METHODS TO PREVENT THE PREMATURE ACTIVATION OF RELIEF DEVICES ON TRANSPORT TANKS

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Amendments from 184/18

Section	Change
4.1	Note: small changes
4.3.2	Small amendment
4.5.4	Last paragraph amended
App A	Minor changes

Note: Technical changes from the previous edition are underlined

1 Introduction

There have been a number of incidents during transport when the relief valves on tanks for refrigerated liquefied gases have operated. These events have led to delays in shipments and in some cases the involvement of competent authorities for transport. The operation of the relief devices is not a safety issue as they are designed to operate in the event of the pressure exceeding a set value in the tank.

Venting of product during transport can produce noise and a vapour cloud. If this occurs during a rail journey, it can lead to the train being stopped. The journey will only continue after the pressure in the tank has been lowered, usually when a representative of a gas company has attended and lowered the pressure. This results in a delay to the transport and to a possible fine for the shipper.

For UN portable tanks in a port area, the tank is usually moved to a safe area until the pressure can be lowered, once again with a delay in the transport and possible loss of product.

This is usually not an issue when the tank is accompanied, for example, during road transport as the pressure can be controlled by the driver. Thus, the main issue is during transport by rail or sea.

A number of competent authorities have asked EIGA to look at the situation with regard to actual holding times. In the transport regulations, there are two holding times referenced:

- ‘Reference holding time’; this is supplied by the manufacturer when the tank is new; and
- ‘Actual holding time’ which is the expected time within which the relief valves on the tank would not be expected to operate.

2 Scope and purpose

2.1 Scope

This publication applies to tanks for refrigerated liquefied gases (full tanks or empty tanks with residual refrigerated liquid) transported by rail and sea, portable tanks and tank containers transported by road, where the pressure of the tank cannot be controlled during the transport operation, that is, they are unaccompanied. Tank vehicles are excluded from this publication. However, the principle to lower the pressure prior to any form of transport of refrigerated liquefied gases, including empty tanks, would apply to prevent premature operation of the safety devices.

2.2 Purpose

This publication provides shippers with a simple check list that may be used to ascertain the condition of any tank prior to a transport operation commencing, to ensure the ‘actual holding time’ is achieved.

Furthermore, this publication gives guidance on how actual holding times can be determined.

3 Definitions

3.1 Publications 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 and need not

Indicate 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.

3.2 Technical definitions

3.2.1 Tank

In this publication, tank applies to tank wagons, portable tanks, tank containers and demountable tanks that are presented for carriage using a variety of modes of transport.

NOTE For regulatory definitions, refer to the appropriate transport regulations, RID, ADR and IMDG [1,2,3][1]

4 Holding times

4.1 General

For UN portable tanks, there is a requirement in the transport regulations to calculate the actual holding time for each journey and mark the tank accordingly. (RID/ADR text is in italics)

"4.2.3.7 Actual holding time

4.2.3.7.1 The actual holding time shall be calculated for each journey in accordance with a procedure recognized by the competent authority, on the basis of the following:

(a) The reference holding time for the refrigerated liquefied gas to be carried

(see 6.7.4.2.8.1) (as indicated on the plate referred to in 6.7.4.15.1);

(b) The actual filling density;

(c) The actual filling pressure;

(d) The lowest set pressure of the pressure limiting device(s)."

"4.2.3.7.2 The actual holding time shall be marked either on the portable tank itself or on a metal plate firmly secured to the portable tank, in accordance with 6.7.4.15.2."

For tank-containers and tanks (as defined in RID) there are similar provisions in ADR and RID since 2017. The following provisions come from RID and ADR. They apply to tank-containers transported by road and tanks transported by rail.

"4.3.3.5 The actual holding time shall be determined for each journey of a tank-container (RID: tank) *carrying a refrigerated liquefied gas on the basis of the following:*

(a) The reference holding time for the refrigerated liquefied gas to be carried (see 6.8.3.4.10) as indicated on the plate referred to in 6.8.3.5.4;

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

(b) The actual filling density;

(c) The actual filling pressure;

(d) The lowest set pressure of the pressure limiting device(s);

(e) The deterioration of the insulation[4].

NOTE: ISO 21014:2006 'Cryogenic vessels – Cryogenic insulation performance' details methods of determining the insulation performance of cryogenic vessels and provides a method of calculating the holding time.

The date at which the actual holding time ends shall be entered on the transport document (see 5.4.1.2.2. (d)).

Tank-containers (RID: tanks) *shall not be offered for carriage:*

(a) In an ullage condition liable to produce an unacceptable hydraulic force due to surge within the shell;

(b) When leaking;

(c) When damaged to such an extent that the integrity of the tank-container (RID: tank) *or its lifting or securing arrangements may be affected;*

(d) Unless the service equipment has been examined and found to be in good working order;

(e) Unless the actual holding time for the refrigerated liquefied gas being carried has been determined;

(f) Unless the duration of carriage, after taking into consideration any delays which might be encountered, does not exceed the actual holding time;

(g) Unless the pressure is steady and has been lowered to a level such that the actual holding time may be achieved[4].

[4] Guidance is provided in the European Industrial Gases Association (EIGA) document "Methods to prevent the premature activation of relief devices on tanks" available at www.eiga.eu."

To avoid disruption to any journey the actual holding time should always be greater than the anticipated journey time, no matter what mode of transport is used.

It is recognised that where there are delays in the journey the actual holding time could be exceeded, and consequently the relief valves could operate.

Having drawn on the experience of experts from within the industry what is important to achieve the maximum actual holding time for a tank is ensuring:

- that the tank is cooled down correctly prior to filling (if it is warm) and
- that the tank pressure is reduced as close to the time of travel as possible.
  NOTE: This applies to tanks that are considered to be full, whereas the ullage can vary depending on the type of product, but also to empty tanks that may have residual refrigerated liquefied gas in the tank after having been emptied.

To this end, EIGA has developed a check list, Appendix A, that may be used for any tank prior to shipping; companies may use their own procedures and check lists.

4.2 Standard used to calculate holding times

At the date of this publication there is no standard for calculating holding times of tanks according to the scope of this document in the transport regulations.

ISO 21014: *Cryogenic vessels — Cryogenic insulation performance* [4], provides a method to calculate equilibrium holding time for stationary vessels which can be used as guidance for calculating holding times for other tanks. For the calculation, various thermodynamic data is required for the fluid in the tank and also the value of the heat leak (Q) into the tank from the environment. The heat leak into the tank determines the holding time; the greater the heat leak into the tank the faster the pressure will rise within the tank and therefore the holding time will decrease. One of the main factors that influences the heat leak into the tank is the thermal performance of the insulation system used on the tank.

4.3 Tank insulation systems

There are two types of tanks that are used for the transport of Class 2 liquids, tanks that are foam insulated, typically used for the carriage of carbon dioxide, and tanks that are vacuum insulated which are used typically for argon, nitrogen and oxygen.

The only values for the thermal performance of the insulation system will be available from the tank manufacturer when the tank is new, to provide the reference holding time. To be able to provide an accurate calculation of the actual tank holding time any decrease in performance of the thermal insulation system over time shall be taken into consideration.

4.3.1 Foam insulation systems

Tanks that are foam insulated are typically used for the carriage of carbon dioxide. The actual performance of the insulation cannot be calculated precisely in service. If the foam breaks down or the vapour barrier is damaged the insulation performance will degrade at variable speeds, depending on the level of damage. Frost patches on the outside of the insulation and premature activation of the relief devices can be indications of deteriorated foam insulations.

If no data is available from experience then for foam insulated tanks a decrease in thermal performance of 3% per year may be used in calculations, starting from the date of tank manufacture. However, if the tank insulation has been refurbished then the efficiency of the insulation system can be returned to ‘as new’, from the date of refurbishment.

4.3.2 Vacuum insulation system

Cryogenic liquids that are carried in vacuum insulated tanks are typically at very low temperatures less than -150 °C. Due to these cold temperatures there is a large difference between the temperature of the liquid and the environment. A small amount of heat in leak will cause a rapid pressure rise in the tank pressure. Frost patches on the outside of the outer vessel and premature activation of the relief devices can be indications of defective vacuum insulations.

For vacuum insulated tanks the situation is different to that of foam insulated tanks as the performance of the vacuum can be measured in service (vacuum measurement) and reinstated if required, thus fully restoring the insulation performance. Furthermore, a vacuum reading/measurement is a requirement of the periodic inspection of vacuum insulated tanks.

As long as the vacuum is intact no deterioration of the insulation properties is expected.

4.3.3 Vacuum insulation system with a nitrogen shield

There is another type of insulation system used typically for refrigerated liquefied hydrogen and refrigerated liquefied helium, which consists of a vacuum insulation with a nitrogen shield system. The indications of a defective insulation are the same as for typical vacuum insulations, see 4.3.2. If the quality of vacuum is kept according to the manufacturers design no deterioration of the insulation is expected. It is however important that the nitrogen shield remains operational for as long as possible during transport. Nitrogen can be expected to vent during standard operation of the shield system.

4.4 Establishing thermal performance

For any tank the actual performance of the thermal insulation system may be gauged from experience of the tank in operating conditions. This can be achieved when the tank is fitted with telemetry, for example, allowing the pressure rise to be recorded over a period of time or when the tank is loaded in a known condition and the pressure rise can be monitored over a fixed period of time.

The issue with any calculation is that the thermal performance varies with a number of external factors, including:

- Condition of the foam and vapour barrier on the tank;
- Ambient temperature;
- If the tank is stationary or moving; and
- If the tank is parked in direct sunlight.

4.5 Factors that impact holding time

There are a number of influences that determine the actual holding time.

4.5.1 Environmental conditions

External environmental conditions include external air temperature and exposure to direct sunlight.

4.5.2 Tank condition

Condition of the tank:

- Is the insulation in good condition?
- Has the tank been cooled down correctly? and
- Has the tank been blown down, that is the pressure lowered prior to transport?

4.5.3 Properties and condition of the liquid/gas

Properties of the liquid/gas affect the holding time, for example the liquid heat capacity and latent heat. The holding time will depend on the initial equilibrium conditions of the liquid/gas. Venting the container before shipping will lower the equilibrium pressure, temperature and enthalpy of the liquid allowing the container to absorb more heat energy before reaching relief valve pressure.

The level of the liquid will also affect the holding time. If the tank is nearly full and therefore, the gas phase only has a small volume to fill, the pressure rises quickly as the liquid evaporates. When the tank is partly or almost completely empty, the tank warms up quicker due to a faster increase of enthalpy of the fluid. For filling levels between partially and nearly full, the pressure increase is lower. The filling level at which the pressure increase is lowest, depends on the type of gas and the design of the tank.

4.5.4 Tank journey

Issues concerning the transport include:

- How long is the tank held after it has been blown down prior to starting its journey;
- How long is the anticipated journey, and
- Were there any delays during the journey?

The consignee can only influence certain aspects of the process; the condition of the tank is fixed i.e. the state of the insulation, the condition of the liquid that is being filled, this will typically come from a plant, and will be at a fixed temperature and pressure. What can be influenced by the consignee is that the tank is cooled down correctly and the pressure is lowered prior to the journey commencing.

Lowering the tank pressure does not necessarily result in immediately lowering the temperature of the liquid as some time can be required to reach equilibrium between the gas and liquid phases if the liquid is not saturated. It could be that the pressure will need to be lowered a number of times to reach equilibrium and a stable pressure is reached.

In some cases, mixing of the liquid and the gas by moving the tank can decrease the time to reach equilibrium.

By filling the tank to less than its maximum capacity, it is possible to increase the holding time as there is a greater ullage space, see 4.5.3.

When a full tank has been ‘emptied’ and is being prepared for transport the only influence that the consignee can have is to lower the tank pressure as far as possible prior to the journey commencing. It is recommended to perform this task as closely as possible to the beginning of the journey. Furthermore, if possible, this should be done more than once if the tank remains stationary for a longer period prior to the journey.

5 Recommendations

ISO 21014 [4] should be recognised as a basis for calculating the actual holding time. However, it cannot be expected that a consignee does complex calculations to decide the actual holding time based on factors such as unknown tank insulation efficiency and product properties at filling.

Values used for the actual thermal performance of the insulation system should be obtained from either:

- Charts or calculations provided by the tank manufacturer or owner based on practical experience; or
- A practical holding time test, where the tank is filled with liquid and it is allowed to stand so the pressure rise can be recorded.

As stated in 4.3.1, where no actual values are given for the efficiency of the insulation system, a deterioration of the thermal performance of foam insulated tanks of 3% per year may be used. This deterioration rate should be re-assessed if the tank has been refurbished.

The shipper should ideally be provided with a simple graphical method by the tank owner which can be used to estimate the actual holding time, this may be in the form of a graph or chart.

During the journey, the tank may have the pressure lowered by qualified personnel to increase the holding time. Then, the actual holding time should be re-assessed and documented.

6 References

Unless otherwise stated, the latest edition shall apply

[1] Convention concerning International Carriage by Rail (COTIF) Appendix C – Regulations concerning the International Carriage of Dangerous Goods by Rail (RID) www.otif.org

[2] European Agreement Concerning the International Carriage of Dangerous Goods by Road, (ADR) www.unece.org

[3] International Maritime Dangerous Goods Code, (IMDG) www.imo.org

[4] ISO 21014: Cryogenic vessels — *Cryogenic insulation*, www.iso.org

Appendix A –
Example of a Tank Wagon/Portable Tank/Tank Container/Swap Body inspection sheet

Tank Wagon/Portable Tank/Tank Container inspection sheet

Departure Empty ☐ Full ☐ (1)

Place of departure: Date: ____/____/_______

Owner of tank: Tank no.:

Destination: Expected Journey time (days):

Product: Nitrogen, (UN 1977) ☐ Oxygen, (UN 1073) ☐
Argon, (UN 1951) ☐ Carbon dioxide, (UN 2187) ☐

Comments

Tank depressurized (2): Yes ☐ No ☐

Analysis OK (if necessary)? Yes ☐ No ☐

Lines vented (3): Yes ☐ No ☐

Valves closed: Yes ☐ No ☐

Coupling caps in place: Yes ☐ No ☐

Doors closed and sealed: Yes ☐ No ☐

Labelling correct: Yes ☐ No ☐

Visual inspection OK (4): Yes ☐ No ☐

Transport documents OK: Yes ☐ No ☐

Pressure at time of departure: bar (gauge)

Estimated actual holding time: days

If the condition of the tank is not satisfactory due to damage, too high a pressure, etc. the consignor shall be contacted and the issues resolved before transport.

Give a general description of faults below.

Additional Comments:

Name and signature of the inspector:

(1): Full refers to a tank after it has been filled at a filling site or one that has been partially discharged. Tanks that have been fully discharged are considered as empty for this inspection sheet.

(2): For empty nitrogen/oxygen/argon tanks: depressurize to below 0.5 bar
For full nitrogen/oxygen/argon tanks: depressurize to below 1 bar
For empty carbon dioxide tanks: depressurize to 11 bar
For full carbon dioxide tanks: depressurize to 15 bar
Note: The above values are for guidance only, and the actual values depend on the design of the particular tank.

(3): Only part of piping that can and should be vented after filling/discharging depending on the design of the tank.

(4): According to any additional company specific check list.

Tanks presented for carriage should comply with all the applicable transport regulations for the mode of transport and be at a pressure such that the actual holding time of the tank exceeds the expected travel time.
Tanks that have been delayed prior to transport may require to have the pressure reduced again prior to starting the journey.
It is important that 'warm' tanks are adequately cooled to avoid flash gas and the rapid build-up of pressure, the cool down of the tank should be to a recognised procedure.