSIFIED CHES/NAVFAC-FPO-1-80 (12) F/G 13/2 NL

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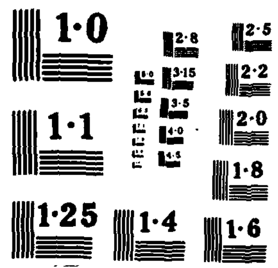
1·0
2·8
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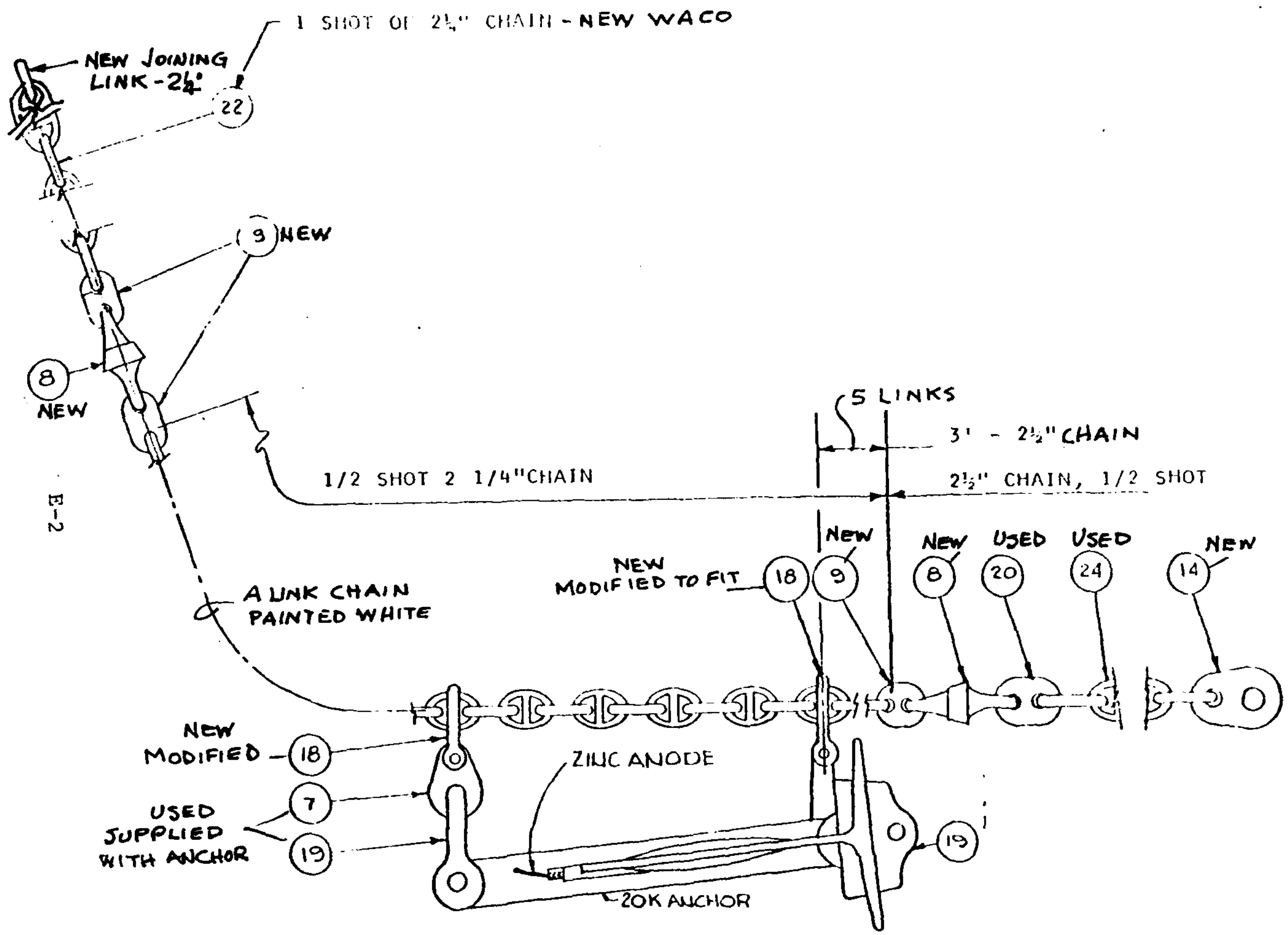
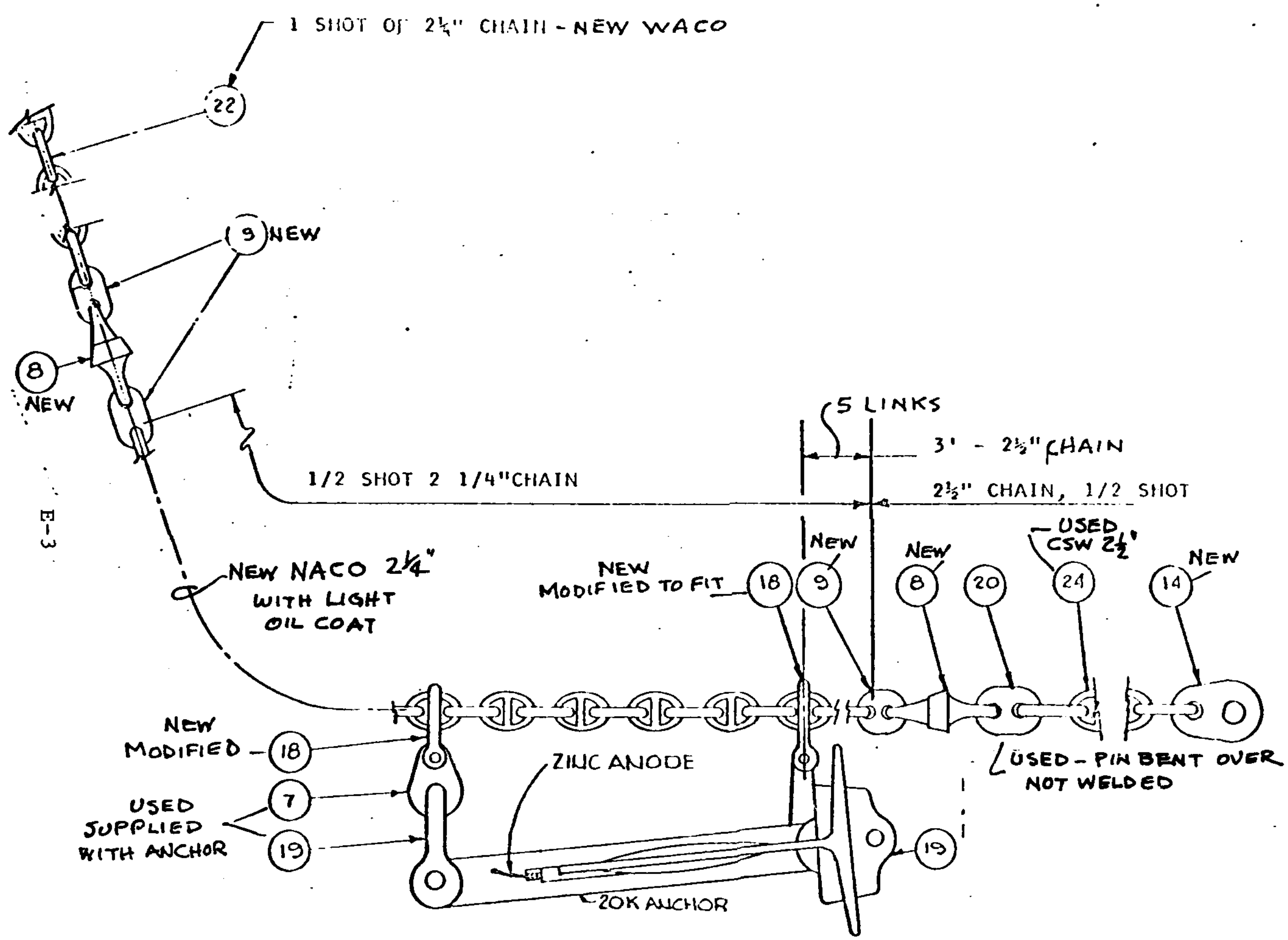
1·4
1·6



LEG - NORTH 1
FIGURE E-1

REFERENCE G

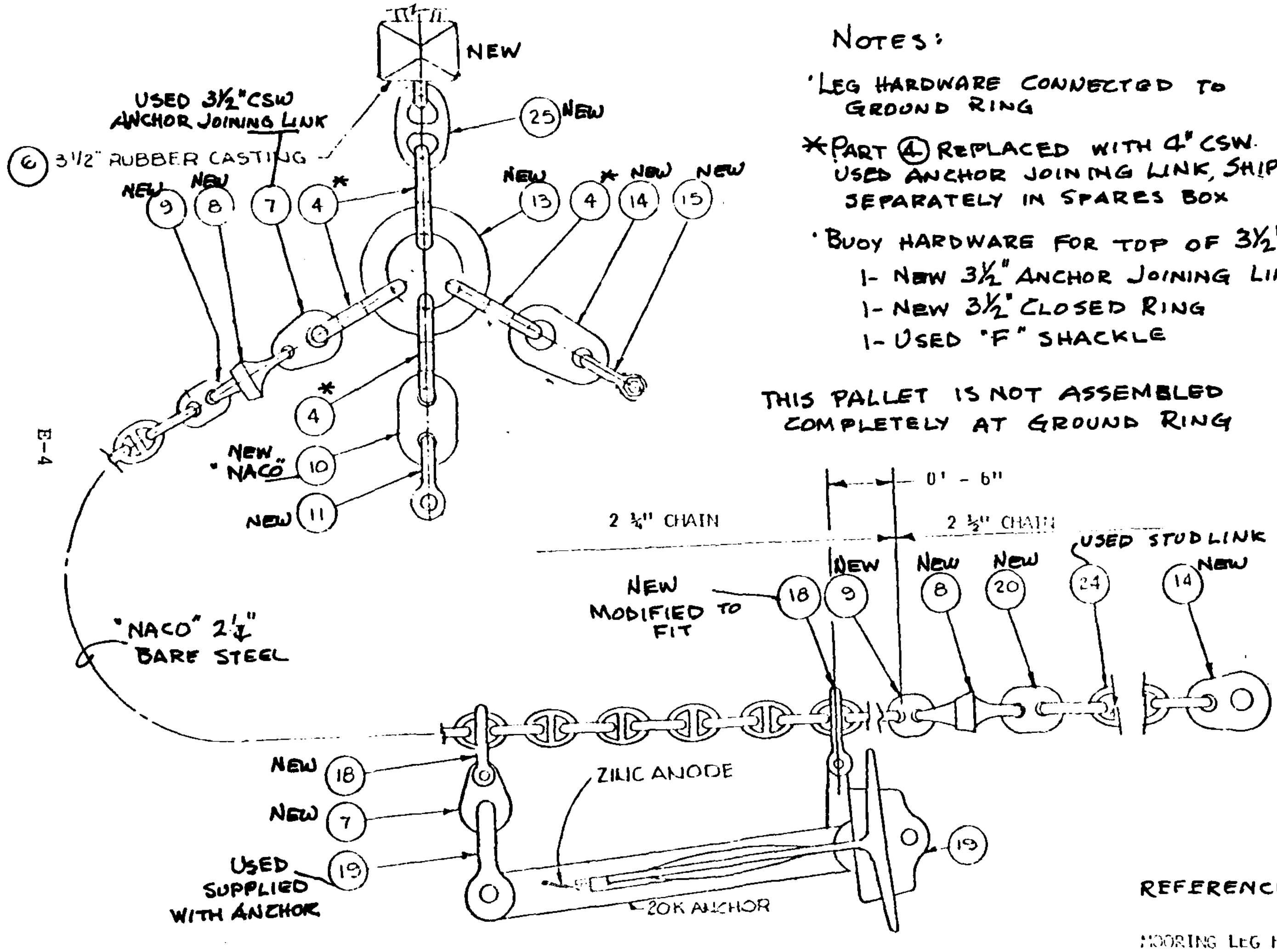
MOORING LEG
HARDWARE COMPONENTS



LEG-NORTH 2
FIGURE - E2

REFERENCE 6

MOORING LEG
HARDWARE COMPONENTS



NOTES:

- LEG HARDWARE CONNECTED TO GROUND RING

* PART ④ REPLACED WITH 4" CSW. USED ANCHOR JOINING LINK, SHIPPED SEPARATELY IN SPARES BOX

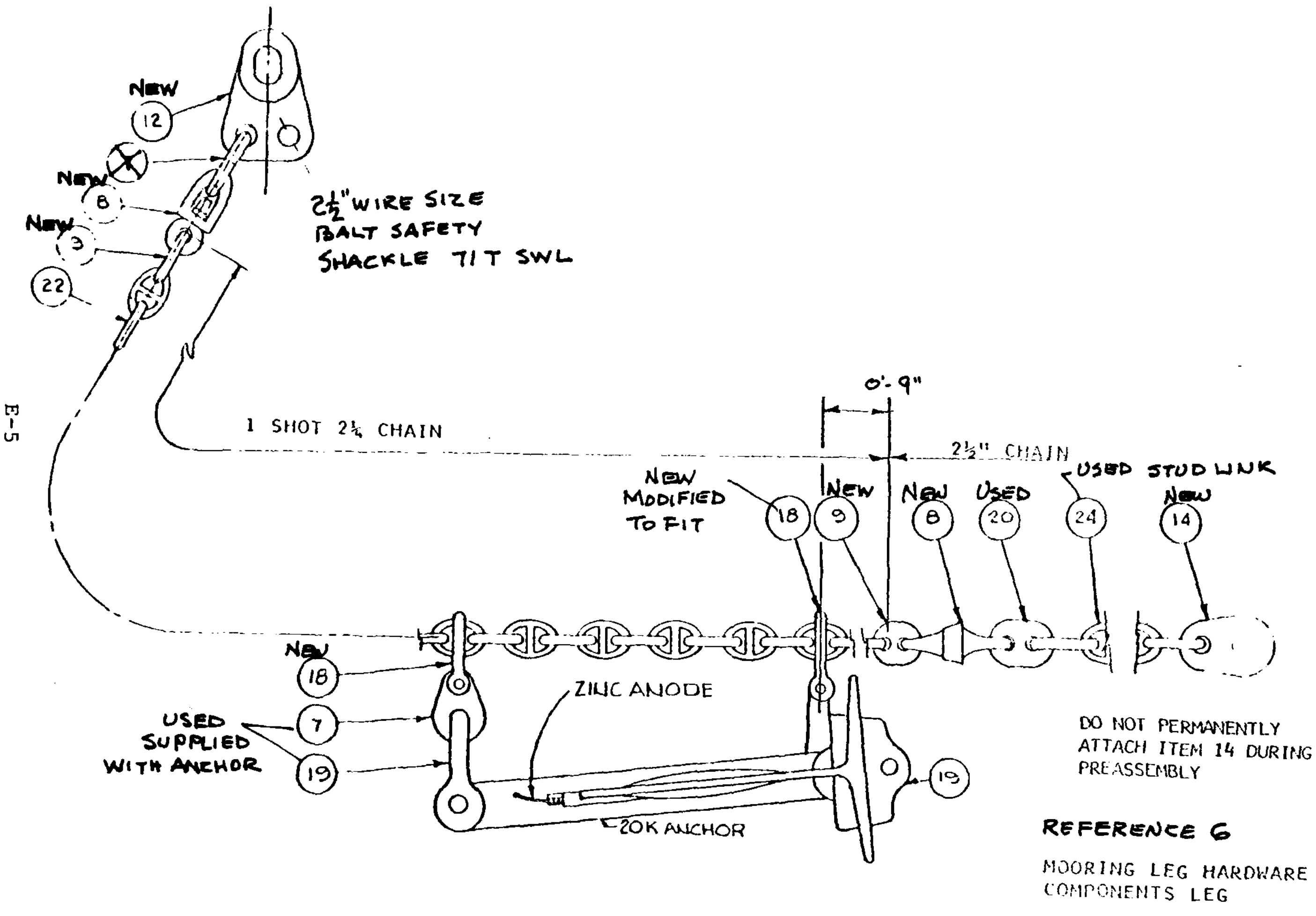
- BUOY HARDWARE FOR TOP OF 3½" CHAIN IS
  - 1- NEW 3½" ANCHOR JOINING LINK
  - 1- NEW 3½" CLOSED RING
  - 1- USED "F" SHACKLE

THIS PALLET IS NOT ASSEMBLED COMPLETELY AT GROUND RING

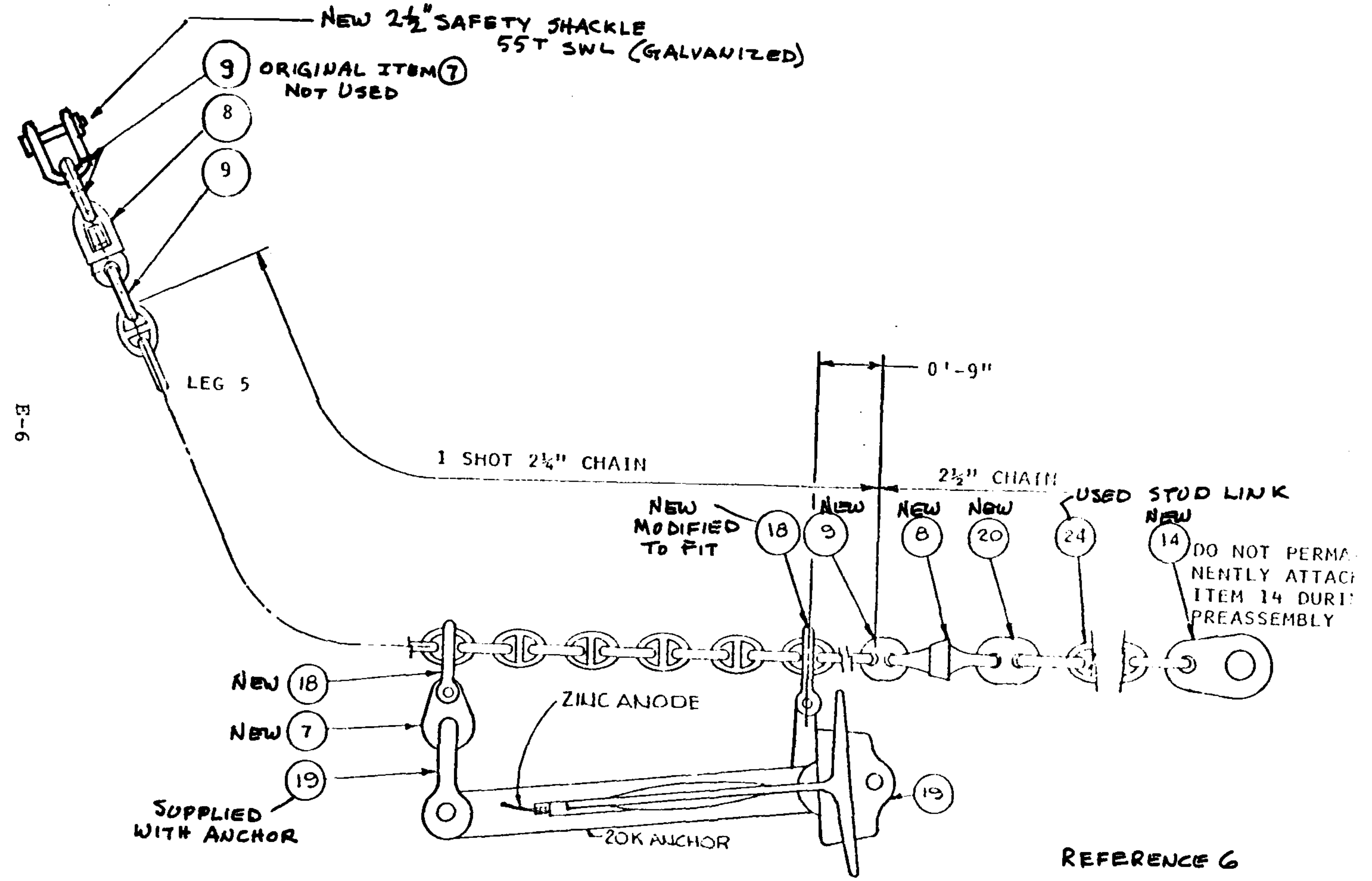
LEG NORTH 3
FIGURE - E3

REFERENCE 6

MOORING LEG HARDWARE COMPONENTS



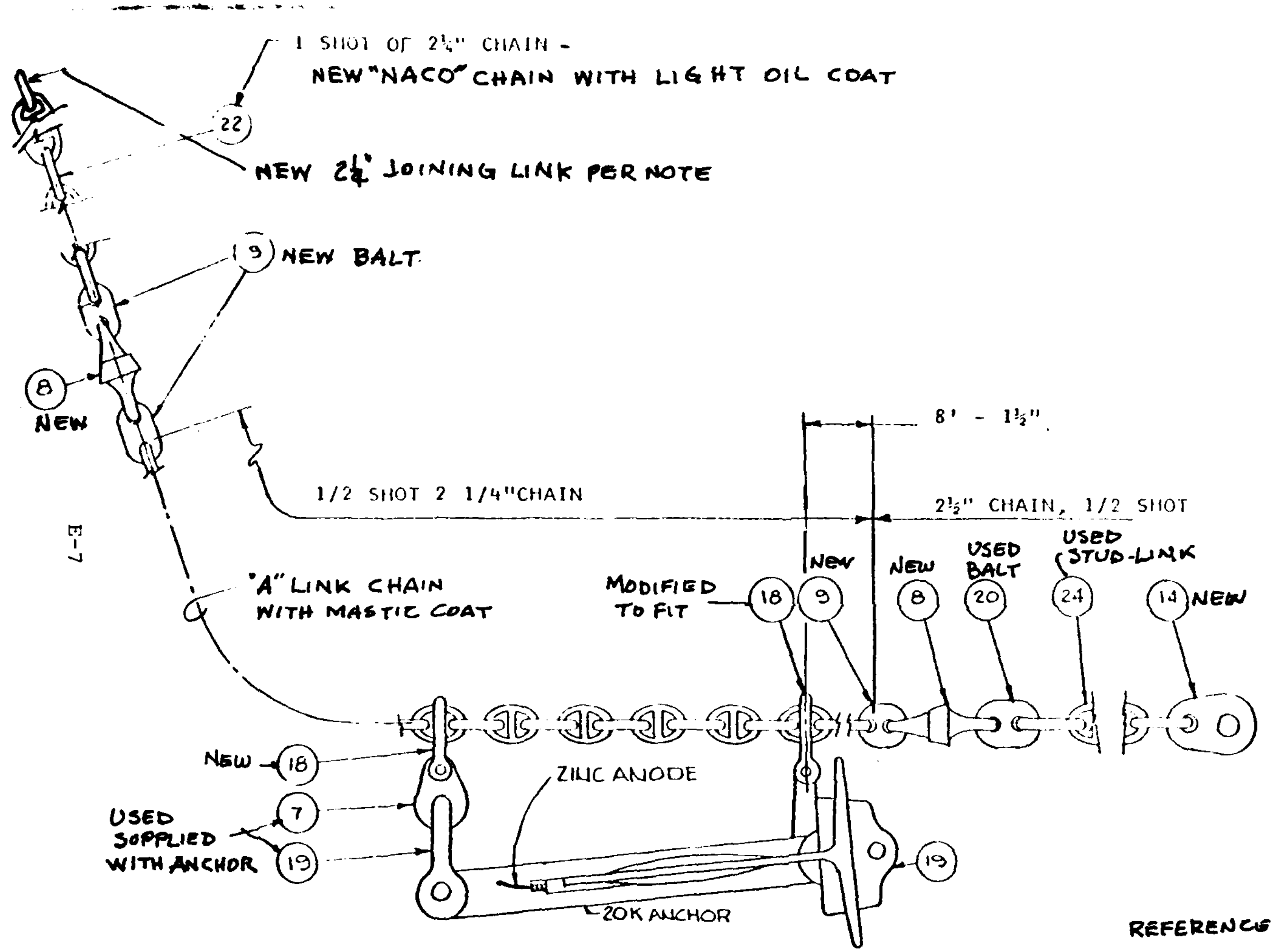
LEG - NORTH 4
FIGURE - E4



REFERENCE 6

MOORING LEG HARDWARE COMPONENTS

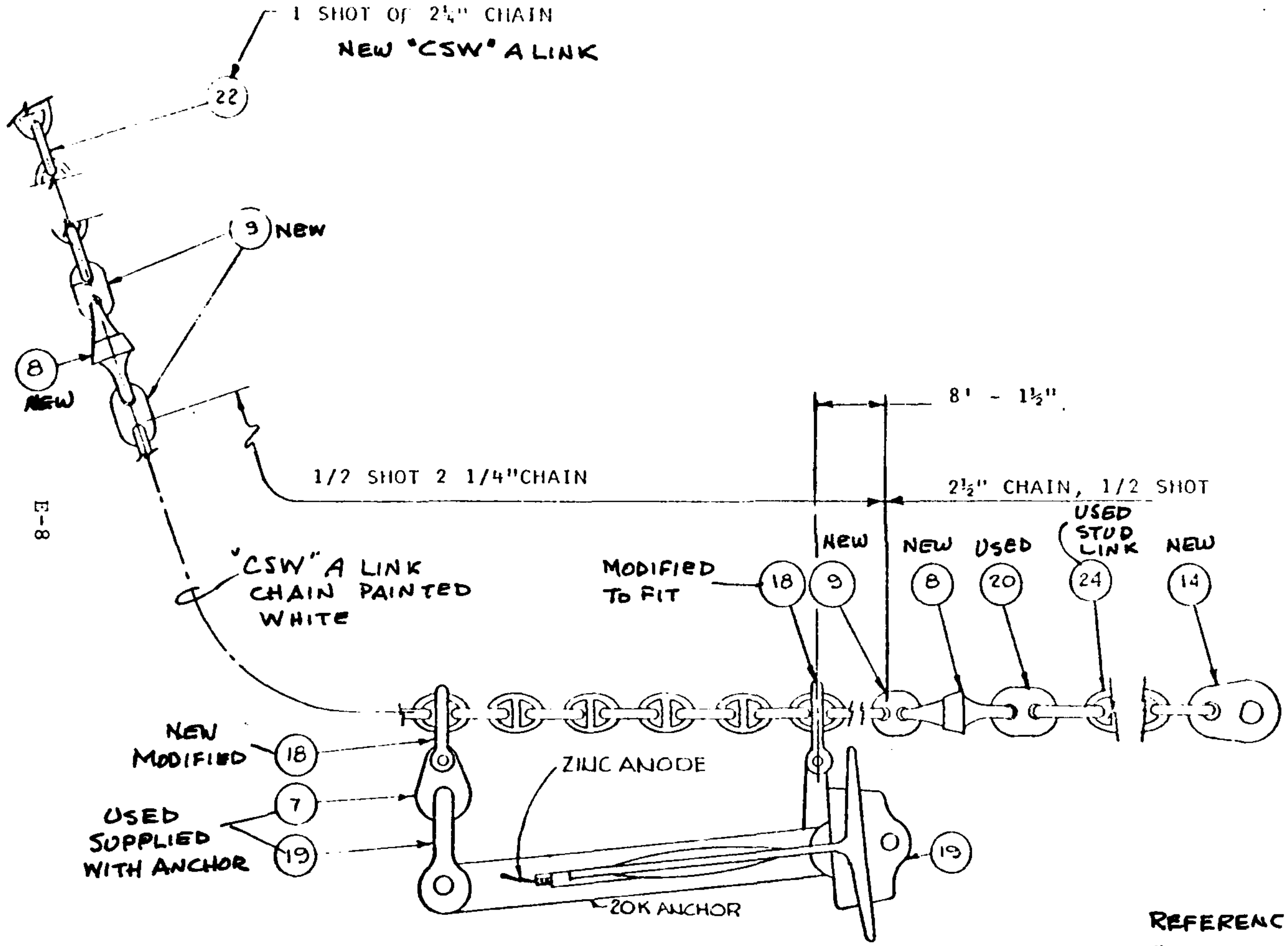
LEG- NORTH 5
FIGURE E5



REFERENCE 6
"CONUS PREFAB"

MOORING LEG
HARDWARE COMPONENT

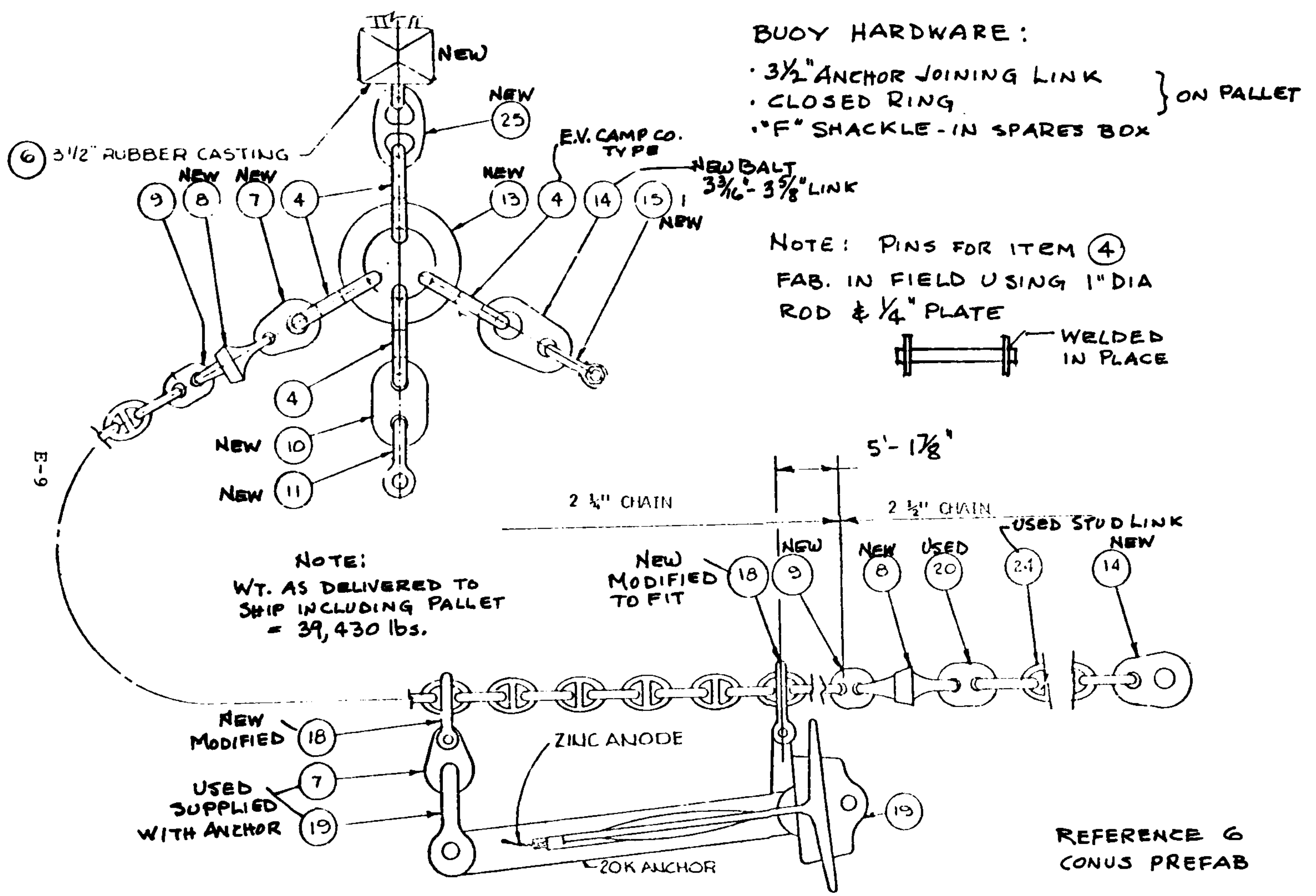
LEG- SOUTH 1
FIGURE E6



REFERENCE 6
"CONUS PREFAB"

MOORING LEG
HARDWARE COMPONENTS

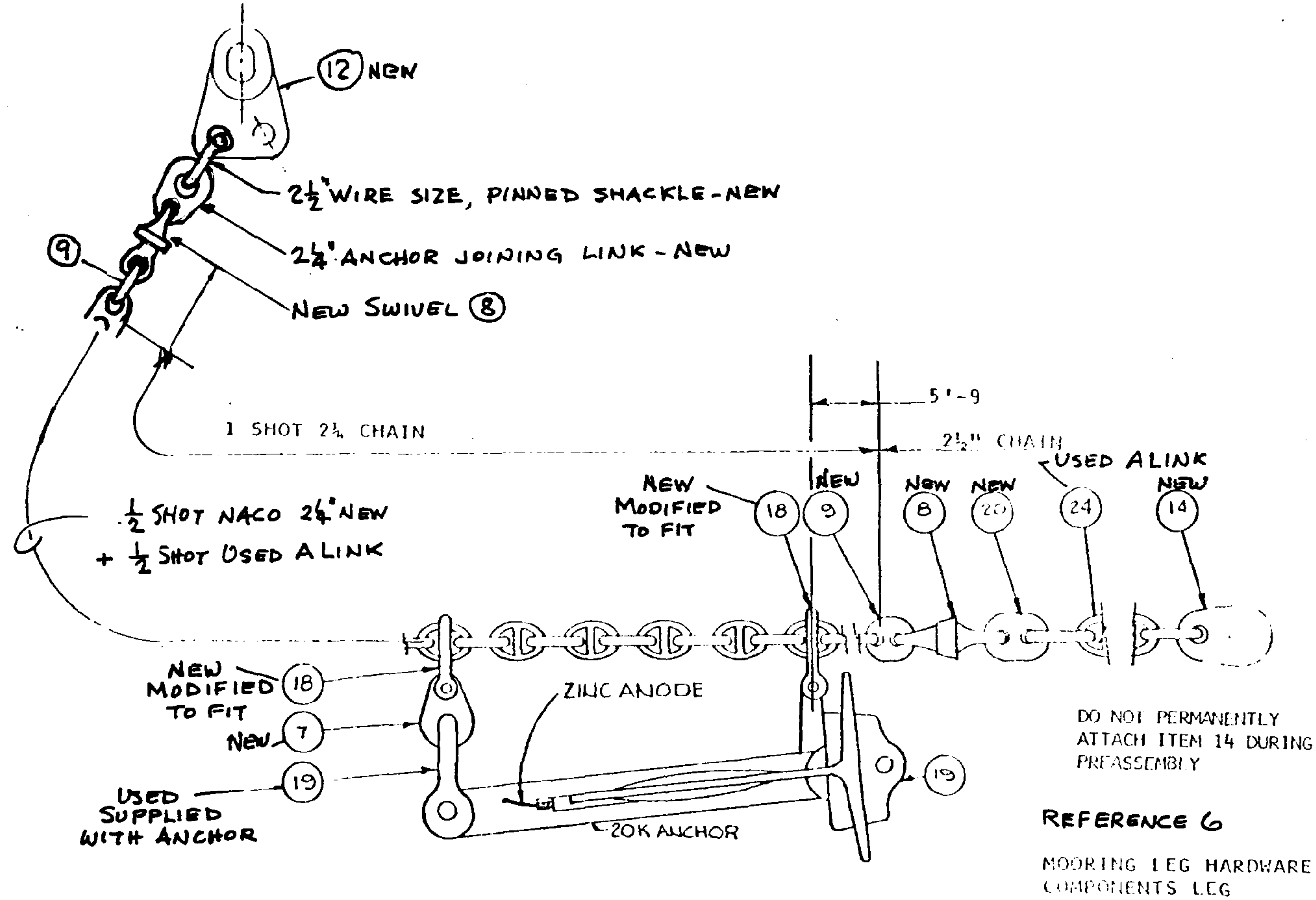
LEG - SOUTH 2
FIGURE- E7



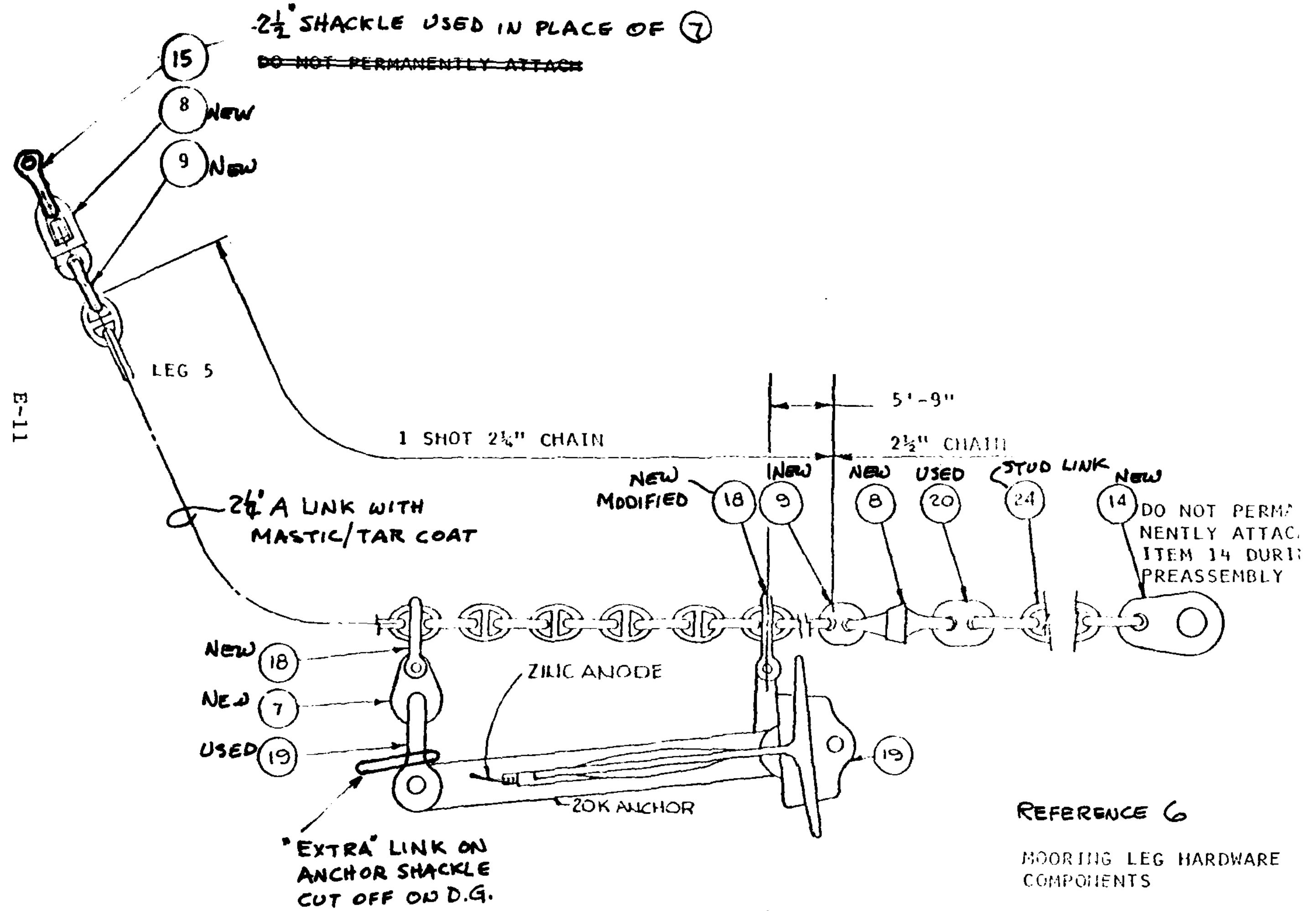
LEG - SOUTH 3
FIGURE - E8

REFERENCE 6
CONUS PREFAB

MOORING LEG HARDWARE COMPONENTS



LEG · SOUTH 4
FIGURE - E9



LEG-SOUTH 5
FIGURE - E-10

REFERENCE 6

MOORING LEG HARDWARE COMPONENTS

APPENDIX F

FIELD MEASUREMENTS

OF

CHAIN COMPONENTS

Excerpt from Reference 6

DIEGO GARCIA BUOY MOORING PROJECT
MOORING COMPONENT DATA SHEET

APPENDIX F

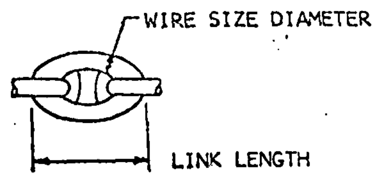
DATA BY K. COOPER DATE 1-26-80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH X SOUTH ---

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
1	24	2½" DIA	$2\frac{1}{2}/14\frac{7}{8}$	1ST LINK 2½ AT ITEM 20
1	24	2½" DIA	$2\frac{15}{32}/14\frac{15}{16}$	10 LINKS FROM ABOVE
1	24	2½" DIA	$2\frac{1}{2}/14\frac{7}{8}$	10 LINKS FROM ABOVE
1	22	2¼" DIA	$2\frac{5}{16}$/--	1ST 2¼ LINK NEAR ANCHOR
1	22	2¼" DIA	$2\frac{5}{16}/14\frac{1}{2}$	CENTER 2¼ LINK IN ½ SHOT
1	22	2¼" DIA	$2\frac{1}{4}/14\frac{9}{16}$	LAST 2¼ LINK IN ½ SHOT
1	22	2¼" DIA	$2\frac{1}{4}$/--	1ST 2¼ LINK AT ITEM 9
1	22	2¼" DIA	$2\frac{1}{4}$/--	15 LINKS FROM ABOVE
1	21			SWAGED SHANK DIAMETER
1	21	2"		WIRE DIA 3' FROM FITTING

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD

DIEGO GARCIA BUOY MOORING PROJECT
MOORING COMPONENT DATA SHEET

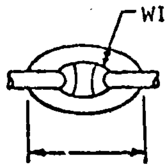
DATA BY KEITH COOPER DATE 1-22-80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH X SOUTH ---

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
2	24	2½" DIA	2 7/16 / 14 7/8	1ST LINK 2½ AT ITEM 20
2	24	2½" DIA	2 7/16 / 14 15/16	10 LINKS FROM ABOVE
2	24	2½" DIA	2 1/2 / 14 7/8	10 LINKS FROM ABOVE
2	22	2¼" DIA	2 1/4 / --	1ST 2¼ LINK NEAR ANCHOR
2	22	2¼" DIA	2 1/4 / --	CENTER 2¼ LINK IN ½ SHOT
2	22	2¼" DIA	2 1/4 / --	LAST 2¼ LINK IN ½ SHOT
2	22	2¼" DIA	2 1/4 / --	1ST 2¼ LINK AT ITEM 9
2	22	2¼" DIA	2 7/32 / --	15 LINKS FROM ABOVE
2	21			SWAGED SHANK DIAMETER
2	21	2"		WIRE DIA 3' FROM FITTING
2	16	1" PLT		SIDE PLATE THICKNESS
2	16	1" PLT		SIDE PLATE THICKNESS
2	16	1" PLT		EQUALIZIER CONNECTION PLT.
2	16 (ZINC 1)			ZINC HGT AT CTR ABOVE PLT
2	(ZINC 2)			DITTO
2	(ZINC 3)			DITTO
2	(ZINC 4)			DITTO
2	(ZINC 5)			DITTO
2	(ZINC 6)			DITTO

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD
WASHINGTON, D.C. [illegible]

MOORING COMPONENT DATA SHEET

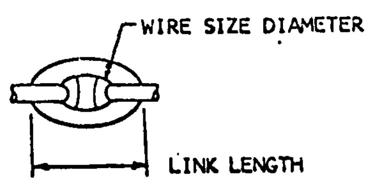
DATA BY Keith Cooper DATE 1/24/80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH X SOUTH --

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
3	24	2½" DIA	2 1/2 / -	1ST LINK 2½ AT ITEM 20
3	24	2½" DIA	2 1/2 / -	10 LINKS FROM ABOVE
3	24	2½" DIA	2 1/2 / -	10 LINKS FROM ABOVE
3	22	2¼" DIA	2 7/32 / -	1ST 2¼ LINK NEAR ANCHOR
3	22	2¼" DIA	2 1/4 / - -	CENTER 2¼ LINK IN ½ SHOT
3	22	2¼" DIA	2 7/32 / -	LAST 2¼ LINK IN ½ SHOT
3	22	2¼" DIA	2 7/32 / -	1ST 2¼ LINK AT ITEM 9
3	22	2¼" DIA	2 1/4 / -	15 LINKS FROM ABOVE
3	21			SWAGED SHANK DIAMETER
3	21	2"		WIRE DIA 3' FROM FITTING
3	4	6 1/2" DIA		WIRE DIA OF GROUND RING
3	4			I.D. OF GROUND RING
3	25	3½" DIA		1ST LINK ABOVE GROUND RING
3	11	3-3/4"DIA		SHACKLE PIN DIA
3	15	2-3/4"DIA		SHACKLE PIN DIA

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD
WASHINGTON, D.C., 20374
ATTN: CODE FPO1-CG

DIEGO GARCIA BUOY MOORING PROJECT
MOORING COMPONENT DATA SHEET

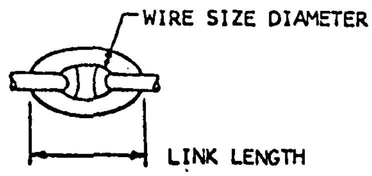
DATA BY Keith Cooper DATE 1-26-80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH X SOUTH --

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
4	24	2½" DIA	2 7/16/-	1ST LINK 2½ AT ITEM 20
4	24	2½" DIA	2 7/16/-	10 LINKS FROM ABOVE
4	24	2½" DIA	2 15/32/-	10 LINKS FROM ABOVE
4	22	2¼" DIA	2 3/16/-	1ST 2¼ LINK NEAR ANCHOR
4	22	2¼" DIA	2 7/32/-	CENTER 2¼ LINK IN ½ SHOT
4	22	2¼" DIA	2 7/32/-	LAST 2¼ LINK IN ½ SHOT
4	22	2¼" DIA	2 3/16/-	1ST 2¼ LINK AT ITEM 9
4	22	2¼" DIA	2 3/16/-	15 LINKS FROM ABOVE
4	21			SWAGED SHANK DIAMETER
4	21	2"		WIRE DIA 3' FROM FITTING
4	12	3"		PLATE THICKNESS

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD

DIEGO GARCIA BUOY MOORING PROJECT
MOORING COMPONENT DATA SHEET

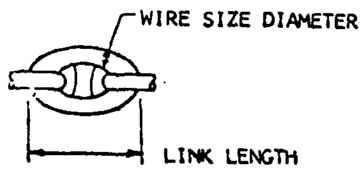
DATA BY Keith Cooper DATE 1/26/80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH X SOUTH --

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
5	24	2½" DIA	2 7/16/-	1ST LINK 2½ AT ITEM 20
5	24	2½" DIA	2 7/16/-	10 LINKS FROM ABOVE
5	24	2½" DIA	2 7/16/--	10 LINKS FROM ABOVE
5	22	2¼" DIA	2 3/16/-	1ST 2¼ LINK NEAR ANCHOR
5	22	2¼" DIA	2 7/32/-	CENTER 2¼ LINK IN ½ SHOT
5	22	2¼" DIA	2 7/32/-	LAST 2¼ LINK IN ½ SHOT
5	22	2¼" DIA	2 1/4/-	1ST 2¼ LINK AT ITEM 9
5	22	2¼" DIA	2 1/4/-	15 LINKS FROM ABOVE
5	21			SWAGED SHANK DIAMETER
5	21	2"		WIRE DIA 3' FROM FITTING
-------	-------	-------	-------	-------
---	6 (BUOY)			ZINC HGT AT CTR ABOVE PLATE
	6			DITTO
	6			DITTO
	6			DITTO

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD

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MOORING COMPONENT DATA SHEET

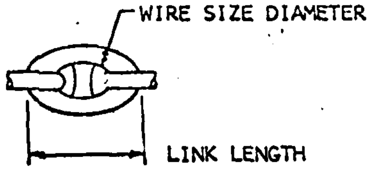
DATA BY Keith Cooper DATE 1-26-80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH --- SOUTH X

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	ø/LGTH. FIELD DIMENSION	REMARKS
1	24	2½" DIA	2 7/16 / 15	1ST LINK 2½ AT ITEM 20
1	24	2½" DIA	2 1/2 / 15	10 LINKS FROM ABOVE
1	24	2½" DIA	2 1/2 / 14 15/16	10 LINKS FROM ABOVE
1	22	2¼" DIA	2 7/32 / 13 7/16	1ST 2¼ LINK NEAR ANCHOR
1	22	2¼" DIA	2 7/32 / 13 1/2	CENTER 2¼ LINK IN ½ SHOT
1	22	2¼" DIA	2 1/4 / 13 9/16	LAST 2¼ LINK IN ½ SHOT
1	22	2¼" DIA	2 1/4 / --	1ST 2¼ LINK AT ITEM 9
1	22	2¼" DIA	2 1/4 / --	15 LINKS FROM ABOVE
1	21			SWAGED SHANK DIAMETER
1	21	2"		WIRE DIA 3' FROM FITTING

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD

DIEGO GARCIA BUOY MOORING PROJECT
MOORING COMPONENT DATA SHEET

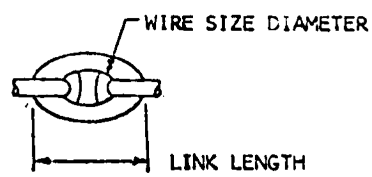
DATA BY Keith Cooper DATE 1/26/80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH --- SOUTH X

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
2	24	2½" DIA	2 11/16 / –	1ST LINK 2½ AT ITEM 20
2	24	2½" DIA	2 3/8 / 15"	10 LINKS FROM ABOVE
2	24	2½" DIA	2 3/8 / --	10 LINKS FROM ABOVE
2	22	2¼" DIA	2 7/32 / –	1ST 2¼ LINK NEAR ANCHOR
2	22	2¼" DIA	2 7/32 / 13	CENTER 2¼ LINK IN ½ SHOT
2	22	2¼" DIA	2 7/32 / –	LAST 2¼ LINK IN ½ SHOT
2	22	2¼" DIA	2 1/4 / --	1ST 2¼ LINK AT ITEM 9
2	22	2¼" DIA	2 1/4 / --	15 LINKS FROM ABOVE
2	21			SWAGED SHANK DIAMETER
2	21	2"		WIRE DIA 3' FROM FITTING
2	16	1" PLT		SIDE PLATE THICKNESS
2	16	1" PLT		SIDE PLATE THICKNESS
2	16	1" PLT		EQUALIZIER CONNECTION PLT.
2	16 (ZINC 1)			ZINC HGT AT CTR ABOVE PLT
2	(ZINC 2)			DITTO
2	(ZINC 3)			DITTO
2	(ZINC 4)			DITTO
2	(ZINC 5)			DITTO
2	(ZINC 6)			DITTO

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD
WASHINGTON, D.C.

MOORING COMPONENT DATA SHEET

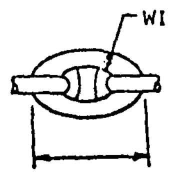
DATA BY Keith Cooper DATE 1-20-80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH --- SOUTH X

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
3	24	2½" DIA	2½/	1ST LINK 2½ AT ITEM 20
3	24	2½" DIA	2½/14 7/8	10 LINKS FROM ABOVE
3	24	2½" DIA	2 7/16/14 15/16	10 LINKS FROM ABOVE
3	22	2¼" DIA	2 3/16/–	1ST 2¼ LINK NEAR ANCHOR
3	22	2¼" DIA	2 7/32/ -	CENTER 2¼ LINK IN ½ SHOT
3	22	2¼" DIA	2 3/16/ -	LAST 2¼ LINK IN ½ SHOT
3	22	2¼" DIA	2 3/16/ --	1ST 2¼ LINK AT ITEM 9
3	22	2¼" DIA	2 7/32/13 7/16	15 LINKS FROM ABOVE
3	21			SWAGED SHANK DIAMETER
3	21	2"		WIRE DIA 3' FROM FITTING
3	4	6 1/2" DIA		WIRE DIA OF GROUND RING
3	4			I.D. OF GROUND RING
3	25	3½" DIA		1ST LINK ABOVE GROUND RING
3	11	3-3/4"DIA		SHACKLE PIN DIA
3	15	2-3/4"DIA		SHACKLE PIN DIA

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD
WASHINGTON, D.C., 20374
ATTN: CODE FPO1-CG

DIEGO GARCIA BUOY MOORING PROJECT
MOORING COMPONENT DATA SHEET

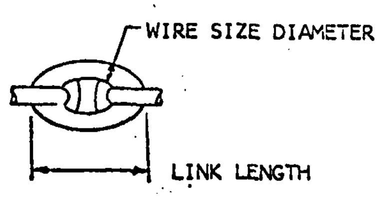
DATA BY Keith Cooper DATE 1-22-80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH -- SOUTH X

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
4	24	2½" DIA	2 1/2 / -	1ST LINK 2½ AT ITEM 20
4	24	2½" DIA	2 1/2 / 15"	10 LINKS FROM ABOVE
4	24	2½" DIA	2 5/8 / 14 7/8	10 LINKS FROM ABOVE
4	22	2¼" DIA	2 7/32 / -	1ST 2¼ LINK NEAR ANCHOR
4	22	2¼" DIA	2 7/32 / -	CENTER 2¼ LINK IN ½ SHOT
4	22	2¼" DIA	2 3/16 / 13 3/8	LAST 2¼ LINK IN ½ SHOT
4	22	2¼" DIA		1ST 2¼ LINK AT ITEM 9
4	22	2¼" DIA		15 LINKS FROM ABOVE
4	21			SWAGED SHANK DIAMETER
4	21	2"		WIRE DIA 3' FROM FITTING
4	12	3"		PLATE THICKNESS

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD

O GARCIA BUOY MOORING PROJECT

MOORING COMPONENT DATA SHEET

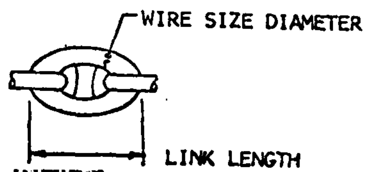
DATA BY Keith Cooper DATE 1-21-80

REFERENCE: NAVFAC DRAWINGS 3017737 AND 3017738

MOORING SITE: NORTH — — SOUTH X

LEG NO.	DWG IDENT ITEM NO.	NEW ITEM DIMENSION	FIELD DIMENSION	REMARKS
5	24	2½" DIA	2 13/32 / –	1ST LINK 2½ AT ITEM 20
5	24	2½" DIA	2 15/32 / 14 15/16	10 LINKS FROM ABOVE
5	24	2½" DIA	2 13/32 / 14 7/8	10 LINKS FROM ABOVE
5	22	2¼" DIA	2 1/4 / 13 1/16	1ST 2¼ LINK NEAR ANCHOR
5	22	2¼" DIA	2 3/16 / –	CENTER 2¼ LINK IN ½ SHOT
5	22	2¼" DIA	2 3/16 / –	LAST 2¼ LINK IN ½ SHOT
5	22	2¼" DIA	2 5/16 / –	1ST 2¼ LINK AT ITEM 9
5	22	2¼" DIA	2 7/32 / –	15 LINKS FROM ABOVE
5	21			SWAGED SHANK DIAMETER
5	21	2"		WIRE DIA 3' FROM FITTING
------	------	------	------	------
---	6 (BUOY)			ZINC HGT AT CTR ABOVE PLATE
	6			DITTO
	6			DITTO
	6			DITTO

COMMENTS



RETURN DATA SHEET TO:
COMMANDING OFFICER, CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 57, WASHINGTON NAVY YARD

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DATE
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