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MANUAL

EQUIPMENT IN LPG INSTALLATIONS

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DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for main equipment (pumps, compressors, strainers, valves, flexible loading arms, quality measuring instruments and odorisation facilities) available for use in LPG installations. LPG includes commercial propane, commercial butane and mixtures thereof.

This DEP is a revision of the DEP with the same number dated November 1986.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors nominated by them (i.e. the distribution code is "C", as defined in DEP 00.00.05.05-Gen.).

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

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environment, economic and legal aspects.

In all cases the contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

The **Contractor** is the party which carries out all or part of the design, 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 supplied 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 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.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (10).

2. PUMPS

2.1 GENERAL

The choice of pumps depends on:

- the power consumption;
- the reliability required;
- the required flow rate;
- the net positive suction head (NPSH) available;
- the differential head requirements.

2.2 PUMP SELECTION

Centrifugal pumps are the preferred type for LPG handling. However, certain conditions may prevail in which centrifugal pumps are not the optimum solution, in which case a positive displacement pump may be selected. For details, refer to DEP 31.29.02.30-Gen., DEP 31.29.06.30-Gen. and DEP 31.29.12.30-Gen.

2.3 NET POSITIVE SUCTION HEAD (NPSH)

An important consideration when selecting a pump is the NPSH required ($NPSH_R$) or available ($NPSH_A$). The difference between $NPSH_A$ and $NPSH_R$ shall be at least 1 metre liquid under all circumstances.

2.4 DIFFERENTIAL HEAD

When calculating the differential head required, the following shall be taken into account:

- Pressure decrease in the supply vessel because of vaporisation of liquid to replace the product removed.
- Pressure increase in the receiving vessel, due to condensation of vapour as the liquid level rises.

NOTE: The pressure in the supply/receiving vessel is affected by the presence or absence of a vapour return line.

Figure 1 illustrates differential head and NPSH.

2.5 INSTALLATION REQUIREMENTS

2.5.1 General

Refer to DEP 31.29.00.10-Gen. and DEP 31.29.02.11-Gen.

Pumps shall be located as close as practicable to the supply vessel, while complying with safety (refer to DEP 30.06.10.12-Gen.), process operating and maintenance requirements. The location of pumps shall be such that in the event of leakage from glands, connections, etc., potential flame impingement on vessels and piping shall be prevented.

Pumps shall be located as close as possible to the supply vessel to:

a) Minimise friction in the pump suction system, thereby having a positive effect on the NPSH available;

b) Minimise heat transfer into the suction piping system, e.g. from solar heat. Heat transfer can be reduced by, for example, painting the pipes in a light, heat-reflecting colour, fitting sun shades or applying insulation. If sun shades are used, they should not obstruct fire fighting. Insulation should also be effective in protecting piping against flame impingement.

2.5.2 Suction lines

Suction lines shall be provided with suction strainers (see Section 4) to remove extraneous solid material. They shall slope continuously downward from vessel outlet to pump inlet and, wherever possible, a straight length of pipe should be fitted immediately upstream of the pump suction flange. The pressure rating of the pump suction valve, as well as of the piping between this valve and the pump, shall be the same as that selected for the discharge piping.

2.5.3 Isolation valves

All pumps and strainers shall be provided with isolation valves to enable them to be taken out of service for maintenance.

2.5.4 Bypass lines/'No Flow' cut-off

If a pump is operated against a closed discharge valve, the temperature of the liquid will rise, possibly causing vaporisation of the product and damage to the pump. To avoid this, a bypass line should be provided to return the liquid to the supply vessel.

For non-centrifugal pumps, the bypass lines shall be fitted with either a pressure differential valve, set to lift at, or just below, the pump maximum working pressure, or with a low-flow controller. For centrifugal pumps, the bypass line and valve shall be sized for the minimum allowable flow of the pump, which shall be at least 25% of the pump's design flow rate at its best efficiency point.

For positive displacement pumps, the bypass system shall accommodate 100% of the pump's design flow rate.

For pumps with 'direct on-line' starting, overheating of the liquid shall be avoided by the provision of a 'no flow' switch in the discharge line. A suitable time delay should be included before the switch operates.

2.5.5 Discharge lines

Centrifugal pumps shall be fitted with a non-return valve close to the discharge flange to prevent 'back-flow' and consequent reverse rotation.

2.5.6 Vent valves

To allow accumulated vapour to be vented before starting, pumps shall have a vent valve at the highest point and should also have one at the seal chamber, where applicable. In marketing depots/consumer installations small pumps need not have a provision for venting seals. Where venting is applied the vented vapour should be returned back to the suction vessel.

Drain points on LPG pumps should be permanently blanked without valves.

2.5.7 Mechanical seals

Refer to API 610, API 682 and DEP 31.29.02.30-Gen.

3. COMPRESSORS

3.1 GENERAL

The choice of compressor depends on:

- the reliability required, i.e. the cost of out-of-service time;
- the required flow rate;
- the differential head required;
- the discharge pressure;
- whether the use is continuous or intermittent.

Compressors provide a flexible means of transferring LPG but are generally restricted, in terms of performance, to use in systems where differential pressures do not exceed around 2 bar.

Compressors are also used to evacuate vessels, piping and other equipment and to recover vapour. This is an important consideration when LPG is transported in vessels which do not drain completely, e.g. ships or rail tank wagons which are unloaded through a top connection dip pipe.

Vapours may cool and condense in piping, and the compressor installation shall be designed so that condensate does not drain back towards the compressor.

Compressors should be located as close as possible to the vessel being unloaded.

Compressors shall be selected in accordance with DEP 31.29.40.10-Gen. Installation shall comply with the requirements of DEP 31.29.00.10-Gen. Selected compressor type shall comply with the type related DEP.

3.2 CENTRIFUGAL COMPRESSORS

Centrifugal compressors - essentially constant pressure, variable volume machines - shall be used only for flow rates above 120 litres per second at compressor discharge conditions. Refer to DEP 31.29.40.30-Gen.

3.3 RECIPROCATING COMPRESSORS

Reciprocating compressors - essentially constant volume, variable pressure machines - are used for services where the flow/pressure requirements would cause problems with a centrifugal type, i.e. when small flow but high pressure is required.

For LPG service, oil contamination of the gas shall be avoided. The gas system shall be isolated from the lubrication system. Refer to DEP 31.29.40.31-Gen.

3.4 SCREW COMPRESSORS

Oil-free screw compressors should not be used as they are close-clearance machines running at high speed, needing careful attention and operation.

3.5 INSTALLATION REQUIREMENTS

3.5.1 General

Refer to DEP 31.29.00.10-Gen. and DEP 31.29.40.10-Gen.

Compressors should be conveniently sited for process and operating requirements. Easy access for maintenance is important. Adequate ventilation of the location shall be ensured in LPG service.

3.5.2 Suction lines

Compressor suction lines shall be provided with suction strainers to remove solid material (refer to (4)). To prevent condensed product from reaching the compressor, knock-out vessels are required which shall have double-valve draining/bleed systems. A liquid high level emergency alarm with trip shall be provided on knock-out vessels.

3.5.3 Isolation, non-return and pressure relief valves

All compressors and their ancillaries (strainers, knock-out vessels, etc.) shall be provided with isolation valves (preferably with spectacle blinds) to enable the unit to be taken out of service for maintenance.

As centrifugal compressors can only generate a limited pressure increase before surging, it is normal practice to design upstream equipment so that it can cope with the maximum pressure produced by a centrifugal compressor at its surge point. If this is not economic due to the high differential pressures between normal operating pressure and surge pressure, a full flow pressure relief valve (PRV) followed by a non-return valve shall be fitted immediately downstream of the compressor to prevent back-flow and minimise surge effects.

Reciprocating compressors shall be provided with PRVs set to protect the system from pressures higher than the maximum working pressure.

Isolation and non-return valves shall be suitable for operation at the low temperatures which can occur during venting or depressuring.

3.5.4 Bypass lines

Bypass lines and valves shall be sized to take the full design flow rate of the compressor units being bypassed.

3.5.5 Discharge lines

If a compressor is used for liquid transfers (refer to DEP 30.06.10.13-Gen.), the loss of compressor head shall be minimised; hence the compressed product discharge lines shall be as short as possible. In cold climates and/or with long discharge lines, insulation and/or tracing may also be necessary. This is not a requirement for other applications.

To check compressor performance, suitable instrumentation indicating flow rate, temperature and pressure shall be provided.

3.5.6 Cooling water supply

Any cooling water supplied to compressors shall be at a temperature at least 5 °C above the gas entry temperature in order to prevent condensation.

3.5.7 Anti-surge control

In order to ensure that a centrifugal compressor only operates in the stable region between its surge point and its rated point, an anti-surge control and independent trip system shall be provided. Facilities should be provided so that in the event of a trip, adequate seal oil pressure is maintained to obviate the need for depressuring the compressor.

3.5.8 Purging facilities

Suitable purging connections on the inlet and discharge piping shall be provided to enable compressors to be safely commissioned and maintained.

4. STRAINERS

Refer to DEP 31.29.00.10-Gen., DEP 31.38.01.11-Gen. and Standard Drawings S 38.002, S 38.004 and S 38.041.

5. VALVES

DEP 31.38.01.11-Gen. shall apply. For the uses of the various types of valves, refer also to DEP 30.06.10.12-Gen., where valves are described in relation to the systems in which they perform their specific functions:

- drain valves;
- vent valves;
- pressure relief valves;
- emergency valves;
- non-return valves;
- excess flow valves;
- thermal expansion relief valves.

A wide range of shut-off valves are available for LPG service, including ball, gate, butterfly, plug or globe valves, and the choice will depend on the type of operation, the service (including fire-safe features), piping class requirements and economic factors.

If the first valve in the bottom line of a vessel is larger than DN 150 it shall not be a gate valve (refer to DEP 30.06.10.12-Gen.).

General technical considerations relevant to all valves are as follows:

- Careful consideration shall be given to those parts of LPG systems where valves may be subjected to fire engulfment. This is of particular relevance for emergency shut down (ESD) valves (refer to DEP 30.06.10.12-Gen.). Such valves shall be fire-safe in accordance with BS 6755 or API Spec. 6FA.

- Although gate valves are considered to be fire-safe due to their all-metal construction, they tend to leak when subjected to flame engulfment. Ball valves with special two-piece valve seal designs, with a primary soft (PTFE) seal and a secondary (back-up) metal seal, are also considered to be fire-safe. High-performance butterfly valves, often with a triple seal design, also meet current fire-safe requirements.

- In general, ball valves with PTFE sealing are recommended.

6. FLEXIBLE ARMS, HOSES AND COUPLINGS

Refer to DEP 30.06.10.13-Gen.

7. MEASURING/CONTROL INSTRUMENTS

7.1 GENERAL

Suitable measurement and control equipment shall be installed in LPG pressure storage facilities, to provide:

- operational measurement data and warning signals, should undesirable or unsafe operating conditions develop (the same equipment giving warning signals may automatically initiate corrective actions);
- measurement data with sufficient accuracy to ensure the effective operation and control of stocks and custody transfers.

The installation and selection of instruments used on LPG pressure storage facilities shall be guided by:

- The safe operation procedures of the facilities (including presentation to the operator of measurement data, and the facilities allowing maintenance and calibrations to be performed without disturbing normal operations).
- The required method of displaying operational and accounting measurement data, e.g. local read-out only, or local read-out with data display in a central operations or accounting centre.

Safety/operating aspects, local regulations and economic justifications will normally determine the extent of automation (refer to DEP 32.31.00.32-Gen.).

7.2 SPECIFIC REQUIREMENTS

Instruments shall be LPG-compatible and suitable for operation at the design pressure of the storage vessel, and preferably at its test pressure.

Wetted parts of instruments shall be suitable for use with LPG containing traces of sulphur, sodium hydroxide and other contaminants unless the absence of these can be guaranteed.

If the presence of liquid LPG in the instrument tubing adversely affects instrument performance, then such tubing shall drain into the vessel liquid space.

Conversely, instrument connections made to the liquid space shall vent to the vapour space. This is important because small temperature differences between the instrument tubing and the storage vessel can cause vaporisation of liquid LPG or condensation of gaseous LPG.

Electrical and electronic instruments shall be suitable for the hazardous area class in which they are located (see 9.1).

Glass gauges shall not be used.

If instruments are not mounted in pockets which are an integral part of the vessel (e.g. thermowells) then they shall be connected to the vapour space or shall be provided with means (e.g. restricted orifices) to minimise product loss in the event of failure.

Instruments with a detachable sensor which is unlikely to need maintenance (e.g. solid state) should be used wherever possible.

7.3 LEVEL GAUGING EQUIPMENT

Level gauging in LPG storage vessels shall be possible under all circumstances. Storage vessels shall be equipped with one self-revealing level gauge, of the servo-operated or radar type. For details, refer to DEP 30.06.10.12-Gen. and DEP 32.31.00.32-Gen.

For operational information, an accuracy of 1% of measuring span is adequate. For accounting purposes, the resolution of the level gauge shall be approximately 2 mm or equivalent. Level gauges used for custody measurements usually require the approval of the Local Authorities.

Ready verification of the datum setting shall be possible for calibration purposes.

7.4 PRESSURE INSTRUMENTS

Pressure measurements in the vapour space of LPG storage vessels shall be possible for the following reasons:

- as a check on product quality, as the vapour pressure is related to temperature and product characteristics;
- to enable the calculation of the liquid equivalent of the vapour phase;
- as a safety check against overpressure.

Pressure gauges are also used for operational control purposes, e.g. pump pressures, pipeline pressures.

For details, refer to DEP 32.31.00.32-Gen.

7.5 TEMPERATURE MEASURING INSTRUMENTS

Refer to DEP 32.31.00.32-Gen.

7.6 WEIGHING EQUIPMENT

Only approved equipment meeting at least the requirements of the local regulations shall be used.

Weighbridges with concrete or steel platforms for handling complete vehicles with capacities up to 120 tonnes are available. They may be equipped with electronic ticket printers, etc. The bridge should be protected from excessive wind forces, and shall be properly ventilated and drained.

7.7 QUALITY MEASURING INSTRUMENTS (QMIs)

7.7.1 General

QMIs shall be selected in accordance with DEP 32.31.50.12-Gen.

For a full description of LPG quality specifications, test procedures, methods and equipment, refer to ASTM D 1835, EN 589 and ISO 9162.

7.7.2 Sampling equipment

High pressure sample containers or bombs shall be used for taking samples. The size and type of the sampling bomb used depends upon the tests and analyses required on the sample. For details, refer to ASTM D 1265.

7.7.3 Quality measuring

LPG transactions are generally on the basis of mass or weight. In most countries commercial transactions are carried out as weight in air. The density must be known in order to calculate this.

The density of LPG can be measured manually by means of a pressure hydrometer or by automatic on-line density analysers. Alternatively, the density can be calculated from the compositional analysis of the LPG as determined by GLC analysis, but such equipment is not normally available in the relatively small scale operations involving ambient temperature pressurised LPG. GLC analyses are more often performed when dealing with refrigerated LPG, where densities can then be calculated close to operational temperatures in order to give more accurate results.

Representative sampling is essential for overall accuracy, and so for custody transfer operations direct on-line density measurement should be employed rather than spot sampling followed by laboratory measurement. This is particularly relevant if product is being drawn from a stratified storage vessel, where a series of spot samples taken from the delivery line may not reflect the average quality.

7.8 METERING EQUIPMENT

7.8.1 General

Refer to DEP 32.31.00.32-Gen.

For batch transfers (e.g. into bulk road vehicles and rail tank wagons) volume difference measurements in the storage or transport vessels may not give the required accuracy. For these product deliveries, weighing or metering is more accurate and should be used instead. A weighbridge has the advantage that the amount remaining in the transport vessel is taken into account when determining the tare weight, and the required fill quantity is adjusted accordingly.

For product deliveries via ship and pipeline, quantity assessments are usually made either by in-line metering (often on-line density measurement), or by measurement of tank levels and density analysis.

Quantities delivered to customers are normally measured by metering. Meters can be fitted with mechanical temperature compensators which automatically adjust the meter register to give a readout in volume units at standard reference temperature (normally 15 °C). In some types of meters this temperature compensator is designed specifically for one product (e.g. propane). If different quality LPGs are passed through the one meter, then the temperature compensated readout may be in error. In automated installations electronic instrumentation should be applied. Pulse transmitters are installed on the meter shaft, while resistance thermometers are located either in the meter body or in the piping adjacent to the meter, and the transmitted signals from both instruments are processed in a micro-processor. Digital outputs of ambient and temperature-compensated volumes can be given, and the software can be written to allow changes of expansion coefficient to reflect changes in flowing product density. It is also possible to adjust the reference temperature to a value different from the normal 15 °C, if required.

If a vapour return line is not used, the meter indicates directly the transferred quantity. Otherwise a correction has to be made for the returned vapour.

Factors affecting the choice of meters:

- suitability for LPG service;
- required degree of accuracy and repeatability;
- range of ancillary equipment which can be combined with them;
- maximum flow rate turndown and operating pressure;
- price, delivery times, service and provision of spare parts.

Factors affecting the performance of meters:

- LPG has poor lubricating properties. This may create wear problems with the moving elements of turbine and positive displacement (PD) meters. In some designs of PD meters, forced outside lubrication can be employed. Other designs rely on self-lubricating materials such as PTFE impregnated with glass fibre or carbon, and PTFE plus lead-impregnated porous bronze.

- In the design and operation of metering systems, care shall be taken to ensure that back-pressure on the meters is kept above the product vapour pressure. Partial vaporisation will impair the accuracy of metering and may cause damage to meters with moving parts, due to overspeeding and cavitation effects. To ensure the absence of small amounts of gas the use of vapour eliminators is required, unless the system pressure is sufficiently high to exclude the presence of gas.
- Both PD and turbine meters require the fluid to be filtered. PD meters require a finer degree of filtering because of the small clearances used between rotating parts and the meter casing. For turbine meters the degree of filtering may be coarser as the meter has mainly to be protected from impact of large particles on the blades. The coarser filter needs of turbine meters can be of great benefit as LPG can sometimes have a heavy dirt load.
- Because LPG has a high thermal coefficient of expansion, an accurate measurement of temperature is required to obtain volume correction to standard temperatures. It shall also be taken into account that the coefficient of expansion varies with product composition.

NOTE: LPG which contains traces of caustic soda as a result of processing deficiencies will cause corrosion problems in metering systems with aluminium or aluminium alloy components.

7.8.2 Metering installations

A typical layout for a metering installation is shown in Figure 2.

If the pumping characteristics allow flow rates to exceed the maximum rated capacity of the meter, a flow limiting valve or restriction orifice should be installed downstream of the meter. In some transfer operations the flow is too great to be handled conveniently by a single meter, in which case two or more meters should be connected in parallel. In this case each meter should be protected by some type of flow limiting valve.

For meters designed for flow in one direction only, a non-return valve or the like shall be provided to prevent flow in the reverse direction.

Connections to proving systems should be as close as practicable to the associated meter. A positive shut-off device is necessary to ensure that all product passing through the meters enters the prover during proving. This can be a combination of two valves with an intermediate bleed valve. A single, specially designed gate valve with double seal (block and bleed) may also be used for this purpose, possibly with cost and space advantages. In the closed position, the integrity of the seals can be checked by an indicator valve in the valve body.

7.8.3 Selection of flow meters

Refer to DEP 32.31.00.32-Gen.

7.8.4 Meter prover systems

Refer to DEP 32.31.00.32-Gen.

7.9 GAS DETECTORS

Refer to DEP 32.30.20.11-Gen. and DEP 80.47.10.30-Gen.

8. ODORISING FACILITIES

8.1 GENERAL

LPG used for most commercial purposes, e.g. as a fuel gas, shall be given a distinctive and preferably unpleasant odour to assist its detection in the event of leakage. However, odorisation shall not be used if detrimental to the use or further processing of the LPG (e.g. for certain applications, such as feedstocks and aerosols) or if it would serve no useful purpose as a warning agent in such cases.

LPG is odorised by the addition of controlled quantities of suitable odorising agents, e.g. ethyl mercaptan, dimethyl sulphide. The odorant content should be sufficient to permit detection by smell whenever the concentration of the vapour in air is at least one-fifth of the lower flammable limit, i.e. 0.3% butane in air.

The odorant used shall be non-corrosive, shall have the lowest practicable sulphur content and shall have a boiling point as close as possible to that of LPG.

Odorants are toxic in concentrated form and shall be handled with care.

Some odorants tend to be absorbed by the iron oxide present on the steel walls of new storage and transport vessels so that increased doses may be necessary when new units are first used.

Non-odorised or odourless product shall be segregated from odorised product and stored/transported in separate vessels, cylinders, pipes, etc., which have either not been used for the odorised product or have been thoroughly cleaned.

8.2 ODORISING AGENTS

The recommended and most commonly used odorant is ethyl mercaptan. Possible alternatives are dimethyl sulphide, or tetrahydrothiophene (THT). In Japan, two products known under their trade names of AL-741 and CP-380 are generally used. The properties of these products are given in Table 1.

8.3 HEALTH AND SAFETY HAZARDS

As shown in Table 1 the odorising agents are generally volatile, highly flammable liquids, the vapours of which are heavier than air and may spread over the ground. As well as giving an unpleasant odour some odorants also have toxic properties, particularly ethyl mercaptan.

Ethyl mercaptan is a moderately toxic substance if ingested or inhaled, causing temporary effects on the nervous system. It is an irritant to the skin and mucous membranes, and is irritating to the eyes. Its threshold limit value (TLV) as a time-weighted average (TWA) concentration for a normal 8-hour working day or 40-hour working week), is 1 mg/m^3. Its TLV as a short term exposure limit (STEL) (maximum concentration to which workers can be continuously exposed for a period up to 15 minutes without suffering irritation, chronic or irreversible tissue change or narcosis) is 3 mg/m^3.

Every plant shall have copies of the odorant manufacturer's safety data sheet readily available at all times.

The storage and handling facilities for odorising agents shall be designed with due regard to the above properties (refer to (8.5)).

Small odorant spills should be chemically neutralised with ordinary household bleach solution (5%) and subsequently washed away with water. Solid bleach (active component sodium hypochlorite) shall never be used as it may produce a violent reaction with the odorant. The use of bleach solution is less effective with sulphide type odorants which are far more oxidation-resistant than mercaptans.

The unpleasant smell accompanying a small spill may be counteracted with masking agents. It shall be appreciated, however, that the masking agent does not destroy the odorant but merely counteracts the odour.

If concentrations are higher than the TLV, self-contained respiratory equipment should be worn. Protective clothing shall include chemical type safety goggles, PVC/special rubber type gloves and cotton overalls or laboratory coats.

A water eye-bath facility shall be available. Toxicological and first-aid information on the type of odorant in use shall be readily available at the plant. Additional information should be available from the supplier.

8.4 ODORANT INJECTION RATES

The recommended injection rates vary according to the type of odorant used.

Sometimes a certain concentration of odorant is required by the product specification. In all other cases the recommended injection rate shall be applied. These are based on NFPA or suppliers' recommendations as shown in Table 2.

As some odorants, e.g. ethyl mercaptan, react with iron oxide which is normally present in newly built installations, vessels, pipes, etc. in the form of rust, a substantial quantity of odorant can initially be lost during the commissioning stage of new installations.

It is therefore advisable to over-odorise initially, by two to three times the recommended dose depending on the amount of rust present, and to check at the final take-off point whether the LPG is sufficiently odorous.

8.5 STORAGE AND HANDLING OF ODORANTS

Because of their characteristics (refer to (8.2)), odorants shall be stored in sealed containers in a well-ventilated area, sheltered from rain and direct sunlight. The electrical area classification and fire protection provisions of the storage and handling area shall conform to the same codes as those applicable to LPG facilities in general (refer to DEP 30.06.10.12-Gen.).

Odorants may be supplied in disposable drums (25 to 200 litres), in semi-bulk containers (1,000 to 2,000 litres) or in bulk. At the site of use, either local storage may be provided (involving transfer of the odorant from the transport container into the storage) or, preferably, returnable containers may be used.

Transfer devices which fit directly to drum outlets are commercially available (Figure 3).

An inert gas, e.g. nitrogen, shall be used for the transfer of the odorant.

Bulk vessels for odorants shall be fabricated in accordance with DEP 31.22.10.32-Gen. or DEP 31.22.20.31-Gen. The design pressure shall take into account any pressure applied to the vessel for operational reasons, e.g. transfer of the odorant.

Vent lines from tanks/containers and relief valve outlets shall be lined up to flare. If this is impossible the vented fumes shall be scrubbed through a bed of activated carbon in order to absorb the odorant.

8.6 INJECTION SYSTEMS

8.6.1 General

Odorant injection systems may differ according to the requirements of the individual application. Factors influencing the choice of a system include the size of batches to be odorised, whether consignments consist of a single batch as in bulk road vehicles or rail tank wagons or multiple batches as in ships, and the available metering/control facilities in the LPG stream. Three possible systems are discussed in (8.6.2), (8.6.3) and (8.6.4). In all cases the following general remarks apply:

- To avoid contamination of product in storage vessels and transfer lines, odorant should whenever possible be injected into pump delivery lines to cylinder/bulk filling points, or into the transport vessel itself.
- All piping and vessels shall be thoroughly cleaned before putting them into odorant service because of possible damage to fine tolerance metering, pumping and control units.

8.6.2 Pressure injection system

Figure 4 shows a typical layout where the odorant measuring vessel can be filled with sufficient odorant for, say, one bulk load. The odorant is injected into the LPG line by the pressure of the blanketing gas. Injection takes place either in one shot shortly after the start of loading or gradually during loading under the control of a needle valve. In the latter case, the injection rate may be checked by isolating the bottom of the sight glass and exposing it to the LPG line (see Figure 4). To prevent the blanketing gas from entering the LPG line, the odorant valves shall be closed immediately after completion of the LPG loading operation. Automation of this shut-off may be considered, e.g. by using the no-flow signal from the LPG line.

This simple injection method is suitable for very constant LPG flows or for single batch bulk loads, but this manual operation requires proper supervision. In the case of bulk loads, a single injection early during loading ensures proper mixing with the LPG, due to the turbulence created in the receiving tank by the incoming LPG.

8.6.3 Metering pump injection system

Figure 5 shows a typical flow scheme of an odorant injection system using a metering pump. The injection quantity is controlled by the total injection time and by pump stroke frequency and/or the displaced volume per pump stroke.

The odorant flow rate is independent of the LPG flow. A timer stops the injection automatically upon completion of odorant injection. A pump 'running' visual signal may be used to indicate the correct operation of the system.

8.6.4 Flow proportional injection system

In this system (Figure 6) the LPG flow controls the operation of the odorant injection pump, in order to maintain the required odorant injection ratio at all LPG flows. Control may be by on-off operation (in the case of small, solenoid-operated pumps), by pump stroke frequency and/or stroke volume. In all cases, the pump is stopped when the LPG flow ceases. Additional facilities (such as a pump 'running' visual signal) may be provided to indicate proper operation of the system. The complete system is commercially available as a package.

This system is especially applicable when variable LPG flows have to be dealt with, e.g. when loading a number of tanks in a ship.

8.7 EQUIPMENT MATERIALS FOR HANDLING ODORANTS

Although pure and dry odorants generally have little corrosive effect on carbon steel, stainless steel should normally be used, in particular where intermittent exposure to liquid odorant and air is unavoidable. Copper and copper alloys shall not be used. At all times care shall be taken to avoid any mixing of water with odorants (ethyl mercaptan in particular) i.e. the system shall be thoroughly dried before the introduction of odorant, in view of corrosion problems.

9. AREA CLASSIFICATION, EARTHING AND BONDING

9.1 AREA CLASSIFICATION

Area classification shall be in accordance with DEP 80.00.10.10-Gen.

The construction and installation of electrical equipment in hazardous areas shall comply with IEC 79-14.

9.2 EARTHING AND BONDING

Earthing and bonding shall be in accordance with DEP 33.64.10.10-Gen.

All equipment used for handling LPG other than hoses or loading arms connecting ship to shore shall be bonded and earthed. Bonding/earthing stubs or connections shall be provided at all loading and discharge points. For rules applicable to loading arms and hoses used for loading and discharging ships, refer to DEP 30.06.10.13-Gen.

Tests to ensure electrical continuity shall be carried out. In flanged connections the connecting bolts usually provide the necessary electrical continuity, but if this is not so, bonding strips shall be fitted. The resistance to earth shall also be tested to ensure it is in accordance with the above requirements.

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.
Pressurised bulk storage installations for liquefied petroleum gases	DEP 30.06.10.12-Gen.
Liquefied Petroleum Gases - Bulk transfer and transportation	DEP 30.06.10.13-Gen.
Installation of rotating equipment	DEP 31.29.00.10-Gen.
Pumps - Selection, testing and installation	DEP 31.29.02.11-Gen.
Centrifugal pumps (amendments/supplements to API 610)	DEP 31.29.02.30-Gen.
Centrifugal submerged motor pumps in refrigerated product service	DEP 31.29.06.30-Gen.
Reciprocating positive displacement pumps and metering pumps (amendments/supplements to API Std 674 and API Std 675)	DEP 31.29.12.30-Gen.
Compressors - Selection, testing and installation	DEP 31.29.40.10-Gen.
Centrifugal compressors (Amendments/supplements to API Standard 617)	DEP 31.29.40.30-Gen.
Reciprocating compressors (amendments/supplements to API Std 618)	DEP 31.29.40.31-Gen.
Piping - General requirements	DEP 31.38.01.11-Gen.
Fire, gas and smoke detection systems	DEP 32.30.20.11-Gen.
Instruments for measurement and control	DEP 32.31.00.32-Gen.
On-line process stream analysis- Analysers	DEP 32.31.50.12-Gen.
Area classification (amendments/supplements to IP 15)	DEP 80.00.10.10-Gen.
Assessment of the fire safety of onshore installations	DEP 80.47.10.30-Gen.

STANDARD DRAWINGS

NOTE: The latest editions of Standard Drawings are identified in DEP 00.00.06.06-Gen.

Y-type strainers ANSI classes 150 and 300	S 38.002
Bucket-type suction strainers, carbon steel, ANSI class 150	S 38.004
Temporary strainer for compressors	S 38.041

AMERICAN STANDARDS

Centrifugal pumps for general refinery service	API 610

Shaft sealing systems for centrifugal and rotary pumps	API 682
Specification for fire test for valves	API Spec. 6FA

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

Standard practice for sampling Liquefied Petroleum (LP) gases (manual method)	ASTM D 1265
Standard specifications for Liquefied Petroleum (LP) gases	ASTM D 1835

Issued by:
American Society for Testing and Materials
100 Barr Harbour Drive
West Conshohocken, PA 19248-2959
USA.

BRITISH STANDARDS

Testing of valves Part 2: Specification for fire type-testing requirements	BS 6755

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
United Kingdom.

INTERNATIONAL STANDARDS

Automotive fuels; requirements and test methods	EN 589

Issued by:
Comité Européen de Normalisation
Rue de Stassart 36
B-1050 Brussels
Belgium.

Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)	IEC 79-14

Issued by:
International Electrotechnical Commission
3 Rue de Varembé
1211-Geneva 20
Switzerland.

Petroleum Products - Fuels (class F) - Liquefied petroleum gases - Specifications	ISO 9162

Issued by:
International Organization for Standardization
Case Postal 56
CH-1211 Geneva 20
Switzerland.

Copies can also be obtained from national standards organisations.

APPENDIX 1 TABLES

Table 1 Physical properties of LPG odorants (mainly based on suppliers' data)

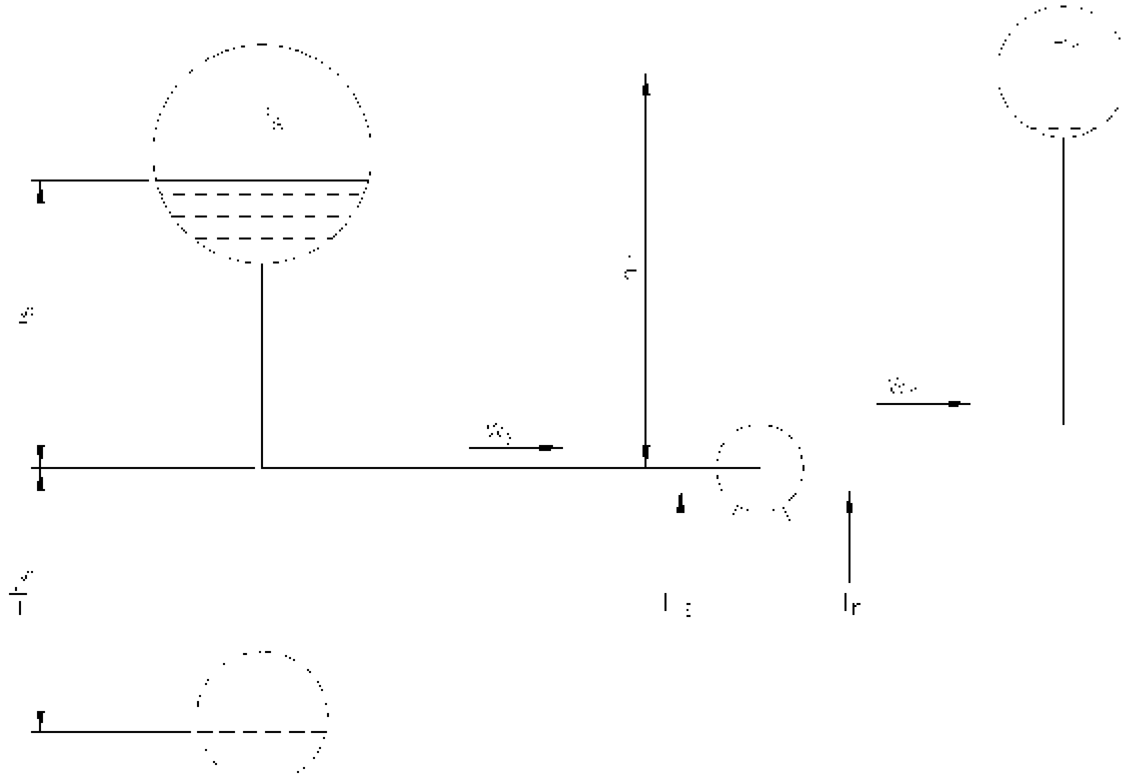
Odorant	Ethyl mercaptan	Dimethyl sulphide	Tetrahydro-thiophene	AL-741	CP-380
Chemical formula	C_2H_5SH	$(CH_3)_2S$	$(CH_2)_4S$		
Type of compound/ product				Blend of lower alkyl mercaptans, sulphides and hydrocarbons	Non-mercaptan
Molecular weight	62.1	62.1	88.2	Average 85	
Density, kg/m³ at 15 °C					680-720
Density, kg/m³ at 20 °C	837	845	999		
Relative density 20/20 °C				0.738	
Atmospheric boiling range, °C					
IBP	34.4	36.0	118.0	48	
95%	36.1	40.0	122.0	75	
Vapour pressure mbar absolute, at:					
20 °C	575	505	20		
30 °C				307	
37.8 °C	1124 (RVP)	1030	69 (RVP)		853
50 °C	1665	1600	85		
Flash point open cup, °C	<-20	-33	13	<0	<0
Auto-ignition temperature, °C	295				
Limits of flammability in air, % volume	2-18.2	2.2-19.7			
Viscosity					
at 20 °C, mPa.s				0.32	
at 25 °C, mm²/s	0.26				
at 30 °C, mm²/s					0.38
Freezing point, °C	-121	-103	-46	<-70	
Colour (Hazen max.)	40	35	20		
(WW = water white)	WW	WW	WW to very pale yellow	WW	Faintly yellow
Water solubility at 20 °C, g/100 ml	0.7		Negligible	Nil	
Odour	Penetrating garlic-like				'Gassy'

Table 2 Recommended odorant injection rates

		Injection Rate		
Type of odorant	Source	g/m^3	cm^3/m^3	mg/kg
Ethyl mercaptan	NFPA 58	12	14	20-25
Dimethyl sulphide		No value available		
Tetrahydrothiophene	NFPA 58	77	77	130-160
AL-741	Supplier			40-60
CP-380	Supplier			>40

APPENDIX 2 FIGURES

Figure 1 Diagrammatic illustration of differential head and NPSH



P_s	Pressure in supply vessel
h_s	Height of liquid level in supply vessel above/below pump centre in line (minimum)
w_s	Total head loss in suction line between supply vessel and pump
$H_s = P_s + h_s - w_s$	Total minimum suction head
P_r	Pressure in receiving vessel
h_r	Height of liquid level in receiving vessel above/below pump centre line (maximum)
w_r	Total head loss in discharge line between pump and receiving vessel
$H_r = P_r + h_r + w_r$	Total maximum discharge head
$H = H_r - H_s$	Differential head

H_s - product vapour pressure = Net Positive Suction Head (NPSH) at the pump inlet

Figure 2 Typical layout for a LPG metering station

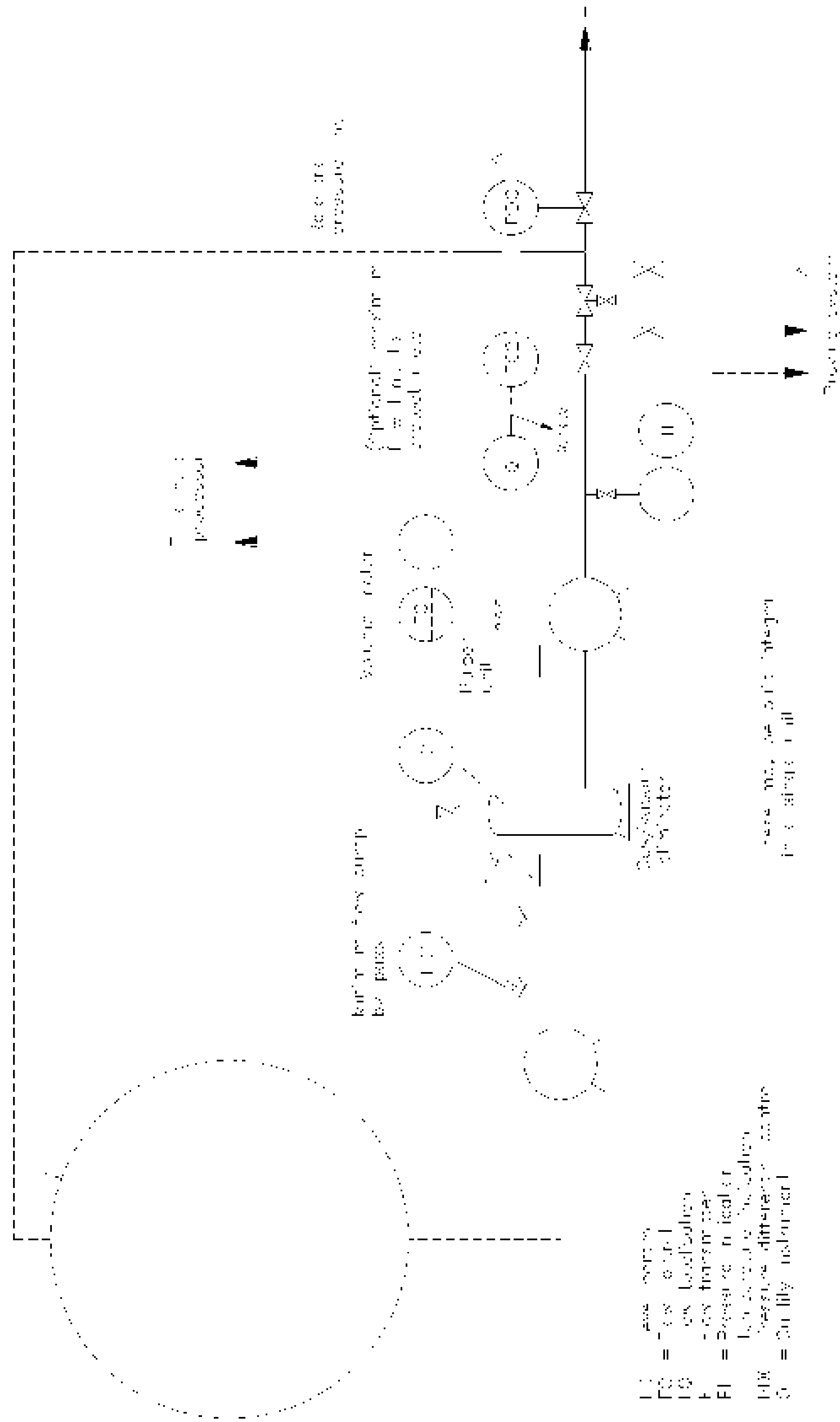


Figure 3 Details of odorant storage

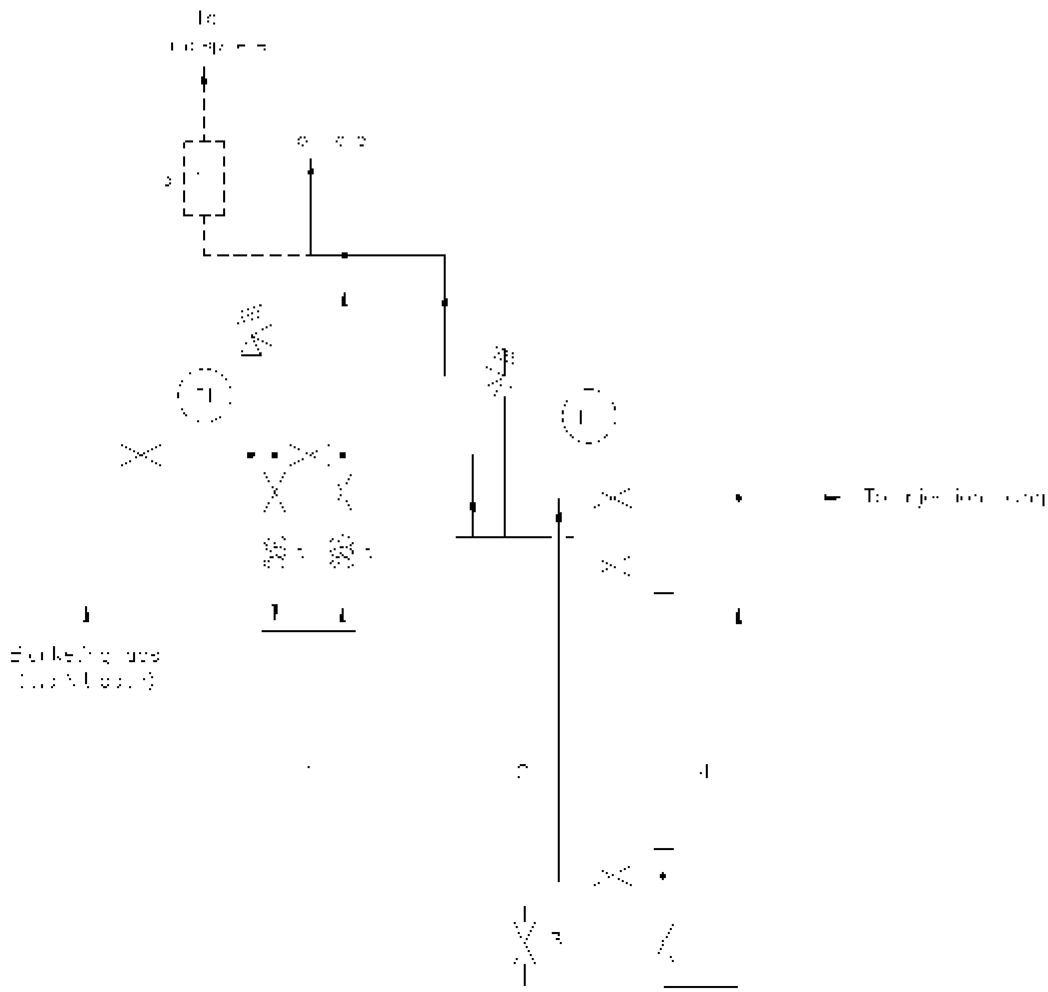


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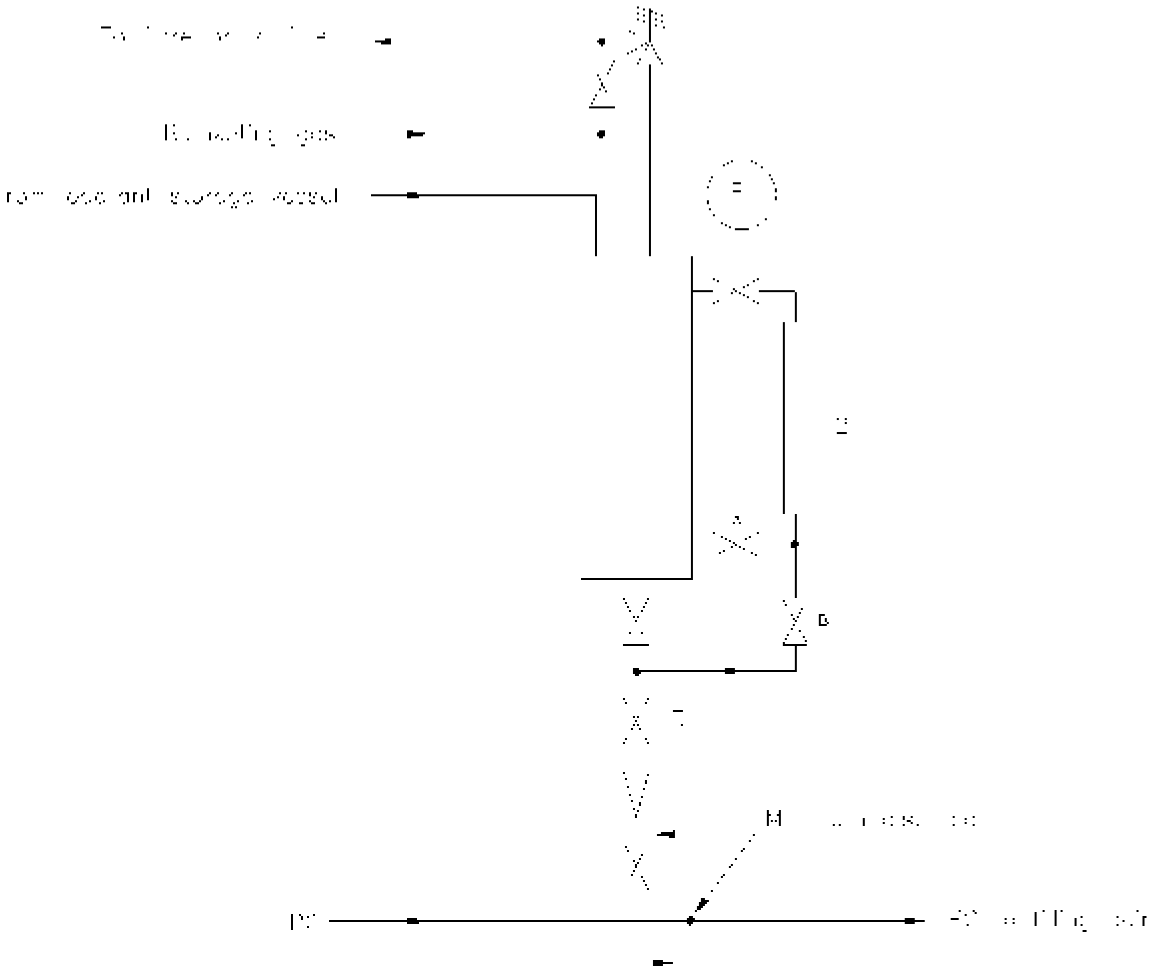
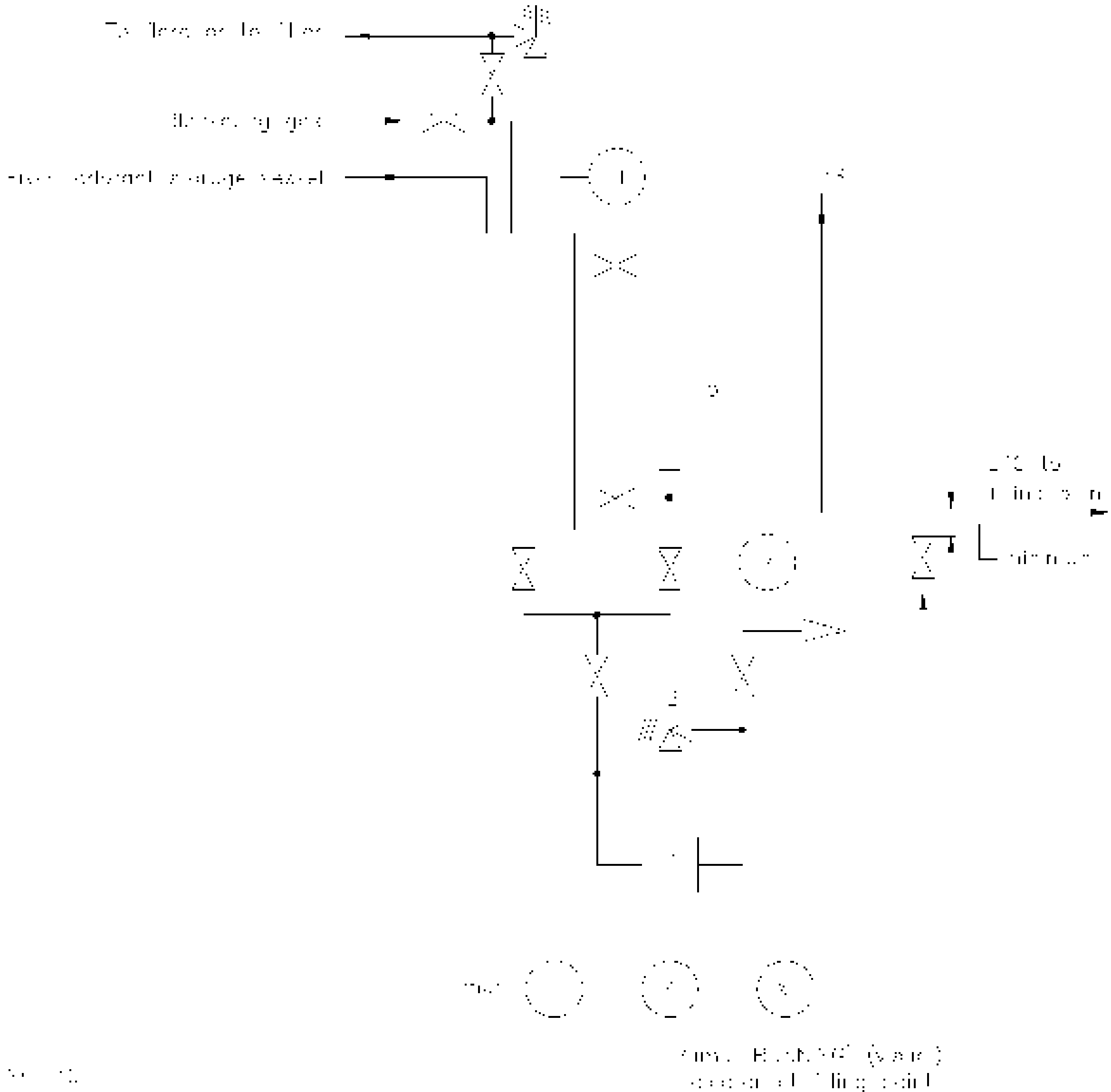
Figure 4 Pressure injection system



1. Odorant measuring vessel.
2. Calibrated sight glass (see note 4).
3. Needle valve.
4. To make a simple check on odorant flow rate, close valve 'A' and open valve 'B'

Figure 5 Metering pump injection system



[illegible]

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. Calibrated sight glass

Figure 6 Flow proportional injection system