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REVISION MEMO

03/04	General 5-year update to further clarify safety considerations and to make them consistent with the Marine Terminal Standards document. New sections were also added to provide guidelines for: Foam Application and Additional Considerations for Sites Using Roving Operators.
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SCOPE

This section covers safety considerations and features that should be incorporated to ensure safe operation of new, fixed (conventional dock-type) marine terminals. The considerations herein represent the cumulative experience of ExxonMobil terminals worldwide along with appropriate guidelines from international standards.

To determine the applicability of these safety features for existing facilities, a site specific study that incorporates the local conditions and risk management methodology is recommended.

REFERENCES

DESIGN PRACTICES

DP XV-F	Emergency Isolation, Depressuring and Shutdown Systems
DP XXXI-F	Cargo Transfer Equipment - Loading Arms
DP XXXI-J	Ship-to-Shore Electrical Isolation
DP XXXI-N	Gangways

GLOBAL PRACTICES

GP 3-2-3,	Firewater Systems
GP 3-7-1,	Piping Layout, Supports and Flexibility
GP 3-11-1,	Marine Cargo Transfer Hose
GP 3-11-2,	Marine Loading Arms
GP 3-12-1,	Valve Selection
GP 14-3-1,	Fireproofing
GP 15-7-2,	Protective Systems
GP 15-9-2,	Electric Motor Operators for Valves
GP 16-1-1,	Area Classification and Related Electrical Design for Flammable Liquids, Gases or Vapors

OTHER REFERENCES

- Exxon Company International, *Safety in LPG Design*, January 1996.
- Oil Companies International Marine Forum, *Design and Construction Specification for Marine Loading Arms*, Third Edition Revision 1999.
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- ExxonMobil Research & Engineering Co., PC-SMART Users Guide v.2.4, CPEE 136, 1997.
- LHG Marine Cargo Transfer Fire/Explosion Risk Assessment Procedure*, 93 CMS2 010, Jan. 1993.
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- Guidelines for Marine Terminal Training and Drills to Improve Emergency Readiness*, ER&E Report EE.1TT.86, 1986.
- Planning and Selection Guide for Oil Spill Response Equipment*, ER&E Report EE.101E.94, 1994.
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- Guidelines for Selection and Installation of Emergency Block Valves*, ER&E Report EE.27E.84, March 1984.
- Emergency Shutdown Systems (ESSs) for Marine Terminals*, ER&E Report EE.108E.98, Dec. 1998.
- International Chamber of Shipping, Oil Companies International Marine Forum, International Association of Ports and Harbors, *International Safety Guide for Oil Tankers & Terminals (ISGOTT)*, Fourth Edition, 1996.

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INTRODUCTION

Marine terminalling operations involve hydrocarbon cargo transfers, where the potential for an incident is always present; and a large inventory of product is on hand. In view of the vital importance of marine facilities to the continuing operation of most plants, it is necessary to avoid hydrocarbon releases, to control ignition sources, and to provide adequate fire protection by proper design and effective operations. Some of the features described herein will be useful in preventing oil spills; however, Report EE.101E.94 (**Reference 9**) should be consulted for further information on oil spill response.

SETTING THE SAFETY BASIS

Protective equipment recommended for a marine terminal depends upon many factors including the following:

- Potential for personal injury.
- Criticality of the terminal to the supply/distribution circuit.
- Proximity of the terminal to populated areas and non-petroleum industry facilities.
- Product volatility.
- Layout of marine facilities.
- Available fire fighting capabilities.
- Ship size and cargo transfer rate.

For purposes of Fire Protection, Emergency Shutdown (Isolation) Systems and Cargo Drainage and Containment, all facilities should be classified based on the importance of the terminal's marine operations to the business interest (product supply system) of the company. Classification is according to Group I, II, or III based on the criteria in [Table 1](#).

Table 1 - Classification Criteria for Marine Terminals

Group I	Those marine terminals, which are critical to the business interests of the company , are in highly congested areas, or for other reasons require a high level of protection (normally includes refining terminals and large distribution terminals).
Group II	Those marine terminals which are important to the business interests of the company (normally includes distribution terminals which supply a large area, are a single source of company product for an area or country, or for other reasons are judged to require some degree of protection).
Group III	Those marine terminals where elimination of the terminal would not seriously affect the business interests of the company (normally includes distribution terminals which either supply a small area or for which there are alternative sources of product).

Classification by Group should include appropriate input from senior management of the affiliate company. The purpose of classifying marine terminals according to Group is to identify the level of investment justified to protect against a financial loss that would impact the facility for an extended period of time. In all cases, safety, health, environmental and public impacts will be addressed.

MINIMUM SPACING CRITERIA

Summarized in the following section are spacing and dimensioning guidelines for multiple berth piers and vessel turning basin.

TURNING BASIN

The turning basin is an area designed to allow a vessel to turn, usually in a 180° direction from that which it entered. Turning a vessel is usually done prior to berthing to allow departure from the berth under a wider range of environmental conditions.

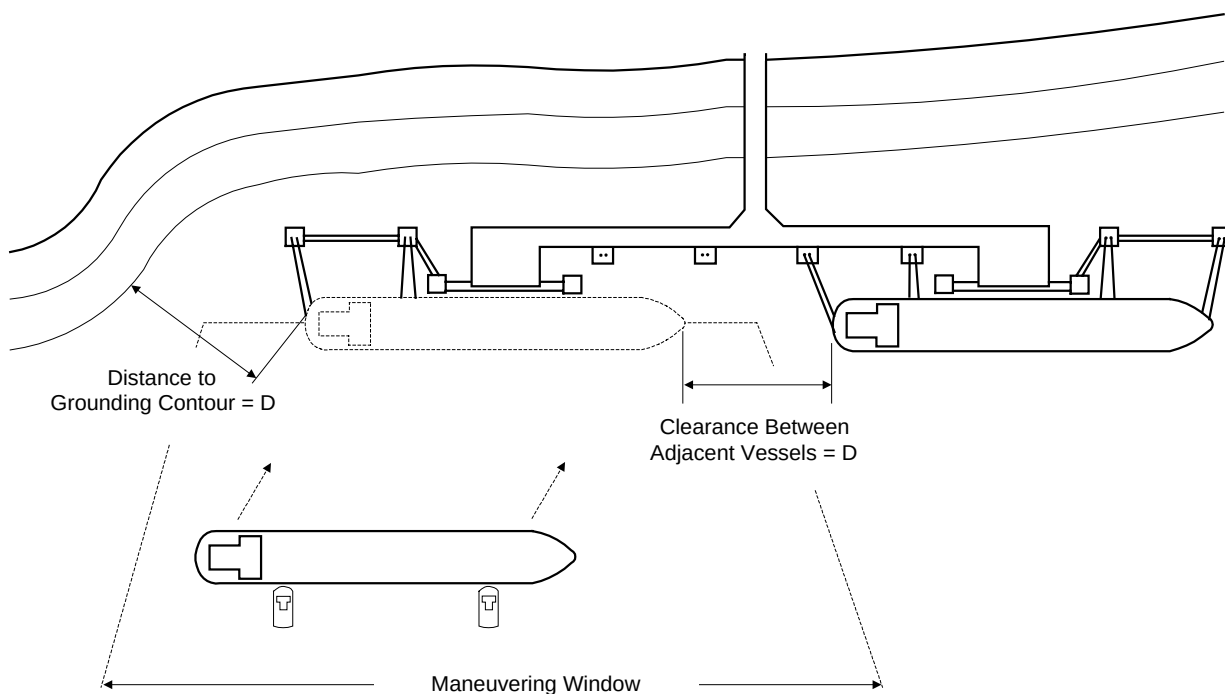
For larger vessels, tug assistance is usually required for any turning maneuver due to the excessive area required if the turn was unassisted. The minimum diameter of the turning basin should be 4 times the overall length of the ship (LOA) for unassisted vessels and 2 times LOA for vessels where tugs assist.

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SPACING BETWEEN BERTHS

Considerations for clearance spacing (bow to stern, bow to bow, stern to stern) between vessels in shallow water are shown in [Figure 1](#).

Figure 1 - Spacing Between Berths



Minimum Spacing Distances for Various Ship Sizes

TYPE OF VESSEL	DISTANCE (D)
Tug-Maneuvered Barges and Vessels < 2,000 DWT	30 ft (9.1 m)
Self Propelled Barges and Vessels < 10,000 DWT	60 ft (18.3 m) or One Vessel Width, Whichever is Larger
Vessels < 50,000 DWT	100 ft (30.5 m) or One Vessel Width, Whichever is Larger
Vessels > 50,000 DWT	150 ft (45.7 m) or 1.5 Vessel Widths, Whichever is Larger

Note: Final clearances should be based on discussions with appropriate marine specialists

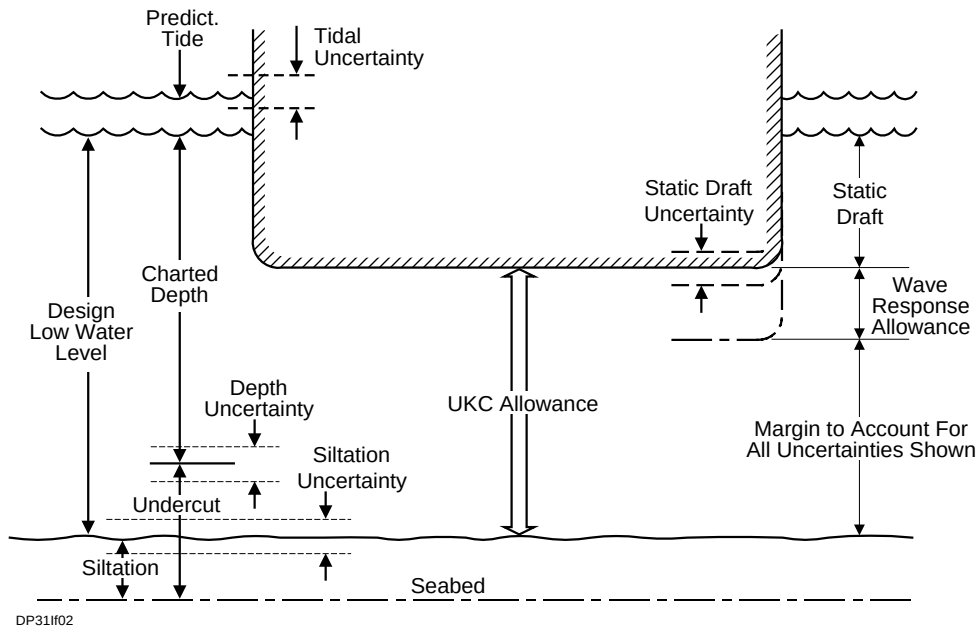
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UNDERKEEL CLEARANCE AT BERTHS

Determination of the underkeel clearance (UKC) as a function of vessel size and sea conditions at a port is a complicated subject which can be dependent upon numerous factors which are summarized schematically in Figure 2. Among the most important of these factors for establishing a vessel's UKC is the Design Low Water Level. For coastal areas subject to semidiurnal tide, the design low water level is typically set equal to the mean low water (MLW). For coastal areas subject to diurnal or mixed tides, the design low water level is typically equal to the mean lower low water (MLLW). Other factors are discussed in the next section.

Figure 2 - Underkeel Clearance Factors



FACTORS AFFECTING UNDERKEEL CLEARANCE

Charted Depth - This is obtained from surveys, and the precision of the information varies depending on survey errors, round-off errors, and the like. As a result, there is some allowance for uncertainty associated with the charted depth. For locations with a muddy bottom, the depth can be defined as the depth at which a material density of 15.5 lb/ft³ (1.2 g/cm³) is first encountered.

Tide - The periodic rise and fall of sea level causes the available water depth to fluctuate. Tidal predictions are used to forecast the actual working depth at any given time. These predictions account for astronomical effects, but not other unpredictable effects such as wind shear forces, fresh water run off, unknown current, storms, barometric variations, etc. Therefore, in addition to the tidal allowance due to astronomical effects, an allowance must be added to UKC based upon the tidal uncertainty due to the factors mentioned above.

Undercut - In certain areas the ship channel is dredged deeper than indicated by the charts (to account for future siltation). The charted depth uncertainty usually covers the undercut uncertainty.

Siltation - Water depth is often reduced by siltation. This siltation can be accounted for if siltation rates are known. However, if siltation rates are not known, then a siltation uncertainty or deviation must be included to account for possible depth reduction due to siltation.

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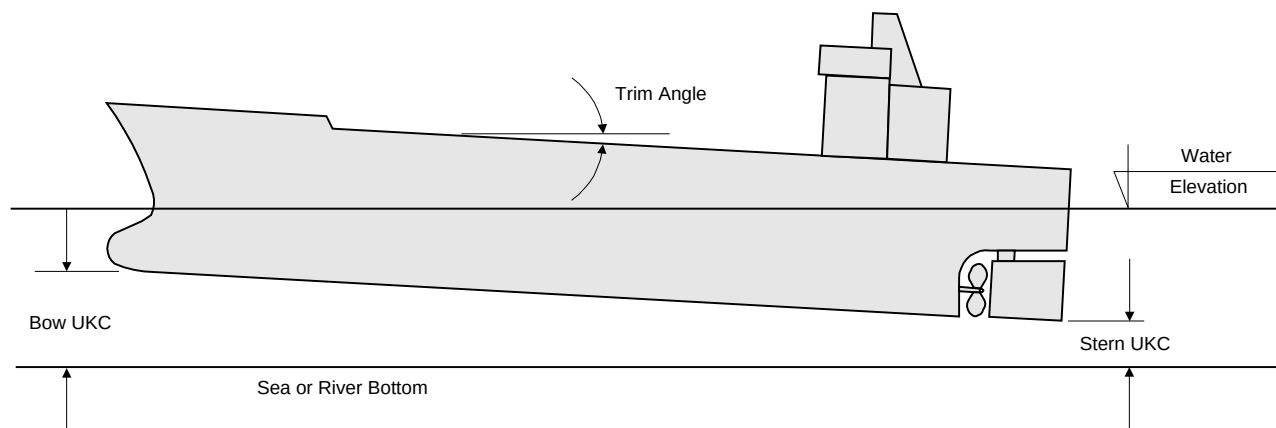
UNDERKEEL CLEARANCE GUIDELINES

The minimum underkeel clearance refers to the distance between the ship's bottom and the seabed that will provide for the maximum vessel draft while providing an appropriate allowable to prevent grounding. The general requirements for minimum underkeel clearance at a berth are as follows:

1. Minimum underkeel clearance at a berth located in sheltered waters should be not less than 5-10% of the maximum draft of the vessel unless a more detailed analysis is performed. The 10% value should be considered for sites having rocky bottoms, high sediment rates, strong currents, and for early planning studies. For terminals handling only light draft vessels, a check should be made to ensure the minimum underkeel clearance is satisfied at the appropriate trim angle (see [Figure 3](#)). Typical trim angles range from up to: 5° for ships <16,000 Dead Weight Tons (DWT); up to 2.5° for ships <150,000 DWT; and 0.5°-1.0° for ships >150,000 DWT.
2. The practice of "pumping-over-the-tide," whereby the vessel relies on high tide to maintain minimum underkeel clearance, is not permitted at ExxonMobil terminals
3. For berths located in exposed locations subject to waves with a significant height of 3.1 ft (1 m) or more, the underkeel should be established by rigorous calculation. **Reference 11** provides a rational method for determining UKC using a generalized probabilistic procedure. The minimum UKC can also be estimated by performing a dynamic mooring analysis.

In the absence of a detailed analysis, the minimum average UKC should be not less than 10-15% of the maximum draft of the vessel. Contact IMT, SeaRiver Maritime, or EMRE for assistance. The 15% value should be considered for sites having rocky bottoms, high sediment rates, strong currents, and for early planning studies.

Figure 3 - Underkeel Clearance at the Berth



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MOORING ARRANGEMENTS

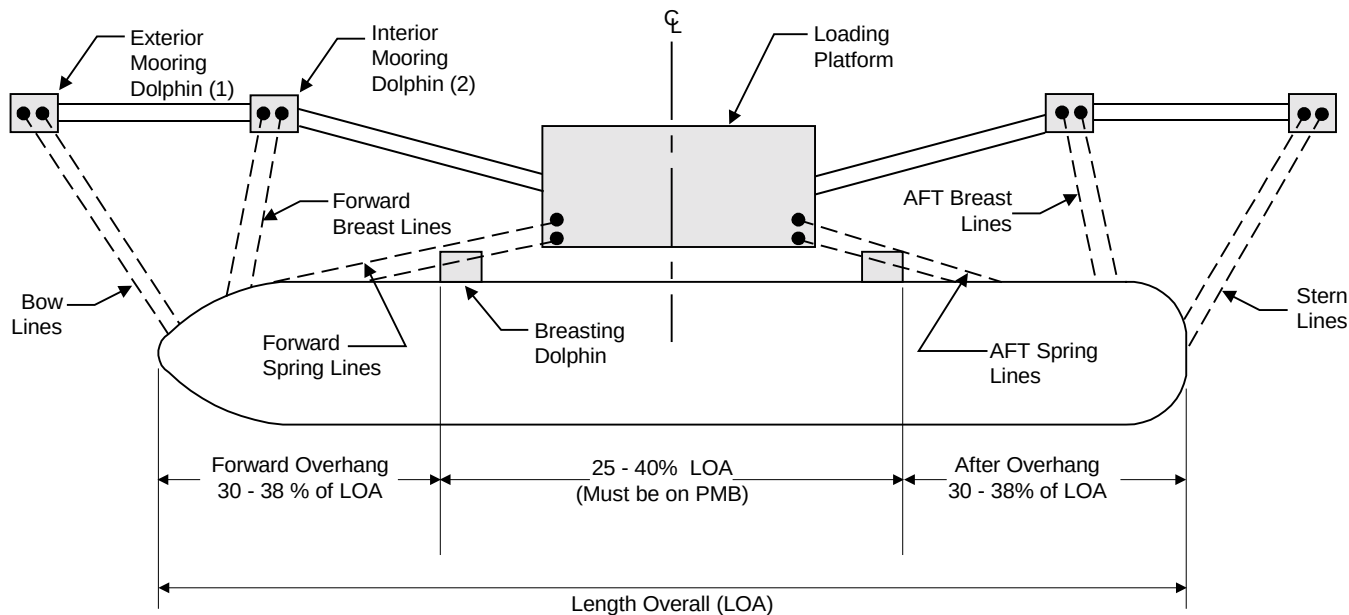
The mooring facilities provided at a berth should be designed to permit the full range of vessel sizes that are to be accommodated to remain safely moored alongside. Mooring structures of a facility restrain the vessel against wind, wave, and current forces.

The procedures for calculating the wind, wave and current forces on ships are covered in **Reference 4**. Because of the complexity of these calculations, they are generally performed using a computer program such as PC-SMART (**Reference 5**) which is maintained by the Marine Terminalling Section of ExxonMobil Research & Engineering.



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Figure 4 - Typical Mooring Arrangement



Notes:

- (1) Distance from berth centerline to the center of the exterior dolphin should be slightly more than 1/2 of the LOA of the largest vessel which will normally call at the berth.
- (2) Interior mooring dolphins should be located to optimize the breast lines (as perpendicular to vessel longitudinal center-line as possible) for the full range of vessels that will call at the berth.

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An appropriate mooring arrangement can be developed by adhering to the general mooring principles listed below. An example of a good mooring arrangement is shown in [Figure 4](#).

1. Mooring points should be arranged as symmetrically about the center point as possible. The ideal mooring layout allows for mooring lines (breasting lines) to be run perpendicular from the bow and stern of the vessel such that they restrain lateral motions away from the pier. Additional mooring points are provided to allow for spring lines to be run parallel to the vessel to restrain longitudinal motions.
2. To minimize the amount of mooring line tending required to accommodate tide or vessel draft changes and for efficient use of mooring lines to resist mooring loads, mooring points for breasting lines should be set back far enough to keep the vertical angles less than 30°. Mooring points for spring lines should also be located such that vertical angles of spring lines are kept below 30°.
3. When mooring dolphins are used, they should be set back sufficiently from the breasting face to prevent being struck by vessels berthing/departing at angles of up to 15°.
4. The design wind and current forces on the ship should be calculated for the wind and current conditions under which the ship may remain moored at the berth.
5. Maximum allowable loads in any one mooring line should not exceed 55% of its Minimum Breaking Load (MBL) for the most severe environment in **Paragraph 4** above. For cargo transfer operations, mooring line loads should not exceed 35-40% of the MBL.
6. Mooring limits for mooring facilities should be developed using the PC-SMART computer program. EMRE can provide affiliates with the necessary assistance or appropriate training.

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