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Revision Memo

5/04 Highlights of this revision are as follows:

1. References have been updated.
2. Definitions have been expanded.
3. Fig. 15 updated



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SCOPE

This design practice subsection covers the offsites systems aspects of marine, tank truck, and rail car product loading systems for refineries and chemical plants. System planning and design procedures are presented, supplemented by component design considerations.

Specialized product handling systems such as pressurized LPG loading are covered in Subsection B. Pipeline movements of products are outside the scope of this section.

REFERENCES

DESIGN PRACTICES

[DP XIV](#), Fluid Flow

[DP XV](#), Safety in Plant Design

[DP XXII](#), Storage Facilities

BASIC PRACTICES

GP 03–11–01, Marine Cargo Transfer Hose

GP 03–11–02, Marine Loading Arms

GP 04–04–01, Marine Piers and Mooring Facilities

GP 09–07–01, Accessories for Atmospheric Storage Tanks

GP 15–04–01, Flow Instruments

GP 16–01–01, Area Classification and Related Electrical Design

API STANDARDS

API Manuals of Petroleum Measurement Standards.

API 1003, "Precautions Against Electrostatic Ignition During Loading of Tank Truck Motor Vehicles."

API RP 1004, "Bottom Loading and Vapor Recovery for MC–306 Tank Motor Vehicles."

OTHER LITERATURE

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25. Singapore Aromatics Project--Preliminary Report--SAC Marine Vapor Control Facility, May 2, 1994. Document Number: GER-046.
26. Port Jerome Benzene Vapor Control Study, June 5, 1990. Document Number: 90 EEEL 0518.
27. Screening Study for Hydrocarbon Emission Reduction during Loading Operations at the Esso Refinery; Rotterdam Refinery, June 1992. By H. C. M. Van Benthem. (No document number available).
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BACKGROUND

Product loading systems consist mainly of equipment to transport liquid products from storage tanks to loading areas, to load the products into product carriers, and to measure the amount of product loaded for billing purposes. Loading systems deliver product to marine, truck, and rail product carriers. Vapor collection systems collect displaced vapor and process it to comply with environmental regulations.

The basic modes of product loading are described and system design considerations and procedures are presented.

DEFINITIONS

(See also [DP XXII-A](#))

ARRIVAL PATTERNS

The distribution of vessel arrivals over a given period for a particular type of product carrier.

BOTTOM LOADING

The method for loading liquid into the bottom of a tank truck or railcar from ground level with a dry disconnect type fitting.

BUNKER FUEL

Fuel used to power a marine vessel.

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BUNKERING

The transfer of bunker fuel to a vessel's storage tanks. Commercial bunkering is the sale and transfer of bunker fuel to a ship calling exclusively for that service.

CUSTODY TRANSFER

A loading operation in which ownership of the product changes hands.

DARK PRODUCTS

Products composed primarily of residual stocks and generally classified as fuel oils.

DEAD MAN VALVE

A valve which closes unless manually held in the open position.

DEMURRAGE

The excess of actual vessel turnaround time over the allowed port time. Demurrage charge; a cost penalty associated with demurrage.

DWT (DEAD WEIGHT TONS)

A figure representing vessel displacement loaded, less displacement empty, expressed in 2240 lb. "long" tons. DWT indicates the weight that the vessel can carry including cargo, stores, and gear. Cargo weight is typically 85% of total DWT. Total ship displacement includes the weight of the ship and is greater than DWT.

FAST-TABLET II

A computer simulation program that is often used to evaluate alternative marine product loading configurations.

LIGHT PRODUCTS

Products composed primarily of distillate stocks and ranging from gasolines and naphthas to diesel oils.

LOADING ISLAND

The area on which is mounted the loading equipment (meters, control valves, loading arms, control equipment, etc.) necessary to load a tank truck. Islands can have single or multiproduct loading positions (spots) on one or both sides depending on the design.

LOADING RACK

The complete loading facility structure consisting of one or more truck or rail loading islands.

MECHANICAL DISPLACEMENT METER PROVER

A device for calibrating meters consisting of a cylindrical container (pipe) of known volume, a mechanical sealing element and two signaling detectors. The metered stream is diverted through the prover, displacing the sealing element past the signal detectors. Simultaneously the corresponding metered volume is indicated.

OCCUPANCY

The amount of time a loading location (such as a marine berth) is occupied, often expressed as a percentage of either total or available time. Berth occupancy includes not only pumping time but also includes the time required for maneuvering the vessel into and out of the berth, and the time required for product sampling and analysis prior to vessel departure from the berth.

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OPERATING ENVELOPE

The volume in space that contains all of the expected vessel manifold positions during the cargo transfer. For marine loading, this volume must include ship manifold location variations due to differences in ship sizes, ship load on board, water level (tides), and allowances for surge and sway. The surge and sway allowances typically used are 10 ft(3m) each for the forward direction, backward direction, and drift away from the face of the berth. For truck loading it must include bottom manifold or top dome location variations due to differences in trucks as well as an allowance for truck position variations.

POSITIVE DISPLACEMENT METER (PDM)

An in-line device used for measuring the volume of product transferred. PDM's mechanically isolate the flowing liquid into segments of known volume.

PRE-SET (SET-STOP) VOLUME OR WEIGHT CONTROL

Automatic feature which stops a loading operation when a programmed volume or weight has been loaded.

PRODUCT DEMAND PATTERN

A tabulation distributing calendar day product yields over the various modes of product shipping. This tabulation should reflect variations over time, if any.

RESIDENCE TIME (RELAXATION TIME)

The time it takes liquid leaving a filter to reach the receiving vessel at the maximum flow rate of the system. During this time a reduction in electrostatic charge, or relaxation takes place.

SORTING HUMP

Elevated section of track that permits rail car sorting without the yard engine entering the marshalling yard.

SPLASH FILLING

The method of top loading product into a tank truck where the fill pipe extends only partially into the product compartment, leaving a vapor space between the end of the fill pipe and the liquid level. This results in much splashing, considerable vapor emissions, and generation of static charge in products with low electrical conductivity (static accumulators).

SPURS

A section or sections of track not on the main railroad line.

STRIPPING

The removal of the heel from a ship's compartment at the conclusion of an unloading operation. Stripping may also include the removal and transfer to the ship of product remaining in a loading line. Although not common, stripping is usually done with special pumps.

SURGE PRESSURE

Transient pressures in long lines resulting from rapid changes in flow.

TOP LOADING

The method for loading liquid into a tank truck or rail car via hatches on the top of the carrier. Open top loading is the insertion of the fill pipe loosely through an open hatch. Closed Top loading involves a vapor-tight fit between the fill pipe and the hatch and is used when vapor recovery is used.

TURBINE METER

An in-line device used for measuring the volume of product transferred. Turbine meters consist of a rotor that senses the linear velocity of a flowing stream. The moving fluid imparts a rotational velocity to the rotor that is proportional to flow rate.

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TURNAROUND TIME

The start to finish elapsed time for loading product onto a ship, rail car or truck. This time includes not only pumping time but time spent at the loading dock/rack for other reasons such as hose connect/disconnect and document clearance.

Note: Definitions of other terms used in this section but not covered here are covered in [DP XXII-A](#).

MODES OF PRODUCT LOADING

MARINE

Marine product loading is most commonly conducted over a conventional pier or jetty with the product vessel moored to the fixed structure. Other less common installations include breasting islands, multiple buoy berths and single point moorings. Choice of the type of facility depends on local conditions, sizes of vessels, and cargos to be handled.

Vessels arriving for product can be company-owned, leased or independent, and can range in size from small barges (less than 1000 DWT) to large tankers (100,000 DWT and greater). The local affiliate is relied upon to establish fleet characteristics for planning and design of new or expanded marine loading facilities.

The number of berths and loading rates are based on economics. Vessel waiting charges (demurrage charges) supply the incentive for increasing marine facilities investment and reducing ship turnaround times. Pumping rates vary widely depending upon target vessel turnaround times. These in turn depend upon ship size, tidal constraints, and other local conditions.

TANK TRUCK

Tank trucks are loaded at island-type racks. In general, a rack is equipped with several islands, each of that has loading positions (spots) on one or both sides. Each loading spot is generally equipped with several product loading arms, a vapor recovery connection, and metering and electrical grounding equipment.

In the past, most terminals were designed for top loading - generally through a top opening dome using a metal loading arm ([Figure 1](#)). However, due to emission regulations bottom loading is used extensively in the U.S. and Canada and is becoming more common in Europe. Bottom loading offers numerous advantages over top loading. It increases safety by eliminating the need for personnel on top of the truck, and reduces fire risk due to splashing and vapor emissions. It also decreases turnaround time, spillage, vapor emissions, and loading rack investment. A dry-break type disconnect coupling is used between the truck and the loading arm which allows quick and safe connection and disconnection without the loss of product.

The truck fleet can consist of company-owned vehicles, hired trucks and/or independent haulers. Total truck capacities vary from 1,500 to 15,000 gallons (6 to 57 m³), the average within ExxonMobil ranging from 4,000 to 13,000 gallons (15 to 49 m³). The vehicles are generally divided into 2 to 6 separate compartments, but can be equipped with more.

The number of loading spots and loading rates provided for a particular location are based primarily on minimizing vehicle waiting times to within acceptable limits during periods of daily peak operation, and on maintaining rack occupancies within recommended ranges during longer duration peaks and average operations. Pumping rates are often in the 500 to 800 gpm (30 to 50 dm³/s) range and turnaround times are usually about 15–20 minutes.

RAIL CARS

Rail cars are loaded at single or double-sided racks with one or more spots per side. Top loading is the standard loading position in the U.S. and Canada with metal loading arms or telescoping arms inserted through top-opening domes. However, pressurized rail cars are loaded through other positions in other regions. In Europe, some rail cars are loaded through a position that is midway between the bottom and the side centerline. Bottom loading also exists in other regions.

Most rail cars are leased from rail car companies, however, some rail cars are company-owned. The cars usually have a single compartment with average sizes ranging from 7,500 to 30,000 gallons (25 to 113 m³). In Europe, LPG rail car size has been increased to the 20,000 gallon (75 m³) range.

Loading rack configuration and rates are selected to handle the anticipated daily peak load of cars. Efficient car handling is also required since railroad charges for switching/moving rail cars is a major cost factor. Turnaround times are often set by the Railroad based on contractual requirements.

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DESIGN CONSIDERATIONS

A typical loading system consists of a pumping installation, a loading control system, a method for product measurement, a loading arm for tie-in to the product carrier and vapor emission control facilities if required. In addition, a physical structure, e.g., a pier or loading rack, is required to accommodate the product vessel or vehicle and downstream equipment associated with the loading operation. Tankage is a major component of the overall product movement system. Tankage sizing criteria are given in other sections of these Design Practices ([DP XXII](#)). Product shipping facilities are also sometimes used for blending, mixing or inter-tank transfer operations requiring tie-ins between blending and shipping. The design considerations that follow deal with various aspects of these components.

For existing refineries and chemical plants, the emphasis of planning and design work is to identify the means of accommodating throughput or product slate changes without having to add an additional pier or berth. The relatively high cost of marine structures requires that alternatives such as loading rate increases, loading system reconfigurations (additional lines, increased line size, simultaneous product loading, etc.), and larger shipping parcel sizes be investigated prior to considering additional piers/berths.

LOADING CONTROL SYSTEMS

[Figures 2 and 3](#) show several possible control systems.

Normally the loading pumps are started manually, either locally at the pump pad and/or remotely at the loading location. Automatic pump cut in on low pressure can be provided when two or more pumps per product are specified. Rail and truck loading facilities may also provide more than one pump per product in which case the control system described above would be provided.

Low flow protection is usually provided for loading pumps to maintain flow above the minimum continuous requirement of the pump. The protection can be provided in several ways:

- Low flow cut-out (with time delay if loading can involve intermittent flow).
- Recirculation line with flow controller or restriction orifice sized to maintain minimum pump rate.

A means of limiting the initial filling and final topping off velocities in the vessel and shore side loading systems to 3 ft/s (0.9 m/s) is necessary to avoid electrostatic charge accumulation when during initial loading, and hydraulic surge at shutdown. It will also minimize vapor generation and the chance of overfilling the product carrier.

The methods of control for marine and tank truck/rail car loading are discussed below:

Marine loading at reduced rates can be accomplished in one of the following ways:

1. **Gravity flow**, which requires a bypass around the loading pump. Topography, i.e., relative elevations of storage tank and berth, must be suitable.
2. **Loading control valve**, the FCV in [Figure 2](#) and automatic pump recirculation. This device is mounted upstream of the loading arm and is operable from a remote location such as from the deck of the ship. Manpower savings and faster turnarounds may justify this approach over alternative 1.

Tank truck and rail car loading facilities are generally provided with a multi-purpose valve (FCV in [Figure 3](#)) which automatically performs flow rate control functions using signals from the meter and the preset. A two-stage valve is required in order to limit fill pipe velocity to 3 ft/sec (0.9 m/s) at the start and the end of the loading operation. This slower rate is necessary to avoid electrostatic ignition when initiating loading operations for a static accumulator and to avoid hydraulic surge problems prior to shutdown. The slow rate also minimizes vapor generation and the likelihood of overfilling the product carrier. The valve generally also performs the following functions:

1. **Pre-set volume/weight control** in conjunction with the meter/ weigh scale (refer to "Terminal Automation").
2. **Permissive loading control** to insure that the vehicle is properly grounded and a ticket is inserted in the printer.

Local and/or remote push-bottoms are provided to initiate the loading cycle and stop the operation in the event of an emergency.

After initial filling, the loading velocity may be increased. In order to avoid excessive turbulence, inlet (fill pipe) velocities are generally limited to a value of 64/d (English Units) or 500/d (Metric Units) where velocity is in ft/s (m/s) and pipe diameter (d) is in inches (mm).

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The pumps in all loading system designs should be evaluated for possible problems resulting from the low initial and final topping-off rates. High horsepower, high vapor pressure applications are the most prone to operating difficulties during these modes of operation. When excessively low flows can be imposed, an additional, smaller pump or automatic recycle back to the suction system should be provided.

The occurrence of hydraulic pressure surge is a function of line length and rate of change of flow. It is more common in long lines equipped with motor operated valves. It is controlled by increasing or staging valve closing time or adding gas pressurized surge vessels in the line. Additional information is contained in EMRE Report No. EE. 62E.86.

PRODUCT MEASUREMENT

Techniques of measuring parcel size fall into three categories - gauging, metering and weighing. For custody transfer operations, designs must comply with local regulations and the Corporate Measurement Guidelines for Custody Transfer.

Gauging

Manual ship or tank gauging is typically used for custody transfer in many locations. See Design Practice [DP 22B](#) for details of tank gauging.

Metering

Metering is the primary method used to measure tank truck and rail car product shipments. Although not a firm requirement, truck and rail loading systems often include small day tanks that isolate these systems from the overall product storage and marine loading system.

For marine shipments, metering is required if more than one product vessel is loaded simultaneously from the same product tank. In some locations, deduction of truck loading rack meter readings from tank level readings is acceptable in lieu of metering every stream leaving the tank.

Positive displacement (PDM) and turbine (TM) are the two types of flowmeters acceptable as primary measurement instruments for custody transfer of liquid petroleum products. They both typically provide volumetric accuracy at line conditions of $\pm 0.2\%$. The rangeability of a TM is typically 10:1 whereas PDM rangeability can be 30:1 and more.

TMs use a bladed rotor contained in a flow tube that is axially suspended in the direction of flow. As fluid passes through the tube, the rotor spins at a rate proportional to the fluid velocity. Blade rotation is generally detected by a sensor whose output is used to infer a volumetric flowrate.

A PDM divides the flowstream into discrete volumetric segments. A known volume of fluid is mechanically isolated in the meter and passed from inlet to outlet by the alternate filling and emptying of compartments. This process is usually translated into a rotary motion that operates a counter. Most PDMs are direct reading and do not require an external power source. Each segment of fluid volume passing through the meter is counted to yield a measure of total volume. Terms used to describe the type of PDM include rotating disk, oscillating piston, sliding vane, bi-rotor and oval gear designs. TMs infer a volumetric flowrate from a velocity measurement whereas PDMs do not measure flowrate but measure totalized volume directly.

Both PDMs and TMs can be used for products with viscosities lower than about 10cSt (mm^2/s). PDMs are normally selected for products with viscosities higher than about 10cSt (mm^2/s). PDMs with special clearances are the choice for metering very viscous products such as asphalt. Both types of meters are available for design temperatures up to about 500°F (260°C). For the same capacity, TMs have lower capital cost than PDMs.

TMs can be used for lower flow rates than PDMs but this characteristic is not important for product loading systems. TMs are available for capacities up to 40,000 gpm (2515 dm^3/s) and PDMs are available up to 9,000 gpm (565 dm^3/s). The need for parallel meters is limited to pipeline or marine loading applications. Both PDMs and TMs are available in standard sizes. Good practice is to select a meter such that the normal operating flow is about 70% of the specified maximum flowrate.

TMs are relatively small in size and lightweight whereas PDMs are relatively large and heavy. For revamp projects, plot space and foundation requirements require consideration, particularly for large meter capacities.

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TMs can register incorrectly and become damaged by over-speeding as a result of loss of backpressure. One vendor recommends 25 psig be used as a minimum TM backpressure. PDM backpressure is not as critical as that of TMs but they can cavitate. In both cases, the designer should check backpressure conditions with meter vendors or an instrumentation specialist. The pressure drop across the meter should also be obtained from meter vendors. For planning purposes, a pressure drop of 10–15 psi (69–104 kPa) can be assumed.

Both types of meters contain moving parts that are subject to mechanical wear especially for products contaminated with abrasive particulates. Strainers and possibly filters are therefore required upstream of both types of meters. If the loading system is susceptible to air entrainment, an air eliminator is required upstream of the meter.

PDMs require little or no upstream and downstream piping runs. TMs require upstream and downstream straight piping runs of 5 to 10 diameters. In addition, straightening vanes are often included within the upstream piping run for TMs.

Temperature measurement is part of the metering system as this is required to convert meter readout at the operating temperature to a standard reference temperature.

Generally, TMs are equipped with electronic pickups and pulse counting systems. PDMs have traditionally been supplied with mechanical readout systems. However, PDMs equipped with all–electronic accessories and readouts minimize meter maintenance and improve meter performance. Electronic readout systems are also compatible with microprocessor equipment that can perform a wide variety of control and data reporting functions. Most meter vendors offer microprocessor-based packages as part of their meter supply.

TMs, if allowed to operate at very low flowrates, will stop registering whereas this is not the case for PDMs. For this reason, TMs should be applied in conjunction with reliable electronic register/preset systems that offer protection against “meter milking” (unauthorized removal of product from the loading system).

Meter design specifications should include the following information:

- Properties of the liquid to be metered - viscosity, density, vapor pressure, contaminants, corrosiveness, and lubricity.
- Operating flow rates - normal, minimum, and maximum.
- Operating temperature - normal, minimum and maximum.
- Type of meter and accuracy requirements over the intended flow range.

Periodic proving is required when meters are used for custody transfer. Four types of provers are available. These are:

- Pipe provers - both unidirectional and bi-directional.
- Compact or Low Volume provers
- Master meter provers - both positive displacement and turbine meters may be used for this service.
- Volumetric tank provers.

In selecting a prover, the most important consideration is the capability to prove the meter over its full range of operating conditions (viscosity, temperature, etc.). Other factors to take into account are:

- Number of meters, location, and accessibility.
- Time, manpower, and personnel skills required for proving operations.
- Applicability of portable versus stationary provers.
- Government regulations and contractual requirements.
- Environmental and industrial regulations.

All provers should be located as close as possible to the meters. Manifolding can be provided to allow calibration of a number of meters with a single prover or a single high capacity meter with two or more provers. In these cases, the provers must be flushed and alternative routes or pump back facilities must be provided for the downgraded products.

An instrumentation technology specialist should be consulted for additional details and requirements for meter provers.

Weighing, rather than volume measurement by metering, is sometimes used to measure product shipments in rail cars. In addition, weigh scales are often used to measure tank truck shipments of some special products such as sulfur, asphalt, and bulk solids such as petroleum coke. The purpose of a weigh scale is not only to measure the weight of product for billing purposes but to insure that the road and rail systems are not being overloaded by the product carrier.

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Both static and in-motion weigh scales are available. In-motion weighing of coupled rail cars is commonly practiced in the coal industry for shipments involving 100 car or more unit trains. For the large majority of refinery and chemical plant weigh scale applications, uncoupled static rail car weighing is acceptable.

The design parameters associated with static weigh scale specifications are as follows:

- Dual use (truck and rail) or single use - the high cost of weigh scales indicates dual use wherever possible.
- Tank truck and rail car fully loaded weights - sets scale capacity.
- Physical dimensions of trucks and rail cars and wheel loads - sets vendor's design of weigh bridge and layout of scale approach and departure ramps.
- Desired accuracy (generally expressed as % of full load capacity) and precision (generally expressed in absolute units - pounds, tons, etc.).
- Pitless (low profile) or pit type of scale - Pitless type is less expensive, generally is of lower accuracy than pit type, eliminates safety concerns of large pits, and is acceptable for most refinery applications. If a pit-type of scale is required to insure a highly accurate system, the pit should be provided with a fan to prevent the accumulation of hazardous vapors. In addition, the pit will probably require a sump pump.
- Extent of desired scale automation - weight documentation only, pre-set control of product to be loaded, etc. Availability of electronic load cells for weighing in combination with microprocessor technology have created a very wide range of automation options. The justification for automating the weigh scale system should be decided on a case-by-case basis based on Owner review.

Weigh scales, where used for custody transfer, are under the jurisdiction of local Weights and Measures authorities. These authorities have very specific requirements which must be adhered to both during the weigh scale system design and during operations (such as scale calibration requirements, maintenance, and frequency thereof).

LOADING ARMS

Marine loading operations are conducted with all-metal loading arms or flexible hoses. Although loading arms are higher cost than hoses, higher loading rates, safer operation and increased life are the primary factors responsible for a trend away from flexible hoses to hard piping. When comparing the costs of hoses and loading arms, facilities for handling and storing hoses must be considered since these represent a substantial portion of a hose system cost. For guidelines on the mechanical specifications of hoses or metal arms for marine service, consult an EMRE marine specialist. Refer to [DP XV-J](#) for guidance on safety features for loading arms and hoses used in marine loading operations.

Loading arms generally include several segments of pipe (riser, inboard and outboard segments) with swivel assemblies at the joints and at the ends. The arm acts as a mechanical linkage with many degrees of freedom which enable it to reach the manifolds of the different vessels expected and to accommodate vessel movement. The arms are frequently counterweighted and provided with other devices, such as cables, pulleys, or hydraulics, to assist movement.

Selection of number and size of arms for a given berth depends upon the number of products which can be loaded simultaneously, the number of products which can be handled in a common arm, and loading rates.

Normally a sufficient number of arms are provided to enable a vessel to simultaneously load the maximum number of products, limited by vessel manifolding and manifold spacing. Most tankers have three or four independent piping systems. Product barges can generally load up to three products simultaneously.

When both light and dark products are handled at a berth, it is necessary to install separate arms for each product class or to use common light/dark arms (see "Manifolding and Loading Arms").

The velocity through a loading arm should preferably be limited to 30 ft/s (9 m/s) and this criterion should be applied for sizing. Higher velocities can cause excessive vibration and stresses.

Actual test data on the specific type of arm to be employed should be used to establish pressure drop. When this is unavailable or the type of arm is unknown, pressure losses can be approximated by expressing the entire loading arm in terms of equivalent length of steel pipe. Typical arm pressure drop at full flow is approximately 10 psi (70 kPa). A typical ship rail pressure should be 15 to 20 psi (105 to 140 kPa)

Loading arms can be engineered for sizes up to 24 inches (600 mm) diameter. Manual operation is generally possible with arms up to 8 inches (150 mm) diameter depending on the arm length. Winches or hydraulic assistance are needed for larger sizes.

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The counterweighted arms are generally balanced in the empty condition. Following a transfer operation, the outboard leg is drained to the tanker and the inboard leg to a sump at the pier. A vacuum vent at the apex of the arm is employed to insure complete drainage. Provision must be made to pump the contents of the sump to slop or crude tankage for reprocessing.

Purge systems employing an inert gas under pressure are sometimes used to drain the loading arms following the transfer operation. Advantages over simple gravity draining include a faster and more thorough operation, a reduction in the risk of spills and positive flushing even if the apex is lower than the loading arm heel. The loading arms should be purged to the vessel, if purging is done to the shore tank gas pockets can accumulate under the tank's floating roof and potentially sink the floating roof.

Range controllers are also often included. These consist of devices to monitor ship movement and detect excursions outside the loading arm design envelope. The system can be instrumented to alarm and even shut down the loading operation when safe limits are exceeded.

Tank truck and rail car loading can either be from the top or bottom.

Most rail car, and many truck loading operations are done through a top opening dome or hatch. All metal arms are recommended for top loading applications. The spring-balanced, pantograph-type metal arm ([Figure 4](#)) is generally preferred over the bulky and less maneuverable counterweighted type. The loading valve is located at the base of the inboard arm so that most or all product is drained to the truck, or rail car thus allowing the arm to be stored empty.

For top loading installations, it is common to provide individual loading assemblies dedicated to one side of the island. Although this requires two sets of assemblies for each product, the additional investment is offset by the increased operational efficiency, particularly where high truck or rail car volume is anticipated. In some situations though, it may be desirable to provide a common assembly serving both sides. If this is the case, the arm selected must be capable of 360° rotation and the layout of the platform and loading equipment must enable such rotation without interfering with the arm movement. Also, for invoicing purposes, a side select switch connected to the automation system may be required at the base swivel joint to indicate on which side of the island the product is being loaded.

Hose loaders and "A" frame loaders ([Figures 5 and 6](#)) are the two basic arm choices available for bottom loading operations. A hose loader configuration is recommended where three or more products will be loaded simultaneously and multiple crossover of the arms is required. Both of these bottom loaders are the wet-line type, meaning that they are stored filled with product and must be balanced accordingly.

Truck loading arms are normally 3 or 4 inches (80 or 100 mm) diameter with 6 inch (150 mm) diameter arms available for specific applications.

Hose arrangements are often required for vapor recovery when emissions during loading operations must be collected.

Truck loading arms are generally restricted to a single service because of the high utilization factor and the small parcel sizes involved. Consideration should be given to providing common rail car loading arms for compatible products, to maximize the flexibility of a single spot.

Fill pipes on arms in static accumulator services should extend as close as possible to, and preferably contact, the bottom of the tank truck or rail car compartment being top loaded. The fill pipe should end in a 45° slice as an additional precaution against splashing and misting. In addition, for both top and bottom loading, provision should be made to ground trucks prior to loading and to provide time (typically a minimum of 30 seconds) between static generators such as some filters and the discharge tip of the fill pipe. Refer to the Safety Technology Manual TMEE073 for further discussion of the hazards associated with static accumulators.

Other accessories which should be considered are vacuum breakers to insure complete drainage, and lockup and lockdown latches, the latter item restraining the "jet" reaction to sudden pressure surges caused by pump cut-ins and cut-outs. When preset volume or weight control is not employed, a loading valve with a "dead man" feature should be provided to protect against overfilling. The valve should be of the shockless closing type to avoid hydraulic hammer.

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MANIFOLDING AND LOADING ARMS

Manifolding of light or dark products maximizes marine cargo transfer flexibility by permitting multiple products to be handled through a given loading arm. It may be necessary to drain common piping. The use of single, soft seat, double-face type block valves with integral body bleed generally provides adequate product segregation. Although flexibility has advantages, it also has the potential for increased incidents as a result of improper equipment lineups. This potential must be minimized through careful design and clear operating procedures.

When frequent and/or extensive draining is required, consideration should be given to a stripping system to pump the contents of arms and manifolds to the ships' compartments. The economic justification for stripping versus recycling through the ballast and/or crude systems depends on the cost of re-running product. A system with common manifolding is shown in [Figure 7](#).

When light and dark products are handled at the same berth, provision of a single arm for both services rather than multiple arms may offer investment savings although this is not a normal practice. Washing of the arm with a solvent such as naphtha may be required when switching from dark to light stocks. In addition, vessel turnaround time will be greater than for simultaneous loading with two or more loading arms.

MULTI-PRODUCT LOADING LINES

The cost of marine loading lines can often represent a substantial portion of the investment in loading facilities, particularly where long piping runs, pipe trestles or submarine lines are involved. In these instances reducing the number of lines and placing others in multiple product service may be justified by the significant savings obtained.

When line service is changed, line contents can be pumped to the tanker, back to tankage or slopped. The two basic methods of displacing the line are discussed below:

Direct interfacial contact, where one product is pumped behind the other. The amount of detectable interface contamination will depend upon how far the interface has traveled in the line (line length) and property differences between the two products. A rough estimate of the detectable interface contamination length in a line is as follows:

$$L_c = k(L)^{0.5}$$

where: L_c = Length of line with detectable contamination: ft(m)
 L = Line total length over which interface travels: Miles (km)
 k = constant as follows:

API Gravity Difference	50	25	10	2	1	0.5
k (FT/mile units)	300	260	240	170	130	90
k (m/km units)	72	62	58	41	31	22

The contaminated volume is equal to the volume of liquid contained in the contaminated line length. Additional information may be found on interface contamination in ER&E and Pipeline Research reports such as PLR-F-60-63.

Pigging, which employs an element at the interface, physically separating the two products. An intermediate propulsion fluid (inert gas, water or a third more compatible product) has also been used to reduce contamination. Although a pigged system can reduce the number of lines, it is more complex to operate and raises the risk of incidents. Historically, pigged systems have been used in cases involving very long lines and many products. In addition, these systems have been used where product specifications are tight and therefore have minimal tolerance for direct interfacial contact contamination volumes.

The following factors should be considered against the investment credit when evaluating the justification for common loading lines:

Interproduct Contamination - Direct interfacial contact will result in an operating cost debit for either product giveaway or reprocessing. Pigging may also require some interface flushing as a result of residuals remaining in the line.

Impact on Shipping - Use of common lines will impose restrictions on the loading of multiple products. Operating costs may be incurred as a result of increased vessel waiting time.

Investment debits for additional equipment required for the line clearing operation.

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LAYOUT OF THE LOADING AREA

Layout of the marine loading platform cannot be finalized until detailed engineering on piping, manifolding and other equipment has been completed. However, the final layout should consider the following requirements:

1. Piping, including blending, metering and pigging equipment.
2. Product loading arms, hoses and hose supports.
3. Vapor collection arms and hoses and associated equipment in the loading area: compressors, flame or detonation arresters, knockout/seal drums, etc.
4. Pumps and sumps associated with stripping, draining and washing the loading lines and arms.
5. Access platforms for valves, meters, etc.
6. Loading control house or operator's shelter.
7. Electrical equipment and shelters.
8. Fire fighting equipment.
9. Stores handling equipment.
10. Landing platform.
11. Ship gangway.
12. Bollards and quick release hooks.
13. Vehicular and personnel access.

Bulk loading and shipment of containerized products, e.g., asphalt drums, lube oil drums, LPG cylinders, etc, over a common pier should be avoided. The storage space and special equipment required for handling of containers restrict accessibility and interfere with the safety and operability of the bulk loading operation. A separate berth or pier in dedicated containerized shipping service is recommended. LPG is also frequently handled over a separate berth.

Layout of the truck loading area requires careful consideration of traffic flow. A smooth pattern of flow as the trucks progress through the area will promote safe and efficient handling of the trucks and minimize turnaround time.

[Figure 8](#) presents an idealized plot plan for a truck loading facility. The dispatching method may require trucks to stop at the office on entrance, exit, or both. Space should be allocated for a queue wherever stopping is required. Traffic patterns should not require crossing traffic as part of the normal flow.

The parking area should allow for easy movement of the trucks out of and into the normal flow of traffic. The path can be directed past a service facility to encourage use during the waiting period. The size of the parking area is generally based on the average anticipated waiting time during peak periods and terminal throughput. The morning queue at the start of daily operations should also be considered when establishing parking requirements.

A queue space at the entrance to the rack provides for sorting prior to entry. Ample approach space should be provided ahead of all rack positions so that the largest trucks can enter without backing up.

The loading racks consist of islands which usually provide loading on both sides for top-loaded operations and on one side for bottom-loaded operations (See "Loading Racks").

A separate truck park for loaded trucks is shown on the outgoing path. It is located there for safety and operational reasons.

LPG loading racks should be located a minimum of 150 feet (45 m) from main paths of traffic flow. Truck movements should not be permitted within this radius during an LPG loading operation, since this zone has a Division 1 area classification (see GP 16-01-01 for definitions of area classifications). Additional particulars on LPG loading are covered in Subsection B.

For other spacing criteria, refer to [DP XV-G](#).

A rail car loading layout can generally be broken down into the following functional plot areas:

1. Shipping and receiving spurs.
2. Sorting spur.
3. Marshalling yard.
4. Transfer and approach spurs.
5. Loading spurs and racks.