

VERIFICATION OF SPREAD MOORING SYSTEMS FOR FLOATING DRILLING PLATFORMS

VOLUME IV: A STATIC MODEL FOR MOORING REVIEW

by

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Prepared for

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RESTON, VIRGINIA 22091

Under Contract N00167-85-D-0002 with

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PREFACE

As offshore oil exploration moves into ever deeper waters, greater demands are placed on mooring systems. Safety of the crew, preservation of the environment, and protection of the rig itself demand that mooring systems perform reliably during operations and storms alike. It is the responsibility of the Minerals Management Service (MMS) of the U.S. Department of the Interior to insure the satisfactory performance of mooring equipment aboard exploratory oil rigs in service in United States offshore oil fields. This work was commissioned to provide MMS personnel with a manual for the analytical and physical evaluation of rig mooring systems.

This is Volume IV of a four-volume set. The purpose of these manuals is to provide a procedural structure to support the activities of MMS described above. It does not purport to be a textbook of mooring analysis or design, nor a compendium of mooring design data. That ground has been well plowed by others. Rather, a procedure for evaluating the mooring gear for a drilling rig is described.

- Volume I Methods for Spread Mooring Review
- Volume II Methods for Spread Mooring Inspection
- Volume III Dynamic Modeling in Spread Mooring Review
- Volume IV A Static Model for Spread Mooring Review

Volume I describes five steps for evaluating a mooring design and illustrates the procedure by evaluating a sample semisubmersible mooring. Volume II is a review of mooring evaluation from the standpoint of the hardware itself - the components of a typical mooring, their inspection and testing. Volume III illustrates dynamic modeling of a spread-moored drilling platform.

This manual - Volume IV - documents a computer program called RIGMOOR which was prepared to simplify estimating the static holding power of spread moorings.

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INTRODUCTION

RIGMOOR is a computer model for evaluating the holding capacity of spread moorings (Figure 1). It emphasizes the needs of mooring evaluation rather than mooring design. The goal has been to provide a tool that is easy to use by people who are not mooring specialists, a tool that can be as convenient as a modern personal computer, yet a tool that encompasses the variety of design common to spread moorings. This model is not intended as a tool for monitoring spread moorings in real time. A mooring monitor program supports such real-time functions as relocating the drilling platform within the operational watch circle, optimizing load sharing among legs for a specific weather load and the like.

1. Oppenheim, B.W., Manual for Computer Program "BOMOOR 2.00" for Interactive Mooring Analysis, B.W.Oppenheim, PhD & Associates, Inc., Santa Monica, CA, 1984.

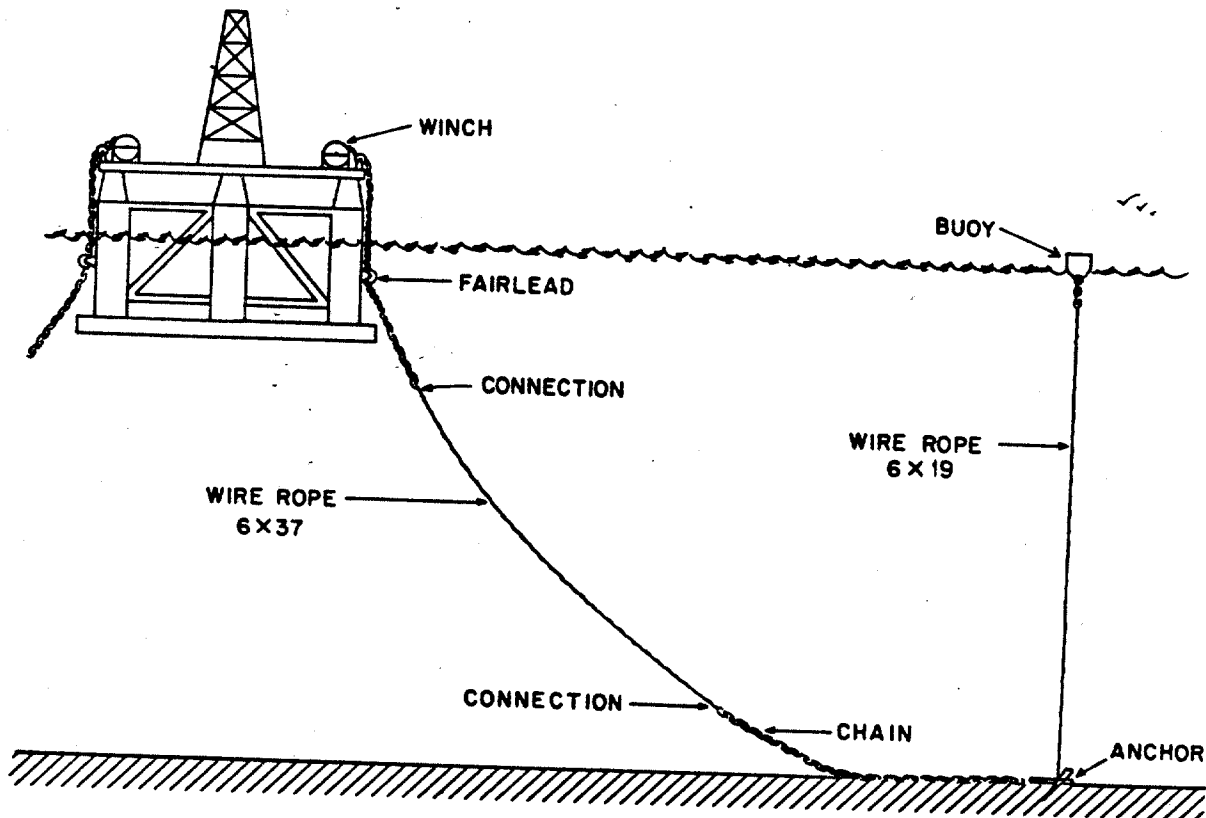


Figure 1. Typical Spread Mooring for Floating Drilling Platform

Consistent with the goal that RIGMOOR should be easy to use, the program is designed around a central menu (Figure 2). The menu lists ten functions performed by RIGMOOR clustered in groups. A summary directive is displayed below the menu: "Enter 0 through 9 or Q". That is, press any numeral or the "Q" key and then press the key marked "ENTER" or "RETURN". This directive is followed by the cryptic note "?=Help: ". This note appears throughout RIGMOOR when an operator entry is desired. It serves as a reminder that the operator may respond to any prompt by entering "?". In response RIGMOOR will display more explanation for the expected entry.

All functions end by re-displaying the function menu.

Functions 0 and 9 relate to defining mooring cases and selecting among them. Functions 1 through 4 perform mooring computations and functions 5 through 8 display results in tables. These groups are discussed in sections 1, 2, and 3.

RIGMOOR accommodates from two to twelve spread mooring legs, deployed from fairleads located around the perimeter of the platform. Spread moorings commonly use a single leg design for simplicity and symmetry. RIGMOOR accommodates this by the concept of leg type: the user describes one leg, and its properties are assigned to all similar legs.

Up to twelve individual types can be defined for a single mooring, which permits analysis of a mooring (probably absurd) in which every leg was different. The sample problem analysed in Volumes I and III illustrates a hypothetical mooring with ten legs and three leg types. The four legs at bow and stern are all chain, the two legs on the beam are wire rope with 9 shots of chain at the anchor and the four diagonal legs are all wire rope.

Since the weight, strength and elasticity of a leg element depend on its size and construction, only the size and construction are required entries. RIGMOOR will estimate the other parameters, using models for high strength stud-link chain and 6x37 Monitor AA wire rope (either fiber core or independent wire rope core). Unusual values can be specified directly.

Oil rigs commonly use one of three kinds of mooring legs - all chain, all wire rope, or a segment of chain near the anchor linked to a segment of wire rope at the upper end. RIGMOOR permits as many as five segments to be coupled in a single leg.

These three models are sufficient for most purposes. The definition of a mooring is stored in a computer disk file. The mooring definition file is a text file that can be edited using ordinary editor or word processing utilities. Punctilious users can change the derived parameters to reflect an unusual leg element, and expert users can create the entire definition file using the editor.

More common in spread moorings for ships and barges than for drilling platforms, buoyant or heavy objects may be placed at any junction between segments in a leg. The location of each buoy (weight) on or below the surface (above the bottom) is determined according to the load in the leg. Buoys and weights may be mingled in a leg, but surfaced buoys may not be nearer the anchor than bottomed clumps, a simplification in accord with common sense.

RIGMOOR

MULTI-LEG SURFACE MOORING DESIGN REVIEW

Version 1.00

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Note: Enter ? in place of any entry to receive on-screen help.

Enter Drive and Rig Name

A:RIGNAM

?=Help:

a. RIGMOOR Title Screen

EXPLORATORY OIL RIG MOORING LEG ANALYSIS

David B. Dillon EG&G, Inc.

Current Rig Definition Root: SAMPLE

Entry	Operation
1	Compute operational and survival holding power rose for mooring
2	Adjust anchor leg lengths for mooring preload
3	Compute preload vs scope (H vs S) for each leg type
4	Compute offset vs load (X vs H) for each anchor leg
5	Display and print operational and survival holding power roses
6	Display and print preload vs scope tables
7	Display and print offset vs load tables
8	Display and print current rig definition
9	Select another rig definition file, old or new
0	Define a new rig
Q	Quit

Enter 0 through 9 or Q

?=Help:

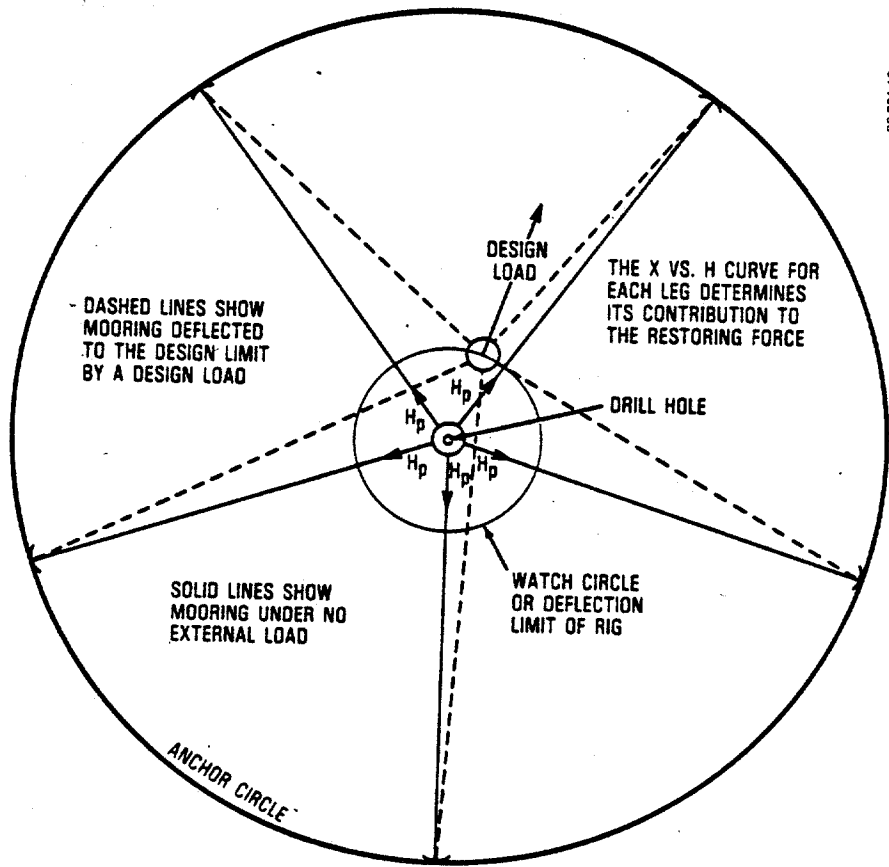
b. Main Menu of Functions

Figure 2. RIGMOOR Control Screens

RIGMOOR assumes that the bottom is flat and that the leg fairleads are at a common level on the platform.

Anchor patterns for spread moorings are usually symmetric as shown in Figure 3, where the legs are uniformly spaced around a circle. Circular symmetry offers the most uniform holding power against loads from any direction. Another common pattern has left/right or bow/stern symmetry. This pattern can give greater holding power to resist storms from a prevailing direction. The sample problem has both right/left and bow/stern symmetry. RIGMOOR accepts anchor patterns with or without symmetry. RIGMOOR may be slick, but it won't slide uphill, and solutions may not be attained for highly unsymmetric mooring patterns.

RIGMOOR analyzes each leg and the anchor pattern to determine how the preload should be distributed among the legs in order to center the moonpool over the blowout preventer in the absence of external forces. With symmetric patterns and uniform leg construction, all the legs are loaded to the same preload; an unsymmetric pattern or leg construction will require the legs to have different preloads. RIGMOOR develops a table expressing the ratio of the actual preload in each leg to the average preload for the mooring. The user can enter the average preload or let RIGMOOR estimate it.



21.00012

Figure 3. An Anchor Pattern with Circular Symmetry

RIGMOOR's preload minimizes the anchor radius on the philosophy that a leg overload should drag its anchor before parting the leg. Using the theory presented in Appendix B of Volume I, RIGMOOR estimates a preload such that:

The design load will deflect the leg to the design watch circle;

The design load will stress the leg to its working stress limit, i.e. tension divided by safety factor; and

The design load will lift all the leg from the bottom except a reserve of about five percent of the water depth.

RIGMOOR prepares a table of preload vs leg length for each different leg type so that the user can select other preloads.

RIGMOOR has no module to compute the dynamic response of the drilling vessel to ocean waves. These computations require specialized technical knowledge to match hydrodynamic theory with the geometry of the vessel. None of the large computer models that perform these computations will operate within the constraints of the present generation of personal computers. The assumption is justified by the prevalence of semi-submersible floating drilling platforms. The semi-submersible platform is noted for an inherently low response to wave action. RIGMOOR, however, does not ignore the motion of the platform. While it cannot make an estimate of the heave motion of the platform, it can show the quasi-static effects of heave on both holding power and tensile safety factor in the mooring legs. The static holding power can be re-calculated with the vessel displaced up or down from its nominal draft.

RIGMOOR is written in Fortran-77 in order to be easily installed on a variety of computers. Using the \$STRICT metacommand of MicroSoft's Fortran compiler, version 3.31, ensures that no proprietary extensions to Fortran-77 are included. It is well-suited for use on any IBM-PC compatible machine with at least 192 Kb memory, one 360 Kb floppy disk drive, and 80 column printer. A second "floppy" makes separating case files from RIGMOOR program files more convenient. A "hard" disk accelerates file operations for any program. Execution time depends upon the number of leg types in a case and the number of segments in a leg. As a rule of thumb, it takes roughly as long to analyse a case (Function 1) as it does to define it (Function 0). A numerical co-processor (8087, etc.) speeds execution substantially, but without it case times are still measured in minutes.

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