KLM Technology Group
#03-12 Block Aronia,
Jalan Sri Perkasa 2
Taman Tampoi Utama
81200 Johor Bahru
Malaysia

PROCESS DESIGN OF LOADING AND UNLOADING FACILITIES FOR ROAD TANKERS

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Project Standards and Specifications covers minimum requirements for process design and engineering of loading and unloading facilities for road Tankers in OGP Industries.

It should be noted that the scope of this Standard is limited to liquid applications and road tankers only. Furthermore in this manual the unloading part is limited to probable discharges of the products remaining in the tankers that arrive for loading.

This manual forms part of a series that may be developed ultimately to embrace all facilities connected with bulk loading and unloading of road vehicles, rail tank wagon and on-shore facilities for loading/discharging of water bore craft.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. API (American Petroleum Institute)

API RP 2003	"Protection Against Ignitions Arising Out of Static, Lighting and Stray Currents"
API MPMS	"Manual of Petroleum Measurement Standards", "Loading Rack and Tank Truck Metering Systems"

2. BSI (British Standards Institution)

BS SP 3492	"British Standard for Road and Rail Tanker Hoses and Hose Assemblies for Petroleum Products, Including Aviation Fuels"
BS 5173	"Methods of test for rubber and plastics hoses and hose assemblies Part 102: Hydraulic pressure tests Section 102.8 Pressure impulse test for rigid helix reinforced thermoplastics hoses"

3. NFPA (National Fire Protection Association)

   NFPA 70 "National Electrical Code"

4. Text Book

   NIST HDBK 44 7th Ed. ,2007 "Specifications, Tolerances, and other Technical Requirements for Weighting and Measuring Devices"

DEFINITIONS AND TERMINOLOGY

Filling Installations - Facilities for truck loading from entering time up to leaving.

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

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.

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

SYMBOLS AND ABBREVIATIONS

SYMBOL/ABBREVIATION	DESCRIPTION
DN	Diameter Nominal, in (mm).
d_w	Number of working days per week.
HVP	High Vapor Pressure.
LNG	Liquefied Natural Gas.
LPG	Liquefied Petroleum Gas.
LVP	Low Vapor Pressure.
n_d	Number of truck per spout per day.
N_d	Total number of trucks per day.
n_l	Number of simultaneous loading.
N_s	Number of spouts.

OGP	Oil, Gas and Petrochemical.
RVP	Reid Vapor Pressure.
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).
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).

UNITS

This Standard is based on International System of Units (SI) except where otherwise specified.

TRUCK LOADING AND UNLOADING

Loading

1. General

   This Standard Specification is limited to provision of, process design of new facilities for loading of bulk road vehicles at normal installations for different products. For this reason, the designs shown include features which will not be necessary in all situations; and when new facilities are planned it is recommended that the simplest facilities that will efficiently perform the filling operation should be constructed. These requirements can also be used for the modernization and/or extension of existing loading facilities for road tankers.

   Specifying the yearly average loading capacity, the size of tanker and loading assembly may be fixed and pump capacity will be calculated.
   It should be noted that in case there is freedom in tanker size and/or loading assembly then economical evaluation shall be considered for such selections.

2. Loading facilities in the context of the overall distribution system

   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 latter are an integral part of the distribution system and should not be studied in isolation; changes in the system and/or operating procedures can have a considerable effect upon vehicle loading requirements. In this context 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.

Firstly, 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.

Secondly, 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;

The objective being to improve utilization of existing facilities and of the existing road transport fleet.

For new installations the above information may not be available. In such cases an operational system must be established in which the various factors mentioned are carefully considered in relation to practice in the local industry, and in consultation with the designers.

3. Environmental conservation

   a. It is the policy of 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.

b. 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 described in (ii) below.

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.

c. 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.

d. 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.

4. Health and safety

   a. General

      Loading facilities are labor intensive (because of numbers 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.

   b. Static electricity

      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. See NFPA 70.

      Secondly, maximum safe flow rates in the loading system should be considered.

5. Loading systems

   a. General

      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.

   b. 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.

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

      Besides above mentioned limitations, 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 counter-balanced 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.

6. Control system

   a. Control of product flow:

      i) Filling by volume

      Measurement of product volume governs the amount of product filled into each compartment and this is normally arranged by flow through a positive displacement meter.

      However, truck loading racks were designed for use with displacement meters, however, technological advances and blending applications have encouraged the introduction of other meter designs such as turbine and Coriolis meters. When retrofitting existing displacement metering systems with turbine and Coriolis meters, care should be taken to ensure proper application of these technologies. At a minimum, to ensure proper operating performance, meters should be installed according to manufacturers' recommended practices.

      Slowing down and stopping the flow is usually controlled by a preset quantity control device which represents the first line of control. In the event of any emergency, e.g., malfunction of the mechanism, or incorrect setting of the preset, etc. the possibility of a spillover occurs, and a second line of control is necessary. Methods of achieving this are as follows:

      - Top filling

        The fitting of a 'deadman control' in the form of a 'hold-open' valve also enables the operator-when filling through an open manhole-to watch the level of the product and to stop the flow immediately in any emergency. The valve operating lever (or control rod) must be located so that the filler can see the product in the compartments at high level, while avoiding the vapor plume emitted from the manhole. However, the temptation to tie the hold-open valves in the open position, has resulted in spillovers.

        This factor, together with the necessity for operators to stand on vehicles while fillings, has led to the increasing use of liquid-level control equipment as a positive secondary means of stopping product flow in an emergency.

        Where two or more compartments are required to be filled at the same time, liquid level control equipment is strongly recommended as a secondary means of stopping the flow of product.

        Access from the loading rack platform to the top of the truck is usually afforded by ramps, adjustable stairways, or platforms that are hinged to the side of the loading rack platforms and can be swung down to the top of the truck. A handrail should be provided for the safety of truck loaders standing on top of the truck or platform.

- Bottom filling

  With all loading operations at ground level, and vehicle manhole covers remaining closed, the use of an overfill protection system based upon liquid-level detection equipment becomes essential. The system shall be equipped with a preset device to shut off the flow of product after a predetermined amount has been metered. Also, an overfill shutdown system shall be provided in case too large a volume is entered into the preset device or the vehicle compartment is not empty immediately before loading starts.

  The liquid-level control equipment should be linked into an interlock system which covers bonding of the vehicle, and access to the products by means of controls on the loading arms. This enhances safety and provides the basis for an automatic control system.

ii) Filling by mass

Where the weighbridge is positioned at the loading bay, the filling can be controlled by a preset mechanism operating in two stages before cutting off at the total loaded mass. Only one compartment can be loaded at a time with this method. The requirement of secondary protection against overfilling is met:

- For bottom loading; as above.
- For top loading: use of a 'hold-open' type valve on loading arm with operator standing on gantry platform (NOT VEHICLE) in a position to observe compartment being loaded. For single (or large compartments) it may be desirable to fit liquid-level control equipment if the driver/loader has other things to do on the loading platform.

b. Automation

i) General

An interlock system whereby product will not flow unless and until:

- The vehicle is properly earthed or bonded;
- The loading arm is in its correct position.

Measurement of product flow into vehicle compartments should be through a positive displacement meter. This enables systems to be