MANUAL

# LOADING FACILITIES FOR BULK ROAD VEHICLES

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**DESIGN AND ENGINEERING PRACTICE**

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**APPENDICES**

# 1. INTRODUCTION

## 1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design of loading facilities for bulk road vehicles for common white and black oil products. This DEP may also apply to other hydrocarbon and chemical products such as bitumen and solvents, however the Principal should be consulted for such applications. This DEP clarifies the design issues and describes the hardware required but it does not cover detailed design or engineering.

This DEP is a revision of and replaces a set of four earlier DEPs: DEP 31.06.11.11-Gen., DEP 31.06.11.12-Gen., DEP 31.06.11.13-Gen. and DEP 31.06.11.14-Gen., all dated January 1982.

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This DEP is intended for use in oil refineries, supply/marketing installations, chemical plants, gas plants and, where applicable, in exploration and production facilities.

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## 1.3 DEFINITIONS

### 1.3.1 General Definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

### 1.3.2 Specific definitions

**Air eliminator**

A device installed in a petroleum piping system to separate free vapour to a specified level from a flowing product stream, and discharge the separated vapour either automatically or by manual venting.

**Bay**

(1) Each side of a top loading gantry at which road vehicles can be filled at both sides.

(2) Alongside the island of a bottom-loading facility.

**Bonding**

The connecting together of metal parts to ensure electrical continuity.

**Bottom-loading envelope**

The positioning of road vehicle adapter connections as recommended by API RP 1004.

**Bulk road vehicle**

A tank or other container mounted on a road-going chassis that is towed or self-propelled and capable of carrying petroleum products in bulk.

**Class I, II, or III petroleum products**

The method by which a petroleum product is classified for storage and handling by its flash point temperature. Class I products have a flash point below 21 °C, Class II products between 21 °C and 55 °C inclusive, and Class III products above 55 °C - refer IP-Part 2 and IP-Part 3.

For road transport vehicle specifications, reference should be made to national standards.

**Common black oil products**

Class III oil products such as heavy fuel oils and residual fuel oils.

Not included in common black oil products are:

- Bitumen;
- Contaminated products (e.g. with free water, particle matter, $H_2S$).

**Common white oil products**

Gasolines, kerosenes, gasoils and distillates of oil products with a viscosity (unheated) of less than 20 $mm^2/s$ and a Final Boiling Point of less than 385 °C (e.g. white spirits, toluene).

Not included in common white oil products are:

- Contaminated products, e.g. with free water, particulate matters, $H_2S$;
- Products with true vapour pressures above 0.86 bar (12.5 psi), e.g. LPG, pentanes;
- Toxic or lethal products, e.g. benzene;
- Chemicals, e.g. ketones, alcohols, ethers, MTBE.

**Flame arrestor**

A device used in gas vent lines to prevent the passage of flames into enclosed spaces.

**Foot valve**

The valve fitted at the outlet of a road vehicle tank compartment and sometimes referred to as an emergency valve or bottom outlet valve.

**Gantry**

The structure associated with a product supply system and provided with all equipment necessary for loading and safe access for road vehicles.

**Hose loader assembly**

A system of pipe, swivel and hose connection for bottom loading.

**Loading area**

The collective area embracing all filling islands and bays but excluding vehicle waiting areas.

**Loading arm**

A system of pipes and swivels which is balanced for easy movement, and through which product is transferred from the supply pipe into a vehicle tank.

**Loading island**

The area on which the equipment necessary to load a vehicle is mounted, e.g. meter(s), control valve, loading arms, hose loaders, control equipment etc. Islands may be designed for multi-product or single product loading.

**Loading terminal or facilities**

A combination of one or more loading bays or gantries, including additional facilities such as parking areas, waiting lanes, dispatch office, social amenities, and the product and utilities supply piping, from the point at which it enters the loading area.

**Meter pre-set control**

A device or system which controls the quantity of incoming product loaded into a compartment of a road vehicle, sometimes called primary level control.

**Occupancy ratio**

That proportion of any particular period for which the loading bay is in use for loading vehicles.

**Overfill protection**

A system which is installed in addition to the meter pre-set control and is designed to cut off flow if the product rises above a predetermined level in the compartment of the vehicle tank being filled. The equipment comprises sensors in the form of thermistors or float-controlled reed switches, solenoid or air-operated flow-control valves etc.

**Static electricity**

An electric charge on a non-conductor or poor conductor, often caused by mechanical friction (e.g. product flow in a pipe).

**Ullage**

The depth of free space left in a tank above the liquid.

**Vapour**

One or more of the components of petroleum when in the vapour phase.

**Vent**

A device for the release of vapour or air from pipes, tanks, or fittings, and for the entry of air.

**Vent lines**

A piping system for the transfer of vapour or air to or from pipes, tanks, or pipe fittings, e.g. air eliminators.

**Working platform**

The area of the gantry structure from which the person loading the vehicle from the top operates the meters, loading arms etc., and from which access is gained to the top of the vehicle tank.

### 1.3.3 Abbreviations

COPS Cross Over Protection System

ESD Emergency Shut Down

MTBE Methyl Tertiary Butyl Ether

| | |
|---|---|
| NRV | Non-Return Valve |
| PD | Positive Displacement |
| VOC | Volatile Organic Compound |
| VRU | Vapour Recovery Unit |

## 1.4 CROSS-REFERENCES

Where cross-references are made, the number of the section or sub-section referred to is shown in brackets.

All publications referred to in this DEP are listed in (10).

# 2. BASIC DESIGN OF A LOADING TERMINAL

## 2.1 GENERAL

In the design of a loading terminal the total cost of loading vehicles should be minimised. The costs of the loading terminal include:

a) Capital charges for the loading facilities (e.g. gantry, structures, pumps, lines, automation system, VRU etc.)

b) Manpower costs for the administration and surveillance of the loading activities.

c) Maintenance costs of the loading facilities.

The above costs should be balanced against:

d) The cost of vehicle time while occupying the loading bay and while queuing for a loading bay (vehicle standing charges).

e) The customer relation problems arising from vehicle queuing.

The size and cost of the loading facilities largely depends on the demand during peak hours/periods. Changes in operating methods which may have a considerable impact on demand or terminal throughput during peak periods should therefore be considered during the design phase. Examples of such changes are:

- Vehicle capacities.
- Shift patterns, including staggered starts and pre-loading. In this context the method of operation can be single or double shift patterns, or 24-hour service, or a combination of these.
- Improvements in vehicle marshalling (e.g. traffic control systems).
- Changes in the operation of outlets/service stations which allows a reduction in peak demand.

Where new loading facilities are being planned, discussions should be held with the Sales organisation about possible changes in operations at delivery sites/service stations. Changes like unattended deliveries, late night deliveries and deliveries on Saturday could reduce the peak requirements of the distribution operation, thus reducing the investment in gantries and vehicles.

Having established the likely future pattern of vehicle arrivals during peak hours (2.2), different loading options should be developed and costed, e.g. top or bottom loading (3.3), different loading flow rates (2.3), or simultaneous loading using two or more arms/hoses (2.4). Having chosen the most cost-effective option, the number of loading bays (2.5) and the allocation of loading arms/hoses to the bays can be determined (2.6) and the pump capacities can be calculated (2.7).

## 2.2 PEAK DEMAND

Any loading facility should be designed to meet the forecast loading demand during peak periods. A statistical analysis of historical figures should be the starting point, but the effects of planned improvements in methods and loading equipment, and any changes likely to occur in working hours, shift patterns, vehicle sizes, variations in growth rates of different products, requirements for additional or fewer grades etc., shall be taken into account.

To calculate the facilities required, it is necessary to determine the peak period demand for each grade. If product grades are loaded in different types of vehicles or in multi-grade vehicles the peak period demand of each product should be broken down further in "cargo combinations". "Cargo combinations" are defined as combinations of types of vehicles and product grades for single product cargos and combinations of types of vehicles and mixtures of product grades for multi product cargos. The reason for this breakdown is that different "cargo combinations" have different loading rates and may need different types of loading bays.

As product volumes are normally forecast on a yearly basis, it is usually necessary to establish ratios between:

(i) The demand in the peak month of the year and the average monthly demand.

(ii) The demand in the peak day of the month and the average daily demand.

(iii) The demand in the peak hour of the day and the average hourly demand.

Where higher than average demands for one product during certain months coincide with lower than average demands for another product (i.e. seasonal demand variations), savings in the total number of loading bays may be possible. Loading facilities could be re-allocated between these "counterbalancing" grades, provided that the pumping capacity is available to meet the maximum requirement for each of the grades involved. In such a case the monthly demand pattern over a complete year should be considered, and the results of calculations for the number of loading arms and bays should also be shown on a monthly basis.

## 2.3 LOADING FLOW RATES

### 2.3.1 Determination of loading flow rate

Flow rates are restricted by the economic size of pumps, piping and measuring equipment or by the hazard of static electricity, (see 2.3.2).

High loading flow rates reduce time spent by a vehicle at a loading gantry, resulting in the following:

(i) A reduction in vehicle idle time, i.e. standing charges.

(ii) A reduction in the bay occupancy time, which could reduce the total number of loading bays required.

On the other hand the additional costs for pumps, larger bore piping, loading arms, flow meters and other equipment, together with increased energy consumption, shall also be taken into account.

The product flow rate of 3 inch systems will normally be limited by the flow meter capacity at around 1250 l/min. The product flow rate of a 4-inch system will normally be limited by the static electricity hazards (2.3.2) to 2500 or 1800 l/min.

For bottom road loading, a 4 inch system should be employed, see (3.5.1).

### 2.3.2 Maximum flow rates due to static electricity hazards

Static electricity is generated during loading. When non-conductive liquids (e.g. common white oil products without anti-static additive) are loaded static electricity may build up, resulting in sparks.

Therefore if a flammable atmosphere may be present (e.g. when loading flammable products and/or when switch loading is applied) the loading velocities shall be limited to:

a) Bottom loading with central conductor (e.g. dip tube):

$v * D < 0.5\ m^2/s$ and $v < 7\ m/s$

(e.g. 1800 l/min for 3-inch and 2500 l/min for 4-inch systems)

b) Top loading and bottom loading without central conductor:

$v * D < 0.38\ m^2/s$ and $v < 7\ m/s$

(e.g. 1400 l/min for 3-inch and 1800 l/min for 4-inch systems)

In which v is the velocity in m/s and D is the internal pipe diameter in metres. D should normally be the diameter of the smallest section upstream of the tank being filled, however, if the smallest section is less than 10 m long and has a diameter of at least 67% of the next smallest section, the diameter of the next smallest section may be used.

If contaminated non-conductive liquids are loaded the loading velocity should be limited to 1 m/s. Contaminated liquids are mixtures of substantially different products or liquids containing gross amounts of free water or dirt (i.e. more than 0.5% volume of free water and/or more than 10 mg/l of suspended solids).

For liquids with a conductivity of more than 50 pS/m, no loading velocity restrictions apply for static electricity reasons, however the loading velocity should still be limited to 7 m/s.

For more information refer to the Shell Safety Committee publication "Static Electricity, Technical and Safety Aspects".

### 2.3.3 Nominal loading rate

The normal high flow rate of the facilities will be achieved only during part of the loading time. The remainder of the time will be used for entering the bay, setting the flow meters, connecting the loading arms/hoses, starting to load at a low flow etc. The figure required for further calculation is the nominal loading rate, which is defined as follows:

$$\text{Nominal Loading Rate} = \frac{\text{Total Quantity Loaded } (m^3 \text{ or tonnes})}{\text{Total Time the Vehicle Occupies the Loading Bay } (hr)}$$

Examples of nominal loading rate calculations are given in appendix A.4. The best way to determine nominal flow rates is to use historical data from other terminals and to correct this data for variations in the number of compartments, compartment volumes etc.

The nominal loading rates depend on:

- the type of vehicle which is loaded (size and number of compartments);
- the combination of products which are to be loaded;
- the number of hoses/arms which can be used simultaneously;
- the product flow rate.

## 2.4 SIMULTANEOUS LOADING USING TWO OR MORE ARMS/HOSES

Considerable benefit can be achieved by using two or more loading arms or hoses simultaneously to load a vehicle. The additional cost of meters or loading arms etc. is usually more than offset by the savings from reduced vehicle time in the bay, and by a reduction in the number of loading bays required.

For bottom loading, it is advantageous to have several loading arms per bay to allow simultaneous loading of multi-compartment vehicles.

For top loading, the simultaneous use of two or more arms will result in the need for additional equipment to prevent overfilling which may otherwise not be necessary see (4.5.1). The cost and other consequences arising from such equipment shall be taken into account in the economic comparison.

## 2.5 CALCULATION OF NUMBER OF LOADING BAYS

### 2.5.1 General

It is important to determine the optimum number of loading bays for new loading facilities, or for modernised and extended facilities, because this directly affects capital costs of the facilities on the one hand, and operating costs of the vehicle fleet on the other.

Depending on local circumstances the design of loading facilities should distinguish between two design concepts:

(i) the 'morning peak period' design concept;

(ii) the 'waiting time' design concept.

### 2.5.2 The 'morning peak period' design concept

If vehicles queue outside the gate waiting for the installation to open in the morning, the loading facilities should be designed on the basis of a virtually 100% occupancy of the loading bays during the first morning hours, which is the 'peak period' in this case. This method usually applies to installations serving a 'home based' fleet.

The demand in this 'peak period' has a considerable effect on the size of the final arrangement and hence must be ascertained by consulting local staff. If all waiting vehicles have to be loaded in one hour (resulting in an average waiting time of half an hour for those vehicles which cannot be served at once) the loading facility will be twice as large as one where all the vehicles have to be loaded in two hours (resulting in an average waiting time of one hour for those vehicles which cannot be served immediately).

During the rest of the day vehicle arrivals will be essentially random, the occupancy will fall and the average waiting time per vehicle will usually be shorter than during the peak period. If bay occupancy and hence average vehicle waiting time remain quite high outside this peak period, the 'waiting time' design concept should also be applied.

### 2.5.3 The 'waiting time' design concept

If the arrival of vehicles is irregular the design procedure should be based on a specified maximum average waiting time per vehicle. Such is the case, for example, in terminals operating 24 hours a day, or in terminals which try to spread the working load as evenly as possible over the working day. In such cases, vehicles will not arrive at exactly the required time intervals to ensure that all loading bays are occupied 100% of the time; periods frequently occur when bays are empty, or when all are full with vehicles waiting. Clearly, the total waiting time at such an installation will decrease if the total number of available bays increases.

Techniques such as 'multi-server queuing theory' have to be used to determine the number of bays and corresponding bay occupation rates required to ensure that the desired average waiting time is not exceeded. Appendix B includes Tables showing average vehicle waiting time expectancy for various conditions, based on random arrival of vehicles.

### 2.5.4 Manual estimation of the number of loading bays required

The first step is the calculation of the 'peak period' demand; this is defined as follows for each method:

- In the 'morning peak period' method, the peak period demand is the offtake by those vehicles which queue outside the gate and which must be loaded in the first morning period (one or more hours).
- In the 'waiting time' design method, the peak period demand is defined as the offtake during (any) one hour in a period which has the highest vehicle arrival frequency. This period may be longer than one hour and can occur on more than one occasion in any one day.

The peak period demand for each product should be broken down into the quantities loaded into single-grade vehicles and those loaded in multi-grade vehicles. This breakdown in "cargo combinations" may require a further breakdown into quantities loaded into different sizes and types of vehicles. This may be necessary where vehicle sizes in a fleet are significantly different for each grade, or if different vehicles have significantly different loading rates, e.g. due to their ability or inability to be loaded with multiple arms.

2.5.4.1 "Morning peak period" design concept

The theoretical number of loading bays required to load the peak period demand of product or a "cargo combination" within the required maximum waiting period can be calculated as follows:

Theoretical number of loading bays

$$= \frac{\text{Peak Period Demand } (m^3)}{\text{Max Waiting Period (hr)} * \text{ Nominal Loading Rate } (m^3/hr) * \text{ Loading Bay Occupancy}}$$

As the road tankers queue in front of the gate the loading bay occupancy will be virtually 100% during the peak period. The loading bay occupancy ratio can thus be chosen as one (1).

The total theoretical number of loading bays can be obtained by adding the requirements of all the products and/or "cargo combinations". An example of a loading bay requirement calculation is given in Appendix A.5.

2.5.4.2 "Waiting time" design concept

In the waiting time concept the number of loading bays needed to satisfy the demand of a product or "cargo combination" is given by:

$$\text{Number of bays} = \frac{\text{Average Hourly Demand during Peak Period } (m^3/hr)}{\text{Nominal Loading Rate } (m^3/hr) * \text{ Loading Bay Occupancy Ratio } (-)}$$

In this formula, the loading bay occupancy ratio is defined as the fraction of the time the loading bay is on average occupied by a road tanker. The higher the chosen loading bay occupancy ratio, the greater the chance that when a road tanker arrives the loading bay is already occupied and the longer the average vehicle waiting time will be.

The Tables of Appendix B give this average vehicle waiting time as a function of the bay occupancy ratio, vehicle loading time and number of loading bays available for the cargo combination. The shorter the loading time and the larger the number of loading bays available for the product or "cargo combination", the higher the bay occupancy that can be chosen to achieve the same maximum average vehicle waiting time.

An example of a loading bay requirement calculation is given in Appendix A.6.

### 2.5.5 Major sensitivities

After establishing the total number of loading bays and arms, major sensitivities should be studied, in particular the effect of reducing the number of loading bays by one (or more) on the waiting time for all vehicles, and vice-versa, in order to ensure that an economic optimum for the whole system is selected. Also, the effect of changing shift patterns and/or otherwise evening out the distribution of vehicle arrivals during the shift should be considered.

### 2.5.6 Computerised design methods

The above manual method (or equivalent spreadsheets) should normally be restricted to relatively straightforward cases such as limited number of products and product combinations, and a small number of loading bays.

For larger loading facilities and more complex arrangements of products the loading facility should be simulated with a discrete event simulation tool, which enables major sensitivities to be checked (see 2.5.5).

## 2.6 ALLOCATION OF LOADING ARMS TO BAYS

For operational reasons, it is desirable to limit the number of loading arms at one gantry/loading bay to five. Allocation of loading arms should take into consideration the combination of products each tanker will carry so that tankers do not have to move from one bay to another during loading. Also, the product grouping requirement of (8.1.5) shall be taken in account.

The manual calculations (or equivalent spreadsheets) will show the gantry requirements per product. The number of loading arms for each product can be inferred from this; examples are given in Appendix A.5.3 and Appendix A.6.3.

## 2.7 PUMP CAPACITIES

### 2.7.1 Single loading arm

If only one product loading arm or hose is allocated for any product, a single pump rated for the maximum design flow rate of the loading system (meters, piping, loading arm/hose) should be provided.

### 2.7.2 Two loading arms

If two product loading arms/hoses are allocated for any product, a single pump rated for the maximum design flow rate of the loading systems for two arms/hoses, operating together, should be provided.

### 2.7.3 More than two loading arms per product

If more than two loading arms/hoses are allocated for any product, a reduced total pumping capacity can be provided to allow for the time when vehicles occupy a loading bay but product is being loaded slowly or not at all, i.e. at the begining or end of the filling cycle. By reducing the pumping capacity, the VRU and pipe work capacity can also be reduced.

The required pumping capacity in such cases can normally be calculated on the assumption that it should meet the maximum flow demand in 90% of all loadings.

The following calculation method can be used if all loading arms for a grade have the same probability of being used and if there is only one loading arm per grade in a bay. In other cases it could only be used for first estimations, and the actual required pumping capacities should be determined with numerical simulations.

First the probability "p" is calculated that a loading arm/hose is found at full flow and the probability "q" that a loading arm is found at zero flow:

$$p = \frac{\text{Full Flow Time } + \text{ Equivalent Full Flow Time}}{\text{Total Bay Time}}$$

q = (1-p)

In which:

| | |
|---|---|
| Total Bay Time: | Total time a road tanker spends on average in the bay, including driving into bay, setting meters, connecting hoses, filling etc. |
| Full Flow Time: | Average time during which the loading arm is on full flow during the time the tanker is in the bay. |
| Equivalent Full Flow Time: | Time during which product is loaded slowly, usually at the start or finish. However it is necessary to convert the time during which loading is at reduced flow to 'full flow' time, e.g. 2 minutes at 25% of full flow rate is equivalent to: <br> 25% * 2 = 0.5 minute 'equivalent full flow time'. |

If A loading arms in total are available for the grade, the probability f(n) that n loading arms or hoses will be loading at full flow for the product under consideration is:

$$f(n) = \frac{A! * p^{n} * q^{(A-n)}}{(A-n)! * n!}$$

The probability g(M) that M or fewer loading arms are loading at full flow is thus the following sum of probabilities:

$$g(M) = f(0) + f(1) + f(2) ...... + f(M)$$

To satisfy 90% of the loadings with a pump capacity for M loading arms, M should be chosen such that:

$$g(M) > 0.9$$

The required pump capacity is thus M times the design flow rate per loading arm.

The design of the system should be such that if the demand is higher than the pump capacity the pump-motor combination will not be overloaded. This can be achieved by choosing a suitable pump-motor characteristic. A second possibility is for the flow control system to reduce the maximum flows or limit the number of loading arms in operation.

NOTE: Irrespective of the outcome of such a calculation, the total pump capacity provided should not be less than that provided for one or two arms as outlined in (2.7.1) and (2.7.2).

# 3. ROAD VEHICLE LOADING SYSTEMS

## 3.1 INTRODUCTION

Two systems exist for the loading of bulk road vehicles: top loading or bottom loading.

In traditional top loading the product is loaded by inserting a loading arm from the top through the open manhole in the tank compartment of the vehicle.

In bottom loading the product is loaded by connecting the loading arm/hose to a dedicated self-sealing coupling at the bottom of the vehicle. The displaced vapours are evacuated via a second arm/hose connected to the vapour collection coupling at the bottom of the vehicle.

This Section describes the choice between the two systems and the construction details of the loading arms/hoses including the provisions for vapour collection. Typical flow schemes are also presented.

## 3.2 TYPICAL FLOW DIAGRAMS

Figures 3.1a and 3.1b give a typical flow diagram of a bottom loading installation. A fully equipped automatic system would include the following main elements:

a) Loading pump: pumps the product to the gantry to one or more loading arms, see (9.3)

b) Emergency Shut Down (ESD) valve: to isolate the system rapidly in an emergency, see (4.4.4).

c) Air eliminators: to eliminate air from the product (optional), see (4.3.6).

d) A filter: to ensure product cleanliness and to protect the flow meter, see (4.3.5).

e) The additive injection system, see (6.)

f) The flow meter, see (4.3).

g) A flow control valve: to control the flow, see (4.4).

h) The loading arm connected to a dry-break coupling, see (3.5 ).

i) The vapour return hose, see (3.5).

j) The overfill protection sensor: to give a signal if the road vehicle is overfilled, see (4.5).

k) The earthing connection (combined with overfill protection connection): to discharge the static electricity which is generated during loading, see (4.6).

l) The interlock system: to check if all conditions for safe operation are fulfilled (earth connected, no overfill, vapour return hose connected etc.), see (4.7).

m) Isolation valves: to make maintenance possible and to stop the product flow in emergencies, see (9.2.9).

n) Drains and vents: to empty the system in case of maintenance, see (9.2.6).

o) Meter prover connections: to connect a meter prover flow meter, see (4.3.4).

p) Relief valves: to protect the system against overpressure, especially against thermal expansion, see (9.2.10).

q) Temperature sensors, see (4.3.2).

r) Pressure point: to enable the connection of a pressure gauge, see (4.3.4)

The flow scheme of a top loading facility is similar, apart from the loading arm and the "dead man" valve, see Figure 3.1c.

Figures 3.2, 3.3 and 3.4 clarify the special symbols used for bulk road loading vehicle flow schemes.

## 3.3 THE CHOICE BETWEEN TOP AND BOTTOM LOADING

Historically, top loading has been predominant. The system is very flexible; almost any type of vehicle can be loaded through an open manhole and dedicated (often specific) couplings as needed in bottom loading are not required. The system is also relatively simple; the personnel can follow the loading operation through the open manhole and fill to a level indicator in the tank compartment. For bottom loading, level sensors are necessary.

However, increasingly the trend is towards bottom loading, due to environmental legislation on vapour emissions both at loading terminals and retail outlets. For example bottom loading is prescribed in the European VOC directive.

Bottom loading should be employed for solvents and common white oil products for the following reasons:

a) Safety and environment
   - Ground level operation (statistics show that top loading gantries are the source of many accidents involving personnel tripping and falling from the elevated working platforms);
   - Reduced exposure to hydrocarbons (e.g. benzene) due to vapour collection;
   - Effective vapour collection possible;
   - Reduced risk of fire/explosion (compartment sealed during loading).

b) Efficiency
   - Fast vehicle turnaround (multi-compartment loadings);
   - Cheaper gantry design possible;
   - No up/down and left/right arm interlocks necessary;
   - Clean operation (dry-break couplings).

c) Product Quality Assurance
   - Dedicated grade-selective couplings available (e.g. for aviation fuels)
   - Cross-over protection system available (COPS).

If changing over to bottom loading is considered, the following costs should be taken into consideration:

a) Vehicle conversion costs;

b) Vehicle recalibration costs, see (3.5.3);

c) Gantry conversion costs (bottom loading is a one-sided operation).

In order to minimise the cost of the changes, consideration should be given to combining a change-over to bottom loading with the introduction of loading automation, and vice-versa. The use of skid-mounted bottom loading gantries, as described in (8.3.4), should be considered.

A change-over to bottom loading should be planned on an industry-wide basis where practicable in order to avoid equipment compatibility problems.

Adequate notice of a proposed conversion should be given to vehicle operators.

Top loading should be employed for the loading of black oil and heated products and for locations where operating standards and maintenance would not allow any alternative.

## 3.4 TOP LOADING ARMS

### 3.4.1 Loading arms

A wide variety of loading arm configurations are available. The main points governing selection are:

- operation on one or both sides of the loading platform;
- loading of single or multiple product vehicles;
- loading rates;
- reach (design envelope) of the loading arm;
- accessories;
- whether vapour collection is required.

The two main types of loading arms that should be employed are:

(a) Articulated or Scissor type arms

Arms of this type are available with an operating radius between 2.5 and 5 metres, and in sizes between 3 and 6 inches; 4-inch is preferred. An example of a typical articulated loading arm is given in Figure 3.5.

Depending upon the configuration of the arms and allocation of products to the arm, a maximum hatch-filling span of 8.5 m can be covered by a single arm, see Figure 3.6.

Articulated or scissors-type arms cost about 25% less than boom types (excluding additional installation costs for boom support), are simpler to operate and maintain, and can be more easily used and stowed on either side of a loading gantry. These arms should be employed where the great reach of a boom is not required now or in the foreseeable future.

(b) Boom type arms

Four-inch boom type arms with an operating radius of up to 5.3 m (or even longer by special order) are available. They are suitable for loading multi-compartment bulk road vehicles which have widely spaced filling hatches.

The common types of booms are illustrated in Figures 3.7 and 3.8 and have the following main features:

(i) Top supported boom: only the outer arms can be used at both bays of the gantry (where more than two arms are fitted on any one gantry).

(ii) Base supported boom: if more than two arms are fitted, constructing adjacent arms at different heights allows all the arms to be used for loading at either bay.

(iii) Post supported boom: the loading arms can be used at both bays of the gantry in the same manner as base supported boom arms, but a greater difference in height between adjacent arms is required.

Where allowed, all the foregoing types of arm can be used to load two different but compatible products. This reduces the overall number of loading arms on a gantry.

If two or more loading arms are used simultaneously per bay, provisions should be made to secure the arms during loading.

The use of loading arms at both bays of a gantry shall be allowed for in any automatic interlocking earthing systems.

For small bitumen bulk loading installations a very simple telescopic loading lance may be used, see Figure 3.9.

### 3.4.2 Provisions to minimise product loss

To prevent evaporation due to splashing during loading of Class I and Class II products the loading arm or filling pipe shall be long enough to reach the bottom of the tank compartment to be filled. The loading arm should be provided with a T deflector at its lower end to divert flow from the vertical to the horizontal. The deflector should direct the flow to at least two opposite sides.

For Class III products, a straight filling pipe or drop tube of shorter length should normally be used so as to minimise clingage and drips.

A drip bucket shall be provided for each loading arm to collect drips when the arm is stowed after use; these will be emptied into the next vehicle tank compartment to be loaded with that product. Loading arms should be installed so that the contents of the arm downstream of the manual shut off-valve will drain into the filled tank compartment prior to stowing the arm. This may entail raising the height of the pedestal base flange.

### 3.4.3 Provisions for automation

See also (5) on automation and (4.7) on interlocks.

New articulated or boom type loading arms for automated top loading facilities should be fitted with the following detectors:

a) Arm left/right position detectors for arms capable of filling on either side of a gantry, in order for the automation and interlock system (e.g. earth and overfill) to interpret on which arm the meter is being used.

b) Arm/up down detectors, which allow automatic shutdown of the appropriate product flows in the event of the loading arm being raised.

The arm/up down detectors can also be used for traffic light and exit barrier control. While the loading arms are down the drive away traffic light will stay red and/or the exit barrier will stay closed.

### 3.4.4 Heating of loading arms

If heated pipelines have to be used, the pipework up to and including the final loading valve on the loading arm should be heated. Where heating is required it is generally economical and practical to use thermostatically controlled explosion-proof electric heating, at least for the facilities installed in the gantry.

For bitumen products, heating is generally required up to and including the final loading lance or drop pipe. For safety reasons, maximum temperatures for loading bitumen should not be exceeded (refer to the "Bitumen Manual").

### 3.4.5 Provisions for vapour collection

Where vapour collection is not yet required by regulations, new and/or modified loading facilities and new bulk loading vehicles should be designed for the appropriate equipment so that they may be easily converted at a later stage.

Effective vapour collection arrangements during top loading are difficult to implement: the loading arms tend to become bulky, the mechanical seal between the loading arm and the manhole tends to leak (especially if manhole diameters are not standardised), and product is lost during the opening and closing of the manhole and by evaporation from the wet loading arm after it is removed from the full compartment. Therefore vapour collection for top loading should not be employed unless required by local regulations and bottom loading cannot be adopted. For such cases the types of vapour collection arrangements for top filling are summarised below:

a) The loading arm is equipped with a vapour head/plug which seals the manhole during loading. The vapour-collecting piping/hose is directly connected to this head.

b) The loading arm is equipped with a vapour head/plug which seals the manhole during loading. One separate vapour offtake point is installed at a convenient location on top of the tank vehicle. The vapours from the different compartments are diverted into pipes connecting the tops of compartments to the central vapour manifold. This vapour return system fitted to the vehicle tank should be designed to minimise pressure build-up during loading (and an excessive vacuum during offloading).

c) The top loading hose/arm is equipped with a self-sealing dry coupling. On the top of each vehicle compartment a self-sealing dry coupling is installed connected to a fixed drop pipe. Vapour collection takes place as in option (b).

Where vapour collection from service station tanks is required, the delivery vehicle may be fitted with a vapour manifold connecting all compartments. In this case a closed filling arrangement based upon (b) or (c) above may be preferred to the more cumbersome combined loading/vapour collection arm.

Bulk road vehicles are normally not designed as pressure vessels and therefore are not built to withstand the maximum discharge pressure of loading pumps that may arise in the event of a failure of the overfill shutdown system or blockage in the vapour line. Each compartment shall therefore be fitted with a liquid relief system capable of handling the maximum loading flow rate so that the compartment cannot be pressurised beyond its normal working pressure. For the vapour collection arrangements (a) and (b) this can be achieved by a pressure relief arrangement which releases the manhole seal at typically 0.3 bar (ga). For option (c) this can be achieved by fitting a manlid which lifts against a spring once a pre-set pressure is exceeded.

For top loading with vapour collection, overfill protection is required as described in (4.5).

## 3.5 BOTTOM LOADING ARMS/HOSES AND COUPLINGS

### 3.5.1 Couplings

Couplers and adapters manufactured to a common standard can be connected up to one another irrespective of Manufacturer.

Liquid and vapour couplings for loading systems and vehicles should be in accordance with API Standard RP 1004 (or equivalent). This nominal 4-inch (101.6 mm) loading coupling system is widely used in the USA. and is prescribed in the 1994 VOC Directive of the European Community.

Figure 3.10 shows the standard 4-inch API liquid adapter on the vehicle to which the female loading coupler on the loading arm should be able to mate. This type of coupling system has the following important design features:

- No twisting is required on attachment (just push the coupler onto the adapter).
- The loading valve which forms an integral part of the coupler can only be opened when the coupling is securely fastened. This valve also opens the valve head on the vehicle adapter.
- Dry-break disconnection which minimises leakage.
- Grade selectivity is possible.

Figure 3.11 shows the standard MIL-C-27487A male 4-inch vapour adapter on the vehicle to which the female vapour coupler on the vapour collection should be able to mate. To avoid the possibility of connecting a product loading line to the vapour system the vapour collection coupling is provided with a cam and groove.

No widely accepted standards for nominal 3-inch (76.2 mm) loading couplings are yet available. If couplings of nominal 3-inch size have to be used similar provisions to those described in API standard RP 1004 should be applied.

Although operational reasons can justify the 3-inch size system, the 4-inch API system is generally preferred due to its higher loading rates and wide acceptance.

### 3.5.2 Couplings for aviation products

All aviation product grades should, wherever possible, be bottom loaded into dedicated single product vehicles equipped with product-selective couplers. Selective couplings shall not only provide selectivity between all aviation grades, but also prevent connection to non-selective couplings at the loading facilities.

Where this is not possible, the provisions of the Shell Aviation Quality Control Manual shall be rigorously followed.

### 3.5.3 Wet gallery lines and calibration

In bottom loading systems the loading gallery lines of the vehicle are left full of product after loading operations are completed due to the self-sealing dry-break couplings. Therefore vehicle compartments should be calibrated to include the volume of the piping.

There may be a need to persuade authorities to change the regulations to permit outlet pipes to be filled with product while on the road, otherwise drainage should be arranged with consequent measurement and operational problems (although foot valves protect against the product in the compartment being lost in case of an accident, some authorities nonetheless limit the percentage of product permitted in the gallery lines).

If bottom loading vehicles can also be used for top loading, only one compartment calibration is used irrespective of the method of loading. This will normally be the calibration which includes the wet gallery lines.

### 3.5.4 Loading arms and hoses

All bottom loading systems use either swivelling piping systems or a flexible hose system, or combinations of both, to make the filling connection and the vapour return connection between the bay and the vehicle. The available systems are described below:

(a) Hoses

A flexible hose is not practical for loading bulk vehicles with heated products, but for other products it is simple and cheap, readily available, easily installed and has low maintenance costs. However, it is too heavy to manhandle in any size over 3 inches when full of product, and even in 3-inch size the hose should be suspended or supported as much as possible to allow easier manhandling.

If the point of support is sufficiently high, good flexibility and reach can be acheived, with ease of connection to vehicle couplings, since most of the weight of the hose is supported from the overhead pipe. This system allows easy connection of up to three hoses simultaneously with system crossover.

(b) Combined hoses/pipes

A length of hose is used to make the final flexible connection between the coupler and the vehicle adapter, and a short length of pipe with the minimum number of swivel joints is used to provide support for the hose weight and increase the reach of the system (see Figure 3.12). Such a system provides a greater reach without increasing the manual effort needed, while keeping the system simple. Figure 3.13 shows an example of a mounting arrangement which facilitates crossovers.

A more expensive version, which further reduces the manual effort, is shown in Figure 3.14. This system is more suitable for use with 4-inch hose and couplings since most of the weight of the hose is supported at all times. It is designed for use where driveway area is limited.

Like the simple hose systems combined hose/piping loading systems are not practical for loading bulk vehicles with heated products.

(c) Balanced articulated loading arms

Loading arms were developed to reduce the manual effort associated with handling hoses, particularly 4-inch hoses. They provide good reach to cater for variations in vehicle coupling location, but to achieve the necessary movements in three planes a number of swivel ball joints together with balance springs or weights should be used, see Figure 3.15. This makes a loading arm rather cumbersome, and additional maintenance may be necessary to avoid product leakage from the joints.

By using different heights, balanced arms can easily be made to cross over one another. Figure 3.16 shows typical loading arms in service.

### 3.5.5 Coupling location and reach of loading arms/hoses

The loading system should be designed so that connections can be readily made for multi-compartment loading, with the liquid and vapour adapters being situated within loading envelopes based on national or international standards.

Figure 3.17 shows the envelope based on the IP Code of Practice for Bottom Loading Vapour Collection and Overfill Prevention.

### 3.5.6 Provisions for automation

In automated terminals proximity switches can be used to check whether loading arms are properly stored after loading. Only after all loading arms have been stored properly will the driveaway traffic light turn green and/or the exit barrier open.

A proximity switch can also be used on the vapour collection hose to check whether it is connected. However, it is preferable to install a switch on the vehicle in the overfill protection circuit so that no loading is allowed if the vapour connection is not made.

### 3.5.7 Provisions for vapour collection

Whether or not vapour collection is required by local regulations, new/modified loading facilities and new bulk vehicles should be designed to allow for the collection of vapour. Collected vapour should be vented to a safe location if a vapour recovery unit is not yet available.

When the terminal is operating at peak throughput, the loading gantry vapour collection system, including the vapour recovery unit, shall not generate a counter pressure at the vehicle side of the vapour collection adapter in excess of 55 mbar.

Bulk road vehicles are normally not designed as pressure vessels and therefore they are not built to withstand the maximum discharge pressure of loading pumps that may arise in the event of a failure of the overfill shutdown system or blockage of the vapour return line. Each compartment shall therefore be fitted with a liquid relief system, capable of handling the maximum loading flow rate, so that the compartment cannot be pressurised beyond its normal working pressure. This is normally achieved by fitting a manlid which lifts against a spring once a pre-set pressure is exceeded.

# 4. FLOW CONTROL AND INTERLOCKS

## 4.1 FLOW CONTROL SYSTEM

During the loading of a bulk road vehicle the flow should be regulated so that the required quantity and grade of product are loaded as quickly and safely as possible.

The filler/driver or automation system should pre-set the quantity to be loaded in the compartment in the flow control system. The loading system should measure the quantity loaded and stop the loading when the required quantity is reached. As this system could malfunction or the pre-set could be incorrectly set, the possibility of overfill remains and a second line of defence is thus necessary. The necessary overfill prevention measures are described in (4.5).

The product flow should only be enabled when all safety interlock conditions have been satisfied. The interlock system is described in (4.6).

The flow control system should start the loading operation with a loading rate substantially lower than the normal high flow rate of the loading system. The system should be regulated in such a way that the high flow rate is only achieved when the loading arm or deflector has been completely submerged. This will prevent splashing. This can be achieved by using a system with a two-stage flow control, with a low flow and a high normal flow. The loading rate of the low flow is usually set at between 20% to 25% of the maximum flow.

At the end of the loading cycle when the required loading quantity is almost reached the flow control system should reduce the loading rate. This will ensure that the pre-set quantity will be loaded with the required precision (normally within 3 or 4 litres). This can be achieved, as during start-up, by a two-stage flow control.

## 4.2 PUMP CONTROL SYSTEM

This system starts the pumps when product is demanded and switches the pumps off when product demand ceases or emergency conditions occur.

In its simplest form, manual on/off switches are activated by gantry fillers as and when they want products. The fillers often forget to switch off the product pump after filling the vehicles. Pumps left running against a closed head over a long period of time, without a spillback to the product tanks, are a potential fire risk because product will overheat. Prolonged running against a closed head will also seriously damage pump components. Therefore audio and/or visual warnings at the loading bays and preferably at the despatch office should be incorporated to warn the fillers/dispatchers of the status of product pumps.

In a sophisticated form, the electronic pump control system is interlocked with the gantry loading automation system whereby pumps are switched on in series based on product demand and only after certain safety conditions have been satisfied. The pumps are automatically stopped, either immediately or with a time lag, when there is no further demand for product. For a busy loading gantry, the number of start/stops per hour at peak period would be high. It is therefore essential to ensure that the motors of these pumps are selected for the duty expected. By allowing pumps to over-run for a short period after product demand has ceased (i.e. stopped with time lag), the number of starts/stops could be reduced. Hence cheaper and less heavy duty motors could be used.

The pump control system is an integral part of the gantry automation system and should be designed and engineered by specialist consultants/contractors.

Additionally the pump control system should be interlocked with the ESD system whereby gantry loading pumps will stop when an emergency switch or a fire/gas alarm is activated.

## 4.3 FLOW MEASUREMENT

### 4.3.1 General

The flow measuring system is the most important part of the loading system. No matter how sophisticated the gantry automation system may be, any error in metering will proliferate through the entire system.

The most commonly used flow meters in road loading systems are:

- positive displacement (PD) meters;
- turbine meters;
- Coriolis mass flow meters

For guidance on selection and installation, refer to DEP 32.31.00.32-Gen.

If the product is dispensed by weight, Coriolis mass flow meters are preferred to weighbridges.

### 4.3.2 Product temperature measurement

If product is dispensed by volume at standard temperature (normally 15 °C) the operating temperature shall be measured to calculate the temperature correction. Furthermore, for accurate stock reconciliation the temperature at which the product is loaded shall be measured.

Hydrocarbons have relatively high volumetric expansion factors:

| | | |
|---|---|---|
| e.g. | Motor Gasoline | 0.12 percent per °C |
| | Kerosene | 0.10 percent per °C |
| | Fuel Oil | 0.08 percent per °C |

It is therefore most important to measure the temperature as accurately as possible.

For this measurement Platinum Resistance Elements accurate to ± 0.2 °C can be used, inserted in a thermowell.

In countries where the ambient temperature can fall well below the product temperature, the thermowell can cause an artificially low temperature to be recorded unless adequate precautions are taken.

Each thermowell should therefore be installed on a pipe bend in order to achieve a greater insertion length, and also to provide adequate thermal insulation material around the assembly and the pipe.

### 4.3.3 Custody transfer requirements

Flow meters used at the points of sales (i.e. where custody transfer takes place) shall be approved for use by the local (Weights and Measures) Authority.

Traditionally, most countries have allowed only PD and turbine meters to be used for custody transfer applications. Recently, however, certain Government agencies have also approved Coriolis mass flow meters for this service. Where Coriolis meters are being considered, the local authority should be approached to obtain formal type approval.

Flow meters used for custody transfer shall be sealed in the presence of a representative from the local authority.

### 4.3.4 Meter proving

Meters, particularly those used for custody transfer, should be proved periodically to determine whether the indicated quantity in relation to actual quantity has changed as result of wear or other factors. Inaccuracies which have developed can be corrected by adjustment of the calibrating mechanism, or by use of a factor derived from the proving runs.

In meter proving, specified procedures shall be followed meticulously. The following general points are emphasised:

a) Generally, bulk meters are proved 'in situ' by one of the following methods:
   1. volumetric proving tanks;
   2. reference meters;
   3. mechanical displacement provers.

   For some applications, e.g. turbine meters used in multi-product pipelines, it is accepted practice to transfer a meter for proving at a central proving station.

b) Methods (1) and (2), using mobile proving equipment, are generally applied to road loading gantry meters. It is essential that a gantry be designed to accommodate and safely operate the proving equipment. This means that suitable stubs with double block and bleed valves should be provided for easy connection of a reference master meter. Alternatively it shall be possible to correctly position a mobile proving tank in order to achieve easy and safe filling and pump out the contents. The layout of the proving system shall also allow easy and safe access to sight glasses, thermometers, registers and scales for accurate measurement.

c) Meters should be proved under conditions of temperature, pressure and flow rate closely resembling those of actual operation.

d) Meters should be proved with products having a viscosity similar to those for which they are normally used.

e) When using proving equipment, there is always a chance of introducing air or vapour into the system. Air or vapour shall be eliminated before proving.

f) Since product and proving equipment temperatures and pressures have to be taken in account, thermometers and pressure gauges shall be available for accurate measurement.

g) Reference meters shall not be equipped with microfilters, in order to prevent static electricity generation.

h) Factors such as type of meter, product characteristics, severity of service etc., play an important part in determining the frequency of proving meters. Operating experience with the particular locations or applications should also be taken into account. However the following may be considered as a reasonable meter proving frequency for a road vehicle loading gantry used on low viscosity clean refined products:
   1. Immediately following installation.
   2. Within 3 months following initial installation.
   3. At intervals not exceeding 6 months following the previous proving, irrespective of the volume transferred during the intervening period.
   4. At intervals less than 6 months depending on the specific wear rate and the economics of product give-away.
   5. Whenever there has been any repair, adjustment or evidence of tampering which might have affected the calibration. Reproving is not required where alterations or repairs do not affect the meter itself.
   6. If the meter is temperature dependent, like turbine meters in high viscosity service (e.g. gasoil) or PD meters, meter reproving in accordance with the prevailing seasonal conditions (summer or winter) should be considered. Alternatively corrections for the temperature change may have to be made.

i) Standard national or internationally accepted equipment and procedures shall be rigorously adopted.

j) In the absence of clear national procedures, the guidelines given in the IP Petroleum Measurement Manual Part X (Meter Proving), or Petroleum Measurement Paper Number 4 “Code of Practice for the Proving of loading Gantry Meters” should be followed.

### 4.3.5 Filters/Strainers

The meter manufacturer's recommendations on mesh size should be followed.

Filters or strainers should be designed for easy cleaning without excessive draining of product. Valves should be fitted in the pipework to enable isolation of the filter/strainer for draining and cleaning, meter replacement etc.

If a filling facility has an underground tank for collecting slops/drains etc., the drains from the filters/strainers should be routed to this tank. A visual flow indicator should be fitted in the lines to show leakage from drain valves.

If aviation products are loaded, reference should be made to the recommendations for filtration given in the "Shell Aviation Quality Control Manual". If vehicles used for other products are also sometimes loaded with aviation products, either the loading lines for the 'other products' should be fitted with fine mesh strainers, e.g. about 180-mesh size 55 gauze, or preferably the vehicle tank, piping and equipment should be appropriately cleaned.

Where turbine fuels which do not contain an anti-static additive are loaded through a micro filter or filter water-separator, the residence time of the liquid in the line between the outlet of the filter and the receiving tank should be at least 30 seconds and the velocity of the liquid in the line should not exceed 3 m/s, see Shell Safety committee publication "Static Electricity, Technical And Safety Aspects".

### 4.3.6 Air eliminators

Air and vapour in product can result in damage and/or large measurement errors when PD meters or turbine meters are used.

Air eliminators (sometimes known as deaerators) need not be used if there is sufficient head in the supply tank to avoid air inclusion/vaporisation in the suction line and pump. However, many local authorities require air eliminators to be installed upstream of meters handling common white oil products. Even if this is not a requirement of the local authorities, space should be provided for future installation.

Figure 4.1 shows typical flow schemes for typical connection systems for air eliminators.

## 4.4 CONTROL VALVES

### 4.4.1 Manual product flow control valves

In traditional top loading a 'deadman control' in the form of a 'hold-open' valve should be provided. This enables the operator, when filling through an open manhole, to watch the level of the product and to stop the flow immediately in an emergency. The valve operating lever (or control rod) shall be located so that the operator can see the product in the compartments at high level, while avoiding the vapour plume emitted from the manhole.

### 4.4.2 Automatic flow control valves

The main function of the control valve is to:

a) prevent product flow until all safety interlock conditions have been satisfied, see (4.7);
b) provide a low flow rate start, see (4.1);
c) provide a controlled maximum flow rate so that the meter is not overloaded;
d) provide a controlled maximum flow rate to prevent static electricity hazards, see (2.3.2);
e) shut down the flow at the pre-set number of litres to go, see (4.1);
f) shut down the flow in the event of a safety interlock condition occurring.

This operation can be performed by a control valve which uses two solenoid valves and makes use of the process pressure to drive the valve open and closed.

At locations where dry air is available a conventional pneumatic control valve should be used (typical refinery terminals or large terminals).

For heated black oils, it is not practical to use valves which rely on the process pressure to operate them, because the small bore piping connecting the solenoid valves may become blocked. If dry air is available, a pneumatic control valve should be used for heated black oils. If dry air is not available, systems using an in-built hydraulic reservoir and pump should be considered.

In the design of the system the surge pressure due to rapid closure of the control valve shall be taken in account, see (4.4.5).

### 4.4.3 Flow-limiting valves

At non-automated loading gantries, flow-limiting valves shall be fitted on each of the loading arms because pump output is not controlled to match product demand. These valves are used to protect equipment against excessive flow rates, which can occur when only one loading arm out of several delivering similar product is used and more than the required number of pumps are running.

For loading gantries specially designed to control pump output, for example with automatic flow control valves, flow limiting valves are not necessary.

### 4.4.4 Emergency shutdown (ESD) valve

Although trip and shutdown systems are designed with great care and make use of fail-safe and self-checking equipment, the actual shutdown depends on the reliability of the final actuator, usually a control valve. Such is the case with road loading gantries, where the batch control valve is closed in the event of an ESD, usually by cutting the power to the solenoid valves.

However, there is always a possibility that the control valve may not close for some reason, such as:

- solenoid sticks in energised position;
- dirt causes a blockage in the small bore piping or in one of the restrictions;
- material such as a welding rod prevents the valve from closing.

Therefore the installing of an additional ESD valve at the main product header from storage to the gantry for each product should be considered. In unmanned terminals or other terminals with increased risk due to spillage (e.g. terminals in built-up residential areas or large terminals) an additional ESD valve shall be included.

In the design of the system the surge pressure due to rapid closure of the ESD valve shall be considered, see (4.4.5).

### 4.4.5 Surge pressure

4.4.5.1 General

Pressure surges in a line are created by a change in momentum of the moving stream, e.g. by the closing of a valve. The theoretical maximum pressure surge that can be created is that caused by an instantaneous total blockage of the flow and would occur at the point where the flow is stopped down, e.g. the valve. The maximum surge pressure is the sum of two components:

- the instantaneous pressure increase at the moment of total flow blockage;
- the subsequent gradual pressure rise due to the 'line packing' effect.

The piping system should be designed to allow for the maximum surge pressure expected, see DEP 31.38.01.11-Gen.

With manually-controlled valves, unacceptably high pressure surges can partly be prevented by the implementation of and strict adherence to well formulated and clearly written operating procedures. With automatic control valves this is not possible.

To reduce the maximum surge pressures and thus the design pressure of the pipe system the following measures should be considered.

4.4.5.2 Slow valve closure

By closing a valve over a sufficiently long period the surge generated may be significantly reduced. This can be implemented either by slowing down the valve actuator or by installing a two speed actuator which reduces the valve closure speed over the (critical) last 10-20% of the valve travel.

However, an overfill shutdown system or emergency shutdown needs quick response of control valves. A balance should be made between valve closure speed, the design pressure of the pipe and the ullage of the vehicle, see (4.5.5).

4.4.5.2 Valve characteristic

If a choice of valve characteristic is available as with conventional control valves (linear or equal percentage) then the equal percentage characteristic should be chosen since this will create less surge pressure shock in the event of an emergency shutdown.

4.4.5.3 Pressure relief systems

If the creation of an unacceptable pressure surge cannot be avoided by slowing valve closure, a pressure relief system can be installed as near to the point of surge origin as practically possible. The system would vent a quantity of product from the pipe to a safe location once a pre-set pressure limit is exceeded, thereby limiting the final surge pressure. This can be implemented using bursting discs or rapid response valves.

4.4.5.4 Surge pressure alleviator

These devices, also called surge accumulators, are generally not required except where extremely long delivery carry high flow rates.

A flanged tee should be installed upstream of the ESD valve, to facilitate installation of an alleviator if surge pressure is found to be a problem.

No surge pressure alleviator shall be installed between a PD meter and the control valve, because this will result in extra pulses being generated by the pulse transmitter as the alleviator first absorbs product and then pushes it back down the line. In such cases the alleviator (or 'T' piece) should be installed directly upstream of the PD meter.

## 4.5 OVERSPILL PROTECTION SYSTEM

### 4.5.1 Necessity of overfill prevention systems

In traditional top loading the driver can monitor the level of the product through the manhole and stop the product flow immediately in an emergency by releasing the 'hold-open' valve. However, the temptation to tie the "hold-open' valve in the open position has resulted in overfills. The trend towards higher flow rates has also increased the risk of overfilling and spillage and hence the possibilities of fire and pollution. Therefore overfill systems should be installed for new top loading installations.

For all closed systems where it is not possible to monitor visually the liquid level (thus for bottom loading and top loading with vapour collection), an overfill protection system shall be installed. An overfill protection system shall also be installed where two or more compartments are top-loaded simultaneously.

### 4.5.2 Overfill protection systems

The following different types of overfill protection systems are available:

#### 4.5.2.1 Flow valve on gantry, sensor on vehicle

In this system, a liquid level control sensor is fitted permanently in each vehicle compartment. The sensors on the vehicle are connected to the gantry flow control/interlock system. Loading is only permitted when none of the sensors gives a high liquid level signal.

Sensor systems, connectors and connector location envelopes should be designed to a national or international standard in order to facilitate exchange deals.

The European VOC directive prescribes a combined overfill/earthing 10-pin female industry standard connector which is attached with a flying lead to the gantry-mounted flow control unit. The gantry control unit should be suitable for both 2-wire and 5-wire liquid level sensor systems. Figure 3.17 gives the envelope for the connection. The IP “Code of Practice for Bottom Loading, Vapour Collection and Overfill Prevention” describes the system in detail.

#### 4.5.2.2 Flow valve and sensor on gantry

This system is only used for top loading. Liquid level sensors are fitted on the loading arms and in case of overflow the control system on the gantry stops the flow to the loading arm.

The advantage of this system is that vehicles do not need converting.

This system should not normally be employed because loading arm mounted sensors are susceptible to mechanical damage and it is difficult to deal with different vehicle compartment heights.

#### 4.5.2.3 Flow valve and sensor on vehicle

This self-contained vehicle-mounted system is only used for bottom loading. Each compartment of the vehicle is permanently fitted with a liquid level sensor and with a foot valve which closes in case of high level. The foot valves are generally special pressure-balanced valves which are hydraulically or pneumatically operated. As the system has to be fitted in each compartment of each vehicle the overall costs are generally high.

The operation of these foot valves can cause surge pressures which can damage vehicle gallery lines, the loading dry-break coupling and the gantry flow system. The system requires a means of overriding the overfill protection so that the compartment foot valve can be opened and held open when the vehicle is discharging. Failure of any part of the vehicle system renders the system inoperative. Maintenance of the vehicle mounted equipment is likely to increase vehicle idle time, with a consequent loss of operating efficiency and increase in transport costs.

The installation of this system is viable only for a small fleet of large capacity vehicles with only one or two compartments (e.g. filling of bridging vehicles).

### 4.5.4 Liquid sensors

Many different types of liquid level sensors are available; the following are the most common.

#### 4.5.4.1 Thermistor systems

In this type of system the element which detects the liquid is a temperature sensitive resistor, a thermistor. This thermistor is heated by an electric current and at the moment the level reaches the sensor the liquid cools down the thermistor which causes a change in its electrical resistance. This drop in resistance is detected.

Thermistors typically require 30 seconds warm-up time before the 'permissive' signal is obtained. This need not be a problem because during this time the driver positions or connects the loading arms etc. However, where there are problems with dirty plug/socket connections, clearing and waiting for a permissive signal can be a nuisance.

Common white oil product systems use a two-wire thermistor and the system can handle a maximum of eight compartments if the standard 10-pin connector is used. The IP “Code of Practice for Bottom Loading, Vapour Collection and Overfill Prevention” describes the system in detail.

Heated common black oil product systems use a three-wire double thermistor system for increased sensitivity. Black Oil systems can handle up to a maximum of four compartments with a standard 10-pin connector.

Thermistor systems are generally simple in construction, reliable in service, require little maintenance and can be designed to be self-checking and fail-safe.

#### 4.5.4.2 Optical systems

These systems are now taking over from thermistors on common white oil product duties because of the immediate permissive signal (no warm-up required). Early problems caused by the 'fogging' on the sensors have been overcome. However, optical systems are not suitable for black oils.

Two different systems are available:

- Two-wire systems which are cross-compatible with two-wire thermistor systems, handle a maximum of eight compartments and require 'dummy' circuits.
- Five-wire systems which can handle up to twelve compartments and do not require dummy circuits.

Optical systems are generally simple in construction, reliable in service, require little maintenance and can be designed to be self-checking and fail-safe.

#### 4.5.4.3 Capacitance sensors

These sensors can be used on common white and black oil products, and provide the convenience of an immediate permissive signal when the plug is connected.

There are doubts whether such systems are truly 'fail-safe'.

#### 4.5.4.4 Floaters and displacers

Floaters and displacers contain mechanical parts and are susceptible to failure particularly when operated under bad road conditions. Mechanical failure of moving parts or sticking can cause these devices to fail in a condition still permitting the flow of the product (not fail-safe). Therefore these devices should not be employed.

The advantage of floaters and displacers is that they can give directly a pneumatic or hydraulic output signal which can be used to close the control valve in case of overfill.

#### 4.5.4.5 Air reaction

A small flow of nitrogen or dry air flows downwards through a small bore tube. When the liquid level reaches the tube the back-pressure in the tube increases and is detected. A flow meter is installed which measures the air or nitrogen flow. If the flow decreases the product flow is stopped.

This system can be used for special applications such as liquid sulphur or bitumen.

### 4.5.5 Ullage of compartments and valve closure time

The total elapsed time between the high level signal initiated by the liquid level control sensor and the final closure of the valve shall be such that there is no possibility of a spill over from compartments. However, in order to minimise the shock pressure (surge) in the piping system due to valve closure, it is often necessary to slow down the valve closure, see (4.4.5). Hence the quantity of product which passes through the valve during the closure period shall be taken into account when setting ullage in vehicle compartments, especially in those with a small capacity.

At an assumed product flow of 2300 litres/minute (approximately 40 litres/second), this means that with control equipment having an overall delay of 3 seconds before final closure at least 120 litres of ullage shall be provided. For small compartments this is large proportion of the available compartment volume. The following actions should be taken:

a) Plan for the elimination of small compartments.

b) Use hydraulic analysis of the loading system to minimise the likelihood of pressure surges. If high pressure surges cannot be avoided, consider fitting flow control valves with 'equal percentage' characteristic to reduce surge pressure.

c) Downrate the compartments of existing vehicles where necessary by the amount necessary for safe liquid cut-off.

d) Allow for appropriate ullage in the design of new bulk vehicle compartments.

### 4.5.6 Requirements for design and maintenance of overfill systems

Overfill systems, including connectors and connector envelopes, should be designed according to a recognised standard such as the IP “Code of Practice for Bottom Loading, Vapour Collection and Overfill Prevention”.

The system should be known to be reliable in service, particularly for operation over poor road surfaces, and for all product handling conditions such as temperature, viscosity, surface temperature etc.

Sensor systems should be fail-safe, i.e. not permitting loading in case of failure. This can be achieved by using self-checking systems.

Sensing probes shall be suitable for use in petroleum products and electrical/electronic probes shall be certified safe for operation in Zone 0 when connected to a certified controller. The wiring for the sensing probe system on the vehicle should be both physically and electrically isolated from other vehicle circuits, by the use of dedicated conduits and vehicle boxes.

## 4.6 EARTH INTERLOCK

Static electricity is generated during loading. When non-conductive liquids are loaded an accumulation of static electricity can take place resulting in sparks, see (2.3.1). To reduce the charge build-up an earthing cable shall be connected to the vehicle before any other operations are carried out (e.g. opening man lids, connecting hoses etc.). The bonding resistance between the vehicle and the gantry shall be less than 10 ohms, and this earth shall remain in position until all other loading operations have been completed.

Loading shall not be permitted by the flow control system/interlock system if the vehicle is not bonded effectively. If an overfill protection system is provided, the overfill protection connection should be combined with the earthing connection.

For non-automated loading gantries (e.g. top loading with mechanical pre-set) the earthing cable between the loading facilities and the road car shall be clearly visible and equipped with a status warning light.

## 4.7 INTERLOCK SYSTEM

The loading facility interlock system secures the safety, security and quality of the loading. It may include the following features:

a) Overfill protection, see (4.5).

b) Earth interlock, see (4.6).

c) Low flow trip: typically at 10% of the maximum flow. This alarm/trip is designed to prevent the driver/loader from obtaining product at slow rate without it being registered by the meter (so called 'milking'). The low flow rate trip is associated with a time delay which permits the flow rate to increase from zero at the beginning of the load and also reduce to zero at the end of the load without initiating an alarm trip condition.

d) High flow rate alarm/trip.

e) Verification of vapour collection connection see (3.5.7).

f) Left/right detectors and up/down detectors for top loading arms, see (3.4.3).

g) Loading arm stored after use, see (3.5.6).

g) Loading platform up/down (only for top loading, see (8.3.2.2)).

h) Additive injection control: checks if the right amount and type of additive is injected, see (6.2.3) and (6.3).

i) Fire detectors, see (9.1.5) and (9.1.7).

j) ESD switches, see (9.1.7).

k) Gas detectors (e.g. near to LPG loading installations).

l) Product temperature alarms: these alarms are not usually considered necessary, particularly on non-heated products. However they can be used to detect errors in the temperature measurement system by setting the high/low temperature alarms just outside the normal operating range.

On the vehicle the following interlocks may be considered:

a) Driveaway interlock, e.g. a lift bar normally covers all product connections: when lifted the brakes are applied.

b) Air pressure interlock: a pressure switch contact shall be connected to the overfill detection system, so that a loss of vehicle air pressure will cause the gantry loading valve to be closed.

c) Vapour vent interlocks: the vapour vent valves which connect each compartment to the vapour collection manifold on the vehicle should be open before loading is permitted.

d) Verification of vapour collection connection: a proximity switch contact shall be connected to the overfill protection system so that loading is only permitted if the vapour collection connection is made.

In automated loading terminals the interlock system will exchange information with other terminal systems and other features will be available, see (5).

# 5. AUTOMATION

## 5.1 INTRODUCTION

Automation in bulk loading facilities is increasing as operators strive to achieve a more efficient, secure and safe gantry operation.

Modern technology now allows the gantry automation system, loading terminal (e.g. tank farm) monitoring system and administrative system (order taking, vehicle scheduling, vehicle routing, invoicing) to be combined within a single integrated system. This integration streamlines terminal operations whilst providing an integrated management information system.

Loading terminals which are being upgraded to full automation should be interfaced with existing marketing systems (such as MOTAS/LOPAS, SAP, JDE (order taking and scheduling) and CROSS (vehicle routing)) in order to automatically download/upload relevant loading data. Protocol and compatibility issues should be addressed beforehand.

## 5.2 ADVANTAGES OF AUTOMATION

Automation offers many advantages over manual systems. New installations shall be automated and the automation of existing installations should be considered at the earliest opportunity.

The advantages offered are:

- **Safety**: earth connection monitoring, overfill protection, leak detection, cargo/vehicle compatibility monitoring and rapid response in event of emergency.
- **Security**: access gate control, authorisation of product loading, timed and automatic shut-off, guaranteed allocation of product loaded, reduced risk of cross-over when loading.
- **Quality assurance**: audit trail of all events, confirmation of correct operations, e.g. additive injection.
- **Improved stock accounting**: on-line automatic temperature correction to provide standard volumes of products metered and standard volumes in the tank gauging system, integrated with the administration system for accounting purposes.
- **Efficiency**: improved vehicle turnaround time due to simultaneous loadings, faster paperwork and less manual supervision.

The newly developed skid (modular) bottom loading gantry which offers considerable advantages is designed specifically for gantry automation, see (8.3.4).

## 5.3 ASSESSMENT OF FUNCTIONAL REQUIREMENTS

A rigorous assessment of functional requirements shall be made prior to automation. The assessment team should include technical, operations and project expertise. Selection of the vendors who can offer a standard solution to the functional requirements is preferable to making modifications to standard solutions offered by vendors. Automation systems based on open infrastructure standards (e.g. Windows NT) are preferred to systems based on the automation Vendor’s standard.

For the details on assessment guidelines, reference is made to the publications:

- Bulk-Loading Automation Guidelines for the Assessment of Functional Requirements;
- Guidelines for the Automation of Small Terminals (also useful for large terminals).

# 6. ADDITIVE INJECTION

## 6.1 GENERAL

Additives are added for several reasons such as safety, quality improvement, tax laws and, most commonly, product differentiation.

Further advice on additive dosing including Safety Data Sheets (SDS) is given in Volume 1 of the Fuel Additive Quality System.

## 6.2 DOSING LOCATION

There are many factors which influence the selection of dosing location, including the type of facilities available, whether these are shared or owned by third parties, and the extent of product exchange agreements.

Before it is decided to inject at the loading gantry the advantages and disadvantages of dosing at other locations should be considered.

### 6.2.1 Refinery dosing

Refinery dosing - or dosing as product is received into storage - is only possible if all of the product is sold with the same additive. Refinery dosing has the following advantages:

a) maximum time to detect and correct for under/overdosing;

b) purchase of additive in bulk by ISO tank or road tanker;

c) improved quality control by incorporating back-up systems and downstream checking before the product leaves the refinery/depot;

d) minimum number of injection points, thus reducing costs;

e) greater product homogeneity.

However, there is an inevitable long supply chain which leads to the following disadvantages:

a) potential slow additive build-up through the distribution system before the correct dose is delivered to the customer;

b) inflexibility during changes of additive, leading to mixtures of varying composition being present in the system for long periods;

c) less freedom for future product differentiation.

### 6.2.2 Depot tank dosing

This avoids most of the disadvantages of refinery dosing, while retaining the advantages of simplicity and relatively low cost. However, it is not as flexible as gantry dosing (below), and does not appreciably facilitate future differentiation.

### 6.2.3 Loading gantry dosing

Where product is required both with and without additive, or where third parties require different additives the additive will normally be injected at the gantry, just upstream of the product flow meter. This has the following advantages:

a) flexibility;

b) facilitates future differentiation initiatives.

The disadvantages are:

a) high initial investment costs;

b) increased quality assurance requirement (there is a risk that each road bulk vehicle can be incorrectly dosed; there is often no time to discover an incorrect dosing before the product reaches the customer).

To make gantry dosing acceptable, the following measures should be taken:

a) a secure additive selector system shall be used (automatic selection is preferred to manual or key selectors);

b) the injector control system shall incorporate a feedback signal which confirms that dosing is taking place. If dosing does not take place within the specified limits, loading should be interrupted;

c) additive volume totaliser meters, in order to enable a periodic check on the correct injection ratio (at least daily, but preferably at the end of each shift) shall be provided.

### 6.2.4 On-board dosing

Additives may be added manually into the compartments. Manual dosing of additive is generally not acceptable because of the dangers of poor quality control, poor mixing and Health and Safety considerations.

Delivery vehicle on-board injectors are also available. These should not be employed because quality control is difficult and product homogeneity is hard to guarantee. They should only be used as a temporary measure or where justified by local conditions.

## 6.3 GENERAL DESIGN GUIDELINES

### 6.3.1 Turndown ratio

Continuous developments in the formulation of additives very often requires adaptation of the dosage rate. A high turndown ratio is therefore an important design criterion for on-line injection facilities into bulk products. This flexibility has the added advantage of allowing a switch from one supplier of additives to another, should this be desirable on additive performance and/or economic grounds.

### 6.3.2 Additive type

A major influence affecting the design rules for injection facilities are the characteristics of the additives themselves. The main characteristics which have to be considered are:

- toxicity;
- chemical and thermal stability (including shelf life of the additive);
- viscosity;
- compatibility with additive system materials (e.g. elastomers).

Toxic additives require gas-tight designs, pump seals and special precautions for their transfer. The pump seals should be compatible with the type of additives to be used. Thermal stability properties will dictate the requirements for temperature alarming, safety relief valves and the use of special injection systems such as eductor systems. Viscous material may pose particular handling problems when the additive is delivered from the Manufacturer.

The different characteristics of each additive may require specific design and operating guidelines.

### 6.3.3 Quality assurance

The quality assurance requirements for additive injection for automotive fuels are described in: "Automotive fuels: Marketing Quality, Volume 1 - Fuels Additive Quality System".

### 6.3.4 Injection methods

The injection methods can be subdivided into:

- batch-wise (timed) introduction;
- flow-proportional injection;
- modified flow-proportional injection (including line clearance).

Batch-wise introduction should be avoided as the mixing of product and additive cannot be guaranteed. Furthermore, one product is often delivered into multi-compartment storage facilities on board a road tanker, possibly resulting in an overdose in one compartment and underdose in another.

If it is a simple case of injecting an additive into own loads and not injecting additive into competitor loads, then there is no problem with contamination, and the injection errors caused by switching between loads with and without additive are small provided that the volume between the injection point and the vehicle is small compared to the batch size. Hence simple direct ratio injection is acceptable.

However, different additives can be selected, greater care should be taken to avoid cross-contamination of additives. For these applications modified flow-proportional additive injection should be employed. With this method no additive is injected before the final amount (say 200 litres) of the batch, thus leaving the loading linework purged of all additivated product.

## 6.4 GANTRY ADDITIVE INJECTION SYSTEM

### 6.4.1 Additive receipt facilities

To ensure that the correct additive is safely discharged and received into the right storage tank the following measures shall be taken:

a) Vehicle/rail discharge points shall be clearly marked to identify the additives in accordance with their delivery documents.

b) The systems for different types of additives and additives of competitors shall be kept completely segregated. Thus separate connections and pumping systems shall be used. Valve cross-overs shall be avoided. Dedicated connections should be employed wherever possible.

### 6.4.2 Additive storage vessel

The capacity of the storage vessel is determined by a number of aspects such as:

- the dosing rate;
- annual throughput and seasonality;
- stability;
- premixing/dilution requirements (additive strength);
- parcel size and security of supply.

In general the capacity of the vessel should be sufficient for at least one month, in order to minimise additive handling activities.

The maximum capacity of the vessel required is determined by the parcel size and supply security of each specific additive as well as the additive shelf life. The maximum capacity is also often related to the seasonality of a particular product quality, e.g. cold flow properties for gasoils.

Pre-mixing of the additive by the supplier makes the on-site operating procedure simpler, but could add to the transportation costs. If mixing on site is selected then the quality control procedures shall be defined.

Depending on the physical and chemical properties of the additive, heating and/or insulation may be required. Care should be taken with the maximum storage temperature of many additives, in particular ignition improvers. Temperature alarms shall then be provided, as well as e.g. water-spray cooling for fire protection or the use of underground storage tanks.

Tank mixers and tank filling/draining facilities shall be provided.

For storage of light and/or toxic additives, pressure/vacuum valves should be fitted to prevent emissions.

Means of establishing the amount of additive in the storage tank (dipping or level gauging) shall be provided to allow reconciliation of stocks.

For further information on safety precautions related to fire protection for storage facilities, refer to: DEP 80.47.10.30-Gen.

For further information on the design of storage tanks, refer to DEP 34.51.01.31-Gen.

### 6.4.3 Injection system

The systems can be categorised as follows:

#### 6.4.3.1 Mechanical systems

Some Manufacturers deliver PD meters in which the additive injection mechanism is an integral part of the meter. A direct drive from the PD meter drives reciprocating additive pumps. The main advantage of this type of system is that it is simple and reliable and requires no power supply. However, the disadvantage is that the injection ratio is fixed and there is no guarantee that the additive is actually being injected. Therefore, additional safeguards are required such as an additive flow switch coupled to an alarm system.

These systems should not normally be employed for loading gantry applications.

#### 6.4.3.2 Turbine driven injectors

A turbine wheel is installed in the main product flow. This mechanically drives a series of piston injectors which are connected to an additive supply line held at a positive pressure.

The system operates without an external power supply and is most useful where continuous proportional injection is required, such as dosing when product is delivered during receipt into storage.

These systems tend to be large and are expensive for use on loading gantries.

#### 6.4.3.3 Pneumatically driven injectors

The system basically comprises two units; a pneumatic transmitter and a piston pump unit.

The transmitter unit is normally positioned between the PD meter and the counter, and houses a simple gear train which operates two whisker switches via a peg gear. These whisker switches send pneumatic signals to drive a shuttle valve which in turn drives the pump unit.

These units are now tending to be replaced by their electronic counterparts which are regarded as more reliable.

#### 6.4.3.4 Electronic injector systems

These systems normally compromise four basic components, see Figure 6.1:

1) An electronic pulse transmitter (often dual pulse) which is driven by the PD meter (turbine meter pulses or the signal of a Coriolis meter can be used directly).
2) A control unit which acts as a pulse scaler, and also provides integral additive selection facilities.
3) An electro-mechanical piston injector which is controlled by a pulsed output from the controller.
4) A pressurisation pump which pumps the additive to one or more injectors.

The additive piston injector should be fitted with a proximity sensor which sends feedback pulses to the controller, thus confirming that the injector is operating correctly. Depending on the control system these systems are capable of 'modified proportional injection' (e.g. line clearing).

This kind of system is widely used and should be employed for gantry additive injection systems.

#### 6.4.3.5 Electronic flow-proportioning control

A typical system (see Figure 6.2) comprises:

1) An electronic pulse transmitter (single or dual pulse) fitted to the PD meter in the main loading line (this is regarded as the 'wild' flow by the additive controller).
2) A PD meter with electronic pulse transmitter located in the additive line, and a control

valve located downstream of the meter (this is the 'controlled' flow). Coriolis mass flow meters may also be used for this purpose.

3) A ratio controller which compares the measured 'wild' flow signal and adjusts the 'controlled' flow to provide the desired ratio. Typically this is via a combination of proportional and integration action (P and I).

4) Pressurisation pump which pumps the additive to one or more streams.

Depending on the control system these systems are capable of 'modified proportional injecting' (e.g. line clearing).

### 6.4.4 Injection nozzle

The additive injection point should be positioned upstream of the flow meter.

In general no problems are encountered with the design of the injection nozzle, as sufficient turbulence is created by meters, pipework etc. Static mixers may be used if insufficient mixing is suspected before on-line sampling takes place. The non-return valve (NRV) should be positioned as close as possible to the product rundown line. This will prevent the product from entering the additive line when the additive is not being injected. Should a next batch require additives, then the position of the NRV will ensure that the additive is introduced into the product stream immediately after the injection system is started.

# 7. VAPOUR EMISSION CONTROLS

## 7.1 GENERAL

There are increasing concerns about the environmental and health effects of emissions of volatile organic compounds (VOCs). The principal man-made sources of VOCs in the developed countries are solvents and gasolines. The distribution and storage of gasoline contributes to these emissions.

Legislation limiting VOC emissions from the storage and distribution of gasoline has been implemented in a number of industrialised countries around the world, including the USA, Japan, Australia and the countries of the European Union.

The reduction of emissions during the storage, loading and off-loading of gasoline is known as 'Stage 1' vapour control. Stage 1 is subdivided into:

Stage 1a: The control of emissions during the storage and loading of gasoline at loading terminals.

Stage 1b: The control of emissions during off-loading at service stations.

The control of emissions generated during automobile refuelling can be undertaken either by using a system on-board the automobile (e.g. carbon canister) or by modifying the gasoline dispenser and feeding the vapours back to the service station storage tank. The latter is known as 'Stage 2' vapour control.

Both Stages 1 and 2 comprise 'closed' systems. Uncontrolled emissions occur when any of the 'open' tanks in the distribution and marketing chain are filled, e.g. the compartment of a road tanker, a rail tank car, the hold of a marine vessel, the underground tank at a service station, or the fuel tank on an automobile.

In a closed system, vapours are prevented from being emitted to the atmosphere by being captured and collected either for recovery in a vapour recovery unit (VRU) or for destruction by incineration.

## 7.2 EMISSION STANDARDS

At loading terminals in the USA, the Environmental Protection Agency (EPA) stipulates a maximum level of VOC emissions of 35 mg/l of gasoline loaded. This equates to a maximum outlet concentration in the VRU effluent vent gas of around 50 g/$m^3$.

The German "Technical Instructions on Air Quality Control" (TA Luft) prescribe maximum emission levels for three categories of VOCs. Most gasoline vapour constituents belong to category III, which means that the total emission of hydrocarbons, excluding methane, should not exceed an amount of 150 mg/$m^3$ of vent gas. This limit applies if the total emission exceeds the 3 kg/h threshold. Benzene belongs to category I, with a prescribed limit of 5 mg/$m^3$ above a mass flow of 25 g/h. The TA Luft standard is much more stringent than the EPA standard and requires a VRU efficiency of around 99.99%.

The European Commission has issued a directive on the control of VOC emissions, which covers the receipt, storage and delivery of gasoline. The limit for VOC emission is 35 g/$m^3$ in the VRU effluent. The requirements of this directive can be met with a single-stage VRU operating at a recovery efficiency of 98%.

## 7.3 APPLICATION OF VAPOUR EMISSION CONTROLS.

### 7.3.1 Vapour collection and recovery

Operating Units in Europe should prepare themselves for the installation of vapour collection systems and VRUs at their major loading terminals. The implementation of the European VOC Directive will be phased over 9 years commencing end 1995. For new constructions, the vehicle loading gantries shall be of the bottom loading type. Existing top loading facilities shall be converted for bottom loading during the phasing-in period.

### 7.3.2 Reduction of vapour generation

Considerable reduction in vapour emissions can be achieved not only by installing a vapour collection system but also by avoiding free fall and splashing of volatile products in top and bottom filling operations. Loading facilities should therefore be designed as follows:

a) Top loading

The loading arms should be sufficiently long to reach the end compartments of a vehicle tank so that the down pipe can be inserted vertically to the bottom of the compartment, see (3.4.2).

b) Bottom loading

Deflectors should be fitted in the vehicle tank at the point of entry of the product into the compartment in order to prevent 'jetting'.

c) Loading rates

It is normal practice to begin and end a loading operation with a filling rate substantially lower than the normal high flow rate of the loading system. The lower start loading rate will assure that the loading arm or deflector will be submerged before the high flow rate will be reached.

## 7.4 VAPOUR COLLECTION SYSTEM

A vapour collection system routes the vapours from the emission sources (e.g. road tanker, rail tanker car, marine vessel or storage tank) to the vapour recovery unit or incinerator or to a safe location for venting to atmosphere (assuming no local regulation for VOC emissions). The following types of systems are available:

### 7.4.1 Direct system

In this system, the vapours collected during vehicle loading are passed directly to the vapour recovery unit or incinerator. The vapour recovery unit can be activated by a signal that loading is about to commence, from either the product pump or loading arm.

With bottom loading of road tankers the vapours from all compartments will be collected, including those from non-gasoline loading (e.g. automotive gasoil). These additional vapours, plus the vapours generated during the loading itself (e.g. by evaporation of the product), shall be taken into account when sizing the vapour collection and vapour recovery unit or incinerator.

### 7.4.2 Direct system with vapour holding tank

To even out fluctuations in the vapour flow a variable volume vapour holder (gasometer) can be installed in the vapour line to the vapour recovery unit or incinerator. The vapour holder is sized to contain the vapour produced in excess of the vapour recovery unit’s or incinerator’s capacity.

The advantages of a vapour holding tank are:

- lower peak capacity of VRU;
- lower energy use due to smaller VRU running at optimum working point;
- higher reliability as vapour holding tank can buffer vapours during short shutdowns/ maintenance of VRU

The vapour holding tank shall be protected against over and under pressure. If a flexible diaphragm is used in the holder then its material shall be compatible with the composition of the vapours and shall be designed to eliminate static electricity hazards.

### 7.4.3 Vapour balancing system

In this system the vapours displaced during loading are routed back to the ullage of the tank from which product is being pumped. The vapours are fed to the vapour recovery unit or incinerator when the tank is being filled. A vapour holder may be included in the system. To prevent product contamination due to vapour condensation only gasoline storage tanks should be connected into the balancing system.

### 7.4.4 Design of vapour collection systems

Vapour collection systems should be designed and sized according to the IP “Guidelines for the Design and Operation of Gasoline Vapour Emission Controls". The vapour collection system shall be adequate to cater for the peak loading rate anticipated at the loading gantry, including displacement from gasoil compartments on mixed loads in multi-product gantries. In direct systems the vapour generation in product tanks due to ambient temperature changes and solar radiation should be considered.

Consideration should be given to:

- collection, detection and draining of any product carried over into the connection line during an overfill or any condensate formed in the vapour line;
- prevention of vapour leakage from the connection when it is not in use due to pressure in the vapour collection system.

## 7.5 VAPOUR RECOVERY UNITS

### 7.5.1 Types of vapour recovery units

Vapour recovery units are devices which separate hydrocarbons from air and convert them back into liquid. The main types of vapour recovery units on the market are:

#### 7.5.1.1 Carbon adsorption

The incoming vapour stream is passed through a bed of granular carbon. The hydrocarbons in the stream are adsorbed onto the surface of the carbon. The carbon bed is regenerated by pulling a vacuum with a liquid ring pump and flushing it with air in the reverse direction. The hydrocarbons liberated during the regeneration are recovered by passing them counter current to a gasoline stream from storage in a reabsorber column or are condensed by refrigeration.

This technology has been used extensively in the USA and Europe. The technology has matured and the initial overheating and carbon filter problems have been overcome. However, the processing of solvent, additive or chemical vapours can still result in overheating. This is the only well-proven recovery technology for obtaining very low outlet concentrations with a single stage unit.

#### 7.5.1.2 Lean oil absorption

The incoming vapours are absorbed into a liquid of low vapour pressure, e.g. chilled kerosene. The mixture is distilled and separated into concentrated gasoline vapours and the absorbing medium. The absorbing medium is chilled and recycled to a buffer capacity. The gasoline vapours are recovered by passing them counter current to a gasoline stream in a reabsorber column. To prevent icing an anti-icing additive, e.g., methanol, has to be injected. This additive will end up in the waste water, which can pose environmental problems.

This technology has been used extensively in Europe. This technology has a high peak-handling capacity as the absorbing medium can be stored. It could be considered for recovery of chemical vapours and crude vapours.

#### 7.5.1.3 Refrigeration/Condensation

The incoming vapours are condensed at very low temperature (around -90 °C) using a cold heat exchange medium. This medium can use refrigeration processes or a liquefied gas such as nitrogen. The condensed product can be pumped straight to storage and the amount of recovered product can thus be measured very easily. The system has to be defrosted on a regular basis.

The energy efficiency of this process is low due to the very low temperatures needed. The system based on liquid nitrogen is very simple to operate and could be suitable for small loading terminals (annual throughput less than 50 000 $m^3$).

#### 7.5.1.4 Membranes

Hydrocarbon-selective membranes are used to separate the incoming vapours from the air. The necessary pressure differential across the membranes is created by compressing the incoming vapours with a compressor and/or pulling a vacuum at the other side with a vacuum pump. The concentrated gasoline vapours are recovered by passing them counter current to a gasoline stream from storage in a reabsorber column.

This technology has been extensively been used in Europe. As the process cannot cope with large variations in throughput, a vapour holder tank (gasometer) upstream of the VRU is normally needed. Special consideration shall be given to the safety aspects of having rotating equipment within the vapour collection system.

### 7.5.2 The choice of vapour recovery unit

The different types of units have different fields of application. The following considerations should be taken into account in the choice of a VRU:

a) throughput profile (peak, 15 minutes, hourly, four hourly and daily capacity);

b) required outlet concentration;

c) type of vapours to be processed (only gasoline, or also diesel, solvent, chemicals, additive or MTBE vapours);

d) energy, utility and other consumables (anti-icing additives, absorption liquid, carbon, glycol etc.) consumption;

e) availability of utilities at the site (steam, electricity, cooling water, hot oil, sewage system, absorption liquid, instrument air, nitrogen etc.);

f) simplicity of operation and maintenance;

g) environmental aspects (waste water, spent active carbon, refrigeration medium);

h) accuracy of recovered gasoline measurement (to allow the prepaid duty on the recovered gasoline to be reclaimed);

g) experience of, and technical back-up (service organisation / spare parts) supplied by, the Manufacturer;

h) safety.

The technology and market situation of vapour recovery units is rapidly evolving. Presently, carbon adsorption units are normally used in marketing installations as they need only electricity as utility, are relatively easy to operate and maintain and have proven themselves in practice. For large capacity installations membrane units in combination with a vapour holder tank should be considered.

Liquid absorption units could be considered for high peak throughput units which have to handle solvent, chemical or crude vapours at sites where the necessary utilities are available (typically refinery sites).

### 7.5.3 Design of VRUs

VRUs should be designed and sized according to the IP “Guidelines for the Design and Operation of Gasoline Vapour Emission Controls”.

Area classification shall be in accordance with IP-Part 15. The electrical requirements shall be in accordance with (9.4).

Most Manufacturers build their VRUs according to a standardised design. If a Manufacturer's design is proven in practice in similar situations, that design should be adopted (as far as possible) in order to prevent redesign resulting in excessive cost and the risk of improperly functioning units.

### 7.5.4 Incineration

An alternative to vapour recovery is incineration or flaring, which could be an alternative for difficult to handle products such as crude vapours or solvents. Installations are expensive because of the many safety precautions, and running costs are high since additional fuel is required for optimum combustion. Guidance for the selection and operation of incineration systems can be found in the IP “Guidelines for the Design and Operation of Gasoline Vapour Emission Controls”.

In several VRUs, incineration is used as a second stage. The outlet vapours of a conventional single stage VRU are fed to a gas or diesel engine and are burnt. Low outlet concentrations can be obtained if the exhaust is equipped with a catalytic converter. The energy produced can be used to generate electricity. This type of unit tends to be maintenance intensive.

## 7.6 FIRE AND EXPLOSION PROTECTION

Vapour collection systems connect different parts of the system. Often, vapours in the collection system are in, or pass through, the flammable range, for example during the start of loading or when a mixture of vapours of high flash (e.g. gasoil, kerosene) and low flash products (gasoline) are loaded through the system. If ignition occurs somewhere in the system, e.g. static electricity discharge during loading, fire in VRU, or lightning strike, the fire/explosion can spread through the system.

As the collection system consists of large bore pipe with lengths often of hundreds of metres and with obstructions such as valves and bends, the initial deflagration (a subsonic flame front) can rapidly develop into a detonation (a supersonic flame front). The consequences of a detonation, which can generate shock waves with pressures of over 50 times the initial pressure, are even much greater than the consequences of a deflagration, which generates pressures up to around 10 times the initial pressure.

To limit the consequences of an ignition the following techniques or a combination of them can be used:

### 7.6.1 Containment

The process is designed to contain the explosion event by ensuring that the entire process can withstand the maximum explosion/detonation pressure without rupture.

Road loading vehicles and storage tanks are generally not designed to withstand the forces of a deflagration. Normally it is not feasible to design the system to withstand the extreme forces of a detonation.

### 7.6.2 Explosion venting

This is a technique to relieve the explosion pressure and flame in a controlled manner to atmosphere by installing weak membranes in components or pipelines. The vents should be placed at intervals less than the predicted run-up distance to detonation and should be at least equal to the cross sectional area of the pipe. In normal operation the discharge of flame and pressure from the pipe can be considerable, therefore great care should be taken with the location of the vent and the direction in which the flame will be released. Explosion vents will reduce the effects of accumulated pressure within the pipe but are unlikely to prevent a flame from continuing past the vent.

### 7.6.3 Active explosion suppression or isolation

The flame is detected and suppressed by rapid injection of a chemical suppressant or is isolated by rapidly activating a valve. Due to their complicated design these techniques should not be employed.

### 7.6.4 Deflagration and detonation flame arresters

These are wound crimped steel ribbon devices installed in the pipe, quenching the flame by removing the heat as the gas passes through the numerous narrow channels.

There are two different types, deflagration and detonation flame arresters.

Deflagration flame arresters are not designed to withstand the forces of a detonation. Therefore, they should only be installed in positions where an initial deflagration cannot develop into a detonation before it reaches the flame arrester. The effects of obstructions in the pipe, such as bends and valves, should be taken into consideration as they can accelerate the flame front and considerably shorten the run-up length to a detonation. Deflagration flame arresters can be used for open vent stacks.

Detonation flame arresters are similar to deflagration flame arresters but they can also absorb and withstand the large forces of a shock wave. Therefore they are much heavier and more expensive. Care should be taken during installation as many detonation flame arresters are not bi-directional and can only protect against a shock wave coming from one direction.

In the design of the vapour collection system the often considerable pressure drop of flame arresters shall be taken into consideration and an extra allowance for fouling of the flame arresters shall be made.

Flame arresters are susceptible to fouling (by rust particles), freezing and corrosion, all of which will impair the functioning of the flame arrester. They are also prone to collecting condensate.

They should be installed so as to allow easy access for inspection and maintenance (often regular cleaning is necessary). Provisions for isolation should be considered.

Flame arresters shall have been demonstrated to work under actual conditions and shall have been tested to an appropriate standard, e.g. BS 7244 or US 33-CFR-154.

### 7.6.5 Risk assessment and cost effectiveness of protection

Detonation arresters do not reduce the frequency of explosion incidents but can mitigate the effects of knock-on effects (i.e. explosions and fires in other parts of the system). The cost-effectiveness of detonation arresters, in averting loss of life and loss of installations due to knock-on effects, may vary depending on the configuration and operation of the vapour collection network and on how the detonation arresters themselves are arranged.

Especially for large installations (more than 4 connected loading bays or more than 8 connected tanks) a Quantitative Risk Analysis study should be performed to determine the most cost effective arrangement of detonation arresters. Within such a study the following parameters should be considered:

a) ignition probability of tank cars, VRU and product tanks;

b) probability that the vapours within the vapour collection network are within the flammable range;

c) the number of loading bays and tanks (the larger the installation the greater the risk of an ignition and knock-on effects);

d) cost of loss of installation (including loss of market business);

e) probability of people being situated within areas which could be exposed to knock-on effects (e.g. road tanker drivers and operators close to tanks or the VRU);

f) investment, maintenance and operating costs (pressure drop, blockage) of detonation arresters.

The installation of detonation arresters at the following positions is generally considered as cost effective:

a) on each product road/rail loading point;

b) on the VRU vapour header;

c) on vapour headers to groups of more than 4 tanks (in general a detonation arrester on every tank is not considered cost effective).

# 8. LOADING TERMINAL DESIGN

## 8.1 LOADING TERMINAL LAYOUT

### 8.1.1 General

Facilities should be laid out to make the most efficient use of the area available, and to allow for future expansion.

### 8.1.2 Loading area classification

Hydrocarbon vapour concentrations sufficient to cause an explosive atmosphere may develop during filling of vehicles when vapour is expelled from open manholes or tank vents, or as a result of a spillage. For the design, layout and selection of equipment and systems for areas where flammable gas or vapour risks may arise, area classification drawings shall be prepared based on IP-Part 15.

### 8.1.3 Safety distances

The minimum safety distances shall comply with the IP-Part 2 or IP-Part 3 and local regulations.

The minimum safety distances shown in Figure 8.1 should be observed. Where possible, larger safety distances should be provided, particularly for separation from areas where personnel tend to be present.

### 8.1.4 Traffic and parking

Traffic lane sizes, roadway bends and parking spaces should allow for the largest size of rigid, tractor semi-trailer, and rigid plus full (drawbar) trailer combination vehicles expected in the foreseeable future. Figures 8.2, 8.3 and 8.4 show some typical sizes of vehicles presently in use. Figure 8.5 shows typical area requirements for large capacity bulk vehicles including arrival, waiting, filling and departure.

Crossing of incoming and outgoing traffic lanes and contra-flow of vehicle movements shall be avoided.

Entrance and exit roads should be wide enough to allow two traffic lines in each direction, so that stationary vehicles (e.g. those halting to collect documents) do not obstruct vehicles wishing to enter or to leave.

For loading terminals with automated entry/exit, consideration should be given to access by rescue services and to site evacuation by vehicles and personnel in case of emergencies or power failures.

Sufficient parking should be provided for loading vehicles queuing for a free loading place. At large automated loading terminals a separate parking place is often provided, with electronic overhead display panels which instruct the driver to which loading bay to proceed. Also sufficient parking space should be provided for vehicles being parked so that drivers can collect documents etc., for those queuing for weigh bridges and for the overnight parking of the home fleet.

Slip or bypass roads around the loading facilities should be provided to allow vehicles to evacuate the loading area without driving through the loading bays or crossing traffic in the event of an emergency.

Vehicle washing bays (if installed), workshops, fuelling stations, weigh bridges and drop zones for returned liquid etc., should be positioned to allow unobstructed traffic flow. Vehicles parked overnight should not obstruct movement of vehicles in the loading area during night operations.

At large terminals and refinery terminals bulk road vehicle traffic flow should be separated from any other traffic.

Figures 8.6 and 8.7 show the layouts of some typical bulk road vehicle filling installations.

### 8.1.5 Product grouping

Similar products should be grouped together at loading facilities, e.g. common white oil products together and common black oil products together. Where both common white oil and common black oil products are filled at the same loading facilities one side of the available area should be reserved for each group of products and to allow space for future extension in both directions, see Figures 8.6 and 8.7.

For safety reasons and operational convenience it may be desirable to separate some Class I and special products (e.g. cutbacks) from others, and always ensure that aviation products are properly separated from other grades.

Loading facilities for all products should be concentrated in one area to minimise traffic movement within refineries/depots. If storage facilities for heated black products are distant from the planned loading centre, it may be advisable for economic and operational reasons (to prevent long heated and insulated pipes) to provide separate facilities for these products close to the storage areas. However, where separate loading areas are used, vehicles should follow the same traffic pattern so that the documentation for all products can be handled at one office.

### 8.1.6 Dispatch office

Supervision and documentation of road vehicle loading operations can be carried out most effectively from an office overlooking the loading operations and located near the installation boundary or between the incoming and outgoing vehicle streams.

Office facilities should be designed and constructed taking into account the higher-than-normal noise levels caused by nearby vehicles. They should be large enough to accommodate at least all personnel involved in order-taking (bulk and packed), road vehicle routing, scheduling and dispatching, and stock control, and also include a waiting room for drivers, social areas and space for document files and automation equipment.

## 8.2 LOADING ISLAND/ BAY LAYOUT AND DESIGN

### 8.2.1 General

The loading island is the area where the equipment necessary to load the vehicle is mounted.

The two types of island layout that should be employed (see Figures 8.6 and 8.7) are:

(i) straight-through gantry layout;

(ii) angled gantry layout.

The total ground area requirements are very similar whichever type of island layout is chosen, and the decision normally depends upon the shape of the available site. However, gantry construction and pipe routing is normally easier and less expensive with straight gantries.

The loading system layout should not permit more than one vehicle in line on either side of any island. In the loading position, vehicles shall face the exit gate at all times so they can be driven away quickly in an emergency.

### 8.2.2 Top loading island/bays

Examples of top loading islands are illustrated in Figures 8.8 and 8.12.

Design of double-sided bays should allow for two of the widest vehicles to park between gantries with at least one metre clearance between them. The gantry structure shall not obstruct the opening of cab doors or prevent drivers from leaving or entering their cabs.

The concrete islands under the platforms should be typically 2.2 m wide, see Figure 8.13. If pipes and meters etc., for more than four product grades, or heavy fuel oil or bitumen lines with heating and insulating have to be installed, it may be necessary to increase the width of the concrete islands to 2.5 m with a corresponding increase in the distance between the gantries.

The island surface should be graded to prevent product from accumulating under the platform.

### 8.2.3 Bottom loading island/bays

Examples of bottom loading island layouts are given in Figures 8.9, 8.14 and 8.15. Design and layout of the island on the various drawings allow for the following main dimensions:

- 1.7 m width of islands at loading connections;
- 0.8 m for working (between vehicle and edge of island kerb);
- 0.4 m clearance between vehicle and kerb of adjoining island;
- 0.3 m clearance between bollard kerb and vehicle;
- 2.5 m maximum width of vehicles.

Under these circumstances the minimum distance between the centres of islands is 5.4 m. Whilst this is adequate as a basic design, if space is available it is better (and often necessary) to widen the bays to 6 m or even 6.5 m to provide a greater safety margin for manoeuvring into the bays.

If pipes and meters etc., for more than four product grades, or heavy fuel oil lines with heating and insulation facilities have to be installed, it may be necessary to increase the width of concrete islands to 2.4 m. For loading gantries in which equipment is skid-mounted above the bay, the width can be decreased.

The island surface should be graded to prevent product from accumulating under the platform.

The gantry structure shall not obstruct the opening of cab doors or prevent drivers from leaving or entering their cabs.

### 8.2.4 Protection of equipment against vehicles

To protect loading equipment installed on loading islands, particularly those at the ends, against accidental damage by poor or careless driving, the following safeguards should be considered in the design of loading islands:

a) Provision of a minimum 200 mm high kerb on loading islands. This step between the island and the ground level should be clearly marked (i.e. properly painted) to warn personnel working in the area against tripping.

b) Where modular pre-fabricated bottom loading gantries are installed they can be positioned flush with the surrounding concrete, thus avoiding trip hazards whilst the gantry steelworks still provides protection.

c) Installation of protective barriers and/or bollards at the entrance of loading bays.

d) Provision of breakaway connections on loading arms/hoses.

e) Ensuring that no parts of the equipment or pipes protrude over the edge of the islands.

### 8.2.5 Paving and drainage

The general area of access to and from loading bays should be concrete surfaced. Bitumen surfacing should not be used. The concrete should be of a type resistant to oil penetration.

Loading bays should be paved with heavy duty concrete, rather than bitumen asphalt, to help dissipate static charge built up during movement of the vehicle. The waiting and parking areas may be paved with either heavy duty concrete or bitumen asphalt.

Drainage should be provided at each bay to collect spillage of products. Drainage should be directed away and contained to protect the vehicles in event of a fire (product should not drain to other bays and/or collect beneath vehicles).

The area extending to 1 m beyond all loading islands and the outermost loading bays should be designed to collect product spillage, which should be routed to collecting pits or oil interceptors.

Access roads and paved areas outside the loading gantry catchment area should drain away from the loading bays in a separate drainage system from the oily drainage system.

Spillages in the gantry area should be taken away by the drainage system into the oil interceptor. Any remaining oil on the surface should be mopped clean by using suitable oil absorbent material.

Tundishes with covers should be provided where small quantities of products are regularly drained from bulk road vehicle outlets into buckets. Figure 8.10 gives an example of a typical tundish for slops.

Figure 8.11 gives an example of a typical closed drainage system with an underground vessel for slops used to collect drainage from tundishes, air eliminators, filters etc.

For further details on the design of drainage facilities, refer to DEP 34.14.20.31-Gen.

## 8.3 GANTRY DESIGN

### 8.3.1 General

The gantry is the structure associated with a product supply system and provided with all equipment necessary for loading and providing safe access to road vehicles during top loading.

### 8.3.2 Top loading gantry

Figure 8.16 shows a typical example of a top loading structure. The main design features are discussed below.

#### 8.3.2.1 Working platform

Gantry platforms should allow a free passage at least 0.75 m wide over their entire length to enable operators to move freely, regardless of whether the loading arms are in use or stowed. Equipment should be positioned to cause minimum interference; it should not expose the operator to the risk of physical contact with equipment, nor prevent him from crossing the platform at each loading arm position.

The platform should be provided with stairs at each end. If space is restricted then stairs should be provided at one end and at the other end either access to a passway connecting all gantry islands or a ladder.

Working platforms may be of either concrete or steel construction and should be provided with a non-slip material or finish. With open grating a metal flame shield should be fitted under the grating as a means of protecting both personnel and electric cables in the event of fire.

#### 8.3.2.2 Access ramps

Each working platform should be provided with two balanced and hinged access ramps on either side, to enable personnel to walk easily and safely to and from the tops of road vehicles (see Figure 8.17 for an example of a hinged access ramp). The ramp should be easily adjustable by one man to cater for vehicles of various heights, and any treads fitted should be of the self-levelling type. The under surface of all access ramps or treads should be fitted with soft buffers to minimise damage to tank top surfaces.

A long (6 m) hinged grid side panel, see Figure 8.18, offers operational convenience, but as it is narrower its use should be restricted to gantries where vehicle sizes/heights are fairly uniform.

The access ramps should be provided with up/down detectors which will prevent loading when the ramp is up. While the access ramp is down the loading bay traffic light will stay red and/or the exit barrier will stay closed.

#### 8.3.2.3 Guard rails

The working platform, all stairways, hinged ramps etc., should be fitted with guard rails on all open sides; handrails (see Figure 8.19) should be constructed opposite the ramp at each bay to provide protection for personnel standing on top of the vehicle tanks. Unless conditions dictate otherwise, the height of the guard rails should be 1m.

### 8.3.3 Traditional bottom loading gantry

In the traditional bottom loading gantry all equipment is mounted on the concrete island. Figure 8.20 shows a typical example of such a gantry structure.

### 8.3.4 Skid mounted bottom loading facility

There is a general trend within the industry towards bottom loading. To assist the development of new facilities or conversion of existing ones a skid mounted design has been developed and successfully installed at several Shell locations. Figure 8.21 shows the principle of the design. Each skid includes the following equipment (with minor alterations to meet local requirements):

- product supply header and return header for meter calibration;
- filters;
- flow meters with pulse transmitters and temperature measurement;
- control valves;
- additive injection units;
- loading arms/hoses with 4-inch API dry-break coupling;
- vapour collection hose with 4-inch cam and groove coupling;
- earthing and overfill protection controller and connector;
- fully wired automation system;
- local fire and emergency shutdown buttons;
- intercom systems.

The skid systems offer a tried and tested standard design with the following advantages:

- easier management of supply during construction phase;
- better quality control due to controlled build environment;
- minimum disruption to loading terminal operations when replacing existing facilities;
- cost saving arising from batch production and faster fabrication;
- cost savings on engineering designs;
- the possibility of moving the gantry from one location to another as networks are rationalised.

Other types of skid-mounted bottom loading facilities have been developed in which the skid is mounted above the loading bays. This approach reduces the space requirement and the amount of piping and results in an unobstructed working space at ground level. Figure 8.22 shows the principle of this design.

### 8.3.5 Roofs/shelters

The construction of a roof over a bottom loading gantry is not required and where climatic conditions permit, roofs are often not installed. Sensitive process equipment such as card readers, emergency switches etc., should be installed inside a small shelter for their protection (bottom loading only). In areas where adverse climatic conditions would not otherwise permit safe and efficient loading, a roof should be installed over the loading gantry, or it should be located in a weather protected area.

For top loading a roof should be installed to prevent contaminants such as (rain)water, snow, sand etc. getting in through the open manlids.

Roofs, where installed, shall have suitable ventilation to prevent accumulation of vapour.

For top loading gantries the roof should be sufficiently high to store loading arms vertically.

Rainwater from roofs should be routed to the uncontaminated water drain.

### 8.3.6 Other requirements

All supporting columns of the gantry structure should be fire-protected with fire resistant material.

Meter heads or meter pre-set readings should be clearly visible and readable from the product loading control points.

Control valve equipment should be within easy reach of the operator in normal loading positions. All handles of valves should be operated in the same direction.

Bays and loading islands should be clearly numbered to enable vehicles to be directed to filling points. Product grade plates should be provided at the entry side of the gantry to clearly indicate product availability at the bay concerned. Loading arms, meters and connections should be clearly marked for product identification.

Sufficient illumination should be provided for night operations, see (9.5).

The construction of barriers at the exit of loading bays should be such that they can be driven through in an emergency (e.g. barrier bends or snaps off).

# 9. MISCELLANEOUS

## 9.1 EMERGENCY AND FIRE PROTECTION

### 9.1.1 General

Fire protection systems shall be in accordance with DEP 80.47.10.30-Gen. and DEP 80.47.10.31-Gen.

### 9.1.2 Requirements of fire fighting facilities

The degree of sophistication of fire fighting facilities should be considered in the light of:

a) size and complexity of loading terminal;

b) strategic importance of the loading terminal to the business;

c) manning level and availability of emergency services;

d) proximity to other facilities and/or presence of people;

e) type of loading system (bottom loading terminals with overfill protection and other automated controls are considered less vulnerable).

Depending on the above considerations loading terminals should have:

a) a system with fixed and/or mobile monitors (see 9.1.3 and 9.1.4) and/or

b) a fixed water/foam spray system (see 9.1.5).

At unmanned terminals an automatic foam spray system should be installed. For terminals with low level of manpower an automatic system should also be considered.

### 9.1.3 Fire hydrant main and mobile monitors

The system essentially comprises a fire hydrant ring main with the necessary number of hydrant points strategically located around the terminal facilities. In the event of an emergency, mobile water or foam monitors will be deployed by the terminal staff who should be organised and trained to operate the fire fighting facilities.

Facilities for generating foam (with appropriate capacity) should be provided e.g. mobile foam generators, fire trucks or foam stations.

### 9.1.4 Fixed or oscillating monitors

As above, but fixed or oscillating water/foam monitors are used instead. These monitors shall be located at least 20 m away from the gantries on the prevailing upwind side in order to facilitate access in the event of obstruction by abandoned vehicles.

### 9.1.5 Automatic foam spray systems

The main purpose of this system is to extinguish pool fires quickly, enabling drivers and gantry personnel to escape to a safe area. Actual fire fighting requires more resources.

The automatic fire detection system should be capable of quickly detecting flames/fire/heat in the gantry area and activating the spray system. An alarm should be raised at the loading terminal dispatch office/control room and at the local fire service if the terminal is unmanned.

The system shall be designed to protect the whole surface area of the road tanker including driver's cab, engine, underside and an area of 2 m around the tanker. The design should be sufficient to provide protection for all bays in the gantry simultaneously.

Foam application at 3% concentration shall be maintained for 10 minutes at a net minimum rate of 6.5 $l/min/m^2$ equipment surface. Non-aspirated aqueous film forming foam (AFFF) systems are preferred.

The system should have an emergency stop valve at each loading bay.

### 9.1.6 Mobile and/or portable equipment

The basic minimum requirements for mobile and portable equipment for road loading terminals are:

a) 11 kg dry-powder chemical extinguishers:

- Top loading:
  Two extinguishers per loading island: one positioned on the working platform adjacent to the top of the stairway, and one at ground level adjacent to the stairway.
- Bottom loading:
  One extinguisher per island at a convenient location (e.g. shelter).

b) One 70 kg dry-powder chemical extinguisher (or one 90-litre AFFF unit) per four loading bays.

c) One or more fire blanket(s) should be provided at a strategic point close to the loading facilities.

### 9.1.7 Emergency and fire alarm

Independently of any other control, an emergency switch should be provided at each of the following positions:

- top loading gantry: at the bottom of each stairway;
- bottom loading gantry: at each end of the island;
- at no less than two easily accessible locations in the loading area, at least 30 m away from the nearest loading gantry;
- in the dispatch office/control room.

The emergency switch shall override all other controls, immediately cease all product flow by stopping the loading pumps and closing flow control valves, and actuate an alarm in the control room.

If there is any risk of product gravitating to the loading area after the pumps have been stopped, clearly indicated isolation valves shall be fitted at a safe distance from the loading gantry.

Restarting of product flow should only be possible after manually resetting the appropriate shutdown system (i.e. systems should not be self-resetting).

The fire alarm system should also initiate an emergency shutdown and, where automatic entry/exit gates are installed, cause the gates to open.

The fire alarm signal should be directly relayed to the local fire brigade.

### 9.1.8 Emergency shower and eye wash

At least one emergency shower and eye wash should be provided at easily accessible locations at the loading gantry. There should be at least one unit at each end of the loading gantry.

## 9.2 PIPING

Piping shall be in accordance with DEP 31.38.01.11-Gen. and DEP 31.38.01.12-Gen.

### 9.2.1 Delivery piping

In establishing the size of delivery piping at loading terminals, the maximum product velocity in main piping should be 5 m/s. If lines are long, consideration shall be given to using a lower velocity to avoid an excessive pressure drop.

To prevent static electricity hazards the flow velocities in delivery piping, including loading arms, shall be limited as described in (2.3.2). Where no hazards exist, a maximum velocity of 7 m/s may be applied in short lengths of connecting pipework, loading arms and hoses.

Piping shall be designed to allow for maximum loading rates at the loading gantry.

### 9.2.2 Pump suction piping

Pump suction piping should be kept as short as possible and without ‘kinks’ (over bundwall or other pipes).

If it is necessary for a pump to operate under negative static head conditions, the suction piping should be laid level or preferably with a slight upward slope towards the pump. Under negative head conditions, the maximum velocity in the suction line should be limited to 1.5 m/s.

### 9.2.3 Routing

To minimise pressure losses, pressure surges and heat losses, the shortest practicable route should be chosen for pipes, with a minimum use of bends, tees, valves and other fittings.

Overhead pipes are preferred to underground pipes for the following reasons:

a) they are easier and cheaper to install;

b) any leakage or failure can be seen immediately and can be easily and quickly rectified, eliminating the chance that an undetected leakage liable to cause pollution and/or hazard may occur;

c) other than painting the external surface of overhead pipes, special corrosion protection (e.g. cathodic protection as is often necessary for buried pipes) is not required;

d) overhead lines allow flexibility for changing a supply to other loading arms with less disruption to loading operations;

e) additional product lines can be laid without excavation of working areas;

f) overhead lines are easily drained for alteration, repair or extension.

Overhead pipes at the gantry should be high enough to enable loading arms to move freely in all directions, and shall have the following overhead clearance:

| | |
|---|---|
| Railway tracks | 6.0 m |
| Main roads | 6.0 m |
| Road vehicle access | 4.0 m |
| Fork lift truck access | 2.7 m |
| Walkways and platforms | 2.1 m |

Pipes should not be laid in open trenches below the adjacent ground level.

### 9.2.4 Piping material

Aluminium, copper or plastic pipes shall not be used at the loading gantry because of their lower resistance to fire.

Carbon steel lines containing aviation jet fuels should be internally lined with Epikote paint, at least between the loading line filter and loading arm. Alternatively, stainless steel lines or fittings can be used, see 'Shell Aviation Quality Control' manual Section IV. In systems containing aviation jet fuels, the use of copper alloys with a copper content exceeding 35% shall be avoided.

### 9.2.5 Fire protection of piping

In the event of a fire, the piping structure supports should be protected to prevent collapse of the overhead pipes (see DEP 34.19.20.11-Gen.).

Heavy equipment (e.g. meters) in the piping system should be independently supported to reduce the chance of collapse in case of fire.

### 9.2.6 Air vents and product drains on equipment

Vents fitted at high points in product lines shall be kept to a minimum, and piping should be designed to be self-draining. Manually operated drain valves should be located at low points to enable pipework to be drained.

### 9.2.7 Surge pressure

The piping system should be designed to allow for the maximum surge pressure expected, see (4.4.5).

### 9.2.8 Extension and change of use of facilities

Changes in market demands, and hence product offtakes, may require modifications to the gantry pipework, e.g. re-allocation of product grades for loading arms. The design of the gantry pipework should allow for such changes to be effected without having to severely disrupt filling operations. Ends of pipe runs should be fitted with blind flanges and offtakes to individual bays should be made with flanged tee connections.

Product and vapour lines should be large enough to accommodate higher flow rates if the number of loading bays is increased.

### 9.2.9 Isolating valves

Main product supply lines to the loading bays should be fitted with cast or forged steel isolation valves at least 10 m from the nearest bay in addition to the shut-off valves on each gantry or loading arm. The isolation valves should be fitted with bypass pressure relief valves.

### 9.2.10 Relief valves

Vent points of relief valves and automatic vents of piping systems discharging directly into atmosphere shall be avoided. These points should be piped away to the nearest drainage (liquid) or to a safe location (gas phase).

## 9.3 LOADING PUMPS

Loading pump capacities should be determined as described in (2.7).

Loading pumps used in terminals which form an integrated part of a refinery should for standardisation reasons be selected, specified and installed in accordance with DEP 31.29.02.11 and DEP 31.29.02.30

Loading pumps used in stand alone terminals should be specified according to one of the following standards:

- API 610 (in many cases loading pumps do not need to comply fully with API 610, see API 610 Appendix “Non-conforming pumps”);
- ISO 5199;
- ANSI B73 1.M;
- ANSI B73 2.M;

Loading pumps should be located as close as possible to the product tanks, but positioned outside the bunded area where they will not be affected in the event of a spillage.

In the specification of the electric motor the frequent start up and shut down of loading pumps should be considered.

In deciding the number of loading pumps the following factors should be taken in consideration:

a) Sparing philosophy.

b) Turndown ratio. The required turndown depends on the number of loading arms as the system should be able to operate with one loading arm as well as with all loading arms in operation. As pumps have only a limited turndown (typically 1 on 3) the turndown ratio of the system can be increased by using more pumps. The installation of a spillback could also be considered to increase the turndown ratio.

c) Start-up current (the start-up current of one large electric motor could overload the grid of a small terminal).

d) Energy use. If more pumps are used, pumps can operate closer to their optimum efficiency point.

e) Use of variable speed drive pumps. By using variable speed drives pumps can be given a higher turn down ratio and less pumps could be used. Also energy efficiency could be increased.

Using skid-mounted pumps of standard size should be considered in the sparing philosophy. A broken down pump could be quickly replaced by an already aligned skid-mounted pump from stores.

## 9.4 ELECTRICAL REQUIREMENTS, EARTHING AND BONDING

### 9.4.1 General

Electrical equipment, electrical power distribution systems, and systems for protection against lightning or the accumulation of static electricity shall comply with DEP 33.64.10.10-Gen.

### 9.4.2 Electrical installations

Electrical equipment should be located in the least hazardous area (see 8.1.2) as far as practical and economical.

Where electrical equipment has to be installed in hazardous areas, equipment with a type of protection suitable for the relevant zones as classified in (8.1.2) shall be selected, specified and installed in accordance with recognised standards.

Attention should be paid to the routing of cables and to the positioning of electrical fittings etc., to minimise or eliminate dangers arising from mechanical damage caused by vehicles, loading arms or personnel. In addition, PVC sheathed and insulated cables are susceptible to hydrocarbons, and routes for buried cables should therefore avoid areas where product spillage could occur. Otherwise, hydrocarbon-resistant, (e.g. lead-sheathed) cables should be used.

Electrical cables associated with loading arms (e.g. heating cables for black oils, cables to limit switches, cables to switches for electronic earthing units etc.) shall be of a suitable type and should allow full movement of the loading arm without stretching the cable. Stops shall be fitted to prevent excessive movement which could damage cables. The following cable types are normally suitable for these applications:

- 2.5 $mm^2$ XLPE/SWA/PVC* for cables to limit switches, lighting etc.
- 4 $mm^2$ braided copper conductor with green/yellow PVC sheath, or equivalent for bonding cables.
- The required cross-section of heating feeder cable depends on the cable current loading. XLPE/SWA/PVC* type should however be used.
- Copper conductors, cross-linked polyethylene (XPLE) insulated, galvanised steel wire armoured (or braided up to and including 10 $mm^2$) and PVC over-sheathed.

In existing facilities where improvements are planned, the electrical requirements associated with the installation of automatic data capture and transmission facilities (automation) shall be considered. Whether or not automation is likely, a pipe (duct) of at least 150 mm diameter shall be installed at normal cable laying depth between the gantries and the edge of the loading area near the office location, to accommodate future cabling for automation, if required.

Cabling for automation shall be laid separately from electrical cables for power supply and shall be suitably shielded.

Pipe ends shall be sealed to prevent ingress of hydrocarbons or water. All cable pipes at new facilities should be large enough to allow 50% spare capacity for future extension of electrical systems.

### 9.4.3 Earthing and bonding

The whole of the loading bay canopy structure, gantry, product piping and fittings shall be electrically bonded and earthed. Electrical equipment shall be earthed as specified by DEP 33.64.10.10-Gen.

Loading arms shall be bonded to the gantry earth and shall be electrically continuous (resistance less than 10 ohms). Where this is not ensured, then bonding straps should be fitted and/or conductive grease used on swivels.

Where hoses are used, the internal and external reinforcing helices should be electrically continuous and bonded to the connectors at both ends.

Non-conductive filling pipes shall not be used for loading bulk vehicles.

All parts of the bulk vehicle should be bonded together (chassis, tank, piping, dip pipes, fittings etc.) and shall have a bonding resistance of less than 10 ohms.

An earthing cable shall be connected to the vehicle before any other operations are carried out (e.g. opening man-lids, connecting hoses etc.). The bonding resistance between the vehicle and the gantry shall be less than 10 ohms, and this earth shall remain in position until all other loading operations have been completed. See also earth interlocks (4.6).

## 9.5 ILLUMINATION

General illumination should be provided at all loading and discharge points if operations are to be carried out during the hours of darkness. Attention should be paid to vehicle entry and exit routes, personnel working areas, platforms and stairs, flow control valves and emergency swithes. Minimum requirements for illumination are given in DEP 33.64.10.10-Gen.

Lighting fittings should conform to the area requirements as specified in (8.1.2). Generally, fluorescent Ex'e' lighting fittings are the preferred type, although high pressure discharge lamps are also acceptable. Low pressure sodium discharge lamps shall not be used because of the potential fire hazard in the event of breakage.

## 9.6 PAINTING

DEP 30.48.00.31-Gen. and DEP 70.48.10.10-Gen. should apply.

Pickling or blast cleaning and primer coating of steelwork at the supplier's works offers constructional advantages and should be done this way rather than waiting until the structure is completed.

Colour schemes should be chosen which harmonise as far as possible with the surroundings and give a pleasant appearance at the work area.

## 9.7 DRAINAGE AND PAVEMENT

See for pavement and drainage (8.2.5).

# 10. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.


**SHELL STANDARDS**

| | |
|---|---|
| Index to DEP publications and standard specifications | DEP 00.00.05.05-Gen. |
| Painting and coating of new equipment | DEP 30.48.00.31-Gen. |
| Pumps - Selection, testing and installation | DEP 31.29.02.11-Gen. |
| Centrifugal pumps (amendments/supplements to API Std 610) | DEP 31.29.02.30-Gen. |
| Piping - General requirements | DEP 31.38.01.11-Gen. |
| MF Piping classes | DEP 31.38.01.12-Gen. |
| Instruments for measurement and control | DEP 32.31.00.32-Gen. |
| Electrical engineering guidelines | DEP 33.64.10.10-Gen. |
| Drainage and primary treatment facilities | DEP 34.14.20.31-Gen. |
| Fire hazards and fire proofing/cold splash protection of steel structures | DEP 34.19.20.11-Gen. |
| Standard vertical tanks - Selection, design and fabrication | DEP 34.51.01.31-Gen. |
| Maintenance painting | DEP 70.48.10.10-Gen. |
| Assessment of the fire safety of onshore installations | DEP 80.47.10.30-Gen. |
| Active fire protection systems and equipment for onshore facilities | DEP 80.47.10.31-Gen. |

**SHELL MARKETING MANUALS**

| | |
|---|---|
| Installations and depots | Ref No: Z1/A01/A1B<br>Z1/A10/A1B |
| Oil measurement and product conservation manual | Ref No: Z1/A18/A1B<br>Z1/A21/A1B |
| Bitumen manual | Ref No: M/L/93/D0576 |
| Bulk-loading automation guidelines for the assessment of functional requirements | MF 89-0998 or<br>SM R/89/2 |
| Guidelines for the automation of small terminals | SM No: R/C/94/D1091 |
| Automotive fuels: Marketing quality Volume 1 - Fuels additive quality system | SM No: M/C/94/D/1057 |

**OTHER SHELL PUBLICATIONS**

| | |
|---|---|
| Static electricity, technical and safety aspects | Shell Safety Committee |
| Shell aviation quality control manual | Shell Aviation |

**AMERICAN STANDARDS**

| | |
|---|---|
| Specification for horizontal end suction centrifugal pumps for chemical process | ANSI B73 1. M |
| Specification for vertical in-line centrifugal pumps for chemical process | ANSI B73 2. M |

*Issued by:*
*American National Standards Institute*
*11 West 42nd street*
*New York NY 10036*
*USA.*

| | |
|---|---|
| Bottom loading and vapour recovery for MC-306 motor vehicles | API RP 1004 |
| Centrifugal pumps for general refinery service | API 610 |

*Issued by:*
*American Petroleum Institute*
*Publications and Distribution Section*
*1220 L Street Northwest*
*Washington DC. 20005*
*USA.*

| | |
|---|---|
| US Code of Federal Regulations (CFR), Title 33, Part 154, Facilities Transferring Oil or Hazardous Material in Bulk | 33-CFR-154 |

*Issued by:*
*Department of Transportation*
*U.S. Coast Guard*
*400 Seventh street*
*Washington, DC 20590*
*USA*

**BRITISH STANDARDS**

| | |
|---|---|
| Flame arresters for general use | BS 7244 |

*Issued by:*
*British Standards Institution*
*389 Chiswick High Road*
*London W4 4AL*
*UK.*

Institute of Petroleum - Model Code of Safe Practice in the Petroleum Industry:

| | |
|---|---|
| Part 1: Electrical Safety Code | IP-Part 1 |
| Part 2: Marketing Safety Code | IP-Part 2 |
| Part 3: Refining Safety Code | IP-Part 3 |
| Part 15: Area Classification Code for Petroleum Installations | IP-Part 15 |

Institute of Petroleum - Guidelines for the design and operation of gasoline vapour emission controls

Institute of Petroleum - Code of Practice for bottom loading, vapour collection and overfill prevention

Institute of Petroleum - Petroleum measurement manual part X (meter proving)

Institute of Petroleum - Paper number 4, Code of Practice for the proving of loading gantry meters

*Issued by:*
*Institute of Petroleum*

*61 New Cavendish Street*
*London W1M 8AR*
*UK*

**EUROPEAN STANDARDS**

| | |
|---|---|
| European Parliament and Council Directive 94/63/EC on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations | European VOC directive |

*Issued by:*
*CEN Secrétariat Central*
*Rue de Stassart 36*
*B-1050 Brussels*
*Belgium.*

*Copies can also be obtained from national standards organizations*

**INTERNATIONAL STANDARDS**

| | |
|---|---|
| Technical specifications for centrifugal pumps, class II | ISO 5199 |

*Issued by:*
*International Organisation for Standardisation*
*1, Rue de Varembé*
*CH-1211 Geneva 20*
*Switzerland.*

*Copies can also be obtained from national standards organizations.*

## APPENDIX A EXAMPLES OF LOADING BAY CALCULATIONS

Two different types of loading terminal operations are considered. In the first, a peak in demand exists as the road tankers queue outside the gate as the terminal opens in the morning; here the "morning peak hour" design concept is used. In the second case it is assumed that the terminal is open 24 hours a day and the "waiting time" design concept is used.

### A.1 BASIC DATA

The loading terminal has to be designed for the following forecasted product demands given in Table A.1 below:

**Table A.1 Annual demand (design figure)**

| **Product** | **Demand $m^3$/year** | |
|---|---|---|
| U.Mogas | 300 000 | (Unleaded mogas) |
| L.Mogas | 50 000 | (Leaded mogas) |
| AGO | 100 000 | (Automotive gasoil) |
| Kerosene | 50 000 | |
| IGO | 150 000 | (Industrial gasoil) |
| **Total** | 650 000 | |

The expected seasonal demand fluctuations and the number of working days per month are given in Table A.2. In the summer months there is a strong demand for mogas and in the winter months there is a strong demand for industrial gasoil. Furthermore it gives the "peak day/average demand" factor, which is defined as the demand during the peak working day of the month divided by the monthly average demand on a working-day.

**Table A.2 Monthly fluctuations (percentage of yearly throughput), working days and peak day demand**

| **Product** | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | tot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas | 7.1 | 6.7 | 8.2 | 8.7 | 8.8 | 9.4 | 9.5 | 9.7 | 8.5 | 8.2 | 7.5 | 7.7 | 100 |
| L.Mogas | 7.1 | 6.7 | 8.2 | 8.7 | 8.8 | 9.4 | 9.5 | 9.7 | 8.5 | 8.2 | 7.5 | 7.7 | 100 |
| AGO | 7.7 | 8.0 | 8.3 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 8.5 | 8.0 | 8.2 | 8.3 | 100 |
| Kerosene | 8.0 | 8.3 | 8.1 | 7.7 | 8.0 | 8.3 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 100 |
| IGO | 11.4 | 9.4 | 8.2 | 6.2 | 5.6 | 6.2 | 6.5 | 7.0 | 8.5 | 9.5 | 10.1 | 11.4 | 100 |
| **Working days** | 21 | 20 | 22 | 19 | 19 | 22 | 21 | 21 | 21 | 22 | 22 | 18 | 251 |
| **Peak day / average demand** | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | |

## A.2 CARGO COMBINATIONS

The different products are dispatched in different types of vehicles and in single and multi-grade cargos. Therefore the demand should be split up into "cargo combinations":
into combinations of products and types of vehicles for single grade cargos and into combinations of mixtures of products and types of vehicles for multi-grade cargos. The reason for this split is that different "cargo combinations" have different loading rates and need different types of loading bay.

The kerosene and IGO are only shipped in single-grade vehicles. The automotive grades (U.Mogas, L.Mogas and AGO) are shipped in single-grade cargos (cargo combinations: "U.Mogas (S)", "L.Mogas (S)" and "AGO (S)") as well as in mixed grade cargos (cargo combination "Mog. + AGO").

All products are bottom loaded. However, some of the IGO is also top loaded (cargo combination "IGO-top"). Table A.3 shows which percentage of the product demand is dispatched by which cargo combination. For example 70% of the Unleaded Mogas demand is dispatched in single grade cargos (cargo combination "U.Mogas (S)") and the remaining 30% is dispatched together with Leaded Mogas and AGO in multi-grade cargos (cargo combination "Mog. + AGO").

**Table A.3 Distribution of Products between Cargo Combinations**

| Cargo combination | Product | | | | |
|---|---|---|---|---|---|
| | U.Mogas | L.Mogas | AGO | IGO | Kero |
| U.Mogas (S) | 70% | | | | |
| L.Mogas (S) | | 20% | | | |
| Mog. + AGO | 30% | 80% | 60% | | |
| AGO (S) | | | 40% | | |
| Kero-bottom | | | | | 100% |
| IGO-bottom | | | | 50% | |
| IGO-top | | | | 50% | |
| **Total:** | 100% | 100% | 100% | 100% | 100% |

## A.3 LOADING TIMES OF CARGO COMBINATIONS

### A.3.1 U.Mogas (S)

The single grade cargo combination "U.Mogas (S)" is, like all other automotive grades, loaded in road tankers with 5 compartments with a volume of 8.5 $m^3$. On average 8 $m^3$ are loaded in each compartment.

The product is bottom loaded with 4-inch loading arms at a high flow rate of 2300 l/min. The first 500 litres and the last 200 litres are loaded at a low flow rate of 500 l/min. Therefore, the time to load one compartment is:

| | | | | |
|---|---|---|---|---|
| Connect coupling | | | 0.3 | (minutes) |
| Low flow | 500/500 | = | 1.0 | (minutes) |
| High flow | (8 000 - 500 -200) / 2300 | = | 3.2 | (minutes) |
| Low flow | 200/500 | = | 0.4 | (minutes) |
| Disconnect coupling | | | 0.3 | (minutes) |
| | Total compartment loading time: | | 5.2 | (minutes) |

It is assumed that two compartments can be loaded simultaneously. The total loading time is determined by the activities on the critical path, i.e. the time to load 3 compartments (the remaining 2 compartments can be loaded in the meantime with the second arm).

Further, it is assumed that the preparatory activities take 2 minutes (e.g. drive into bay, stop, choose products, set meters, connect overfill/earth, connect vapour collection hose) and the finishing activities take 2 minutes (disconnect overfill/earth, disconnect vapour collection hose and leave bay). Therefore the total bay time is:

| | | | |
|---|---|---|---|
| Preparation time | | 2.0 | (minutes) |
| Loading 3 + 2 compartments: 3 * 5.2 | = | 15.5 | (minutes) |
| Finishing | | 2.0 | (minutes) |
| Total bay time: | | 19.5 | (minutes) |

### A.3.2 L.Mogas (S)

The single grade leaded mogas cargo combination "L.Mogas (S)" is loaded in the same road tankers as the other automotive grades. Therefore the compartment loading time is the same as calculated in the previous paragraph, i.e. 5.2 minutes.

As the demand for the cargo combination "L.Mogas (S)" is small, it is assumed that loading bays with two arms for leaded mogas cannot be justified. Consequently, the total bay time for the single leaded mogas cargo combination will be longer:

| | | | |
|---|---|---|---|
| Preparation time | | 2.0 | (minutes) |
| Loading 5 compartments 5 * 5.2 | = | 25.9 | (minutes) |
| Finishing | | 2.0 | (minutes) |
| Total bay time: | | 29.9 | (minutes) |

### A.3.3 Mog + AGO

The mixed unleaded, leaded mogas and AGO cargo combination "Mog. + AGO" is loaded in the same road tankers as the other automotive grades, therefore the compartment loading time is the same, i.e. 5.2 minutes.

The number of compartments loaded with each product will vary from road tanker to road tanker. From Tables A.1, A.2 and A.3 the average cargo composition can be calculated as shown in Table A.4:

**Table A.4 Average number of compartments for "Mog. + AGO" cargo combination**

| Product | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas | 2.3 | 2.2 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | **2.5** | 2.4 | 2.4 | 2.3 | 2.3 |
| L.Mogas | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | **1.1** | 1.1 | 1.1 | 1.0 | 1.0 |
| AGO | 1.7 | 1.8 | 1.6 | 1.6 | 1.6 | 1.5 | 1.5 | 1.5 | 1.6 | 1.6 | 1.7 | **1.7** |
| **Total** | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

It is assumed that two compartments can be loaded simultaneously. The total loading time is determined by the activities on the critical path, i.e. the time to load 3 compartments (the remaining 2 compartments can be loaded in the meantime with the second arm). Therefore the total bay time will be the same as for the "U.Mogas" cargo combination, i.e. 19.5 minutes.

This cargo combination could be loaded in a bay with one single loading arm for each grade. However, if there are cargos with 4 compartments of the same grade the loading time will be longer than the loading time calculated above (there will be 4 compartments on the critical path). If this is the case for a large proportion of the cargos, consideration should be given to splitting the "Mog. + AGO" cargo combination into several cargo combinations with different compositions. In this example it has been assumed that this is not the case.

Also if there is a large proportion of cargos with only 2 grades instead of 3 grades, the alternative of splitting the "Mog. + AGO" cargo combination into several cargo combinations should be considered. These cargo combinations could be loaded in a bay with only 2 loading arms instead of 3.

### A.3.4 AGO (S)

The single grade automotive gasoil cargo combination "AGO (S)" is loaded in the same type of road tankers as the other automotive cargo combinations. It is assumed that 2 compartments can be loaded at the same time. Therefore the total bay time is the same as for the "U.Mogas (S)" cargo combination, i.e. 19.5 minutes.

### A.3.5 Kero-bottom

The "kero-bottom" cargo combination is loaded into road tankers with 2 compartments of 21 $m^3$. On average 20 $m^3$ are loaded into each compartment.

The product is bottom loaded with 4-inch loading arms at a high flow rate of 2300 l/min. The first 800 litres and the last 200 litres are loaded at a low flow rate of 500 l/min. Therefore the time to load a compartment is:

| | | | | |
|---|---|---|---|---|
| Connect coupling | | | 0.3 | (minutes) |
| Low flow | 800/500 | = | 1.6 | (minutes) |
| High flow | (20 000 - 800 - 200) / 2300 | = | 8.4 | (minutes) |
| Low flow | 200/500 | = | 0.4 | (minutes) |
| Disconnect coupling | | = | 0.3 | (minutes) |
| | Total compartment loading time: | | 10.9 | (minutes) |

It is assumed that the two compartments can be loaded simultaneously. Using the same assumptions as before, the total bay time is:

| | | | |
|---|---|---|---|
| Preparation time | | 2.0 | (minutes) |
| Loading compartments | = | 10.9 | (minutes) |
| Finishing | | 2.0 | (minutes) |
| Total bay time: | | 14.9 | (minutes) |

### A.3.6 IGO-bottom

The single grade cargo combination "IGO-bottom" is bottom loaded into the same type of vehicle as the cargo combination "Kero-bottom". Using the same assumption, the loading time will also be the same, i.e. 14.9 minutes.

### A.3.7 IGO-top

The single grade cargo combination "IGO-top" is top loaded into road tankers with one single compartment of 42 $m^3$. On average 40 $m^3$ are loaded in the compartment.

The product is loaded with one 3-inch loading arm at a high flow of 1250 l/min The first 800 litres and the last 200 litres are loaded at a low flow rate of 250 l/min. Therefore the compartment loading time is:

| | | | | |
|---|---|---|---|---|
| Insert loading arm | | | 0.5 | (minutes) |
| Low flow | 800/250 | = | 3.2 | (minutes) |
| High flow | (40 000 -800 - 200)/1250 | = | 31.2 | (minutes) |
| Low flow | 200/250 | = | 0.8 | (minutes) |
| Remove loading arm | | | 0.5 | (minutes) |
| Total compartment loading time: | | | 36.2 | (minutes) |

The total bay time is:

| | | |
|---|---|---|
| Preparation time | 2.0 | (minutes) |
| Loading compartments | 36.2 | (minutes) |
| Finishing | 2.0 | (minutes) |
| Total bay time: | 40.2 | (minutes) |

## A.4 NOMINAL LOADING RATES

By dividing the total cargo volume by the total bay time, the nominal loading rates can be calculated for the different cargo combinations, see Table A.5. The nominal loading rate represents the average quantity of product which could be loaded in one bay in one hour if the bay was occupied 100% of the time.

**Table A.5 Nominal loading rates**

| **Cargo combination** | Required loading arms in bay | Number of compart-ments | Cargo volume ($m^3$) | Total bay time (min) | Nominal loading rate ($m^3$/hr) |
|---|---|---|---|---|---|
| U.Mogas (S) | 2 * U.Mogas | 5 | 40 | 20 | 123 |
| L.Mogas (S) | 1 * L.Mogas | 5 | 40 | 30 | 80 |
| Mog. + AGO | 1 * U.Mogas<br>1 * L. Mogas<br>1 * AGO | 5 | 40 | 20 | 123 |
| AGO (S) | 2 * AGO | 5 | 40 | 20 | 123 |
| Kero-bottom | 2 * Kerosene | 2 | 40 | 15 | 160 |
| IGO-bottom | 2 * IGO | 2 | 40 | 15 | 160 |
| IGO-top | 1 * IGO (3" top) | 1 | 40 | 40 | 60 |

Note the difference in nominal loading rate between cargo combinations which are loaded with two arms simultaneously (e.g. "U.Mogas (S)") and cargo combinations which are loaded with a single arm (e.g. "L.Mogas (S)"). Also note the much higher loading rate of the "IGO-bottom" cargo combination which is bottom loaded with two 4-inch arms as compared to the "IGO-top" cargo combination which is top loaded with a single 3-inch arm.

## A.5 'MORNING PEAK PERIOD' CONCEPT

The 'morning peak period' concept is applicable to situations where the demand is not evenly distributed over the day, e.g. where road tankers queue in the morning in front of the gate.

In this case, the size of the loading facilities will be determined by the demand during the peak period and the period of time within which this demand has to be satisfied.

### A.5.1 Peak period demand

In this example it is assumed that a two-shift system is used and that in the morning (the peak period) the road tankers queue in front of the gate. It is assumed that the demand in this peak period is:

Peak Period Demand = 20% of Daily Demand.

Using the basic data of Table A.1 and Table A.2, the peak period demand per product can be calculated as shown in Table A.6:

**Table A.6 Peak period demand per product (at peak day of the month, in m$^3$)**

| **Product** | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas | 264 | 261 | 291 | 357 | **361** | 333 | 353 | 329 | 316 | 291 | 266 | 316 |
| L.Mogas | 44 | 44 | 48 | 60 | **60** | 56 | 59 | 55 | 53 | 48 | 44 | 53 |
| AGO | 95 | 104 | 98 | 118 | **118** | 102 | 106 | 97 | 105 | 95 | 97 | 114 |
| Kerosene | 50 | 54 | 48 | 53 | 55 | 49 | 53 | 49 | 53 | 51 | 51 | **59** |
| IGO | 212 | 183 | 145 | 127 | 115 | 110 | 121 | 119 | 158 | 168 | 179 | **234** |
| **Total** | 664 | 646 | 631 | 714 | 709 | 649 | 692 | 648 | 685 | 653 | 637 | **775** |

Example: The demand for unleaded mogas during the peak period of the peak day in January is calculated as follows:

= Annual Demand * (January Demand/ Annual Demand) * (Peak Day Demand / Average Demand) * (Peak Period Demand / Daily Demand) / Working Days

= 300 000 m$^3$ * (7.1% / 100%) * (1.3) * (20% / 100%) / 21 d = 264 m$^3$

Using Table A.3, this demand can be distributed over the different cargo combinations as shown in Table A.7:

**Table A.7 Peak period demand per cargo combination (at peak day of the month, in $m^3$)**

| Cargo combination | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas (S) | 185 | 183 | 204 | 250 | **253** | 233 | 247 | 230 | 221 | 204 | 186 | 221 |
| L.Mogas (S) | 9 | 9 | 10 | 12 | **12** | 11 | 12 | 11 | 11 | 10 | 9 | 11 |
| Mog. + AGO | 171 | 176 | 185 | 225 | **227** | 205 | 217 | 201 | 200 | 183 | 173 | 205 |
| AGO (S) | 38 | 42 | 39 | 47 | **47** | 41 | 43 | 39 | 42 | 38 | 39 | 45 |
| Kero-bottom | 50 | 54 | 48 | 53 | 55 | 49 | 53 | 49 | 53 | 51 | 51 | **59** |
| IGO-bottom | 106 | 92 | 73 | 64 | 57 | 55 | 60 | 59 | 79 | 84 | 90 | **117** |
| IGO-top | 106 | 92 | 73 | 64 | 57 | 55 | 60 | 59 | 79 | 84 | 90 | **117** |
| **Total** | 558 | 554 | 558 | 651 | 651 | 594 | 632 | 589 | 606 | 569 | 547 | **658** |

The maximum peak period demand of "automotive" grades occurs in May due to the higher seasonal demand and (in some countries) fewer working days. The maximum peak period demand of kerosene and IGO occurs in December for the same reasons.

### A.5.2 Theoretical number of loading bays

It is assumed that the period of time within which this demand has to be satisfied is:

Maximum Waiting Period = 45 min = 0.75 h

The average waiting period for the road tankers will thus be half of this period. The theoretical number of loading bays needed to satisfy this demand is:

Theoretical number of loading bays

$$= \frac{\text{Peak Period Demand } (m^3)}{\text{Max Waiting Period (h)} * \text{ Nominal Loading Rate } (m^3/h) * \text{ Loading Bay Occupancy}}$$

As the road tankers will queue in front of the gate the loading bay occupancy ratio will be virtually 100% during the peak period. Using the nominal loading rates of Table A.5 and the peak period demand figures of Table A.7, the theoretical loading bay requirements can be calculated as shown in Table A.8.

**Table A.8 Theoretical loading bay requirements (peak period concept)**

| **Cargo combination** | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas (S) | 2.0 | 2.0 | 2.2 | 2.7 | **2.7** | 2.5 | 2.7 | 2.5 | 2.4 | 2.2 | 2.0 | 2.4 |
| L.Mogas (S) | 0.1 | 0.1 | 0.2 | 0.2 | **0.2** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 |
| Mog. + AGO | 1.9 | 1.9 | 2.0 | 2.4 | **2.5** | 2.2 | 2.4 | 2.2 | 2.2 | 2.0 | 1.9 | 2.2 |
| AGO (S) | 0.4 | 0.5 | 0.4 | 0.5 | **0.5** | 0.4 | 0.5 | 0.4 | 0.5 | 0.4 | 0.4 | 0.5 |
| Kero-bottom | 0.4 | 0.5 | 0.4 | 0.4 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | **0.5** |
| IGO-bottom | 0.9 | 0.8 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.7 | 0.7 | 0.7 | **1.0** |
| **Total bottom** | 5.7 | 5.7 | 5.8 | 6.8 | **6.9** | 6.3 | 6.7 | 6.2 | 6.3 | 5.9 | 5.6 | 6.8 |
| IGO-top | 2.4 | 2.0 | 1.6 | 1.4 | 1.3 | 1.2 | 1.3 | 1.3 | 1.8 | 1.9 | 2.0 | **2.6** |

The maximum bottom loading bay requirement is in May, when 6.9 bays are required. The maximum top loading bay requirement is in December, when 2.6 bays are required. As the high IGO demand occurs only during a relatively short period, consideration should be given to accepting a longer waiting period during this period and allocating only two top loading bays to IGO.

Also the validity of the "peak period concept" calculation method should be questioned here for the "IGO-top" cargo combination; the peak period demand in the peak month of 117 $m^3$ represents only (117 $m^3$ / 40 $m^3$) = 3 road tankers. From this simple calculation it follows that two top loading bays would be sufficient for IGO: 2 road tankers could be serviced immediately and the third could start loading after 40 minutes, thus within the specified maximum waiting period of 45 minutes.

### A.5.3 Allocation of loading arms to loading bays

In the allocation of loading arms to loading bays the following factors should be taken into account:

a) The theoretical loading bay requirements should be fulfilled, see Table A.8.

b) For each cargo combination the right number and type of loading arms should be available, see second column of Table A.5.

c) The product grouping requirements should be taken into account, e.g. similar products should be combined, see also (8.1.5).

d) The number of loading bays should be minimised.

e) The number of loading arms should be minimised. Minimising the number of loading arms will also minimise the capacity of pumps, lines and VRU.

f) The number of arms per loading bay should preferably be limited to 5, see (2.6).

A graphical presentation of the loading bay requirements as shown in Figure A.1 can be helpful in allocating loading arms to bays. Table A.9 shows a proposal for the allocation of the bottom loading arms to the loading bays in which the above factors are taken in account.

First, full bays have been allocated to cargo combinations requiring one or several full bays (e.g. "U.Mogas (S)" and "Mog. + AGO"). Then the remaining cargo combinations which require less than a full loading bay are combined and allocated to bays (e.g. "Kero-bottom" and "IGO-bottom" to Bay 7 and "L.Mogas (S)", "U.Mogas" and "Mog. + AGO" to Bay 3).

In combining kerosene and IGO in one bay it has been assumed that kerosene loading arms have grade-specific couplings. If this is not the case a separate loading bay for kerosene should be considered.

To reduce the requirement for loading arms and bays, use has been made of the fact that the peak in demand of IGO in winter coincides with a low demand for the automotive grades. In winter the two mogas arms of Bay 6 are switched to IGO. It has here been assumed that the meter system of these arms can handle the difference in viscosity between IGO and mogas.

**Figure A.1: Bottom loading bay requirements (peak period concept)**

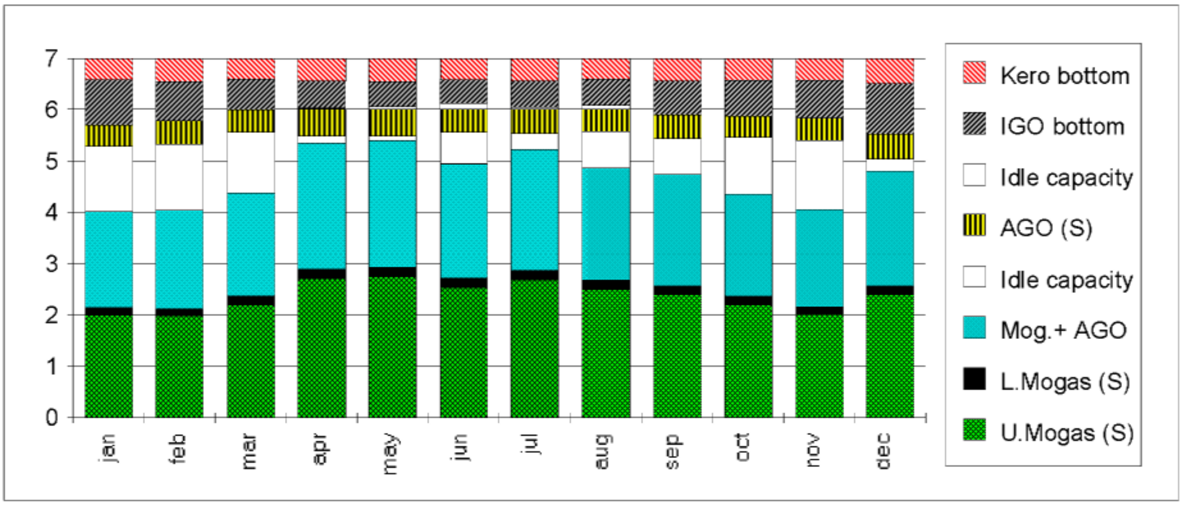


**Table A.9 Proposed allocation of bottom loading arms to bays (peak period concept)**

| **Bay no** | 1 | 2 | 3 | 4 | 5 | 6 summer (winter) | 7 | **Total summer (winter)** |
|---|---|---|---|---|---|---|---|---|
| U.Mogas | 2 | 2 | 2 | 1 | 1 | 1 (0) | | **9 (8)** |
| L.Mogas | | | 1 | 1 | 1 | 1 (0) | | **4 (3)** |
| AGO | | | 1 | 1 | 1 | 2 | | **5** |
| Kerosene | | | | | | | 2 | **2** |
| IGO | | | | | | 0 (2) | 2 | **2 (4)** |
| **Total** | 2 | 2 | 4 | 3 | 3 | 4 | 4 | **22 (22)** |

## A.6 'WAITING TIME' METHOD

The waiting time method is applicable to situations in which road tankers arrive randomly at the terminal, thus in cases where **on average** the demand is constant during the period under consideration (e.g. the working day).

The size of the loading terminal will be determined by the demand and the acceptable average waiting time during the peak days.

### A.6.1 Average hourly demand during peak days

In this example it is assumed that the loading terminal operates on a 24 hours basis. Using the same basic data as in the "peak period concept" (Table A.1 and Table A.2) the average hourly demand can be calculated as shown in Table A.10:

**Table A.10 Average hourly demand per product during peak days of the month ($m^3/h$)**

| **Product** | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas | 55 | 54 | 61 | 74 | **75** | 69 | 74 | 69 | 66 | 61 | 55 | 66 |
| L.Mogas | 9 | 9 | 10 | 12 | **13** | 12 | 12 | 11 | 11 | 10 | 9 | 11 |
| AGO | 20 | 22 | 20 | 25 | **25** | 21 | 22 | 20 | 22 | 20 | 20 | 24 |
| Kerosene | 10 | 11 | 10 | 11 | 11 | 10 | 11 | 10 | 11 | 11 | 11 | **12** |
| IGO | 44 | 38 | 30 | 27 | 24 | 23 | 25 | 25 | 33 | 35 | 37 | **49** |
| **Total** | 138 | 135 | 131 | 149 | 148 | 135 | 144 | 135 | 143 | 136 | 133 | **162** |

Example: The average hourly demand for unleaded mogas during the peak day in January is:

= Annual Demand * (January Demand/ Annual Demand) * (Peak Day Demand / Average Demand) / (No of Working Days per Month * Working Hours per Day)

= 300 000 $m^3$ * (7.1% / 100%) * (1.3) / (21 d * 24 h) = 55 $m^3$/h

Using Table A.3 this demand can be distributed over the different cargo combinations as shown in Table A.11:

**Table A.11 Average hourly demand per cargo combination during peak days of the month ($m^3$/h)**

| Cargo combination | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas (S) | 38 | 38 | 42 | 52 | **53** | 49 | 51 | 48 | 46 | 42 | 39 | 46 |
| L.Mogas (S) | 2 | 2 | 2 | 2 | **3** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Mog. + AGO | 36 | 37 | 39 | 47 | **47** | 43 | 45 | 42 | 42 | 38 | 36 | 43 |
| AGO (S) | 8 | 9 | 8 | 10 | **10** | 8 | 9 | 8 | 9 | 8 | 8 | 9 |
| Kero-bottom | 10 | 11 | 10 | 11 | 11 | 10 | 11 | 10 | 11 | 11 | 11 | **12** |
| IGO-bottom | 22 | 19 | 15 | 13 | 12 | 11 | 13 | 12 | 16 | 18 | 19 | **24** |
| IGO-top | 22 | 19 | 15 | 13 | 12 | 11 | 13 | 12 | 16 | 18 | 19 | **24** |
| **Total** | 116 | 116 | 116 | 136 | 136 | 124 | 132 | 123 | 126 | 118 | 114 | 137 |

### A.6.2 Theoretical loading bay requirements

In the waiting time concept the number of loading bays needed to satisfy the demand is given by:

Number of loading bays

$$= \frac{\text{Average Hourly Demand } (m^3/h)}{\text{Nominal Loading Rate } (m^3/h) * \text{ Loading Bay Occupancy Ratio } (-)}$$

The loading bay occupancy in this formula is defined as the fraction of the time the loading bay is on average occupied by a road tanker. The higher this loading bay occupancy ratio, the greater the chance that when a road tanker arrives the loading bay is already occupied and the longer the average vehicle waiting time will be.

In this example an average vehicle waiting time of 10 minutes for peak days has been assumed as acceptable.

The Tables in Appendix B give this average vehicle waiting time as a function of the bay occupancy ratio, the vehicle loading time and the number of loading bays available for the cargo combination. The shorter the loading time and the higher the number of loading bays available, the higher the bay occupancy can be chosen for the same average vehicle waiting time.

Making use of the Tables in Appendix B and Table A.5 for the loading times, the following bay occupancy ratios were chosen for further calculation, see Table A.12. It was here assumed that only one bay is available for each cargo combination. Later this assumption will have to be checked; if several bays are available for a cargo combination, a higher bay occupancy ratio can be chosen.

**Table A.12 Bay occupancy ratio per cargo combination**

| Cargo Combination | Bay Occupancy |
|---|---|
| U.Mogas (S) | 0.5 |
| L.Mogas (S) | 0.4 |
| Mog. + AGO | 0.5 |
| AGO (S) | 0.5 |
| Kero-bottom | 0.55 |
| IGO-bottom | 0.55 |
| IGO-top | 0.35 |

Using the above bay occupancy ratios, the average hourly demands of Table A.11 and the nominal loading rates of Table A.5, the loading bay requirements can be calculated as shown in Table A.13:

**Table A.13 Theoretical loading bay requirements (waiting time concept)**

| Cargo combination | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.Mogas (S) | 0.6 | 0.6 | 0.7 | 0.9 | **0.9** | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.6 | 0.7 |
| L.Mogas (S) | 0.1 | 0.1 | 0.1 | 0.1 | **0.1** | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Mog. + AGO | 0.6 | 0.6 | 0.6 | 0.8 | **0.8** | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.7 |
| AGO (S) | 0.1 | 0.1 | 0.1 | 0.2 | **0.2** | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 |
| Kero-bottom | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | **0.1** |
| IGO-bottom | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | **0.3** |
| **Total bottom** | 1.8 | 1.8 | 1.8 | 2.1 | **2.1** | 1.9 | 2.1 | 1.9 | 2.0 | 1.8 | 1.7 | 2.1 |
| IGO-top | 1.1 | 0.9 | 0.7 | 0.6 | 0.6 | 0.5 | 0.6 | 0.6 | 0.8 | 0.8 | 0.9 | **1.2** |

### A.6.3 Allocation of loading arms to loading bays

For the top-loaded IGO, 1.2 loading bays are theoretically required in the peak month (December). However, having only 1 loading bay should be considered. This would result in an average loading bay occupancy during the peak days of December of:

Occupancy = Demand / (Nominal Loading Rate * Number of Loading Bays)

= 24 $m^3/h$ / ( 49 $m^3/h$ * 1 ) = 0.49

From the Tables in Appendix B, it follows that this bay occupancy would result in an average vehicle waiting time of 20 minutes during the peak days of December.

The maximum bottom loading bay requirement occurs in May when 2.1 bays are required. If a slightly higher average waiting time is accepted this demand could theoretically be fulfilled with 2 loading bays, however this would result in a design with complicated loading bays with many arms and products. Therefore the following allocation of loading arms to loading bays is proposed (Figure A.2 and Table A.14):

**Figure A.2: Theoretical loading bay requirements (waiting time concept)**

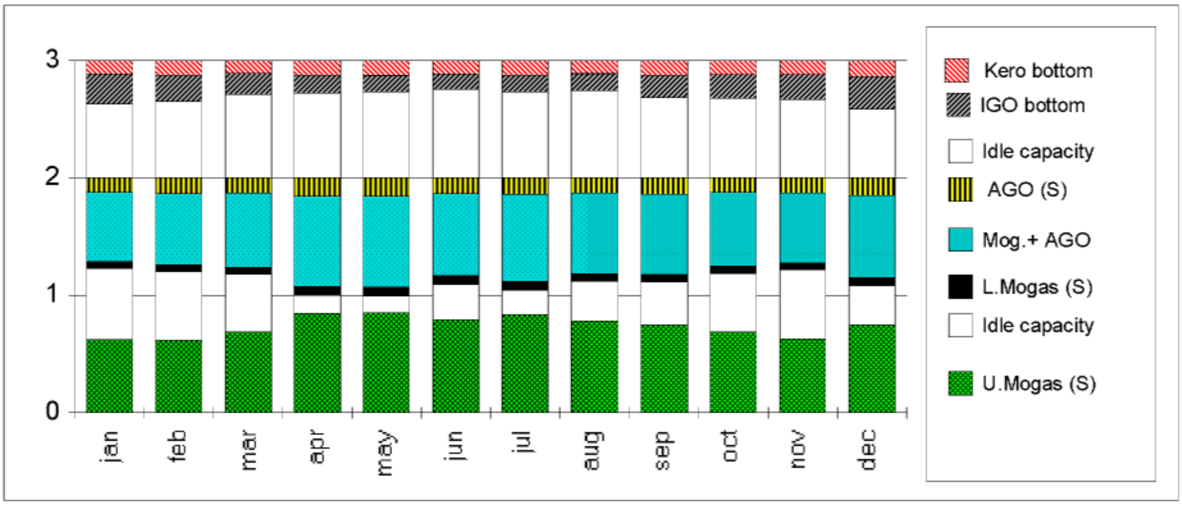



**Table A.14 Proposed allocation of loading arms to bays (waiting time concept)**

| **Bay no** | 1 | 2 | 3 | **Total** |
|---|---|---|---|---|
| U.Mogas | 2 | 1 | | **3** |
| L.Mogas | | 1 | | **1** |
| AGO | | 2 | | **2** |
| Kerosene | | | 2 | **2** |
| IGO | | | 2 | **2** |
| **Total** | **2** | **4** | **4** | **10** |

Strictly speaking, adding the theoretical loading bay requirements of cargo combinations is only valid if the loading times and bay occupancies of the different cargo combinations are the same. However, in this case the bay loading times and bay occupancies of the different cargo combinations allocated together to one bay are reasonably close to each other. In such a case, the results should be checked by numerical simulations.

## APPENDIX B AVERAGE VEHICLE WAITING TIME EXPECTANCY

**Table B.1 Total bay time = 15 minutes**

| Average bay occupancy ratio | Available number of bays for a product | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0.4 | 5.0 | 1.6 | 0.7 | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| 0.5 | 7.5 | 2.7 | 1.3 | 0.7 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 0.6 | 11.3 | 4.4 | 2.4 | 1.5 | 1.0 | 0.7 | 0.5 | 0.4 | 0.3 | 0.2 |
| 0.7 | 17.5 | 7.4 | 4.3 | 2.8 | 2.0 | 1.5 | 1.2 | 0.9 | 0.8 | 0.6 |
| 0.8 | 30.0 | 13.5 | 8.3 | 5.8 | 4.3 | 3.4 | 2.7 | 2.3 | 1.9 | 1.6 |
| 0.9 | 67.5 | 32.2 | 20.7 | 15.0 | 11.7 | 9.4 | 7.9 | 6.7 | 5.9 | 5.2 |

**Table B.2 Total bay time = 20 minutes**

| Average bay occupancy ratio | Available number of bays for a product | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0.4 | 6.6 | 2.1 | 0.9 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| 0.5 | 10.0 | 3.5 | 1.7 | 1.0 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| 0.6 | 15.0 | 5.9 | 3.2 | 2.0 | 1.3 | 0.9 | 0.7 | 0.5 | 0.4 | 0.3 |
| 0.7 | 23.3 | 9.9 | 5.7 | 3.8 | 2.7 | 2.0 | 1.6 | 1.3 | 1.0 | 0.8 |
| 0.8 | 40.0 | 18.1 | 11.1 | 7.7 | 5.8 | 4.5 | 3.7 | 3.0 | 2.6 | 2.2 |
| 0.9 | 90.0 | 42.9 | 27.6 | 20.0 | 15.5 | 12.6 | 10.5 | 9.0 | 7.8 | 6.9 |

**Table B.3 Total bay time = 25 minutes**

| Average bay occupancy ratio | Available number of bays for a product | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0.4 | 8.3 | 2.6 | 1.1 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 |
| 0.5 | 12.5 | 4.4 | 2.2 | 1.2 | 0.8 | 0.5 | 0.3 | 0.2 | 0.2 | 0.1 |
| 0.6 | 18.8 | 7.3 | 4.0 | 2.5 | 1.6 | 1.2 | 0.9 | 0.6 | 0.5 | 0.4 |
| 0.7 | 29.2 | 12.3 | 7.2 | 4.7 | 3.4 | 2.5 | 2.0 | 1.6 | 1.3 | 1.0 |
| 0.8 | 50.0 | 22.6 | 13.8 | 9.7 | 7.2 | 5.7 | 4.6 | 3.8 | 3.2 | 2.7 |
| 0.9 | 113 | 53.7 | 34.4 | 25.0 | 19.4 | 15.7 | 13.2 | 11.2 | 9.8 | 8.6 |

**Table B.4 Total bay time = 30 minutes**

| Average bay occupancy ratio | Available number of bays for a product | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0.4 | 10.0 | 3.1 | 1.3 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 |
| 0.5 | 15.0 | 5.3 | 2.6 | 1.5 | 0.9 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 |
| 0.6 | 22.5 | 8.8 | 4.8 | 2.9 | 2.0 | 1.4 | 1.0 | 0.8 | 0.6 | 0.5 |
| 0.7 | 35.0 | 14.8 | 8.6 | 5.7 | 4.1 | 3.0 | 2.4 | 1.9 | 1.5 | 1.3 |
| 0.8 | 60.0 | 27.1 | 16.6 | 11.6 | 8.7 | 6.8 | 5.5 | 4.6 | 3.8 | 3.3 |
| 0.9 | 135 | 64.4 | 41.3 | 30.0 | 23.3 | 18.9 | 15.8 | 13.5 | 11.7 | 10.3 |

## APPENDIX C EXAMPLE OF PUMP CAPACITY CALCULATION

Even during the peak demand period loading arms are only at full flow during part of the time. The rest of the time, the road tanker drives into the bay, couplings are connected, other product grades are loaded with other arms etc. Therefore, if there are many loading arms for one grade, the probability is small that they will all be at full flow at the same time. Therefore the required pumping capacity for a product grade can be chosen smaller than that required for all loading arms at full flow. This Appendix gives an example of the calculation method to determine this reduced pumping capacity.

### C.1 BASIC DATA

Given is a loading terminal with 5 loading bays. Each loading bay is equipped with 1 loading arm for unleaded mogas, 1 for leaded mogas and 1 for AGO.

The products are shipped in the same type of tankers with 5 compartments as in Appendix A, see (A.3). The average number of compartments loaded per product per tanker is shown in Table C.1:

**Table C.1 Average number of compartments per product per tanker**

| **Product** | **Average number of compartments** |
|---|---|
| Unleaded Mogas | 2.6 |
| Leaded Mogas | 0.6 |
| AGO | 1.8 |
| **Total** | 5.0 |

It is assumed that two compartments can be loaded at the same time and that the loading rates and times are the same as in Appendix A.3.3.

The pump capacity should be chosen such that in more than 90% of the cases the flow demand can be met during the peak demand period.

### C.2 CALCULATION OF EQUIVALENT FULL FLOW TIME OF ONE COMPARTMENT

As indicated in (A.3), a compartment is first loaded at a reduced flow rate of 500 l/min for one minute, after which it is loaded at a full flow rate of 2300 l/min for 3.2 minutes. At the end of the loading cycle the compartment is loaded at a reduced flow rate of 500 l/min.

Therefore the total equivalent full flow time is (see (2.7.3)):

| | | | | |
|---|---|---|---|---|
| Low flow start | 1 min * | (500 / 2300) | = | 0.22 min |
| Full flow | | | = | 3.2 min |
| Low flow end | 0.4 min * | (500 / 2300) | = | 0.09 min |
| | | | | ------------- |
| Total equivalent full flow time: | | | = | 3.5 min |

### C.3 PROBABILITY OF HAVING ONE ARM AT FULL FLOW

The probability "p" of having a loading arm at full flow for a product can be calculated in this case as follows:

$$p = \frac{\text{Number of compartments} * \text{Equivalent Full Flow Time per Compartment}}{\text{Total Bay Time}}$$

Using Table C.1 for the average number of compartments loaded, 3.5 minutes for the equivalent flow time per compartment and 19.5 minutes for the total time the tanker spends on average in the bay (see (A.3)), the probabilities of having a loading arm at full flow can be calculated as shown in Table C.2:

**Table C.2 Probability "p" of having a loading arm at full flow**

| Product | p |
|---|---|
| Unleaded Mogas | 0.47 |
| Leaded Mogas | 0.11 |
| AGO | 0.32 |

C.4 PROBABILITY OF HAVING SEVERAL ARMS AT FULL FLOW

The probabilities f(n) that n loading arms of the 5 available loading arms (A = 5) will be loading at full flow at the same time can be calculated by using the formula of (2.7.3) as shown in Table C.3:

**Table C.3 Probability f(n) that n loading arms are loading at full flow**

| f(n) | Unleaded mogas | Leaded mogas | AGO |
|---|---|---|---|
| f(0) | 0.043 | 0.565 | 0.142 |
| f(1) | 0.188 | 0.342 | 0.339 |
| f(2) | 0.330 | 0.083 | 0.324 |
| f(3) | 0.290 | 0.010 | 0.155 |
| f(4) | 0.127 | 0.001 | 0.037 |
| f(5) | 0.022 | 0.000 | 0.004 |

By adding the above values of f(n) the probabilities g(M) that M or less than M loading arms are loading at full flow can be calculated as shown in Table C.4:

**Table C.4 Probability g(M) that M or less loading arms are loading at full flow**

| g(M) | Unleaded mogas | Leaded mogas | AGO |
|---|---|---|---|
| g(0) | 0.043 | 0.565 | 0.142 |
| g(1) | 0.231 | **0.907** | 0.481 |
| g(2) | 0.561 | 0.989 | 0.805 |
| g(3) | 0.851 | 0.999 | **0.959** |
| g(4) | **0.978** | 1.000 | 0.996 |
| g(5) | 1.000 | 1.000 | 1.000 |

## C.5 REQUIRED PUMPING CAPACITY

To satisfy the maximum flow demand 90% of the time, M should be chosen such that g(M) > 0.9. From Table C.4 it follows that the pumping capacities should be chosen as shown in Table C.5:

**Table C.5 Required pumping capacity**

| | Unleaded mogas | Leaded mogas | AGO |
|---|---|---|---|
| Smallest M for which g(M) > 0.9 | 4 | 1 | 3 |
| Chosen M | 4 | **2** | 3 |
| Design flow rate of loading arm (l/min) | 2500 | 2500 | 2500 |
| Required pumping capacity (l/min) | 10000 | 5000 | 7500 |

From Table C.4 it follows that for leaded mogas a pumping capacity for only 1 loading arm would be sufficient 90% of the time. However, if two or more loading arms are allocated for a product grade, the pumping capacity is never chosen smaller than that required for two loading arms, see Note under (2.7.3), therefore M=2 has been chosen.

## APPENDIX D FIGURES

**FIGURE 3.1a Typical flow diagram of automated bottom loading installation; gantry based equipment**

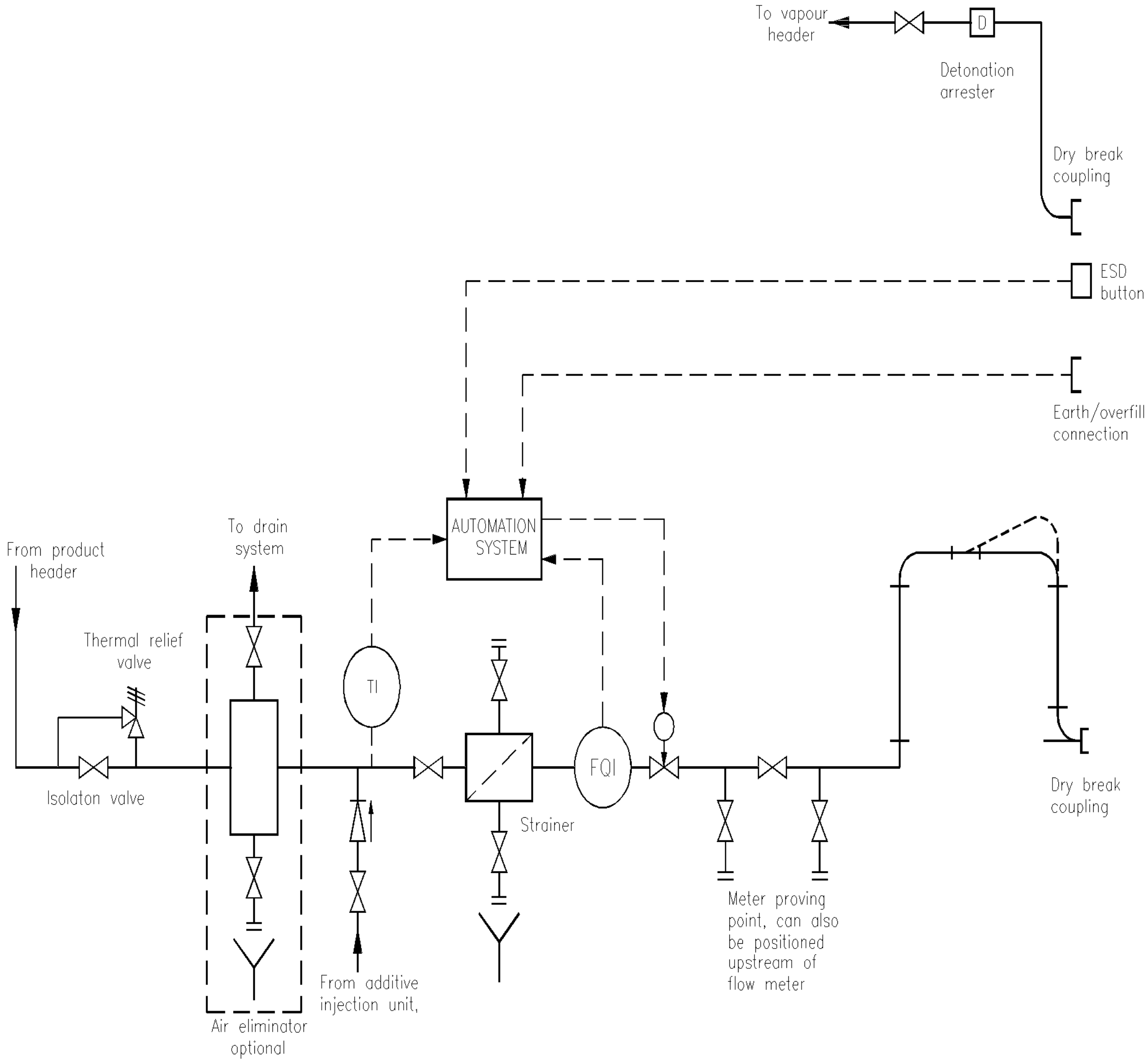


**Figure 3.1b Typical flow diagram of automated bottom loading installation**

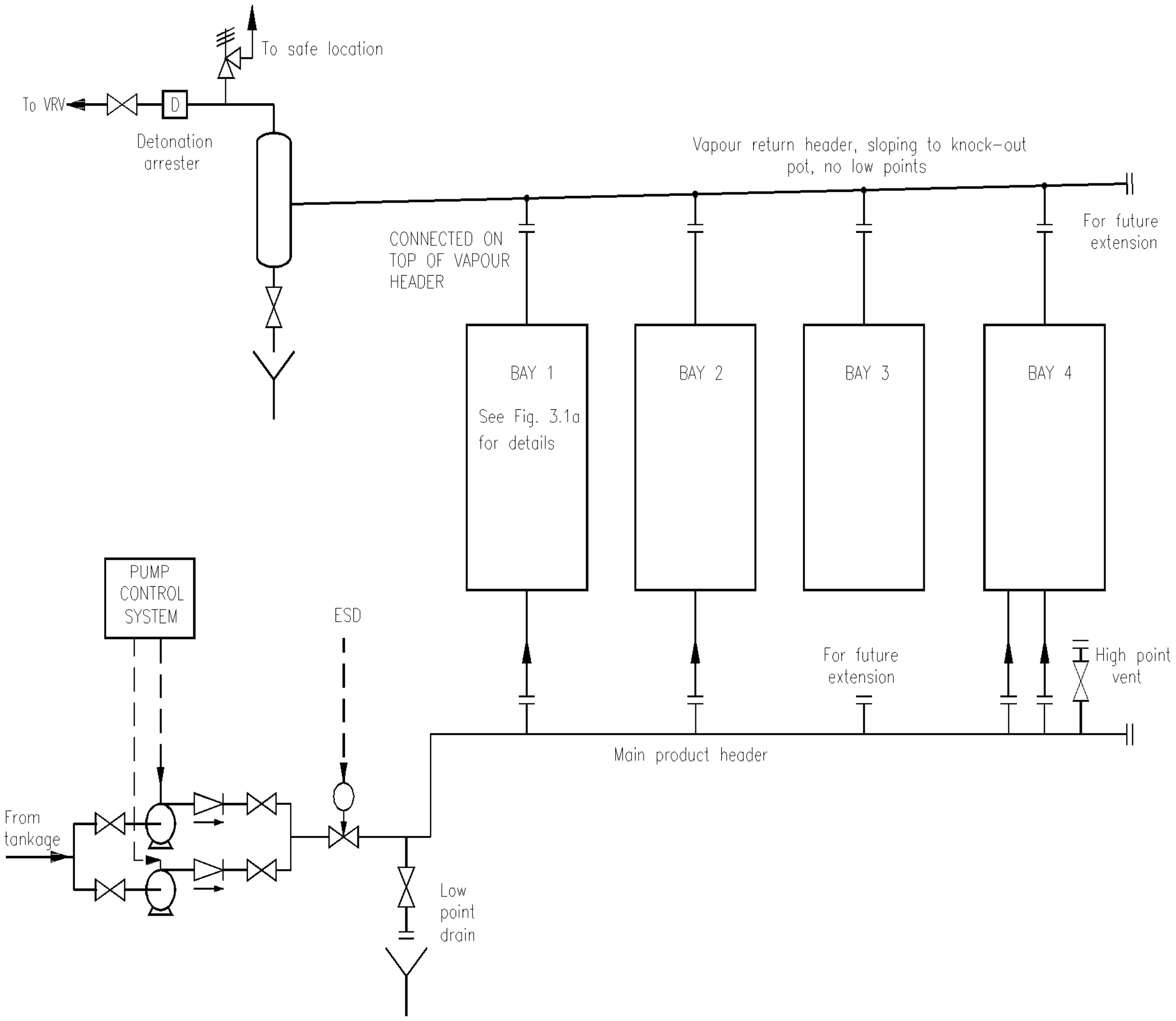


**Figure 3.1c Typical flow diagram of automated top loading installation without vapour recovery**

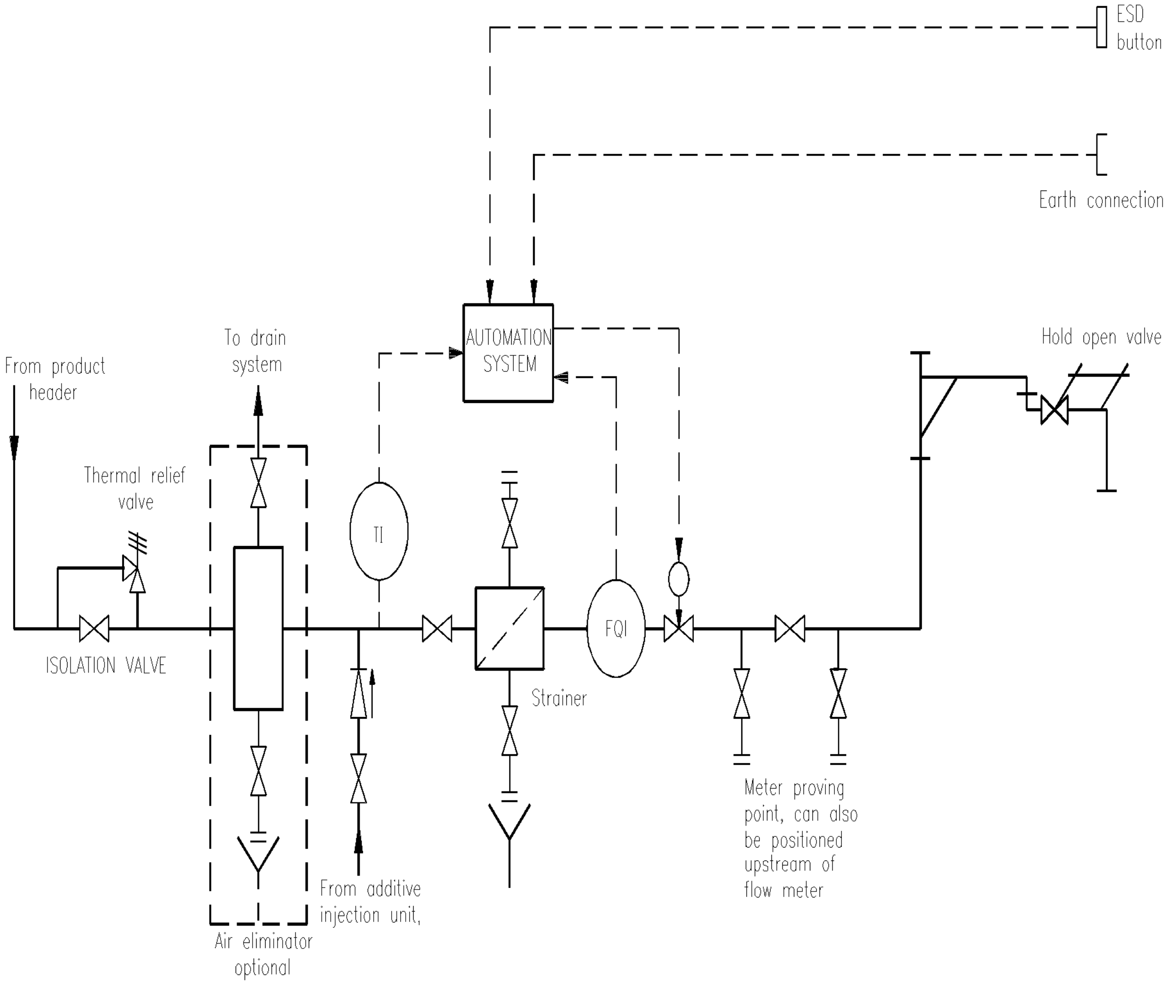
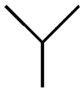
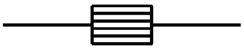


**Figure 3.2 Symbols for bulk road vehicle loading installation flow schemes**

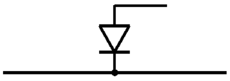
Flow limiter



Slops tundish

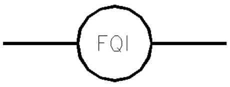


Flame arrester



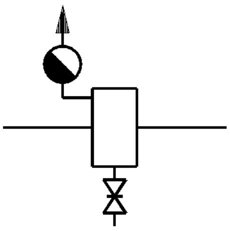
Vacuum–breaker valve

Breating vent



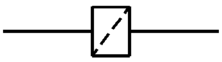

Flow meter
with local indicator

Hose coupling
(female half)

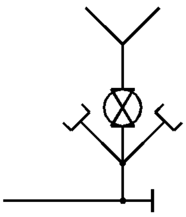


Air–eliminator with
automatic air vent
and drain valve

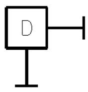
Hose coupling
(male half)



Filter



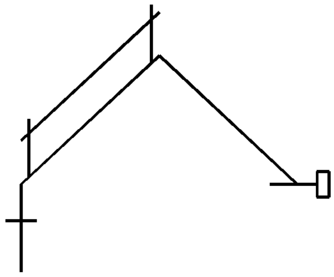
Slops tundish with
hose coupling



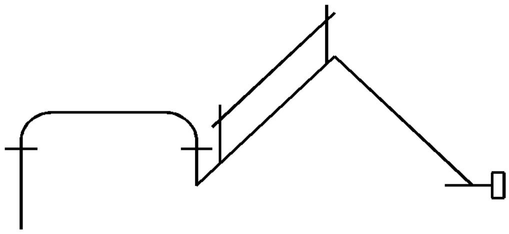

Detonation protector


Sight glass indicator

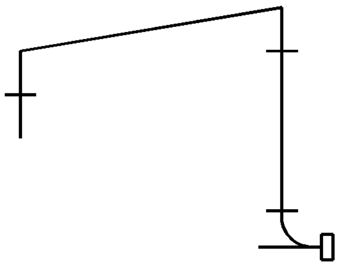
**Figure 3.3 Symbols for bulk road vehicle bottom loading arms and hoses**



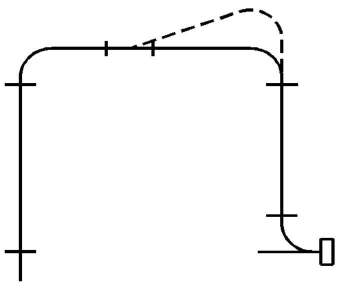
Articulated loading arm
with self–sealing coupling



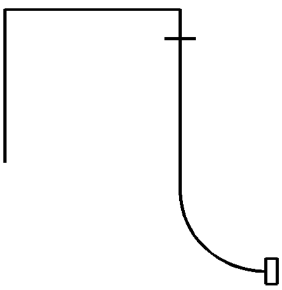
Boom type articulated loading arm
with self–sealing coupling



Spring balance type hose loader
with self–sealing coupling

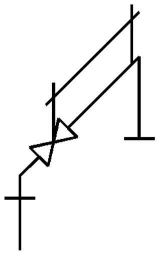


Hinged joint type hose loader
with self–sealing coupling

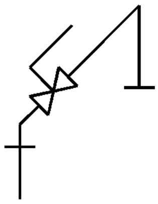


Hose loader with self–sealing
coupling

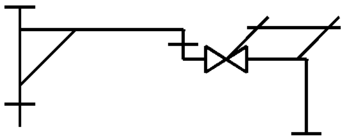
**Figure 3.4 Symbols for bulk road vehicle top loading arms**



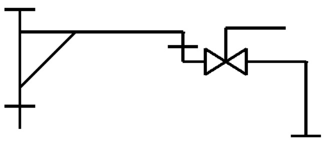
Articulated loading arm with hold-open hand-operated loading arm valve for white and black oil products



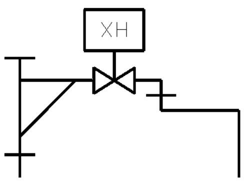
Articulated loading arm with stay-open hand-operated loading arm valve for white and black oil products



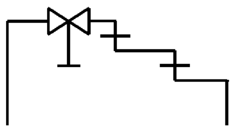
Long range boom type loading arm with deflector and hold-open hand-operated loading arm valve for white products



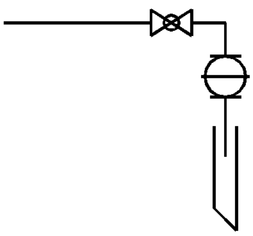
Long range boom type loading arm with deflector and stay-open hand-operated loading arm valve for white products




Short range boom type loading arm with hold-open hand-operated loading arm valve controlled by a hand-operated hydraulic system for black oil products

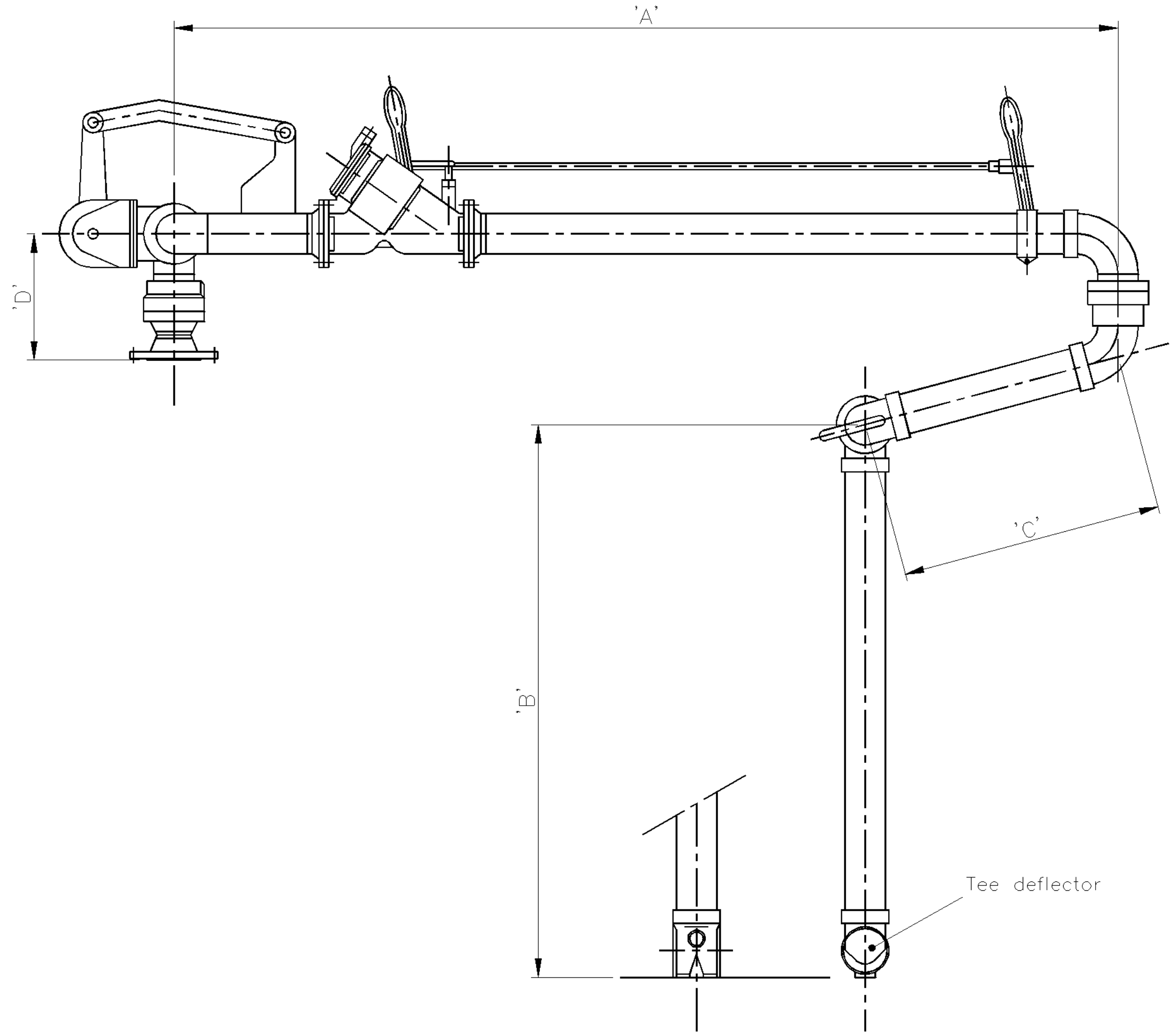


Short range boom type loading arm for bitumen with hand-operated loading valve



Telescopic loading lance with ball swivel and hand-operated

**Figure 3.5 Typical articulated loading arms**




Dimensions in mm

| SIZE | A | B | C | D | TYPE |
|---|---|---|---|---|---|
| 4–inch | 2.8 | 1.676 | 0.850 | 0.250 | Standard reach, 2–spring |
| 4–inch | 2.997 | 1.676 | 1.219 | 0.250 | Maximum reach, 2–spring |
| 4–inch | 3.8 | 1.676 | 1.370 | 0.250 | Maximum reach, 4–spring |

Alternative: Pneumatic balance control

**Figure 3.6 Example of articulated loading arm envelope**

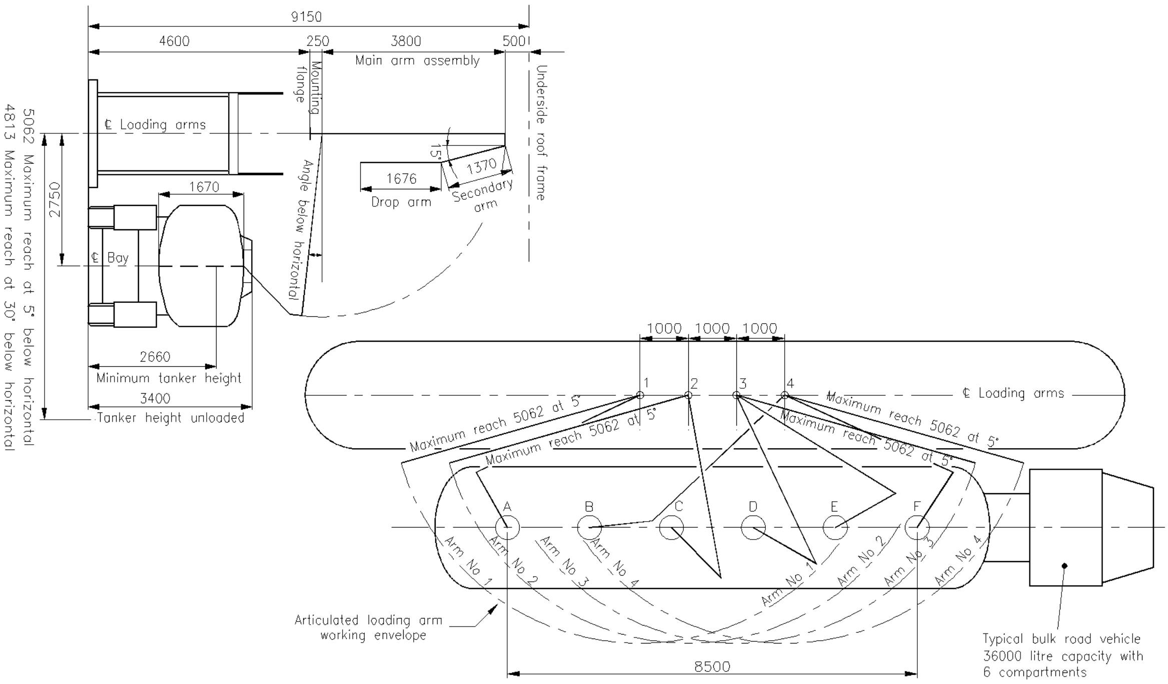



**Figure 3.7 Typical boom loading arms for white products**

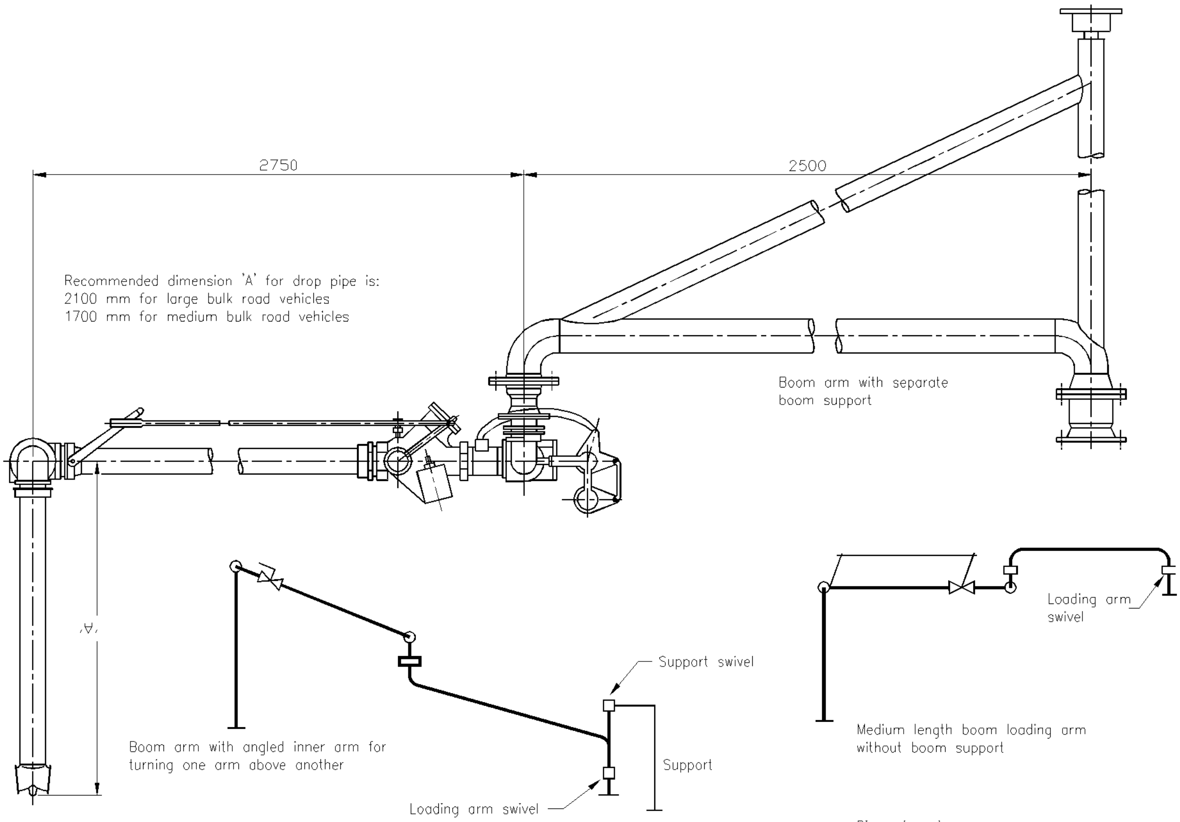
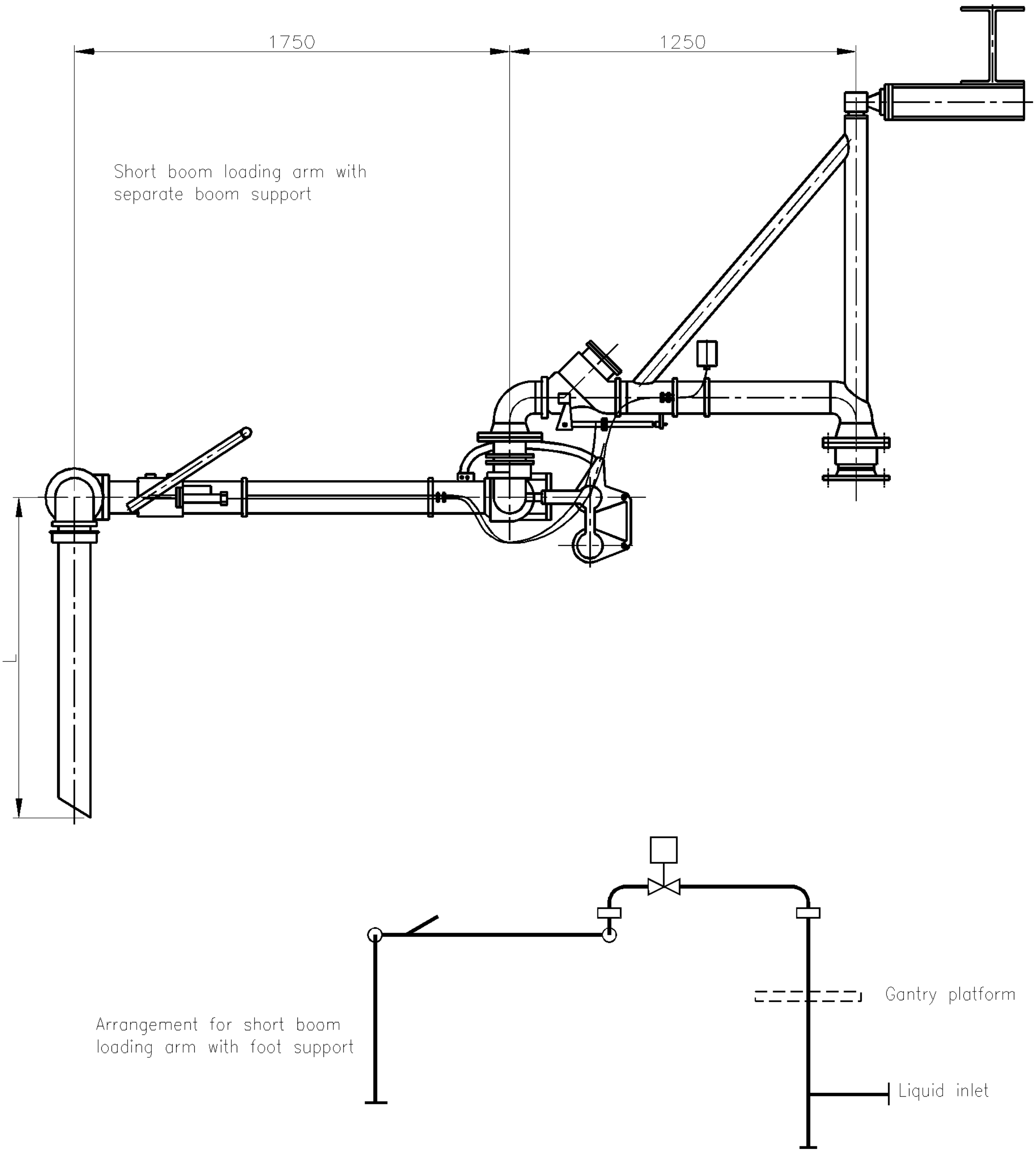


**Figure 3.8 Typical short boom loading arms for heavy fuel oil**




Dimensions in mm

**Figure 3.9 Simple telescopic loading lance for bulk bitumen**

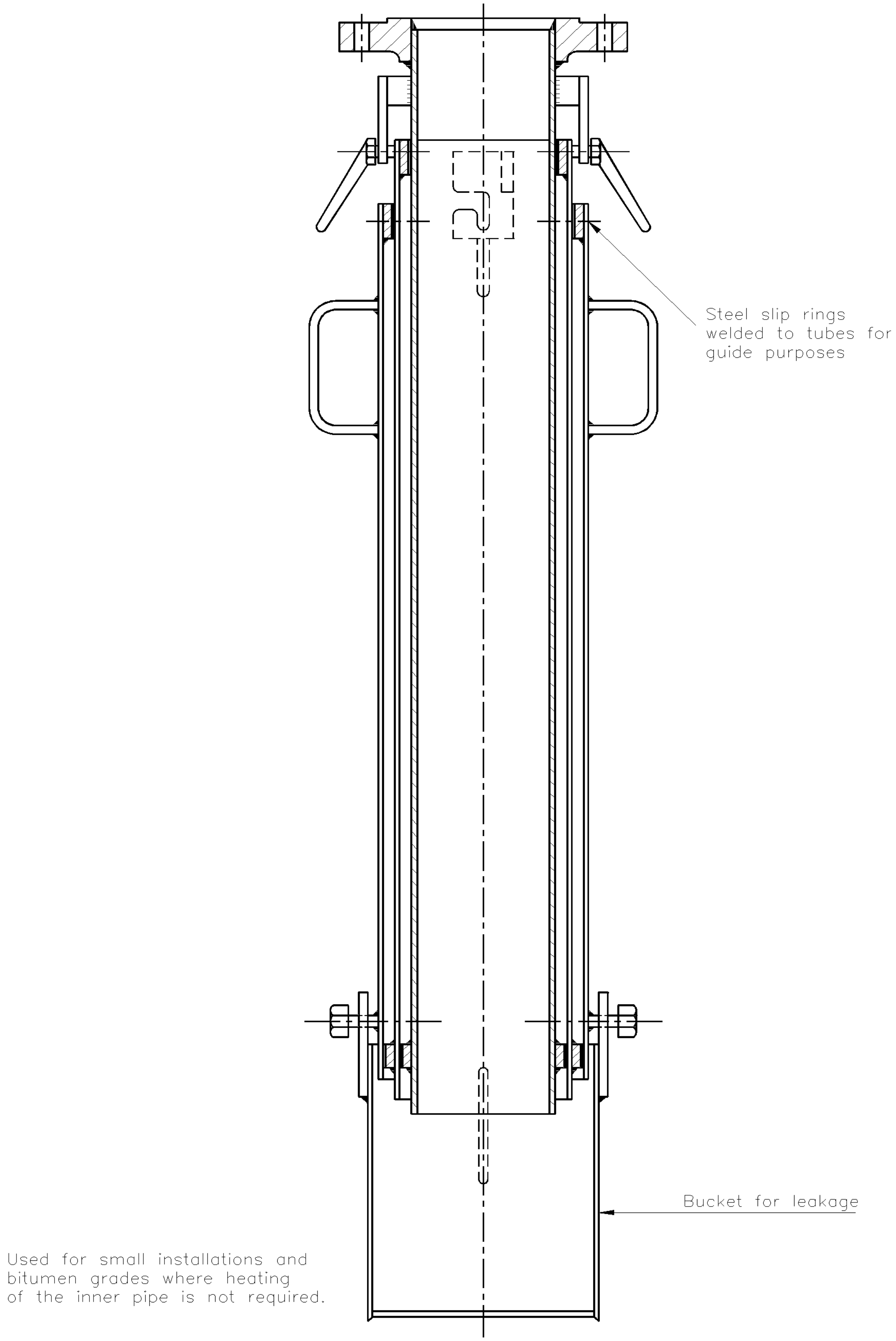


**Figure 3.10 Tank vehicle adaptor for bottom loading API Standard RP 1004**

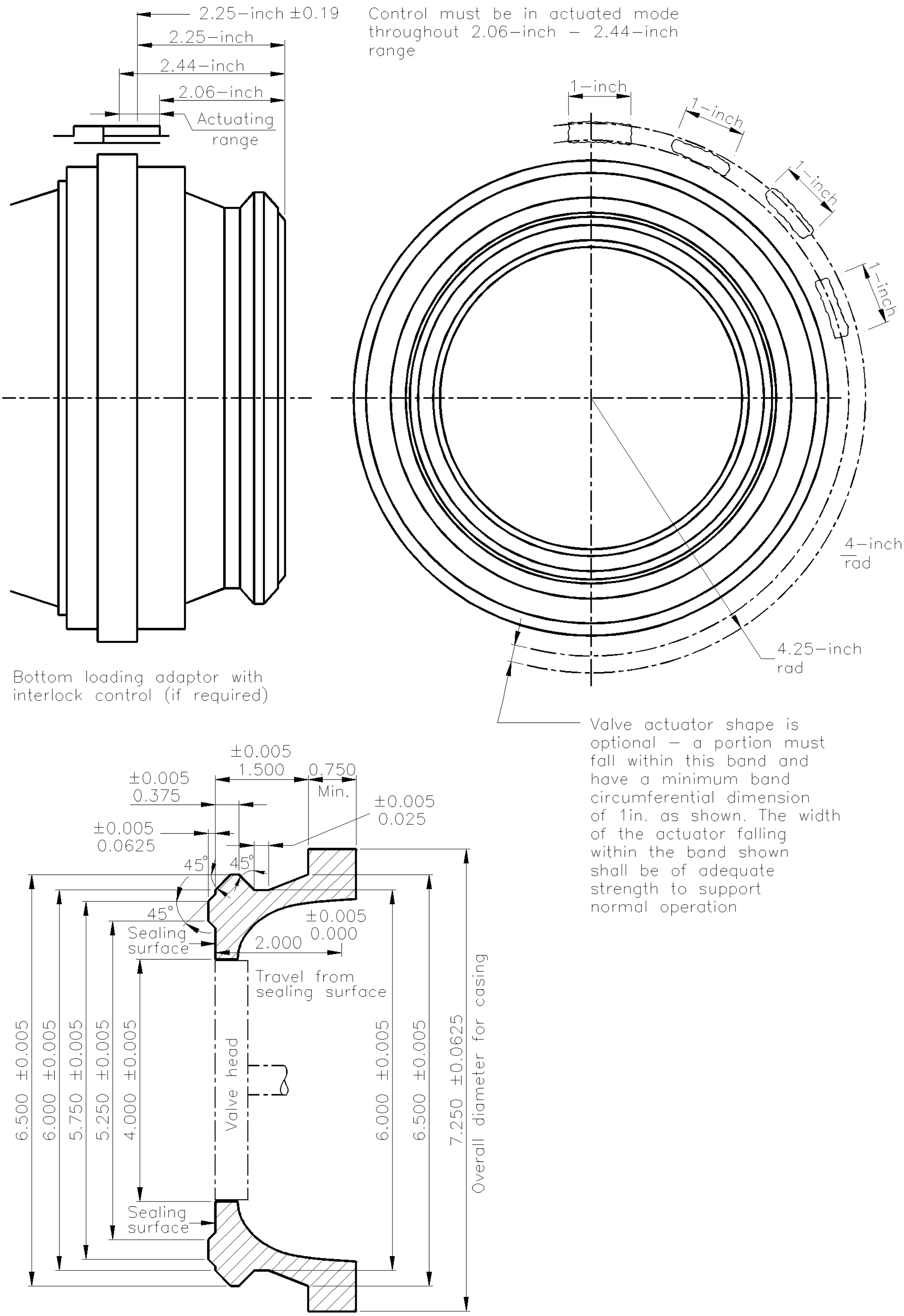


**Figure 3.11 Typical 4 inch vapour collection adaptor**

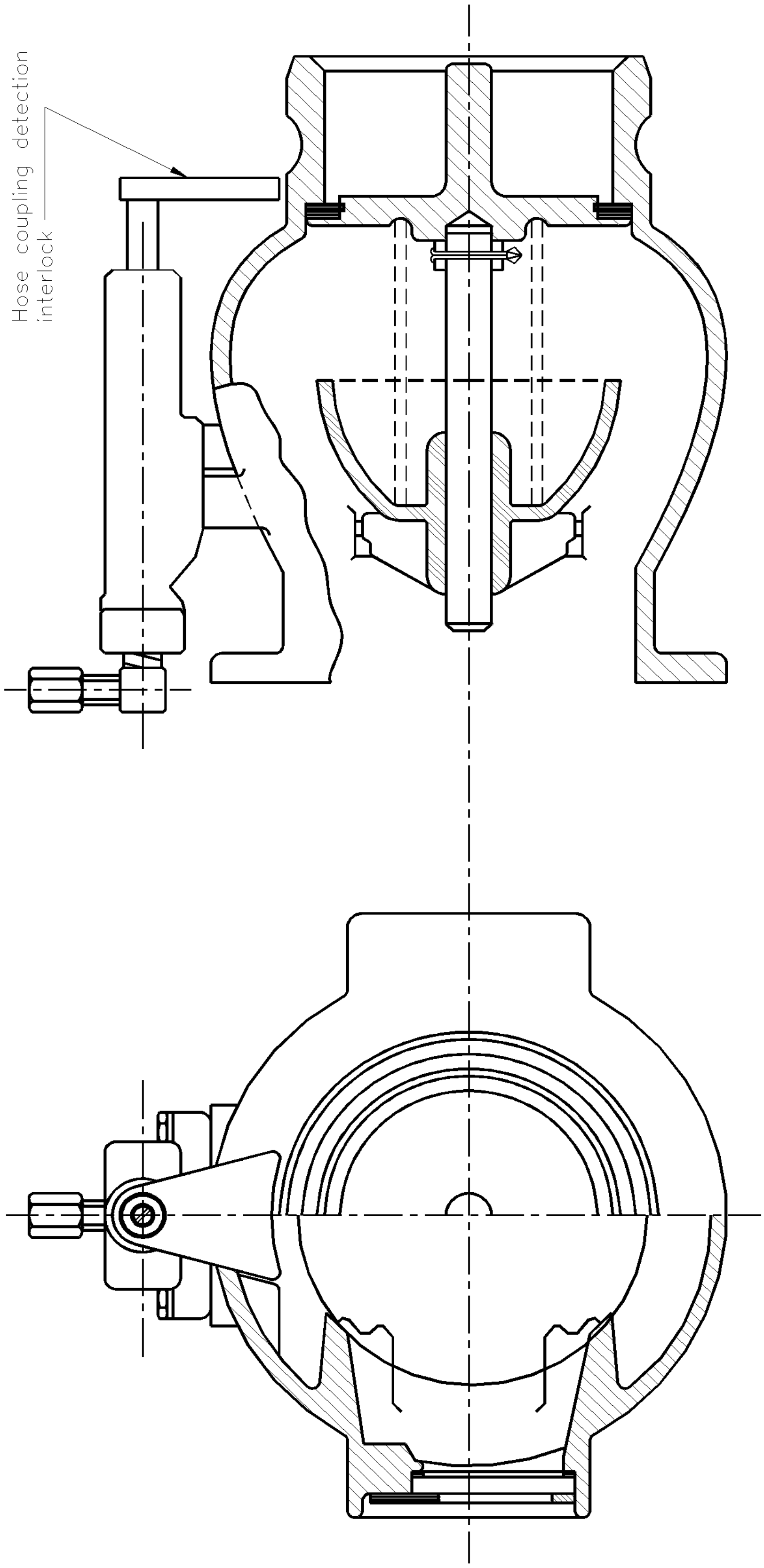


**Figure 3.12 Typical hose/swivel type loader**

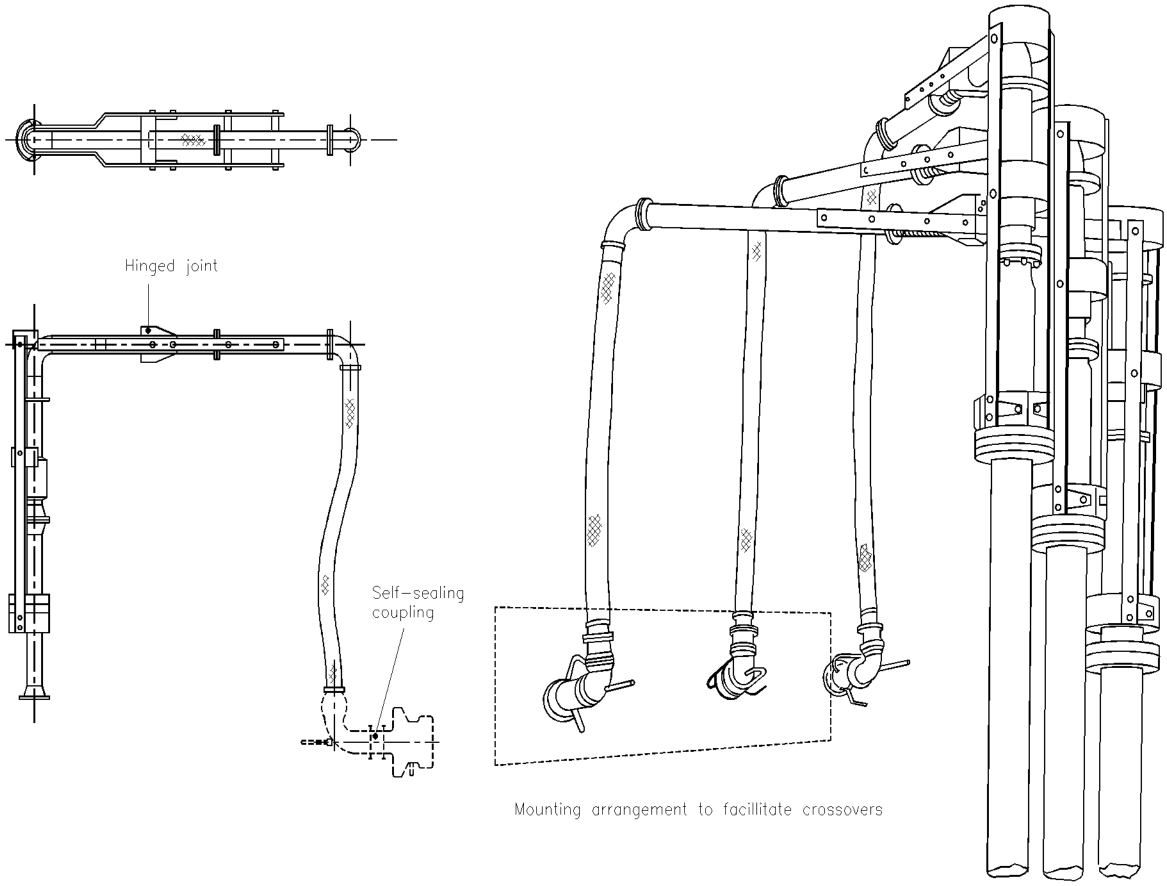
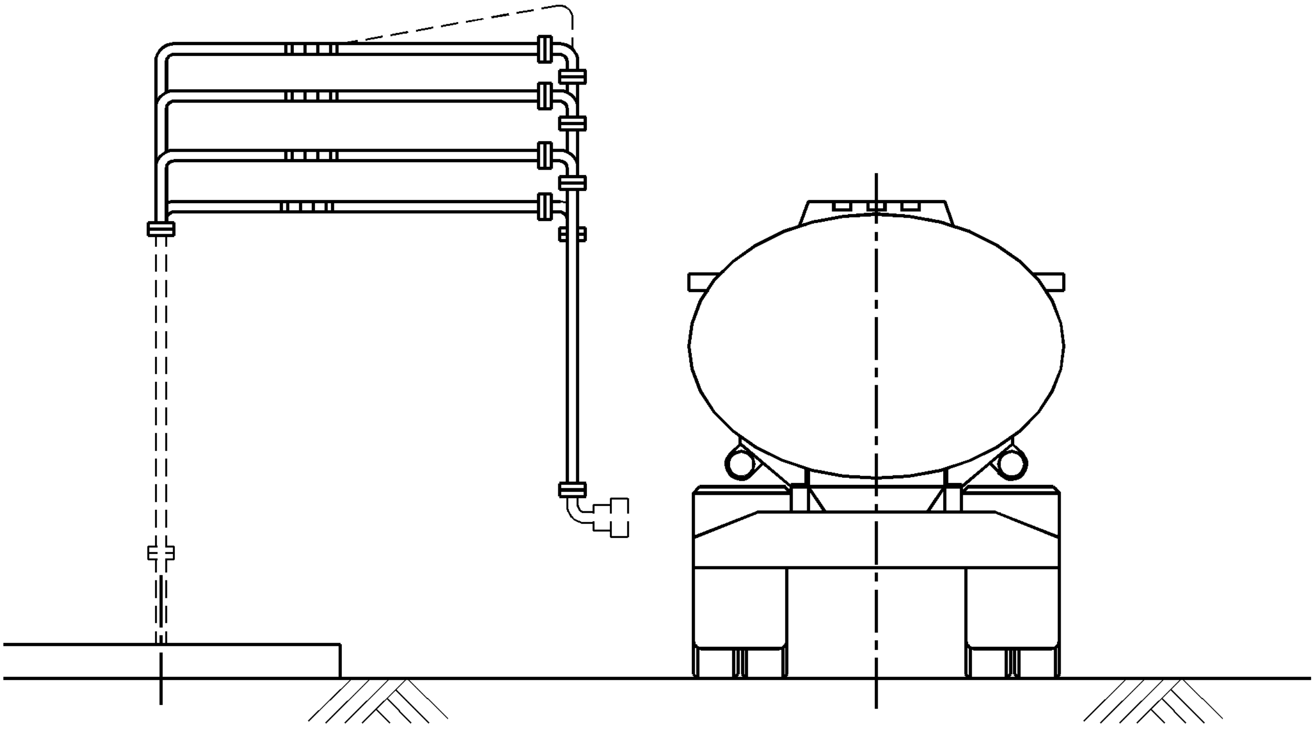


**Figure 3.13 Hose type loaders: examples of mounting arrangement to facilitate crossovers**



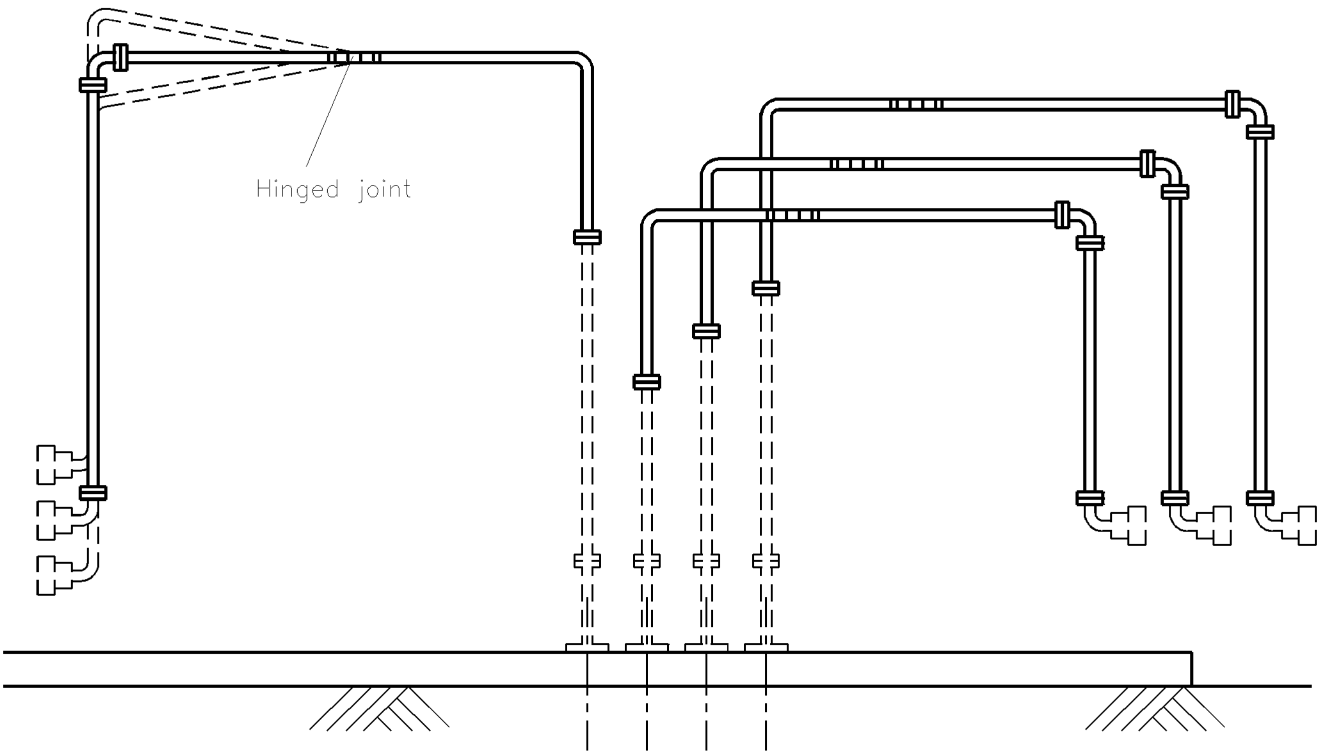
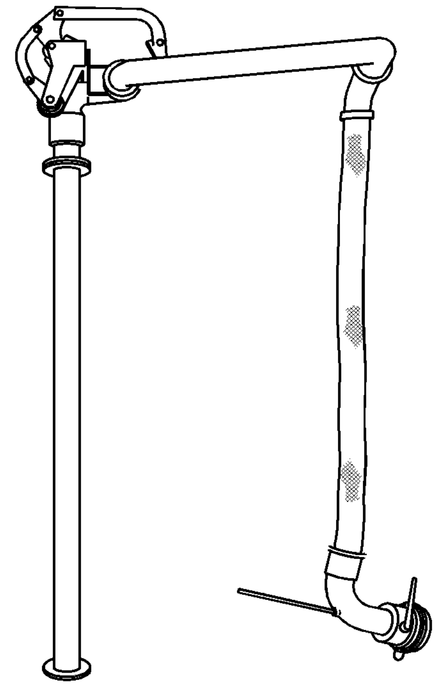
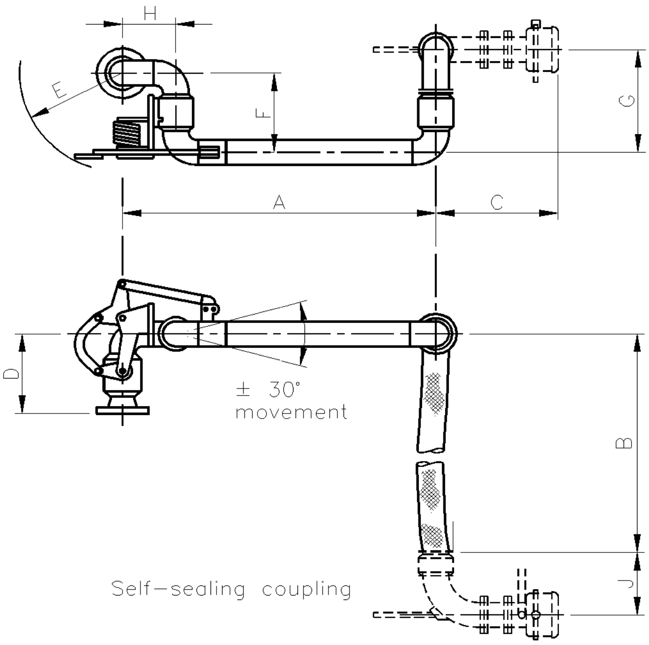



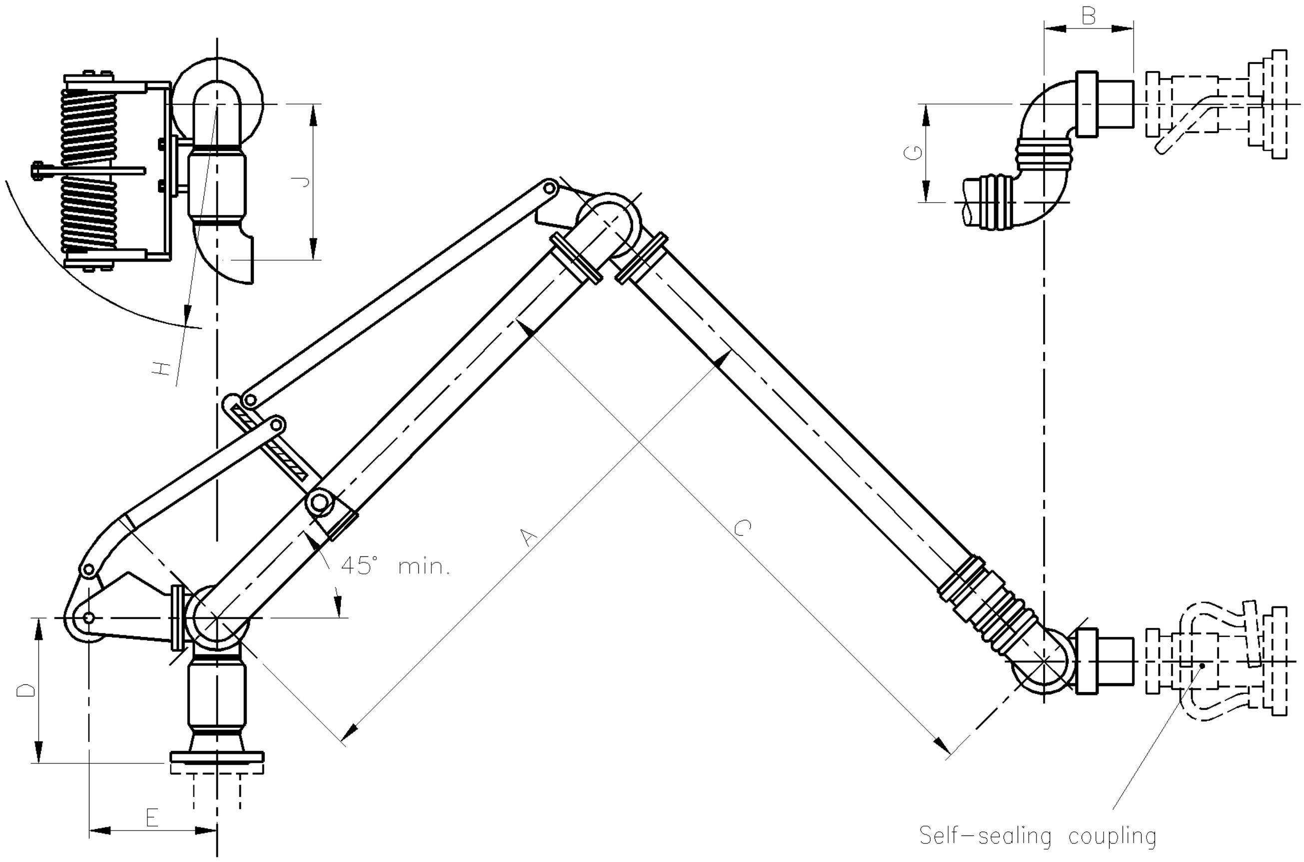
**Figure 3.14 Typical spring-balanced type hose loader**






| | Dimensions in mm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | G | H | J |
| 4 inch | 1320 | Variable | 535 | 360 | 495 | 457 | 203 | 280 |

**Figure 3.15 Typical articulated loading arm with self sealing couplings**




| | Dimension in mm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | G | H | J | |
| 4 inch | 1372 | 257 | 1524 | 357 | 317 | 235 | 508 | 383 | |

**Figure 3.16 Mounting arrangement to facilitate crossovers of articulated loading arms**

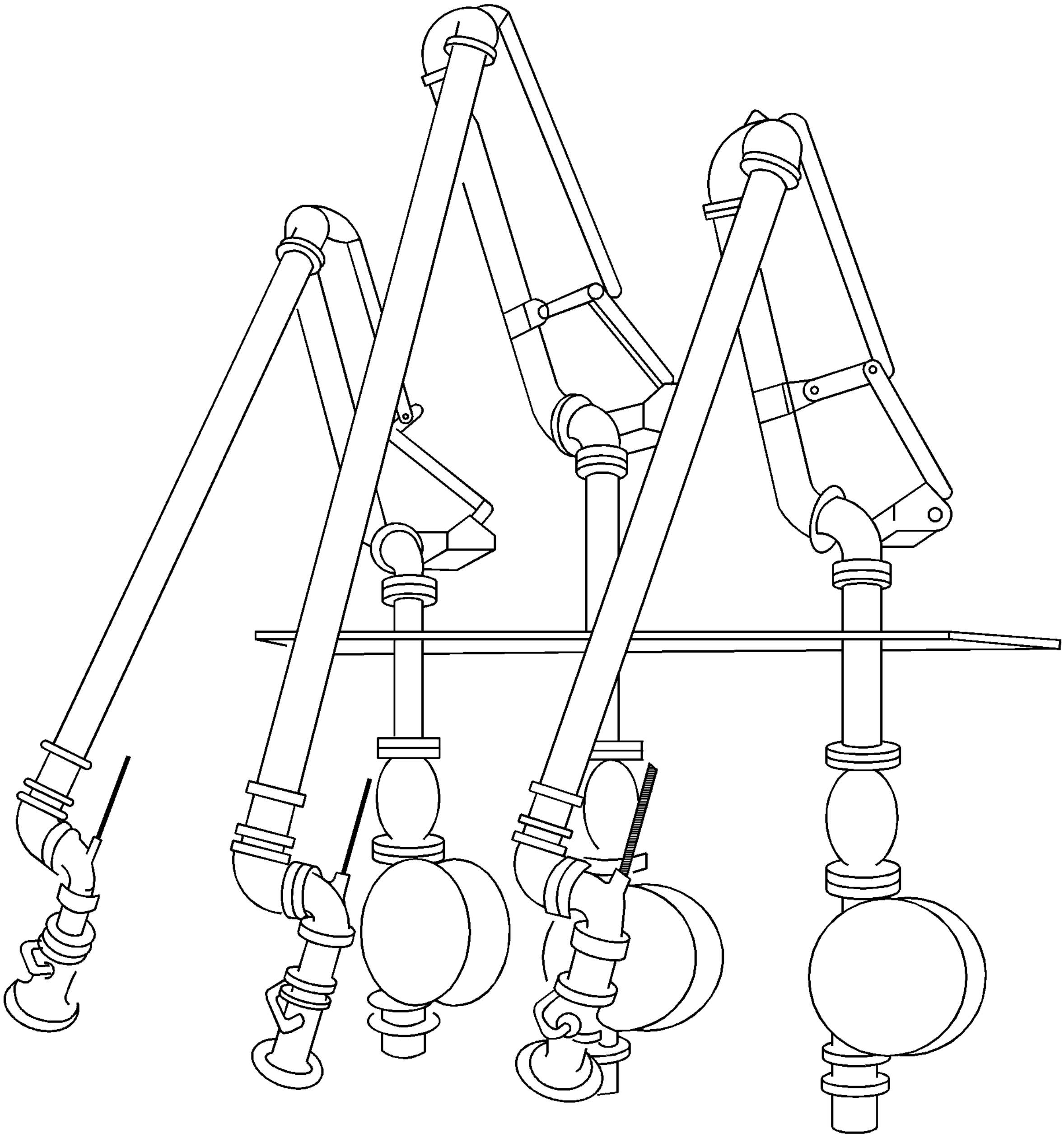


**Figure 3.17 Connection envelopes**

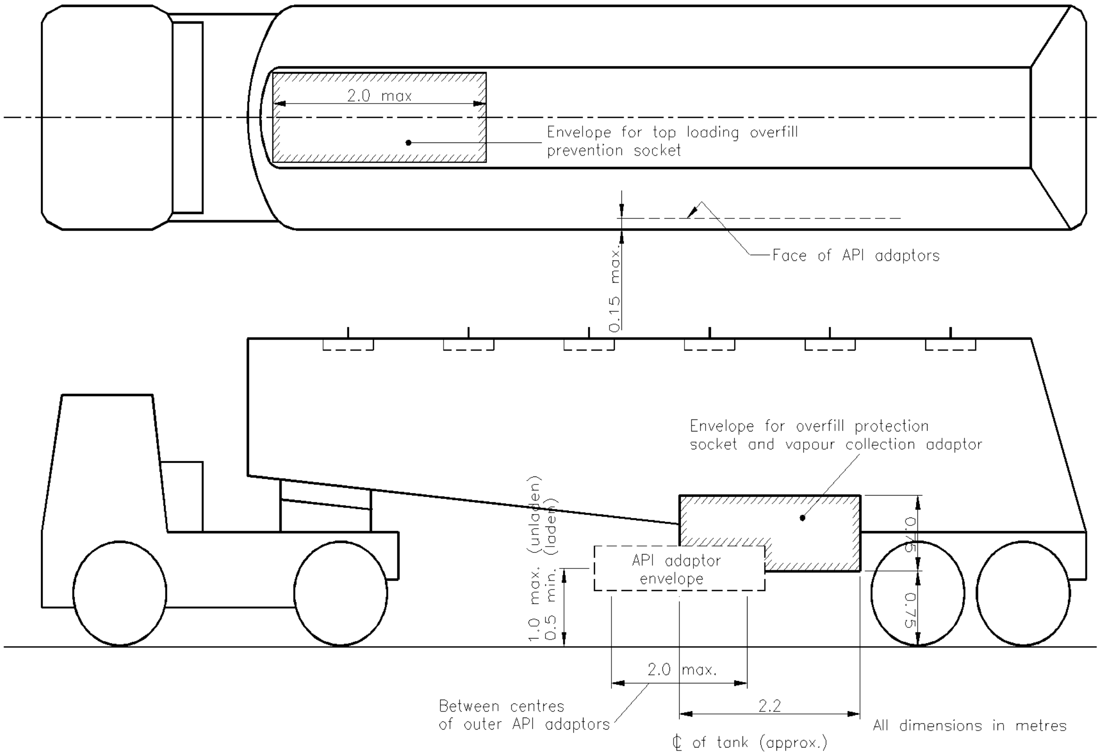
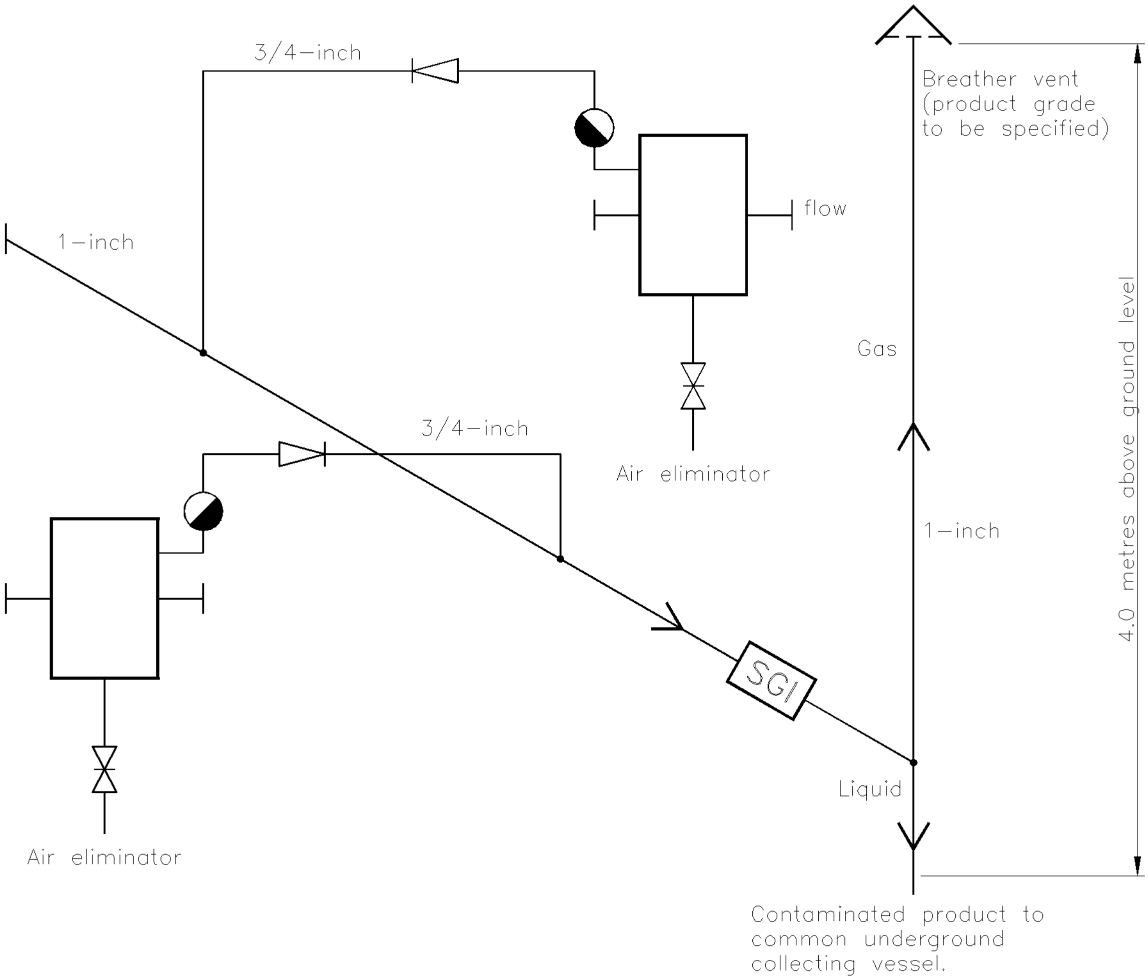
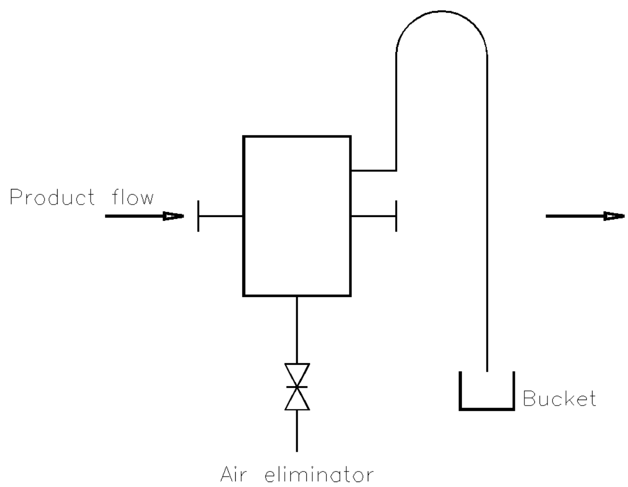


**Figure 4.1 Typical pipeline collection systems for air eliminators**




SCHEME FOR CLOSED OUTLETS




SCHEME FOR OPEN OUTLETS

**Figure 6.1 Typical additive injection system: electronic injector system**

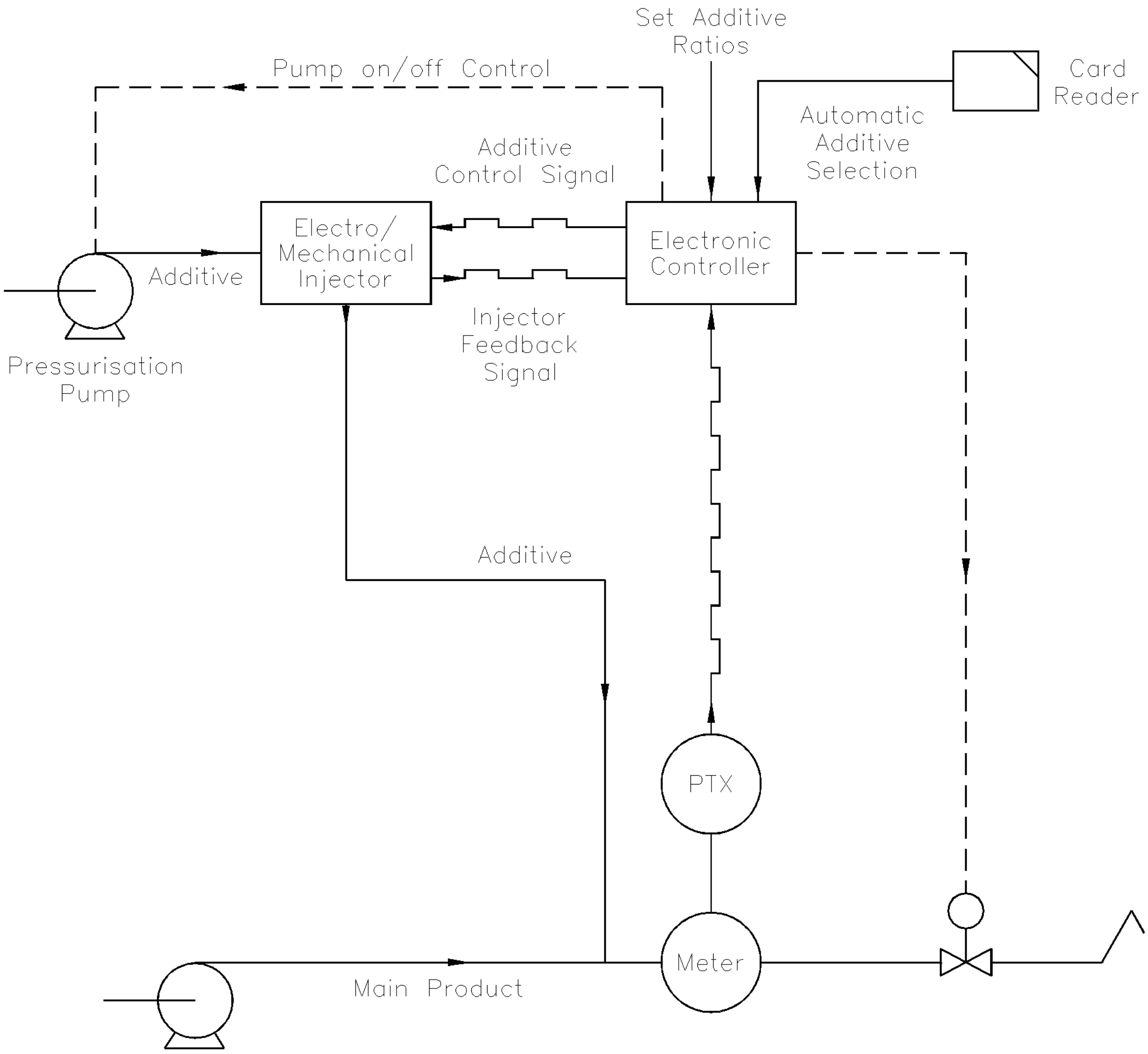


**Figure 6.2 Typical additive injection system: electronic flow proportioning control**

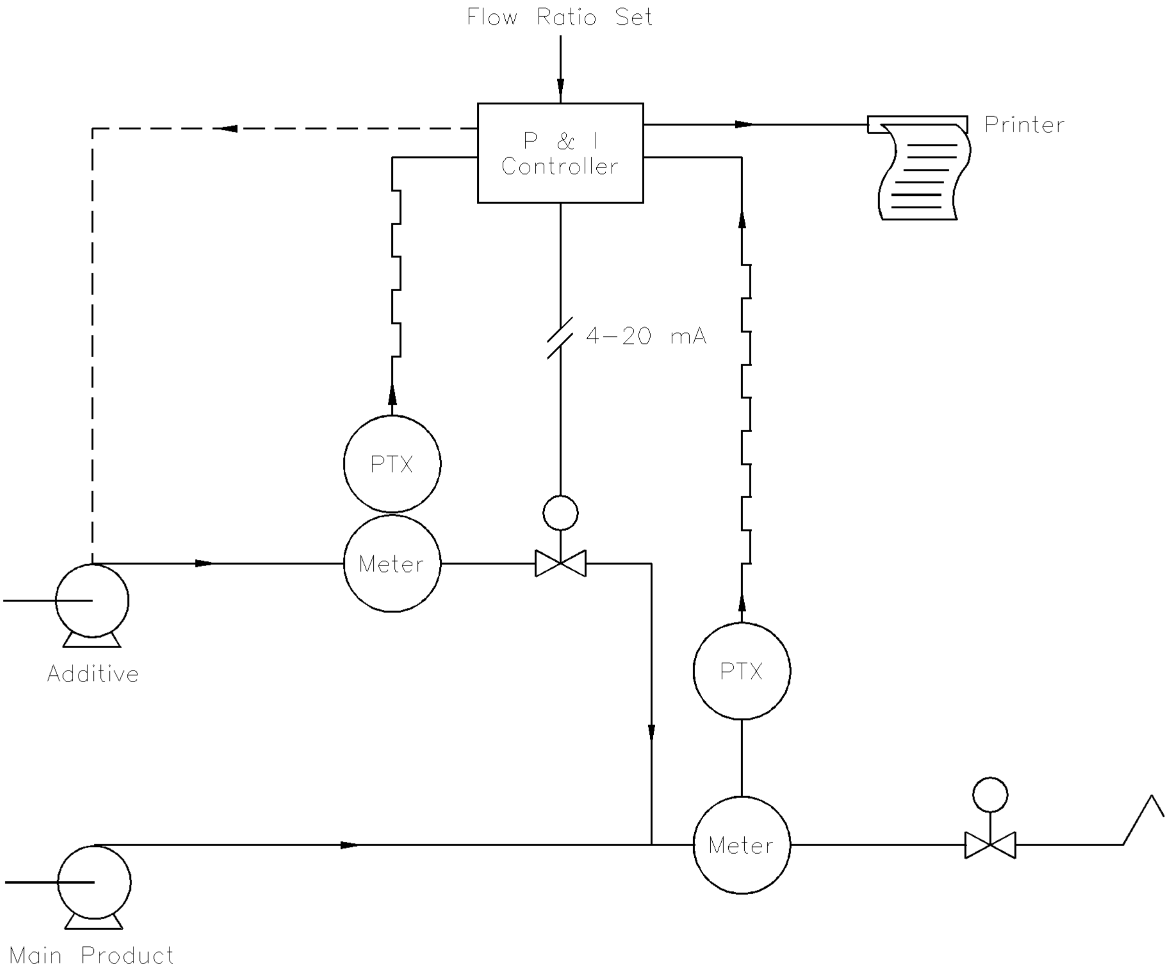


**Figure 8.1 Minimum safety distances to loading gantry**

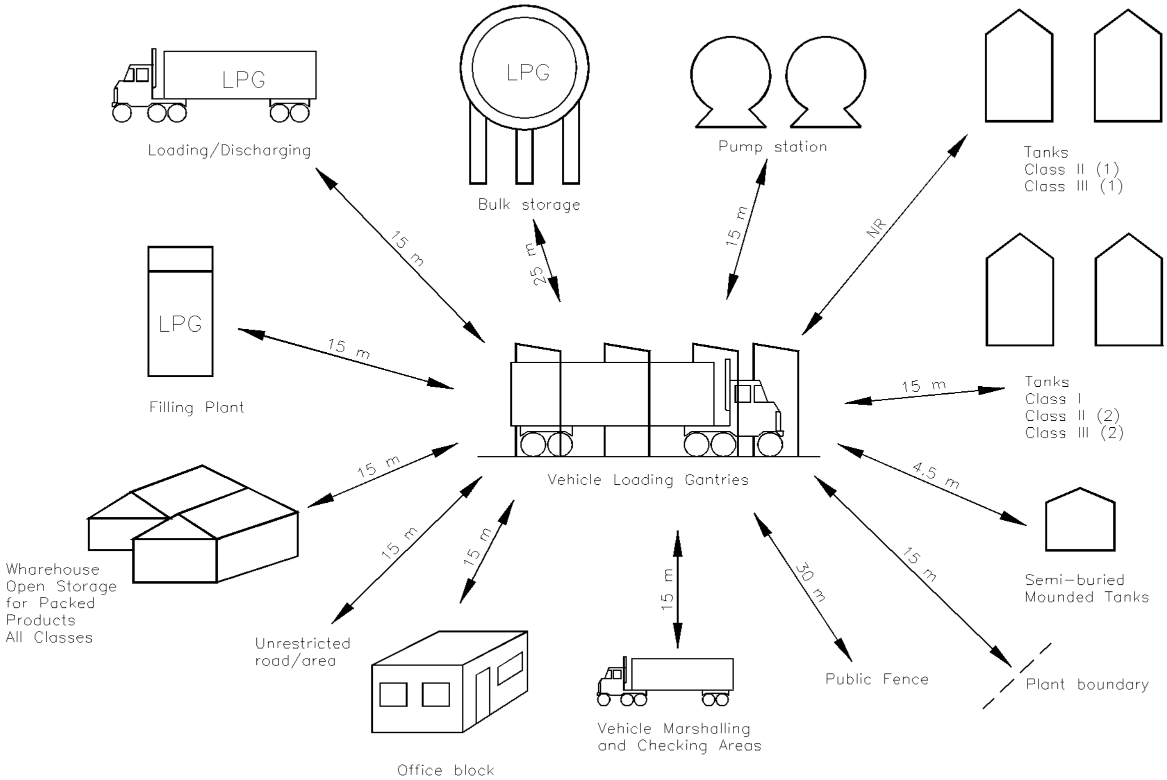



**Figure 8.2 Typical 38 tonne bulk road vehicle**

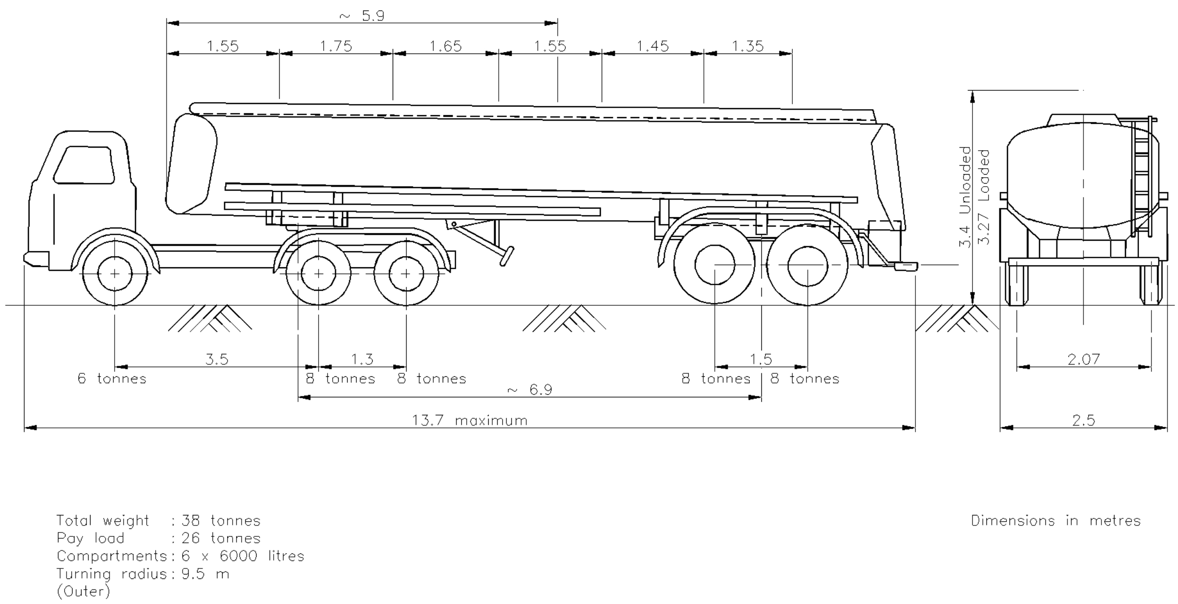


**Figure 8.3 Typical bulk road vehicle with trailer**

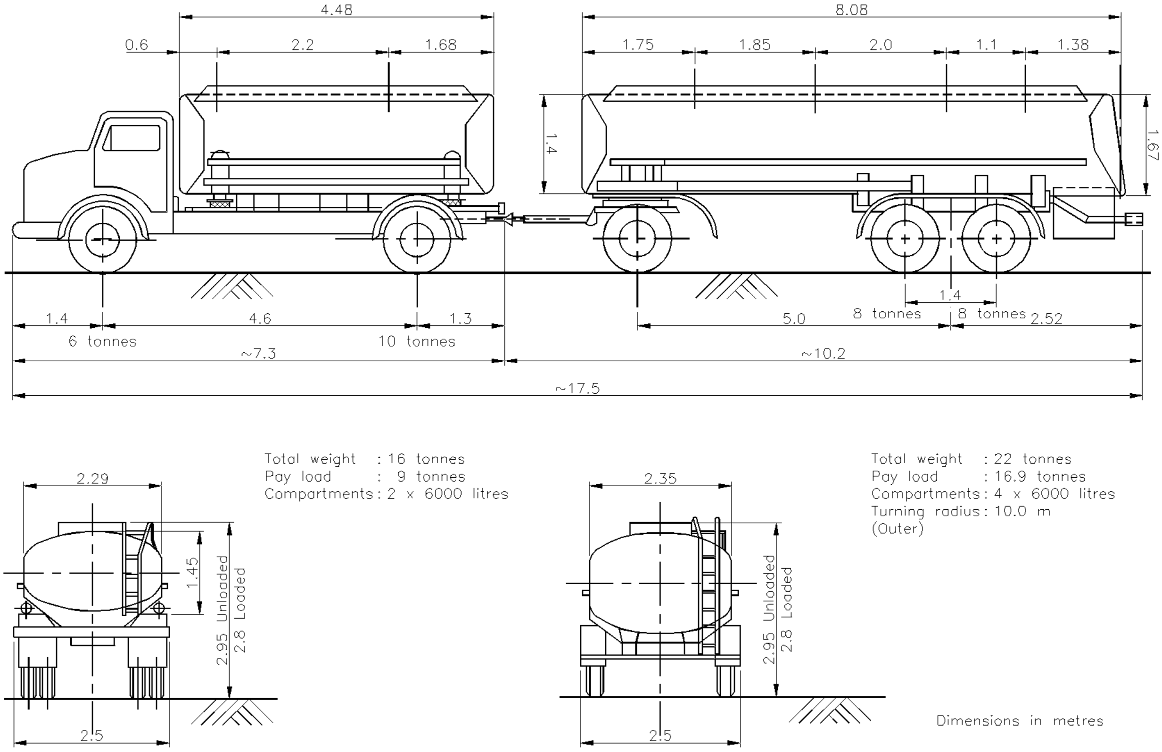
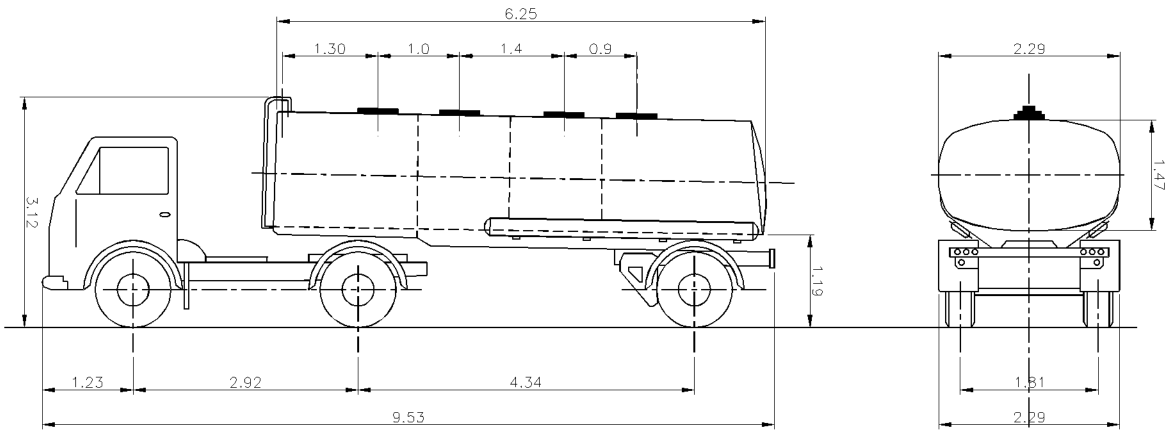



**Figure 8.4 Typical bulk road vehicle - 16.5 m$^3$ capacity**




Total weight : 18.5 tonnes
Pay load : 16 500 litres
Compartments : 2 x 5500 litres
2 x 2750 litres
Turning radius : 8 m

**Figure 8.5 Typical area requirements for bulk road vehicle loading facilities**

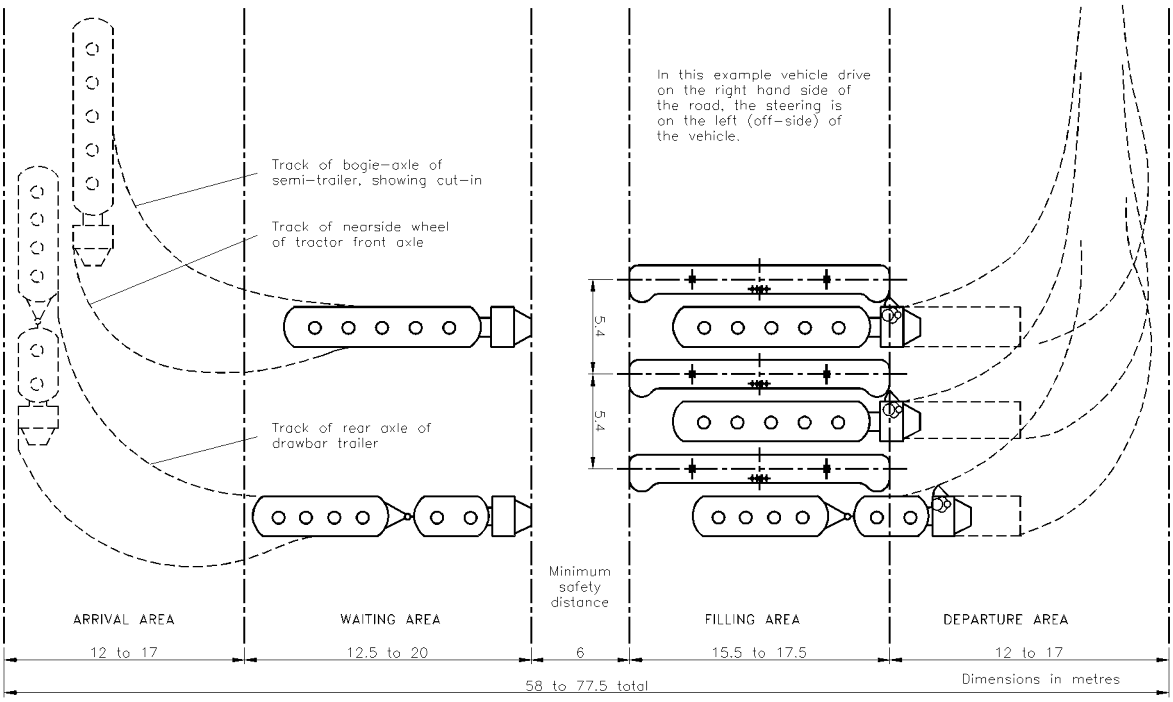
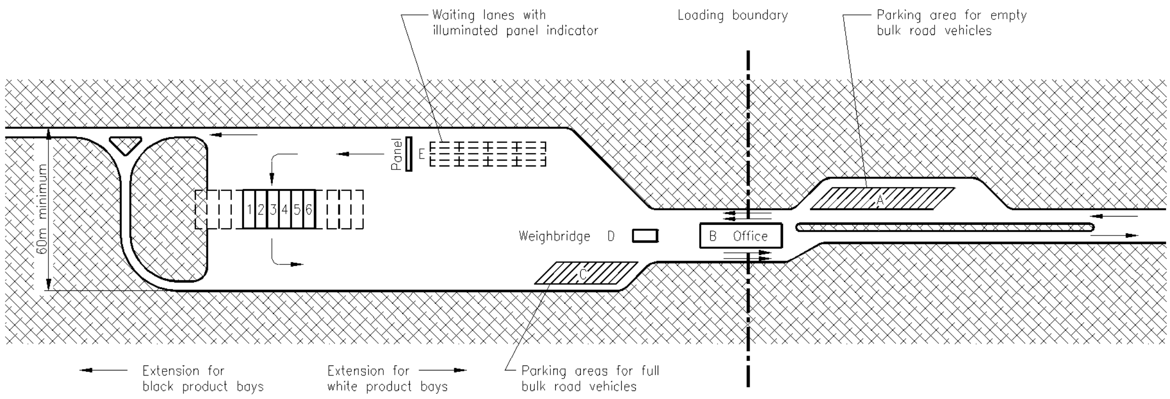



**Figure 8.6 Example of layout of filling installation with straight bays**

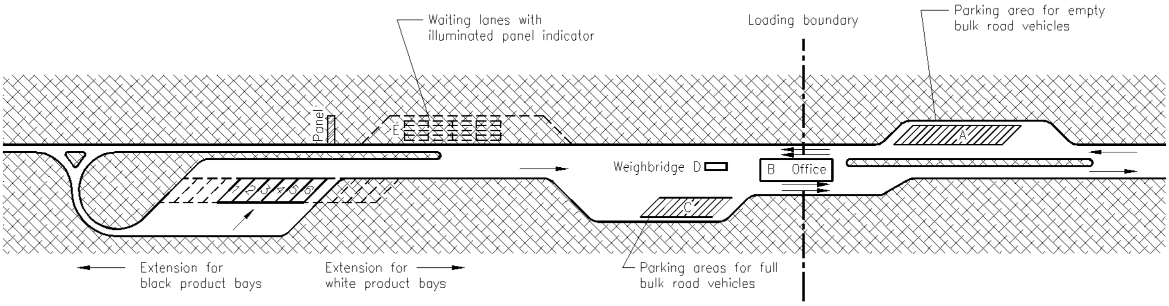



Notes: (1) The layout of loading facilities and traffic flow should take account of other activities of bulk vehicles, in particular:
- Bunkering company-owned vehicles
- Washing company-owned vehicles
- Return product and pump-off

(2) Parking of vehicles overnight must not obstruct movement of vehicles in the loading area during night operations.

A Installations with sufficient throughput need parking space for empty vehicles, to avoid excessive queuing at office or entrance.
B Reccomended location for office.
C Necessary only if excessive queuing can occur.
D Any weighbridge to be sited for convenient use by both incoming and outgoing vehicles.
E Installations with a daily capacity exceeding approximately 400 vehicles may benefit from a system to direct traffic to empty bays.

## Figure 8.7 Example of layout of filling installation with angled bays




Notes: (1) The layout of loading facilities and traffic flow should take account of other activities of bulk vehicles, in particular:
- Bunkering company-owned vehicles
- Washing company-owned vehicles
- Return product and pump-off

(2) Parking of vehicles overnight must not obstruct movement of vehicles in the loading area during night operations.

A Installations with sufficient throughput need parking space for empty vehicles, to avoid excessive queuing at office or entrance.
B Reccomended location for office.
C Necessary only if excessive queuing can occur.
D Any weighbridge to be sited for convenient use by both incoming and outgoing vehicles.
E Installations with a daily capacity exceeding approximately 400 vehicles may benefit from a system to direct traffic to empty bays.

**Figure 8.8 Layouts of top loading islands**

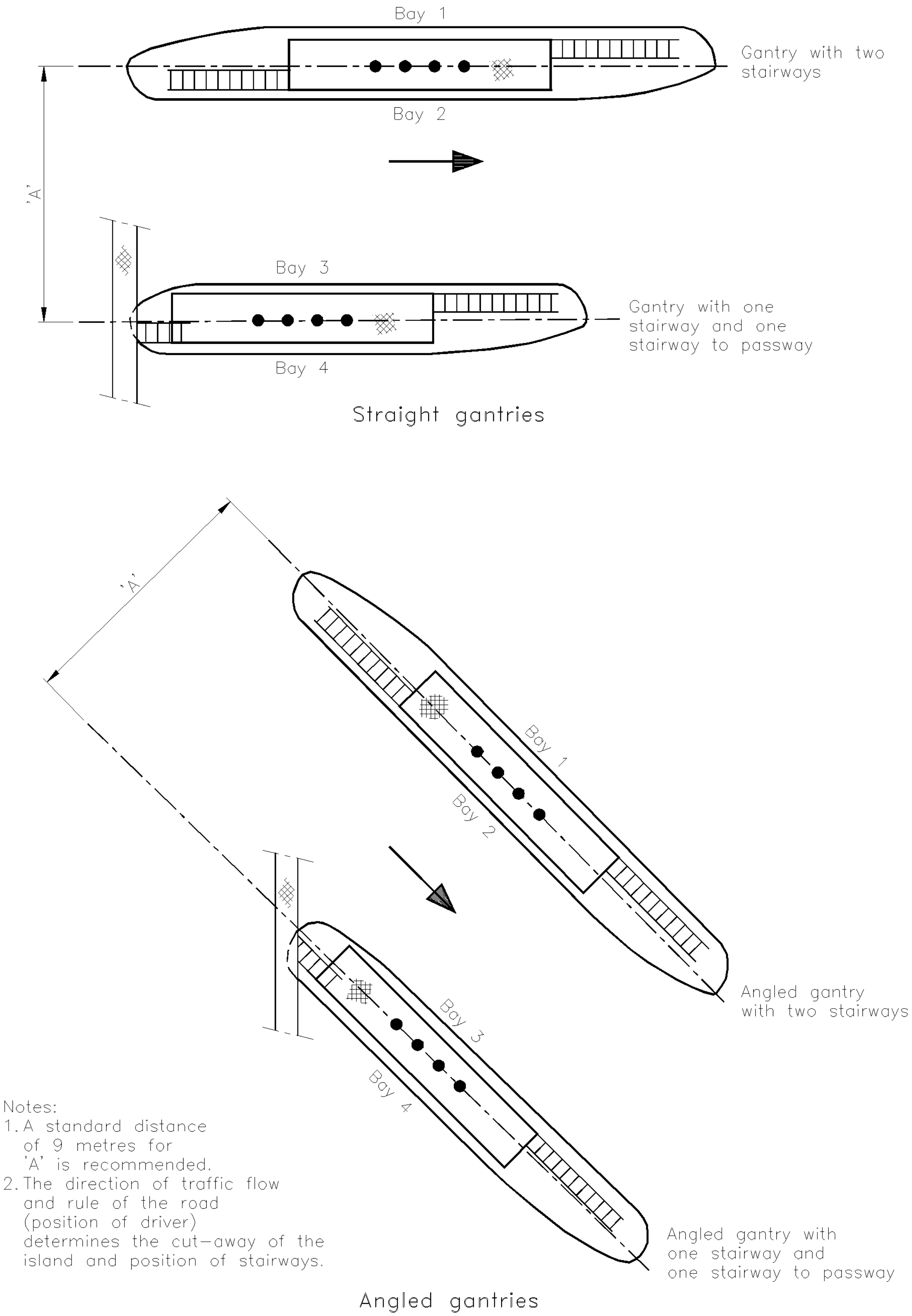


**Figure 8.9 Layout of bottom loading bays**

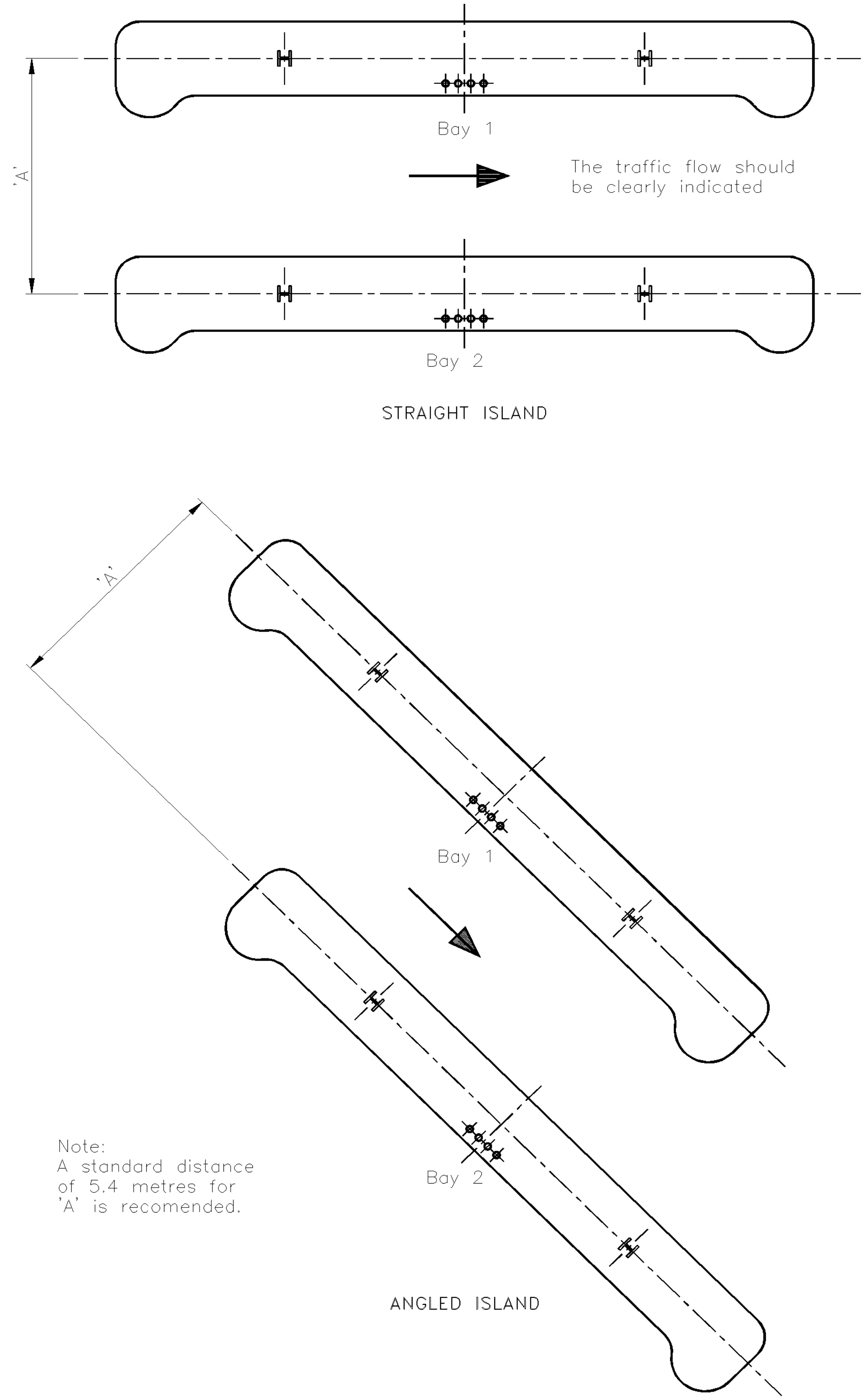
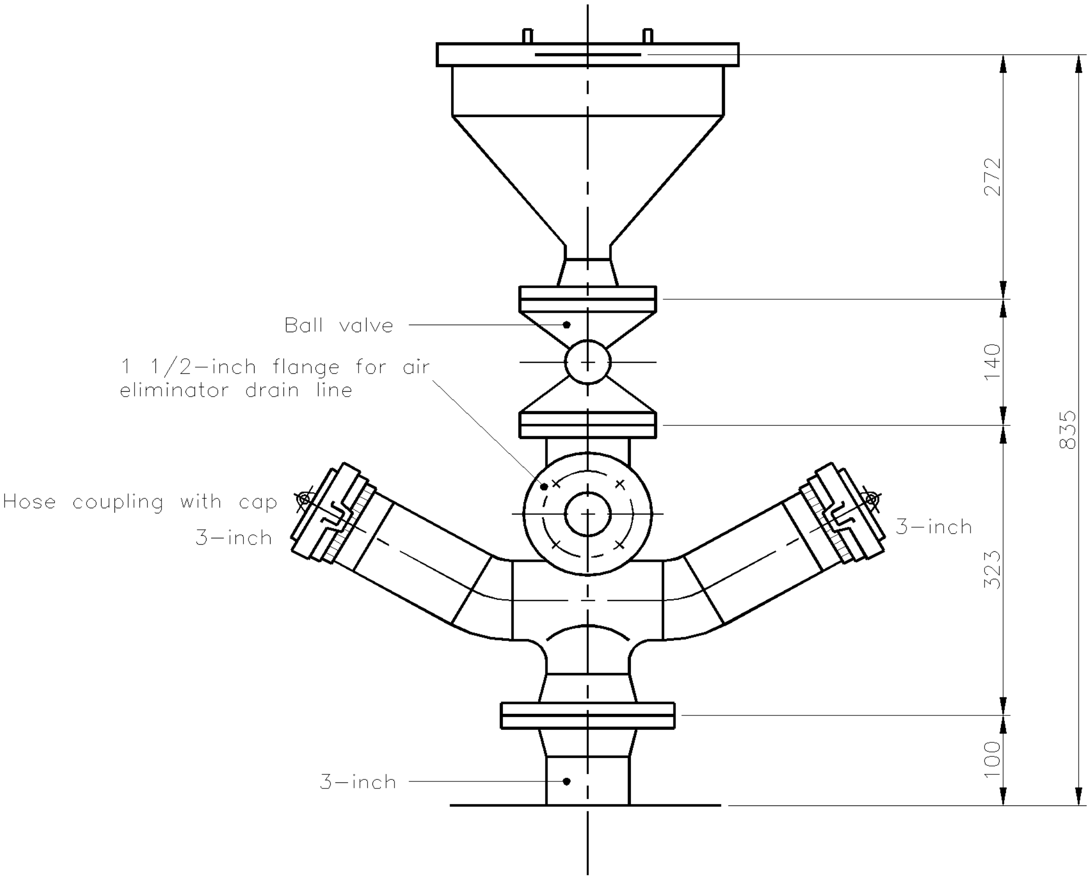
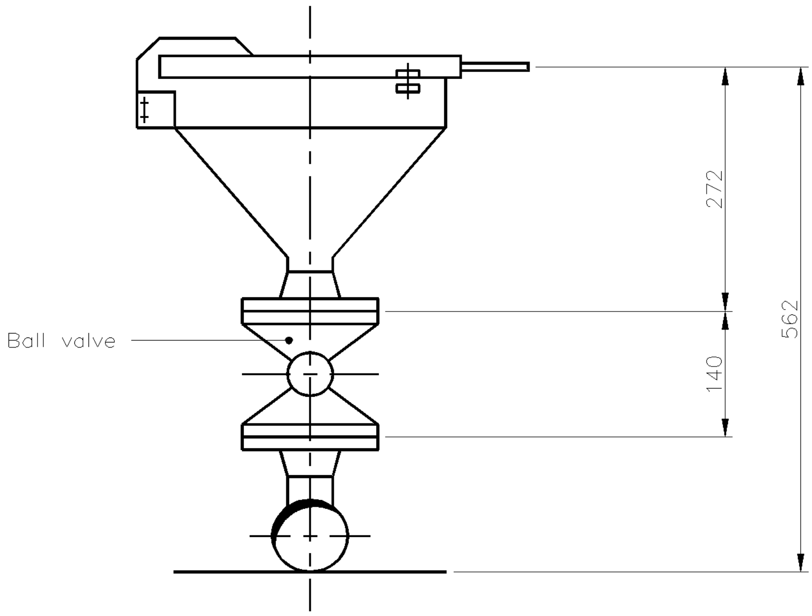


**Figure 8.10 Typical tundish for slops**

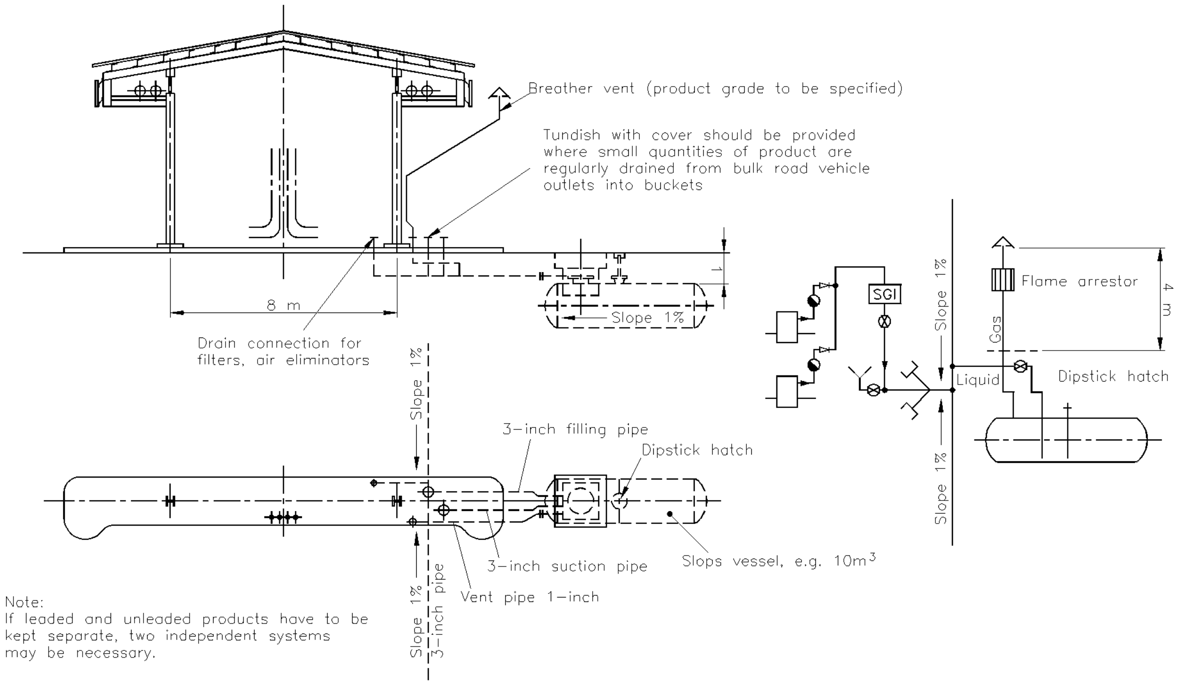



TUNDISH FOR SLOP COLLECTION WITH HOSE CONNECTIONS




TUNDISH FOR SLOP COLLECTION

**Figure 8.11 Closed drainage system for white oil slops with underground container**




UNDERGROUND VESSEL FOR SLOPS

**Figure 8.12 Typical concrete island for top loading gantries**

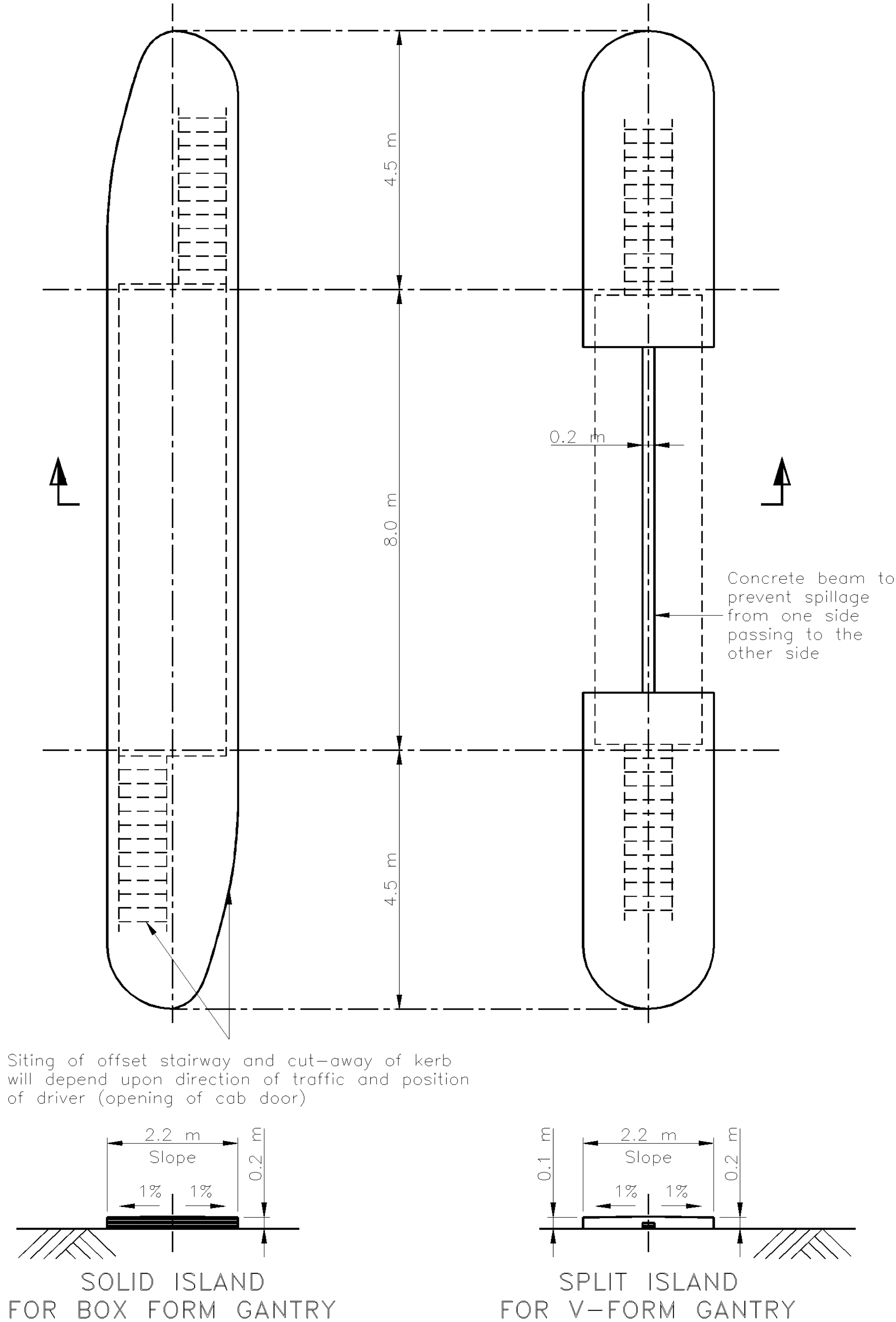


**Figure 8.13 Typical top loading gantry dimensions**

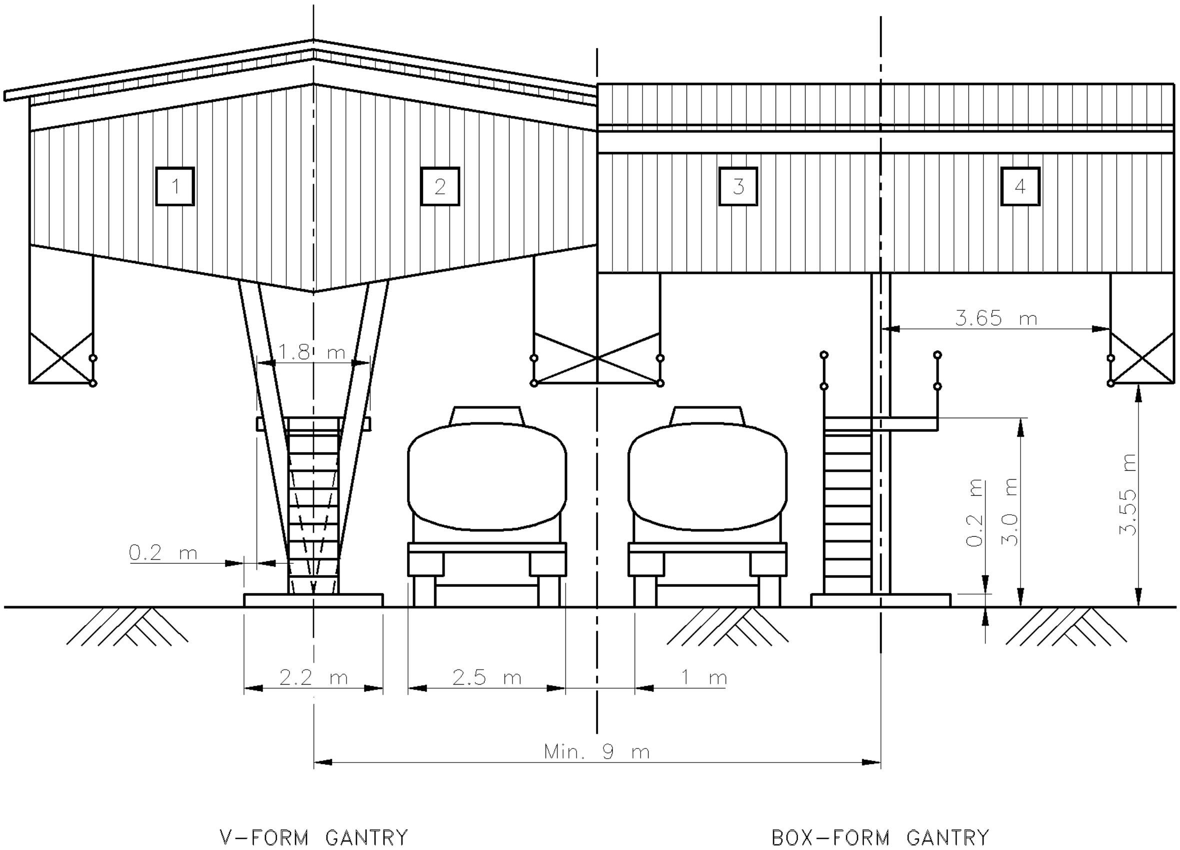


**Figure 8.14 Typical bottom loading island layouts**

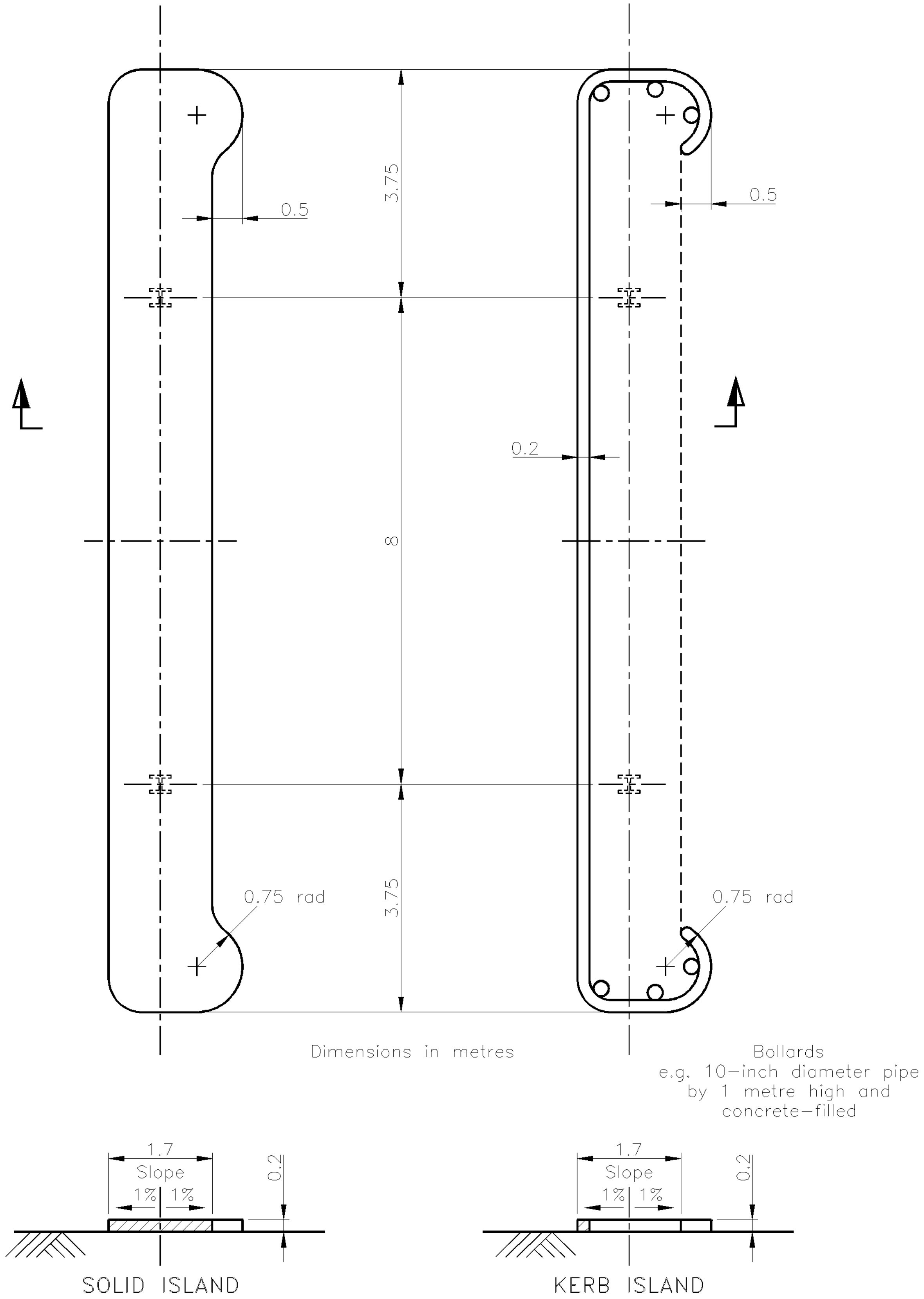


**Figure 8.15 Typical bottom loading bay dimensions**

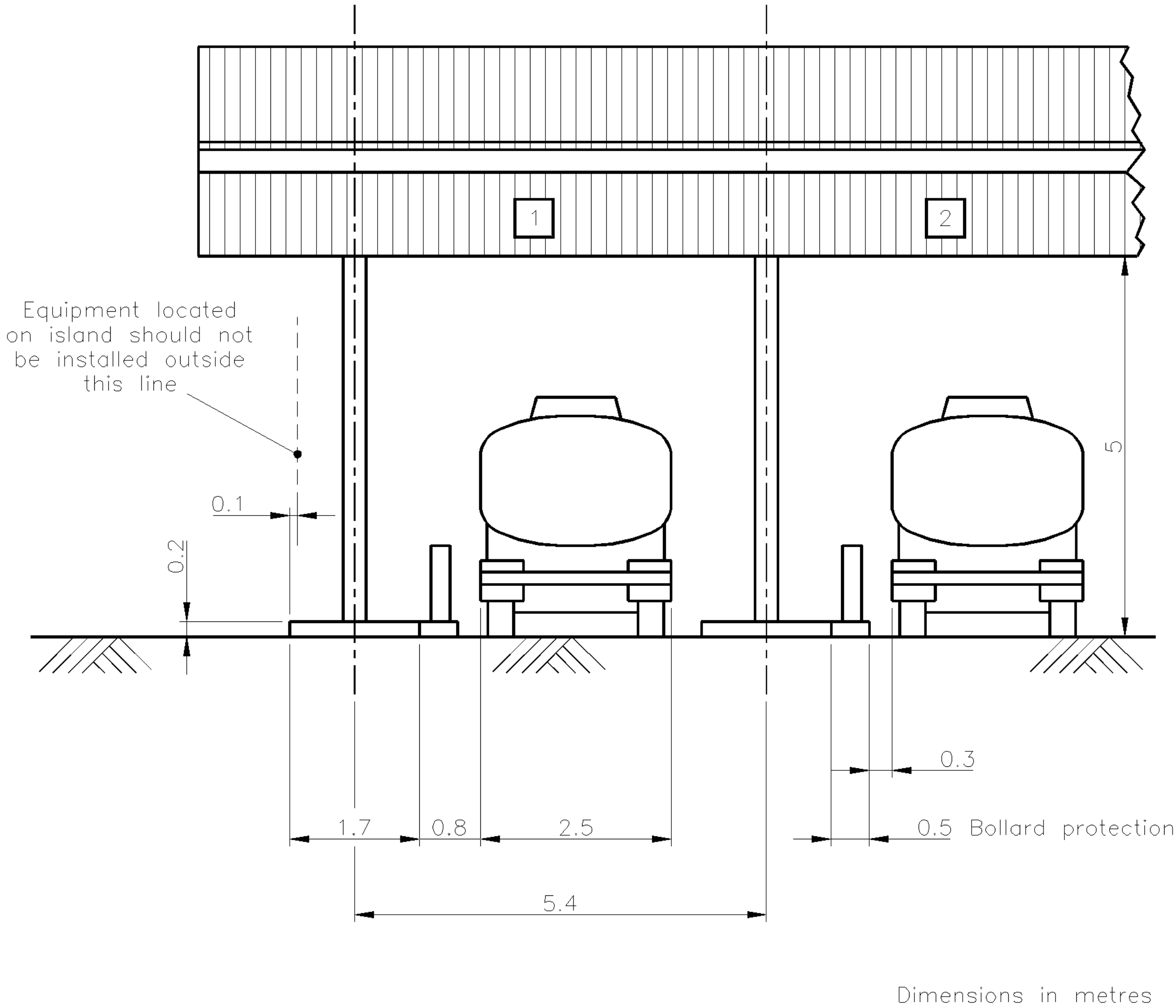


**Figure 8.16    Typical example of traditional box form top loading gantry**

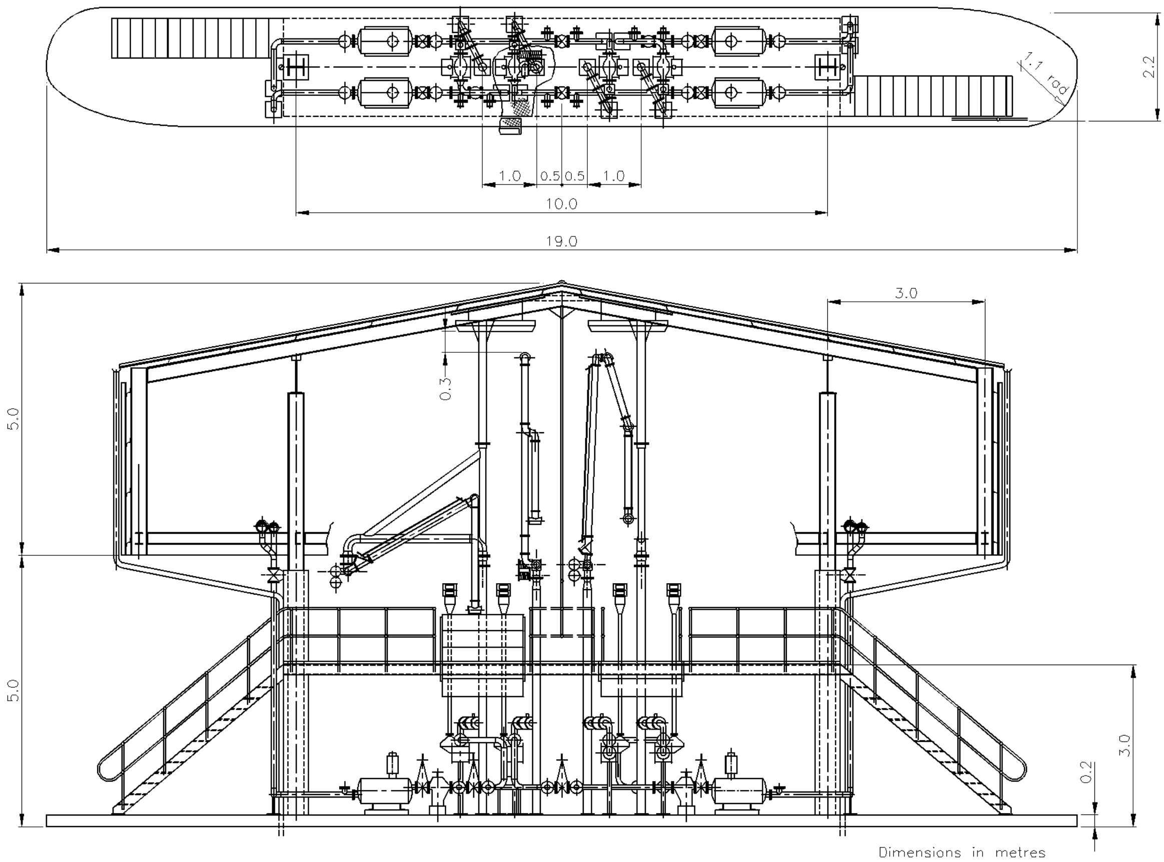


**Figure 8.17 1.3 metre hinged ramp with self-levelling steps**

| No of steps | Dimensions in mm | | |
|---|---|---|---|
| | A | R | Width |
| 3-steps | 1845 | 840 | 1300 |
| 4-steps | 2265 | 1260 | 1300 |

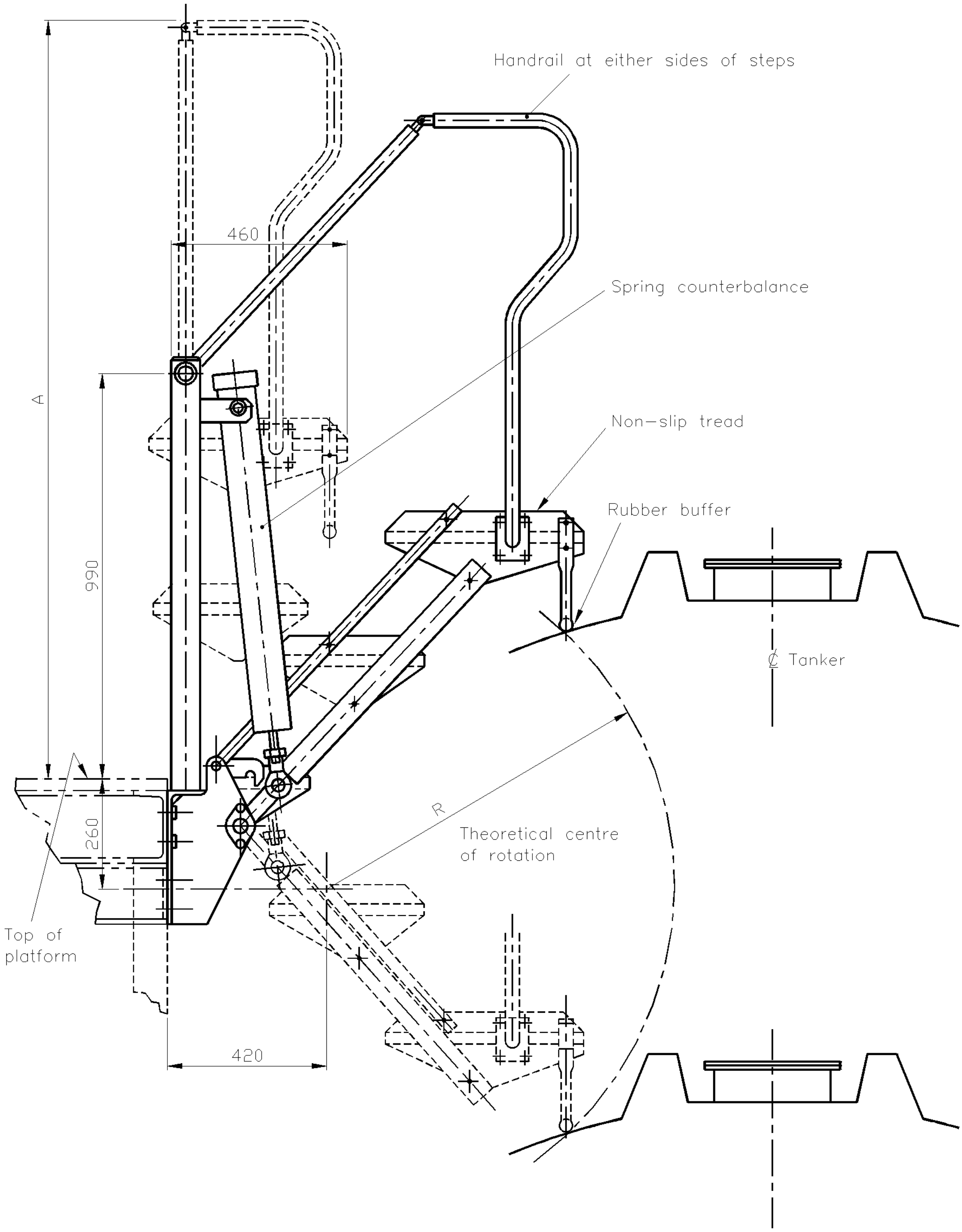


**Figure 8.18 6 metre hinged ramp**

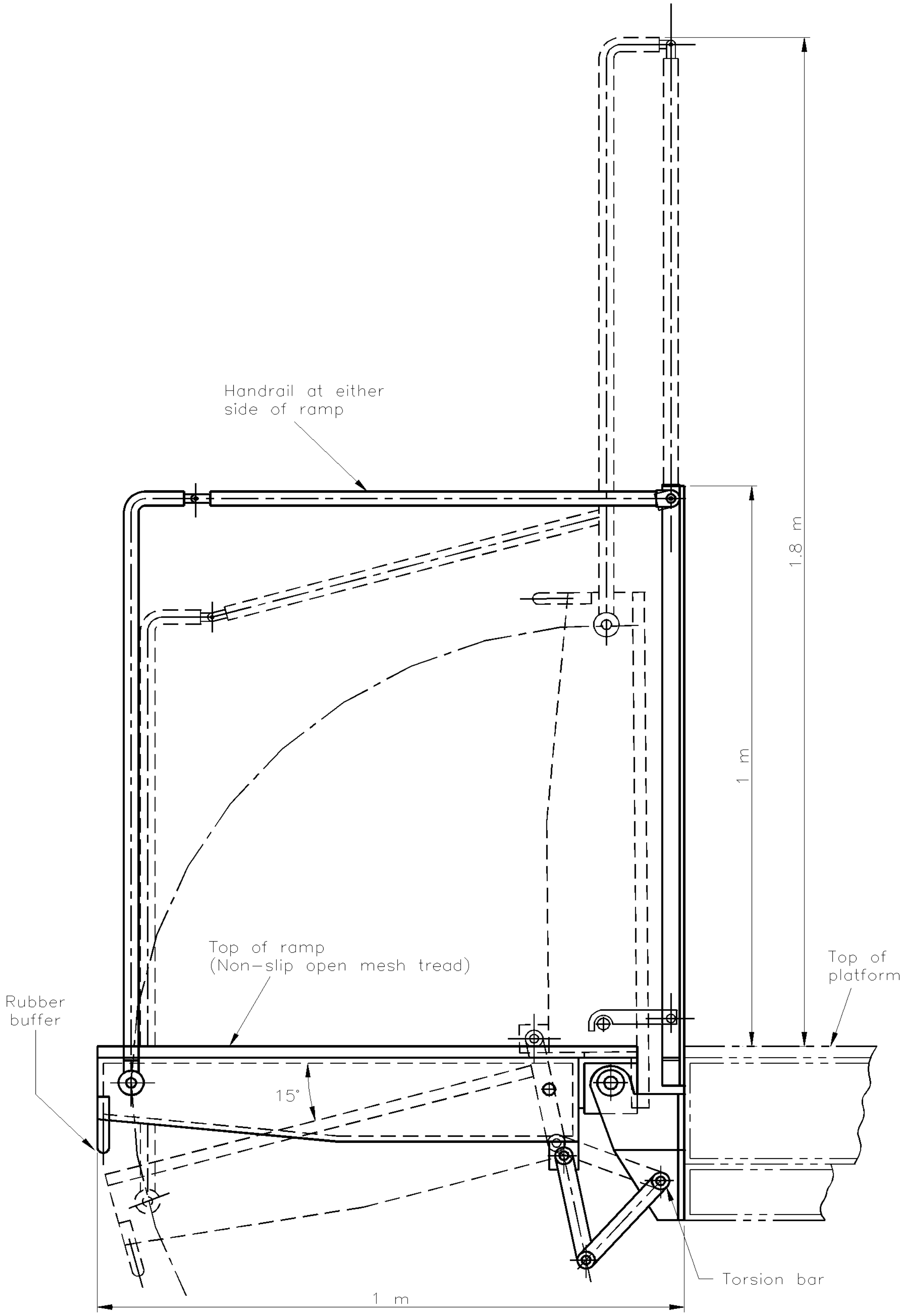
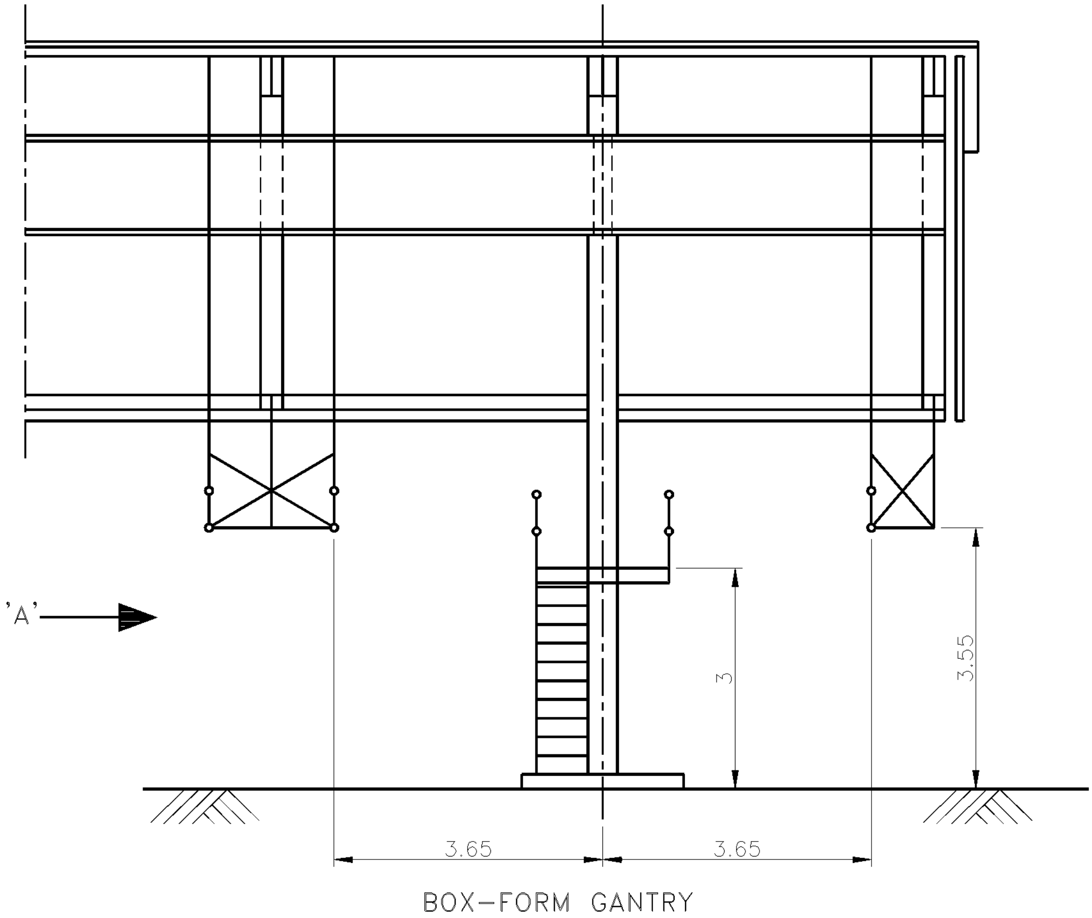
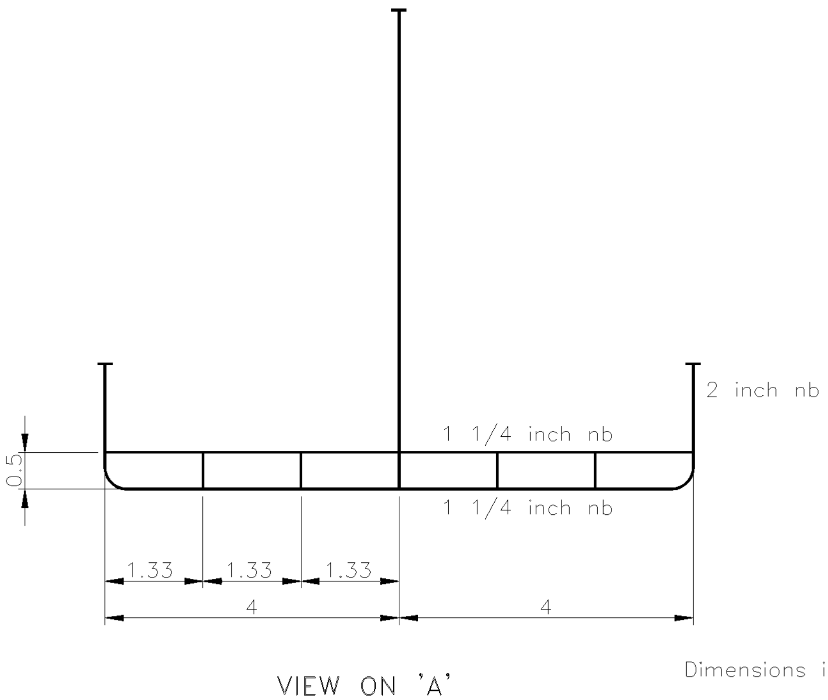


**Figure 8.19 Typical handrail support**




Dimensions in metres

**Figure 8.20 Typical traditional bottom loading structure**

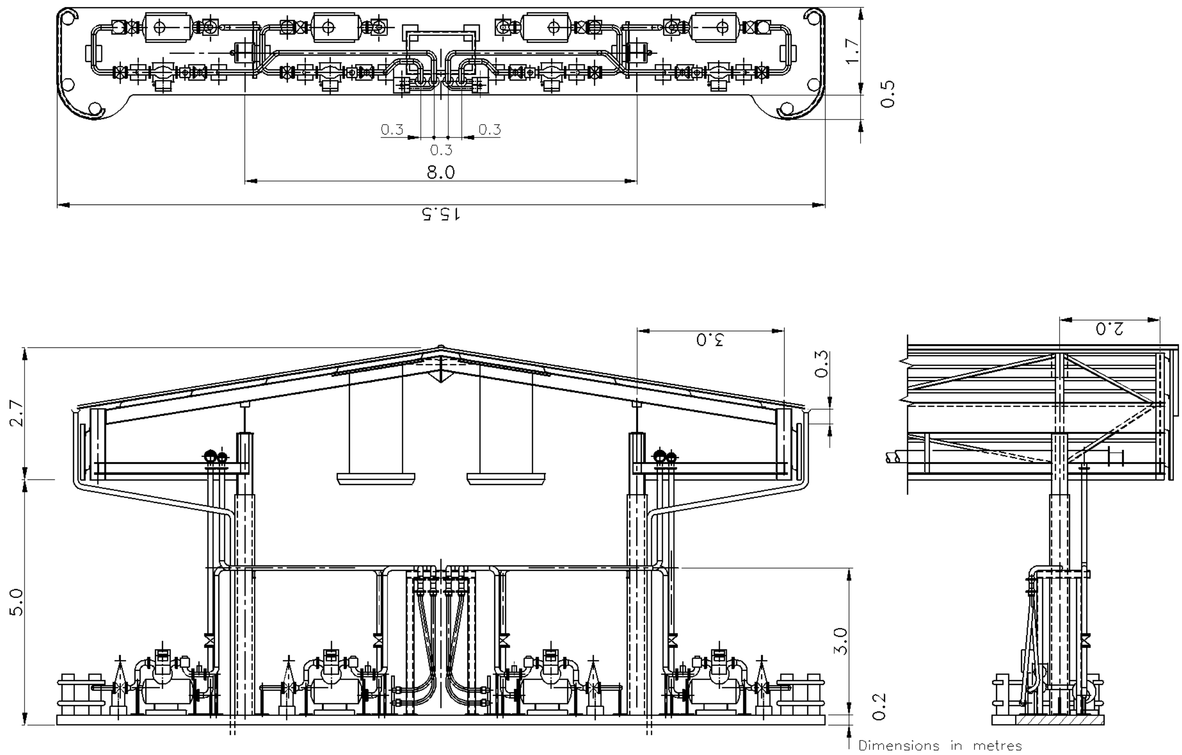


**Figure 8.21a Typical skid mounted bottom loading gantry**

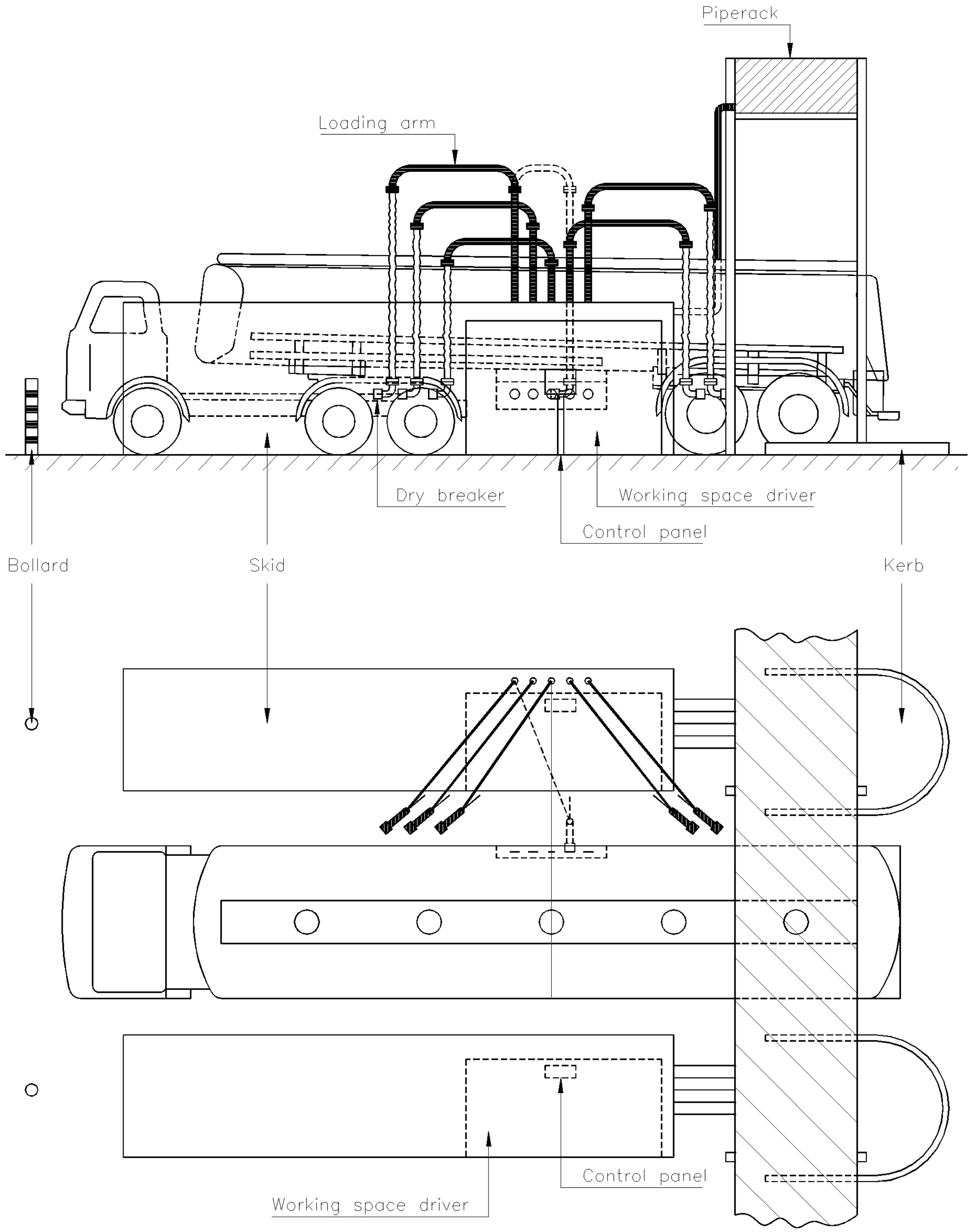


**Figure 8.21b Typical skid mounted bottom loading gantry**

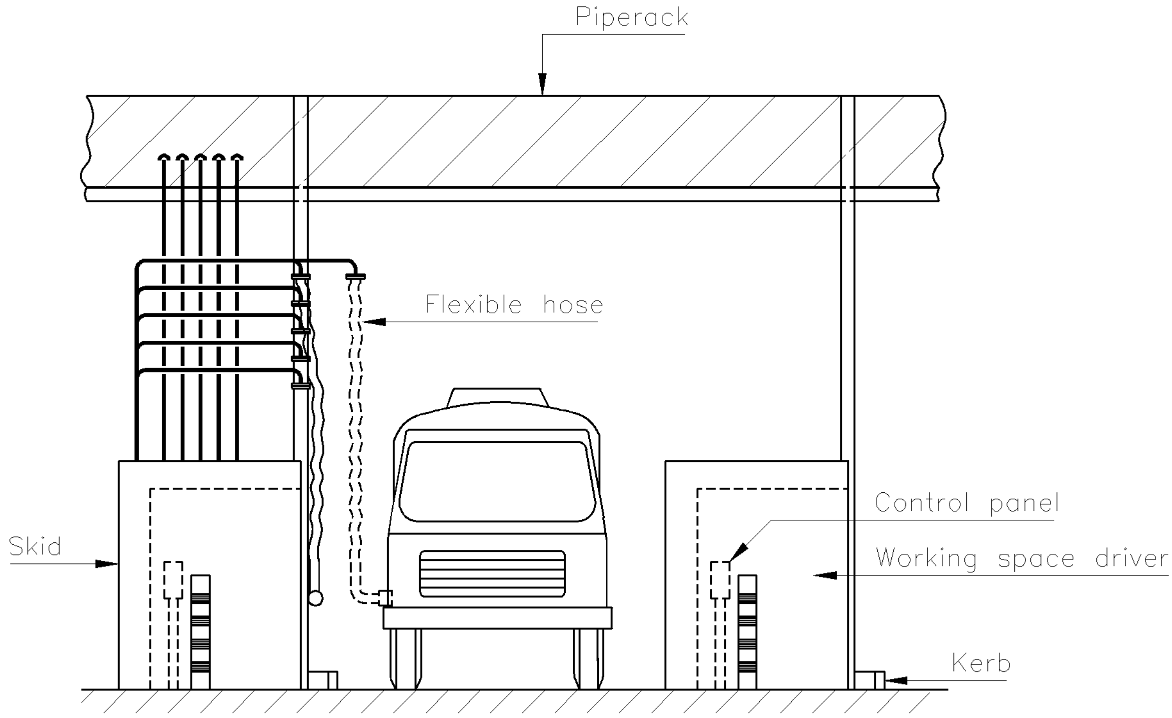



**Figure 8.22a Typical skid mounted bottom loading gantry**

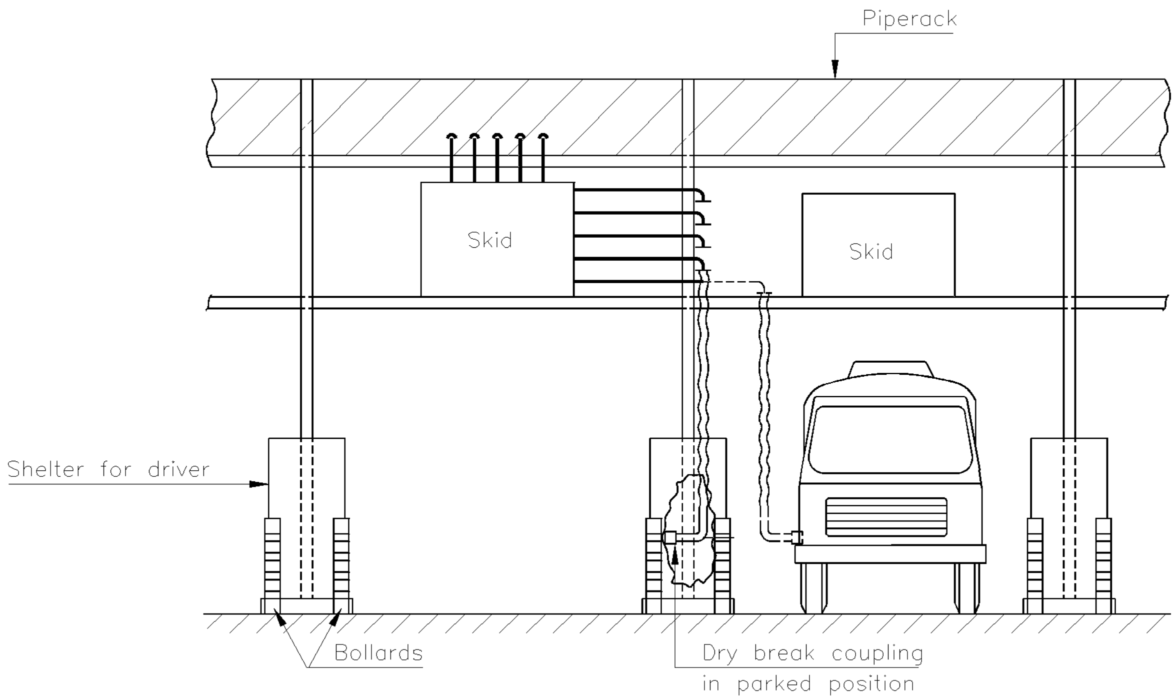


**Figure 8.22b Typical skid mounted bottom loading gantry**