PREVENTION OF CARBON DIOXIDE BACKFEED CONTAMINATION

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Table of Contents

Tables

Amendments from 68/08

Section	Change
	Editorial to align with EIGA Style Manual
3.1	Addition of definitions section
4.1	Additional examples added
4.3	Appendix C moved to new section
8	New paragraph added
10	Reference section added
Appendix C	Moved to 4.3

Note: Technical changes from the previous edition are underlined

1 Introduction

All deliveries of liquefied carbon dioxide potentially represent a risk for backfeed and contamination of the supplying tanker. The widespread use of a gas phase return connection when delivering carbon dioxide increases the probability of spreading that contamination to other customers.

This publication gives guidance on how to minimise the probability of contamination arising in customer's carbon dioxide storage tanks. By ensuring that customer's tanks remain free from contaminants, the hazard of contamination being spread throughout the supply chain are also controlled.

2 Scope and Purpose

2.1 Scope

This publication is concerned with preventing contamination that enters the carbon dioxide storage tank at the user's premises and subsequently contaminates the delivery tanker and depot storage tank.

2.2 Purpose

To provide recommendations that will protect against backfeeding of contaminants from the customer's process into the customer's storage tanks and consequently spreading to other customers via the delivery tanker.

3 Definitions

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

4 Examples of contamination

The following are examples of how contamination can arise in users' storage tanks that can also lead to contamination of the delivery tanker.

4.1 Contamination occurring at user's premises

Contamination can occur at the users' premises in the following circumstances:

- Recovered carbon dioxide from breweries or other processes where carbon dioxide is recovered;

- Build-up of contaminants due to distillation of liquid carbon dioxide in tank when a substantial proportion of product is withdrawn from the top of the tank as gas or following accidental depressurization;

- Oil contamination from customer's transfer pumps. These pumps are installed where the customer wants to avoid the noise of the tanker engine which powers the tanker mounted transfer pump;

- Flow into the storage tank of material from the degradation of the delivery hose lining. This usually occurs with rubber lined hoses, either by the lining breaking down or by liquid carbon dioxide dissolving plasticisers;

- Use of hoses whose connections are contaminated with oil, grit, mud or water. The correct application of procedures avoids this contamination;

- The backfeeding of any chemical contaminant into the storage tank from the customer's and /or carbon dioxide recycling processes/loops;

- The flow of contaminated carbon dioxide into the storage tank from filling returned cylinders without blowing down the returned gas when the overpressure protection relief device exhausts into the storage tank;

- Contamination due to the backflow of cleaning fluids from beverage processes;

- Contamination with residual water or foreign particles during inappropriate operations of user and/or truck trailer retesting; and

- Contamination through inappropriate food contact materials (design or maintenance operations).

4.2 Backflow into the delivery tanker in fault conditions

Backflow into the delivery vehicle can occur into the delivery tanker in the following fault conditions:

- Backflow of contaminated liquid stored in 80 bar tanks. Despite single hose filling, contamination can return due to the pressure gradient if pumping systems or procedures fail; or

- Backflow of contaminated gas due to use of a gas balance line to increase the speed of delivery where the driver's instruction requires the use a liquid hose only.

4.3 Distillation in storage containers

The methods of storage and use employed by gas users can affect the composition of carbon dioxide supplied to the point of use or in the liquid phase of the gas user's container.

When carbon dioxide is drawn from the vapour phase of a container there will be a single plate distillation effect. This will affect the concentration of impurities in the liquid phase dependent upon the relative volatility of the impurity concerned.

Where the volatility of the impurity is such that its concentration is increased in the liquid phase through distillation, the concentration of the impurity in the withdrawn gas phase will also rise and could eventually exceed the levels specified in the production and/ or delivery specification.

It is recommended that when vapour phase withdrawal from a container is used liquid carbon dioxide is withdrawn at intervals determined by appropriate testing, to restrict the impurities to within acceptable levels.

5 Method of protecting against contamination

The approach taken is that customers are required to advise their suppliers of the nature of their process of using carbon dioxide. Customers are also asked to notify suppliers of any subsequent changes to the process or installation. A model questionnaire is given in Section 9. Based on the information supplied, the gas supplier shall evaluate the probability of contamination and recommend that engineering modifications are made to the user's installation and, where required, to the method by which the tanker delivers into the tank.

No distinction is made between the different substances which can cause contamination because even air could be considered by some users as a contaminant. The emphasis of this guidance is therefore placed on maintaining the purity of the carbon dioxide at the level of the agreed delivery specification.

Guidance on determining the probability of contamination for various user processes is given in Section 5. Section 6 gives recommendations on the preventive measures which are necessary for each category of probability.

Where more than one carbon dioxide supplier fills a storage tank, the suppliers shall liaise to ensure that each is following the guidelines in this publication.

6 Risk definitions, categories and examples

The categories run from 0 to 4, with 4 representing the highest probability of carbon dioxide contamination. A further category X is also defined for one specific type of storage tank configuration.

6.1 Category 0

Category 0 includes processes in which the contact between the carbon dioxide and the product takes place at atmospheric pressure.

Examples of category 0 include:

- Food freezing and chilling;
- Processes using snow horns;
- In-transit refrigeration;
- Rubber deflashing;
- Meat tumbling;
- Food packaging with pure carbon dioxide; and
- Inerting.

6.2 Category 1

Category1 includes processes in which there is a continuous connection between the storage tank and the process, but a high forward pressure differential is maintained at all times, except during maintenance.

Examples of Category 1 include:

- Carbonation;
- ph control;
- inerting;

- heat treatment;
- foundries, for example sand hardening; and
- medical carbon dioxide baths.

6.3 Category 2

Category 2 are processes in which, under fault conditions, the pressure can become higher than the storage tank pressure.

Examples of category 2 include:

- processes using gas mixers e.g. modified atmosphere packaging of food;
- blow moulding; and
- aerosol propellant.

6.4 Category 3

Category 3 includes processes at a pressure which is higher than the storage tank pressure.

Examples of Category 3 include:

- cylinder filling (carbon dioxide and carbon dioxide mixtures);
- cylinder filling on top of returned gas;
- inerting under pressure;
- polystyrene extruders;
- blow mould cooling (air forming);
- nuclear reactor coolant systems; and
- foam and plastic expansion.

6.5 Category 4

Category 4 is where the storage tank is part of the customer's process. The installation is designed to allow gas or liquid from the process to flow back into the tank.

Examples of Category 4 include:

- breweries with carbon dioxide recovery systems;
- tobacco expansion;
- recirculating carbon dioxide lines;
- extraction processes; and
- atomization processes.

6.6 Category X

Category X is where contamination in the tank builds up over time due to evaporation of gas from the liquid in the storage tank leaving an increasing residue of impurities in the liquid phase.

Examples of Category X include all storage tanks in which a high proportion of gas is withdrawn from the top of the tank. Internal heaters are used.

NOTE - This source of contamination is not specific to any particular process and depends upon the configuration of the storage tank and gas supply system. The risk presented depends upon the nature of low level impurities present in the delivered product and on the proportion of gas consumed from the top outlet of the tank. This category has therefore not been included in the numerical series of probability categories.

7 Recommended preventive measures for each category

7.1 Preventive measures

The following table lists the minimum recommended measures. Alternative engineering solutions that give equivalent or better protection may be used.

Table 1 Preventative measures

Category	Preventive measure
0	None
1	Check valve with periodic testing of effectiveness
2	Shut-off valve operated automatically by pressure differential
3	Double block and vent valves operated automatically by pressure differential with manual reset Also consider single line filling system.
4	Separate storage tank and process vessel with single line transfer between them. This transfer line shall have appropriate backflow protection (eg, double block and vent).
X	Sample analysis of liquid at appropriate intervals

NOTE - Examples of the preventive measures are shown as simplified schematic drawings in Appendix B 2.

7.2 Recommended frequencies for inspection of preventive measures

The following are the recommended frequencies for the inspection of the preventative measures to prevent backfeeding.

Table 2 Recommended frequencies

Category	Recommended frequency
1 and 2	In accordance with company policy on planned maintenance visits to tank
3 and 4	Every twelve months
X	Dependant on the rate of consumption of carbon dioxide gas from the gas phase of the storage tank

8 Methods of delivery and procedures

Two basic methods of delivering liquid carbon dioxide into users' bulk storage tanks are described in Appendix A. These procedures are not definitive and may differ from company to company depending on their particular practices and from site to site depending on the installation details. Examples of storage tanks with two and single hose filling are shown in Appendix B 1 as simplified schematic drawings.

The first procedure is the one most widely used where two hoses are connected between the tanker and the storage tank. In addition to the liquid hose, a gas phase connecting hose is coupled between the tanker head space and the storage tank head space. This connection allows the gas displaced by the liquid delivered into the storage tank to flow into the tanker and hence balance the pressure of the two vessels.

The second uses only one hose to deliver liquid and alternative strategies may be used to deal with the displaced gas. Appendix A 2 describes the simplest implementation in which the surplus gas is vented to atmosphere (if necessary).

Appendix A does not give complete instructions to effect safe delivery. Reference should be made to the EIGA Doc 56 *Carbon dioxide Tanker Driver Manual*, [1][1] and the relevant company instructions. These instructions do, however, contain recommendations to minimise the probability of contamination.

It is an essential requirement that all storage tanks carry a notice showing whether the single or two hose delivery method is to be employed and listing any special checks that the driver has to carry out.

Single hose filling clearly reduces the probability of contamination in the storage tank flowing back into the tanker. That probability is further reduced when the liquid is delivered into the gas phase at the top of the tank.

However in many cases liquid carbon dioxide single hose transfer leads to pressure increase of customer tank and gas shall be vented. This venting operation shall not be done with tank safety valves and an appropriate gas venting system has to be installed to prevent hazard including secured driver ambiance.

9 Customer process questionnaire

The following list is considered the basic information required in order to categorise the probability and select the appropriate preventive measures

9.1 Tank ownership and site identification

9.1.1 Storage tank details

- normal working pressure;
- maximum working pressure;
- relief pressure;
- capacity;
- internal heater;
- refrigerated;
- two hose filling (gas and liquid connections);

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

- single hose filling through the gas phase;
- single hose filling into the liquid phase;
- Is carbon dioxide taken from tank as liquid?
- Is carbon dioxide taken as gas from top of tank? (reference category x and the build-up of contaminants by distillation.)
- If carbon dioxide is taken from both top and bottom of the tank, what proportion is taken as gas?

9.1.2 Fluid return lines

- Does gas or liquid enter tank under normal conditions, e.g. a recirculating liquid line?
- Does gas or liquid enter tank under fault/emergency conditions?

9.1.3 Liquid supply pipework details

- normal supply pressure
- maximum supply pressure
- relief pressure

9.1.4 Gas supply pipework details

- Normal supply pressure
- Maximum supply pressure
- Relief pressure

9.1.5 Application details

- What process will the carbon dioxide be used for? Food, Pharmacopeia or industrial grade?
- What product(s) will the carbon dioxide contact?
- At what pressure does the carbon dioxide contact the product(s) under normal conditions?
- What is the maximum pressure at which the carbon dioxide can contact the product under fault conditions?

9.1.6 Existing preventive equipment or measures

- What devices (if any) prevent backflow?
- If a check valves is fitted is there provision to test for effectiveness and to maintain it?

9.1.7 Other suppliers

- Do other suppliers fill the storage tank?

9.1.8 Hazard analysis and critical control points analysis (HACCP)

In the case of carbon dioxide used for food applications, individual HACCP analysis is required for each storage tank or installation involving multiple manifolded tanks feeding the same process

10 References

Unless otherwise specified the latest edition shall apply.

[1] EIGA Doc 56 *Carbon dioxide Tanker Driver Manual* www.eiga.eu

[2] EIGA Doc 136 *Selection of Personal Protective Equipment* www.eiga.eu

Appendix A: Procedures for Filling Storage Tanks

These procedures are not definitive and can differ from company to company depending on their particular practices and from site to site depending on the installation details. These are not complete instructions to effect safe delivery. Reference should be made to EIGA Doc 56 *Carbon dioxide tanker driver manual* [1] and the relevant company instructions. These instructions do, however, contain all the requirements to minimise the probability of backflow from the storage tank to the tanker.

A.1 Procedure for tanker driver using both liquid and gas connecting hoses

A.1.1 Report to the person on the customer's site who is responsible for the receipt of bulk carbon dioxide.

a) Obtain confirmation that it is safe to unload;

b) confirm quantity of carbon dioxide to be delivered; and

c) record tanker and storage tank contents and pressures.

A.1.2 Check that the installation appears to be in a safe condition and free from obvious defects.

a) Put on personal protective equipment, see EIGA Doc 136 *Selection of Personal Protective Equipment* [2];

b) Read the instructions on the tank to verify whether or not single line filling is required and undertake any special checks listed;

c) Check that the contents gauge (liquid level gauge or scale) indicates sufficient capacity available in the storage tank for the load to be delivered;

d) Check that the tank is below the maximum safe working pressure; and

d) Check that the storage tank pressure is at least P[2] barg or above;

- If below P barg report back to the gas company for instructions before making delivery; or
- If pressure is above P barg proceed with delivery.

A.1.3 Connect the gas balance and liquid hoses between the tanker and the storage tank and attach safety harnesses to each end of both hoses.

A.1.4 Open the gas valve on the storage tank slowly to check that the connections are gas tight.

A.1.5 Purge air from the gas balance line by opening the tanker gas line purge valve for a few seconds and then close it.

A.1.6 Slowly open the gas valve on the tanker to equalise the gas pressures. For flow meter systems the gas valve of the tanker will open automatically while the filling proceeds.

A.1.7 Slowly open the liquid valve on the storage tank, check the connections are tight.

[2] P is the pressure corresponding to the minimum design temperature of the tank. This is usually marked on the storage tank as a pressure, but may be shown as a minimum temperature.

A.1.8 Open the tanker liquid line purge valve slowly and purge air from the liquid hose and pipework. Close purge valve and slowly open tanker liquid valve. For flow meter systems the gas valve of the tanker may open automatically after the filling procedure has been started.

A.1.9 Start the pump and commence liquid transfer (for non-automatic systems).

A.1.10 When the required amount of liquid has been transferred:

a) Stop the pump or the automatic fill procedure;

b) Close liquid and gas valves on the tanker if they do not close automatically;

c) Close the gas valve on the storage tank;

d) Close liquid valve on storage tank after 3 minutes (so that part of the liquid can vaporise into the storage tank); and

e) Open tanker gas and liquid line purge valves slowly, to depressurise the hoses.

A.1.11 With the safety harnesses still in position, slacken off the connections at the storage tank end on the gas and liquid hoses to ensure that no pressure remains, then disconnect both hoses completely.

A.1.12 Report to the responsible person on the customer's site.

a) Obtain confirmation that the installation has been left in a safe and satisfactory condition;

b) Record the tank contents and pressure; and

c) Obtain a signature confirming that the load has been delivered.

A.2 Procedure for tanker driver using only a liquid connecting hose

A.2.1 Report to the person on the customer's site who is responsible for the receipt of bulk carbon dioxide.

a) Obtain confirmation that it is safe to unload;

b) confirm quantity of carbon dioxide to be delivered; and

c) record tanker and storage tank contents and pressures.

A.2.2 Check that the installation appears to be in a safe condition and free from obvious defects.

a) Put on personal protective equipment, see EIGA Doc 136 *Selection of Personal Protective Equipment* [2];

b) Read the instructions on the tank to verify that single line filling shall be used and undertake any special checks listed;

c) Tanks requiring any special variations to single liquid line fill operation should be subject to approved written procedures;

d) Check that the contents gauge (liquid level gauge, scale, etc.) indicates sufficient capacity available in the storage tank for the load to be delivered;

e) Check that the tank is below the maximum safe working pressure; and

f) Check that the storage tank pressure is at least P[3] barg or above;

- If below P barg report back to the gas company for instructions before making delivery; or
- If pressure is above P barg proceed with delivery.

A.2.3 Connect the liquid hose between the tanker and the storage tank. The connection is made to either the bottom (liquid phase) or top (gas phase) connection on the storage tank according to the written procedure of the gas company. Attach safety harnesses to each end of the hose.

A.2.4 Slowly open the liquid valve on the storage tank, check the connections are tight.

A.2.5 Open the tanker liquid line purge valve slowly and purge air from the liquid hose and pipework. Close purge valve and slowly open tanker liquid valve.

A.2.6 Start the pump and commence liquid transfer.

A.2.7 Continuously monitor pressure on storage tank - reduce pressure when necessary by venting from gas phase to ensure pressure is below the maximum safe working pressure of the storage tank.

A.2.8 When the required amount of liquid has been transferred:

a) Stop the pump;

b) Close liquid valves on the tanker;

c) Close liquid valve on storage tank after 3 minutes (so that part of the liquid can vaporise into the storage tank); and

d) Open liquid line purge valves slowly, to depressurise the hoses.

A.2.9 With the safety harnesses still in position, slacken off the connections at the storage tank end on the liquid hose to ensure that no pressure remains, then disconnect both hoses completely.

A.2.10 Report to the responsible person on the customer's site.

a) Obtain confirmation that the installation has been left in a safe and satisfactory condition;

b) Record the tank contents and pressure; and

c) Obtain a signature confirming that the load has been delivered.

[3] P is the pressure corresponding to the minimum design temperature of the tank. This is usually marked on the storage tank as a pressure, but may be shown as a minimum temperature.

Appendix B: Examples of Storage Installations and of Preventive Measures

All the drawings of storage tanks shown in this appendix are simplified. The tanks can be insulated either by a vacuum jacket or by conventional low temperature insulating materials such as polyurethane foam.

B.1 Examples of storage installations

Figure 1: Storage tank with two-line filling

Figure 2: Storage tank with one-line filling into liquid phase

Figure 3: Storage tank with one-line filling into gas phase

B.2 Examples of preventive measures

Figure 4: Storage tank with the customer's supply taken from the gas phase showing a check valve.

Figure 5: Storage tank with the customer's supply taken from the liquid phase showing a double block and vent.

Figure 6: Vacuum insulated storage tank.

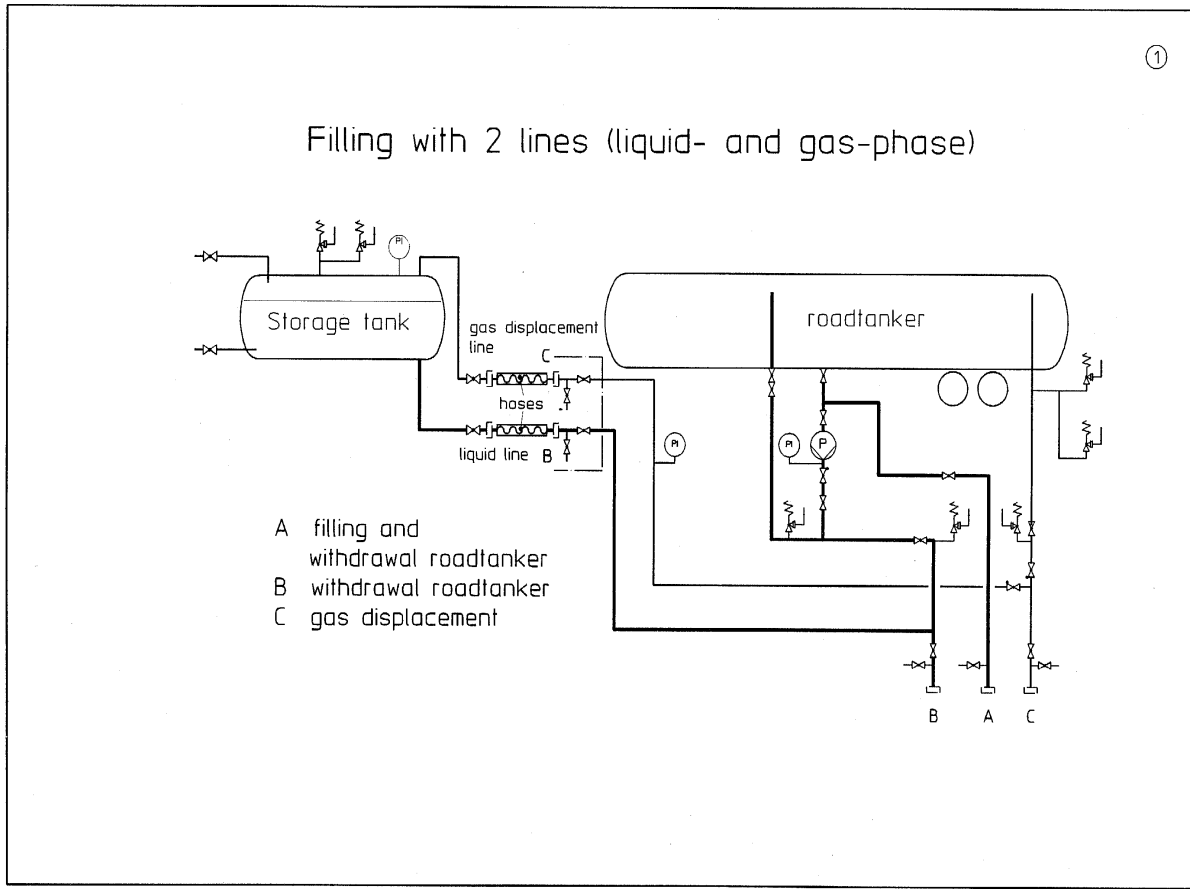


Figure 1 Storage tank with two line filling

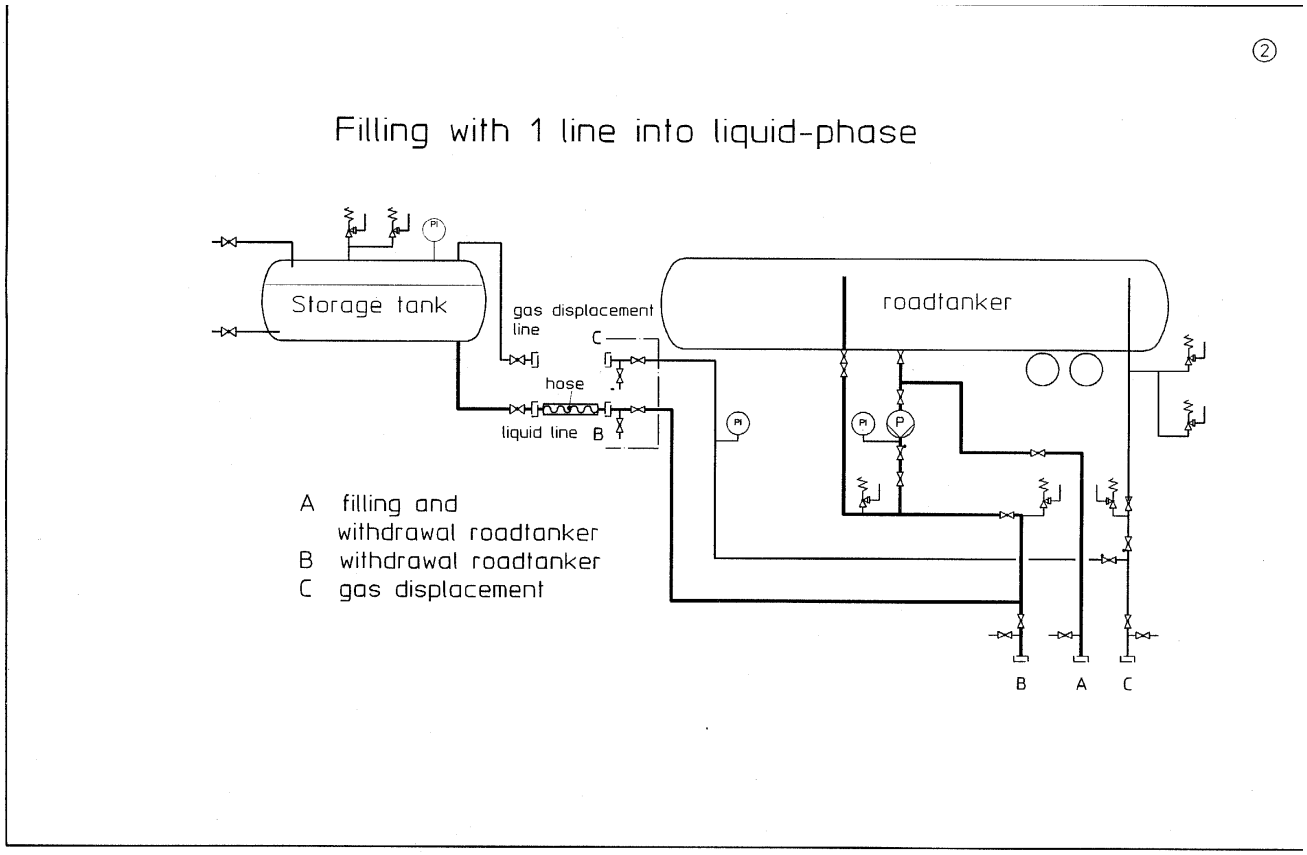


Figure 2 Storage tank with one line filling into liquid phase

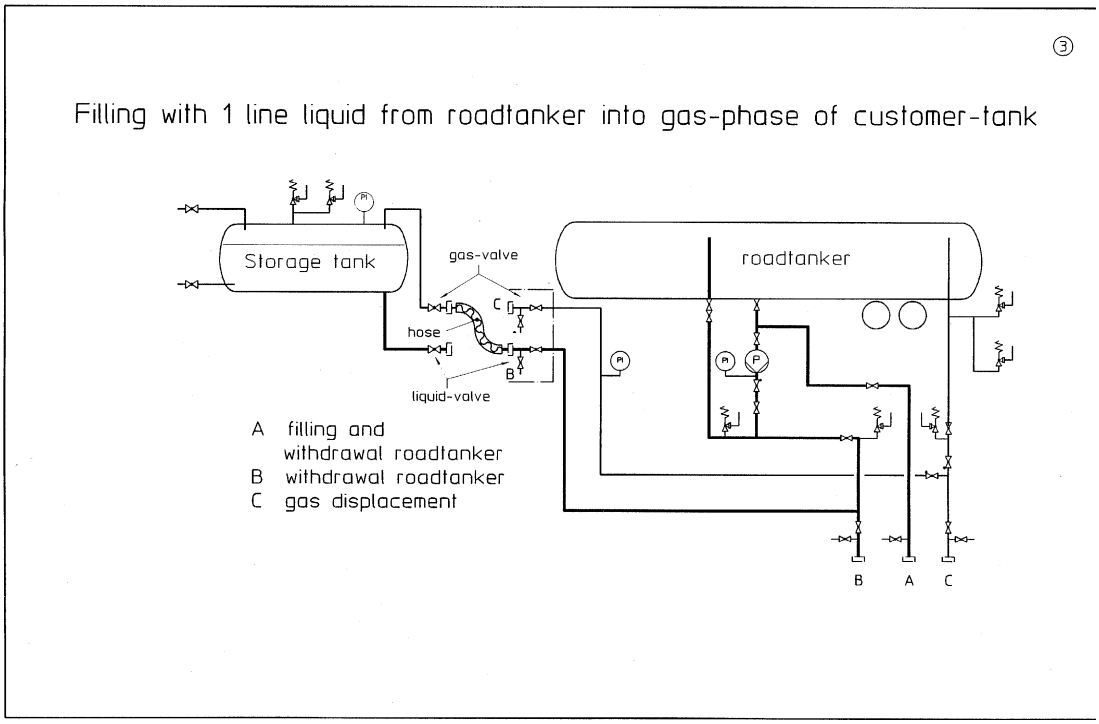


Figure 3 Storage tank with one line filling into the gas phase

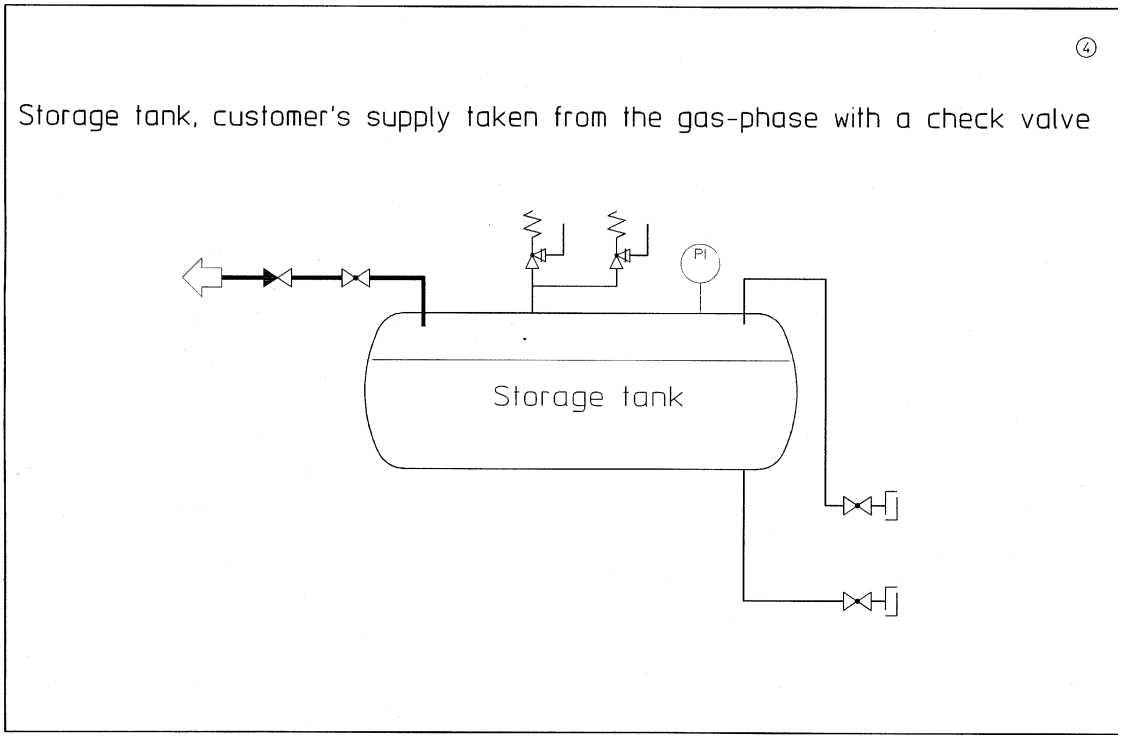


Figure 4 Storage tank with the customer's supply taken from the gas phase showing a check valve

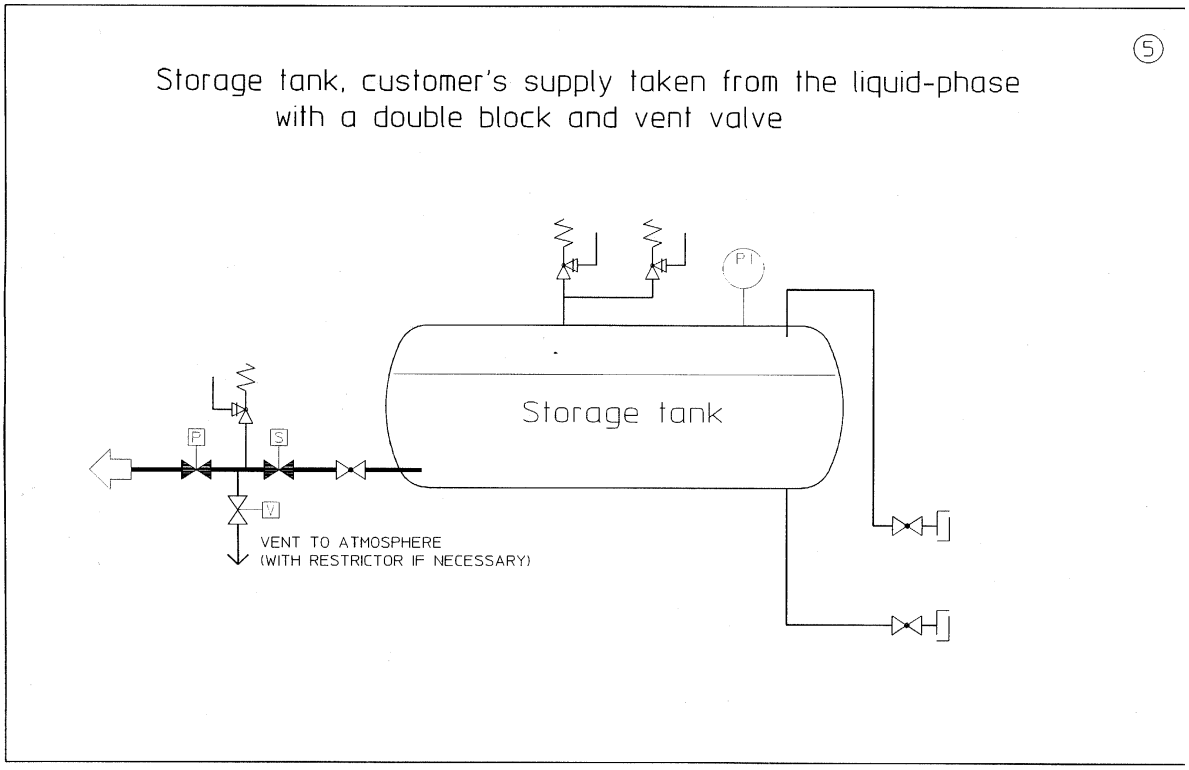
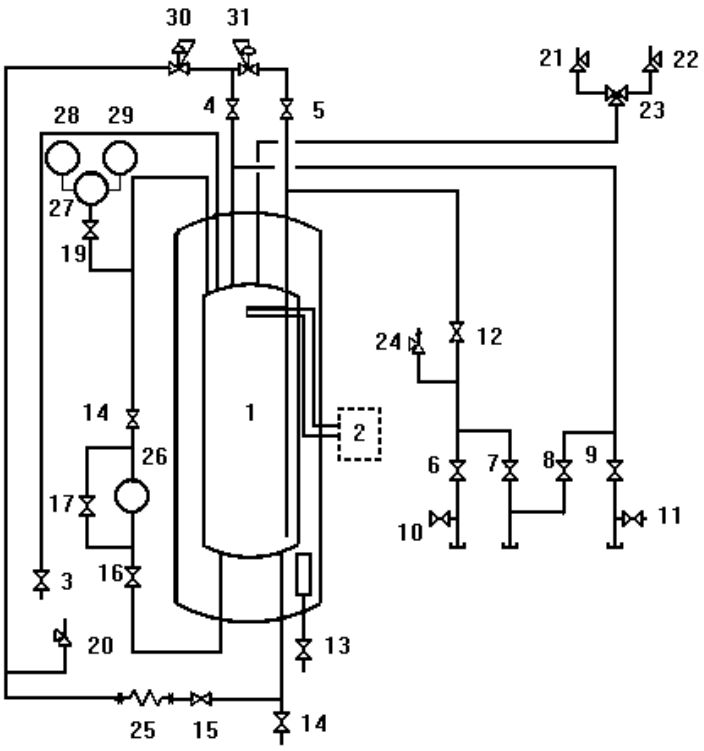


Figure 5 Storage tank with the customer's supply taken from the liquid phase showing a double block and vent.



1. Overflow shut-off valve
2. Pressure vessel
3. Refrigeration unit
4. Shut-off valve
5. Shut-off valve
6. Shut-off valve
7. Shut-off valve
8. Shut-off valve
9. Shut-off valve
10. Liquid vent valve
11. Gas vent valve
12. Shut-off valve
13. Vacuum probe valve
14. Liquid vent valve
15. Shut-off valve
16. Shut-off valve
17. Shut-off valve
18. Shut-off valve
19. Manometer shut-valve
20. Relief valve
21. Relief valve
22. Relief valve
23. Change-over valve
24. Relief valve
25. Pressure building coil
26. Level indicator
27. Pressure gauge
28. High pressure switch
29. Low pressure switch
30. Pressure building regulator
31. Pressure building regulator

Figure 6 Vacuum insulated storage tank