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1) Process Engineering Equipment Design Guidelines
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6) Distillation Equipment Supply (Random and Structured Packing, Trays)
7) Commissioning Assistance

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INTRODUCTION

Scope

Loading facilities are labor intensive (because of number of driving personnel) and vulnerable because of the potential for emission of vapors. It is the most likely source of accidents in a depot and hence particular attention needs to be paid to working conditions. To minimize the hazard of static electricity it is essential to ensure that the vehicle tank and loading equipment are at the same electrical potential. Ideally, the loading system should be able to fill all compartments of the vehicle without needing to move the vehicle.

The importance of bulk vehicle loading facilities as part of the total distribution complex must be fully realized when plans are made for the construction of new facilities, or the modernization and extension of existing arrangements. It is therefore necessary to examine the operation of the distribution system in order to optimize both its efficiency and the size of the loading facilities.

Product loading for volatile, organic, and petroleum products need special attention to minimize emission losses. Loading losses are the primary source of evaporative emissions from rail tank car, tank truck, and marine vessel operations. Loading losses occur as organic vapors in "empty" cargo tanks are displaced to the atmosphere by the liquid being loaded into the tanks.

General Design Consideration

The importance of bulk vehicle loading facilities as part of the total distribution complex must be fully realized when plans are made for the construction of new facilities, or the modernization and extension of existing arrangements. It is therefore necessary to examine the operation of the distribution system in order to optimize both its efficiency and the size of the loading facilities.

The objective must be to optimize the number of loading bays, and product loading spouts per bay, in relation to the overall distribution system, capital investment and operating expenditure.

1. The cost of own and Contractor's vehicles should be assessed for the time spent (vehicle standing charges) while:
   - Queuing for a loading bay;
   - Waiting for a loading arm while in the bay;
   - Being loaded in the bay.

2. For existing installations the traffic flow must be studied to establish the present arrival patterns of vehicles at the loading facilities and hence the peak loading periods. The types of delivery such as urban, country, and over long distances, will influence arrival patterns.

   Application of simple methods planning techniques to these operations will show whether efficiency can be improved by changes in:
   - Working hours;
   - Shift patterns;
   - Staggered starting times;
   - Night loading;
   - Dispatching and delivery systems;

Environmental Considerations

Environmental conservation is the policy of oil, gas, and petrochemical (OGP) industries to conduct their activities in such a way that proper regard is paid to the conservation of the environment. This not only means compliance with the requirements of the relevant legislation, but also constructive measures for the protection of the environment, particularly in respect of avoidance containment of spillages.

A. Vapor recovery system

The recovery of product vapors such as gasoline is of interest for economic, safety and environmental reasons. In most locations where bulk lorries are loaded, the total gasoline vapor emissions have not been considered a significant factor affecting the quality of the local environment. Nevertheless, at the design stage, system should be reviewed to see if it becomes necessary to install a vapor collection system return line for poisonous, hazardous and high vapor pressure products. [RVP > 0.34 bar (abs)]

In addition, it is not safe to assume that the presence of a vapor recovery system will ensure a safe atmosphere within the tank truck compartments. When different vapor pressure products are being loaded using a common vapor recovery system, a flammable atmosphere may be introduced into the compartments. Such systems should be carefully reviewed to determine whether this hazard is significant at the particular facility.

However, it is essential to minimize the generation, and hence the emission of vapors during loading by eliminating the free fall of volatile products and reducing jetting and splashing. In areas where action has been required by National authorities to minimize vapor emissions at loading facilities, bulk vehicles may have to be filled with a closed vapor system; this entails the following modifications to loading arrangements:

i. Top loading

As the majority of loading facilities in service are top loading, the best solution would be to replace (or modify) the existing loading arms so that when volatile products are loaded, the manhole is sealed and vapors are diverted into a vapor return system. The latter may be either integral with the loading arm or a vapor manifold on the vehicle connected to all the tank compartments which would be similar to the system of bottom loading.

ii. Bottom loading

Bulk vehicles equipped for bottom loading require a pipe connection from the vapor emission vent of each compartment into a vapor recovery manifold, which should terminate in a position which is easily accessible from ground level for use at both the loading bay or retail outlets as required. The coupling connections for liquid and vapor must be different types.

B. Reduction of vapor emissions

Apart from installing a full vapor recovery system, considerable reduction in vapor emissions can be achieved by avoiding free fall and splashing of volatile products in top and bottom filling operations, as follows:

i. Top filling:

The loading arms should be designed to reach the end compartments of a vehicle tank in such a manner that the down pipe can penetrate vertically to the bottom of the compartment. However, the downspout should not rest “full circle " on the bottom. A “T " deflector or a 45-degree bevel should be used on the end of the downspout. If a deflector is used, it should be designed to prevent the downspout from lifting off the tank bottom when flow starts.

ii. Bottom filling:

Bottom loading minimizes the possibility of electrostatic hazards that could result from improper bonding or positioning of the downspout in top loading. However, in the initial stages of bottom loading, upward spraying of the product can increase charge generation and should be prevented by reducing the filling velocity and using a spray deflector or other similar device.

Such measures have the following advantages:

- Minimizing the hazard of static electricity;
- Minimizing the amount of vapor formation;
- Reducing product losses;
- Reducing the fire risk: the concentration of vapor emanating from the compartments will be dissipated faster to below the explosive limit.

C. Spillage control

The main items to be considered at the loading facilities are provision of:

- Emergency shut-off valve to prevent or reduce spillage due to overfilling, hose failure, etc.;
- Emergency push-button switch to stop the pumps, activate an alarm, and close all flow control and block valves on the island;
- Adequate drainage and interception arrangements.

Health and safety

Loading facilities are labor intensive (because of number of driving personnel) and vulnerable because of emission of vapors. It is the most likely source of accidents in a depot and hence particular attention needs to be paid to working conditions.

To minimize the hazard of static electricity it is essential firstly, to ensure that the vehicle tank and loading equipment are at the same potential. This should be arranged by providing a bonding interlock system connecting the vehicle tanks to the downspout, piping or steel loading rack flow-control valves. If bonding is to the rack, the piping, rack, and downspout must be electrically interconnected. Bonding is usually achieved by means of a bond wire. Grounding the loading system (i.e. rack, piping and downspout) in addition to bonding provides no additional protection from electrostatic ignition. Grounding of metallic loading rack components, however, may be necessary for electrical safety. Secondly, maximum safe flow rates in the loading system should be considered.

Loading systems

Ideally, the loading system should be able to fill all compartments of the vehicle without needing to move the vehicle. The spacing between loading systems at the loading island should allow the loading arms or hoses to be operated independently, without interference between each other, or meter heads, and with minimum obstruction of access for the operator.

1 Choice of loading system-top or bottom. The first criteria for selection of loading system is the volatility characteristics of the product. If RVP (Reid Vapor Pressure) of the product at 38°C is higher than 0.55 bar (abs) in summer or 0.83 bar (abs) in winter then bottom loading shall be used.

2 The second aspect is the requirements to restrict emissions from a specific product which dictates to use bottom loading.

The relative merits of top and bottom loading system are summarized in Table 1.

Table 1. The Relative Merits of Top and Bottom Loading

	BOTTOM LOADING	TOP LOADING
Safety Features		
Worksite	Ground level	On platform. Can be made safe by provision of guard rails and access ramps to vehicles, but at extra cost.
Vapor emissions (no vapor recovery)	Closed manhole covers gives rise to small pressure build-up to operate the vents resulting in marginally less vapor emission.	Open manhole covers therefore slightly greater vapor emission.
Control of product flow assuming meter preset does not work	Reliance on overspill protection equipment.	Positive visual control by loader assuming 'hold-open' valve is correctly used. Two-arm loading requires overspill protection when the conditions are the same as for bottom loading.
Product handling equipment	Arms and particularly hoses filled with product are heavier to handle. Generally, hose diameters should be limited to DN 80 (3 inches).	Care is needed to ensure that the down-pipe of loading arms is correctly positioned in each compartment. DN 100 and DN 150 (2 and 6 inches) diameter counterbalanced arms are easily handled
Electrostatic precautions	Flow rates restricted to 75% of that for equivalent top loading system.	

Environmental Conservation		
Vapor recovery (loading bay)	Vehicles must be fitted with a vapor recovery manifold connecting each compartment; of sufficient capacity to cope with simultaneous loading of 2, 3 or 4 compartments.	Each product loading arm must be fitted with a vapor sealing head so that vapors are diverted into a vapor recovery system; either (a) on loading arm, or (b) manifold provided for gasoline deliveries to retail outlets. Care must be taken to position collar seal in fill opening. Liquid level sensing equipment must be fitted on loading arms or in each vehicle tank compartment
Vapor recovery (service stations)	Vehicles already equipped with vapor return manifold for use when loading.	Vehicles must be fitted with vapor return manifold.
Performance		
Preparation for loading (normal)	Removal of caps and connecting couplings is contained within small operating envelope. (No significant difference between systems)	Greater area of operation because of positioning of manhole covers. (No significant difference between systems.)
Preparation for loading (vapor return)	Additional coupling connection to vapor manifold. (No significant difference between systems.)	Care must be taken to position arm/vapor head in fill opening. (No significant difference between systems.)
Loading arrangement	Simultaneous loading of 2 or more compartments more easily	

	arranged.	
Product flow rates	25% slower per compartment than equivalent top handling system because of electrostatic hazard in certain filling operations.	
Costs		
Capital costs	1. Approximately 17% more loading space is required than that of an equivalent top-loading gantry. Additional cost for greater roof area. 2. i. All vehicle compartments must be fitted with loading dry-break couplings. ii. To minimize over-filling risk, vehicles must be fitted with liquid level sensing equipment. iii. Deflectors must be fitted to foot valves to minimize jetting and turbulence. iv. Additional product handling equipment on islands. Depending upon by group's requirements, this may be about 30-50 more.	Additional structure and safety equipment for working platform.
Maintenance Costs	The additional equipment above will require to be maintained / replaced. Out-of-service time of vehicles for maintenance may be increased.	Maintenance of working platform and safety features

Constraints		
Vehicle accommodation	Can more easily accept range of vehicle capacities and heights (present and future).	Less flexible than bottom loading arrangement
Compatibility with competitors and Contractors vehicles	All vehicles likely to use loading bays must be fitted with suitable equipment. Industry agreement to adopt similar practices should be encouraged	More flexible
Compartment outlets full or empty	Possible need to persuade authorities to change law to permit outlet pipes filled with product, otherwise drainage must be arranged with consequent measurement and operational problems.	No problem.
Sophistication	Less flexible operation. Increased maintenance. Need for greater control of maintenance	More flexible operation.

DEFINITIONS

Ballast - For ships: water taken onboard specific tanks in ships to permit proper angle of response of the vessel in the water, and to assure structural stability.
For mobile offshore drilling rigs: weight added to make the rig more seaworthy, increase draft, or sink it to the seabed. Seawater is used for ballast, but sometimes concrete or iron is used additionally to lower the rig's center of gravity permanently.

Ballast Water - Seawater, used for stable navigation when added to the cargo tanks and ballast water tanks of empty tankers.

Barrel - A quantity of 42 US Gallons (34.97 UK Gallons). The traditional unit of measure of oil volume. $1m^3$ oil = 6.29 barrels of oil

Berth occupancy time - Total time, during which a tanker exclusively uses the occupation surface area around the berth, amounting to the total of time given below including loading/unloading time. Berth occupied time consist of Berthing time, Loading/unloading time and De-berthing weighting time and De-berthing time.

Berthing time - Loading/unloading waiting time plus De-ballasting time

Bunker 'C' - A heavy residual fuel oil obtained as a result of distillation of crude oil, and used as fuel primarily for marine steam generation.

Cargo pump - Pump used for loading/unloading and its driver

Cargo Tank - Tank to store oil in tankers. Cargo tanks are specifically structured according to oil conditions such as temperature and pressure.

Casing - Steel pipe placed in an oil or gas well as drilling progresses to seal the well and to prevent the wall of the hole caving in during drilling, to prevent seepage of fluids, and to provide a means of extracting petroleum if the well is productive. A number of casing strings (lengths) are used in decreasing diameters.

Closure - Four-way (all round) closure or seal is necessary, over the top and down the gradients on the sides of a potential reservoir, before it can trap or retain hydrocarbons.

Closure may be structural as in an anticline, or may be partly due to an impermeable fault, or stratigraphic trapping or e.g. salt intrusion.

Crude Oil - An unrefined mixture of naturally-occurring hydrocarbons. Because it is essentially a mixture, the density and properties of Crude Oil vary widely. Light Crude normally has an A.P.I. gravity of 30° or more. Gravities of 20° to 30° include the medium gravity crudes, while those below 20° are known as Heavy. Heavy oils are found right down to the residual solid state. See Section 8. Sour crude has a significant sulphur content; Low sulphur crude is described as sweet.

Dead Weight Ton (DWT) - Transportation Capacity, which includes weights of fuel, foods, water, and ship articles, in addition to cargoes directly, affecting the transportation capacity. Where high pressure LPG tankers are used, high-pressure tank weights appear to be also included in the DWT.

The ratio of cargo weight to DWT, which is different between coastal tankers and tankers for export, is generally calculated as follows.

— Coastal tanker (Oil): Cargo weight = 0.9 * DWT
— Coastal tanker (LPG): Cargo weight = 0.6 * DWT

Tanker for export: Cargo weight = 0.9 to 0.95 * DWT

Derrick - A large load-bearing structure, usually of bolted construction.

Downstream - “Downstream” is a relative term (the opposite of “Upstream”) in oil industry operations. For instance, a refinery is “downstream” of a crude oil production unit, and a petrochemical unit, and a petrochemical plant usually downstream of a refinery. The term has also come to mean all operations occurring after the delivery or lifting of saleable quality crude or gas from the production unit or associated delivery terminal

Downtime - A period when any equipment is unserviceable or out of operation for maintenance etc.

ESDV - Emergency shut down valve – an automatically operated, normally open valve used for isolating a subsea pipeline.

Flammable Liquid - An ignitable liquid with a flash point below 100°F.

Free Water - Water present in a tank, which is not in suspension or dissolved in the petroleum. Free water may be gauged with the innage gauging procedure.

Gantry - A framework on a loading island, under or besides which one or two loading bays with some articulated loading arms/hoses are arranged.

Hazardous Area (location) - An area where volatile gases or substance exist or may exist and only certified electrical equipment can be used and where a ‘permit to work’ situation exists.

Hydraulic Seal (Liquid Seal) -A vessel, which holds a solution of water and glycol through which the vapors must pass on their way to a vapor destruction unit

Inerted - The oxygen content of vapor space in a tank vessel’s cargo tank is reduced to eight (8) percent by volume or less.

Liquid Knockout Vessel - A device, which prevents the accumulation of liquids in the vapor system

Loading Arm/Hose - A piping or hose arrangement for filling in a truck.

Loading Bay - An inlet for trucks to stay under product loading.

Loading Facilities - Facilities consist of pumping and filling installations.

Loading Island - A raised area over which loading arms/hoses and related facilities are installed.

Loading/Unloading Time - Period of time, during which oil is loaded or unloaded between a tanker and the storage facility.

Spout - An outlet for loading through an arm or a hose, identical with "loading point".

Tanker Size Distribution and Standard Tanker Size - The structure of a berth is designed so as to withstand berthing energy and to secure the required depth of the water by establishing a design tanker size. What size tankers will use the berth at what rate? This is called “tanker size distribution”.

Working hours before/after loading/unloading - Berthing time and Loading/Unloading time.

NOMENCLATURE

d_w	Number of working days per week.
L_L	loading loss, pounds per 1000 gallons (lb/10^3 gal) of liquid loaded
M	molecular weight of vapors, pounds per pound-mole (lb/lb-mole)
n_1	Number of simultaneous loading.
n_d	Number of truck per spout per day
N_d	Total number of trucks per day.
N_s	Number of spouts
P	true vapor pressure of liquid loaded, (psia)
q_1	Loading capacity per spout, in (m^3/h).
Q_a	Average product rate, in (m^3/d).
q_p	Product pumping rate, in (m^3/h).
S	a saturation factor
T	temperature of bulk liquid loaded, °R (°F + 460)
t_1	Loading time per truck (filling only), in (min)
T_1	Total loading time per truck, in (min).
t_d	Working time, hours per day.
t_p	Preparation time of a truck, in (min).
V_a	Average truck capacity, in (m^3).
V_T	Specific truck capacity, in (m^3).

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