

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	ExxonMobil Proprietary	
		Section XXXI-F	Page 1 of 53
		March, 2004	

Changes shown by ↕

CONTENTS

Section	Page
1 SCOPE	4
2 REFERENCES	4
2.1 DESIGN PRACTICES	4
2.2 GLOBAL PRACTICES	4
2.3 OTHER REFERENCES	4
3 INTRODUCTION	5
3.1 GENERAL DESCRIPTION	5
3.2 TYPES OF LOADING ARMS	6
3.3 ANCILLARY EQUIPMENT	6
4 GENERAL STEPS IN A LOADING ARM PROJECT	7
4.1 EXISTING FACILITIES	7
4.2 NEW FACILITIES	8
5 SELECTING THE NUMBER AND SIZE OF ARMS	8
5.1 GENERAL	8
5.2 CALCULATION PROCEDURE	8
5.3 PRODUCT SLATE	8
5.4 TANKER MANIFOLD CHARACTERISTICS	9
5.5 LOADING RATE	10
5.6 EXAMPLE CALCULATION	12
6 DEVELOPING THE OPERATING ENVELOPE	12
6.1 GENERAL	12
6.2 REFERENCE ENVELOPE	13
6.3 EXAMPLE DEVELOPMENT OF REFERENCE ENVELOPE	16
6.4 COMPOSITE ENVELOPES	19
6.5 PROCEDURE FOR DEVELOPING COMPOSITE ENVELOPE	20
6.6 EXAMPLE DEVELOPMENT OF COMPOSITE ENVELOPE	20
7 MECHANICAL DESIGN	31
7.1 LOADING CONDITIONS	31
7.2 MANIFOLD CONNECTION CRITERIA	35
7.3 COUNTERBALANCING	35
7.4 MATERIALS	35
7.5 STRESS ANALYSIS REQUIREMENTS	36

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	ExxonMobil Proprietary	
		Section	Page
		XXXI-F	2 of 53
		March, 2004	

7.6 FOUNDATION REQUIREMENTS	40
8 RANGE MONITORING SYSTEMS	42
8.1 GENERAL DESCRIPTION	42
8.2 TWO-STAGE RANGE MONITOR SYSTEMS	43
8.3 DESIGN REQUIREMENTS	44
9 COUPLER SYSTEMS	44
9.1 GENERAL DESCRIPTION	44
9.2 BASIC DESIGN REQUIREMENTS	45
9.3 COUPLER CONTROL FEATURES	45
9.4 COUPLER SAFETY FEATURES	45
9.5 GENERAL DESCRIPTION	47
9.6 BASIC DESIGN REQUIREMENTS	48
9.7 ERS TIE-IN WITH SHORE ESD SYSTEM	50
9.8 ERS SAFETY FEATURES	50
9.9 ARM BALANCING WHEN ERS INSTALLED	50
9.10 ARM LOCKING AFTER EMERGENCY RELEASE	50
9.11 ARM MANEUVERING AFTER EMERGENCY RELEASE	51
10 DRAINAGE SYSTEMS	51
10.1 GENERAL	51
10.2 GRAVITY DRAINING	51
10.3 STRIPPING SYSTEMS	51
10.4 PURGING SYSTEMS	52

TABLES

Table 1 - Common Types Of Loading Arms	6
Table 2 - Safety Related Ancillary Equipment	6
Table 3 - Efficiency Related Ancillary Equipment	7
Table 4 - Number Of Arms Based On Product Segregation Requirements (FORM)	9
Table 5 - Product data (FORM)	9
Table 6 - Oil Tanker Manifold Diameters	9
Table 7 - Maximum Loading Arm Flow Rates	11
Table 8 - Loading Arm Drift Allowances	13
Table 9 - Reference Envelope Governing Conditions	14
Table 10 - Data Required To Develop Loading Arm Reference Envelope	15
Table 11 - Oil Tanker Manifold Spacing	20
Table 12 - Type Of Marine Loading Arm Loads	31
Table 13 - ERS Actuation Requirements	48

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	ExxonMobil Proprietary	
		Section XXXI-F	Page 3 of 53
		March, 2004	

FIGURES

Figure 1 - Marine Loading Arm.....	5
Figure 2 - Vessel Design Discharge Capacity.....	10
Figure 3 - Flow Rate vs. Number Of Arms	11
Figure 4 - Arm Operating Envelope.....	13
Figure 5 - Schematic Of Loading Arm Governing Conditions.....	14
Figure 6 - Example Problem Operating Conditions	17
Figure 7 - Example Problem Final Reference Envelope	18
Figure 8 - Vessel Spotting Positions	19
Figure 9 - Spotting Position For Arm 2 In Single Service	22
Figure 10 - Reference Envelope For Arm 2 In Single Service.....	23
Figure 11 - Spotting Position For Arm 2 Connected Together With Arm 1	24
Figure 12 - Reference Envelope For Arm 2 Connected Together With Arm 1	25
Figure 13 - Superimposing Reference Envelope From Step 4 With Reference Envelope From Step 2.....	26
Figure 14 - Spotting Position For Arm 2 Connected Together With Arm 3.....	27
Figure 15 - Reference Envelope For Arm 2 Connected Together With Arm 3	28
Figure 16 - Superimposing Reference Envelope From Step 7 With Combined Envelope From Step 5	29
Figure 17 - Final Composite Envelope	30
Figure 18 - Determination Of Maximum Shut-In Pressure	32
Figure 19 - Manifold Cantilever Length	35
Figure 20 - Operating envelope positions for stress analysis.....	37
Figure 21 - Handling Loading Arm Foundation Loads At Existing Facilities	41
Figure 22 - Types Of Range Monitors	42
Figure 23 - Two Stage Range Monitor	43
Figure 24 - Loading Arm Coupler.....	44
Figure 25 - Coupler Safety Systems	46
Figure 26 - Emergency Release System.....	47
Figure 27 - ERS Logic Diagram	49
Figure 28 - Loading Arm Stripping System	52
Figure 29 - Loading Arm Purging System	53

Revision Memo

03/04 General update with notable changes to oil tanker manifold dimensional data and wind-loading design conditions.

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	ExxonMobil Proprietary	
		Section XXXI-F	Page 4 of 53
		March, 2004	

1 SCOPE

This design practice covers marine loading arms and marine loading arm ancillary equipment for the loading or unloading of ships and barges at conventional marine pier and sea island facilities. It covers the design of loading arms through the Design Basis Memorandum and Design Specification stage. It does not cover NPQC, Commissioning, or Start-Up of the arms.

2 REFERENCES

2.1 DESIGN PRACTICES

DP XXIII	Product Loading Systems
DP XXIX-A	Civil Design Data
DP XXIX-D	Design Loads

2.2 GLOBAL PRACTICES

GP 03-11-02	Marine Loading Arms
GP 04-01-03	Design Loads for Structures

2.3 OTHER REFERENCES

ASCE 7, Minimum Design Loads for Buildings and Other Structures.

ICS/OCIMF, *International Safety Guide for Oil Tankers and Terminal* (ISGOTT).

OCIMF, *Design and Construction Specification for Marine Loading Arms*, Witherby & Co., Ltd., London, England.

OCIMF, *Recommendations for Manifolds for Refrigerated Liquefied Gas Carriers for Cargoes from 0 °C to minus 104 °C*, Witherby & Co., Ltd., London, England.

OCIMF, *Recommendations for Manifolds Refrigerated Liquefied Natural Gas Carriers (LNG)*, Witherby & Co., Ltd., London, England.

OCIMF, *Recommendations for Oil Tanker Manifolds and Associated Equipment*, Witherby & Co., Ltd., London, England.

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	Section XXXI-F	Page 5 of 53
		March, 2004	
		ExxonMobil Proprietary	

3 INTRODUCTION

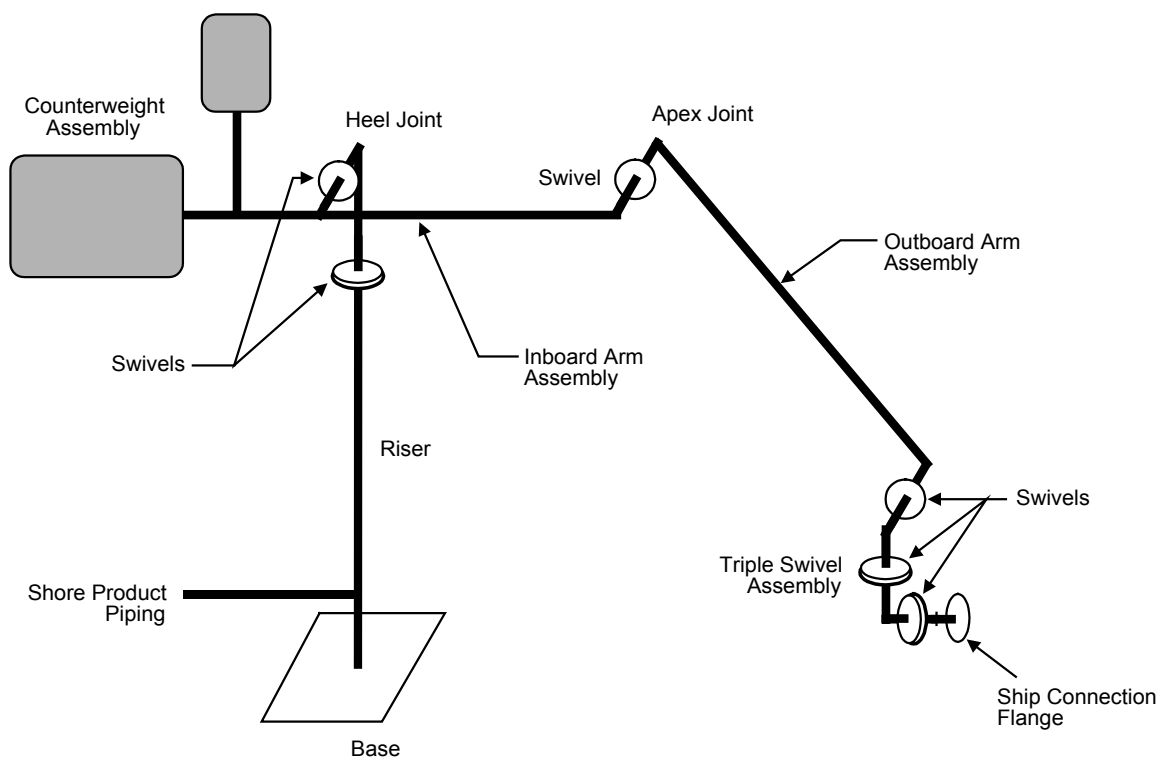
3.1 GENERAL DESCRIPTION

A marine loading arm connects the shore piping to the vessel piping (vessel's manifold) and allows the loading or discharging of a vessel at a marine berth. The use of the word "loading" in the name is by tradition only, as many terminals use their arms for both loading and unloading, or for unloading only.

A loading arm consists of five main components as shown in Figure 1: a riser, inboard arm assembly, outboard arm assembly, triple swivel assembly, and counterweight system.

Swivels in the system allow the arm to move in three-dimensional space, and follow the movements of the ship as it rises or falls with change of draft or change in tide. The arm can also slew, or rotate, in the horizontal direction to allow for vessel motions up and down the pier, or to account for the fact that the ship does not always perfectly align itself with the loading arm when it maneuvers itself against the berth. The arm also allows some perpendicular motion of the vessel away from the berth to account for different manifold setback distances and a limited amount of elongation in the ship's mooring lines.

Figure 1 - Marine Loading Arm



DP31F01

The counter weight system, attached to the backside of the inboard arm, is designed such that the arm is balanced when it is empty. Without this balancing, it would require large forces to move the arm when connecting it to the ship or returning it to the stored position after cargo transfer is complete.

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	ExxonMobil Proprietary	
		Section XXXI-F	Page 6 of 53
		March, 2004	

3.2 TYPES OF LOADING ARMS

There are many types of loading arms, usually differentiated by the method the arm is controlled or the temperature of the product to be handled. [Table 1](#) lists some of the more common types of loading arms.

Table 1 - Common Types Of Loading Arms

Manual Arm	Simplest type of arm. Connected to the ship using guide ropes to pull it into position.
Hydraulic Arm	Arm movements controlled by hydraulic pistons attached to the arm which are operated from a control console on the berth or by a portable pendant controller which allows the operator to move around the berth while operating the arm.
High Temperature Arms	Special arms designed to handle bitumen (asphalt), molten sulfur, or other heated products. Normally equipped with electrical or steam heat tracing. Usually equipped with insulated product piping.
LPG & LNG Arms	Hydraulic arms built of special low temperature materials. Some designs separate the product carrying piping from the support structure to allow easier design for thermal contraction and expansion.
Piggy-Back Arm	A special type of loading arm with secondary product piping mounted on the same riser and supported by the main product inboard and outboard arm assemblies. Usually used for LPG service with the secondary piping used for vapor return.

Manual arms should be limited to single line, 6 in. diameter or less (8 in. diameter if the operating envelope is unusually small). Larger arms, and Piggy-Back arms of any size, are difficult to control by guide ropes, especially in high wind conditions due to the weight of the arm and larger windage area.

LPG and LNG arms should be hydraulically controlled, regardless of size, as these arms require special hydraulically operated safety systems (see section on **Emergency Release Systems**).

3.3 ANCILLARY EQUIPMENT

Ancillary equipment falls into two categories: safety systems and efficiency systems. The installation of these on a specific arm depends on the products transferred and the requirements of the operating affiliate. Normal standards are listed in [Tables 2 & 3](#).

Table 2 - Safety Related Ancillary Equipment

SAFETY SYSTEM	NORMAL STANDARD
Electrical Insulation Joint	Required for all arms at salt or brackish water locations.
Storm (Parking) Lock	Required for all loading arms.
Range Monitoring System	Recommended for hydraulically operated loading arms.
Emergency Release System [ERS]	Recommended for all LPG or LNG arms. Decision to not install should be based on detailed risk assessment.

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	Section	Page
		XXXI-F	7 of 53
		March, 2004	

Table 3 - Efficiency Related Ancillary Equipment

EFFICIENCY SYSTEM	STANDARD INSTALLATION
Manual Couplers	Recommended for small diameter, manually operated loading arms.
Hydraulic Couplers	Recommended for all hydraulically operated loading arms.
Nitrogen Purge Systems	Recommended for all LPG or LNG arms.
Stripping Systems	Recommended for high value products or sites without sump systems.

4 GENERAL STEPS IN A LOADING ARM PROJECT

4.1 EXISTING FACILITIES

Many loading arm projects involve the design, manufacture, and installation of new loading arms on existing marine berths. This type of project often involves the replacement of existing arms that are so old that maintenance has become frequent and expensive. In some cases, the facility needs new arms to increase throughput or to cater for larger vessels. In other cases, risk assessment of the facility's operations indicates that new arms are required to increase the safety of the operations.

Generally, new arm projects for an existing facility include the following steps through to the Design Specification:

1. Screening Study or DBM
 - a. Develop Alternative Cases for Number and Size of New Arms
 - (1) Vessel Size and Throughput Considerations
 - (2) Berth Occupancy and Demurrage Considerations
 - b. Determine Requirements for Ancillary Equipment
 - (1) Coupler systems
 - (2) Emergency Release Systems
 - (3) Range Monitoring Systems
 - c. Gather Budgetary Quotes for Various Alternative Cases
 - (1) Costs for Each Case
 - (2) Foundation Loads for Each Case
 - d. Select Best Case & Confirm with Affiliate or Local Project Team
 - (1) Investment Costs (Including foundation modifications, if required)
 - (2) Operating Costs (Including maintenance considerations)
 - (3) Demurrage or Vessel Delay Costs
 - (4) Safety Considerations
2. Design Specification & Recommended Vendors List
 - a. Design Specification Based on **GP 03-11-02 & OCIMF**, *Design and Construction Specification for MARINE LOADING ARMS*
 - b. Vendor's List Based on Consultations with Senior Engineers of the Marine Terminal Engineering Section

ExxonMobil		ExxonMobil Proprietary	
DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	Section XXXI-F	Page 8 of 53
		March, 2004	

4.2 NEW FACILITIES

New (grassroots) facilities generally follow the same steps except that the selection of the size and number of loading arms is part of a larger, overall optimization study that includes selecting the number of berths, pumping and piping systems, and shore storage facilities (tankage). These types of optimization studies are normally carried out by EMRE Offsites Section (see Offsites' [DP XXII-A, Basic Loading Systems](#)).

Loading arm foundations are also less of a concern with a new facility as the berth deck structure can be designed to allow the loading arm baseplate to bolt directly to the berth deck. It is still necessary, however, to develop preliminary estimates of the loading arm foundation loads so that the berth designer can account for the arm loads at an early stage of the berth design. Final foundation loading is usually not available until several months after contract award.

5 SELECTING THE NUMBER AND SIZE OF ARMS

5.1 GENERAL

The following factors influence the selection of the size and the number of loading arms to be installed at a berth:

- The number of products to be transferred and the degree of segregation required to avoid product contamination.
- The maximum safe loading or unloading rate required to achieve a reasonable vessel turnaround time (relates to ship size).
- The maximum and minimum size vessel manifold to which the loading arm is expected to be connected (relates to ship size).
- Foundation capacity and space available on berth (for existing terminals).

5.2 CALCULATION PROCEDURE

1. Determine the number of cargo transfer systems required based on the product slate, considering product segregation and requirements for vapor return.
2. Determine maximum cargo transfer rate (use [Figure 2](#) for discharging vessels or use site specific loading pump rates and system restrictions for vessels).
3. Determine maximum arm size based on vessel manifold characteristics (limit the arm size to two sizes larger than the minimum vessel manifold diameter expected, e.g., if the minimum vessel manifold is expected to be 8 in. diameter, the arm should not be larger than 12 in. diameter).
4. Determine minimum number of arms required to meet maximum cargo transfer rate based on [Figure 3](#). Several alternatives may be possible, such as two 16-in. diameter arms or three 12-in. diameter arms.
5. Develop budget estimates of arm costs and select final number of arms based on an evaluation of cost versus efficiency and effective operations.

5.3 PRODUCT SLATE

Normally enough arms should be provided to enable the vessel to simultaneously discharge or load the maximum number of products to be loaded or unloaded on the vessel. For example, if a vessel were scheduled to load two separate grades of gasoline, it would significantly delay the operation if first one product is loaded, the arms flushed, and then the second product is loaded.

Specifications on some products are so strict that they must have separate loading arms; flushing the arm to change products is not sufficient to avoid contamination. For example, when both light and dark products are handled at the same berth, it is necessary to install separate arms for each class of product.

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	ExxonMobil Proprietary	
		Section XXXI-F	Page 9 of 53
		March, 2004	

The product slate is provided by the affiliate for whom the arms are being designed. Typically the following tables are provided or filled out by the site or affiliate project team:

Table 4 - Number Of Arms Based On Product Segregation Requirements (FORM)

ARM NUMBER	PRIMARY PRODUCT	SECONDARY PRODUCTS

Table 5 - Product data (FORM)

PRODUCT TO BE TRANSFERRED	DENSITY kg/m ³	VISCOSITY CST AT ____ °C	TEMPERATURE °C		DESIGN PRESSURE Barg	FLOW RATE m ³ /sec
			MIN.	MAX.		

Some products, such as LPG, require that vapors be returned to shore during loading operations. This should be clarified at the time the design basis is set.

5.4 TANKER MANIFOLD CHARACTERISTICS

The size of the loading arm must be compatible with the size of the ship's manifold diameter. The arm is balanced for the empty condition, thus the weight of the product, along with any wind or ice loads, is partially carried by the vessel's manifold to which the arm is connected. A support jack at the end of the arm will relieve the vessel's manifold of some of this load, but not all. If the load transferred to the ship's manifold is too high because the arm is oversized for that size vessel, the manifold may deform or fail.

Generally, a loading arm should not be larger than two sizes greater than the ship's manifold. There is no problem with connecting a smaller diameter loading arm to a larger diameter manifold using a reducing spoolpiece. For screening level studies, the following table gives typical vessel manifold diameters for various size vessels:

Table 6 - Oil Tanker Manifold Diameters

VESSEL DWT	MANIFOLD DIAMETER (in.)
900 to 15,000	8/10
16,000 to 25,000	12
26,000 to 160,000	16
≥ 160,000	20

For design studies, the range of vessel manifold diameters should be generated from the Marine Engineering Section's "Vessel-Log" computer program and consultations with the affiliate's transportation group and local site operating personnel.

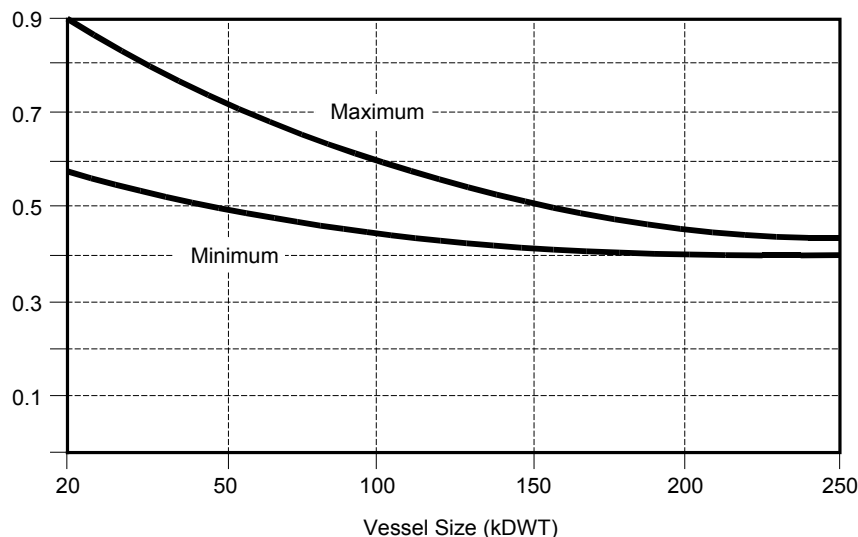
5.5 LOADING RATE

The major factor, which limits flow velocity through marine loading arms, is cavitation. Cavitation is a high-frequency phenomena involving the formation and explosive collapse or implosion of vapor bubbles due to rapidly changing pressure conditions in a fluid. For the most part, cavitation in loading arms occurs in the short radius elbows at high flow rates. Cavitation can result in erosion damage, vibration, and dynamic stresses in an arm, and eventually can lead to fatigue failure of a loading arm or vessel's manifold. To avoid cavitation, flow velocities in marine loading arms should be limited to 36 ft/sec (11 m/s).

The maximum total cargo transfer rate is based on the maximum achievable throughput rates for the ship and shore combined and may require more than one arm be used to meet the 36 ft/sec flow velocity limitation. Generally the ship's pumping capacity controls for discharge operations and shore pumping rates control for loading operations. Figure 2 can be used to estimate maximum discharge rates for conventional crude carriers and product tankers.

Figure 2 - Vessel Design Discharge Capacity

BBLS/HR/DWT



1. Capacity is for the total number of main cargo pumps

2. Multiply the capacities determined by the following correction factors:

Product Viscosity	Centrifugal Pumps	Pos. Disp. Pumps
Light	1.00	1.00
Medium	0.94	0.87
Heavy	0.88	0.73

3. Viscosities 100°F (37.78) are defined as follows:

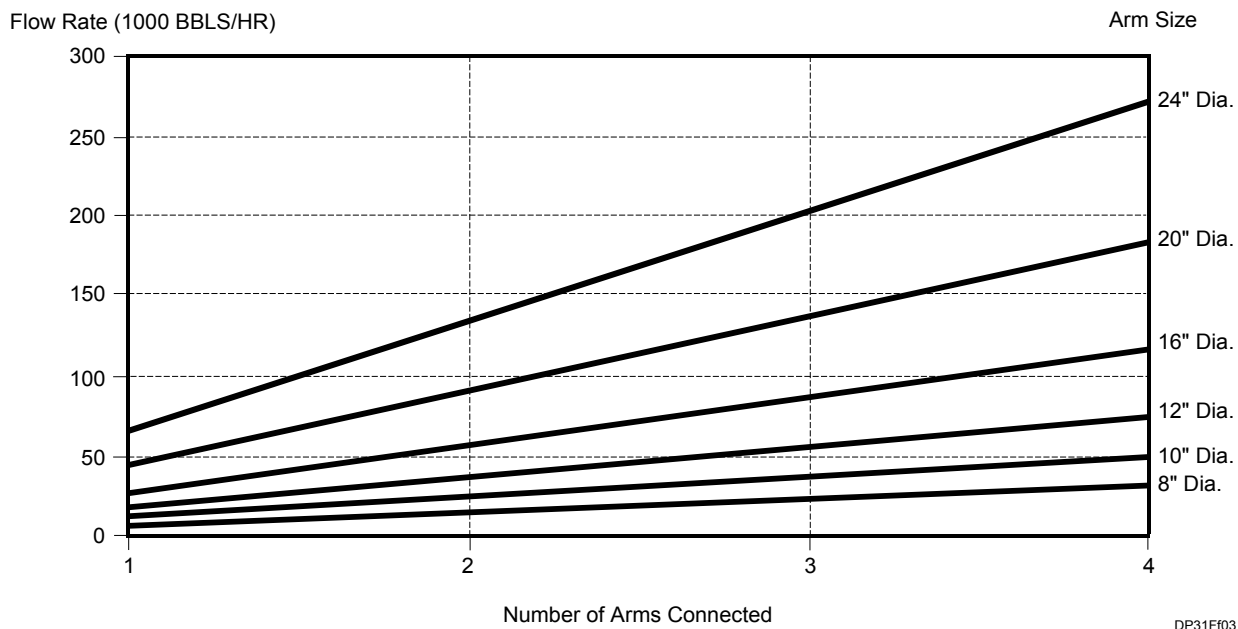
	SSU	cTs
Light	<320	<68
Medium	>320 <3200	>68 <680
Heavy	<3200	>680

Dp31Ff02

Discharge rates for LPG, LNG or chemical carriers should be checked with International Maritime Transportation (IMT), SeaRiver, or the affiliate's Supply and Transportation Department.

Once the affiliate site's product segregation requirements are known, the total cargo transfer rate desired has been determined, and the maximum size arm selected, Figure 3 can be used to determine the number of arms required.

Figure 3 - Flow Rate vs. Number Of Arms
Based On Limiting Flow Velocity To 36 Ft/Sec (11 M/S)



For a more accurate determination of rate vs. number of arms, or when dealing in units other than Bbls/Hr, [Table 7](#) can be used multiplying the number of arms by the value from the table.

Table 7 - Maximum Loading Arm Flow Rates
Based On Limiting Flow Velocity To 36 ft/sec (11 m/s)

ARM DIAMETER	VOLUME FLOW RATE				WEIGHT FLOW RATE
	Bbls/hr	Gal/min.	m ³ /hr	ft ³ /hr	Tons*/hr @ S.G. = 1.0
8	8015	5610	1273	45007	1252
10	12632	8842	2007	70938	1974
12	18121	12684	2879	101751	2832
16	29255	20478	4648	164278	4572
20	46622	32635	7408	261802	7287
24	68010	47607	10806	381907	10630

* 1 Ton Weight = 2240 lb.

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	ExxonMobil Proprietary	
		Section	Page
		XXXI-F	12 of 53
		March, 2004	

5.6 EXAMPLE CALCULATION

Given: New berth facility being designed to import Arabian heavy crude oil. Maximum vessel size expected is 100,000 dwt due to channel depth restrictions in the port approaches, although smaller vessels down to 80,000 dwt may call at the berth on occasion. What is the number and size of loading arms that should be installed?

Solution:

Determine Maximum Discharge Rate for Largest Vessel (100 kDWT)

From [Figure 2](#), Bbls/Hr/DWT = 0.6 Correction Factor = 0.88
(Assume conservative value as no information given on type of pumps)

Maximum Expected Discharge Rate = 100,000 x 0.6 x 0.88 = **52,800 Bbls/Hr**

Determine Maximum Size of Arm

From [Table 6](#), 80,000 DWT Vessel Will Have 16 in. Manifold
100,000 DWT Vessel Will Have 16 in. Manifold

Determine Minimum Number of Arms Required Size of Arm

From [Figure 3](#), For 52,000 Bbls/Hr, Two 16 in. Arms Adequate
Three 12 in. Arms Adequate

The final selection of the number of arms should be made based on budgetary quotes from loading arm manufacturers. Depending on ancillary equipment requirements, three 12-in. arms may be less expensive than two 16-in. arms. Three smaller arms also provides more flexibility for maintenance and may require less berth modifications for existing facilities because of lower foundation loading (deadweight and overturning moment).

6 DEVELOPING THE OPERATING ENVELOPE

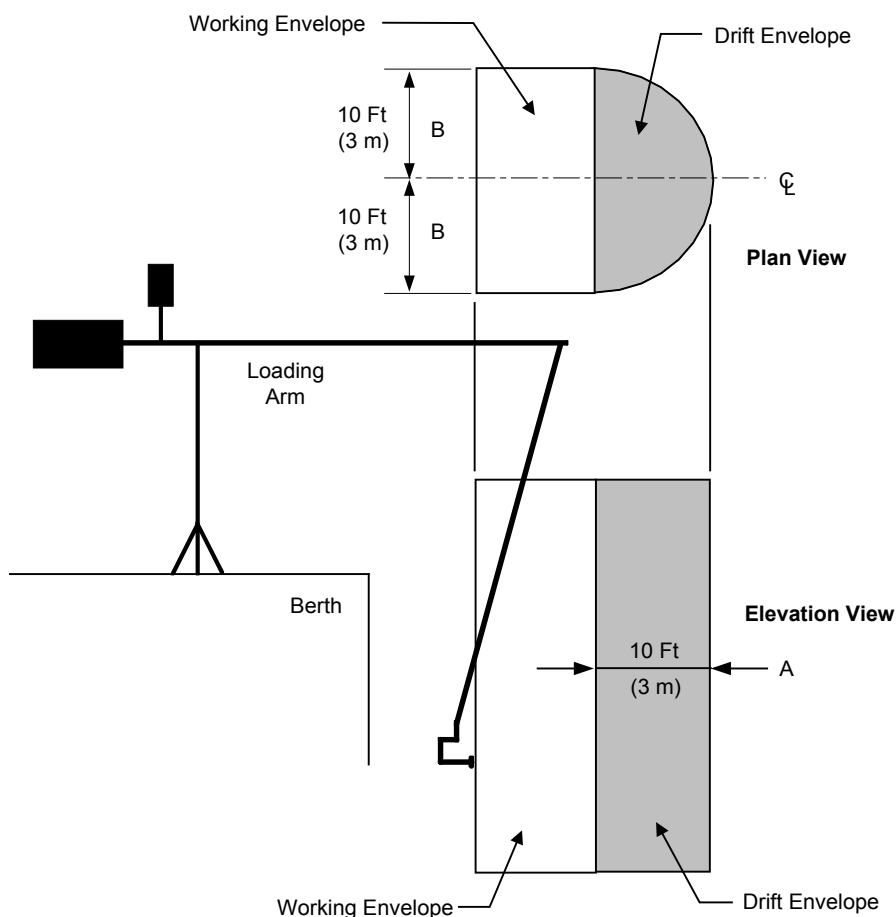
6.1 GENERAL

In order to properly determine the length to the arm components (riser, inboard arm, and outboard arm), the loading arm manufacturer needs to be provided information about the arm operating envelope. The operating envelope is the window in space through which the end of the loading arm can safely move. It is actually made up of two separate envelopes, the "**Working Envelope**", and the "**Drift Envelope**" as shown in [Figure 4](#) below:

The working envelope contains the space which includes all the possible positions that the ship's manifold might reach during normal operations and must account for variability in the position of manifolds on the decks for the entire range of vessels expected to use the arm, as well as the range of vessel elevations due to changes in draft from loading or unloading or changes in tide.

The drift envelope is an additional allowance to account for abnormal movement of the ship in the berth, usually caused by environmental forces acting on the vessel. For new sites, the allowances given in [Table 8](#) and shown in [Figure 4](#) should be used. At existing sites with a number of loading arms, these allowances are normally set equal to the allowances for existing arms for consistency, provided the allowances are at least equal to those that would be specified for a new site.

Figure 4 - Arm Operating Envelope



DP31F104

Table 8 - Loading Arm Drift Allowances
(Ref. Fig. 4)

A	Movement perpendicular to berth (normally caused by wind, passing ship effects, or a combination of the two).	10 ft (3 m)
B	Movement along the berth in either a forward or astern direction (normally caused by current or a combination of current and wind).	10 ft (3 m)

6.2 REFERENCE ENVELOPE

The envelope for a single arm connected to a vessel with the vessel's manifold correctly centered on the loading arm is called the **"reference envelope"**. Development of the reference envelope is the first step in finalizing the operating envelope for a marine loading arm. The reference envelope is site specific and must be developed as part of the project design basis. The governing conditions for the reference envelope parameters are shown schematically in Figure 5 and listed in Table 9.

Figure 5 - Schematic Of Loading Arm Governing Conditions

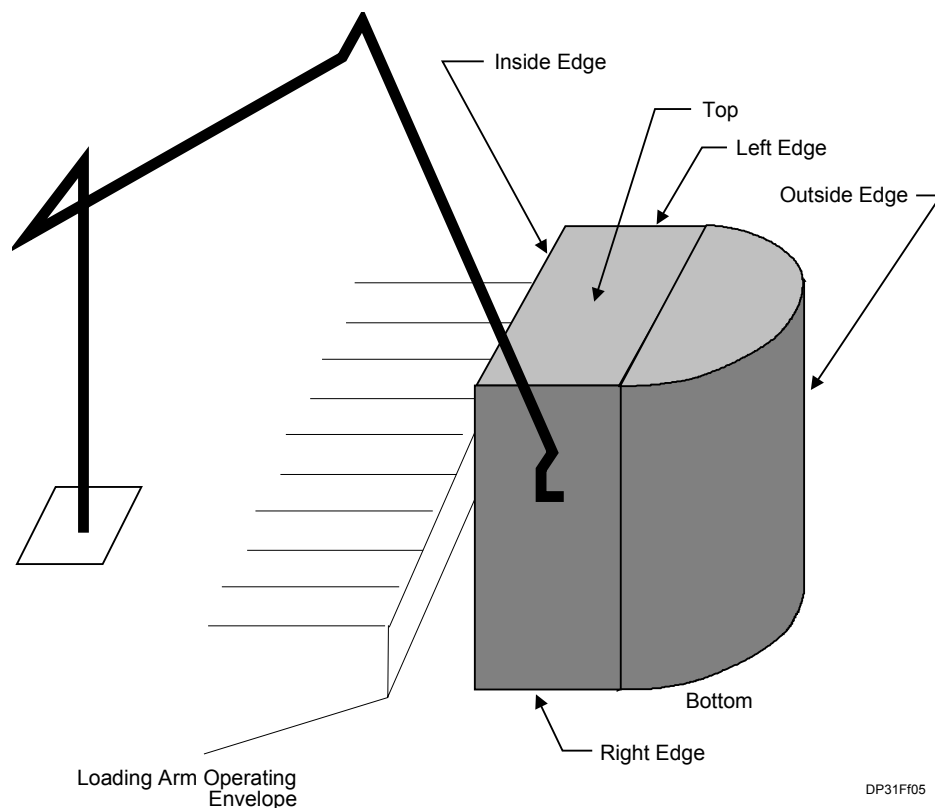


Table 9 - Reference Envelope Governing Conditions

Left Edge	Maximum Vessel Stern Surge Allowance
Bottom	Smallest Vessel, Fully Loaded, at Lowest Low Tide
Top	Largest Vessel, Fully Light, at Highest High Tide
Inside Edge	Smallest Manifold Setback
Outside Edge	Largest Manifold Setback plus Maximum Vessel Drift Allowance
Right Edge	Maximum Vessel Forward Surge Allowance

Table 10 can be used to collect the required data to develop the reference envelope. Some of this data can be generated from the Marine Engineering Section's **"Vessel-Log"** computer program; the site or affiliate's project team must supply other information.

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	Section	Page
		XXXI-F	15 of 53
		March, 2004	

Table 10 - Data Required To Develop Loading Arm Reference Envelope

Berth Data Required			
Elevation of Pier Deck			
Distance from Arm to Fender Face			
Environmental Data Required			
Highest High Water Elevation			
Lowest Low Water Elevation			
Ship Data Required	Minimum Ship	Maximum Ship	
Ship Size (DWT)			
Fully Light Freeboard			
Minimum Manifold Setback			
Minimum Manifold Height Above Deck			
Fully Loaded Freeboard			
Maximum Manifold Setback			
Maximum Manifold Height Above Deck			

ExxonMobil DESIGN PRACTICES	MARINE TERMINAL CARGO TRANSFER EQUIPMENT LOADING ARMS	Section	Page
		XXXI-F	16 of 53
		March, 2004	

6.3 EXAMPLE DEVELOPMENT OF REFERENCE ENVELOPE

Given:

	Minimum Ship	Maximum Ship
Size (DWT)	16,500	48,000
Loaded Freeboard (ft)	9.0	11.5
Light Freeboard (ft)	31.0	38.0
Distance Manifold to Rail (ft)	8 to 14	10 to 15
Manifold Height above Deck (ft)	4.5	5.0

Surge Along Pier = 10 ft in each direction

Drift Away From Pier = 10 ft

LLW Elevation = 0.0 (Reference Datum)

Elevation of HHW = 2.0 ft above LLW

Elevation of Pier Deck = 13.0 ft. above LLW

Loading Arm Setback From Fender Face = 15 ft