



Safe Operation and Maintenance of Dry Dock Facilities

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Safe Operation and Maintenance of Dry Dock Facilities

Prepared by
the Dry Dock Asset Management Task Committee of
the Ports and Harbors Committee of
the Coasts, Oceans, Ports, and Rivers Institute of
the American Society of Civil Engineers

Edited by
Paul A. Harren



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94	Inland Navigation: Locks, Dams, and Channels		

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PREFACE

Prior to the publication of this manual of practice, there was no documentation available to commercial facilities that provides guidance for the operators of the four types of dry dock facilities: floating dry docks, graving docks, marine railways, and vertical lifts. As a result, some facilities have been operated and maintained without a thorough understanding of the design of the dry dock and, therefore, the features that are vital to the safe operation of the facility.

Several dry dock failures in recent years have underscored the need for understanding and vigilance when operating and maintaining dry docks. The most vivid example occurred on March 27, 2002, at Dubai Dry Dock No. 2, one of the world's largest ship repair facilities. With five vessels in dock, a section of the gate failed, causing uncontrolled flooding of the dock.

This manual is intended for commercial entities that inspect, maintain, or operate the types of dry docks addressed in this manual, with a capacity of 400 long tons or greater. This manual is not applicable to facilities that are certified to MIL-STD-1625 (D)SH (2009) for the drydocking of U.S. Navy ships. Personnel safety requirements are outside the scope of this manual.

Four activities are vital to maintaining and operating a dry dock safely. These activities include:

Condition Assessment: The condition assessment evaluates the physical condition of the dry dock, reviews design documentation, and performs calculations to determine the capacity of the dry dock in its current condition.

Maintenance: Maintenance includes scheduled preventive maintenance tasks as well as maintenance to correct deficiencies that are

identified through a condition assessment, a preventive maintenance task, a control inspection, or during dock operations.

Control Inspection: The control inspection is a comprehensive but qualitative review of the dry dock facility to evaluate the effectiveness of the maintenance program in keeping the dry dock in a condition to support operating at the rated capacity as determined in the condition assessment. This is effectively an audit of the maintenance program.

Dock Operations: Dock operations encompass all tasks associated with the act of docking a vessel in a dry dock. This includes, but is not limited to, calculations to ensure the stability of the vessel and dock throughout the evolution; proper blocking to ensure proper loading of both the vessel and dock; and procedure requirements.

Sections of this manual are dedicated to each of these activities. The goal is to provide a cost-effective program that provides guidance to maintain and operate a dry dock in a safe manner.

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1

BACKGROUND

This section will provide basic information about the different types of dry docks. Knowledge of the types of dry docks and their design features is useful for understanding the structural and operational limitations of a dry dock. Additionally, an explanation of basic terms used in the following sections will be provided.

1.1 TYPES OF DRY DOCKS

1.1.1 Floating Dry Docks

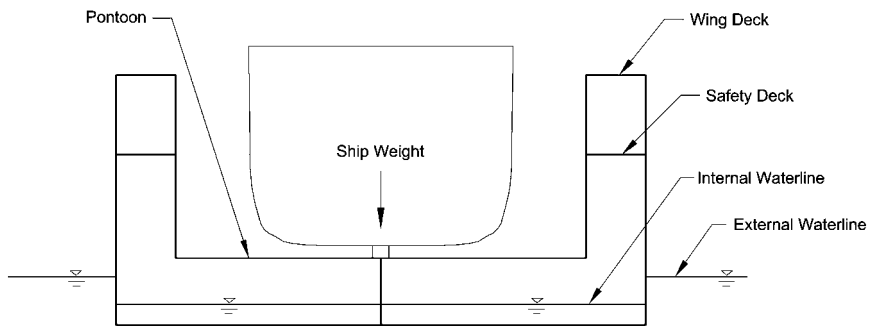
Floating dry docks, often referred to as “floaters,” are structures with sufficient size, strength, displacement, and stability to lift a vessel from the water using buoyancy. Figure 1-1 shows a floating dry dock. These docks can be operated with list and trim to reduce block loading and reduce or eliminate vessel stability problems when docking or undocking. Some shipyards are equipped to transfer vessels to shore from a floating dry dock, which enables concurrent work on multiple vessels. Floating dry docks are comprised of a pontoon and wing walls.

The pontoon is the main structural component (Fig. 1-2) that must be designed to distribute the concentrated blocking loads from the vessel to the dock and ultimately to the uniform buoyant force on the hull. The pontoon provides the transverse strength for the dock as well as contributing to the longitudinal strength. Additionally, the pontoon must have sufficient volume to provide the displacement to lift the vessel and dock out of the water using buoyancy.

The wing walls provide stability when the pontoon is submerged, and longitudinal strength to distribute the ship’s weight to the uniform



Figure 1-1. Floating dry dock. Source: U.S. Navy photo by Mass Communication Specialist Seaman Kelly E. Barnes.



FLOATING DRY DOCK COMPONENTS

Figure 1-2. Floating dry dock components.

buoyant support. Stability can be critical in floating docks with small wing walls or those that have walls that are not continuous over the full length of the dock.

Categories of floating dry docks are discussed in 1.1.1.1 through 1.1.1.3.

1.1.1.1 Pontoon Dock. Pontoon or “Rennie” type docks have continuous wing walls with sectional pontoons. Typically, the pontoon



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sections are designed to be self-docking. To do this, a section of the pontoon is disconnected from the wing walls, rotated 90 degrees to align its long dimension (normally transverse) to the longitudinal direction of the dock, and docked on the remaining sections of the pontoon. The discontinuous pontoon deck results in reduced longitudinal stiffness because the wing walls provide the only longitudinal strength.

1.1.1.2 Caisson Dock. A caisson dock, also referred to as a box or one-piece dock, is constructed with continuous wing walls and pontoon. Caisson docks are not self-docking and require being drydocked in a larger facility for maintenance or inspection. This type of dock can be lighter and stronger than other types of floating dry docks because the full lengths of both the pontoon and wing walls are effective for longitudinal strength.

1.1.1.3 Sectional Dock. Sectional docks are comprised of a series of sections, each containing a pontoon and wing walls. The sections are joined with locking logs, hinge pins, or moment connections. Locking logs loosely align the sections but cannot take much force. Hinge pins can provide shear strength but have no moment capacity. Sectional docks with moment connections at the top and bottom of the wing walls act like pontoon docks. It is very important that the pins or plates that comprise the moment connection be inspected and maintained. Sectional docks are usually self-docking.

1.1.2 Graving Docks

Graving docks, or basin dry docks as they are sometimes called, are a type of dry dock that is distinguished by the fact that the floor upon which the blocks bear is below the level of the adjacent water. Figure 1-3 is a graving dock being flooded for a docking evolution. The basic structure of a graving dock consists of a floor, sidewalls, headwall, and a gate (Fig. 1-4). Alters (stepwise changes in the wall thickness) may be incorporated into the walls for structural stability. Graving docks can be further subdivided into the following three categories that relate to the means used to resist the buoyant force on the dock resulting from the displacement of the water volume of the dock.

1.1.2.1 Full Hydrostatic Graving Dock. A full hydrostatic graving dock relies on its own weight or an anchorage system to resist the hydrostatic forces acting on the dock. Regardless of the surrounding geology (even “solid” rock), it must be presumed that the dock structure will be exposed to the full hydraulic pressure. Therefore, in a full hydrostatic dock the full buoyant force of the dry dock at the highest water table



Figure 1-3. Graving dock. Courtesy of General Dynamics Electric Boat, Groton, CT.

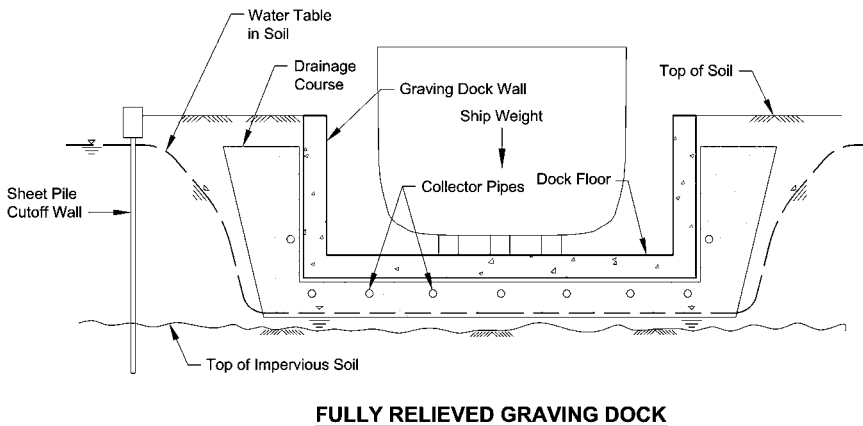


Figure 1-4. Graving dock components.

elevation must be resisted by either the weight of the structure, the combined weight of the structure and foundation material (rock, soil, etc.) engaged by hold-down devices such as anchors or piles, the weight of soil resting on the ledge formed by projections of the floor beyond the side walls, or friction created by the soil on the sidewalls.

1.1.2.2 Fully Relieved Graving Dock. A fully relieved graving dock does not have sufficient weight to resist the hydrostatic forces acting on the dock. This type of dock relies on a drainage system to remove the surrounding water behind the walls and beneath the slab to alleviate the hydrostatic pressure. This type of dock is less expensive to construct because it is lighter and does not require as much material; however, it does require the continual cost of operating and maintaining the drainage system throughout the life of the dock.

1.1.2.3 Partially Relieved Graving Dock. A partially relieved graving dock requires relief of the hydrostatic force under the floor slab only. The walls are designed for a full hydrostatic head of water. A sheet-pile cutoff wall is typically driven at the perimeter of the floor slab to reduce seepage under the slab. This type of dock also requires the continual cost of operating and maintaining the drainage system throughout the life of the dock.

1.1.2.4 Closure Gates. All graving docks have a closure gate that is removed from its seat to allow a vessel to enter or exit the dock and is put in place to dewater the dock. The two major types of gates are caisson gates and hinged gates, each with various implementations.

1.1.2.4.1 Caisson Gates. Caisson gates are structures that are either floated or rolled to be removed from the entrance to a graving dock. The floating caisson gate is probably the most widely used closure gate for graving docks. Floating caisson gates contain trim tanks to ballast the gate. Controlling the ballast water requires pumps, typically located on the machinery deck inside the gate.

1.1.2.4.2 Hinged Gates. Hinged gates have been implemented with either side or bottom hinges. This type of gate is fast operating. However, major repairs require removal of the gate, which is typically difficult and costly.

1.1.3 Marine Railway

A marine railway is a mechanical means of hoisting a ship out of the water along an inclined track (Fig. 1-5). This type of dry dock consists of a cradle that rides on inclined rails that extend from shore into the water. The cradle is moved by a hauling chain driven by a winch (Fig. 1-6). A marine railway is fast operating and has relatively low initial cost. However, the mechanical system requires periodic replacement of some moving parts such as the hauling chain and cradle rollers. Additionally, underwater maintenance of the tracks is required. The tracks are also



Figure 1-5. Marine railway. U.S. Coast Guard photo by PA2 Kyle Niemi.

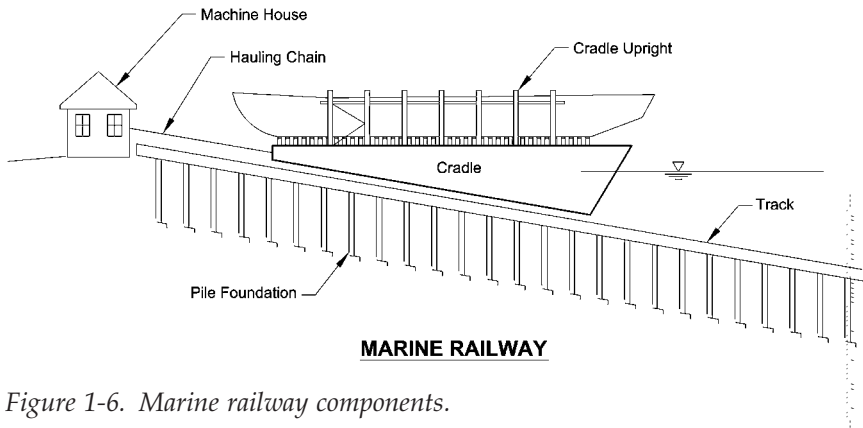


Figure 1-6. Marine railway components.

prone to damage, particularly in the tidal zone where debris can impact the tracks.

1.1.4 Vertical Lift

A vertical lift is a mechanical device for hoisting a ship out of the water vertically (Fig. 1-7). It consists of a platform, a series of synchronous hoists, and hoist support piers (Fig. 1-8). The platform is lowered into the water. The vessel is then floated over the platform and the synchronized

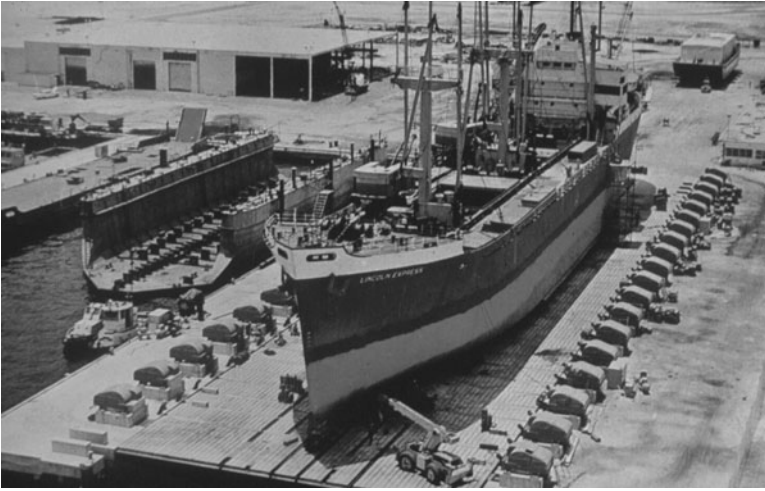


Figure 1-7. Vertical lift. Courtesy of Heger Dry Dock, Holliston, MA.

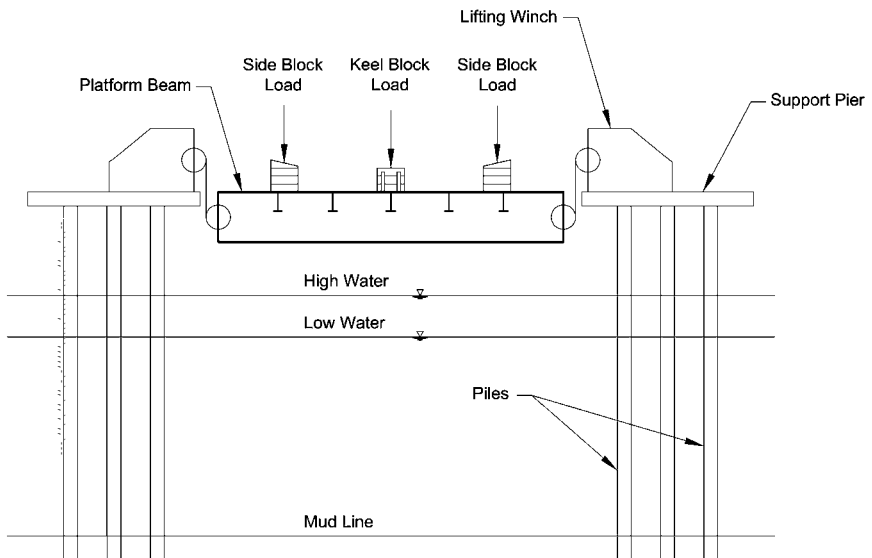


Figure 1-8. Vertical lift components.

hoists raise the platform and vessel out of the water. A vertical lift is a fast operating dry dock and can be equipped with a rail system to transfer vessels from the platform onto shore. However, the maintenance costs are relatively high.

1.2 TERMS USED IN THIS MANUAL

Altar	A stepwise change in the wall thickness of a graving dock. This allows a greater wall thickness at the base to resist overturning while reducing the volume of construction materials.
Anode	A sacrificial zinc or aluminum ingot attached to a hull or other steel element to help prevent corrosion of the steel.
Ballast	Liquid or solid mass loaded on a vessel, dry dock closure gate, or floating dry dock to improve stability and trim. Temporary ballast is usually water stored in dedicated tanks. Permanent ballast is usually solid lead castings or concrete.
Block Load	The force on a keel or side block due to gravity and seismic and wind forces acting on a vessel.
Bollard	A mooring bit, usually located alongside the top of a dry dock wall.
Breasthook	Horizontal plate brackets connecting opposite sides of hull plating at the ends of a caisson gate.
Bulkhead	(1) A vertical <i>structural</i> partition dividing a vessel's interior into various compartments for strength and safety purposes. (2) Term applied to vertical partition walls subdividing the interior of a vessel, closure gate, or floating dry dock into separate compartments.
Capstan	Steel warping drum that rotates on a vertical axis for the handling of mooring lines.
Cathodic Protection	A sacrificial or impressed current system of corrosion protection of hull, tanks, piping, or other steel members.
Center of Buoyancy	The centroid of the submerged volume of a vessel or dock.
Center of Gravity	The location at which an object's weight could be replaced by a concentrated force without changing its behavior.
Cradle	The movable structure of a marine railway that supports the vessel.

Deflection Monitoring System	Typically an optical (sight or laser) arrangement of targets measured from a reference point to determine the relative displacement along a dock.
Displacement	All-inclusive weight of a vessel or floating structure equal to the weight of the water displaced.
Dock Draft	The vertical distance from the lowest point on a dock, typically the keel, to the waterline.
Dock Master	Individual responsible for the operation of a dry dock.
Docking Evolution	The act of bringing a vessel into a dry dock from preparation through the final condition in which work will be performed.
Docking Reference Point	A point on the vessel being docked that aligns with a known point on the dock used to position the vessel on the blocks.
Docking Plan	Detailed structural plan and profile of the lower hull structure required for correct location of the vessel and blocking in a dry dock.
Draft	The vertical distance from the keel to the waterline.
Dry Dock	General term for a graving dock, floating dry dock, vertical lift, marine railway, and marine travelift used for the maintenance and repair of vessels.
Drydock	The action of bringing a vessel into a dry dock.
Dry Dock Translation System	A mechanism used to change the location of a floating dry dock.
Fair-Lead	A fitting through which a line may be passed so as to preserve or change its direction without inducing excessive friction.
Fairwater	An external shroud projecting the hull of a vessel in way of an underwater intake or sea chest. The fairwater has an open face on the downstream edge. The purpose is to reduce turbulent intake.
Fendering Timber	An intermediate member that is used to transfer load between a vessel and dock or pier to prevent damage to the vessel or structure. The material is typically wood, plastic, or rubber.

Freeboard	The elevation above the waterline of a floating dry dock's pontoon deck.
GM (measure of stability)	The vertical distance from a vessel's center of gravity (G) to its metacenter (M).
Hauling Side Blocks	Supports used to prevent the overturning of a vessel in dry dock. They can be positioned against the hull during the docking evolution.
Hydrographic Survey	An assessment of a water-covered area to determine the depth of water relative to a reference plane (i.e., mean low water).
Hydrostatic Curves	Also referred to as <i>curves of form</i> or <i>displacement and other curves</i> (D&O curves). A graphical description of properties of the vessel's form, which are plotted against the draft of the vessel. Properties that are always included in the hydrostatic curves are displacement, longitudinal center of buoyancy (LCB), height of transverse metacenter above keel (KM), tons per inch immersion (TPI), longitudinal center of flotation (LCF), and moment to trim one inch (MT1").
Hydrostatic Forces	Forces acting on a stationary body by a fluid.
Hydrostatic Head	A pressure caused by the height of fluid above the point of interest.
KB	The vertical distance from the keel of a ship (K) to the center of buoyancy (B).
Keel	The principal bottom structural element of a ship extending along the centerline for the full length of the vessel.
Keel Block(s)	Movable structural supports that are aligned under the hull structure of a vessel to be dry-docked and above the dock structure to transfer the deadweight of a vessel to the dock structure.
KM	The vertical distance from the keel of a ship (K) to its metacenter (M). The metacenter is considered to be fixed for small angles of heel.
Knuckle Block	The first keel block upon which the ship bears.
Knuckle Reaction	As the vessel first contacts the blocks, usually the aft-most block, a force develops at the knuckle block which rotates the ship until it makes contact with all the keel blocks. This

Light Dock Condition	can be eliminated on a floating dry dock by trimming the dock to match the vessel.
Light Weight	The normal, unloaded state of a floating dry dock with all operating equipment on board and the water level in all tanks as low as the dewatering pumps can obtain.
List	The weight of the complete ship including hull, machinery, outfit, equipment, and liquids in machinery, but not including any variable or movable weights such as ballast water, cargo, fuel, or stores.
Longitudinal Center of Buoyancy (LCB)	A measure of the deviation from vertical of a ship's vertical axis in the athwartship direction. Measured as a difference in the port and starboard draft readings.
Longitudinal Center of Flotation (LCF)	The longitudinal center of the displaced volume referenced to either the forward reference point or amidships.
Longitudinal Strength	The longitudinal centroid of the waterplane, referenced to either the forward reference point or amidships. It is the point about which the vessel trims as a constant weight is shifted longitudinally aboard the vessel.
Megger Test	The capacity of a structure to resist global shear and bending due to uneven distribution of loads, such as buoyancy and weights, along its length.
Metacenter	An electrical test performed using a megohmmeter that verifies the integrity of the insulation on an electrical cable or motor windings.
Metacentric Height (GM)	The point through which a vertical line from a ship's center of buoyancy as the ship rolls intersects the original vertical centerline of the ship.
Moment Capacity	Vertical distance between the center of gravity of a ship (G) and its metacenter (M). A positive value (M higher than G) is required in order for a vessel to have upright stability.
Moment Connections	The maximum moment that a structural member can transfer.
	An attachment between two structural members that is capable of transferring a moment.

Moment to Trim 1 Inch (MT1")	A hydrostatic property of the vessel indicating the necessary differential variation of weight acting at a distance required to influence the trim of the vessel by 1 in.
Mooring Dolphin	A structure used to secure a vessel on location. This typically comprises a series of driven piles.
Naval Architect	Company or individual qualified in the design, construction, and repair of marine vessels.
Overturning Moment	The result of a load located or perturbed away from the center of gravity (G) that tends to increase the list of a vessel.
Planner	Representative of the shipyard who coordinates the work to be performed in the dry dock.
Righting Moment	A vessel's ability to right itself, resulting from an offset in location of the center of buoyancy (B) and center of gravity (G).
Safety Deck	An intermediate watertight deck within the wing wall of a floating dry dock, forming the upper boundary of the ballast tanks. In a properly designed dock, the elevation of the safety deck ensures sufficient buoyancy to keep the dock afloat when all ballast tanks are flooded. Graving dock caisson gates are also designed with safety decks.
Sea Chest	An enclosure, attached to the inside of the underwater shell and open to the sea, fitted with a strainer plate. A sea valve and piping connected to the sea chest passes seawater into the vessel for ballasting, cooling, or fire-fighting purposes.
Ship Owner	Company or designated representative that is responsible for the vessel.
Shipyard	Company or designated representative that is performing the drydocking.
Shore/Shoring	A structural member, such as a strut, used to brace a vessel in the transverse direction in a dock.
Stoplog	A dam consisting of a piece or pieces in slots in the sides of a waterway to shut off flow (usually for temporary use).

Tank Level Indicator (TLI)	A means of measuring the water level within a tank.
Tons Per Inch Immersion (TPI)	A hydrostatic property of the vessel indicating the differential change in displacement for every inch the vessel is submerged.
Transfer	The physical act of moving a vessel from landside to a dry dock or vice versa.
Translate	The physical act of moving a floating dry dock from one position to a second position. For example, moving the floating dry dock from its moored position to a vessel transfer position at a bulkhead.
Transverse Bending Strength	The capacity of a structure to resist a transverse bending moment.
Transverse Center of Gravity (TCG)	The athwartship (port or starboard) location of the center of gravity measured from the longitudinal center line of a vessel.
Transverse Inertia	The moment of inertia of a structural member that would be effective for a transverse bending moment.
Transverse Strength	The capacity of a structure to resist loads that are unevenly distributed across its width, such as block loads or the concentrated weight of a floating dry dock's wing walls.
Trashrack	A grille, usually of vertical metal bars, used to screen out debris from the entrance to the dry dock flood ports or pump well.
Trim	The difference in the forward and aft draft of a ship.
Trim and Stability Booklet (T&S book)	A handbook placed aboard a vessel for use by the vessel operators to assist in calculating the stability of the vessel. The document consists of tables and drawings indicating the essential characteristics of all spaces aboard a vessel where loads may be placed.
Ultrasonic Thickness (UT)	A technique used to measure the thickness of a steel member using sound waves.
Vertical Center of Gravity (VCG or KG)	The vertical location of the center of gravity (G) measured as a distance above the keel (K).
Weather Deck	Uppermost hull, closure gate, or floating dry dock deck exposed to the weather at all times.
Weep Hole	Opening provided in a wall or bulkhead to facilitate drainage of water. It usually serves

	to reduce hydrostatic pressure behind the structure.
Winch	An engine fitted with a rotating drum for hauling ropes, cables, or chains. Some are fitted with multiple drums, a gypsy head for hauling ropes, or a wildcat for hauling chains.
Wing Tank	Ballast tank adjacent to the hull side.

1.3 OVERALL PHILOSOPHY

The effective management of a dry dock facility requires a broad view of the four activities discussed in this manual: condition assessment, maintenance, control inspection, and dock operations. The condition assessment determines the safe capacity of the dry dock. The other three activities are intended to ensure the dry dock remains in a condition to maintain the ability to safely operate at the rated capacity. Information obtained from preventive maintenance tasks, control inspections, failures, and dock operations must be analyzed to determine the root cause of component failures that occur, or deficiencies noted during inspections and potential impacts on the rated capacity. The impact on the condition assessment must be considered with respect to deficiencies observed from any of these sources. Figure 1-9 shows the process of evaluating deficiencies to determine their effects on the facility condition.

Initially, the dry dock owner performs a condition assessment of its dry dock facility to determine asset condition and operational criticality. During this stage, the structural and operations capacities are defined and documented for the dry dock asset. Ideally, condition assessments are performed at initial asset installation or when a significant configuration change occurs. Throughout the asset's life cycle, if the asset is properly maintained and documentation is routinely kept up to date, the rated capacity of the facility should be maintained.

Control inspections are performed on a periodic basis to verify asset performance to requirements set forth during the condition assessment. The dry dock is visually inspected and operationally tested with the results documented. All deficiencies are entered into the maintenance management system for subsequent planning and scheduling of repairs.

Maintenance includes routine, reactive, and preventive maintenance (PM). Routine and preventive maintenance are typically planned and scheduled in advance of the work. Reactive maintenance occurs due to mechanical equipment or structural failure. Reactive repairs are unplanned and the failures can cause unsafe as well as costly conditions. It is imperative to perform causal analysis of all failures in critical systems to deter-

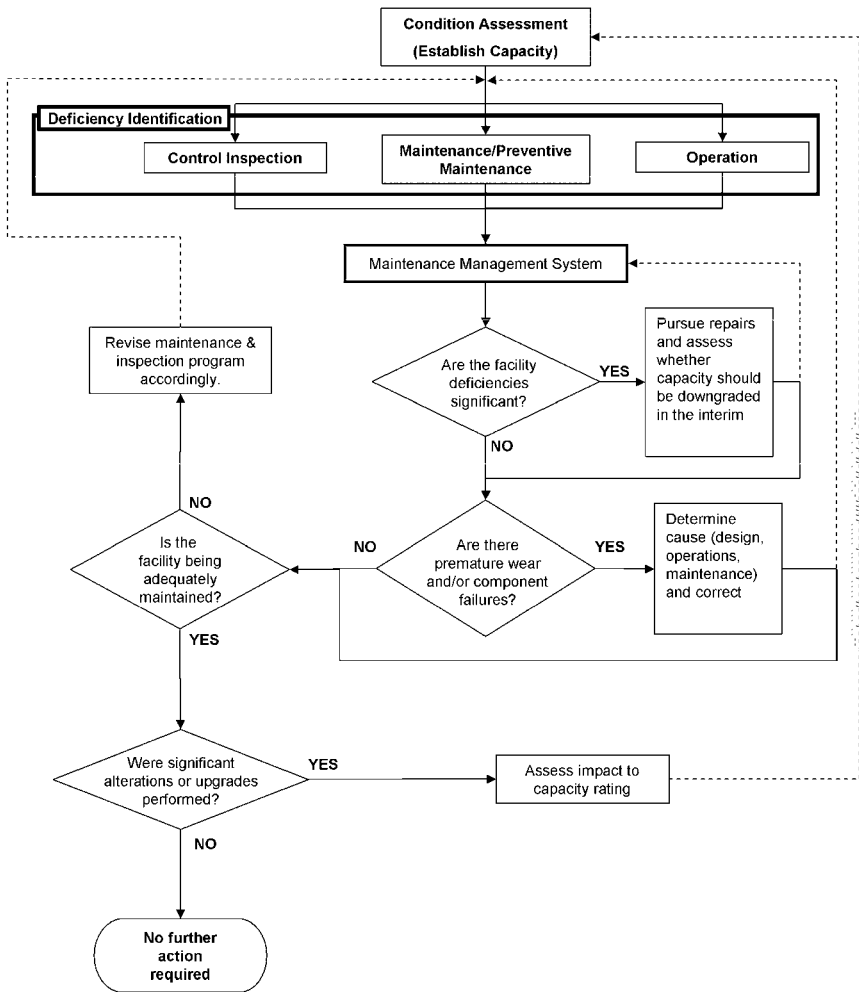


Figure 1-9. Interaction between dry dock management activities.

mine the root cause of the problem so the appropriate corrective actions can be initiated.

Operations personnel are responsible for operating the dry dock equipment within the specified capacities defined during condition assessment. Dry dock operators also provide the first line of defense against unplanned breakdowns because they are most familiar with the asset and are in the ideal position to report early detection of unusual conditions or circumstances.

Regardless of the functional area, all individuals have a responsibility to promptly report and document all deficiencies in the maintenance management system. Historical records should be periodically analyzed to identify systemic problems that may require a change in asset design, configuration, operation, or maintenance program. If a change of design or configuration occurs, a condition assessment is performed to determine its new capacities.

2

DRY DOCK CONDITION ASSESSMENT

2.1 GENERAL

2.1.1 Purpose

The purpose of the dry dock condition assessment is to establish a baseline condition of the structural, mechanical, and electrical components and determine safe operational limitations for the facility. The baseline condition of the facility will be used to develop control inspection procedures and a maintenance schedule. The established operational limitations will be used by the dock operator to ensure the dry dock's operational capabilities are not exceeded.

2.2 ASSESSMENT PROCEDURES

2.2.1 Condition Assessment Process

The condition assessment of a dry dock requires the design review team to gather all pertinent design data on the facility and conduct a material condition survey to establish the present condition of the facility. These data are used in the analysis of the facility.

2.2.2 Design Data: Document Review

Documents governing or prepared for the original design and construction, rehabilitation, alteration, or repair of the facility shall be reviewed if available.

The design data required will vary depending on the type of facility being reviewed. In general, the design data will include:

- (A) General arrangement of facility
- (B) Structural drawings and specifications
- (C) Mechanical drawings and specifications
- (D) Electrical drawings and specifications
- (E) System descriptions
- (F) Operating manual/procedures
- (G) Hydrographic data
- (H) Geotechnical information
- (I) Design calculations
- (J) Design ship data

Refer to the individual sections on each type of dry dock for more detailed design data requirements.

2.2.3 Material Condition Survey

A material condition survey is required to establish the existing condition of the facility. The survey must be detailed enough to ascertain the actual condition of all critical components of the facility and verify that the design data are correct.

The material condition survey will vary depending on the type of facility being reviewed. In general, the survey will include:

- (A) Visual survey of all structural components
- (B) Ultrasonic thickness (UT) or other measurements to establish the extent of corrosion/deterioration
- (C) Witness operational test of all critical mechanical and electrical components
- (D) Witness operational test of all control systems
- (E) Witness of the dock in operation
- (F) Underwater inspections
- (G) Maintenance records

Refer to the individual sections on each type of dry dock for more detailed survey requirements.

2.2.4 Design Review

The design review consists of calculations to substantiate the operational limitations. The design review is conducted using the “as-is” condition of the facility.

2.2.5 Summary of Findings, Evaluation, and Recommendations

Results of the design review shall be summarized in a written report. The report shall include:

- (A) Scope of Investigation
- (B) Description of Structure
- (C) Dates of Construction, Modifications, and Repairs
- (D) History
- (E) Design Data
- (F) Material Condition Survey Report
- (G) Design Review Summary
- (H) Recommended Future Surveys
- (I) Safe Rated Capacity

2.3 CONDITION ASSESSMENT OF FLOATING DRY DOCKS

2.3.1 Qualifications and Equipment

2.3.1.1 Personnel Qualifications. All personnel involved in the assessment shall possess the technical qualifications, including practical experience, education, and professional judgment, required to perform the individual tasks assigned. Interpretation of results and conclusions shall be performed by a professional engineer or naval architect experienced in the design and inspection of floating dry docks.

2.3.1.2 Equipment. Equipment shall be obtained as appropriate to accomplish or perform the various tests and inspections specified in this manual of practice. All equipment shall be in good working order. For equipment that can be calibrated, calibration shall be current and reports of calibration shall be available for owner review.

2.3.2 Design Data: Document Review

Documents governing or prepared for the original design and construction, rehabilitation, alteration, or repair of the facility shall be reviewed if available.

The design data required will vary depending on the type of floating dock being reviewed. In general, the design data will include:

- (A) General arrangement of the floating dock
- (B) Structural drawings and specifications
- (C) Mechanical drawings and specifications
- (D) Electrical drawings and specifications

- (E) System descriptions
- (F) Operating manual/procedures
- (G) Computer-controlled ballast system (where applicable)
- (H) Deflection monitoring system (where applicable)
- (I) Floating dry dock translation system (where applicable)
- (J) Hydrographic data
- (K) Stability data
- (L) Mooring design
- (M) Environmental data
- (N) Design calculations
- (O) Design ship data

2.3.3 Material Condition Survey

A material condition survey is required to establish the existing condition of the facility. The survey must be detailed enough to ascertain the actual condition of all critical components of the facility and verify that the design data are valid.

In general, the survey will include:

- (A) Visual survey of all internal ballast tanks and all sea chests
- (B) Visual survey of machinery spaces, safety deck area
- (C) Visual survey of wing deck areas
- (D) Visual survey of external portions of the dock
- (E) Visual survey of blocking
- (F) Visual survey of mooring system
- (G) Witness operational test of all critical mechanical and electrical components
- (H) Witness operational test of all control systems
- (I) Underwater inspection of hull
- (J) Underwater survey of mooring dolphin/pier pilings
- (K) Freeboard readings
- (L) Witness of the dock in operation
- (M) UT or other measurements to establish the extent of corrosion/deterioration
- (N) Hydrographic survey

The condition of the structural steel, concrete, and/or timber shall be assessed in accordance with ASCE/SEI 11-99, *Condition assessment of existing buildings* (2000).

2.3.3.1 Visual Survey of All Internal Ballast Tanks. During the initial condition assessment survey, 100% of all ballast tanks should be visually inspected. The material condition of structural elements can vary

greatly from ballast tank to ballast tank or even within a single ballast tank due to varying environmental conditions or past renovation projects that repaired some areas but not others. Therefore, it is imperative to visually inspect all members in every ballast tank. Special actions necessary to remove mud, silt, or debris in the ballast tanks should be performed prior to visual inspection.

All structural members should be inspected for condition of protective coating, extent of corrosion, buckling, cracking, or other signs of distress.

The bottom plate and plate stiffeners should be inspected for signs of dock grounding (pushed-up plate, buckled stiffeners and/or frames).

Each sea chest shall be inspected for condition of protective coating, extent of corrosion, buckling, cracking, or other signs of distress.

The side shell plate and plate stiffeners should be inspected for signs of external impact damage (pushed-in plate, buckled stiffeners and/or frames).

Note size and location of all leaks (external, between tanks, through valves, packing glands, etc.).

Note size, location, and probable cause of all holes and/or cracks (impact, corrosion, stress).

Where corrosion has caused a loss of metal thickness or where as-built member thicknesses are in question, ultrasonic thickness (UT) measurements may be necessary to confirm actual member thicknesses. See 2.3.3.13 for more information on UT measurements.

2.3.3.2 Visual Survey of Machinery Spaces, Safety Deck Area. During the initial condition assessment survey, 100% of all machinery spaces and safety deck areas should be visually inspected.

All structural members should be inspected for condition of protective coating, extent of corrosion, buckling, cracking, or other signs of distress.

The side shell plate and plate stiffeners should be inspected for signs of external impact damage (pushed-in plate, buckled stiffeners and /or frames).

Note size, location, and probable cause of all holes and/or cracks (impact, corrosion, stress).

Where corrosion has caused a loss of metal thickness or where as-built member thicknesses are in question, UT measurements may be necessary to confirm actual member thicknesses. See 2.3.3.13 for more information on UT measurements.

The safety deck should be inspected when the dock is fully submerged. At this time, the air in the ballast tank below the safety deck is pressurized. Any leaks in the safety deck plate or packing glands will be evident by hissing air or leaking water.

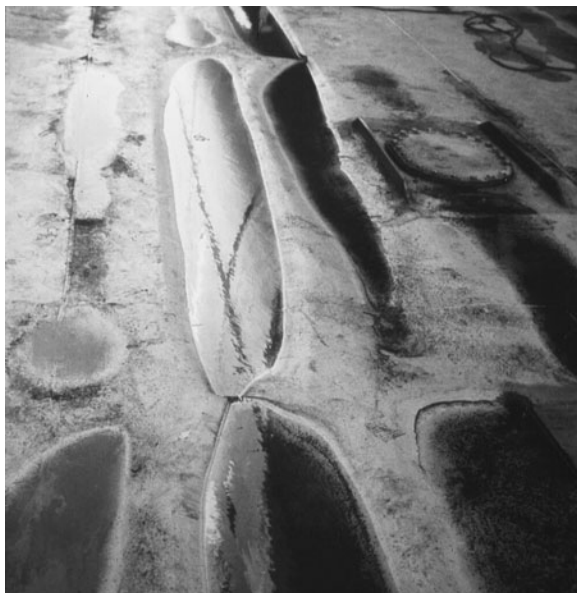


Figure 2-1. Washboarding of pontoon deck. Courtesy of Heger Dry Dock, Holliston, MA.

2.3.3.3 Visual Survey of External Portions of Dock. All abovewater external areas of the dry dock should be visually inspected. These areas include the pontoon deck, wing deck, wing side shells, pontoon side shell, end bulkheads, aprons, fenders, stairs, ladders, handrails, and so forth.

2.3.3.3.1 Local Issues. The pontoon deck is usually one of the first areas to show deterioration. Heavy corrosion is not always evident, however, since rust scale is being continuously worn away by high traffic, heavy wear, and so forth. Check for severe “washboarding” of the deck (dishing of the deck plate between stiffeners; Fig. 2-1). This can significantly diminish the transverse bending strength of the pontoon.

2.3.3.3.2 Global Issues. The wing deck is the top structural flange of the dock which provides its longitudinal strength. This is an extremely important structural member and should not have any cracks, buckles, holes, or severe deterioration.

Check the deck for any large buckles that progress across the entire width of the deck (and usually down the wing sides). Check for cracks in plate. Buckling or cracking in the upper portions of the wing wall may be an indication of longitudinal overstress.

The longitudinal strength of the dry dock is severely impaired by buckling or cracking in the upper or lower regions of the wing. If buckling or cracking is found in this portion of the wing, the dry dock should not be used until the situation can be investigated more thoroughly and repairs made, if necessary.

2.3.3.3.3 Miscellaneous Items. Check the condition of foundation plating around all cleats, bollards, winches, capstans, and so forth. Where the item is fastened to the deck is generally a high corrosion area.

Check the condition of fendering timber and attachments to wings. The wood tends to rot and steel tends to corrode where the wood and steel meet.

Check crane rails and fastenings, if any.

2.3.3.4 Visual Survey of Blocks. The condition of the blocking system shall be visually assessed.

Check the timber for excessive crushing, warping, cracking, checking, rot, or wear from fasteners. Check for loss of contact at edges. In general, minor cracking is acceptable unless bearing area has been lost.

If the blocks have concrete bases, check the concrete for cracking, spalling, and exposed rebar.

If the blocks have steel bases, check the steel for loss of metal thickness by corrosion, cracks, cracked welds, and so forth.

Check the condition of fastenings. All timber shall be adequately secured to prevent floating when the dock is submerged.

If the dock is equipped with hauling side blocks, the hauling block hardware shall be inspected. The hauling block hardware includes chains, sheaves, cranks, slides, and pawls.

2.3.3.5 Visual Survey of Mooring System. The dry dock's mooring system shall be inspected for signs of corrosion and wear.

2.3.3.6 Operational Tests. An operational test of all the dry dock's mechanical and electrical components shall be conducted by the shipyard and witnessed by the surveyor. The operational test shall include witnessing the following:

- (A) Dewatering pumps: check for proper control from control panel, abnormal vibration
- (B) Ballast system valves: check for proper control from control panel, valve position indicator gages or lights working properly
- (C) Tank level indicator gages
- (D) Draft level indicator gages and draft boards
- (E) Primary power source (shore-supplied or onboard generators)

- (F) Emergency backup power: demonstrate the maximum number of ballast pumps that are capable of being operated on the backup power system. The backup power system shall be capable of running the dock controls system, alarms, emergency lighting, and a sufficient number of dewatering pumps to maintain safe operation (minimum of two pumps), albeit at a slower rate, simultaneously.
- (G) Capstans
- (H) Winches
- (I) Vessel centering system (if so equipped)
- (J) Longitudinal deflection monitoring system (requirement for docks 300 feet and longer)
- (K) Alarms
- (L) Lighting
- (M) Emergency lighting
- (N) Fire-fighting system

2.3.3.7 Submergence Test. A submergence test shall be conducted by the shipyard and witnessed by the surveyor. The dock shall be ballasted down to maximum submergence and the dock drafts recorded. In docks designed with a safety deck, the submergence should cease at the maximum design draft with the flood valves open. If the dry dock cannot achieve its design draft, the reason shall be noted (e.g., insufficient water depth at site, incorrect vent tube lengths). The surveyor shall inspect the safety deck areas for leaks when the dock is at maximum submergence.

After a minimum of 30 minutes, the dock drafts should be recorded again just prior to deballasting the dock. Any change in drafts, indicating leakage, shall be noted by the surveyor. If leaks are detected, further testing may be required to isolate the source of the leaks.

The dock shall be deballasted using all the main dewatering pumps. Time to ballast and deballast the dock shall be recorded, with starting and stopping dock drafts noted.

2.3.3.8 Verification of Instrument Calibration. If, during the operational test, the water level indicator gages, ammeter gages, valve position indicators, or other instrumentation do not reflect the actual condition, the errant gages should be recalibrated and checked by comparing the physical measurement to the reading on the gage.

The surveyor shall verify the accuracy of the deflection monitoring system by determining the dock's actual deflection with an independent measuring system and comparing the results with the dry dock's system.

2.3.3.9 Underwater Surveys. An underwater hull survey shall be conducted every 5 years. The surveyor shall inspect for buckled plate, corrosion, condition of sea chest gratings, and marine growth.

Where corrosion has caused a loss of metal thickness or where as-built member thicknesses are in question, UT measurements may be necessary to confirm actual member thicknesses. See 2.3.3.13 for more information on UT measurements.

2.3.3.10 Freeboard Readings. The buoyant capacity of the dock can change over time. The accumulation of mud, sandblast grit, or other items, or the lack of ability of the pumping system to dewater the tanks as low as originally designed, can reduce the buoyant lift capacity. Therefore, the buoyant capacity shall be checked at least once every 3 years.

The buoyancy available to lift the vessel is represented by the volume of the dock's pontoon above the waterline with the dock at its minimum draft. To determine the dock's buoyant capacity, pontoon deck freeboard readings must be taken after the dock has been pumped to its minimum draft (maximum freeboard).

Freeboard is the measurement from the lowest point on the pontoon deck (usually at the inside corner of the wing) to the waterline. The freeboard measurement is used to calculate buoyant capacity of the dock as described in 2.3.4.1.

With no ship on the dock, the dock shall be dewatered by the shipyard using the main deballasting system only. Portable stripping pumps should not be used because they are not permanent dock equipment. With the dock deballasted, the surveyor should take freeboard measurements at each corner of the pontoon and, if possible, at amidships, port, and starboard.

2.3.3.11 Witness of Dock in Operation. The surveyor shall witness one complete cycling of the dock from operating freeboard, to maximum submergence depth, and back to operating freeboard.

2.3.3.12 Light Dock Weight Determination. If the original design documents do not have sufficient information on the light dock condition, a deadweight survey must be conducted. NAVSEA S9086-C6-STM-010/CH096 provides procedures for performing a deadweight survey.

2.3.3.13 Thickness Measurements. Use UT measurements and/or calipers to physically measure steel thickness in areas of high corrosion.

The number and frequency of readings will vary as to the condition of the dock. Steel that still retains all of its protective coating, or steel with many holes through it, may require no readings because the condition

is obvious. Steel that is questionable will require readings to establish remaining thickness. Steel that is due for repair may require many readings to establish the zones for replacement.

If UT measurements are required, a grid pattern shall be established and readings taken at those intervals. Examples are taking a reading every 10 feet longitudinally and 5 feet transversely on plate, or three readings on the web and flange of each vertical stiffener (one each in the upper, middle, and lower zones). The engineer or naval architect in charge of the condition assessment shall establish the frequency and locations of measurements.

2.3.3.14 Hydrographic Survey. A hydrographic survey shall be conducted to establish available water depths at the submergence berth and approach channel. The survey datum shall be clearly labeled with its reference elevation (mean low water, mean high water, etc.). The survey shall be conducted every 5 years unless local site conditions justify a longer or shorter frequency. A severe storm may warrant an updated hydrographic survey.

2.3.3.15 Checklists. See Appendix A for sample checklists that shall be used for summarizing the dock's condition. These checklists should be modified to reflect the actual components of the dock being surveyed. Each item shall be rated according to the following:

- (A) Satisfactory (S): The condition of the item will not result in system damage and, based on measured or estimated deterioration rate, it may be expected to remain satisfactory until the next control inspection.
- (B) Marginal (M): The condition of the item will not result in major damage or, by itself, it will not make the facility unsafe to dock a ship, provided it is corrected, repaired, or replaced in a timely manner. A number of such items as a group can make the facility unsafe. This shall be evaluated by the surveyor.
- (C) Unsatisfactory (U): The condition of the item may cause system damage or loss and shall be corrected, repaired, or replaced immediately (if there is a ship in dock) or prior to docking a ship (if there is no ship in dock).
- (D) Not Applicable (NA): The item listed in the checklist is not present on the dry dock. Note that as items are added, removed, or replaced from the dry dock, the inspection checklist shall be updated to reflect the configuration changes.
- (E) Not Inspected (NI): The item was not inspected as part of the survey. It is not acceptable to mark an item NI unless there is a basis for expecting the item to be in a satisfactory condition.

2.3.3.16 Summary of Results. The surveyor shall prepare a written report summarizing the findings of the survey. The report shall include:

- (A) Experience and qualifications of the surveyors
- (B) Dates and major milestones of the survey
- (C) Scope of the survey
- (D) List of items not inspected and reasons why
- (E) Condition report
- (F) Checklists
- (G) Corrective action plan for making any necessary repairs to the facility

2.3.4 Design Review

The purpose of the design review is to establish the operational limitations of the dock in its present condition. If the design calculations and operational limitations from the original designer exist and, in the opinion of the surveyor, the dock has not significantly deteriorated to the point that these operational limitations should be revised, then a new design review need not be performed and the original operational limitations may be used.

If, however, documentation for the original operational limitations does not exist, or the dock's structure or equipment have deteriorated to the point where the original operational limitations are questionable, or the dock has been modified in any way, or the dry dock's operating location has been changed, then a new design review will be required.

The design review consists of calculations to substantiate the operational limitations. The design review is conducted using the "as-is" condition of the facility as determined by the material condition survey described in 2.3.3.

For a floating dry dock, the design review will include:

- (A) Calculation of buoyant capacity
- (B) Transverse bending calculations
- (C) Longitudinal bending calculations and deflection limits
- (D) Local strength analyses
- (E) Block loading calculations
- (F) Hydrostatic properties of the dock
- (G) Light dock weight determination
- (H) Stability data (KG versus weight curve)
- (I) Mooring analyses
- (J) Ballast system
- (K) Control systems
- (L) Ship handling system

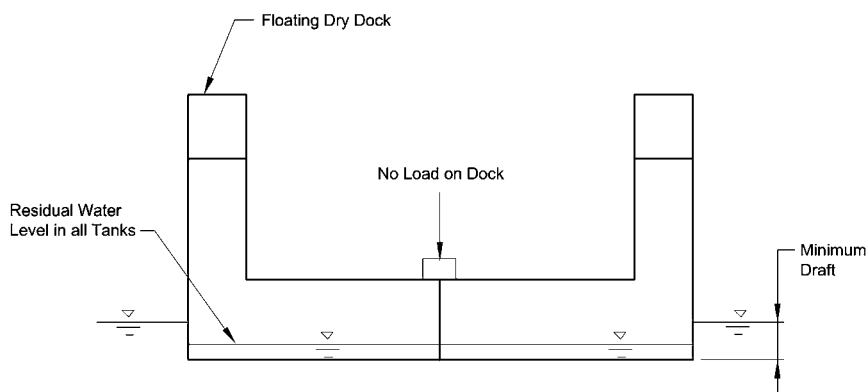


Figure 2-2. Minimum dock draft.

- (M) Electrical power system
- (N) Fire protection system
- (O) Corrosion criteria
- (P) Calculation of maximum sill load (for vessel transfer systems)

2.3.4.1 Calculation of Buoyant Capacity. The buoyant capacity of the dry dock is calculated by subtracting the dock's displacement at minimum draft from the dock's displacement at the operating draft.

The minimum draft is measured after pumping as much ballast water as possible out of the ballast tanks, using the main ballast pumps. Portable stripping pumps should not be used to remove the residual ballast water that cannot be removed by the dock's main ballast system (Fig. 2-2).

The operating draft is calculated by subtracting the operating freeboard from the pontoon depth at the location of the freeboard measurement (Fig. 2-3). The operating freeboard shall be a minimum of 12 inches.

2.3.4.2 Transverse Bending Calculations. The transverse strength of the dry dock is provided by the transverse bulkheads (watertight and nonwatertight) and/or transverse trusses in the pontoon.

The pontoon structure must distribute the concentrated load of the ship along the dock's centerline to the buoyant support of the water over its entire width by its transverse strength.

At least four separate loading conditions should be investigated when analyzing transverse strength:

- (A) Maximum positive bending
- (B) Transverse bending at operating draft

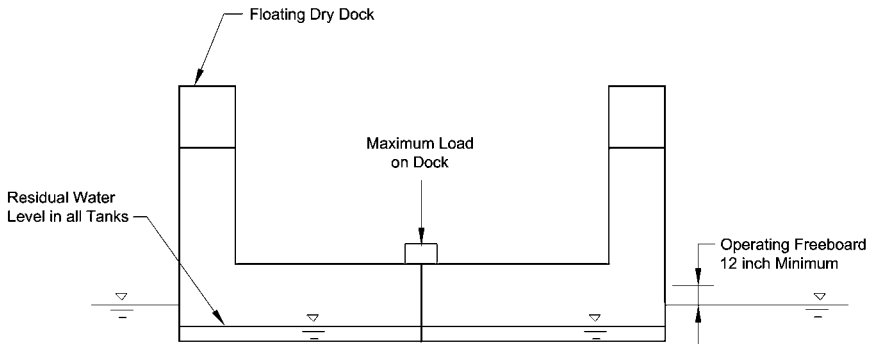


Figure 2-3. Dock operating draft.

- (C) Partial load, maximum head condition
- (D) Reverse bending

The transverse bending stresses must be combined with stresses caused by local conditions such as hydrostatic pressure on the hull, where applicable.

If the section modulus of the transverse frame varies across the width of the dry dock, the maximum transverse bending stress shall be calculated for each different cross section.

When determining allowable stresses, the buckling strength of the pontoon deck, bottom plate, and other members in compression shall be determined for each different panel size, plate thickness, or member size. The “as-is” condition of the member shall be used.

2.3.4.2.1 Transverse Bending with Water at Top of Keel Blocks. During the docking evolution, the dry dock/ship system passes through a condition at which the water level outside the dry dock is at the top of the keel blocks. This condition produces the maximum transverse bending in the floating dry dock. Therefore, the bending moment at the point when the exterior water is at the top of the keel blocks shall be calculated. At this time, 100% of the vessel weight is on the dock while the pontoon and the submerged section of the wing provide buoyant lift.

The submerged section of the wing provides additional buoyancy farther away from the dock centerline, which increases the bending moment. For this case, 100% of the rated load per foot is assumed to act on the keel blocks at the transverse centerline (Fig. 2-4).

2.3.4.2.2 Transverse Bending at Operating Draft. Transverse bending stresses when the dry dock is at its operating draft shall be calculated. In

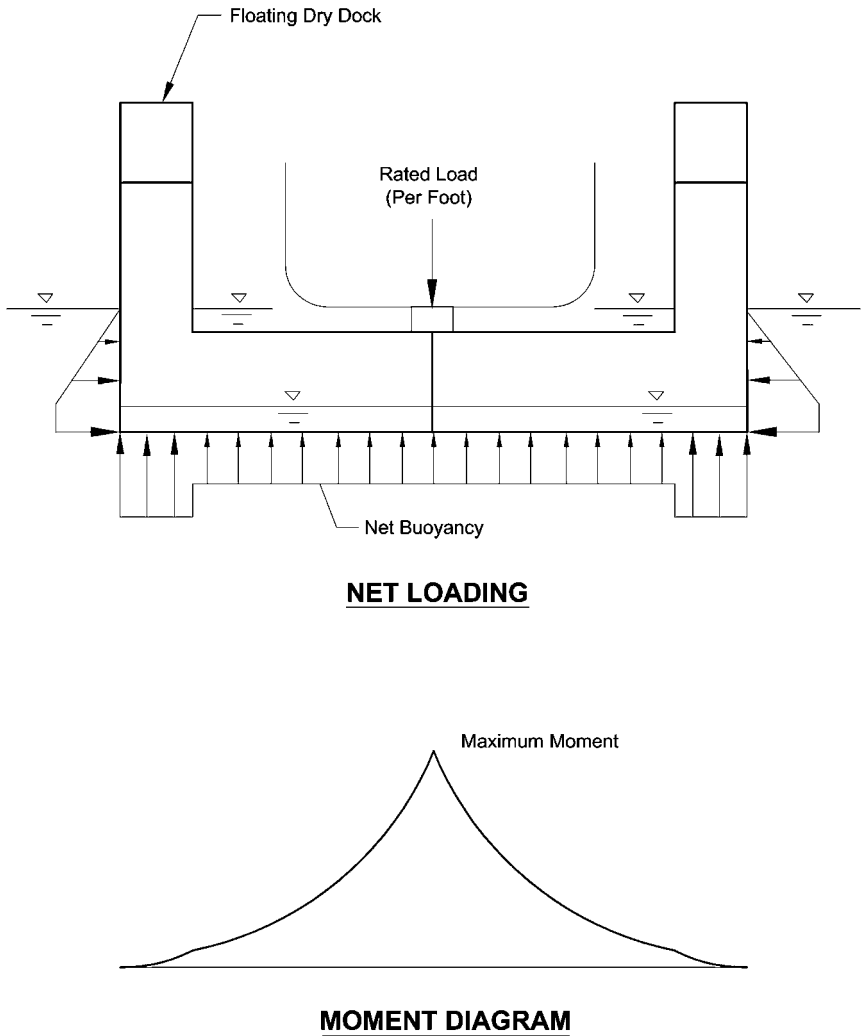


Figure 2-4. Maximum transverse bending condition.

cases where the rated load per foot exceeds the buoyant capacity of the dock at the operating draft, the additional uplift is achieved through shear in the wing walls and longitudinal bulkheads. This increases the transverse bending moment (Fig. 2-5).

2.3.4.2.3 Partial Load, Maximum Head Condition. The partial load, maximum head condition is the point at which the maximum hydrostatic head occurs on the shell of the dry dock.

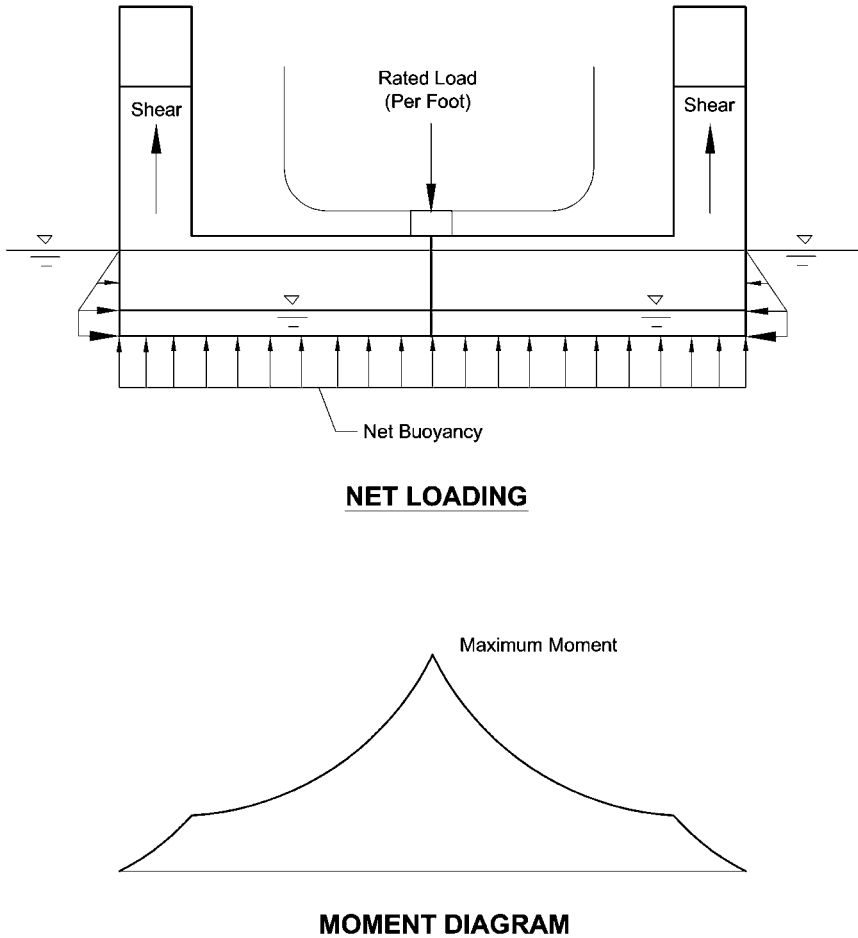


Figure 2-5. Transverse bending at operating draft.

Although the load at the centerline is only a portion of the total vessel load and the bending moment is not as great as in the first case, the bending stresses, when combined with the local stresses caused by hydrostatic head pressure, may control.

The partial load, maximum head condition occurs when the internal water level has reached the base of the wings (Fig. 2-6).

The magnitude of the hydrostatic head, which develops at this point, is a function of the vessel's draft and beam. The deeper the draft and wider the beam of the vessel being docked, the higher the maximum hydrostatic head will be.

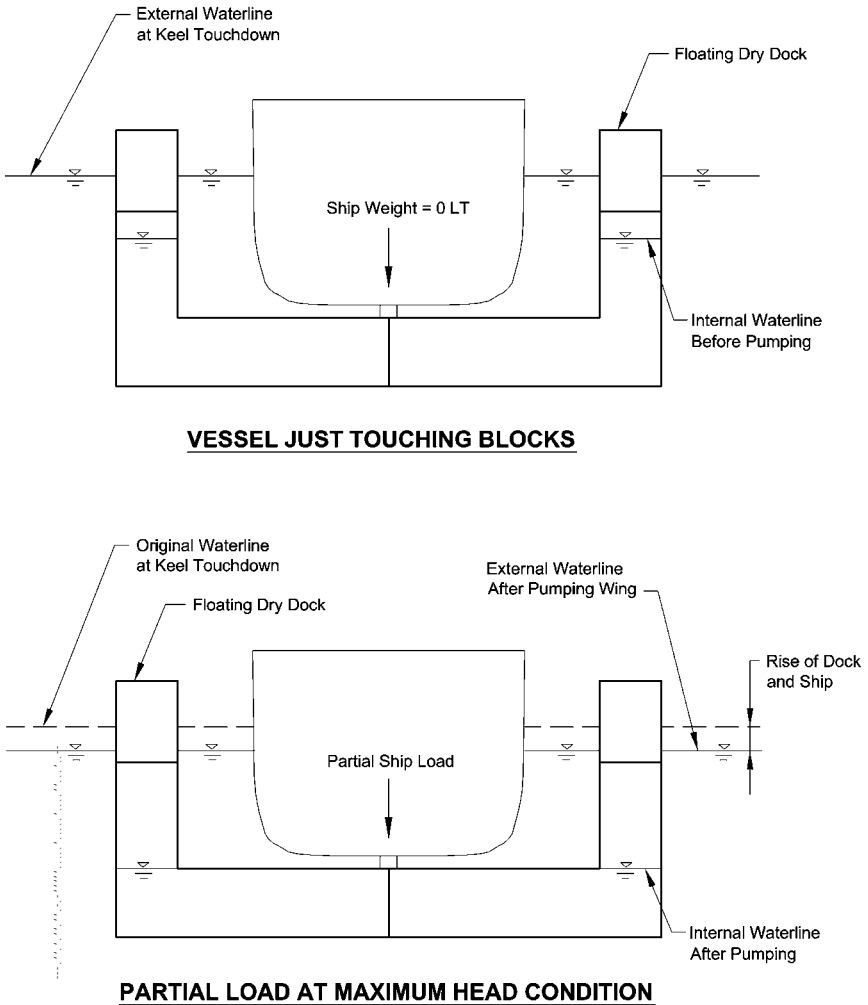
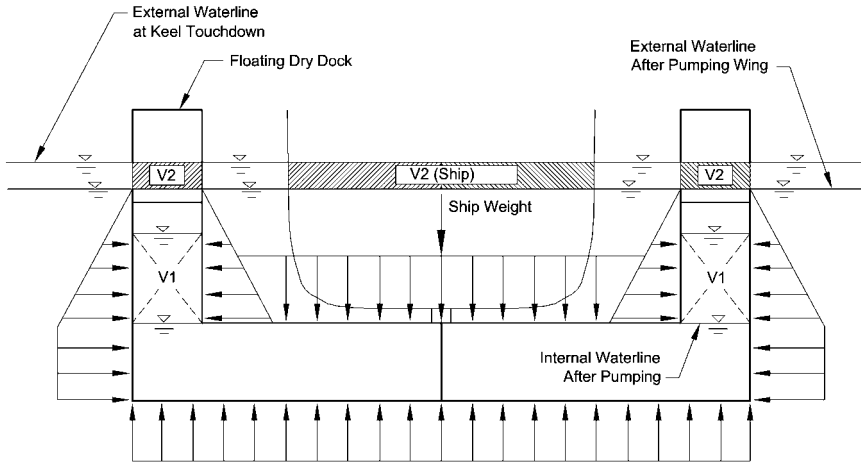


Figure 2-6. Partial load, maximum head condition.

The volume of water that is pumped out of the wing walls (V1) after the vessel's keel contacts the keel blocks is equal to the volume that the vessel and dry dock wings rise out of the water during that pumping (V2). With this volume known, along with the length and beam of the ship and dock wing walls, the rise of the ship and dock can be calculated (Fig. 2-7).

The resulting depth of water over the pontoon deck is the maximum head on the dry dock for that particular vessel.



MAXIMUM HEAD CONDITION

Figure 2-7. Maximum head condition.

The displaced volume of the portion of ship that has been lifted out of the water (V2 Ship) is the weight of the vessel on the keel blocks for this condition.

2.3.4.2.4 Reverse Bending. The reverse transverse bending condition shall be investigated.

This condition occurs wherever there is a dewatered ballast compartment providing uplift in an area where there is no ship weight pushing down, such as an unloaded portion of a partially loaded compartment (Fig. 2-8).

The pontoon is held down at the wings and buoyancy tends to bow it up—the reverse of a typical loading condition.

In this case, the pontoon bottom plate is in compression and must be investigated for plate buckling.

2.3.4.2.5 Transverse Bending Limits. The dry dock should be rated for a maximum allowable load per foot along the keel. With the dry dock supporting the maximum load per foot, transverse bending stresses for each of the above bending cases shall not exceed the established acceptable limits for each member.

2.3.4.3 Longitudinal Bending Calculations and Deflection Limits. The longitudinal bending stresses in the dock shall be calculated

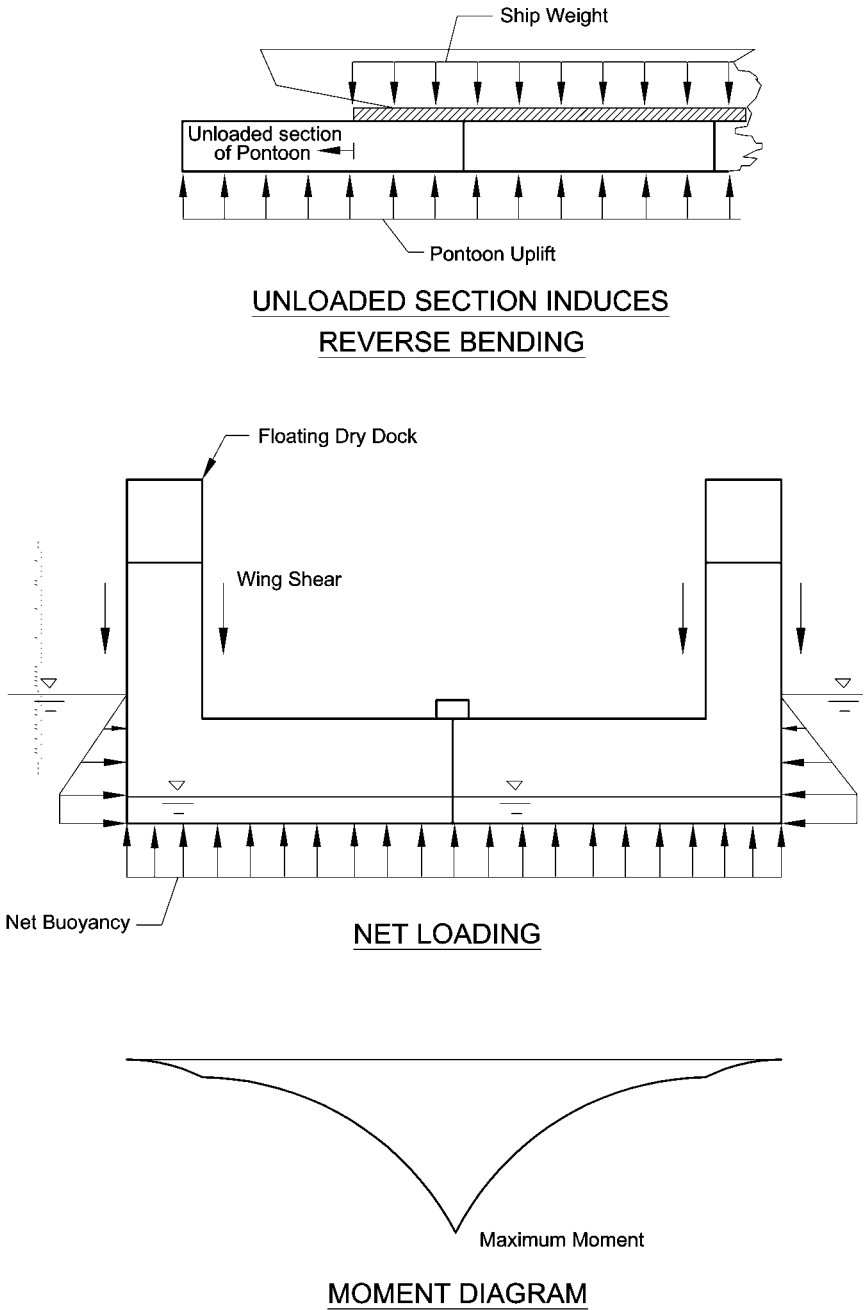


Figure 2-8. Reverse bending at unloaded section.

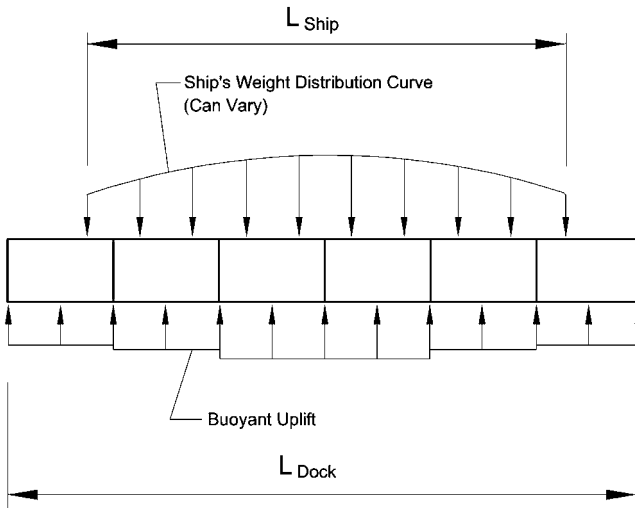


Figure 2-9. Longitudinal bending condition.

for the shortest capacity vessel that will not exceed the dry dock's load per foot limitations. The condition in which a vessel much shorter than the dry dock with a weight per foot at the rated capacity produces an extreme longitudinal bending condition that must be evaluated. This longitudinal bending condition results from the buoyant uplift force on the dry dock forward and aft of the vessel combined with the deadweight force of the vessel.

Longitudinal deflections of the dock shall be calculated for various loading conditions such that the minimum dock deflection that causes the dock to reach working stress limits shall be established. Allowable buckling stresses in the wing deck, upper wing side shell, and pontoon bottom, if lower than normal bending stresses, shall control.

These calculations shall be used to set the operational longitudinal deflection limits described in 2.3.5.6.3.

2.3.4.4 Local Strength Analyses. Calculations shall be performed to determine:

- (A) Allowable hydrostatic pressure on hull
- (B) Allowable hydrostatic pressure on internal bulkheads and safety deck
- (C) Allowable vehicle loading on pontoon deck, aprons, access bridge, etc.

- (D) Mooring loads
- (E) Foundation loads

2.3.4.5 Block Loading Analyses. A description of the blocking system shall be provided. Calculations shall show that the blocks are stable and structurally adequate to support the rated load per block. Calculations shall include:

- (A) Allowable bearing pressure on timber times bearing area
- (B) Structural strength of block base unit
- (C) Local structural strength of dock structure directly supporting blocks

Calculations shall be done for both keel blocks and side blocks, and a rated block load for each determined.

2.3.4.6 Hydrostatic Properties of the Hull. The following hydrostatic properties of the dry dock hull shall be calculated:

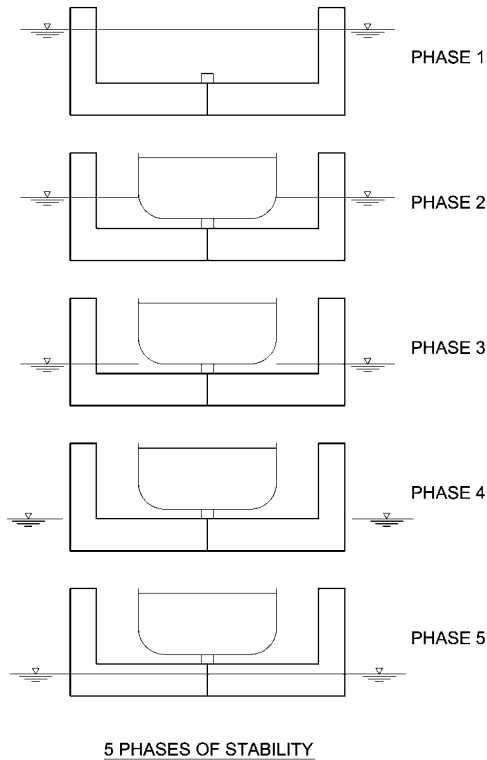
- (A) Displacement of dock versus draft
- (B) KB of dock versus draft
- (C) KM of dock versus draft
- (D) Transverse inertia of dock versus draft
- (E) Ballast tank tables or lift curves

2.3.4.7 Light Dock Weight Determination. If the original light weight and vertical center of gravity (KG) of the dock are unavailable, or if the dock's weight and/or KG have been modified since the original calculations were performed, a new light dock weight and KG shall be calculated. The light weight and KG can be calculated by a theoretical weight estimate verified by a light dock weight survey.

2.3.4.8 Stability Data: KG versus Weight Curve. To ensure stability, the ship/dock combination must maintain a minimum GM throughout the evolution. GM is the measure of stability. Stability of the ship/dock system is usually investigated for five separate phases of the docking or undocking evolution (Fig. 2-10).

These phases are:

- (1) Dry dock at full submergence, no ship
- (2) Partial lift of ship, ship has been lifted approximately half its docking draft
- (3) External waterline at top of keel blocks



5 PHASES OF STABILITY

Figure 2-10. Phases of stability.

- (4) External waterline just over pontoon deck
- (5) Dock at normal operating draft

The minimum stability phase usually occurs at phase 3 or 4.

The required minimum GM varies with the rated lift capacity of the floating dock. Figure 2-11 is the curve of the minimum required GM as a function of the dock's lift capacity. The ship/dock combination must maintain the required GM at all phases of lift.

The minimum stability phase shall be determined and a KG versus weight curve developed for the dry dock for that minimum stability phase. The KG versus weight curve is a plot of the maximum allowable vessel KG (the distance the vessel's center of gravity is above the vessel's keel, adjusted for free liquids onboard the vessel) versus the vessel's docking displacement, which results in the minimum allowable GM for the ship/dock combination. Figure 2-12 shows a sample KG versus weight curve.