International Standard

ISO 21009-2

Third edition
2024-09

# Cryogenic vessels — Static vacuum-insulated vessels —

## Part 2: Operational requirements

*Récipients cryogéniques — Récipients fixes isolés sous vide —*
*Partie 2: Exigences de fonctionnement*



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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 220, *Cryogenic vessels,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 268, *Cryogenic vessels and specific hydrogen technologies applications,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 21009-2:2015), which has been technically revised.

The main changes are as follows:

— updated definition of “authorized person”;

— updated requirements for protective clothing to prevent exposure to cryogenic fluids;

— added requirements for dealing with oxygen-enriched condensation;

— added requirements to use the results of a risk assessment for the design on underground installations;

— added requirements to use measures such as gas monitoring systems and ventilation to mitigate hazards for underground installations;

— added requirements to consider the risks associated with spill containment (diking) for outdoor installations if diking is needed;

— added requirements that controls for filling an indoor tank from an outdoor source shall be accessible to the operator and that vents shall be piped to a safe location;

— added requirements that automatic control devices shall fail to a safe operating mode upon the loss of power or pneumatic supply;

— added requirement to remove moisture as well as contaminants during a first fill;

— added option to use approved first fill procedure in place of manufacturer instructions;

— added requirements to ensure the fill process does not fill beyond a maximum level and pressure;

— added requirement to cap fill fittings to avoid moisture or contaminant entry to the tank;

— added separate recommended procedures for purging hydrogen tanks with helium and for other inert gases;

— updated safety distances for flammable cryogenic fluids.

A list of all parts in the ISO 21009 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Cryogenic vessels — Static vacuum-insulated vessels —

# Part 2: Operational requirements

## 1 Scope

This document specifies operational requirements for static vacuum insulated vessels designed for a maximum allowable pressure of more than 50 kPa (0,5 bar). It can also be used as a guideline for vessels designed for a maximum allowable pressure of less than 50 kPa (0,5 bar).

This document applies to vessels designed for cryogenic fluids specified in ISO 21009-1.

Static cryogenic vessels are often partly equipped by the manufacturer, but can be installed or re- installed by another party, such as the operator, user or owner.

NOTE 1 For the installation of these vessels, additional requirements can apply.

NOTE 2 Some requirements of this document can be covered by local regulations, e.g. safety distances, occupational safety and health.

NOTE 3 Additional requirements can apply to the operation of large scale and field-fabricated vessels.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 21009-1, *Cryogenic vessels — Static vacuum-insulated vessels — Part 1: Design, fabrication, inspection and tests*

ISO 23208, *Cryogenic vessels — Cleanliness for cryogenic service*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

**3.1**
**putting into service**
operation by which a *vessel* (3.7) is prepared to be used

Note 1 to entry: It applies to either a new vessel being used for the first time or an existing vessel being returned to service.

**3.2**
**filling**
operation by which a *vessel* (3.7) undergoes a prefill check, filling with a cryogenic fluid, and an after-fill check

**3.3**
**outdoor location**
location outside of any building or structure and not enclosed by more than two walls

**3.4**
**underground location**
area or room whose ground or floor is on all sides lower than the adjacent ground surfaces

**3.5**
**safety distance**
minimum distance separating a piece of equipment from its inherent hazard that will mitigate the effect of a likely foreseeable incident and prevent a minor incident escalating into a larger incident

Note 1 to entry: The safety distance also can provide protection from foreseeable external impact (e.g. roadway, flare) or activities outside the control of the operation (e.g. plant or customer station boundary).

**3.6**
**gas release**
escape of gas due to operating conditions, or to malfunctions that cannot be reasonably excluded

Note 1 to entry: Gas release for operating reasons can be produced, for example, on vent lines and pressure-release lines.

Note 2 to entry: Gas release due to malfunctions which cannot be excluded can occur, for example, in the case of overfilling, failure of fittings, loose connections, faulty operation, and leakages.

**3.7**
**vessel**
thermally insulated vessel intended for use with one or more cryogenic fluids in a stationary condition

[SOURCE: ISO 21009-1:2022, 3.17, modified — The term “static cryogenic vessel” was changed to “vessel”; the Note to entry was removed.]

**3.8**
**authorized person**
trained and qualified person approved or assigned by the applicable regulations to perform specific types of duties

## 4 Personnel training

Only authorized persons trained for the specific task shall be allowed to install, put into service, fill, handle, operate or maintain the vessel and its equipment.

The training programme shall include:

— normal operating procedures;

— product and hazard identification;

— safe operating limits;

— emergency procedures;

— physical and chemical properties of the vessel's contents and their effects on the human body;

— personnel protective equipment (e.g. safety boots, goggles, gloves);

— basic risk assessment methods and techniques;

— hazards of the cryogenic liquid stored in the vessel.

Training shall be repeated as necessary to ensure that authorized personnel remain competent. A training record shall be maintained which details the information authorized personnel have received.

# 5 General safety requirements

## 5.1 General

The following requirements shall be taken into account in operating instructions:

— Identification labels and plates shall not be removed or defaced.

— Appropriate warning signs regarding product and operational hazards and personnel protective equipment requirements shall be displayed.

— Parts under pressure shall be disconnected only if they have been previously depressurized.

— All surfaces which come in contact with the product shall be kept free from oil and grease. Cleaning shall be in accordance with ISO 23208.

— Leaking valves or connections should be depressurized before rectification. When this is not possible, leaking valves under pressure shall be tightened using suitable tools and procedures. Direct flame or intense heat shall never be used to raise the pressure or de-ice frozen components.

— Valve outlets shall be kept clean, dry and free from contaminants.

— Vessels and their accessories shall not be modified without proper authorization.

## 5.2 Safety considerations

In all operations and training, the following safety considerations shall be taken into account:

— Systems for oxygen service shall consider the compatibility of the materials.

— Small amounts of cryogenic fluids will produce large volumes of vaporized gas. Spillage of oxygen can result in an oxygen-enriched atmosphere; spillage of other cryogenic fluids can result in an oxygen-deficient atmosphere. Provision shall be made for appropriate measures for this, e.g. ventilation or usage of self-contained breathing apparatus.

— Due to the possibility of cold embrittlement, cryogenic fluids shall not come in contact with materials (metals or plastics) which are not suitable for lower bound of the design temperatures.

— Hydrogen embrittlement shall be considered for materials exposed to hydrogen.

— Because of their extremely low temperatures, cryogenic fluids will produce cold burns when coming in contact with the skin. Cold burns can also be produced from contact with uninsulated equipment and pipe. When using vessels, it is necessary to use protective means for exposed areas of the face and skin, as well as clothing which does not allow spilled cryogenic liquid to enter into the shoes.

— Oxygen enrichment due to liquefaction of ambient air can occur on the cold surfaces of equipment which contain fluids with a boiling point lower than that of oxygen, e.g. liquid helium or liquid hydrogen. Areas where this condensate can collect shall be considered for oxygen compatibility.

# 6 Installation

## 6.1 General requirements

The requirements in Clause 6 shall be taken into account in operating instructions.

Vessels shall be installed and operated in such a way that employees or third parties are not endangered. Necessary minimum safety distances shall be observed.

Vessels shall be installed so that the name plate is easily readable.

The installation should allow inspection of vessels on all sides. All vessel controls shall be capable of being operated safely.

Vessels shall be installed in such a way that their filling operation can be carried out safely and easily. Vessels shall be erected in such a way that no inadmissible misalignment or inclination can occur due to:

— the actual foundations;

— the inherent mass of the vessel including its contents;

— external forces, e.g. seismic loads, wind loads.

Gas from pressure-relief devices or vents shall be discharged to a safe place.

Appropriate warning signs regarding product hazards shall be displayed, e.g. in rooms, areas, or on vessels. The operating instructions shall also refer to the properties of the gas.

Vessels shall be installed in locations where there is sufficient ventilation such that the formation of dangerous explosive gas-air mixtures or an oxygen-deficient/oxygen-enriched atmosphere is avoided.

Underground location installations shall be considered on an individual basis after a suitable and sufficient risk assessment has been carried out by the end user. Appropriate measures, such as gas monitoring systems and ventilation, shall be specified. Where the underground location is in a building, the requirements of 6.3 shall apply.

Vessels shall be installed in such a way that adequate space is provided for maintenance and cleaning, as well as for emergency cases.

The space for maintenance and cleaning should be at least 0,6 m around the installation.

Vessels shall not be installed in corridors, passages or thoroughfares, generally accessible lobbies, stair-wells or near steps. Vessels should not be installed close to the aforementioned areas if traffic routes, escape routes or accessibility are limited.

Access by unauthorized persons should be prevented.

The area/foundation under vessels, as well as below detachable connections and fittings to the liquid phase of the vessel of oxidizing gases, shall be of non-combustible materials and free of oil, grease and other flammable contaminants.

Consideration shall also be given to the need for similar precautions for liquid-hydrogen or liquid-helium installations where significant air liquefaction can occur around uninsulated equipment.

To prevent a risk of brittle fracture, consideration should be given to the design temperature of the installation downstream of the installed or fitted vaporizing system and low temperature cut-off systems, if necessary.

It is possible that national regulations require that some duties concerning installations be performed under involvement of third party.

## 6.2 Outdoor installation

Vessels should be installed outdoors.

The drainage of surface water from the place of installation shall be ensured.

Spill containment areas inhibit the vaporization of spilled cryogenic fluids, which leads to longer time to clear the hazard. The risk of spill containment (diking) shall be considered.

On sloping sites, an installation (e.g. a wall) can be necessary to prevent gas from penetrating over the place of installation down into lower rooms, ducts, shafts or air intakes.

Vessels and their components shall be protected against mechanical damage, e.g. by vehicle buffer bars, enclosures, safety distances. The protection of vessel supports against leaking cryogenic fluid should be considered.

## 6.3 Indoor installation

If reasonable attempts to install the vessel outdoors fail, an indoor installation is permitted. Indoor installations shall conform to the following safety precautions.

— The entrance of rooms in which vessels are installed shall be labelled. Reference shall be made to the relevant hazards of the gas.

— Rooms shall:

  — have self-closing doors, where these do not lead directly outside;

  — consist of materials which are fire resistant or non-combustible, with the exception of windows and other closures of apertures in external walls;

  — be separated from other rooms and meet relevant fire resistance requirements;

  — be separated from rooms normally occupied by the public in a gas-tight manner and without any apertures;

  — have adequate ventilation – gas release from the fill indication valve shall be taken into account when assessing the ventilation requirements.

— Precautions/procedures shall be implemented to ensure that personnel entering or within the rooms are not exposed to hazardous atmospheres.

— Rooms containing vessels shall not be used in any other way which can be a danger to the vessels due to mechanical effects, fire or explosion.

— Indoor containment shall be filled from an outdoor source and the necessary controls shall be accessible to the fill operator. Necessary controls can include, but are not limited to, fill connections, hose drains, pressure gauges, liquid level gauges, valves and vents necessary to fill the vessel safely.

— The discharges of all vents, including pressure-relief devices, shall be piped to a safe outdoor location. All piping shall be compatible for the appropriate liquid and gaseous service and designed with no restrictions that affect the safe operation of the vessel.

— In rooms, there shall be no:

  — air intake openings for the ventilation of other rooms;

  — open ducts;

  — duct inlets unprotected against the ingress of gas;

  — open shafts;

  — openings to lower rooms.

## 6.4 Safety distances

The minimum safety distances are not intended to provide protection against catastrophic events or major releases, which should be addressed by other means to reduce either their frequency or consequences, or both, to an acceptable level.

Included in safety distances are:

— distance between the vessel and neighbouring installations, buildings or public roads, in order to protect the vessel from any damage, such as heating as a result of fire or mechanical damage;

— distance between the vessel and an object outside the installation which has to be protected from the effects of a gas release arising from normal operation.

These distances are measured from those points on a vessel from which, in the normal course of operation, a release of product can occur, e.g. vent point, fill connection, flanges and other mechanical joints.

The safety distance is the distance outside of which:

— in the case of flammable gases, danger through formation of an explosive atmosphere is eliminated, i.e. the lower explosive limit (LEL) is not exceeded;

— in the case of inert and oxidizing gases, danger from oxygen deficiency or enrichment is eliminated.

The safety distances may be reduced if a suitable and sufficient risk assessment is completed and documented by the owner/operator.

Recommended safety distances based on experience and calculation of minor release are given in Annex A.

# 7 Inspection

## 7.1 General

The requirements in Clause 7 shall be taken into account in operating instructions.

The tests and inspections shall be carried out by an authorized person. It is possible that national regulations require that some duties be performed under involvement of third party.

## 7.2 Inspection before putting into service

The inspection consists in:

— checking of markings and labelling;

— checking the completeness of the handover documents;

— checking the equipment;

— checking the installation.

## 7.3 Marking and labelling

Marking and labelling shall meet the requirements specified in ISO 21009-1.

## 7.4 Handover documents

In addition to the manufacturer's documentation, where necessary the vessel shall be accompanied by vessel-specific documents and instructions for all items supplied, covering:

— operations;

— auxiliary equipment;

— inspection records.

As appropriate, these documents shall be retained by the owner or user of the vessel.

The user shall have appropriate operating instructions available. Such instructions may be attached to the vessel in a permanent manner.

## 7.5 Equipment

Perform the following equipment checks, when related to safe operation of the vessel:

— Check devices against overpressure for availability, appropriate choice and setting, appropriate arrangement, safe venting location and, in so far as possible, for performance/correct operation.

— Check measuring devices for their availability and appropriate choice in respect of the suitability of the measuring range and, in so far as possible, for performance/correct operation.

— Check shut-off devices for availability, appropriate choice and arrangement in respect of pressure and temperature and, in so far as possible, for performance/correct operation.

— Check other fittings (e.g. fill couplings, gauges and controlling devices), in particular with regard to the medium to be supplied and vented and, where these are automatically driven or controlled, also their failure to a safe operating mode in the event of a power cut or loss of pneumatic supply. As a minimum, coupling types for oxidizing and non-oxidizing products should be different.

The vessel's connections shall be tested for leak-tightness before putting into service.

## 7.6 Periodic inspection

### 7.6.1 General

No external or internal degradation mechanism is reasonably foreseeable on the inner vessel because of the nature of cryogenic fluids, their temperatures, the metallic materials of construction used, and the fact that the inner vessel is inside an evacuated outer jacket.

Therefore, no in-service inspection of the inner vessel or the inside surface of the outer jacket is required.

NOTE Corrosion allowance on surfaces in contact with the operating fluid or exposed to the vacuum interspace between the inner vessel and the outer jacket as well as inspection openings is not provided in the inner vessel or on the outer jacket.

### 7.6.2 Inspections

The periodic inspection shall consist of:

— an external visual inspection of the vessel and equipment;

— functional check of valves;

— leak tests under operating conditions;

— assessment of any changes of the operational conditions of the installation and its surroundings;

— assessment of the vacuum between inner vessel and outer jacket.

Vacuum measurement should only be performed when the thermal performance is deficient as noted by vessel operation.

The tests shall be carried out by an authorized person.

The inspection intervals shall be determined and confirmed by the authorized person after considering local regulations, the operating conditions and the recommendations of the manufacturer, but should typically not exceed five years. The inspection shall be recorded.

## 7.7 Inspection of pressure-relief devices

### 7.7.1 General

The examinations and the inspection intervals shall be determined and confirmed by the authorized person after considering local regulations and operating conditions, taking into consideration the recommendations of the manufacturer. Recommended inspection intervals are given in Table 1.

**Table 1 — Examination/inspection intervals**

| Type of pressure-relief device | Putting into service | Yearly | 5 years | 10 years |
|---|---|---|---|---|
| Pilot-operated | 7.7.2 | 7.7.4 | — | — |
| Reclosable | 7.7.3 | — | 7.7.4 | 7.7.4 |
| Thermal reclosable | 7.7.2 | — | 7.7.3 | 7.7.4 |
| Non-reclosable | 7.7.2 | — | 7.7.3 | 7.7.5 |

Material properties, corrosion by the medium or from the outside, and possible plugging shall be considered. An alternative to the performance test of the pressure-relief devices is to replace them. The inspections shall be carried out by an authorized person.

Inspection intervals may exceed five years if system and equipment performance tests demonstrate proper functionality.

Where redundancy is provided, the inspection intervals may be extended in agreement with an authorized person.

### 7.7.2 Certificates and marking

The certificates and marking or manufacturer's declaration/data shall be examined by an authorized person for the following:

— conformity with drawings, specifications, type approval, as appropriate;

— identification, type approval/marking;

— suitability (fluids, size, temperature, pressure, setting).

### 7.7.3 Visual inspection

The visual inspection shall include a check of certificates and markings in accordance with 7.7.2.

Within the visual inspection, the following should be checked:

— general condition;

— installation/orientation;

— leak tightness;

— vent location;

— unobstructed discharge piping.

### 7.7.4 Performance test

The performance test shall include a visual inspection in accordance with 7.7.3. In addition, reclosable pressure-relief devices shall either be replaced or undergo a functional test (lift or set pressure test) either *in situ* or off the vessel.

The performance test may be made with the valve installed or on the test bench. The results of the tests shall be recorded and kept at least until the next inspection.

### 7.7.5 Changing bursting discs (inner vessel)

Non-reclosable pressure-relief devices, where fitted, shall be replaced according to the instructions of the pressure-relief device manufacturer.

## 8 Putting into service

The requirements in Clause 8 shall be taken into account in operating instructions.

This operation shall follow a written procedure and the results of the steps involved shall be recorded (e.g. in a check list). Such lists shall be retained by the operating company.

The vessel and accessories shall be checked in accordance with 7.2 and 7.5.

The vessel shall be purged with an appropriate gas until the gas emerging from the vessel is sufficiently dry and pure.

The vessel shall be cooled down according to the manufacturer's recommendations. Steps shall be taken to avoid uncontrolled pressure rise due to rapid liquid evaporation.

## 9 Filling

The requirements in Clause 9 shall be taken into account in operating instructions.

Prior to filling, the condition of the vessel shall be checked, especially the:

— data plate/product identification label;

— correct coupling for the product;

— condition of coupling and hose (not damaged, dirty, excessively iced).

An external visual inspection of the vessel and equipment shall be performed, to ensure that the vacuum between inner vessel and outer jacket remains intact (checking of abnormal frosting on tank surface; gas venting from a vacuum protection device; relief valves are continually venting). If the vessel has lost vacuum, the owner of the vessel shall immediately investigate the cause of the vacuum loss. Where a vacuum loss is believed to be associated with an internal pipe failure, for example vapour escaping from the vacuum relief device(s), then the vessel shall be made safe by immediately reducing the pressure to atmospheric and emptying all cryogenic liquid in a safe manner. The reduction of pressure is the most significant action to reduce the level of hazard.

NOTE For more information, in particular to differentiate between loss of vacuum and vacuum decay, see EIGA IGC doc 224/20[3] or CGA P-75:2023, Appendix E[2].

The fill hose should be purged. Depending on the type of vessel, it may be filled by volume or by mass to the level the vessel is designed for, taking into account product density. The necessary measuring equipment shall be in good working order and within the calibration period where required.

If there is no residual pressure in the vessel prior to filling, it should be purged to remove possible moisture or contaminants.

If the vessel is warm, it should be cooled down gradually according to manufacturer's recommendations or an approved first fill procedure. Carbon dioxide vessels shall be pressurized to at least 0,7 MPa (7 bar) with gaseous carbon dioxide before filling with liquid.

The purity of the residual product in the vessel shall be analysed and recorded where required by specification. Where the purity of the residual product is outside specification, the vessel should be purged until it meets specification.

After filling the vessel, mass or level of contents and pressure shall be checked and, if necessary, the vessel should be vented to reach the level required by specification.

If required by specification, the vessel contents shall be analysed and recorded.

It shall be checked that all filling valves are closed, that no cold spots have developed and that valves, piping and fittings are free from leaks.

If the vessel is filled by volume, the appropriate systems shall be used to ensure that the vessel is not exceeding a maximum filling ratio and maximum allowable working pressure as specified in ISO 21009-1.

After filling the vessel, the filling fittings shall be capped by appropriate protection caps to prevent the water or the contaminants entering.

## 10 Taking out of service

The requirements in Clause 10 shall be taken into account in operating instructions.

Taking out of service shall follow a written procedure and the results of the steps involved shall be recorded. If the vessel is intended for further service, such records shall be retained by the owner company.

The procedure shall include the following:

— emptying of the vessel and depressurizing to a positive pressure not greater than 0,2 MPa (2 bar);

— checking of the process by monitoring pressure and mass, if necessary verifying that no line is obstructed;

— giving due consideration to the properties of the product involved.

If the vessel is intended to be put into service again later, the following additional points shall be considered:

— the purging of the vessel and all piping and accessories with inert gas;

— if the vessel is to be transported or stored, protective caps should be fitted on all open connections;

— when in store, a slight positive pressure of dry inert gas shall be maintained in the vessel and the vessel shall be labelled accordingly.

If the vessel is to be scrapped, it shall be purged with inert gas and labelled accordingly.

EXAMPLE “Purged with Nitrogen – To be scrapped”

Product identification labels shall be removed and nameplates rendered unusable.

## 11 Maintenance and repair

The requirements in Clause 11 shall be taken into account in operating instructions.

Maintenance is required to ensure that equipment remains in a safe condition. The responsibility for the maintenance and repair shall be established between the contracting parties (e.g. owner, user, filler). Following maintenance, the vessel shall conform with the current approval documentation.

The issue of work permits shall be considered, e.g. for hot work, modifications, works on electrical equipment and confined space entry.

Before entering the inner vessel, all hazards related to confined spaces, e.g. oxygen enrichment/deficiency or flammability by hazards, shall have been considered and documented.

Maintenance generally comprises:

— checking the condition of the vessel, piping and accessories;

— checking the operability of valves;

— minor repairs, e.g. changing of seals;

— cleaning external surfaces.

Equipment shall not be taken out of service for repair until pressure has been released or until adequately isolated and depressurized.

Any leakage shall be rectified promptly and in a safe manner. Original spare parts should be used. If this is not possible, spare parts with the same characteristics (e.g. with the same set pressure, same sealing) shall be used.

Modifications in design, materials and equipment or repairs shall be approved by an authorized person, and vessel documentation shall be updated according to ISO 21009-1.

Hot work (e.g. welding, soldering, heat treatment and heating) shall be carried out according to the same procedures (e.g. fabrication, qualification of personnel, testing, certification) as during manufacture.

If at any time it is necessary to break the seal for adjustment of a pressure-relief valve, the valve shall be removed from service until it has been reset and sealed. Any adjustment necessary shall be made by the manufacturer or another company qualified by the manufacturer for the repair, adjustment and testing of such valves.

The organization making such adjustment shall attach a permanent tag with the setting, capacity and date to the pressure-relief valve.

Where repair or modification which could have affected the integrity of the vessel has been carried out, the vessel shall be inspected and tested in accordance with ISO 21009-1.

The test shall be carried out by an authorized person.

Vessels shall be internally clean, dry and free from particulate matter and contaminants; vessels for oxidizing fluids shall be free from oil and grease.

Vessels containing $CO_2$ shall be depressurized using a written procedure. Liquid-$CO_2$ vessels that have lost pressure shall be repressurized using a written procedure. The material properties of the vessel and applied stresses shall be considered.

NOTE For guidance, see IGC Doc. 164/20[4] or CGA G-6.7:2019[1].

## 12 Additional requirements for flammable gases

### 12.1 General

The requirements in Clause 12 shall be taken into account in operating instructions.

Vessels shall be installed and operated in such a way that employees or third parties are not endangered. Necessary safety distances shall be observed.

Precautions shall be taken when approaching a leak as the product can ignite and produce a flame. Products such as hydrogen require specific care as the flame is invisible.

Care shall be taken in the choice of personnel clothing, to protect as much as possible against static charges and flames. Electrically conductive footwear shall be worn.

When under pressure, leaking valves or connections shall only be tightened using suitable tools (e.g. non-sparking tools) and procedures.

### 12.2 Electrical equipment

All equipment used and installed within the boundary of the installation shall be in accordance with the requirements of the hazardous area classification.

All electrical component installation and grounding shall be inspected by an authorized person to ensure local regulations are satisfied.

In the classified areas, personnel shall not be permitted to carry sources of flames or non-approved electrical equipment. Consideration shall be given also to all electrical equipment, e.g. mobile phones, radio-transmitters.

## 12.3 Grounding (earthing) system

All parts of the installation shall be bonded to ensure electrical continuity.

Major items of equipment such as the tank and vent stack shall be bonded directly to the earth point and not rely upon the piping as a means to earth.

Consideration shall be given to the need for lightning protection.

NOTE National regulations can apply to earthing installations.

For transferring processes between several installations or between static vessels and transportable vessels, equalizing of the electrical potentials is necessary.

The electrical equalization shall be made in a non-flammable environment.

## 12.4 Installation

Vessels for flammable gases shall not be installed indoors unless permitted by national regulations.

Vessels for flammable gases shall have adequate distance between each other and any other vessels to allow access for fire-fighting.

In the case of cylindrical vessels, an adequate distance is half the diameter of the vessel, but at least 1 m.

The ground in the area of connections and fittings shall be such that escaping fluid cannot penetrate it, or collect in dangerous quantities.

Special layout of the ground is not required if the connections including the fittings on the liquid phase – with the exception of the process measuring and control lines – have no detachable connections.

All vent pipes, including pressure-relief devices and purging valves, shall be connected to a vent line (stack).

The vent line shall ensure a safe venting. It shall not issue at a point where a build-up of gas can be possible, for example under the eaves of buildings.

The collection of water, including condensate, in the vent line (stack) shall be prevented.

In explosion zones, there shall only be constructions and installations which serve for the operation of the vessels.

Works and service roads and tracks are included in such installations.

Only vehicles which serve the operation of the vessels shall travel on such traffic routes.

Vehicles with combustion engines or electrical equipment that is not explosion-proof shall not travel in explosion zones, unless a dangerous explosive atmosphere can reasonably be excluded.

The design of the vessel support structure shall take into consideration the possibility of fire impingement. Appropriate precautions shall be taken, e.g. installation design, thermal insulation, fire- fighting methods.

In the storage areas for flammable gases, there shall be systems for warning in case of fire or risk of explosion.

In the area of storage tanks for flammable gases with a capacity of more than 50 t, an easily visible wind direction indicator should be installed, e.g. a wind sock. If due to the nature of the installation a local wind

direction indicator is not practical, the wind direction may be indicated centrally at the appropriate point for the emergency service, e.g. the works fire brigade.

In installations where the storage capacity exceeds 50 t, which are not occupied by personnel during operation or are not regularly checked, automatic systems shall be in use for detecting and signalling fires or the risk of explosion, e.g. gas monitoring systems connected to a permanently manned position, e.g. control room.

In these areas, there shall be an emergency shut-down system, with easily accessible signalling to a permanently manned position. With the emergency shut-down systems, it shall be possible to block off the connecting pipes between vessels and other parts of the installation, so that no additional dangers arise. See ISO 21009-1:2022, Annex G for shut off valve requirements.

A non-return valve may be built in the filling line instead of the remote-controlled shut off valve.

### 12.5 Filling

Before starting the transfer, the earthing conductor shall be connected, the integrity of the grounding system shall be checked against obvious damage, and the filling hose(s) shall be purged free of air and impurities.

### 12.6 Maintenance, repair and taking out of service

Where maintenance and repair work requires the system to be inerted, as well as when taking out of service, a purging with inert gas shall be carried out until the concentration of flammable gas is below 10 % of the LEL.

Liquid hydrogen vessels should be purged with helium as the inert gas so that the vessel can be filled with liquid hydrogen without requiring additional purges.

Where the liquid hydrogen vessel has been purged with an inert gas other than helium, the inert gas shall be purged with warm hydrogen gas before being filled with liquid hydrogen.

## 13 Emergency equipment/procedures

Emergency procedures shall be prepared to cover fire or any other hazardous events, e.g. spills, which can occur. Emergency procedures should be prepared in conjunction with the emergency services and local conditions should be considered.

The procedure should consider:

— the properties of the cryogenic fluids;

— the quantities involved;

— the local topography;

— the design and equipment of the vessel.

The procedure should include:

— listing of emergency equipment required;

— nomination of back-up personnel/organizations for managing emergencies, and procedures for contacting them both during and outside working hours;

— immediate self-help actions required (e.g. shut down, sounding alarms, evacuation from the area, summoning help).

The procedures should be readily available to all personnel involved, regularly practiced, and checked periodically to ensure that they are up to date.