# METHODS TO PREVENT THE ACTIVATION OF PRESSURE RELIEF DEVICES ON PORTABLE TANKS TRANSPORTED BY SEA AND RAIL

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# METHODS TO PREVENT THE ACTIVATION OF PRESSURE RELIEF DEVICES ON PORTABLE TANKS TRANSPORTED BY SEA AND RAIL

As part of a programme of harmonisation of industry standards, the Asia Industrial Gases Association (AIGA) has published AIGA 133, *Methods to Prevent the Activation of Pressure Relief Devices on Portable Tanks Transported by Sea and Rail,* jointly produced by members of the International Harmonization Council and originally published by European Industrial Gases Association (EIGA) as EIGA Doc 184, *Methods to Prevent the Activation of Pressure Relief Devices on Portable Tanks Transported by Sea and Rail*.

This publication is intended as an international harmonised publication for the worldwide use and application by all members of the International Harmonisation Council whose members include the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.


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## 1 Introduction

Refrigerated liquefied gases can be transported by the following types of equipment:

- UN portable tanks (also known as ISO containers) shipped by rail or sea without a qualified person present to monitor the tank pressure, level, and other operating parameters; and

- Transport semi-trailers and other tanks solely used for road transport accompanied by a driver who can monitor the tank pressure, level, and other operating parameters.

During transport, the pressure of the tank can rise to the set point of the tank's pressure relief devices (PRDs) and vent the contents of the tank, which can create noise and a large vapor cloud. For tanks that do not have a qualified person present to monitor the tank pressure, level, and other operating parameters, the rail and sea operators of the transport equipment typically offload the tank to a safe location suited for venting. Such action can lead to emergency responses by local personnel until a qualified person can arrive to resolve the problem with the tank. To avoid the need for emergency response, it is necessary to determine the holding time for a UN portable tank. The holding time is the amount of time the UN portable tank takes to reach the PRD set point after the tank has been filled. The shipper should plan for a journey that takes less time than the holding time.

NOTE—The operation of the PRDs is not a safety issue as they are designed to operate in the event of the pressure exceeding a set value in the tank. This operation ensures that the pressure in the tank remains less than the maximum allowable working pressure (MAWP).

Tanks used for road transport are accompanied by a driver who can monitor the tank pressure, level, and other operating parameters. On these units, the driver can control the transport tank pressure before it reaches the PRD set point.

## 2 Scope and purpose

### 2.1 Scope

This publication applies to tanks for refrigerated liquefied gases (full tanks or empty tanks with residual refrigerated liquefied gas) transported by sea and by rail (where required by regional regulations), where the pressure of the tank cannot be controlled during transport; that is, they are unaccompanied. Tank vehicles, portable tanks, and tank containers transported by road are not covered by this publication; however, the practices to lower the pressure prior to transport may be used to prevent operation of the PRDs during road transport.

### 2.2 Purpose

This publication provides a method to determine holding times. This publication also provides a checklist that can be used to assess the condition of the tank before shipment and a method to ensure that the holding time of the tank exceeds the duration of transit.

## 3 Definitions

### 3.1 Publications terminology

For purposes of this publication, the following definitions apply.

#### 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

Is 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 Holding time

Time that elapses from the establishment of the initial filling condition until the pressure has risen due to heat influx to the lowest set pressure of the PRD(s).

### 3.2.2 Tank

Tank wagons (also known as rail wagons), portable tanks, tank containers and demountable tanks that are presented for transport using a variety of modes of transport.

NOTE—Tank vehicles (trailers), rigid tanks, or other tanks only used for road transport are excluded from this publication.

NOTE—For regulatory definitions, refer to the appropriate international and country transport regulations. For example, *European Agreement Concerning the International Carriage of Dangerous Goods by Rail* (RID), *European Agreement Concerning the International Carriage of Dangerous Goods by Road* (ADR)*, International Maritime Dangerous Goods (IMDG) Code,* Title 49 of the U.S. *Code of Federal Regulations* (49 CFR), or Transport Canada's *Transportation of Dangerous Good Regulations (TDG Regulations)* [1, 2, 3, 4, 5]. [1]

# 4 Holding times

There are four different types of holding times:

- rated holding time (RHT);
- marked rated holding time (MRHT);
- reference holding time; and
- actual holding time.

For more information on RHT and MRHT including definitions, see 49 CFR Part 178.338-9 [4]. For more information on reference holding time and actual holding time including definitions, see UN *Recommendations on the Transport of Dangerous Goods—Model Regulations* (*UN Model Regulations)* [6].

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

### 4.1 General

For UN portable tanks, there is a requirement in the *UN Model Regulations* to calculate the actual holding time for each journey and mark the tank accordingly [6]. For more information, see 4.2.3.7 and 4.2.3.8 of the *UN Model Regulations*, 22nd edition [6].

NOTE – Per the 2025 version of ADR, calculation of the actual holding time and all other requirements associated with the actual holding time may be waived for road only transport in the states party to ADR. Also follow local country regulations in Asia where available and applicable.

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

When there are delays in the journey, the actual holding time can be exceeded and consequently the PRDs can operate.

It is important to achieve the maximum actual holding time for a tank by ensuring that the:

- tank is cooled down correctly prior to filling (if it is warm); and
- tank pressure is reduced at a time that is as close as possible to the time of transport.

  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, a check list is provided in Appendix A that may be used for any tank prior to transport. Companies may elect to 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 the holding time of portable tanks.

ISO 21014, *Cryogenic vessels — Cryogenic insulation performance* provides a method to calculate equilibrium holding time for stationary vessels, which can be used as guidance for calculating holding times for other tanks [7]. For the calculation, various thermodynamic data are required for the fluid in the tank and also the value of the heat leak 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 can rise within the tank and therefore, the holding time can 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 refrigerated liquefied gases:

- tanks that are foam insulated, typically used for carbon dioxide; and
- tanks that are vacuum insulated, typically used for argon, nitrogen and oxygen but can also be used for hydrogen, ethylene and natural gas.

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

#### 4.3.1 Foam insulation systems

Foam-insulated tanks are typically used for the transport of carbon dioxide and nitrous oxide. The actual performance of the insulation cannot be precisely calculated in service. If the foam breaks down or the

vapour barrier is damaged, the insulation performance can degrade at variable speeds, depending on the level of damage. Frost patches on the outside of the insulation and premature activation of the PRDs can be indications of deteriorated foam insulations.

If no data is available 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

Refrigerated liquefied gases that are transported in vacuum-insulated tanks are typically at very low temperatures less than –150 °C (–238 °F). Due to these cold temperatures, there is a large difference between the temperature of the refrigerated liquefied gas and the environment. A small amount of heat leak can cause a rapid pressure rise in the tank pressure. Frost patches on the outside of the outer vessel and premature activation of the PRDs can be indications of defective vacuum insulations.

Vacuum-insulated tanks are different from foam-insulated tanks as the performance of the vacuum can be measured in service (vacuum measurement) and refurbished if required, thus fully restoring the insulation performance.

If the tank vacuum system 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 typically used for refrigerated liquefied hydrogen and refrigerated liquefied helium that 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 maintained according to the manufacturer's design, no deterioration of the insulation is expected. If deterioration of the vacuum is detected, the vacuum should be refurbished. It is 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 can be determined from the tank 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 insulation (foam or vacuum) 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

Maintaining insulation in good condition, using proper cooldown of the tank prior to filling, and lowering the pressure before transport enables a longer holding time.

#### 4.5.3 Properties and condition of the refrigerated liquefied gas

Properties of the refrigerated liquefied gas such as liquid heat capacity and latent heat of vaporization affect the holding time. The holding time depends on the initial equilibrium conditions of the refrigerated liquefied gas. Venting the tank before transport lowers the equilibrium pressure, temperature and enthalpy of the refrigerated liquefied gas allowing the tank to absorb more heat energy before reaching the set pressure of the PRDs.

#### 4.5.4 Level of the refrigerated liquefied gas

The level of the refrigerated liquefied gas also affects the holding time. If the tank is nearly full and therefore, the gas phase is at the ullage point and has only 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 refrigerated liquefied gas. 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 refrigerated liquefied gas and the design of the tank.

#### 4.5.5 Tank journey

For the purpose of this publication, the tank journey starts after filling the tank and ends with delivering the refrigerated liquefied gases.

A longer journey or journey with delays can increase the likelihood of activation of PRDs. The tank should be depressurized at a time as close as possible to the beginning of transport. The tank may be depressurized multiple times throughout the journey, as required.

The shipper can only influence certain aspects of the process. Other aspects are out of the control of the shipper. The condition of the tank and its characteristics such as the state of its insulation are already established. The state of the refrigerated liquefied gas, which is typically transferred from the liquefaction process, is at an established temperature, pressure and state of saturation. However, the shipper may have the ability to lower the tank pressure to the optimum pressure before the tank is transported.

Lowering the tank pressure does not necessarily lower the temperature of the refrigerated liquefied gases. When the tank gas phase pressure is greater than the liquid phase saturation pressure, blowing down the tank pressure does not immediately cool the refrigerated liquefied gas. It is necessary to continue venting the gas phase until the gas phase pressure has dropped to the liquid phase saturation pressure. Continued venting allows the liquid phase to boil and reduce its temperature. Blowing down a tank by venting saturated liquid boil off takes longer than venting excess gas phase pressure.

In some cases, mixing of the liquid and gas phase of the refrigerated liquefied gas by moving the tank can decrease the time to reach equilibrium by allowing liquid to slosh in the tank and collapse the gas phase pressure.

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 4.5.4.

When a full tank has been emptied, it can still contain residual refrigerated liquefied gas. As it is being prepared for transport, the only influence that the shipper can have on the holding time is to lower the tank pressure as low as possible as close as possible prior to commencing transport. This procedure should be repeated if the tank remains stationary for a period of time before the tank is transported.

## 5 Recommendations

ISO 21014 is used as a basis for calculating holding times [4]. However, it cannot be expected that a shipper does these complex calculations to decide the actual holding time based on factors such as unknown tank insulation efficiency and refrigerated liquefied gas 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 operator based on practical experience; or
- A practical holding time test where the tank is filled with refrigerated liquefied gas and 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 (e.g., graph or chart) by the tank manufacturer or operator that can be used to estimate the actual holding time.

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

## 6 References

Unless otherwise stated, the latest edition shall apply

[1] *European Agreement Concerning the International Carriage of Dangerous Goods by Rail (RID)*, United Nations Economic Commission for Europe. www.unece.org

[2] *European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR),* United Nations Economic Commission for Europe. www.unece.org

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

[4] *U.S. Code of Federal Regulations*, Title 49 (Transportation), U.S. Government Printing Office. www.gpo.gov

[5] *Transportation of Dangerous Goods Regulations*, Transport Canada, Canadian Government Publishing. www.tc.gc.ca

[6] UN *Recommendation on the Transport of Dangerous Goods — Model Regulations*, United Nations Economic Commission for Europe. www.unece.org

[7] ISO 21014, *Cryogenic vessels — Cryogenic insulation*, International Organisation for Standardisation. www.iso.org

## Appendix A—Example of a transport tank inspection sheet (Informative)

**Tank wagon/portable tank/tank container inspection sheet**

**Departure** Empty ☐ Full ☐ [1]

Place of departure: Date: ____/____/_____

Operator/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 (psi)

Estimated actual holding time: _____days

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

Give a general description of faults under Additional Comments.

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 less than 0.5 bar (7.25 psi)
For full nitrogen/oxygen/argon tanks, depressurize to less than 1 bar (14.5 psi)
For empty carbon dioxide tanks. depressurize to 11 bar (159.54 psi)
For full carbon dioxide tanks, depressurize to 15 bar (217.55 psi)
NOTE—The previous 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 transport 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 transport time.**

**Tanks that have been delayed prior to transport may require to have the pressure reduced again prior to transport.**

**It is important that warm tanks are adequately cooled down prior to filling using a recognised procedure to avoid flash gas and the rapid build-up of pressure.**