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AUG 77 T J ANDERSON, E H NICKELL, W F HILL N62477-73-C-0359
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Volume 5.

FIXED OCEAN FACILITIES
BOTTOM MOUNTED
SURFACE STRUCTURES

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The report describes, defines, and interrelates the elements of bottom mounted surface structure types of Fixed Ocean Facilities. The various elements are identified and defined by means of a generic breakdown structure that serves to categorize and completely define the tasks associated with this type of fixed ocean facility.

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FOREWORD

This report was prepared under Contract No. N62477-73-C-0359, Modification P00008, by the Lockheed Missiles & Space Company, Inc., Sunnyvale, California.

The report describes, defines, and interrelates the elements of bottom mounted surface structure types of Fixed Ocean Facilities. The various elements are identified and defined by means of a generic breakdown structure that serves to categorize and completely define the tasks associated with this type of fixed ocean facility.

This report was prepared for the Department of the Navy, Chesapeake Division, Naval Facilities Engineering Command, Washington, D.C. Key personnel involved in its preparation were T. J. Anderson, E. H. Nickell, and W. F. Hill, all of LMSC. Acknowledgment is also made for the specialized contributions from numerous personnel within the Ocean Systems organization of LMSC's Research and Development Division.

CONTENTS

INTRODUCTION

This report documents a detailed breakdown structure of Fixed Ocean Facility components related to Bottom Mounted Surface Structures. The data presented herein describes, defines, and interrelates the elements of bottom mounted (BM) surface structure types of Fixed Ocean Facilities.

SCOPE

The data presented herein are restricted to facilities that are unmanned or that may be temporarily manned during inspection or maintenance – in effect, defining the type of BM hardware that is available and may be employed to construct a facility of the types addressed in this report.

CONTENT AND ORGANIZATION

This report contains a numerical listing of the Breakdown Structure that lists the number and title of each component and subcomponent, a presentation of the Breakdown Structure units with supporting narrative in numerical order, and a bibliography of source documents. Terms that may be considered unusual are defined within the text as they occur. The BM Breakdown Structure is inserted in an envelope preceding the inside back cover, and may be removed and referred to while reading the report.

The narratives conform, in general, to a common format which describes the hardware (DESC), defines its function in the structure (FUNCT), and identifies its function interfaces within the structure (INTER). The descriptions and functions are provided at the lowest identifiable level and the interrelationships are shown generally at the generic grouping level. Other abbreviations and terms used in the text are defined as follows:

Naval Fixed Ocean Facility - An installation mounted on structures erected on the ocean floor or suspended above the ocean floor by means of a mooring system.

Facility Life Cycle - The order of actions in the life of a facility: First, the facility is conceived in the form of requirements and conceptual designs, then it is defined in detail designs and plans, after which it is constructed and put into operation and the mission of the facility can be fulfilled.

Breakdown Structure - The division of a subject into generic categories arranged in a hierarchical structure which serves to completely analyze and define the subject. Each category is subdivided into one or more levels of elements with each element being generically related to and defined by the collection of elements appearing at the level below it.

INSTRUCTIONS FOR THE READER

The Breakdown Structure has been amplified by supporting narrative that identifies and defines BM elements. Each element (BM function) is identified as a bullet under each unit (box) within the Breakdown Structure.

A unique number for reference purposes is assigned each bulleted item. This number appears in the numerical listing and in the narrative description. The narrative describes the subsystem, component, or element; defines its function in the structure; and identifies its functional interface requirements within the breakdown structure. Tabs are provided for each major section.

BM-000 BOTTOM MOUNTED SURFACE STRUCTURES

DESC - Bottom Mounted Surface Structures are a type of Fixed Ocean Facility wherein a structure is mounted above the air-water interface by means of rigid subsurface structural members with foundations that rest on or penetrate the bottom. The first-level breakdown structure is shown in Fig. BM-000-1.

This report considers only facilities that are unmanned or that may be temporarily manned during inspection or maintenance. The facilities may be used for a number of broadly defined missions, including but not limited to: aids to navigation, ranges, communications platforms, surveillance platforms (above or under water), oil storage, ship moorings, electromechanical systems such as power stations or pumping stations, oceanographic or meteorologic monitoring, and/or data collection. Several of these functions could be combined.

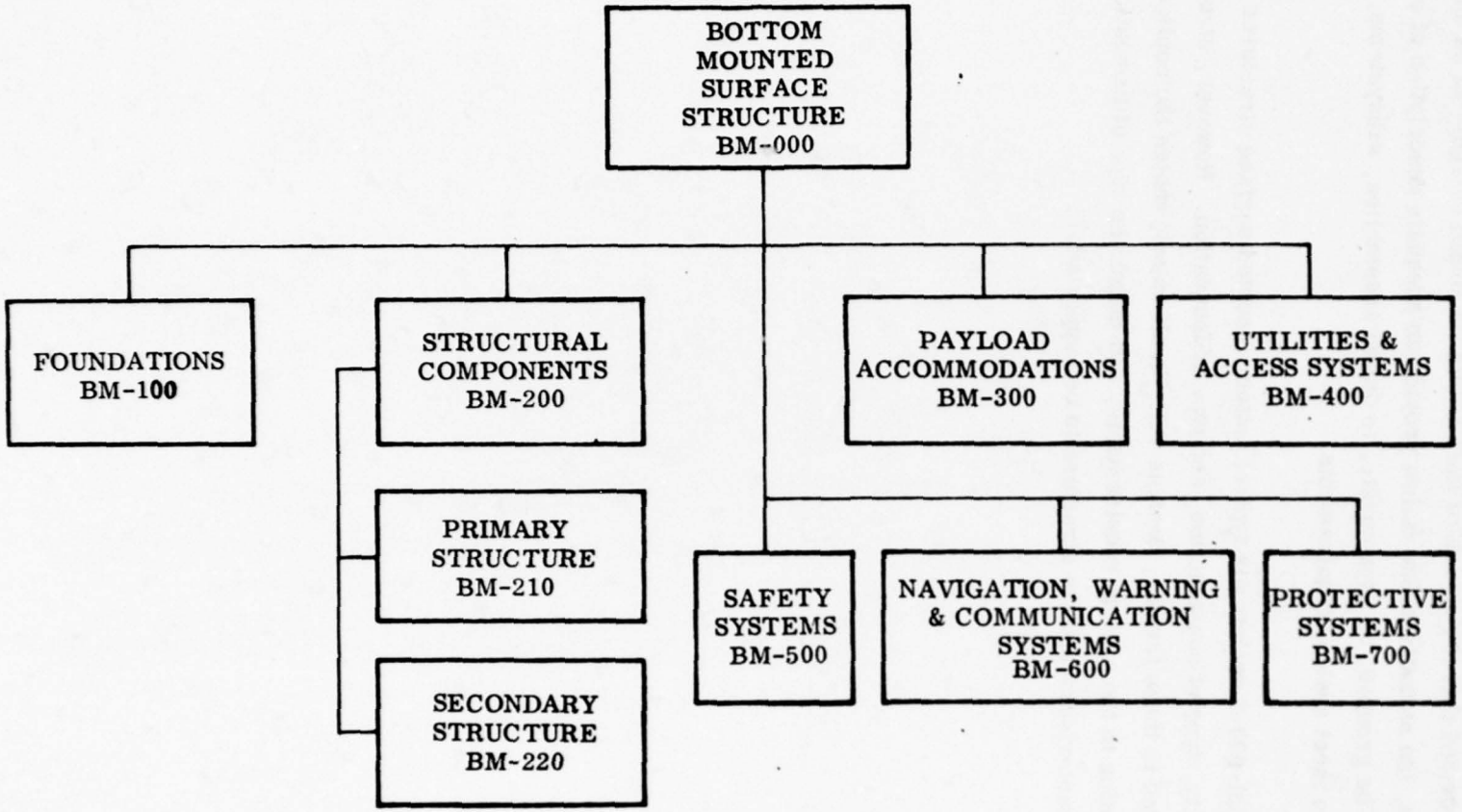

Fig. BM-000-1 Bottom Mounted Surface Structure – First Level Breakdown

For purposes of this report, the specific configuration of a BM structure is unimportant. Provided that the structure falls within the broad category of an unmanned BM structure, the narratives that follow provide an adequate description of components that may be grouped, as appropriate, to define assemblies, subsystems, and the facility to meet system requirements.

Figure BM-000-2 depicts six typical bottom mounted surface structures differing in complexity, type of construction, and type of foundation. However, structures are not limited to these forms. Designs will, in all cases, match the configuration and construction to the system requirements, and match the type of foundation to the seabed characteristics and the structure to be supported.

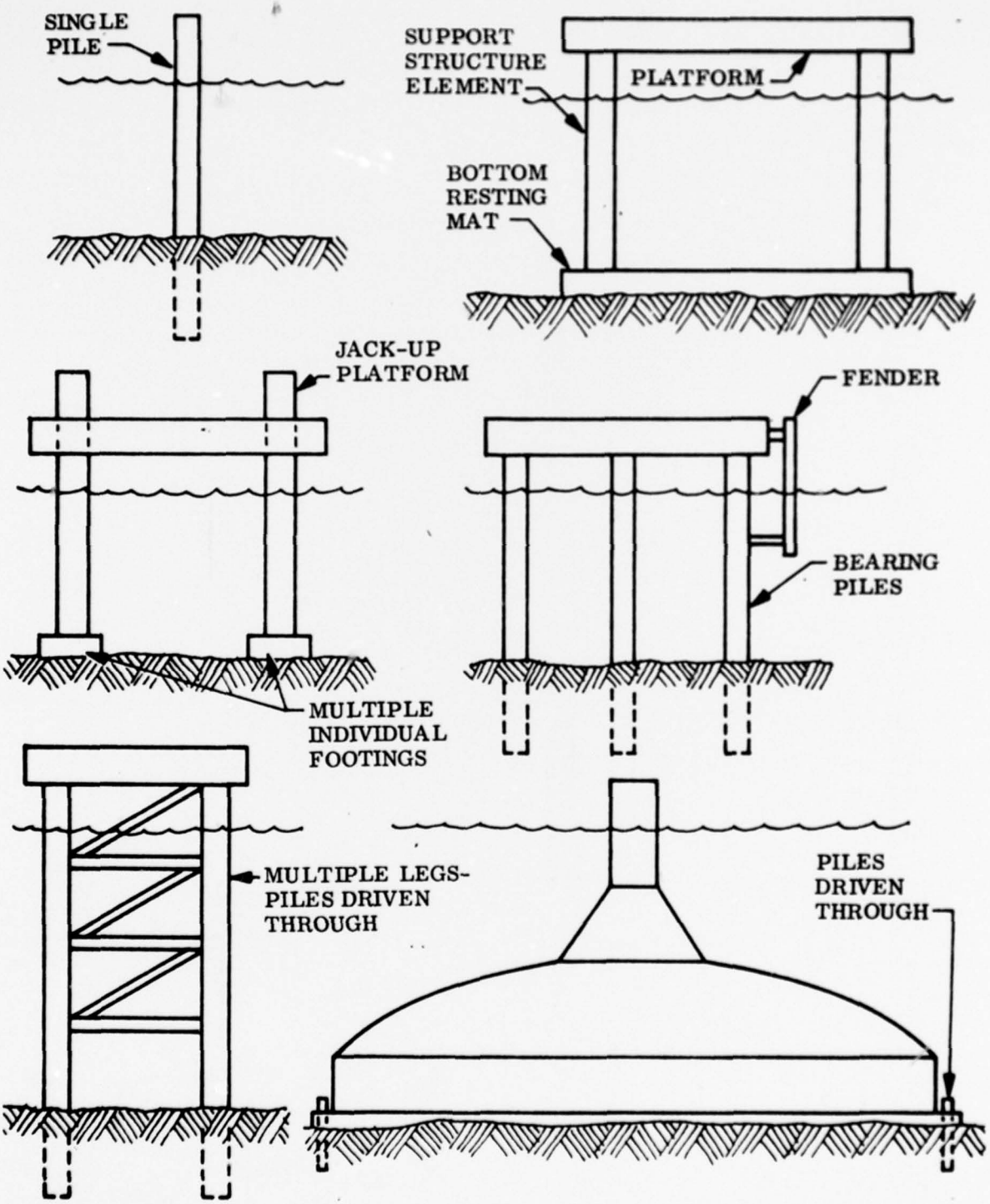

Fig. BM-000-2 Typical Bottom Mounted Surface Structures

NUMERICAL LISTING
OF
BOTTOM MOUNTED SURFACE STRUCTURE
BREAKDOWN STRUCTURE
(BM-100)

BM			ELEMENT
000			BOTTOM MOUNTED SURFACE STRUCTURE
	100		FOUNDATIONS
		110	FOOTINGS
			110.1 Spread
			110.2 Strip
			110.3 Mat
		120	PILES
			120.1 Individual
			120.2 Multiple/Bottom Template
			120.3 Multiple/Platform Template
		130	COMBINATIONS
			130.1 Slab Template with Piles
			130.2 Submersible Hull and Template with Piles
		140	FOUNDATION/STRUCTURE CONNECTIONS
			140.1 Cast-in-Place Concrete
			140.2 Grout
			140.3 Bolts
			140.4 Welds
			140.5 Rivets
			140.6 Pins (Articulated Connections)
		150	SCOUR PROTECTION DEVICES
			150.1 Rip Rap Mats
			150.2 Spread Footing Skirts

NUMERICAL LISTING
OF
BOTTOM MOUNTED SURFACE STRUCTURE
BREAKDOWN STRUCTURE
(BM-200)

BM	ELEMENT		
000	BOTTOM MOUNTED SURFACE STRUCTURE		
200	STRUCTURAL COMPONENTS		
210	PRIMARY STRUCTURE		
	211	BEAMS/COLUMNS	
		211.1	Rolled Section
		211.2	Built-Up
		211.3	Tubular
		211.4	Reinforced Concrete
		211.5	Prestressed Concrete
		211.6	Solid (Timber)
	212	PLATES/SHELLS	
		212.1	Steel
		212.2	Concrete
		212.3	Plastic (Reinforced)
		212.4	Rubberized Fabric
	213	STABILIZING MEMBERS	
		213.1	Stringers/Stiffeners
		213.2	Rings/Arches
		213.3	Tie Rods/Edge Beams
	214	JOINTS/CONNECTIONS	
		214.1	Rivets
		214.2	Bolts
		214.3	Welds
		214.4	Gaskets
		214.5	Adhesives
	215	BRACES/STRUTS	
		215.1	Rolled Section
		215.2	Built-Up
		215.3	Tubular
		215.4	Reinforced Concrete
		215.5	Prestressed Concrete
		215.6	Solid (Timber)

NUMERICAL LISTING (Continued)

BM	ELEMENT
000	BOTTOM MOUNTED SURFACE STRUCTURE
200	STRUCTURAL COMPONENTS (Continued)
220	SECONDARY STRUCTURE
221	WALKWAYS/LADDERS
222	DOORS/HATCHES/CUTOUTS
222.1	Pressure Barriers
222.2	Load Carrying
222.3	Viewports
222.4	Windows
223	FITTINGS/FIXTURES
223.1	Lifting, Hauling/Towing Padeyes
223.2	Tiedowns
224	EQUIPMENT FOUNDATIONS
224.1	Shock Mounts
225	APPURTENANCES
225.1	Valves
225.2	Manifolds
225.3	Pipes
225.4	Vents

NUMERICAL LISTING
OF
BOTTOM MOUNTED SURFACE STRUCTURE
BREAKDOWN STRUCTURE
(BM-300)

BM			ELEMENT
000			BOTTOM MOUNTED SURFACE STRUCTURE
	300		PAYLOAD ACCOMMODATIONS
		310	ENCLOSURES
			310.1 Buildings
			310.2 Vans
			310.3 Work Spaces
		320	ATTACHMENT PLATES AND FITTINGS
		330	LOAD HANDLING/DECK GEAR
			330.1 Deck Winches
			330.2 Cranes
			330.3 Bitts
		340	MASTS

NUMERICAL LISTING
OF
BOTTOM MOUNTED SURFACE STRUCTURE
BREAKDOWN STRUCTURE
(BM-400)

BM	ELEMENT
000	BOTTOM MOUNTED SURFACE STRUCTURE
400	UTILITIES AND ACCESS SYSTEMS
410	ELECTRICAL POWER SYSTEM
411	POWER SOURCES
411.1	Battery
411.2	Fuel Cell
411.3	Engine-Driven Generator
411.4	Wind-Driven Generator
411.5	Nuclear
411.6	Thermoelectric Generators
411.7	Solar Panel
411.8	Shore Power
412	CONDITIONING/CONTROLS
412.1	Fuses
412.2	Circuit Breakders
412.3	Regulators
412.4	Switching Gear
412.5	Rectifiers
412.6	Converters
412.7	Inverters
412.8	Transformers
412.9	Signal Conditioners
413	POWER DISTRIBUTION SYSTEMS
413.1	Electrical Cables
413.2	Junction Boxes
413.3	Connectors
413.4	Slip Rings
420	FUEL SYSTEM
420.1	Storage Facilities
420.2	Distribution Systems
420.3	Fuel Loading Systems

BM	ELEMENT
000	BOTTOM MOUNTED SURFACE STRUCTURE
400	UTILITIES AND ACCESS SYSTEMS (Continued)
430	WATER SYSTEM
430.1	Storage Facilities
430.2	Distribution Systems
430.3	Sources
440	WASTE DISPOSAL SYSTEM
440.1	Waste Collection Devices
440.2	Waste Treatment Devices
440.3	Disposal Systems
450	MECHANICAL POWER SYSTEMS
451	HYDRAULIC
451.1	Power Generator/Regulators
451.2	Valves, Piping and Fittings
451.3	Accumulators/Reservoirs
451.4	Motors/Actuators
452	PNEUMATIC
452.1	Air Compressors/Regulators
452.2	Valves, Piping, and Fittings
452.3	Accumulators/Reservoirs
452.4	Motors/Actuators
453	MECHANICAL
453.1	Weights
453.2	Inertial
453.3	Springs

NUMERICAL LISTING (Continued)

BM	ELEMENT
000	BOTTOM MOUNTED SURFACE STRUCTURE
400	UTILITIES AND ACCESS SYSTEMS (Continued)
460	ACCESS SYSTEM
460.1	Boat Landings
460.2	Helo Landings
460.3	Ladders
460.4	Walkways
460.5	Hatches
470	FLOODING SYSTEM
470.1	Piping and Equipment

NUMERICAL LISTING
OF
BOTTOM MOUNTED SURFACE STRUCTURE
BREAKDOWN STRUCTURE
(BM-500)

BM			ELEMENT
000			BOTTOM MOUNTED SURFACE STRUCTURE
	500		SAFETY SYSTEMS
		510	FIRE FIGHTING EQUIPMENT
			510.1 Detection Devices
			510.2 Alarm Systems
			510.3 Extinguishers
		520	PERSONNEL SAFETY EQUIPMENT
			520.1 Railings
			520.2 Screens
			520.3 Escape Apparatus
			520.4 Protective Clothing
			520.5 Safety Harnesses
			520.6 Remote Shutdown
			520.7 Emergency Signals
			520.8 Lightning Arrestors
			520.9 First Aid Kits

NUMERICAL LISTING
OF
BOTTOM MOUNTED SURFACE STRUCTURE
BREAKDOWN STRUCTURE
(BM-600)

BM			ELEMENT
000			BOTTOM MOUNTED SURFACE STRUCTURE
	600		NAVIGATION, WARNING, AND COMMUNICATION SYSTEMS
		610	ACOUSTIC
			610.1 Bells/Horns/Whistles
			610.2 Transponders
			610.3 Pingers
			610.4 Reflectors
		620	VISUAL
			620.1 Lights
			620.2 Reflectors
		630	ELECTROMAGNETIC
			630.1 Telecommunications
			630.2 Signal Conditioners
			630.3 Radar Reflectors

NUMERICAL LISTING
OF
BOTTOM MOUNTED SURFACE STRUCTURE
BREAKDOWN STRUCTURE
(BM-700)

BM			ELEMENT
000	BOTTOM MOUNTED SURFACE STRUCTURE		
	700		PROTECTIVE SYSTEMS
		710	MECHANICAL (FENDERS)
			710.1 Pneumatic Fenders
			710.2 Rope Fenders
			710.3 Crushable Elements
			710.4 Stand-Off Boom
			710.5 Ship Fenders
		720	COATINGS
			720.1 Paints and Tar
			720.2 Plastics and Rubber
			720.3 Antifouling Paints
		730	CATHODIC PROTECTION
			730.1 Sacrificial Anodes
			730.2 Impressed Current Cathodic Protection (Technique, not a component)

BM-100 FOUNDATIONS

DESC - Foundations are the structural elements that interact directly with the sea floor to support the facility (See Fig. BM-100-1).

FUNCT - Foundations are designed to supply, with an adequate factor of safety, vertical and lateral reactions against all loads imposed by or upon the facility. In addition to preventing catastrophic failure (e.g., bearing capacity failure or overturning), foundations are designed to prevent, or limit to an acceptable level, settlement or lateral displacements of the facility. Foundations perform their function by mobilizing the shearing and bearing resistance of the seafloor soil.

INTER - In addition to the principal interface with the seafloor soil, foundations also interface with the primary structure (BM-200). This interface requires consideration of the means of transferring loads from the primary structure to the foundation elements. This interface is discussed further under Foundation/Structures Connections (BM-140).

BM-110 FOOTINGS

DESC - Footings are rigid foundation elements that derive their supporting capacity by direct bearing upon the seafloor. Footings are usually placed at a depth below the seafloor surface that is less than the minimum dimension of the footing. Various types of footings are used in the construction of Bottom Mounted Surface Structures. The selection of a particular type for an application is based on the size and load of the structure, soil type, and supporting requirements. Types are spread, strip, and mat footings. (BM-110.1, BM-110.2, and BM-110.3, respectively.)

The selection of foundation-to-structure connections is dependent upon the types of loads to be transferred to the footings and the types of materials selected for primary and foundation structures. In lieu of a series of discrete spread footings, Strip Footings (BM-110.2) should be considered where the foundation geometry indicates a row of closely spaced columns. If the total plan area of all spread footings for a facility is greater than about 50 percent of the facility plan area, consideration should be given a Mat Foundation (BM-110.3) in place of spread footings.

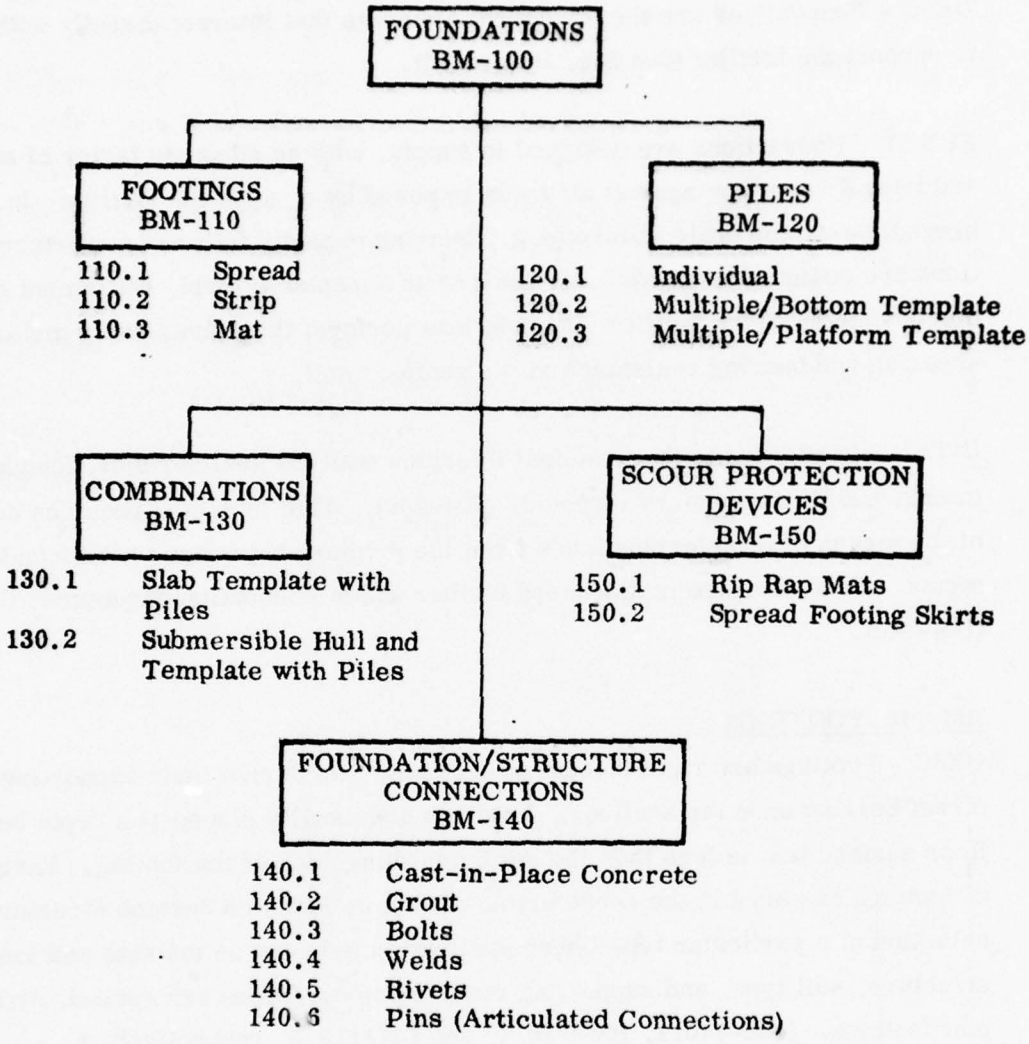

Fig. BM-100-1 Foundations – Breakdown Structure

FUNCT - Footings are designed to transmit column or wall loads over a sufficiently large area of the supporting soil so that:

(1) The shear stresses induced in the soil are less than the ultimate shear strength of the soil and

(2) The net change in normal stresses in the soil beneath the footings is not so large that excessive settlements occur due to soil consolidation.

Because of the large environmental forces frequently imposed upon Bottom Mounted Surface Structures (e.g., wind and wave forces) footings for such structures may also be designed to provide additional weight to resist overturning and to resist lateral loads.

INTER - Covered by general statement in BM-100 and specifications in BM-140.

BM-110.1 Spread

DESC - Spread footings are usually flat plate/slab elements that have plan dimensions much less than the overall plan dimensions of the facility. They are typically fabricated from reinforced concrete or steel plate stiffened by rolled sections.

FUNCT - Spread footings are designed to provide bearing support for a single column or a group of closely spaced columns.

INTER - Spread footings have a functional interface with Columns (BM-211) to which they are attached and furnish bearing support . Descriptions of the interfacing elements can be found in Foundation/Structure Connections (BM-140).

BM-110.2 Strip

DESC - Strip or continuous footings are slab or plate elements whose length is greater than their width (5:1 minimum) and whose length may be equal to a plan dimension of the facility. They are usually made of reinforced concrete or of built-up or rolled steel sections.

FUNCT - Strip footings are used to provide bearing support for a row (or rows) of columns. The continuity provided between columns by the strip footing allows for load sharing and a decrease in possible differential settlements between columns.

INTER - Strip footings have a functional interface with the Columns (BM-211) to which they are attached and furnish bearing and some lateral support. Interfacing connections (BM-140) are dependent upon the type of loading to be transferred to the footing and the material used in both the primary and foundation structure.

BM-110.3 Mat

DESC - Mat foundations are usually large flat plate or slab elements having plan dimensions approaching or greater than the plan dimensions of the facility. They are planned for seafloor penetrations that are quite small in comparison to the mat width. Mat foundations are appropriate if:

(1) The sum of individual footing bases exceeds about one-half the total foundation area
(2) Subsurface soil contains cavities or compressible lenses
(3) Shallow shear strain settlements predominate and the mat would equalize settlements
(4) Limited penetration is desirable, in the event that the mat is to be lifted for relocation

FUNCT - Mat footings are designed to provide bearing support for all primary structure columns and to limit their displacement into subsurface strata.

INTER - Mats have a functional interface with Columns (BM-211) to which they are attached, furnish bearing support, and limit displacement into the ocean bottom soil. Interface connections (BM-140) are dependent upon the type of loading transferred to the soil and the materials used in foundation and primary structures.

BM-120 PILES

DESC - Piles are structural members of timber, concrete, and/or steel that penetrate the ocean floor and are used to transmit loads to lower levels in the soil mass. This load transfer may be friction, bearing, or a combination of both depending on whether

the load is resisted by friction generated along the surface of the pile or whether the point of the pile rests on a stratum firm enough to carry the imposed load. Penetration into the soil mass necessarily tends to fix the pile in place. This degree of fixity depends on the shape and size of the pile, depth of penetration, angle of installation, method of installation, and bottom material properties. A single pile may be capable of providing the required support, but normally many are required.

Steel piles used as foundations are usually pipes or rolled shapes. Screw piles are used for easier penetration and greater resistance to upward pull forces. Simple piling as well as sheet steel interlocking piles are installed by hammering them into the soil with a pile driver. Other installation methods include jetting-in, drilling in, or placing in a hole filled with concrete. Hollow piles may also be filled with concrete for greater strength and/or weight.

Concrete piles may be driven in the same manner as steel piles or the concrete may be cast in place. Precast piles are of round, octagonal, or square cross section, and may be solid or hollow. Prestressed concrete is generally used for marine locations. Drilled-in caissons consist of a steel cylinder filled with concrete and may have a steel shape core. Prestressed concrete sheet piling may be built in various shapes and can be used either as bearing piles or as retaining walls.

Use of wooden piles is generally confined to shallow water.

FUNCT - The function of piles is to provide the supporting forces and stability required to prevent settling, sliding, uplift, or overturning of the facility built upon them. Piles may also be used as retaining walls, but this function is not normally required for a fixed ocean facility.

INTER - Pile foundations interface with the upper portions of the structure. The attachments (BM-140) between the two must be designed for transmittal of all loads imposed. In some cases, the piles are driven through hollow structural columns of the upper structure. The design of the piles must also be compatible with the equipment and methods used to transport them to the site and to install them. This involves equipment for lifting, lowering, holding, and driving, or other methods of embedding.

BM-120.1 Individual

DESC - Individual piles are usually made of steel or concrete and may be emplaced in the sea floor without benefit of a locating template. They should be used only in locations where the upper soil strata strength is adequate to fix the pile in place.

FUNCT - Individual piles have the same general function as described in BM-120. However, a single pile should be considered only if proper attention is given to reinforcement of the load bearing column (BM-211) and the pile itself in order to accommodate eccentricities.

BM-120.2 Multiple/Bottom Template

DESC - A multiple pile foundation with a bottom-sitting template consists of a three-dimensional framework or jig which rests on the ocean bottom and through whose legs piles are driven and made integral. The framework is generally of structural steel and is floated to the site or launched from a barge. This type of foundation is usually used as a permanent installation where the depth does not exceed about 350 ft.

FUNCT - This foundation system is used to transfer loads to deep soil systems wherein pile placement is controlled by a bottom-sitting template and load transfer is accomplished by the piles only. They are generally used where the bearing strength of the surface soil is weak and, hence, would not economically provide sufficient support for a footing-type foundation. Alternatively, they may be used where bearing loads are relatively light and can be carried by piles but where lateral support is also required.

BM-120.3 Multiple/Platform Template

DESC - A multiple pile with a platform template consists of upper and lower decks separated by rigid framework or trusses. Vertical pipe collars are attached at critical points (corners, etc.) through which piles are driven into the sea bottom. The entire system may be floated to the site. Where great depths of penetration are required, or where extra platform height is required, extra leg lengths are welded on at the site.

FUNCT - This foundation system is used to transmit loads, vertical and lateral, to deep soil systems through a pile system whose placement is controlled by the primary structure above the waterline. The system enables the platform to be self elevating, and loading on individual piles may be adjusted.

BM-130 COMBINATIONS

DESC - Combinations of foundation types may be necessary where the nature of the installation or of the bottom soil or the magnitudes and directions of loads imposed by the primary structure indicate that a single type of foundation would be inadequate. These combinations generally consist of slab or mat type foundations penetrated by and made integral with piles. They may also consist of a submersible hull integral with a template and supported on piles.

FUNCT - The function of combination-type foundation is to transfer primary structure loads (lateral, vertical, moment) to the sea floor bottom utilizing both surface bearing and pile penetration for support.

INTER - Combination-type foundations interface with structural Columns (BM-211) through Foundation/Structure Connections (BM-140).

BM-130.1 Slab Template with Piles

DESC - Slab template/pile foundations consist of flat plate elements bearing on the sea floor and penetrated by piles. The slab must have sufficient rigidity to allow the driving of piles through the template in the proper orientation. When the piles have been driven to the required depth, the slab is connected to the piles making a rigid integral structure.

FUNCT - The slab element mobilizes the shearing strength of the soil in bearing capacity while the pile penetrates to deeper strata, providing both bearing and lateral support. A slab template/pile foundation is capable of resisting large downward loads by virtue of the developed bearing capacity. The mass of the slab combined with suction effects adds to the resistance developed by the piles to react large vertical upward forces. The lateral resistance of the piles is enhanced by the slab penetrating the soil surface, providing lateral resistance as with a retaining wall, and frictional resistance at the slab/soil interface.

BM-130.2 Submersible Hull and Template with Piles

DESC - This foundation system consists of a submersible hull and a rigidly attached template for guiding and attaching piles to be driven into the bottom soil. A valuable operating characteristic of this type of structure is the adjustable dimension between the operating platform and the foundation combined with the capability to temporarily overload foundation elements by judicious flooding of buoyancy chambers in the hull.

FUNCT - The hull structure of this foundation, when flooded and buried, acts as a mat-type foundation which resists vertical, lateral, and moment-producing loads. With the hull thus emplaced, piles are driven into the sea bottom, increasing the load resistance of the structure. The weight of the submerged flooded hull can be utilized in preconsolidating the soil directly below it. Generally one pipe can be driven or jacked into the soil with the elevated deck and other legs used as a reaction. Increasing the buoyancy of the hull after preconsolidating and/or overloading the legs reduces the foundation load, providing larger margins of safety against bearing capacity failures. Piles are integrally attached to the template and hull. Hull-type structures do not have the depth capability of other types.

BM-140 FOUNDATION/STRUCTURE CONNECTIONS

DESC - Foundation/structure connections are those mechanical features provided to ensure load continuity across the interface and may take several forms, depending upon the type of structures and loading conditions. Principal forms of connection are: cast-in-place concrete, grout, bolts, welds, rivets and pins.

FUNCT - Foundation/structure connections transfer all vertical, lateral, and bending loads directly from the primary structure to the foundation structure. They are designed with factors of safety at least equal to those imposed on the foundation and the primary structure. The type of connection is dictated by the water depth, the design configuration, the location of the interfaces, and the material used in primary and foundation structures.

INTER - Foundation/structure connections interface with the primary structure Columns (BM-211) and the designated foundation system which may be Footings (BM-110), Piles (BM-120), or Combinations (BM-130).

BM-140.1 Cast-in-Place Concrete

DESC - Cast-in-place concrete connections are formed at appropriate structure/foundation interfaces by the underwater placement of suitable concrete mixes (i.e., tremis) or hydraulic cement. In the placement process, a tube is employed to pipe the concrete into suitable forms. The tube's lower end is kept embedded in the fresh concrete as it is placed. Satisfactory bonds have been made with steel, rock, timber, and other concrete when emplaced under water.

FUNCT - Cast-in-place concrete connections are used for load transmittal from structure to foundation where rigid connections are specified. Vertical, lateral, and moment forces are transmitted directly. Stress levels of 4000 to 6000 psi can be attained.

BM-140.2 Grout

DESC - Grout connections are formed in place underwater in a manner similar to cast-in-place connections. The grout mix may consist of sand, cement, and water with little or no aggregate or may be simply a water and cement mixture. In some installations, the grout mix is intruded into aggregate beds that have been emplaced previously. Other installations may require no aggregate. Careful mixing of the grout constituents is necessary as the material must be fluid enough to penetrate well but must not segregate.

FUNCT - Platform loads are transferred to the foundation through bond action of the grout between the primary structure and the foundation. In grouting steel structures, shear lugs may be welded to the steel in order to increase the effective bond area. Grout connections are capable of transmitting vertical, lateral, and moment loads. The bonding strength capability is on the order of 20 psi and the compressive strength is approximately 1500 psi.

BM-140.3 Bolts

DESC - Bolted connections consist of a number of fasteners, usually steel, arranged in suitable patterns through the primary structure, and connecting/attachment plates.

Bolted structure/foundation attachments may be employed if:

(1) The entire structure is floated to the site

(2) The depth of installation is such that divers may install them

For attaching primary structures to concrete foundations, the bolts are embedded and grouted in the foundation initially (anchor bolts). Tensile load capabilities of anchor bolts are dependent upon the bond stress developed between the bolt and the concrete. Bonding strength can be increased by the use of hooked bolts, hacked bolts, swedged bolts, or by the use of washers welded to the embedded end.

For attachment of primary structures to steel foundations, normal steel construction practice is followed wherein bolts are strategically located in patterns, usually in conjunction with attachment plates or gussets, to provide the required resistance without overloading any one connection.

BM-140.4 Welds

DESC - Welded connections are formed from the fusing of metal between primary structure and foundation structure.

FUNCT - Welded connections are provided in applications where permanent attachment is required. The application of welding to submerged structures is restricted because of the requirement for use of a welding torch for fusion. Connections must be made prior to emplacement of the entire structure or be made in a water depth that does not exceed the limit at which divers are capable of doing the work.

Care is required in selection of weld rod such that the chemistry of the rod and parent material are identical in order to eliminate galvanic action and possible corrosion in a sea water environment.

BM-140.5 Rivets

DESC - Rivets are shear pins (usually steel) that may be used to make permanent mechanical connections between foundation steel and primary structure steel. The use of a riveting gun for placement of the rivets dictates that the foundation primary structure be assembled prior to placement and that the assembly operation be carried out in relatively shallow water, within the limits of diver operation.

FUNCT - Rivets serve essentially the same function as bolts in group applications to provide load transfer. There are two differences, however:

(1) Rivets are not employed in applications where fastener removal may be a requirement

(2) Rivets are not employed in such a manner that tensile loading may result

BM-140.6 Pins (Articulated Connections)

DESC - Structural connecting pins are usually hardened steel cylinders with threaded ends, a head at one end and threads or a hole for a keeper pin at the other end, or keeper pin holes at both ends. For large pins (10 in. in diameter or greater) the pin assembly may include removable caps at the ends held in place by a bolt running lengthwise through the pin. Installation of pins can be accomplished above or below the water surface. Pin connections are usually made through two predrilled structural steel members.

FUNCT - Pin connections are generally used in (but not limited to) installations where no rotational restraint is required at individual connections. The lack of rotational restraint allows pins to be used in structures that are designed to be articulated or where structural design indicates that zero moment is desired. The use of pins in connections subjected to torsion is not recommended because binding of the joint in a torsional mode limits its ability to function as a hinge.

BM-150 SCOUR PROTECTION DEVICES

DESC - Scour protection devices are nonstructural elements emplaced on, or attached to, foundation elements. They may be made up of random sized aggregate (rocks, boulders, broken concrete) heaped around mat foundations or piles, or may be skirts permanently attached to footings.

FUNCT - Scour protection devices are employed where either currents or wave forces are of such magnitude as to cause migration of seafloor particles away from the foundation which, in turn, causes loss of foundation support in vertical and/or lateral directions. Sand and silt-like materials are more prone to scour than clay-like materials. Use of scour protection devices should be based on observed phenomena, as prediction techniques are unreliable.

INTER - Scour protection devices interface with Footings (BM-110), Piles (BM-120), and Combination Foundations (BM-130) at the sea/seafloor interface. Scouring action around piles reduces the lateral load-carrying capability to a much greater extent than it does the vertical load-carrying capability.

BM-150.1 Rip Rap Mats

DESC - Rip rap mats are aggregations of random sized rocks, boulders, broken concrete, etc., placed around and on the exposed sides of piles, mats, and footings. Placement of the aggregates need not be uniform but should contact all sides of the foundation elements even though the predominant current may be unidirectional.

FUNCT - Rip rap mats are designed to dissipate the force of scouring current by breaking up the flow (rip rap).

INTER - See General Statement under BM-150.

BM-150.2 Spread Footing Skirts

DESC - Spread footing skirts are steel or concrete plates permanently attached around a spread footing perimeter and buried in the soil beneath the footing.

FUNCT - Spread footing skirts are designed to prevent removal of material beneath the footing due to the action of currents or wave forces which would degrade the bearing or lateral restraining capability of the supporting soil. Skirts are most effective in sand/silt material.

INTER - Spread footing skirts have a functional interface with Footings (BM-110) and Combination Foundations (BM-130).

BM-200 STRUCTURAL COMPONENTS

DESC - Structural components consist of both primary and secondary structural members (see Fig. BM-200-1). Structural members may vary considerably in both form and size, but essentially all structures are comprised of basic elements whose behavior under load is well understood. Such elements are beams, columns, plates, or shells. Structures can be either frames or plate/shell construction.

Frame structures are of two categories: 1) pin jointed and 2) fixed (rigid) jointed. Pin jointed structures are characterized by their triangulated construction and joints that do not transfer moments to adjoining members.

Fixed jointed structures are framed, but are not necessarily triangulated. Joints are frequently gusseted and have multiple attachments, thereby providing the capability to transfer moments to adjoining members.

A plate/shell structure is a thin-wall assembly that derives its shape-retaining properties, strength, and stiffness from strategic location of stiffening elements or, in the case of a monocoque, from its geometric configuration and type of loading.

Plates and shells may be made from many types of construction materials. Limp, flexible elastomers are also employed in selected membrane applications.

FUNCT - When designed and assembled in an appropriate configuration, the basic generic structural members can meet virtually any system requirements for such diverse structures as helicopter landing pads, equipment platforms, housings and towers, masts, and equipment foundations. They may be fabricated from any material – metal, concrete, ferro-concrete, or timber – that is compatible with the environment.

Pin jointed braced structures are employed usually in applications where:

(1) The overall structural dimensions are small
(2) A design constraint precludes the transfer of moment
(3) A design requirement necessitates articulation
(4) Deflection is not a critical design condition

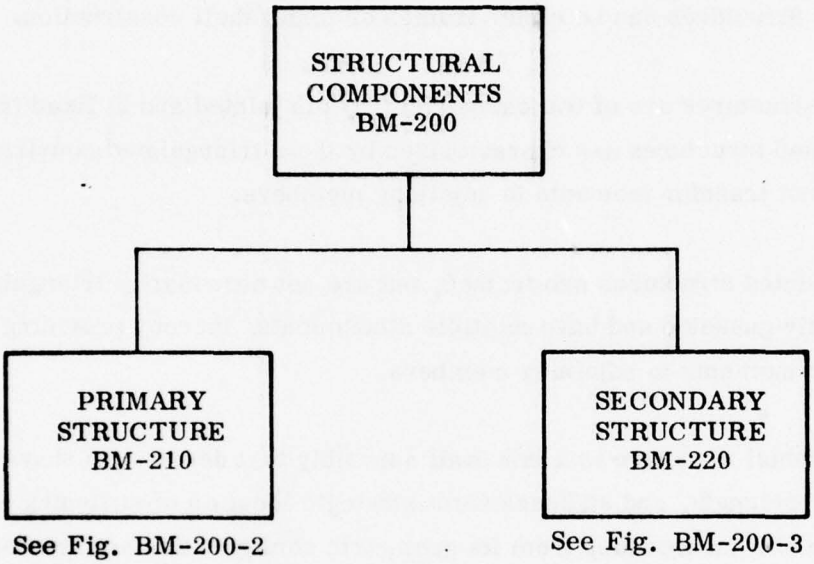

Fig. BM-200-1 Structural Components – Breakdown Structure

Pin jointed structures are fairly small usually because of the practical limitations of manufacture, fit, and assembly of simple pinned connections. Because of tolerances on any pinned connection and because of members axial deformations, the overall deflection is greater than that of a similar fixed jointed structure. For these reasons, usage of this type of structure is often restricted to equipment mountings and supports where the inherent design inefficiency can be offset readily by added mass of material.

Fixed jointed structures have wide application in many forms of bottom mounted FOFs. With virtually no size limitations, rigid frames are found in applications as diverse as the main supports for an ocean platform to any kind of supporting structure in or on an ocean platform. Other advantages of fixed structures are: economic (less material to support a given load or achieve an allowable deflection) and structural rigidity (less deflection per unit weight of structure). Plate/shell structures have wide application wherein high strength-to-weight ratios are desirable, and where compartmentation is a requirement. Such applications include containers, pressure vessels, and housings. These structures are sometimes combined with framed structures to serve various functional requirements.

INTER - Principal interfaces will occur with all other systems (BM-300 through BM-700) wherein the structural elements are the supporting members, and primarily with the Foundations (BM-100) which support the complete structure.

BM-210 PRIMARY STRUCTURE

DESC - Primary structure consists of all structural components of which a failure of any single component could precipitate the collapse of any major portion of the structure. Such failure can be caused by either a single unexpected severe design load or many low-magnitude repeated loads. This structure can consist of members of various forms, sizes, and shapes. The breakdown of elements within the primary structure is shown in Fig. BM-200-2.

FUNCT - All external environmental and internal deadweight or inertial loading are supported and redistributed throughout the structure by the primary structural members.

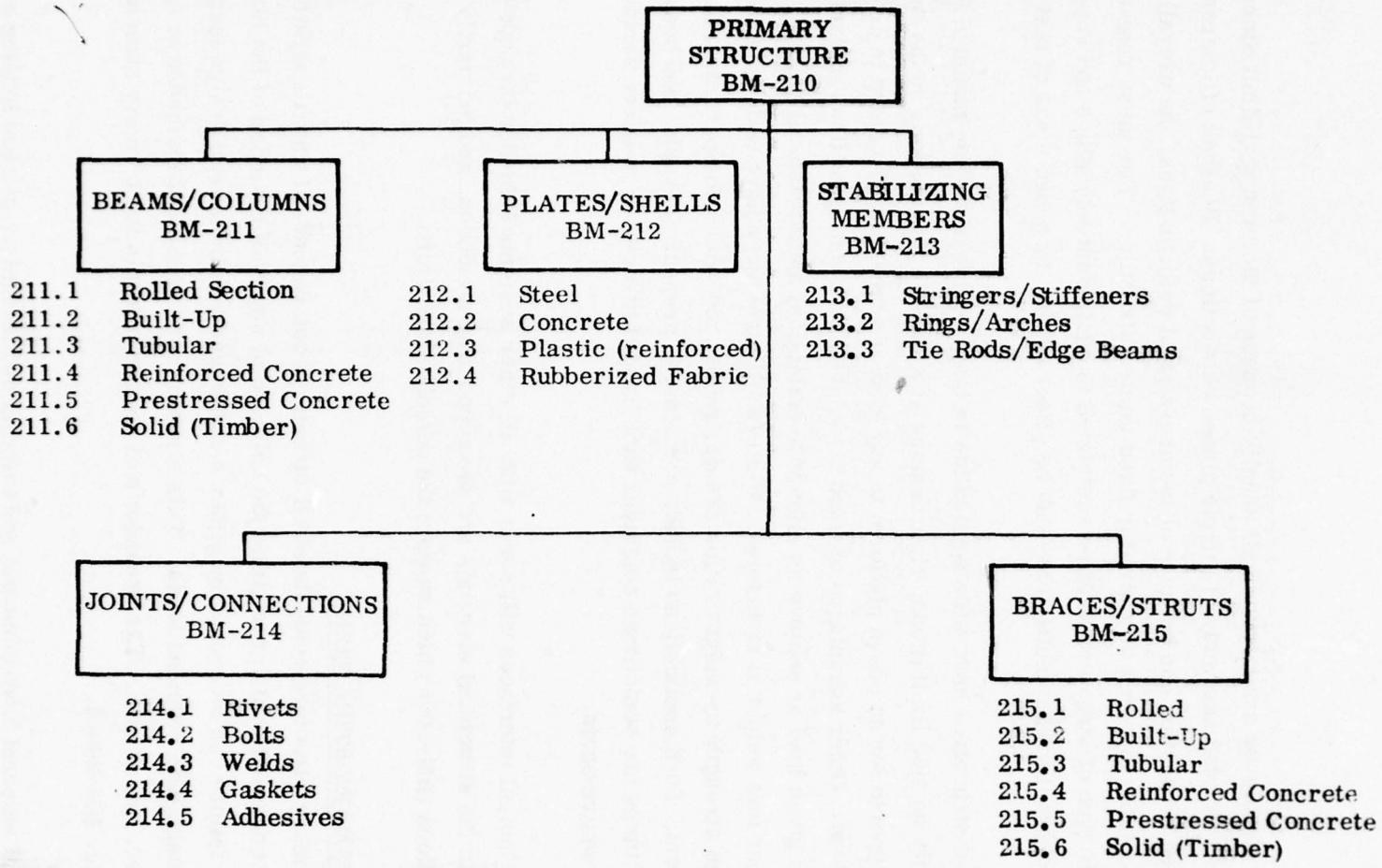

Fig. BM-200-2 Primary Structure – Breakdown Structure

INTER - Primary structure interfaces with Foundations (BM-100) through the Foundation/Structure Connections (BM-140).

BM-211 BEAMS/COLUMNS

DESC - Beams and columns are the primary structural elements of framed structures and can be primary supporting elements combined with plate/shell structural elements.

A beam or column is any structural member with a large length-to-depth ratio. Cross sections of either member may be solid, tubular (box), web and caps, or open truss configurations.

FUNCT - Beams are designed to support/transmit transverse loading. Columns support axial loads. Beam columns are subjected to the combined effects of transverse and axial loads.

INTER - Beams are usually connected to vertical supports, i.e., columns or piles, and to major bulkheads, creating interfaces with Piles (BM-120), Foundation/Structure Connections (BM-140), and Plates and Shells (BM-212).

BM-211.1 Rolled Section

DESC - Beams whose spans do not exceed available lengths of material supplied by rolling mills are frequently designed using standard sections that may be I, H, or T. Such sections offer the economic advantage of low cost and provide good flexural stability characteristics with mechanical strength. These beams are satisfactory in applications where the applied loads are in the plane of the web. Rolled section beams, commonly made from steel, but also available in aluminum, may be joined to other structural elements by welding, riveting, or bolting.

BM-211.2 Built-Up

DESC - For beams in applications where the span or the loading exceeds the limitations of an as-supplied rolled section, built-up sections are commonly employed, using plate and web elements to achieve the required characteristics. For very large beams, the webs may be made from plate (frequently stiffened) or have an open braced construction.

BM-211.3 Tubular

DESC - Closed sections such as pipe and tube are frequently utilized in applications where maximum resistance to applied torsional loading is required. Closed sections are also employed for struts and columns because they offer a large moment of inertia for minimal weight and are not subject to failure modes such as torsional or local instability, which are commonly experienced with open sections. Small closed sections do, however, present difficulty in providing and maintaining corrosion-resistance finishes on the interior surface.

BM-211.4 Reinforced Concrete

DESC - Beams and columns constructed from reinforced concrete offer good economy and excellent resistance to the ocean environment. Concrete members have a compressive strength of approximately 3000 psi and a tensile strength that is approximately 15 percent of the compressive value, although design allowables are significantly less in both cases. Reinforcement within concrete members is designed to provide adequate tensile resistance such that the composite beam or column has the strength to resist applied bending or tensile loading.

BM-211.5 Prestressed Concrete

DESC - The bending strength of ferro-concrete beams is limited by the tensile strength of the conrete, which is very low in relation to the compressive strength. In practice, the tensile strength is often ignored entirely in the design calculations. In applications where tensile stresses are experienced, members are always designed with steel reinforcement. In those instances where the design conditions induce severe tensile loading, members are sometimes prestressed, compressially, to ensure that the net stresses are also compressive.

BM-211.6 Solid (Timber)

DESC - Timber structures have limited application in FOF construction, largely because of the physical limitations of the lumber size. Timber beams may be used to advantage in shallow waters as piles, primary supports, cross-braces, or as beams to support deck planking, etc. In such applications, timber may offer economic

advantages of material and fabrication cost and may also be a better choice in applications such as wharf and piers where the "give" of the structures mitigates the effect of impact loads.

BM-212 PLATES/SHELLS

DESC - Plates are structural members whose thickness is small relative to their length. Plates subjected to transverse loads become curved surfaces and are treated as shells. Shell structures may be monocoque or stiffened. Rolled steel and aluminum plates are available in a wide range of sizes, surface finishes, and alloys. Concrete may be cast in any required plate or shell configuration. Shell structures become membranes when fabricated from very thin metallic, plastic, or fabric materials and are then subjected only to tensile loads.

FUNCT - Plates and shells have wide application in many structures as either shear transfer members or as barriers to applied normal pressure. Typical examples are deep webbed beams, bulkheads, walls, etc., which result in usable compartments.

INTER - In general, plates and shells are part of a larger structural assembly and require, as a minimum, boundary members for attachment and load transfer. Primary interfaces are likely to be in framed Primary Structures (BM-210) or the Foundations (BM-100).

BM-212.1 Steel

DESC - In the as-received condition from the mill, steel plates are usually flat, hot-rolled elements that are available in a variety of standard sizes measuring 8 ft x 4 ft and larger.

Single curvature on thin plates is usually achieved by cold rolling. Thicker plates are frequently hot rolled, depending on the alloy employed. Double curvature is achieved by hammering.

FUNCT - Unstiffened plates are frequently used for closures where load levels are low since, without benefit of stiffening, large plates buckle or cripple at very low stress

levels. For most applications, attached stiffeners provide adequate stability for the plate. Integrally stiffened plates are employed to develop very high working stresses before failure. When failure occurs, it is usually by crippling. However, such elements are comparatively costly, and are not therefore employed if other viable alternatives exist.

BM-212.2 Concrete

DESC - Concrete plates may be pre-cast or cast in place. In either case, the plate will probably contain steel reinforcement. Dimensions of pre-cast plates are limited by transportation/handling considerations, whereas cast-in-place structures have virtually no dimensional limitation.

The composition of the concrete is usually aggregate and the mixture may be varied to meet specific requirements.

Pre-cast plates may be pre-stressed to achieve greater working strengths.

FUNCT - Like any other plate, concrete plates serve to transfer shear or to resist pressure. However, the normal strength of concrete cannot be achieved in thin sections; therefore, it is usually used in structures where the mass is acceptable. In some FOFs, particularly large structures that require adequate mass to preclude motion due to wave action, etc., concrete is economically attractive.

INTER - Principal interfaces are likely to be structural connections.

BM-212.3 Plastic (Reinforced)

DESC - The term plastic is applied to a large family of synthetics that includes acrylics, epoxies, polyesters, polyurethanes, and many more. In sheet form, plastics have little structural strength compared with metals of similar dimensions and must be reinforced to achieve good structural properties. Reinforcement is accomplished in many ways:

(1) By attaching stiffening members

(2) By moulding integral stiffening members

(3) By lamination with other stiffer synthetics (i.e., fiberglass)

(4) Random fiber reinforcement in the matrix

(5) Continuous filament reinforcing at strategic locations

(6) Utilizing the plastic for face sheets of a sandwich with an expanded core

By selection of appropriate materials and specifications, plastics may be obtained in sheet form and in powders or liquids ready for final mixing prior to casting or moulding.

FUNCT - Plastic parts have found wide application in many industries, particularly electrical, where moulded parts such as gears and casings may be produced inexpensively, to fine tolerances, and in a range of colors. Sheets of plastic, either plain or with self reinforcing find application as dividers or partitions where applied loading is of a low order and resistance to marine environmental corrosion is desirable.

Plastics reinforced with continuous fibers such as boron and carbon are very stiff, although expensive, and offer great strength for little weight.

Plastic sandwiches – either laminates or expanded core – are excellent structural members, the latter also offering sound absorption characteristics. Typical applications are in structures where good stiffeners/weight ratios are required with freedom from problems associated with corrosion. Greater stiffness is achieved than stiffened panels of the same depth.

BM-212.4 Rubberized Fabric

DESC - Rubberized fabric is single or multiple layer of woven textiles impregnated with rubber. The fabric provides dimensional stability and strength, while the rubber provides resistance to environmental attack, resistance to fiber breakdown from flexure, and pressure containment. Joining of rubberized fabric elements is achieved by cementing of lap or butt joints. In areas of load concentration such as attachments, cemented reinforcements or boundary members may also be sewn or riveted to provide the required load-transfer capability.

FUNCT - Rubberized fabric is confined to use in flexible structures such as balloons or other gas containers and for containment of fluids, frequently within a rigid structural envelope.

BM-213 STABILIZING MEMBERS

DESC - Stabilizing members are items of structural reinforcement attached to and forming a part of primary structure. Normally they are not in the primary load path but are designed to relieve the primary structure of the effects of secondary or self-induced loads.

FUNCT - Stabilizing members are used particularly in plate or shell structures to stabilize the primary structural members and delay the onset of instability so that they can sustain higher stress levels before failure.

INTER - Primarily interrelationships are with Plates and Shells (BM-212) and with other primary structures such as Beams/Columns (BM-211) and Braces/Struts (BM-215).

BM-213.1 Stringers Stiffeners

DESC - Stringers and stiffeners are special-purpose straight beams or columns that are usually attached to plates of the primary structure. They may take many forms, but are commonly made from rolled angles and tees.

FUNCT - In plates subjected to normal loading, the plate serves to distribute the loading to the stiffeners, which provide the primary bending resistance and limit deflection. For in-place loading, stiffeners effectively reduce panel sizes, increasing the shear stiffness, and are thus loaded in compression.

When attached to plates, the stiffeners "work" with the plate, functioning as an integral part of the stiffener. The effectiveness of a plate in contributing to the bending resistance of a stiffener is approximately 20t on each side of a connection on the compression side and 40t on each side of a connection on the tension side. (t is the thickness of the plate.)

Stringers and stiffeners have application to any FOF in which large plate and shell parts of the structure – such as housing walls, roof panels, or webbed beams – require increased stiffness to transmit the loads, preclude instability, or limit deflections.

INTER - The primary interface is with Plates and Shells (BM-212).

BM-213.2 Rings/Arches

DESC - Rings and arches are special-purpose curved beams or columns that are either curved members for framed structures or attached to plating/membrane shell structures. They may be of any form but are most commonly fabricated from tees.

FUNCT - In shell construction these members are used to increase the structural efficiency by stabilizing the plating or membrane or developing local bending stiffness in the plating or membrane. In framed structures these members are usually used where equipment will not allow the use of straight members. Curved members are not as efficient as straight members in framed construction.

INTER - These members can interface with any of the structural elements of both the Primary and Secondary Structure (BM-210 and BM-220). The basic interface is with Plates and Shells (BM-212).

BM-213.3 Tie Rods/Edge Beams

DESC - Tie rods and edge beams are specialized structural members that supplement the primary structure.

In framed structures there can be solid rod or cables.

Edge beams in shell structures are reinforcements at the edges of plates or membranes.

FUNCT - Tie rods are simple tension members in structures. They are frequently attached between columns or beams to increase the primary structure bending stability or to limit deflections of members to which they are attached.

Edge beams are either tension or compression boundary members for shell structures that support the edge of plates or membranes at openings or in regions of contour changes.

INTER - These members interface with Beams/Columns (BM-211) and Plates/Shells (BM-212).

BM-214 JOINTS/CONNECTIONS

DESC - Joints/connections between structural members may be separate structures to which two or more members are mutually attached, or the joint/connection may be the fastening of two members to each other. Joints may be classified by the type of structure being joined (e.g., pipe joints, beam connections) or by the method of fastening (welding, riveting, bonding, threading) or by the form of the joint (e.g., ball and socket, splice, framed, seated, butt, lap, etc.) or as to whether they are flexible or rigid joints.

FUNCT - Structural joints/connections are required in order to assemble the various elements into an integrated, effective structural whole. Joints must be capable of transmitting all structural loads from one member to another without causing undue stress concentrations. The deflection permitted by the joint is an important parameter. In some cases the deflection must be limited while in other cases it must be unrestricted.

Rigid joints are used to fasten structural members together so that there is no relative motion between them (other than elastic deflection). The joints therefore transmit all types of load, i.e. axial, shear, bending and torsion. Generally, tubular members are joined by welding, in order to develop maximum joint strength. Other methods used in piping connections, such as couplings, unions, and other threaded types of joints do not develop the full strength of the members but may be used in small sizes for convenience or they may be welded after joining. Non-tubular members may be joined either directly to each other by welds, rivets, bolts, or adhesives, or connected to intermediate connections such as brackets or gussets.

In places where movement between the connected elements is required, various types of joints are used, which can transmit one type of load but do not react others. Typical of these are: ball and socket, pin, sliding, or expansion joints, splines, pin and clevis, etc.

INTER - Joints do not generally interface with other elements except those that they serve to connect. Occasionally tubular structures serve dual functions as piping systems, and in such cases the joint's resistance to flow is important and the connection must be leakproof. Joints in the water must be compatible with electrolytic properties of other elements in water, structural or otherwise.

BM-214.1 Rivets

DESC - There are three basic types of joint – lap, single butt, and double butt – each of which may have one or more rows of rivets. In lap and single-butt joints the rivets are in single shear and the joint is subjected to some rotation because of the misalignment of the plates under load. Rivets in double-butted joints are loaded in double shear, the joint has greater load-carrying capacity than the other types, and it is not subjected to assymetric loading. Rivets are not used in joints where the loading is primarily axial on the connections (see Bolts, BM-215.2).

Regardless of type or numbers of rivet rows, no riveted joint can achieve 100 percent efficiency and values rarely exceed 80 percent.

Rivet head formations may conform to any of several standard protruding patterns or may be flush headed. Head configurations have little effect on strength, although flush heads are weaker in sheet applications. Rivets in structural steels are usually driven hot.

FUNCT - Rivets are employed to provide mechanical shear connections between any two members.

INTER - Interfaces may occur with any structural element of the system (BM-200).

BM-214.2 Bolts

DESC - Bolted joints are very similar to riveted joints in many respects, including patterns and efficiency. Unlike rivets, which theoretically completely fill the holes through which they pass, bolted joints are not watertight unless special provisions are made.

FUNCT - Bolts are employed primarily in applications where the joint may need to be dismantled after initial installation, as in the attachment of equipment which must be removed for servicing/replacement during the life cycle of the facility. Bolts are also employed in structural applications where the connectors are subjected to significant tensile loading.

INTER - Primary interfaces will occur with Fittings/Fixture, Appurtenances (BM-225) and to the structural elements to which they are attached.

BM-214.3 Welds

DESC - Weldments are the result of joining structural members by the application of heat to reach the melting point of the metal whereupon the members are fused together, usually with the addition of filler metal. Welding methods applicable to FOFs include submerged arc, shielded arc, gas shielded arc, and plasma arc. The great majority (90 percent) of FOF welding is and will be accomplished by the shielded arc process since the primary material used in FOFs is low-to-moderate strength steel (30 to 100 ksi yield strength) and manual welding with the shielded arc process is the best welding process for erection operations. Weldment designs include full-penetration butt, tee, and corner welds, as well as fillet welds. Fillet welds may be intermittent or continuous. Where the weldment is exposed to sea water, the fillet weld should be continuous.

BM-214.4 Gaskets

DESC - Gaskets may be metallic or nonmetallic materials. Gaskets will be of various materials, shapes, and thickness depending on their function.

In the case of piping they may be circular, square, or rectangular and from 1/32 in. to 1/4 in. thick. Gasket materials include low alloy steel, stainless steel (except where exposed to seawater), asbestos fiber in elastomer matrix, silicone rubber, natural rubber, PVC, and fluorocarbons.

FUNCT - The function of gaskets is to provide relatively low-pressure seals in systems to prevent seawater entry (or exit), hydraulic fluids, hydrocarbon fluids, or low-pressure gases.

INTER - Gaskets may interface with steel-to-steel structures and piping, concrete to steel, nonmetallic piping, materials, rivets, bolts, and adhesives.

BM-214.5 Adhesives

DESC - Adhesives are materials used to provide a bond between materials. The characteristics of the adhesive are that (1) it must be resistant to seawater degradation and the marine biological community, (2) it must retain flexibility where it is used in a dynamically loaded assembly, (3) it must resist seawater pressures, (4) it must be resistant to hydrocarbons (where necessary), and (5) it must not degrade the materials with which it interfaces.

Adhesives used in FOFs should be easy to handle (toxicity, pot life) and apply, and must have relatively high adhesion strength when cured at ambient temperatures.

FUNCT - The function of adhesives is (1) to provide structural and/or nonstructural bonds between components of the structure, (2) to prevent seawater entry, (3) to prevent loss of hydraulic fluid, and (4) to prevent loss of hydrocarbon fluids such as gasoline and fuel oil.

INTER - Adhesives will interface with gaskets and associated steel flanges.

BM-215 BRACES/STRUTS

DESC - Braces and struts are particular forms of short columns.

FUNCT - Braces and struts are utilized in framed or truss structures to stiffen the primary load-carrying members or to reduce unsupported lengths. In pin jointed frames they are compressive members and function as columns. In fixed jointed frames they may be loaded in compression in combination with applied bending.

BM-215.1 Rolled Section

DESC - Members whose spans do not exceed available lengths of material supplied by rolling mills are frequently designed using standard sections that may be I, H, or T. Such sections offer the economic advantage of low cost and provide good flexural stability characteristics with mechanical strength. These braces are satisfactory in applications where the applied loads are in the plane of the web. Rolled section braces or struts, commonly made from steel, but also available in aluminum, may be joined to other structural elements by welding, riveting, or bolting.

BM-215.2 Built-Up

DESC - For braces and struts in applications where the span or the loading exceeds the limitations of an as-supplied rolled section, built-up sections are commonly employed, using plate and web elements to achieve the required characteristics. For very large members, the webs may be made from plate (frequently stiffened) or the member may have an open braced construction.

BM-215.3 Tubular

DESC - Closed sections such as pipe and tube are frequently utilized in applications where maximum resistance to applied torsional loading is required. Closed sections are also employed for braces and struts because they offer a large moment of inertia for minimal weight and are not subject to failure modes such as torsional or local instability, which are experienced commonly with open sections. Small closed sections do, however, present difficulty in providing and maintaining corrosion-resistant finishes on the interior surface.

BM-215.4 Reinforced Concrete

DESC - Braces and struts constructed from reinforced concrete offer good economy and excellent resistance to the ocean environment. Concrete members have a compressive strength of approximately 3000 psi and a tensile strength that is approximately

15 percent of the compressive value, although design allowables are significantly less in both cases. Reinforcement within concrete members is designed to provide adequate tensile resistance such that the composite member has the strength to resist applied bending or tensile loading.

BM-215.5 Prestressed Concrete

DESC - The bending strength of ferro-concrete braces and struts is limited by the tensile strength of the concrete, which is very low in relation to the compressive strength. In practice, the tensile strength is often ignored entirely in the design calculations. In applications where tensile stresses are experienced, members are always designed with steel reinforcement. In those instances where the design conditions induce severe tensile loading, members are sometimes prestressed, compressially, to ensure that the net stresses are also compressive.

BM-215.6 Solid (Timber)

DESC - Timber structures have limited application in FOF construction, largely because of the physical limitations of the lumber size. Timber braces and struts may be used to advantage in shallow waters to support other timber structures. In such applications, timber may offer economic advantages of material and fabrication cost and may also be a better choice in applications such as wharf and piers where the "give" of the structures mitigates the effect of impact loads.

BM-220 SECONDARY STRUCTURES

DESC - Secondary structures consist of all structural members failure of which would not precipitate the collapse of any major portion of the structure. The breakdown of structural members within secondary structures is shown in Fig. BM-200-3.

FUNCT - These are structural members that only support loading of a minor nature such as the dead weight and associated inertia loads of a piece of equipment or piping.

INTER - These members are usually small interconnecting members between the various items of system hardware and the Primary Structure (BM-210).

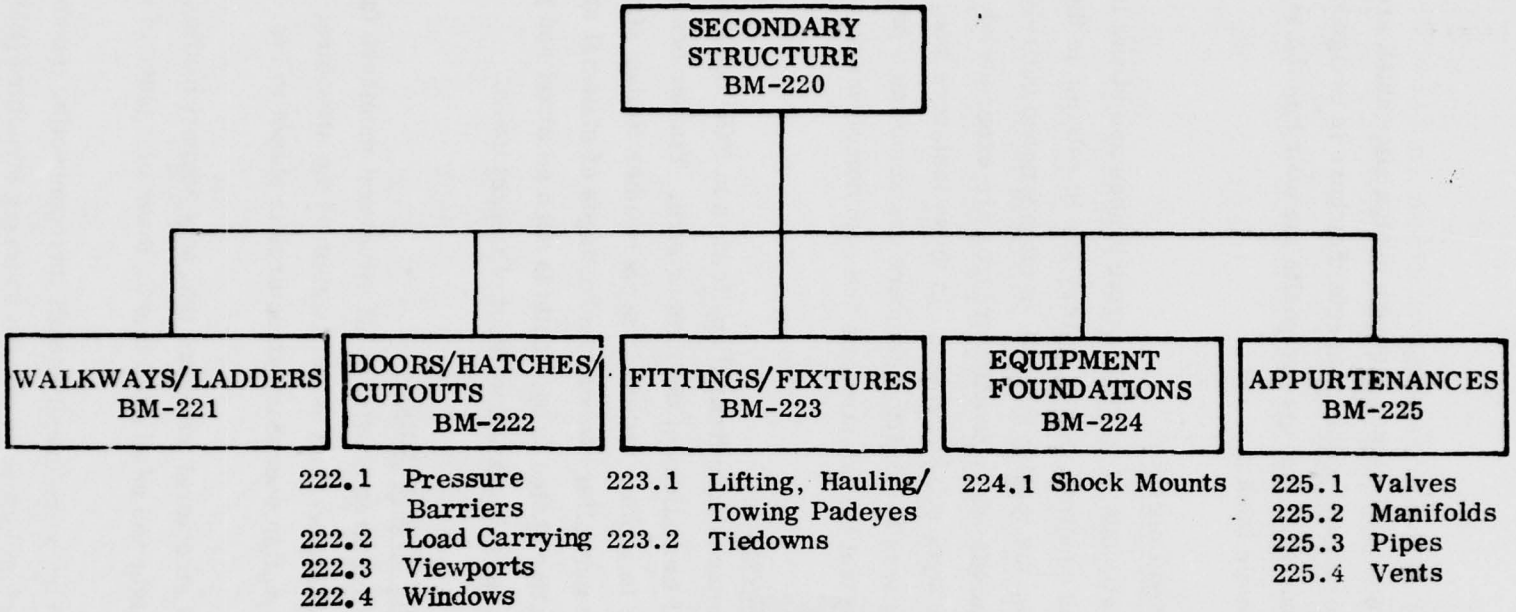

Fig. BM-200-3 Secondary Structures – Breakdown Structure

BM-221 WALKWAYS/LADDERS

DESC - Walkways and ladders are structural components consisting of beams and plates. The beam elements for the sides are usually conventional in form and the rings may be similar, but can also be as simple as a circular rod. Walkways are generally fabricated from expanded metal or dimpled plate. Designated walkways on continuous surfaces, particularly inclined, are covered by a nonskid material that is bonded in place. Such materials provide assured footing, particularly on surfaces that become wet and icy. Ladders can be made from rope, but in general these components are fabricated from metallic materials. Walkways and ladders provide basic stepping areas, but may be built up on the sides by staunchions or pipes that are connected by chains, lines, or pipes for hand support.

FUNCT - Structures for walkways and ladders are special structural components used for the movement of personnel both horizontally and vertically.

INTER - These structural components interface with the Primary Structure (BM-210) and probably with Joint and Connections (BM-214).

BM-222 DOORS/HATCHES/CUTOUTS

DESC - Doors, hatches, and cutouts are openings in the primary structure, usually in the plating or shell. Structure around the opening is reinforced to provide a load path and to maintain structural integrity. The openings are fitted with doors, hatches, or windows to make them pressure, water, weather, fluid, or air tight according to service requirements. In certain cases the doors or hatches may be designed to carry load across the opening.

FUNCT - Doors, hatches, and cutouts give access for personnel or material, permit viewing through the structural shell, and admit light to the internal spaces.

INTER - These structural components interface with Primary Structure (BM-210).

BM-222.1 Pressure Barriers

DESC - Pressure barriers are covers for structural openings constructed from beams and plates or membranes and of a material compatible with the surrounding structure. They are usually hinged and have locking devices such as dogs or latches. Elastomeric seals are fitted around to edges to make the covers watertight, weathertight, or sometimes light-tight, as required.

BM-222.2 Load Carrying

DESC - These components are covers for structural openings which are designed to transfer in-plane structural loads across the opening so that, in effect, the cover is an integral part of the primary structure. This type of construction is particularly useful where a large opening occurs in the plating since, with the cover carrying the load, it is not necessary to design the edges of the opening for stress concentration.

BM-222.3 Viewports

Viewports are openings cut in a submerged structural shell to give visibility from inside the structure. The opening is glass covered with a size limited by the load-carrying capability of the glass when subjected to external pressure. The glass is usually fitted to the exterior surface of the hull so that it tends to be self sealing and has gaskets or seals.

BM-222.4 Windows

DESC - As with viewports, windows give visibility from the structure but above the surface and also serve to admit light. The glass covering is designed to be weathertight and where necessary is hinged and provided with dogs or latches.

BM-223 FITTINGS/FIXTURES

DESC - Fittings and fixtures are special structural items consisting of single or multiple structural elements generally of metallic material. The form of the items can be varied depending upon the function being performed.

FUNCT - These items are used in conjunction with components of other systems. They can be standard fittings such as cleats, padeyes, tiedowns, etc., which are permanently attached to the structure. They can also be platforms, shelves, or special attachments to support a component of some system.

INTER - Fittings and fixtures interface with either the Primary Structure (BM-210) or the Secondary Structure (BM-220), and may interface with one or more of the other systems (BM-300 thru 700).

BM-223.1 Lifting/Hauling/Towing Padeyes

DESC - Structural padeyes may consist of beams, rings, arches, and plates and are designed to be compatible with the primary structure and material with which they connect. On very large structures these padeyes may also be very large and are sometimes integral.

FUNCT - Padeyes are special structural elements for lifting, hauling, and towing a complete or partially complete structural system during the process of erecting or transporting it to the site or between sites.

INTER - Padeyes interface with the Primary Structure (BM-210).

BM-223.2 Tiedowns

DESC - Tiedown fittings are fabricated in a variety of shapes from metallic materials. They may protrude from the surface of a structural member or may be recessed, leaving the structural surface free of obstructions.

FUNCT - Tiedown fittings accommodate cables and lines for securing and for transferring the cable load to the structure.

BM-224 EQUIPMENT FOUNDATIONS

DESC - Equipment foundations are special structural components that support engines, machinery, and other equipment. The foundations may vary considerably in size and shape, depending upon the functions to be performed. Their shape and size may vary considerably.

FUNCT - The equipment foundations are the connecting structures between the equipment and primary structure that transmit the equipment loads to other structure for redistribution.

INTER - Equipment foundations interface with all other components of BM-300 through BM-700 and the Structure (BM-200).

BM-224.1 Shock Mounts

DESC - A shock mount is a specialized device for attaching/connecting equipment to its foundation or to the structure. Shock mounts are available in several forms and in a wide range of sizes to match specific requirements. One or more may be grouped together to provide the required reaction capability.

FUNCT - Shock mounts isolate equipment from the vibrations and/or sound of the supporting structure, and vice versa.

INTER - The mounts interface with the system components (BM-300 thru 600) and the Equipment Foundation (BM-224).

BM-225 APPURTENANCES

DESC - Appurtenances are usually components such as valves, pipes, or fittings in the nonstructural systems. They may be made from any material that is compatible with the environment and components to which they attach.

FUNCT - Appurtenances are elements of the subsystems, and are so located as to serve a particular function with efficiency.

BM-225.1 Valves

FUNCT - Valves are devices to control flow of fluids. Valves are made in a wide variety of types, patterns, and sizes to meet the specific needs of the industry or service for which they are employed. Types commonly used are globe, check gate, rotary plug or ball, butterfly, stop check, needle, and relief valves. Valves may be manual

or power operated, locally or remotely controlled. In marine applications, essentially all valves are metallic and the materials of construction are selected for compatibility with the marine environment and the fluid to be passed.

INTER - Valves generally interface with Pipe (BM-225.3), but can be attached to an opening in a compartment in the basic structure (BM-200). If the valves are remotely controlled, then they may interface with any of the other systems (BM-300 through 600).

BM-225.2 Manifolds

DESC - A manifold is a fluid container with several openings in its walls, or is a group of valves joined together for common use. The manifold can be any shape that is compatible with fabrication and flow requirements with inlets and outlets as required. The material may be selected for compatibility with the adjoining components as well as the fluid being ducted, including its pressure and temperature.

FUNCT - The function of a manifold is to redistribute liquid or gas to/from a single source from/to multiple pipes at the same pressure. Common applications include intake and exhaust manifolds for internal combustion engines.

INTER - A manifold may interface with Structure (BM-200) and Valves (BM-225.1), depending on the system.

BM-225.3 Pipes

DESC - Pipes are long cylinders with relatively thin walls. They can be fabricated of metals or nonmetals and can be in various sizes depending on their design requirements.

FUNCT - Pipes furnish controlled paths for the flow of liquids or gases from one location to another within the FOF.

INTER - Pipes interface with all the elements of the Appurtenances (BM-225) and the basic Structure (BM-200).

BM-225.4 Vents

DESC - Vents are openings that may or may not have closure devices. The openings can be pipes, holes in the structure, duct work, or valves, depending upon their function. Closure devices can be automatically or manually operated.

FUNCT - Vents are valves that have an opening exposed to atmosphere for release of emergency overpressure conditions, to maintain ambient, or to allow the flow of air in or out of a compartment.

INTER - See BM-225.1, Interface. Vents sometimes have special protection requirements because one opening is exposed to the environment (BM-700).

BM-300 PAYLOAD ACCOMMODATIONS

DESC - Payload accommodations are those items of hardware that are designed to support, handle, or enclose facility payload items (see Figure BM-300-1).

INTER - This category provides physical support for the payload on a temporary or on a permanent basis. The main interface is therefore with the Primary Structure (BM-210) or Equipment Foundation (BM-224). Interfaces with other components of BM-400 or BM-600 cannot be defined until specific items of payload are identified.

BM-310 ENCLOSURES

DESC - Enclosures are those accommodations provided for the protection, support, containment, and mechanical/electrical connections of the facility functional components. Where necessary, they must also provide space for maintenance/repair personnel. Enclosures are also required for transporting equipment to and from the facility.

FUNCT - These components provide a favorable environment for the functioning, transport, or maintenance/repair of the facility operational equipment.

INTER - Fixed enclosures interface with the Primary Structure (BM-210) or Equipment Foundations (BM-224) on which they are mounted, and with the components that they enclose. Portable enclosures also interface with Structural Components (BM-200) and with the components during transport or maintenance and repair only; therefore, this interface is of a temporary nature, but the enclosure function must be served during this interval.

BM-310.1 Buildings

DESC - Buildings are those accommodations enclosing major items of facility equipment that must be protected from the environment and that require major and frequent access for inspection, maintenance, and repair. They may also contain major items of equipment required for inspection, maintenance, and repair, as well as providing temporary housing facilities.

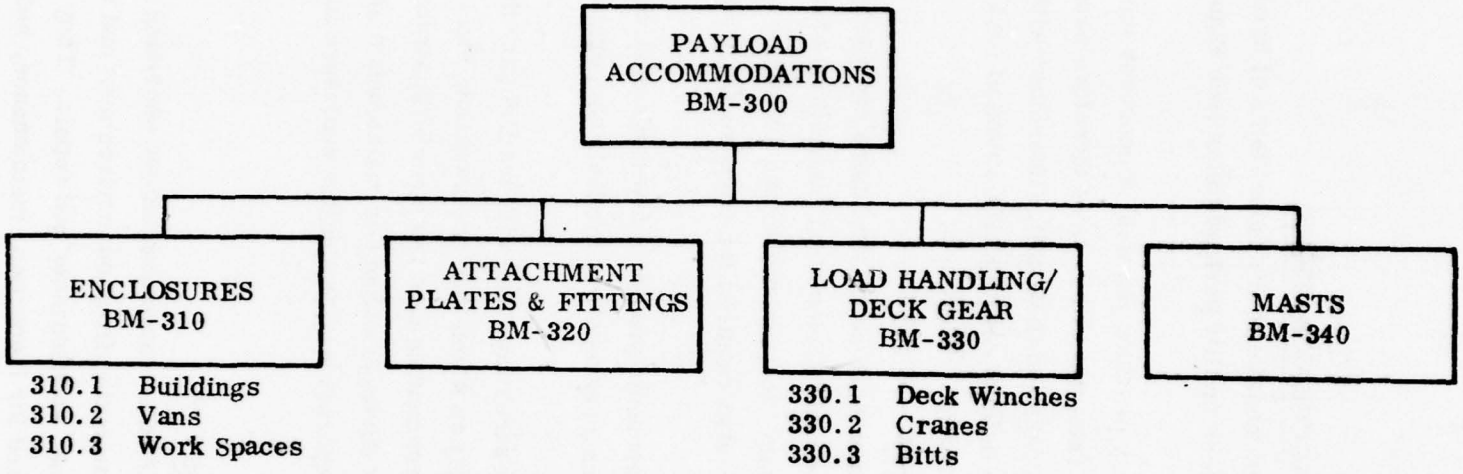

Fig. BM-300-1 Payload Accommodations – Breakdown Structure

BM-310.2 Vans

DESC - Vans are those enclosures used during the transport of inspection, maintenance, and repair equipment from shore-based facilities, via supply ship, to the BM facility. The vans must provide suitable protection for the equipment during transport and usage on the facility and must have temporary support provisions while on shipboard and on the BM facility.

BM-310.3 Work Spaces

DESC - Work spaces are those enclosures provided for operational equipment where buildings are not necessary, but which cannot be exposed to the environment during maintenance/repair or where the environment is such that personnel must be protected. These enclosures may be a permanent part of the BM with access provisions, or temporary enclosures mounted for, and removed after, the maintenance/repair activity.

BM-320 ATTACHMENT PLATES AND FITTINGS

DESC - These are the parts which lie between the payload components and the supporting structure. Generally they are conventional standard hardware and materials. Where the payload component is fragile or sensitive, requiring isolation provision from the structure, special mounts will be employed for absorbing the shock loads of wave or current motion.

FUNCT - The function of plates and fittings is to support payload components in the correct location and orientation relative to the primary structure in such a fashion that excessive loads or motions are not transmitted to the components.

INTER - Attachment plates and fittings interface with either the Primary Structure (BM-210) or the Secondary Structure (BM-220) and with the payload enclosure or other component being supported. At each of these, provision will be made for transferring and distributing the loads from the enclosures.

BM-330 LOAD HANDLING/DECK GEAR

DESC - Load handling/deck gear refer to auxiliary equipment that is required for maintenance or during the emplacement or removal of the facility. It includes weight

handling equipment (such as winches and cranes) and deck fittings (such as bitts, bollards, chocks). The equipment may be powered by electric or hydraulic motors or internal combustion engines, or may be hand operated.

FUNCT - These components provide services required to facilitate the performance of maintenance/repair and resupply functions.

INTER - Load handling deck gear generally carries heavy loads and must be adequately mounted on the Structure (BM-200). The arrangement with respect to other components is important, and must consider the area "swept" by moving equipment and the associated rigging. Power supplies (BM-410, BM-450) may be provided from a central source or be generated by each unit. Where internal combustion engines are used, fuel supply (BM-420) and sometimes cooling water supply (BM-430) must be provided.

Deck gear that is utilized during towing or emplacement of the facility must be compatible with equipment on the ships used in the operation.

BM-330.1 Deck Winches

DESC - These are the winches included in the load handling/deck gear used in the course of maintenance/repair, refurbishment, or emplacement and removal of equipment. Available types include drum and gypsy winches, which may be power or hand operated. Power drives include electric, hydraulic, steam, air, and gasoline engines. Special types of winch, such as constant tension and constant speed, are also available.

BM-330.2 Cranes

DESC - Cranes are those components of a facility used to move heavy equipment onto the facility and into or out of position during maintenance/repair, refurbishment, or emplacement and removal of equipment.

BM-330.3 Bitts

DESC - Bitts consist of a pair of spool-shaped metal components used to attach lines on or to the facility. They provide for a quick secure attachment and for rapid removal.

BM-340 MASTS

DESC - A mast is any tall structure designed to provide the elevated location for equipment that is required to achieve maximum performance.

FUNCT - Masts serve a variety of functions but basically provide a platform at a height where installed equipment can function most efficiently. Typical items of supported equipment are radar dishes, radio transmitter antennas, and telecommunication microwave relays. Masts also serve as control platforms and, in some cases, mountings for lifting equipment.

INTER - The essential connection of a mast is with the Structural Components (BM-200) that provide the support. Other interfaces with service items (BM-400 or BM-600) will also be present, depending on the functions performed by the mast-supported equipment.

BM-400 UTILITIES AND ACCESS SYSTEM

DESC - Utilities are those elements that store and or distribute consumables, energy, disposables, and provisions required for the BM structure's operation. The access system consists of those elements required for personnel movement about the BM structure. The breakdown of components within this system is as shown on Fig. BM-400-1.

FUNCT - This system provides the energy required by the BM structure; the containment and/or disposal of wastes; and safe and convenient access for operation and maintenance of the structure and its payloads.

INTER - Utilities and access systems will probably be located in proximity to the Payload System (BM-300). The size and scope of each of the systems in this category will depend on the primary function and purpose of the activities being supported. Similar considerations determine the size and scope of the water system and the waste disposal system. The fuel system size will be determined by the energy requirements of the payload as well as the requirements of utility functions. The size and convenience of the access systems will depend upon the frequency of access and the traffic. Electrical power systems in these structures will have many characteristics common to shore installations because of protection by the structure from the environment.

BM-410 ELECTRICAL POWER SYSTEM

DESC - An electrical power system is composed of power sources, controls, and distribution systems. Because the range of sizes and the scope of bottom mounted FOFs is great, a wide range of components may be employed, depending upon the mission. For this reason, the electrical power systems can usually be optimized to meet a particular requirement such as cost, endurance, reliability, or maintenance.

FUNCT - The electrical power system provides, regulates, and distributes electrical energy to operate the payload and support the functions of the BM structure.

INTER - The capacity of the electrical power system is usually dependent upon the requirements of the Payload (BM-300). Power is also required for Safety Systems

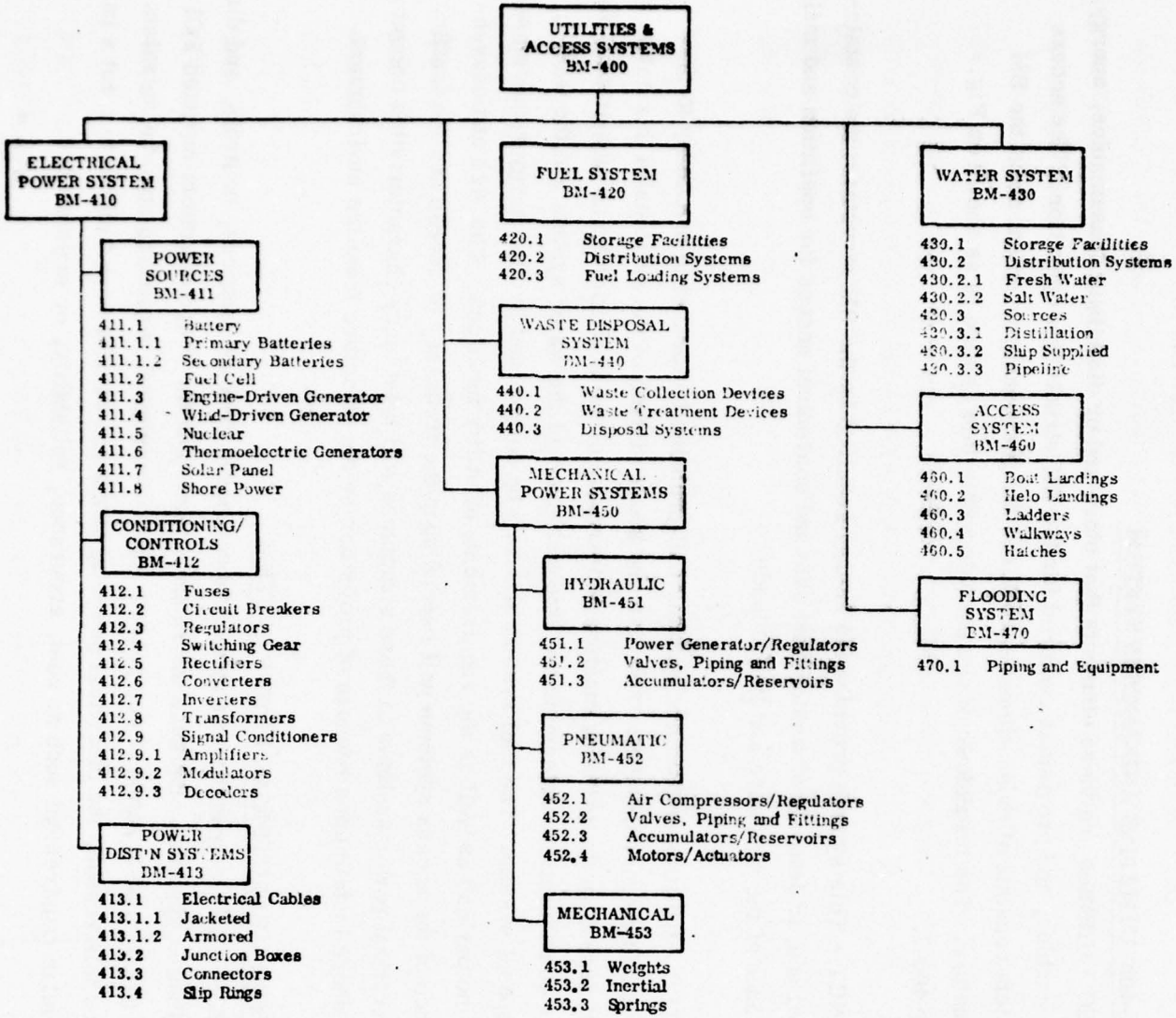

Fig. BM-400-1 Utilities and Access System – Breakdown Structure

(BM-500), Waste Disposal (BM-440), Water System (BM-430), Fuel System (BM-420), and Access System (BM-460), although these auxiliary systems are usually not the primary determinant of the size of the power system. The type of power system, whether ac or dc, will depend upon the optimization of the system with respect to the requirements of the energy consuming loads, i.e., Power Distribution (BM-413) and Power Controls (BM-412).

BM-411 POWER SOURCES

DESC - Power sources includes all equipment used for the primary generation of electrical power by the direct conversion of chemical and electromagnetic or atomic energy, or for providing power from shore-based generation systems. Power sources can be self-contained, in which case electrical power is generated by either a chemical, electromagnetic, or nuclear form which is stored and converted into the electrical energy required by the load. Generation can be in the form of direct current or alternating current, and can range from milliwatt or megawatt power levels and from milivolts to kilovolts.

FUNCT - Power sources provide the energy to operate the payload and other support and utilities systems required for the operation of the facility.

INTER - The power source must have the capacity to provide the steady state and peak required by the Payload (BM-300) and associated support systems – Water System (BM-430), Waste Disposal System (BM-440), Fuel System (BM-420), and Safety Systems (BM-500). The main functional interface is between the power source and the electrical load via Power Distribution Systems (BM-413) and the Control Systems (BM-412).

The power source also is interrelated with the environmental conditions in the structure and must be able to withstand the range of temperatures and pressures normally found on bottom mounted structures, or must be protected against such environments by suitable enclosures. The internal impedance of the power source in conjunction with the load characteristics and varying load conditions will primarily determine the requirement for Regulators (BM-412.3).

BM-411.1 Battery

DESC - A battery is an arrangement of individual cells interconnected in series or parallel. It includes all units used for the direct generation of electrical energy by chemical reaction methods. Batteries are divided into two major classes – primary and secondary.

FUNCT - Batteries provide electrical energy to the bottom mounted structure in circumstances where relatively light loads are required to supply power intermittently or over a long period of time. They also provide capability for peak load situations for the primary source (which have a high output impedance) and a leveling source for intermittent sources such as solar or wind power, or for emergency or start-up purposes.

INTER - For elements that require low power drains, batteries may be provided as an integral part of portable specialty systems and tools and other elements of the FOF such as Alarm Systems (BM-510.2), Detection Devices (BM-510.1), Emergency Signals (BM-520.6), and in other cases where convenience and cost of distribution make the use of the batteries desirable. Batteries are normally used in direct current systems. If batteries are used to power alternating current systems, the additional cost and inefficiency of Inverters (BM-412.7) should be considered. Batteries would probably be used in conjunction with Wind Driven Generators (BM-411.4), Thermoelectric Generators (BM-411.6), and Solar Panels (BM-411.7) to store energy and to provide power in periods of low generation.

Batteries are adversely affected by cold temperatures or extremely warm temperatures. In a bottom mounted FOF, protection is usually provided by housings associated with the main structure and payload.

BM-411.1.1 Primary Batteries

DESC - Primary batteries are systems which generate electricity as a direct by-product of a chemical reaction. These batteries are self-contained, are often sealed, and in their initial state require no energy input to activate them and are comprised of

one or more cells connected in series or parallel. Some primary batteries have a limited capability to be rejuvenated by an external electrical charger once their initial energy is depleted. Primary battery types include:

(a) Carbon zinc – based on the Leclanche cell and also known as dry batteries, they are made in the widest range of sizes, packages, and electrical characteristics. High quality production of these batteries has made this one of the most economic forms of portable electrical energy.

(b) Alkaline – a more advanced form of dry cell which has a high performance for producing electrical power, particularly at reduced temperatures. They can also be obtained in rechargeable form.

(c) Zinc-air – an unsealed unit which consumes air and also uses a liquid electrolyte, thereby requiring attention to physical orientation. It has high power/weight and power/cost ratios. It can be obtained in zinc-oxygen form as a sealed unit.

(d) Magnesium-seawater – suitable for low power drains over long periods of time. Direct interaction with the sea must be carefully considered. Unlimited shelf life before activation.

(e) Lithium-seawater – suitable for high power drains over short time periods. Lithium anodes are consumed and must be replaced to reactivate the battery. The battery produces by-products of hydrogen, lithium hydroxide, and heat which must be allowed for in the design of systems which utilizes them. This type also requires a pump and associated equipment for circulating the seawater electrolyte.

FUNCT - A primary battery produces electrical power directly by the combination of specific chemical elements. Its function is to provide localized dc electric power to sources internal and external to the structure when the specific power requirements of the bottom mounted FOF can be provided most effectively by a particular type of primary battery.

INTER - Primary batteries used in conjunction with other power sources require the addition of diodes or Rectifiers (BM-412.5) in the circuit to prevent the battery from

being overcharged. Whenever batteries are used, provisions must be made for Access (BM-460) for maintenance and replacement, unless the battery is designed to operate for the life of the facility.

BM-411.1.2 Secondary Batteries

DESC - Secondary batteries are units charged with electrical energy that is stored to be released later. A battery may be comprised of one or more cells interconnected in series or parallel. Secondary batteries can be charged several hundreds of times, can deliver hundreds of amperes of current, and include the following types:

(a) Lead acid - the form of secondary battery in widest use, used for high discharge current requirements. This type is usually configured in series cell arrangements in 12-volt and 28-volt batteries.

(b) Nickel Cadmium - available in many series and parallel configurations and in a variety of voltage and power levels. It has good performance/temperature characteristics.

(c) Silver-Zinc - high energy density but expensive to produce due to use of rare metal.

FUNCT - Secondary batteries provide localized dc electrical power to sources internal and external to the structure. They may also be employed to provide the primary source of electrical power to the selected equipments if the secondary batteries are most advantageous.

INTER - Secondary batteries are used when recharging is the method of energy replenishment by terminal connections at the access points, or onboard power sources such as Wind Driven Generators (BM-411.4), Thermoelectric Generators (BM-411.6), or Solar Panels (BM-411.7).

BM-411.2 Fuel Cell

DESC - A fuel cell is an assembly of two electrodes separated by an electrolyte which produces direct-current electricity by the chemical action in the electrolyte. In this respect, they are similar to batteries; however, the electrodes are represented by porous catalysts which provide a chemical reaction between the fuel and the electrolyte.

Fuel cells must be continually supplied with fuel to operate. Several types of fuel cells are suitable for use in fixed ocean facilities. These include:

(a) Hydrogen-oxygen (hydrox) (both gaseous and liquid)

(b) Hydrazine-oxygen

(c) Hydrogen-propane-oxygen (carbox)

(d) Ammonia-oxygen

FUNCT - Fuel cells provide electrical power to the FOF or elements of the electrical power system by conversion of continuously supplied chemical elements (fuel) into direct current electricity.

INTER - Because of their cost and complexity and their requirements for high-pressure or cryogenic fuel storage, fuel cells are only used in circumstances that require their special characteristics such as power-to-weight ratio. If fuel cells are used, provisions must be made in the Fuel System (BM-420), Storage (BM-420.1), Distribution (BM-420.2), and Loading Systems (BM-420.3) for cryogenic and/or high-pressure gases. Access (BM-460) is provided for maintenance and servicing.

BM-411.3 Engine-Driven Generator

DESC - An engine-driven generator is a conventional internal combustion engine coupled to an electric generator. The generator may produce either direct current or alternating current. Power levels vary from hundreds of watts to hundreds of kilowatts, and voltage levels of a few volts to kilovolts. Small units generally produce 28 volts dc or 115 volts ac in the range of 1 to 20 kilowatts of power.

FUNCT - Engine-driven generators provide electrical power for the operation of the bottom mounted FOF with relatively low cost, high reliability, and ease of maintenance and servicing, where space and weight is not a major consideration. For smaller units, the engine-driven generator can provide automatic intermittent operation to charge batteries upon demand.

INTER - The size of the Fuel System (BM-420) will depend on the replenishment cycle and the total power used by the facility. Adequate provisions must be made for

the heat produced by the unit and the exhaust gases. For low-power systems, a generator can be used in conjunction with a battery (BM-411.1), and the generator can operate on command, controlled by the charge condition of the battery. For alternating current units, a battery would be used for starting purposes only. Generators can produce electromagnetic interference and powerline transients during powering up or down, and in the case of dc generators, during operation. Specifications should include allowable electromagnetic interference levels, as appropriate.

BM-411.4 Wind-Driven Generator

DESC - Wind-driven generators extract energy from the wind and convert it to electrical power by means of a propeller turning a shaft that is coupled with an alternator or a direct-current generator. The power range is from watts to several kilowatts.

FUNCT - Wind-driven generators provide a source of electrical power to the FOF where a low power level, essentially maintenance free, and reliable operation without replenishment of energy is required over a long period of time.

INTER - The generator unit will probably be mounted on the Structure (BM-200). It may possibly be on a Mast (BM-340) to achieve a mounting high enough above the air-sea interface to prevent damage to the propeller and the generator during severe storm conditions. Since the wind is variable, the output of the generator will normally be used to charge a Battery (BM-411.1). Provisions should be made in severe storm conditions for turning the propeller out of the wind to reduce the possibility of damage. The design of the system should consider the energy level that can be supplied by the prevailing winds at the FOF site with sufficient battery capacity to provide power during the periods of calm. In order to ensure that the load will always be supplied by the system, the total power-generating capacity should be greater than that required by the load. Excess power will be generated at intervals because of strong winds. Under these conditions, a Regulator (BM-412.3) will be required to prevent overcharging of the battery. If alternating current is required within the FOF powered by a wind generator, an Inverter (BM-412.7) will probably be required.

BM-411.5 Nuclear

DESC - Nuclear systems produce power by producing heat. Heat from radioisotopes is used to power Thermoelectric Generators (BM-411.6) for power ranges of hundreds of watts. Higher power ranges can be attained by employing nuclear reactors using steam or gas as a coolant. These can generally remove as much energy as is stored in the reactor.

FUNCT - A radioisotope generator is used to produce a relatively modest level of power where extremely long life without servicing is required and where the cost of the system is justified. Other types are used where high levels of power are required.

INTER - A radioisotope power source should be used where Access (BM-460) for maintenance, servicing, and replenishment is practically unavailable for the lifetime of the BM structure. Extreme circumstances would be required for use of this power source because of its high cost and lower power output. Radioisotopes require special castings to minimize radiation hazards. Provisions must be made for disposing of waste heat from the radioisotope power source.

BM-411.6 Thermoelectric Generators

DESC - A thermoelectric generator is a mechanical assembly of two dissimilar metals, each at different temperatures, which produce small amounts of dc electricity by direct interaction of the metals at the junction. The combination of cells into stacks can provide tens of watts of power and a few volts. Fuel heaters such as propane or a radioisotope are generally used. These units are relatively inefficient but are characterized by long maintenance-free operation.

FUNCT - These generators produce modest amounts of power for a BM structure over a long period of time with few by-products.

INTER - A thermoelectric generator has few special interface requirements. If propane is used, special consideration should be given to the Fuel System (BM-420) because of the high pressure requirements. These systems are relatively inefficient when the entire system weight and cost per unit of electricity is considered. However,

since there are no moving parts, high reliability can be achieved. Interaction with a radioisotope heat source is discussed under Nuclear (BM-411.5).

BM-411.7 Solar Panel

DESC - A solar panel consists of a number of photo voltaic cells grouped in series parallel arrangements to provide a low voltage source of electrical energy when illuminated by the sun.

FUNCT - A solar panel can provide electrical energy to a FOF if the power requirements are small. It is characterized by high reliability and long-term maintenance-free operation.

INTER - The Structure (BM-200) must provide enough clear area to accommodate the solar panels where they will receive direct illumination by the sun to provide sufficient electrical energy. The area requirements will vary depending upon the exposure of the panel to the sun. The panel should be mounted sufficiently high above the air-sea interface to prevent damage in severe storms and to minimize the buildup of salt spray residue on the sensitive surfaces of the power cells. If power is required when sunlight is not available, a Battery (BM-411.1) will be required for energy demands. Because of the very low power available per square foot from a solar panel, and the reduced efficiency caused by environmental exposure, the application of solar panels is very limited.

BM-411.8 Shore Power

DESC - Shore power is an overhead transmission line or a submarine cable which connects a BM structure to a source of power or to a distribution system on the mainland.

FUNCT - Shore power provides power to the FOF in circumstances where it is desirable not to have onboard power production because of cost, reliability, total energy requirements, logistics, or other considerations.

INTER - With overhead lines, the water should be suitably shallow to allow intermediate line support structures between the FOF and the shore. This would involve a

consideration of the development of Foundations (BM-100) and the Structure (BM-200) of the FOF. Provisions should be made for adequate strength to support the line in severe storm conditions. In considering the tradeoff between an overhead line and a submarine cable, reliable operation of the FOF in severe storm conditions should be considered as well as a backup power source such as a Battery (BM-411.1) or an Engine-Driven Generator (BM-411.3). For a submarine cable shore power system, provisions should be made for protecting the cable from the consequence of traffic or fishing in the area (BM-700). At the FOF, the primary interface is with the Power Distribution System (BM-413), including the Controls (BM-412) that provide protection of overhead power line from lightning strokes, or protection of the submarine cable from faults in the FOF. The type of power source is not pertinent unless the power source is to be constructed or installed as an element of the BM structure.

BM-412 CONDITIONING/CONTROLS

DESC - Control equipment is available in a variety of forms depending on the function and the size. It may be solid state, gas discharge, or rotary. Power capacity ranges from miliwatts to megawatts. Sizes range from fractions of an inch to many feet in any dimension.

FUNCT - Controls convert electrical energy from the source to the frequency, voltage, current, or impedance level required by a load. The equipment also provides protection from damage of the power source because of malfunctions in the distribution system or in the load.

INTER - Control equipment must connect to and match the power level of the Sources (BM-411), Power Distribution Systems (BM-413), and the electrical loads. These include the Payload (BM-300), Fuel System (BM-420), Water System (BM-430), Waste Disposal System (BM-440), loads associated with the access systems such as hoisting cargo, the Navigation, Warning, and Communication System (BM-600), and Cathodic Protection Systems (BM-730).

BM-412.1 Fuses

DESC - A fuse is a fusable link of metal which melts and disconnects the load from the source when a specified level of current is reached. Fuse current levels range from miliamperes to hundreds of amperes. Oil quenched fuses are produced for voltages of thousands of volts.

FUNCT - Fuses prevent damage to systems by disconnecting a faulty system element from the system or by limiting the power dissipation in active system elements to safe levels.

INTER - Ratings of fuses must be established to clear faults before damage occurs, but must not operate for normal overloads or transients. Where fuses are used for protection, the current rating of each individual load must be assessed in order to determine the size of the fuse for the protection desired. Fuses are less expensive than Circuit Breakers (BM-412.2). Access (BM-460) must be provided for replacement of fuses. A fuse operated in extremely high ambient temperature conditions may open at current levels lower than the nominal value specified.

BM-412.2 Circuit Breaker

DESC - A circuit breaker is an automatic mechanical switch which disconnects the load automatically from the source when a specified level of current is reached. Circuit breakers can be made to operate at milliwatt levels with power levels up to megawatts. Voltage levels range from millivolts to kilovolts.

FUNCT - The circuit breaker prevents damage to the system or to the load by disconnecting faulty system elements from the system or by limiting the power dissipated in the active system elements to safe levels.

INTER - While circuit breakers are more expensive than Fuses (BM-412.1), circuit breakers provide a wide range of flexibility of protection. They can be made to operate with very low ground fault current levels with operating power current levels many orders of magnitude greater than the ground fault level. Circuit breakers can be designed to operate remotely and, in some instances, can be considered synonymous

with Switching Gear (BM-412.4). Because the sensing elements of circuit breakers can be designed to recognize the nature of transients and differentiate abnormal overloads, the protection afforded to both equipment and personnel can cover a wide range of circumstances.

BM-412.3 Regulators

DESC - Regulators may be a separate component or may function as an integral part of another component or element such as a transformer, converter, or inverter. Operation may be manual or automatic. Power capacity ranges from milliwatts to megawatts. They may be mechanical, such as an adjustable transformer, or may be solid state. A regulator's capability is usually specified as a percent of input or output nominal voltage within a tolerance specified as a percent of nominal.

FUNCT - A regulator adjusts and controls voltage and frequency of current within limits established by the requirements of the load.

INTER - Input and output voltage, frequency, and power levels must be compatible with sources and loads throughout the FOF. The regulation capability must be adequate to cover all expected operating conditions. Within bottom mounted structures, regulators find application where Payloads (BM-300) are sensitive to voltage variations or where the Power Source (BM-411) fluctuates over wide voltage ranges because of intermittent charging or energy input. Some regulators are designed to protect the source from load short-circuits by current limiting. Higher efficiency and lower capital costs result when regulation is provided in conjunction with other components or elements. If, for example, the regulator is provided as an integral part of the Power Source (BM-411), the regulator might perform its function more efficiently than a separate unit. Provision for adequate cooling is necessary.

BM-412.4 Switching Gear

DESC - A switch is a mechanical or solid state device that opens or closes conductive paths for electrical energy. A relay is a specialized class of switch in which activation is achieved through an electrical signal. Activation of a switch may be manual or powered and relays may be remotely operated. Operating functions range from

simple on-off to complex matrices of both sequential and/or parallel operation. Power capacity ranges from milliwatts to megawatts. Voltage ratings range from millivolts to kilovolts. High-power switches are usually oil immersed.

FUNCT - A switch connects or disconnects a source of electrical energy for one or more loads. Switching gear may be used in bottom mounted structures to control the application of electrical power to the various distribution elements and loads situated throughout the facility.

INTER - Switches must have power voltage and current ratings compatible with sources and loads. Characteristics of some loads may require arc suppression. Contact resistance of some switches increases for very low current applications to the extent that special provisions such as mercury wetted or mercury pool contacts may be required. Method of activation and identification by operating personnel should be considered in locating switches in control panel layouts. Placement of switches for lighting or control functions for Access Systems (BM-460), Fire Fighting Equipment (BM-510), Personnel Safety Equipment (BM-520), and Navigation and Communication Systems (BM-600) should be convenient to the point of need, and/or from which an observation must be made to apply control.

BM-412.5 Rectifiers

DESC - Rectifiers conduct electrical current in one direction only. Half-wave rectifiers, when connected to an alternating current source, conduct on one half of the current cycle. Full-wave rectifiers are configured so that current flows on both halves of the current cycle. Rectifiers are available for multiphase power. Rectifiers range in size from miniature diodes to large power units in the kilowatt range. Very large high-powered rectifier units are usually gas discharge type and they may be air or liquid cooled. Synchronous vibrating and synchronous rotating rectifiers employing commutators have been used in the past in certain types of machinery, but with the advent of solid state and gas discharge equipment, are now seldom used.

FUNCT - A rectifier changes alternating current to direct current where the primary source of power is alternating current and some portion of the payload or other loads require direct current.

INTER - A synchronous vibrating mechanical rectifier and low-power solid state devices would probably be used only in conjunction with Amplifiers (BM-412.9.1) and with an alternating current servo system or controller. Solid state rectifiers would probably be used for supplying small-to-medium power loads in an FOF such as the Payload (BM-300), or in conjunction with Engine-Drive Generator (BM-411.4) power sources. Where the primary power source is alternating current and Cathodic Protection (BM-730) is used, solid state rectifiers would probably be used. Adequate provisions must be made for cooling. Interference is generated in some of this equipment which may be reflected into the source and other equipment as well as loads. Provision must be made for interference in connecting devices or specifications for interference control must be applied. Unless a Battery (BM-411.1) or filter is used in conjunction with a rectifier, large amounts of ripple at harmonics of the power frequency will be induced into the direct current system.

BM-412.6 Converters

DESC - A converter may be a rotating motor generator type of equipment or a chain of devices, including a solid state transformer/rectifier/regulator/chopper chain. It may be air cooled or liquid cooled, and may range in size from inches to many feet. Power capacity ranges from milliwatts to kilowatts.

FUNCT - A converter changes the frequency of an alternating current source in a distribution system to a frequency necessary for operation of specific loads that are not compatible with the source frequency.

INTER - Input and output frequency, voltage, and power levels of converters must be compatible with electrical power sources and loads. Adequate provisions must be made for cooling. Interference may be generated in this equipment and may be reflected into the source and other equipment as well as loads. Provisions must be made for interference control in connecting devices or specifications for interference control must be applied.

BM-412.7 Inverters

DESC - Inverters may be rotating motor-generator types of equipment or solid state equipment. They may be liquid or air cooled. They range in size from inches to many feet. Power capacity ranges from milliwatts to kilowatts.

FUNCT - An inverter matches the characteristic of a power source to a load by changing direct current to alternating current and/or changing the voltage level where the primary source of power in the BM structure is direct current and some portion of the load requires alternating current.

INTER - The inverter would probably be used in conjunction with off-the-shelf equipment designed to use 60 Hz ac power, or 400 Hz ac power. Input and output frequency, voltage, and power levels must be compatible with the power sources and loads. Adequate provisions must be made for cooling. Interference is generated in this equipment which may be reflected into the source and other equipment as well as loads. Provisions must be made for interference control in connecting devices or specifications for interference control must be applied.

BM-412.8 Transformers

DESC - Transformers are constructed of primary and secondary or multiple coils of conductors wound on laminated silicon-steel magnetic cores. Cooling may be provided by air or liquid depending upon the power and voltage ratings. Sizes vary from fractions of an inch to many feet. Power ratings vary from milliwatts to megawatts. Operating frequency is usually 60 Hz in the USA, 50 Hz in many foreign areas, and 400 Hz in special applications.

FUNCT - A transformer changes the level of voltage, current, or impedance of ac systems.

INTER - In an FOF, transformers would probably be used in conjunction with Shore Power (BM-411.8) to change the transmission voltage from the high voltage level for powerline or cable transmission to the voltage to be applied to the FOF Distribution System (BM-413). In addition, transformers would be used in conjunction with specialized loads such as control or signalling systems for Fire Fighting Equipment (BM-510),

and in conjunction with rectifiers to supply impressed current Cathodic Protection (BM-730). Primary and secondary voltage frequencies and power levels must be compatible with sources and loads. Adequate provision must be made for cooling. Where sound levels must be maintained at low values, vibration isolation, acoustic isolation, and/or core material having low magnetostriction properties should be specified.

BM-412.9 Signal Conditioners

DESC - Signal conditioning equipment is basically electronic. It is primarily solid state and may be executed as integrated circuits. It may be housed in rack and panel construction for use in bottom mounted structures. Power input ranges from a few watts to hundreds of watts.

FUNCT - This equipment combines, converts, modifies, or stores electrical signals so that the signals may be transmitted, processed, analyzed, or used for control.

INTER - Signal and impedance levels between elements must be carefully analyzed. Appropriate dynamic range in all elements must be provided to accommodate the range of signal levels which may be encountered. Power supplies must not introduce noise. Protection from electromagnetic interference must be considered for sensitive circuits. Signal conditioners would probably be used in conjunction with instrumentation, and would most likely be used in Payloads (BM-300) or in conjunction with payloads requiring signal transmission to another location.

BM-412.9.1 Amplifiers

DESC - Most amplifiers are solid state and employ feedback to maintain linearity or desired amplification characteristics. Gains may be fixed, variable, or automatically controlled. Gain between input and output is specified as a voltage ratio or power ratio.

FUNCT - An amplifier increases the voltage, current, or power level of an electrical signal and provides isolation or impedance from input to output. In a bottom mounted structure, amplifiers are most likely to be used in conjunction with communications

or signal transmission equipment, or in conjunction with servo or control systems. High-gain amplifiers are sensitive to electromagnetic interference. Input should be balanced and well shielded from the power circuits, and should also be isolated from outputs to avoid oscillation. Power supplies should provide isolation from power circuits. Power amplifiers may require provisions for cooling. Input and output signal levels, power levels, and impedances should be matched to sources and loads.

BM-412.9.2 Modulators

DESC - Modulators operate at frequencies that extend from low sub-audio to high gigahertz ranges. Most modulators are solid state although very high-powered modulators employ vacuum tubes or gas discharge tubes.

FUNCT - A modulator impresses an intelligence-carrying signal upon a carrier frequency.

INTER - Modulators would probably be used as elements of Control Systems (BM-412) in conjunction with amplifiers. As part of transmission equipment for communicating within the FOF or to another facility, modulators can be used as a basic element of systems to transmit multiple signals over one transmission line by employing enough modulators to modulate a number of carriers operating at different frequencies.

BM-412.9.3 Decoders

DESC - Decoders are usually executed in integrated circuits. They may be in the form of one circuit card or one module; or for complex coding, may take the form of a rack in a standard electronic cabinet or panel. They may be digital or analog and in some instances could be called demodulators. A decoder extracts a specific signal from a stream of data or intelligence for display or signalling in a digital system. A decoder recognizes certain pulse formats and provides an output when such a format is recognized. In an analog system, a filter or combination of filters may recognize certain frequencies or patterns of frequencies and accept and extract data. Those frequencies are recognized.

INTER - In some instances it may be desirable to use a power distribution system for signalling or communication. In that instance, decoders would be placed at appropriate places to recognize the data, activate alarms such as Detection Devices in the Fire Fighting Equipment (BM-510.1) and the Alarm Systems (BM-510.2). It also might provide intercom capabilities for Payload Accommodations (BM-300).

BM-413 POWER DISTRIBUTION SYSTEMS

DESC - Power distribution systems are composed of cables, wires, connectors, switchboards, and junction boxes related to the distribution of electrical energy throughout the facility.

FUNCT - Power distribution systems deliver electrical energy from the power source to the loads throughout the BM structure.

INTER - The system must provide at least the capacity to supply peak load requirements. Normally the distribution system capacity decreases as the system branches toward the loads. Tradeoff should be made between initial installation cost of distribution capacity and line losses as well as the consequences of regulation requirements at the load.

BM-413.1 Electrical Cables

DESC - Cables consist of (1) a center core of conductors insulated from each other, (2) an insulating jacket, (3) sometimes an electrical or magnetic shield, (4) armor for protection and/or strength, and (5) an outside cover. Power cables differ in size and number of wires in the center core conductors, as well as the insulation between these conductors and the external environment. Cable conductors can be single stranded or multiple stranded. The size of the strands or the multistrand determines the flexibility of the cable. The conductors in marine cables are usually copper, sometimes with a steel strength member added, or in the case of solid conductors where strength is required, a copper clad steel is used. The power capacity of cables may vary from 18 gage two-wire appliance extension cords to large heavy copper cables capable of carrying megawatts of power.

FUNCT - Cables are used to transmit power to the FOF or through its various elements.

INTER - The power level requirements of the system establish the conductor size and the insulation design. Since the practical range of cable characteristics is limited, the terminal equipment and the cables should be designed as a system to ensure compatibility, efficiency, and reliability. Requirements for protection will influence the decision to bury or armor the cable outside the FOF or to provide protective conduit internal to the FOF. Where protection is not necessary, cables can be routed through the facility in cable troughs or racks in walkways, hallways, or tunnels.

BM-413.1.1 Jacketed Cables

DESC - Jacketed cables are those cables that have an outer jacket which encloses the central core of conductors and the associated insulation and holds it in a tight bundle. The jacket can be lead, polyethelene, rubber, or other suitable covering.

FUNCT - Jacketed cables transmit power to the FOF and distribute it throughout the facility, in circumstances where minimal protection is required from mechanical damage.

INTER - Jacketed cables can be used in a benign or protected environment, such as conduits or troughs within the facility. In hazardous locations, for example in proximity to Fuel Systems (BM-420), explosion-proof or vapor-proof cable lays or conduits should be provided for jacketed cables and terminations.

BM-413.1.2 Armored Cables

DESC - Armored cables consist of a central core of conductors and appropriate insulation, and in some cases a jacket similar to that described in BM-413.1.1, all enclosed in a metallic, braided, or wrapped protective sheath. The armor may in turn be covered with an additional jacket. In some instances, two layers of armor are spiral wound in opposite directions.

FUNCT - Armored cables may be used to transmit power to, and distribute power through the BM structure. Under circumstances where the cable must be mechanically protected by the armor (e.g, a submarine cable transmitting power from the shore to the bottom mounted facility), it may require mechanical protection from dragging anchors, trawls, and other hazards. The addition of the armor adds a considerable amount of tensile strength to the cable. Armored cable would probably rarely be used internal to the facility except in locations where the cable is exposed and subject to damage. The cost of heavily armored cable is considerably higher than jacketed cable.

BM-413.2 Junction Boxes

DESC - Junction boxes are terminal points for cable mains and branches. They can be metal or nonmetallic of various sizes and shapes, sealed or unsealed, with provision for entry of the cables and internal provisions for internal connections of the cables. Some means of attaching the cable to the junction box is usually provided by the cables to provide strain relief from the cable conductors. Explosion-proof or vapor-proof junction boxes are provided with gaskets or other sealing devices. Underwater boxes can be pressure and water proof to the hydrostatic head required, or can be pressure compensated along with the cables or system attached by filling with a fluid, usually oil, and connected to compensators for pressure changes.

FUNCT - Junction boxes provide a protected location for attaching branching circuits to main distribution cables within the FOF. Sometimes fuses or circuit breakers are located in the junction boxes to provide the main distribution protection from faults on the branching circuits.

INTER - The openings in the junction boxes and the attachments to the cable must be compatible with the size of the cables utilized (BM-413.1) and the internal connections must be compatible with the size of the conductors involved with the cables. All junction boxes should be grounded for protection of personnel against inadvertent short of the conductor to the junction box case. Where fusing or switching of branching cables is provided, indicators should be provided to show whether the circuit is connected or

disconnected, whether the fuse is blown or intact, or whether the circuit breaker has been tripped or is closed.

BM-413.3 Connectors

DESC - Many types of connectors may be used in the power distribution systems. Types range from connectors for small appliances and tools to large power connectors suitable for use under water. Power connectors are usually multiple conductors and may withstand high pressure for underwater use without leakage or they may be open-type connectors for use in protected areas within junction boxes. Cables may be connected to strip connectors, circuit breakers, fuses, or switches by copper lugs and bolts or clips. These types of connectors are intended to be permanently attached and would be disconnected only for repair or circuit modification.

FUNCT - Connectors join cables and equipment to the power distribution system and provide a means of joining conductors within the distribution system, so that it can be branched, maintained, and altered to provide power at the points needed within the bottom mounted structure.

INTER - Connectors should be designed so that incompatible circuits cannot be joined. For example, it should not be possible to connect a 110 volt power tool to a 220 volt motor receptacle. It should not be possible to connect a dc motor to an ac power distribution system. Connectors should be compatible with the cable size and the connector should be designed to operate in the environment. In hazardous locations, such as the Fuel System (BM-420) areas, connectors, outlets, lights, and light sockets should be sealed and vapor-proof or explosion-proof.

BM-413.4 Slip Rings

DESC - Conductor rings connected to conductors are usually mounted on a shaft. Brushes or contactors are provided for each ring and are separately connected to the termination of other conductors mounted separately from the shaft. Materials vary widely depending upon the current-carrying capacity of the slip ring system and the noise requirements of each of the circuits. Slip rings are generally made in integral assemblies and for underwater application, and have O-rings or wiper seals to protect

the unit from the environment. Where ac power or signals are used, electromagnetic coupling such as coaxial coils may be used.

FUNCT - Slip rings allow the transfer of electrical power or signals across a rotating interface which must be allowed to rotate an indefinite number of turns in either direction.

INTER - In some circumstances where Payloads (BM-400) or other devices must be coupled electrically across swivels, a slip ring would probably be used for simple circuits which can tolerate inefficiency across the interface. An electromagnetic slip ring can be used because of its advantage of greater reliability and greater tolerance to leakage and fouling. Electromagnetic slip rings are especially susceptible to stray electromagnetic fields while contactor-ring elements are subject to deterioration of the contact interface through wear and corrosion.

BM-420 FUEL SYSTEM

DESC - The fuel system consists of the necessary equipment to store, pump, distribute, and load the facility fuel supply. The fuel may be in liquid or gaseous form. Gaseous fuel requires high-pressure storage containers with safety provisions. The fuel stowage may be in tanks integral with the structure or contained in separate tanks. Many fuel systems include a compensating arrangement using water ballast to replace the fuel used. Sounding, air escape, and overflow systems are generally installed in the tanks; and where cold climate conditions exist, a heating system is installed. Filling provisions must be made in a form compatible with the type of facility and the planned resupply service.

FUNCT - The function of the fuel system is to supply the fuel required by the facility for its operational performance at a temperature, pressure, and condition suitable for the fuel-consuming components.

BM-420.1 Storage Facilities

DESC - Storage facilities are those facilities used to store fuel in the BM structure while maintaining the fuel's quality and purity, and to make it available to the

distribution system as required. The capacity of the system must be adequate for the maximum anticipated periods between resupply events with a safety margin. Resupply may be more frequent when piping from shore facilities is used; thus, a smaller storage capacity may be feasible.

BM-420.2 Distribution Systems

DESC - Distribution systems draw fuel from the fuel storage facilities and distribute it to the fuel-consuming components. More than one component may require fuel from the same source. These systems consist of the necessary piping, valves, pumps, controls, meters, filters, instruments, and safety devices required to pump and distribute the fuel to the consuming components.

BM-420.3 Fuel Loading System

DESC - Fuel loading systems are used to resupply the fuel storage facilities. They may be from supply ships moored to the facility or permanently installed lines from shore facilities. For ship-supplied fuel, special provisions must be made to ensure safe transfer activities. These would include transfer of personnel to the unmanned facility to perform such manual activities as may be required to operate valving and to monitor the operation; provision of equipment, including walkways and ladders, to gain access to the system components; locations and sizes of valves and couplings such that activities are well within human limits; and possibly the provision of special handling equipment to support the weight of, and to transport hoses to, the FOF connections. Provision must be made to protect equipment against the effects of relative ship motion during fuel replenishment at sea. Resupply controlled from shore, if feasible, would greatly simplify the resupply problem, but precaution is required against overfilling.

BM-430 WATER SYSTEM

DESC - The water system consists of the equipment necessary to provide all of the water required for the facility, including sources of supply, storage, and distribution. Separate systems are required for fresh and salt water.

FUNCT - The function of the water system is to provide water of a quality and in the quantity required by the facility.

BM-430.1 Storage Facilities

DESC - Storage facilities are those facilities required to store fresh water in the BM structure. Storage capacity required will vary depending upon the method and frequency of resupply (see BM-430.3). Salt water storage is not required.

BM-430.2 Distribution Systems

DESC - Distribution systems are those components which draw water from the supply source and distribute it to the water-consuming components and equipment. Water may be required for several purposes such as fire fighting, as a cooling agent for machinery, and as a cleaning agent. These systems consist of the necessary piping, valves, pumps, controls, instruments, and other components required to pump and distribute the water to the consuming components.

BM-430.2.1 Fresh Water

DESC - Fresh water is usually used for all water requirements except fire fighting, and a separate (probably multiple) distribution system is required.

BM-430.2.2 Salt Water

DESC - Salt water is usually used for fire fighting only and is supplied from an independent high-pressure system using motor-driven pumps drawing water from a clear area below the surface so that no storage facilities are required. This system requires a much higher pressure and flow capacity than the fresh water system, but involves only intermittent start, duration, and usage.

BM-430.3 Sources

DESC - There are three possible sources of supply for fresh water:

- Distillation
- Ship Supplied
- Piped from Shore

BM-430.3.1 Distillation

DESC - Fresh water may be supplied by a facility mounted distillation system which would maintain the storage tanks at predetermined levels. This system would require a heat source, which may be a combustion heater or a still using the waste heat of the engine exhaust and automatic controls. Its capacity would have to match the facility maximum requirements with an appropriate safety margin.

BM-430.3.2 Ship Supplied

DESC - A supply ship could replenish the fresh water storage tanks. The storage capacity and frequency of supply should be matched to the facility requirements with an appropriate safety factor. This supply frequency should also be matched with other resupply requirements such as fuel, and with inspection periods if possible.

BM-430.3.3 Pipeline

DESC - By this method, the fresh water would be supplied from shore-based facilities through pipes leading along the ocean floor to the BM facility. If the fill valves can be located ashore, or controlled from shore, the problem of resupply would be greatly simplified. Precautions against over filling is a requirement.

BM-440 WASTE DISPOSAL SYSTEM

DESC - This system accumulates the various waste materials generated by the facility.

FUNCT - The function of the waste disposal system is to collect and dispose, or provide for the disposal of, the waste material produced by the facility.

INTER - Each portion of the waste system will interface with the component from which it is collecting waste and with the main Structure (BM-200) on which it is supported.

BM-440.1 Waste Collection System

DESC - Each facility component that generates waste during normal operations must be equipped with a system for collecting the waste and transferring it to collection containers. For unmanned structures this waste material is normally liquids such as oil leaking from engines, hydraulic systems, and pumping systems, or fuel and oil from

tank scuppers. Larger installations will have bilges which will require drainage into the collection system. Although collection may not be required, the gases in large battery compartments and the vapors in engine compartments or from fuel and oil tank vents are a potential explosion hazard, and adequate disposal is a necessity. If the facility is in a sensitive environmental area, it may be necessary to collect these gases and to provide internal combustion engines with exhaust emission control equipment. Waste materials accumulated during maintenance checks (e.g., engine oil, fuel/water/oil filter elements, gaskets, etc.) will be collected and removed by maintenance personnel.

BM-440.2 Waste Treatment Devices

DESC - Waste gases (see BM-440.1) that cannot be disposed of directly to the atmosphere will require chemical treatment. Collection tanks can probably interchangeably accept all of the facility waste liquids. Where there is explosion potential, chemical treatment may be necessary to inert the vaporous material in the tank air space.

BM-440.3 Disposal Systems

DESC - Gases can normally be dissipated to the atmosphere after chemical treatment required by environmental considerations. The tanks collecting liquid wastes will be drained or exchanged by maintenance personnel.

BM-450 MECHANICAL POWER SYSTEMS

DESC - Systems that distribute or provide power to the load in mechanical form are usually hydraulic or pneumatic. Power ratings range from fractions of a horsepower to hundreds of horsepower. Hydraulic systems usually provide continuous power and pneumatic systems provide intermittent or one-shot power applications.

FUNCT - Mechanical power systems provide power to a load or perform a function where the alternative to the use of electrical power is improved efficiency or simplicity and reliability.

INTER - Mechanical power systems may derive their power from electrical Power Sources (BM-411), directly from engine-powered transmissions, or from an Engine-Driven Generator (BM-411.3). Mechanical power systems may require mechanical or

electrical Controls (BM-412). The primary advantage of mechanical power systems over Electrical Power Systems (BM-410) is a higher power-to-weight and volume ratio, and freedom from the possibility of electrical short circuits. Explosion proofing in conjunction with Fuel Systems (BM-420) is simplified.

BM-451 HYDRAULIC

DESC - Hydraulic power systems usually consist of a pump and motor connected through hydraulic tubing and associated controls. There are two general types of hydraulic systems – variable displacement systems, in which the displacement of pump or motor is used to provide power and flow control, and constant displacement systems, in which a pump fills an accumulator until a maximum pressure is reached, at which time the pump output is bypassed to zero pressure while the load is accommodated by the charged accumulator. The variable displacement systems are usually smoothly variable, while constant displacement systems cycle intermittently.

FUNCT - Hydraulic power systems provide power to a load or control power to a load where this can be done more efficiently or more reliably than by the use of electrical power.

INTER - Hydraulic power systems can be powered by electrical Power Sources (BM-411), or pumps can be driven directly by an engine in addition to a Generator (BM-411.3). When hydraulic power systems are operated under water, pressure compensation may be required. Care must be taken to prevent contamination of hydraulic oil by sea water to prevent corrosion. Hydraulic systems are noisy and payload acoustic noise requirements should be taken into consideration.

BM-451.1 Power Generators/ Regulators

DESC - These units consist of a motor- or engine-driven hydraulic pump. Hydraulic power packs are available in many configurations to suit a variety of requirements for pressure and flow. The regulation of output pressure and volume is performed in various ways. With constant displacement pumps the output volume is constant and pressure output is maintained by pressure regulating valves. Variable displacement pumps of several types are available, which may be set to deliver any given volume within their capacity range.

FUNCT - Power generators/regulators convert the mechanical energy delivered by a motor into hydraulic energy in the form of flow and oil under pressure.

INTER - Power generators and regulators interface with Structure (BM-200) through the Equipment Foundations (BM-224). Other interfaces may be with Electrical (BM-410), Fuel (BM-420), or Water (BM-430).

BM-451.2 Valves, Piping, and Fittings

DESC - Many different kinds of valves are available to perform diverse functions in the system. Included are pressure regulating, pressure reducing, check, locking, relief, volume control, directional control, flow dividers, throttling, equalizing, bypass, and selector valves. Some valves are auto-activated, while others may be operated manually or by remote control. Piping and connecting fittings are generally steel, but flexible hose is used where relative movement of connected parts occurs.

FUNCT - Hydraulic valves, pipes, and fittings are used to distribute and control the flow of hydraulic energy to the various parts of the system.

INTER - Valves, piping, and fittings interface with Structure (BM-200) and with Equipment Foundations (BM-224).

BM-451.3 Accumulators/Reservoirs

DESC - Accumulators are containers or tanks that contain fluid which is kept pressurized by means of compressed air or gas. Reservoirs are simply tanks of any shape made from any material compatible with the other components of the system.

FUNCT - Accumulators and reservoirs are used to store hydraulic fluid for the system. Accumulators are reservoirs storing hydraulic energy; reservoirs store the return flow of fluid after use for cooling and reuse in the power generator.

INTER - See INTER/BM-451.2.

BM-451.4 Motors/Actuators

DESC - Hydraulic motors have an output shaft driven in one of various ways. Piston type motors have cylinders disposed radially around the shaft and offer a range of motors having a variety of speeds and torques. Vane-type motors are of simpler construction but are usually used where lower torques are required. Other types of motor have gear-type impellers or flexible roll-type seals or may be of the rotary actuator type (for low speed and high torque).

Hydraulic actuators have either single- or double-acting cylinders and pistons. They are available in a wide range of strokes and loads. Multistage pistons are used where the stroke exceeds the available cylinder length.

FUNCT - Hydraulic motors and actuators convert hydraulic pressure and flow into rotary and linear mechanical motion, respectively.

INTER - See INTER/BM-451.2.

BM-452 PNEUMATIC

DESC - Pneumatic power systems consist of compressors and/or accumulators and pneumatic motors or actuators interconnected by piping and controls.

FUNCT - They are used to provide power to a load or to actuate an element of the bottom mounted surface structure where the reliability, size, weight, or other considerations dictate the use of pneumatic power.

INTER - Air for pneumatic power systems may be supplied by pneumatic compressors driven by auxiliary drive from engines, primarily driving generators (BM-411.3), or may be supplied from high-pressure containers for use when needed. Pneumatic systems provide explosion-proof power to areas such as Fuel Systems (BM-420). In pressurized sealed systems, standby reliability can be achieved over long periods. Safety Systems (BM-500), such as fire extinguishers, alarm systems and actuation of emergency escape apparatus (BM-520), are good candidates for actuation by pneumatic power.

BM-452.1 Air Compressors/Regulators

DESC - A compressed air generator plant includes coolers, dehydrators, and a tank. Regulators consist of pressure switches.

FUNCT - The air compressor is a device to change the mechanical energy of an engine or motor into pneumatic energy as compressed air. The coolers remove the heat of compression. Dehydrators remove entrained moisture. The compressed air in bottles may be the only air supply that requires replenishment. The regulators cycle the compressor as the pressure varies in many configurations to suit a variety of pressure and flow requirements.

INTER - See INTER/BM-451.2.

BM-452.2 Valves, Piping, and Fittings

DESC - Many different kinds of valves are available to perform diverse functions in the system. Included are pressure regulating, pressure reducing, check, locking, relief, volume control, directional control, flow dividers, throttling, bypass, and selector valves. Some valves are auto-activated, while others may be operated manually or by remote control. Piping and connecting fittings are generally steel, but flexible hose is used where relative movement of connected parts occurs.

FUNCT - Hydraulic valves, pipes and fittings are used to distribute and control the flow of hydraulic energy to the various parts of the system.

INTER - See INTER/BM-451.2.

BM-452.3 Accumulators/Reservoirs

DESC - These are containers in spherical or cylindrical shape usually of steel capable of supporting high internal burst pressure. They are designed to high factors of safety to minimize explosive failures.

FUNCT - Accumulators and reservoirs are containers which store compressed air from the compressor or are compressed air bottles, respectively. They are used to

eliminate pulsations in the system, to provide damping for pressure fluctuations caused by varying system demand, and to minimize cycling of compressor or other controls in the system.

INTER - See INTER/BM-451.2.

BM-452.4 Motors/Actuators

DESC - Air motors have an output shaft driven either by vanes or multiple pistons in cylinders arranged either radially or axially. Another type, less generally used, has a turbine drive and is usually used for light loads. Air motors in general are used for more lightly loaded applications than hydraulic motors but are also less costly and have less costly associated piping. Air actuators are similar to hydraulic actuators. Air being compressible is less easily controlled when used for an actuator, compared to the positive displacement of the hydraulic actuator.

FUNCT - Air motors and actuators convert air pressure into rotary and linear mechanical motion, respectively.

INTER - See INTER/BM-451.2.

BM-453 MECHANICAL

DESC - Mechanical power systems include all means of storing and transmitting power by strictly mechanical means. Energy for conversion to power may be stored as potential energy, as in a head of water or a suspended weight; as kinetic energy, as in an inertia weight or an inertia wheel; or as strain energy, as in a spring.

FUNCT - Mechanical power systems are used to receive and store energy for release at a later time as required by the service being powered.

INTER - Mechanical power systems interface with the Structure (BM-200) and with Equipment Foundations (BM-224).

BM-453.1 Weights

DESC - When used in a power system, weights are initially elevated to a position from where they can be released and allowed to drop, either incrementally (to supply a series of pulses) or a "one-shot" impact. Suitably controlled by a brake, it may also be used as a source of continuous power.

FUNCT - See FUNCT/BM-453.

INTER - See INTER/BM-453.

BM-453.2 Inertial

DESC - Inertial power systems consist of a device, such as a flywheel, that can be accelerated by the input of relatively modest power for a long period for release at a higher level in a relatively short time.

FUNCT - See FUNCT/BM-453.

INTER - See INTER BM-453.

BM-453.3 Springs

DESC - Springs are an arrangement of any elastic material so that, when deflected, the strain energy resulting from the deflection can be usefully employed to generate power. Springs are commonly of steel and may be leaf springs deflected in bending, coil springs deflected in torsion, and bending and torsion springs deflected purely in torsion. An example of a coil spring storing energy is the spring in a hydraulic accumulator.

FUNCT - See FUNCT/BM-453.

INTER - See INTER/BM-453.

BM-460 ACCESS SYSTEM

DESC - Access systems consist of facilities for boat and helicopter landings, and of ladders, walkways, and hatches.

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FUNCT - The function of access systems is to provide access by maintenance personnel to the facility by boat or helicopter and within the facility to all compartments that require inspection, maintenance, repair, or refurbishment during the lifetime of the facility.

INTER - The principal interface of access equipment is with the main Structure (BM-200) which supports it, with the components requiring maintenance, and with the maintenance equipment. An interface may also occur with weight-handling equipment (e.g., reach of cranes).

BM-460.1 Boat Landings

DESC - Equipment and facilities must be provided for the mooring of supply/maintenance ships and for the transfer of personnel and equipment from ship to facility and return. If the facility handling equipment (cranes, winches) are to be used to remove heavy equipment from the supply ships, a boat landing requirement must be included in the design.

BM-460.2 Helicopter Landings

DESC - Provision with appropriate markings is required for helicopter landing decks. Tie down equipment is required, as well as the capability to move equipment from the helicopter to the facility location where it is required and to reload as necessary. The facility must also provide a suitably stable platform for helicopter landing and takeoff with minimal obstructions.

BM-460.3 Ladders

DESC - Ladders are required for boarding the facility from a vessel as well as for access within it. They are classified as to configuration (vertical or inclined) or as to type or function (boarding Jacobs, step). In some cases the ladder may be a separable unit bolted to the structure, or it may be integral with the structure, with the steps welded to it or cut into it. Special ladders may be required for helicopter access.

BM-460.4 Walkways

DESC - A walkway may be any structural element provided for the purpose of safe, sure-footed transit by construction and service personnel. On flats or decks, the walkway may be no more than an appropriately identified pathway provided with a suitable nonskid covering. Walkways spanning spaces between any items of structure or machinery often take the form of beams with open mesh walking surfaces to allow good drainage and grip.

BM-460.5 Hatches

DESC - A hatch is required where access is necessary to an area that must otherwise be enclosed. The type of hatch depends on the size and strength required, what must be enclosed (light, environment, pressure), and the frequency of access. Hatches may be nontight, watertight, oil tight, or gas tight and either quick or slow acting. Hatches may be cut into structural or nonstructural members. The strength of the member must be checked to determine the need for reinforcement around the opening.

BM-470 FLOODING SYSTEM

DESC - The flooding system consists of compartments within the existing structure or special tanks attached to the structure. These compartments are joined with piping, valves, vents, manifolds, etc., as required to flood or expel the water from the compartment. The compartments are usually an integral part of either framed or shell FOF structures. In framed structures, plates are attached to basic members to form compartments suitably located for the buoyancy required.

FUNCT - The flooding system is generally applicable to an FOF that is towed to site for erection or transported between different sites. It provides for positive buoyancy for surface operation and negative buoyancy to submerge at the site.

INTER - The flooding system primarily interfaces with the Structural Components (BM-200) or other systems within BM-400.

BM-470.1 Piping and Equipment

DESC - The flooding system consists of valves, vents, piping manifolds, pumps, etc. This equipment is usually selected from commercially available hardware.

FUNCT - Piping and equipment components provide the flow of water and air to compartments.

INTER - Same as INTER/BM-470.

BM-500 SAFETY SYSTEMS

DESC - Safety systems are devices, equipments, and procedures provided to afford personnel, property, and the environment with the optimum degree of safety attainable within the constraints of operational effectiveness, time, and cost. Safety systems may be integral elements of FOF subsystems or may be independent subsystems, devices, or equipment. Safety procedures are an included element of safety systems. The safety systems must anticipate human error, misuse, and malfunction, in addition to the hazardous conditions and events inherent in normal and alternative modes of operations. The breakdown of elements within this category is shown by Fig. BM-500-1.

FUNCT - Safety systems protect personnel, property, and the environment from the consequences of internal and external events such as errors, malfunctions, failures, external forces, and accidents.

INTER - Safety systems, as a minimum requirement, must be in compliance with the standards of all cognizant regulatory agencies. These may include one or more of the *following: USCG/DOT/OSHA/DOL/OSCLA/DOI, FAA/USN/DOD and local jurisdictions.* Another interface of significance to safety is that with supporting forces and craft. Finally, the safety systems will interface in some degree with every FOF subsystem either in affording protection or in utilizing a function of the subsystem as part of the protection for the balance of the system. The following elements will contribute to safety.

BM-510 FIRE FIGHTING EQUIPMENT

DESC - Fire fighting equipment consists of detection devices, alarm systems, extinguishants, and protective equipment and tools for firefighters.

FUNCT - The function of fire fighting equipment is the prompt and effective extinguishing of any fire in the FOF or its equipment using the proper extinguishing agent. An explosion suppression function may be required for some FOFs.

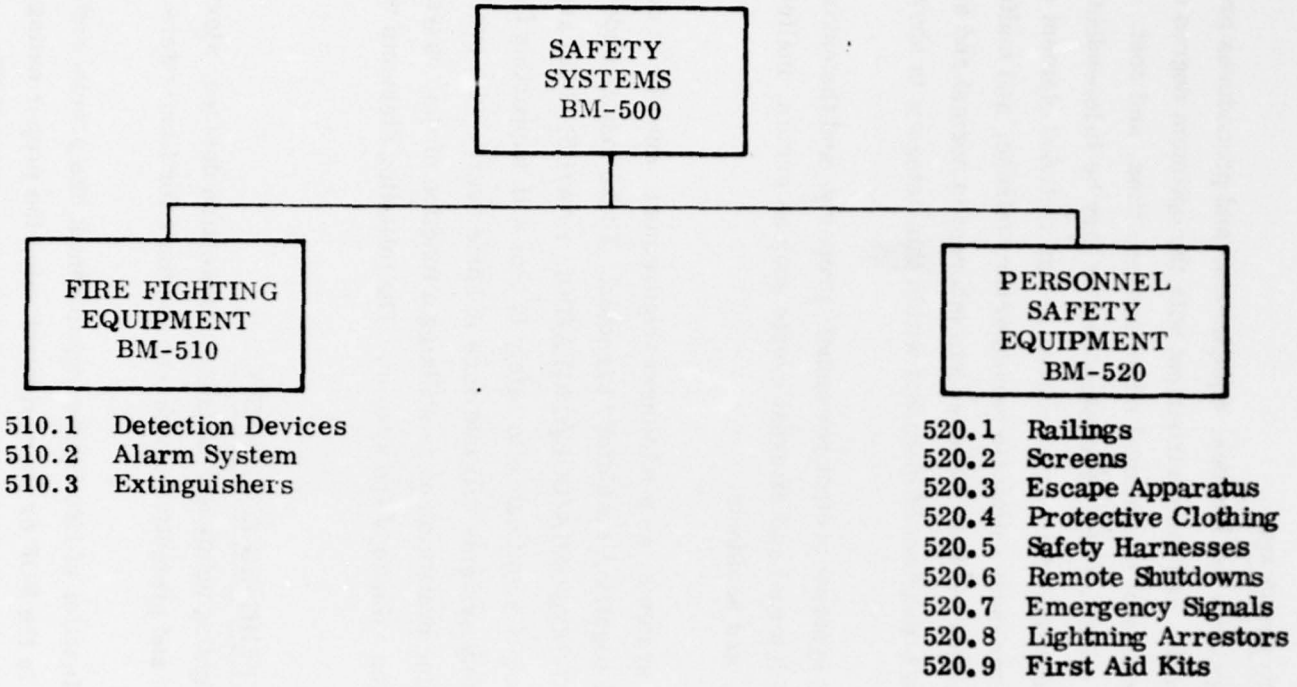

Fig. BM-500-1 Safety Systems – Breakdown Structure

INTER - Principal interfaces from which the fire fighting function derives support are Structure (BM-200), Utilities (BM-400), and Communication Systems (BM-600).

510.1 Detection Devices

DESC - Detection devices contain sensors responsive to smoke, high temperatures, fire, vapor concentrations, and when required, explosion. Active and passive devices are available. Passive devices include fusible plugs, frangible discs, etc. Active devices use sensors sensitive to temperature, smoke, infrared, ultraviolet, particulates, vapors, etc. Redundant devices are normally employed.

FUNCT - The function of detection devices is to sense the existence of hazards and potential hazards of fire and/or explosion. Upon sensing such a hazard, they may initiate alarms or may signal release of extinguishants, or both.

INTER - Detection devices interface with Alarm Systems (BM-510.2), Extinguishers (BM-510.3), and Communications (BM-600). Under normal conditions, active devices usually interface with Power Source (BM-411) and Distribution (BM-413), but are provided with independent emergency power sources.

BM-510.2 Alarm Systems

DESC - Alarm systems are systems which respond to signals from detection devices and provide visual, audible, mechanical, or electrical signals or combinations of the foregoing which compel immediate attention to the existance of hazards. Redundant systems are usually provided.

FUNCT - The alarm systems provide local and, when required, remote alert alarms to enable timely initiation of actions to combat the hazards of fire or explosion. The additional concurrent function of actually initiating action may be incorporated in the alarm system when appropriate.

INTER - The alarm systems interface with the Detection Devices (BM-510.1). They may interface with Extinguishers (BM-510.3). For normal conditions they interface

with Power Sources (BM-411) and Distribution (BM-413). For emergency conditions, independent power supplies are provided. An interface with Communications (BM-600) may be provided for transmission of alarms to remote monitors.

510.3 Extinguishers

DESC - Extinguishers are devices which, when activated, rapidly dispense one of a wide variety of fluids, gases, or dry chemicals capable of extinguishing fire or suppressing explosion. Common extinguishing agents include water, foams, CO_2, Halon, and PKP. Agents are selected on the basis of their effectiveness on fires in the various kinds of combustibles present in the area to be protected. Fixed or portable extinguishers are available. A variation of the extinguisher is a system which maintains an inert atmosphere in a closed area.

FUNCT - The function of the extinguisher is to eliminate the hazard of fire by rapidly and effectively dispensing an extinguishing agent on or around the fire, thereby depriving the combustion process of oxygen or otherwise interfering with the combustion process (Halon). A further function of the extinguisher is the cooling of materials which would otherwise reignite the fire as oxygen becomes available.

INTER - Extinguishers usually interface with Detection Devices (BM-510.1) and Alarms (BM-510.2), although they may be manually activated. When water is the fluid employed, they will interface with the utility Water System (BM-430). Another common interface is Remote Shutdown (BM-520.6) of affected equipment and ventilation.

BM-520 PERSONNEL SAFETY EQUIPMENT

DESC - Personnel safety equipment is comprised of equipments, devices, and elements of the FOF subsystems which assure personnel an acceptable degree of safety from the hazard of operation and maintenance of the FOF, and from the environment under normal and emergency conditions. The variety of equipment ranges from simple protective clothing to self-contained breathing apparatus and elements of structure and machinery such as railings and guards. All safety equipment must conform to the standards of cognizant regulatory agencies.

FUNCT - The function of personnel safety equipment is to provide protection from injury or unhealthful conditions to personnel under normal and abnormal circumstances arising in operation and maintenance of the FOF.

INTER - Safety equipment interfaces with Access System (BM-460) for safe access to and egress from the FOF and for safe traffic among the FOF subsystem equipments. It interfaces with each subsystem in the course of operations, inspections, and maintenance. Under emergency conditions it interfaces with other Safety Systems (BM-500) and with the subsystems involved in the emergency.

BM-520.1 Railings

DESC - Railings, and walkways, hand holds, ladders, safety cages, and the like, are structures which facilitate safe access, egress, and movement about the FOF.

FUNCT - The function of railings and like structures in normal conditions is aid and convenience to personnel movements. In abnormal situations, such as falls, tripping, poor visibility or severe weather they assist personnel to regain and maintain control of their movements and thus avoid injury.

INTER - Railings interface with FOF Secondary Structure (BM-220).

520.2 Screens

DESC - Screens, guards, enclosures, and barricades are structural or mechanical devices which preclude inadvertent contacts by personnel, tools, or equipment with moving machinery, electrical power, hot surfaces, etc.

FUNCT - Screens and like devices provide a mechanical barrier around hazardous objects or conditions and thus protect personnel from injury.

INTER - Screens and like devices interface with Secondary Structure (BM-220).

BM-520.3 Escape Apparatus

DESC - Escape apparatus is equipment such as life lines, life jackets, exposure suits, life rafts or boats, gas masks, rescue breathing apparatus, axes, torches, and hoists, slings and stretchers.

FUNCT - The function of this apparatus is to provide personnel with effective means for promptly and safely escaping from hazardous situations and for aiding others to do the same.

INTER - Escape apparatus does not normally interface with FOF subsystems except Secondary Structure (BM-220) for stowage. Escape apparatus is not utilized in normal operations and maintenance, but is held in readiness for use in emergencies.

BM520.4 Protective Clothing

DESC - Protective clothing consists of special articles of clothing for personnel performing hazardous tasks or exposed to unhealthful conditions. Goggles, masks, gloves, suits, boots, etc., are common articles of protective clothing.

FUNCT - The function of protective clothing is to protect the wearer from injury or other ill effects which could result from normal or abnormal occurrences in the course of his work.

INTER - Protective clothing does not interface with other FOF subsystems except for stowage in Secondary Structure (BM-220). It is normally issued only on occasions when its use is required. Personnel who have a routinely recurring need may have custody of required protective clothing. If contamination is a problem, protective clothing may be collected and packaged for decontamination or may be destroyed, causing an interface with Waste Disposal (BM-440).

BM-520.5 Safety Harnesses

DESC - Safety harnesses are arrangements of straps, buckles, etc., in various configurations designed to securely hold personnel, even if unconscious. They are equipped

with tending, securing, or hoisting lines appropriate to the task at hand. They are employed in work aloft, over the side, and other hazardous locations.

FUNCT - Safety harnesses protect personnel from injury in the event of falls, loss of footing, loss of consciousness, etc., by stopping downward progress and holding the personnel suspended until rescue can be effected.

INTER - Safety harnesses usually interface with Structure (BM-200).

BM-520.6 Remote Shutdown

DESC - Remote shutdown is a redundant control device for mechanical and electrical systems. It is located at a distance from the normal control station - usually in another compartment. It enables personnel to shut down the subsystem or component without approaching it. It also may be employed simply as a convenience device when the primary control is located at a distance from the monitor's station.

FUNCT - The function of remote shutdown is protection of personnel in the event of the occurrence of a hazardous condition which involves the normal control of the subsystem.

INTER - Remote shutdowns interface with the Control Subsystem (BM-412). Since they may be manual or electrically activated, they may also interface with Structure (BM-200).

BM-520.7 Emergency Signals

DESC - Emergency signals are devices provided for personnel aboard the FOF to use to communicate with support craft or others. They may consist of radio transmitters, lights, flares, loud hailers, flags, bells or horns, etc. Independent power sources are provided for those devices not manually operated. A prearranged signal code may be provided.

FUNCT - The function of emergency signals is to provide personnel protection by means of timely and effective communication with support forces as a result of an emergency aboard the FOF.

BM-520.8 Lightning Arrestors

DESC - Lightning arrestors are devices for providing an electrical path to ground. They must be utilized in conjunction with a suitably configured conductive circuit. They are utilized principally in antenna circuits or for the protection of structure.

FUNCT - The function of the lightning arrestor is to divert naturally occurring lightning from antennas to a planned grounding path and thus to protect personnel from injury and equipment from damage.

INTER - The lightning arrestors interface with the Communication System (BM-600), with grounding circuits, and with Structure (BM-200).

BM-520.9 First Aid Kits

DESC - First aid kits are assortments of medical supplies and equipment packaged suitably for long-term storage. They are available in a wide variety to suit the needs of the site at which they may be utilized. Approval of the cognizant regulatory agency should be obtained for the kits to be provided aboard the FOF.

FUNCT - The function of the first aid kit is to provide sufficient medical capability aboard the FOF to sustain personnel suffering illness or injury until such time as they can be provided regular medical treatment.

INTER - First aid kits interface only with Structure (BM-200) for stowage.

BM-600 NAVIGATION, WARNING, AND COMMUNICATIONS SYSTEMS

DESC - Navigation, warning, and communications are systems incorporated in the bottom mounted structure to permit detection, location, and identification of the structure by vessels in the area and to permit communication to and from the structure. They can generally be divided into three classes: acoustic, visual, and electromagnetic, as shown by Fig. BM-600-1. Each of these systems has a defined range of effectiveness for navigation and communication warning and some require the use of compatible equipment on vessels for interrogation.

FUNCT - Navigation, warning, and communication systems are used to assist in the automatic or semiautomatic detection, location, and identification of the bottom mounted structure to allow searching vessels to home to the facility, to provide a geographical point of reference for vessels to assist in navigation, and to alert vessels to the existence of the facility in order to avoid collision.

INTER - The equipment used for navigation, warning, and communications systems interface primarily with the structure which must support it. This generally means the Payload Accommodations (BM-300), but in the case of submerged navigation aids, it may also involve supports on either the Foundations (BM-100) or the Structure (BM-200). There are also interfaces between equipment used in these systems and compatible equipment used on ships or shore stations. Energy using equipment such as lights or electronic gear, unless equipped with self-contained energy sources, will interface with Power Source (BM-411), Controls (BM-412), and Distribution Elements (BM-413). Depending upon the type of equipment, it may also interact with the environment and may require protection against environmental effects. In particular, it may be necessary to consider the effects of fouling and motions of the facility and localized spray effects.

BM-610 ACOUSTIC

DESC - Acoustic systems consist of various kinds of sound-producing, sound-receiving, and sound-reflecting devices. These systems include bells, transponders, pingers, and reflectors. Some systems transmit identification codes and some require special codes for activation.

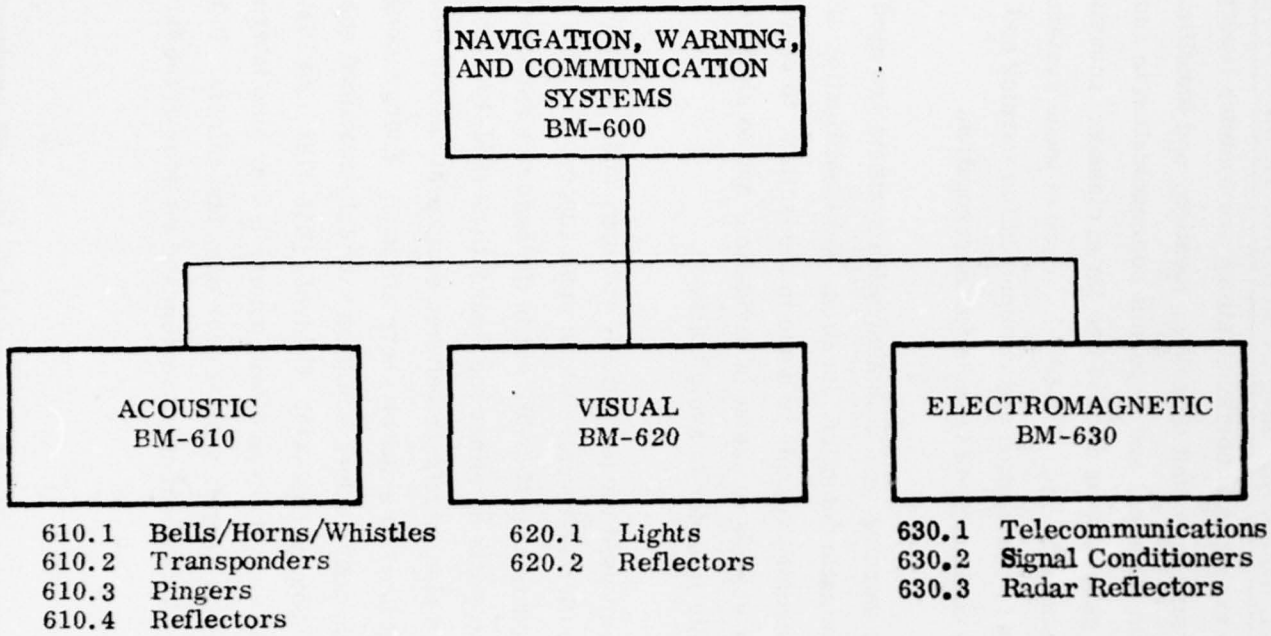

Fig. BM-600-1 Navigation, Warning and Communication Systems – Breakdown Structure

FUNCT - Acoustic systems sense and/or produce acoustic energy for activation of equipment, warning, or communication.

INTER - Active elements of acoustic systems are mounted external to and interface directly with the Structure (BM-200) where they may be a part of Payload (BM-300. Because these elements are exposed to the complete ocean spectrum, they must be protected from or be compatible with the environment. Devices that require electrical power have an integral Power Source (BM-411) and will require penetrators and cables associated with Power Distribution Systems (BM-413).

BM-610.1 Bells/Horns/Whistles

DESC - Bells are mechanical devices that produce sound by the impact of a clapper against the resonant member. Bells may be activated by movements of the sea or may be electrically or mechanically operated. Horns and whistles are usually air-operated, the air being in some cases stored compressed and in other cases expelled by natural sea motion.

FUNCT - Bells, horns, and whistles are primarily used as warning devices.

INTER - On bottom mounted structures, bells, horns, and whistles would interface with the main surface Structure (BM-200). They are mechanical devices and would normally be exposed to the environment. Provisions must be made to prevent fouling or corrosion interfering with their function.

BM-610.2 Transponders

DESC - Transponders consist of a receiver, in some instances a decoder, and an acoustical transmitter. The receiver may respond to a narrow or a broad range of frequencies. The incorporation of a decoder requires that a pattern of frequencies or sound pulses of some predetermined format be received before the transmitter is activated. The transmitter may respond in a code to provide identity for a location. In some circumstances, the signal may be used to actuate devices other than the transmitter.

FUNCT - Transponders respond to an interrogating acoustic signal of a predetermined format to actuate some other device such as a Payload (BM-300), or to produce an acoustic response, warning, or communication.

INTER - Transponders require electrical power and must be compatible with the Electrical Power Systems (BM-410) and must have an integral power supply. Frequencies must be selected for optimum performance of the desired function. As the frequency is increased, the precision of location is improved but range is reduced. Conversely, as frequency is reduced, range is increased and precision is reduced.

BM-610.3 Pingers

DESC - Pingers are devices which produce pulses of acoustic energy at a predetermined frequency and on a specified schedule.

FUNCT - Pingers produce acoustic energy for identification, location, or warning of the presence of obstructions or facilities. They may also be used as markers or elements thereof.

INTER - When used as temporary markers, pingers usually have integral power supplies which provide power during the useful life of the device. Where pingers are mounted on the Structure (BM-200), and must operate over a long period, connection to the Electrical Power System (BM-410) may be provided.

BM-610.4 Reflectors

DESC - Reflectors are devices which cause acoustic energy to be reflected rather than transmitted. Reflection efficiency increases as the discontinuity of density increases. Some reflectors are constructed to return a predominant amount of the reflected energy in the direction of the source.

FUNCT - Reflectors provide a passive means of enhancing the acoustic cross section of the bottom mounted facility so that it may be more easily detected by the sonar on approaching vessels.

INTER - Reflection efficiency increases as the density discontinuity increases and also as the size of the deflector increases. Support for the reflectors would be provided by the Structure (BM-200). Since reflectors are passive, they do not require power.

BM-620 VISUAL

DESC - Visual systems consist of both passive and active components which are attached to the surface elements of bottom mounted structures and which utilize the visual energy spectrum. Passive components consist of surface treatments in the form of paints or other materials arranged in such a way as to maximize or minimize the chances of observation, depending on the requirements. Active components include light beacons utilizing gas discharge lamps or incandescent lamps. Range of visual devices varies from a few feet in heavy fog to several miles.

FUNCT - Visual systems either reflect or emit visual energy as a means of identifying the existance of the facility.

INTER - Range is a function of the specific colors and surface irregularities of the materials used as well as the visibility at the time. Range of passive systems can vary from zero at night and in fog to several miles on a clear day. Passive systems such as paint, reflectors, or lenses must be designed to minimize the effect of fouling and be attached to the Structure (BM-200). Active systems will interface with Electrical Power (BM-410).

BM-620.1 Lights

DESC - Lights are a source of visual energy which may be incandescent or gas discharge and may be continuous, rotated, or flashed.

FUNCT - Lights provide a visual warning of the location of the FOF.

INTER - Lights would be mounted high on the surface Structure (BM-200). Because of the high power requirements of incandescent lamps and rotating devices, lights would probably be employed for night operation. Care should be taken to minimize reduction of efficiency by fouling or spray.

BM-620.2 Reflectors

DESC - Reflectors are passive devices that return light to the direction of its source. Lenses of various designs with highly reflective coatings are designed to introduce color or to respond in a specific manner. Angular response and color response of reflectors can be designed to specific requirements. Reflectors are a low-cost, highly reliable means of enhancing the visual response of surface elements.

FUNCT - Reflectors provide a passive visual indication of the existence of bottom mounted structures and are intended primarily for night operation.

INTER - Reflectors attached to Structure (BM-200) should be located sufficiently high above the water to minimize the effects of spray and fouling, which reduce efficiency.

BM-630 ELECTROMAGNETIC

DESC - Electromagnetic systems consist of beacons, reflectors, transmitters, may be active or passive, and may transmit signals through cables or over radio links.

FUNCT - Electromagnetic systems provide electromagnetic indication of the presence of bottom mounted structures or transmit/receive data.

INTER - Electromagnetic systems will interface primarily with the Structure (BM-200). Active systems will interface with Electrical Power Systems (BM-410), and data systems may interface with the Payload (BM-300).

BM-630.1 Telecommunications

Telecommunications include radio frequency transmitters, receivers, and associated antennas or transmission systems. Also included are warning beacons that consist of either pulsed or continuous wave transmitters, which transmit automatically or when interrogated. Interrogation may be within a wide band of frequencies depending upon the requirement.

FUNCT - Telecommunications equipment transmit data from or to a bottom mounted structure and provide an electromagnetic indication of the existence and/or the location or identity of bottom mounted structures. Transmission can be either into the bottom mounted structure or beamed to the atmosphere.

INTER - For transmittal from the bottom mounted structure, data can be received from Signal Conditioners (BM-630.2), and will be transmitted over Electrical Cables (BM-413.1) or antennas attached to the Structure (BM-200). When data are received, electromagnetic energy will be absorbed by the antennas and transmitted to Signal Conditioners (BM-630.2), or it will be received from Electrical Cables (BM-413.1) and sent to the elements of the facility through signal conditioners.

Warning beacons are usually mounted on the Structure (BM-200) and require connection to a power source and the Power Distribution System (BM-413). Care should be taken to design the antenna to minimize the effects of salt spray and the environment.

BM-630.2 Signal Conditioners

DESC - Signal conditioning equipment is basically electronic and is usually housed in racks. It is primarily solid state and may be executed as integrated circuits. Power input ranges from a few watts to hundreds of watts.

FUNCT - Signal conditioning equipment combines, converts, modifies, or stores electrical signals so that the signals may be transmitted, processed, analyzed, or used for control.

INTER - Signal and impedance levels between elements must be carefully analyzed. Appropriate dynamic range in all elements must be provided to accommodate the range of signal levels that may be encountered. Power Sources (BM-411) must not introduce noise. Protection from electromagnetic interference must be considered for sensitive circuits.

BM-630.3 Radar Reflectors

DESC - Radar reflectors may be of angular metal construction encased in a radome or exposed to the environment. A corner reflector has the characteristic that it will return energy in the direction from which it was received. Reflectors may be dielectric lenses to provide enhanced radar cross section.

FUNCT - Radar reflectors provide a passive indication of the existence or location of bottom mounted structures by returning a large portion of the energy received from the illuminating electromagnetic radar source.

INTER - Reflectivity depends upon the size and the design of the reflectors. They are lightweight buf have a large surface area and must therefore be designed to structurally support large loads when operating in icy environments. They interface with the Structure (BM-200).

BM-700 PROTECTIVE SYSTEMS

DESC - Protective systems are those devices or coatings and techniques which are interposed between the FOF and the environment or other structures or vessels. They are categorized as (a) mechanical, such as fenders, (b) coatings, such as anticorrosion or antifouling paints, and (c) cathodic protection, such as sacrificial anodes.

FUNCT - Protective systems provide a system with immunity or mitigation of the effects of corrosion, biofouling, or collision.

INTER - The principal interface of protective systems is with the element being protected. Fenders are selected and located for the anticipated service as, for example, tieing up a workboat, or working of one structural element against another.

Basic materials for construction and service components should be selected, in so far as is possible, to be compatible with the environment, and when in intimate contact, with each other. Selection is directed toward the choice of materials which in combination yield a lower galvanic difference than the value at which corrosion occurs. Suitable coatings must be provided for incompatible materials to provide isolation. Compatibility of coatings on different components should also be considered.

BM-710 MECHANICAL (FENDERS)

DESC - A fender is a resilient, energy-absorbing device attached to the external surface of a FOF. Fenders may be separate items attached or hung at intervals around a facility, they may be in the form of a continuous wall, or they may be permanent structures integrated with the primary structure.

Mechanical protection may also consist of a boom or similar structure between the structure and an adjacent boat.

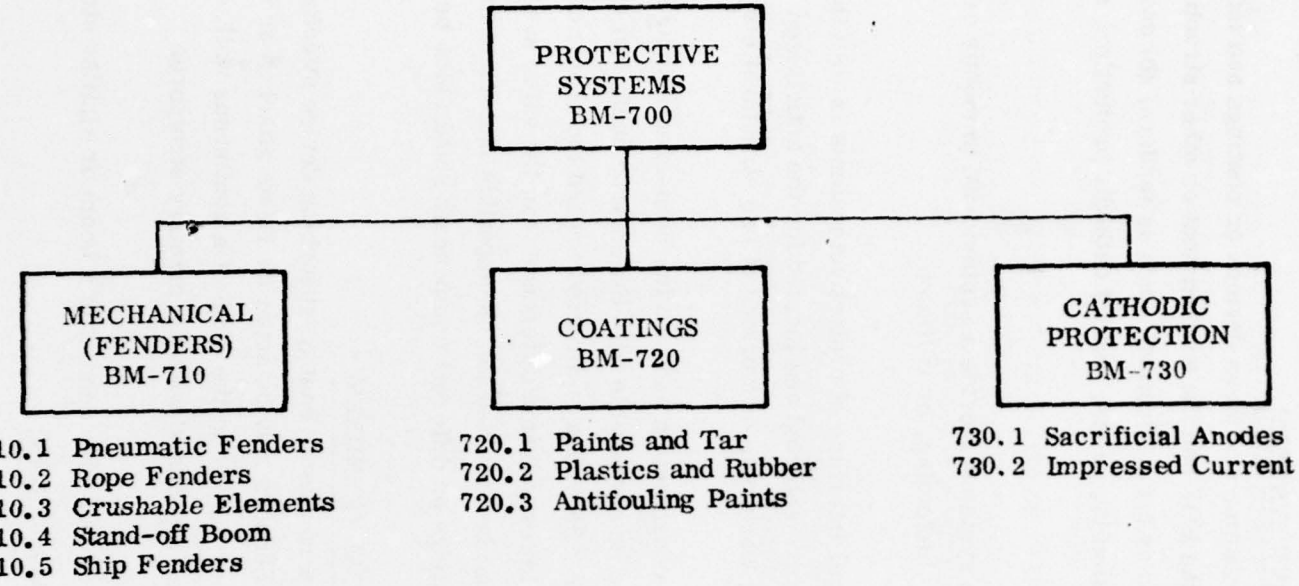

Fig. BM-700-1 Protective Systems – Breakdown Structure

FUNCT - Fenders protect the facility from mechanical damage due to collision, impact, or working of a boat against a part of the structure.

BM-710.1 Pneumatic Fenders

DESC - Pneumatic fenders are fenders whose resiliency or ability to mitigate shock loads is obtained by air contained within a flexible casing. The air may be in a sealed compartment or the casing may be vented so the volume can be reduced as air is forced out.

BM-710.2 Rope Fenders

Rope fenders are constructed of rope that has been knotted, plaited, or otherwise formed to rest against a structure and absorb the impact of adjacent vessels.

BM-710.3 Crushable Elements

DESC - Crushable elements are composed of foam, plastic materials, metal, or plastic honeycomb sections and are sometimes employed as mechanical protective devices.

FUNCT - Crushable elements protect the bottom mounted structure from severe impacts by mitigating the effect to protect the basic structure (BM-100 or BM-200).

INTER - Since the crushable element is damaged when used in a protective capacity, replacement is required at some time. Under these circumstances, other protective devices, such as pneumatic or rope systems (BM-710.1) or (BM-710.2), are provided in conjunction with the crushable elements.

BM-710.4 Stand-Off Boom

DESC - A stand-off boom is a spar, one end of which is attached and pivoted from the facility. Its other end is rigged outboard and has provisions for a workboat or other small boat to tie-up. Rigging will allow the boom to be brought alongside or swung outboard.

FUNCT - Stand-off booms protect structures by providing a means for attachment of a workboat such that impingement is unlikely, thereby precluding impact damage. Boom design and attachment locations should account for variations in sea height due to seasonal tides and storms.

BM-710.5 Ship Fenders

DESC - Ship-supporting fenders are permanent structures consisting of beams supported above and below the water surface. Timber or rubber facings are attached to the outside surfaces. These are very similar to fender protection for piers. The fenders are attached to one or more sides of the FOF where visiting ships and boats are required to tie up.

FUNCT - Permanent ship fenders are integrated with the BM structure to transfer large loads (resulting from ship impact) to the FOF primary structure in such a way that damage will not result.

INTER - These fenders interface with the primary surface and subsurface Structure (BM-210).

BM-720 COATINGS

DESC - Coatings are substances applied to elements of the bottom mounted structure and consist of paints, plastics, tars, and rubbers. They may be applied as liquids which form films or they may be molded in place.

FUNCT - Coatings protect the bottom mounted structure from corrosion and fouling.

INTER - Complete compatibility in sea water of all of the components of the structure including all of the coatings must be considered. For example, an antifouling coating containing compressed oxide will accelerate the sea water corrosion attack of aluminum and steel alloys. Surfaces to be coated must be thoroughly cleaned to ensure good adhesion and to maintain the integrity of the applied film.

BM-720.1 Paints and Tars

DESC - Finishes for marine structures include organic and inorganic zinc-rich paint, epoxy, polyurethane, vinyl, and coal tar coating systems.

FUNCT - Coatings are designed to exclude direct contact with the environment and prevent corrosion attack of FOF components.

BM-720.2 Plastics and Rubber

DESC - Plastics and rubber are applied to elements of the bottom mounted structure by molding or by adhesion. They include polyurethane, vinyl, rubber and other moldable or nonmetallic materials.

FUNCT - Plastics and rubber provide protection from the environment by sealing or excluding the environment from contact with the element of the bottom mounted system.

INTER - This type of protection is usually applied to the smaller elements of the bottom mounted structure such as cables, cable junctions, fittings, and elements where the protective material can be bonded or extruded onto the component. This method is usually expensive.

BM-720.1 Antifouling Paints

DESC - Paints and tar are usually applied in the form of liquid which hardens into a film. Toxic paints are used to prevent biofouling. Corrosion protective coatings include organic and inorganic zinc-rich paint, epoxy, polyurethane, vinyl, and coal tar coating systems. Toxic elements are usually cuprous oxide or organo-tin compounds.

FUNCT - Antifouling paints coat the elements of the bottom mounted structure exposed to sea water and sea environment, exclude direct contact with the environment, and kill marine growth by slow release of toxic materials from the coating into the surrounding sea water.

BM-730 CATHODIC PROTECTION

DESC - Cathodic protection is a means of changing the electrical potential of a structure immersed in salt water in a cathodic direction (i. e., making its voltage more negative). Two methods are used: (a) provision of sacrificial anodes or (b) use of impressed electrical current.

BM-730.1 Sacrificial Anodes

DESC - Sacrificial anodes are metallic elements of aluminum, zinc, or magnesium selected to set up a galvanic cell in sea water. The structure is the cathode of the galvanic couple. Protective current flows to the structure from the anode, which corrodes at a rate that is governed by the size of the structure in the anodes of the materials used.

FUNCT - Cathodic protection operates by ensuring that material loss due to electrolytic action in sea water is confined to an anodic material placed there for that purpose and not from the structural material.

INTER - Installation of cathodic protection should provide for access and consideration of the type of structure (e.g., size, material, construction, and painted area of the structure) to determine the amount and location of anode material. Complex configurations in general require more anodes than an open uniform structure such as a ship's hull. The size, the material in construction, and the configuration of the Structure (BM-100 and BM-200) will determine the type and number of anodes that are required.

BM-730.2 Impressed Current Cathodic Protection

DESC - The impressed current cathodic protection system uses an external power source and a permanent anode such as silicon, iron, graphite, platinum, and the reference electrode to change the electrical potential of a structure in sea water.

FUNCT - The impressed current provides change in potential in the cathodic direction (i.e., from minus 0.6 to minus 0.08 volts per the sea water galvanic series) to protect the structure. The reference electrode measures the potential of the structure and thereby determines if corrosion protection is being achieved.

INTER - The use of impressed current systems to prevent corrosion of bottom mounted structures must consider potential problems of over-protection where the protection level is sufficiently high to cause loss of protective paint coating and adhesion (BM-720). Of equal importance is the potential for hydrogen embrittlement of any high-strength component that would be exposed to a protective current in the system.

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