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GUIDELINES FOR TRANSPORT BY SEA OF MULTIPLE ELEMENT GAS CONTAINERS(MEGCS) AND PORTABLE TANKS FOR TRANSPORT OF GASES

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1. Introduction

This document provides guidance for the safe sea transport of portable tanks and multiple element gas containers (MEGCs) containing gases of Class 2 that are either compressed, liquefied or refrigerated.
The document addresses product characteristics, general safety aspects, preparation for shipment, stowage onboard ship, transport of containers and emergency response.
Normally during sea transport a skilled operator does not accompany these containers and this document has been written for the guidance of parties involved in their preparation and subsequent transportation by sea. Compliance with these guidelines will, under normal conditions, help ensure their safe transport.

2. Scope and Purpose

2.1 Scope

This guideline applies to the transport by sea of portable tanks and MEGCs that are used in the industrial, medical and specialty gases industry for the world wide transport of Class 2 gases.

2.2 Purpose

To provide guidelines for the safe transport of insulated and non-insulated portable tanks and MEGCs by sea, to reduce the potential for unintentional releases of the contents for the duration of a defined journey and to recommend actions in case of an accidental release.

3. Definitions

3.1 Compressed gas

In this document a gas which when packaged under pressure for transport is entirely gaseous at –50 °C, this category includes all gases with a critical temperature less than or equal to –50 °C.

3.2 Container

A container is designed for multimodal use and is fitted with devices permitting its ready stowage and handling particularly when being trans-loaded from one means of transport to another. A container is any portable tank or MEGC that meets the definition of a “container” within the terms of the International Convention for Safe Containers (CSC).

3.3 Liquefied gas

A gas which when packaged under pressure for transport is partially liquid at temperatures above –50 °C. A distinction is made between:

– high pressure liquefied gas, which is a gas with a critical temperature between –50 °C and 65 °C; and

– low pressure liquefied gas, which is a gas with a critical temperature above 65 °C.

3.4 Refrigerated liquefied gas

A gas which when packaged for transport is made partially liquid because of its low temperature.

3.5 Portable tank

A multimodal tank having a capacity of more than 450 L fitted with service equipment and structural equipment necessary for the transport of refrigerated and non refrigerated liquefied gases. The portable tank shall be capable of being filled and discharged without the removal of its structural equipment. It shall possess stabilizing members external to the shell, and shall be capable of being lifted when full. Road tank vehicles, rail tank-wagons, non-metallic tanks and intermediate bulk containers (IBCs) are not considered to fall within the definition for portable tanks.

3.6 Portable tank for refrigerated liquefied gases

A thermally insulated multimodal tank having a capacity of more than 450 L fitted with service equipment and structural equipment necessary for the transport of refrigerated liquefied gases.

This means a construction that normally consists of either:

- a jacket and one or more inner shells where the space between the shell(s) and the jacket is exhausted of air (vacuum insulation) and may incorporate a thermal insulation system; or

- a jacket and an inner shell with an intermediate layer of solid thermally insulating material (e.g., solid foam).

NOTE 1—The insulation in all systems is designed to reduce heat inleak so that the pressure will not normally rise to the set pressure of the inner vessel pressure release device (PRD) during the duration of transport.

NOTE 2—All types of tanks are fitted with pressure gauges, liquid level gauges and suitably sized PRDs. The gauges are usually located in a control cabinet together with valves, pipe-work and couplings used for filling and the emptying operations. The main tank PRDs or their outlets will, in most cases, be positioned at the top of the portable tank. Control cabinets may be positioned at the end or the side of the portable tank.

NOTE 3- For the transport of some products the filling ratio may be reduced to improve the holding time.

3.7 Multiple-element gas containers MEGCs

Multimodal assemblies of cylinders, tubes and bundles of cylinders which are interconnected by a manifold and which are assembled within a framework. The MEGC includes service equipment and structural equipment necessary for the transport of gases. MEGCs may be equipped with PRDs.

3.8 Pressure relief device (PRD)

Device designed to open at a specified value of pressure to prevent the internal pressure from rising above a specified value.
NOTE—It can be a pressure relief valve, a non reclosing PRD, or a non reclosing PRD in combination with a pressure relief valve. The term pressure relief is synonymous with the expression “safety relief” as used in various applicable regulations, codes, standards, or specifications.

3.9 Pressure relief valve (PRV)

Type of PRD designed to relieve excess pressure and to reclose and reseal to prevent further flow of fluid from the container after resealing pressure is achieved.
NOTE—It is characterized by a rapid opening pop action or by opening generally proportional to the increase in pressure over the opening pressure.

3.10 Cylinders

Cylinders are transportable pressure receptacles of a water capacity not exceeding 150 litres.

3.11 Tubes

Tubes are seamless transportable pressure receptacles of a water capacity exceeding 150 l but not more than 3000 l.

3.12 Bundles of cylinders

Bundles of cylinders means an assembly of cylinders that are fastened together and which are interconnected by a manifold and transported as a unit. The total water capacity shall not exceed 3000 l, except that bundles intended for the transport of gases of division 2.3 shall be limited to 1000 l water capacity

3.13 Holding time

Holding time means the time that will elapse from the establishment of the initial filling condition until the pressure has risen due to heat influx to the lowest set pressure of the pressure limiting device(s).

4. Product characteristics

In the case of any escape of product the following should be observed:

4.1 Volume of liquefied gases

When liquefied gases evaporate they will produce approximately 700 to 800 times its volume in gas.

4.2 Gas release

A gas release may go unnoticed because some gases that are transported may be odourless, colourless and/or non-corrosive. They may act as an asphyxiant in confined spaces. Care shall be taken in case of flammable or toxic gases – see section 9.
In free air gases will disperse readily. When refrigerated liquefied gases are released into the air, their low temperature usually causes water vapour in the air to condense forming a "fog".

4.3 Liquid spillage

Severe cold burns to personnel or cracking of certain materials particularly carbon steel; e.g. ships deck plates, can be caused by liquid spillage or improperly controlled venting.

5. General safety aspects

5.1 Personal protection

If there is a requirement to operate the container during transit protective clothing must be worn, as a minimum:

- eye protection
- thick gloves
- appropriate working suit e.g. synthetic materials are not recommended

5.2 Emergency response information

Relevant written information concerning the product should be made available to the shipping line. As a minimum, this should include a contact address/telephone number for technical assistance and any other information required by the mode of transport. The IMDG code contains the EmS section which details the emergency response procedures for ships carrying dangerous goods.

5.3 Operating instructions

Each container should have a flow sheet permanently displayed adjacent to the operating valves. This should clearly identify the designation and function of each valve and include specific operating instructions. It may be appropriate to supply some simple written emergency operating instructions.

6. Preparation for shipment

The consignor should provide a written document (checklist) indicating the conditions that should normally apply during transportation. An example of a typical document for a portable tank is shown in Appendix A.
When preparing a checklist consideration should be given to the type of container design and product e.g. nitrogen shield, fire abatement systems etc.
The consignor and/or operator should complete the pre-trip section of the checklist. This checklist should accompany the container throughout its journey. It is also necessary to carry out the following operations/ checks.
Shore based personnel engaged in the transport of dangerous goods by sea should receive training commensurate with their responsibilities.

6.1 Periodic tests

To ensure that the container is approved for the required mode of transport and that the approval period will not have expired before the anticipated completion of the journey.

6.2 Placarding

Ensure that placarding is in compliance with the relevant marking and labelling requirements.

6.3 Marking/data plates

Every portable tank and MEGC shall be fitted with a corrosion resistant metal data plate attached to the container in a conspicuous place readily accessible for inspection. Data plate marking shall be in compliance with the relevant regulations and shall include the date and type of the most recent periodic test, the last CSC test, and the due date of the next CSC test. The MEGC will also have tube or cylinder retest information on the data plate.

6.4 Emergency contacts

An emergency telephone number shall be clearly displayed on the portable tank or MEGC and shall also be available on the ship.

6.5 Leak test

To ensure that after filling all valves (except pressure gauge and level gauge Isolation valves) are securely closed and that blanking caps or secondary closures are fitted to all fill/discharge couplings with the exception of all PRDs.

Particular attention should be paid to internal leakage across valves, e.g. vaporiser supply valve, by checking for frost formation.

6.6 Working pressure

To ensure that the pressure of the contents of the portable tank is reduced to a level such that the anticipated pressure rise for the duration of the trip will not exceed the set pressure of the vessel PRDs. The actual holding shall be calculated for the journey based on the actual values of the density and the pressure and marked on the portable tank. An example of a calculation to determine the holding time is given in Appendix B.

Note 1: If the actual holding time is shorter than the expected duration of the journey the container must not be transported and the gases industry or their designated operators must be contacted.

Note 2: Where venting of product is required this should be carried out in a safe area, well ventilated and in a controlled manner under the supervision of a trained operator.

6.7 Insulation shields

Where a nitrogen shield is fitted the liquid nitrogen level is adequate for the planned trip and the liquid nitrogen pressure is within specified limits as detailed in the checklist.

6.8 Visual checks

To ensure that the container is inspected for in transit damage with particular attention to:

- structural damage to the frame and support members
- damage which could lead to loss of vacuum.
- damage to twistlocks or corner castings and/or tie down points.
- damage to cabinet which could prevent opening of doors or operation of control components
- damage to control valves, pipework, vaporisers, etc. which could lead to product spillage
- damage, loss or illegibility of data plate

7. Stowage on board ship

It is appreciated that the International Maritime Dangerous Goods Code, (IMDG code) will specify certain requirements that have to be met; however, some advice from the owner or agent should be given to reinforce IMDG obligations or aspects which are not obvious. The following is an example and not a complete list of advice that could be given to the shipping company concerning stowage:

- In a well ventilated area on deck
- At a level such that instruments can be viewed.
- With lashing arranged such that cabinet doors can be opened in an emergency.
- Such that vents do not terminate near human occupied spaces or structural parts of a ship or near other cargo which may be affected by any release and
- Portable tanks containing refrigerated liquefied gases shall be stowed “on deck”. This precaution is to prevent the possibility of asphyxiation due to a release of contents within a confined space (below deck).

8. Transport of empty containers or containers with residual product

Containers with residual product are not considered empty and shall meet the same rules for transport unless specific agreements exist with the relevant competent authorities. For shipping purposes a container is only considered empty if it has been completely purged of any hazardous product and it is below 200 kPa at 20 °C under the condition that this only applies to gases of class 2.2 other than refrigerated liquefied gases, and meets any applicable regulatory requirements for an empty container.

9. What to do in the case of release of product

9.1 Release of gas

Initially, the leaking gas should be identified. The potential hazards can then be established from the appropriate hazard communication information (e.g., EmS, Properties and Observations TREM card portable tank marking, shipping document etc). If the name of the gas cannot be readily identified by the person at the scene, it is recommended that the container is observed from a safe distance for other possible identifying marks or labels.
Persons not wearing positive pressure breathing apparatus and other personal protective equipment should not approach the leaking container unless the content of the container is known and necessary precautions are taken. If it is not possible to identify the leaking gas, (e.g., smoke, vapour cloud) then it is recommended that it should be assumed to be toxic and flammable.

The severity of the leak should be established e.g. whether the leak is audible, if it is fuming and if so, how much.
All gases except air and oxygen and especially liquefied gases represent a potential asphyxiation hazard if leaking into a confined or poorly ventilated area, (see AIGA 008/04).
Oxygen enrichment of the atmosphere may cause fire because most materials burn fiercely in oxygen. As the oxygen concentration in air increases the potential fire risk increases. Areas where there is a risk of oxygen enrichment of the atmosphere shall be well ventilated (see also AIGA 005/10).
If the leaking gas is toxic, then people should be kept away, preferably up-wind. The toxic gas leak should not be approached by unprotected people.
If the leaking gas is flammable, then efforts should be made to ensure the area remains well ventilated and to eliminate ignition sources from the vicinity.

In addition to the above items, a Multimodal Dangerous Goods Form should list emergency schedules contained in the IMDG Code supplement (e.g., fire and spillage schedules).

9.2 Release of vapour from portable tanks containing refrigerated liquefied gases

PRDs on portable tank are sized for adequate pressure release even under fire engulfment conditions. Thus they are suitably sized for any other increase in heat inleak, e.g. pressure increase caused by loss of vacuum.
Whilst the operation of PRDs is accompanied by a lot of noise it does not necessarily indicate an emergency situation.
Controlled venting of gas via the vent system can stop operation of the PRDs. Only trained personnel should perform this procedure. Without manual venting intermittent operation of the PRDs can be expected.

Secondary hazards of vapour release should also be considered (e.g. asphyxiation or oxygen enrichment in the case of a confined space). Portable tanks containing refrigerated liquefied gases shall be stowed “on deck”. This precaution is to prevent the possibility of asphyxiation due to a release of contents within a confined space (below deck).

Precautions must be taken to prevent cold vapour releases from impinging on the container, the ISO frame, or structural members of the ship because this can lead to material embrittlement and failure in certain conditions.

9.3 Release of refrigerated liquid

Avoid contact with the skin – this will cause cold burns; see also section 5.

Low temperatures of steel structures can cause embrittlement and subsequent cracking.
The primary objective is to avoid embrittlement of important steel structures either by diversion of cold liquid flow or by maintaining the temperature of the steel, e.g. applying copious quantities of water.

10. Security

Security is an integral part of the compressed gas industry culture. Safety and security measures protect facilities, employees, and the community by reducing the risk of a wide range of vulnerabilities and mitigating the effects of incidents such as vandalism, sabotage, workplace violence, theft/misuse of product, and terrorism.
The potential theft and diversion of compressed gases is an ongoing concern. Compressed gases have been obtained for illegal drug use, for the manufacture of illegal drugs, and for potential terrorist activities. Compressed gas containers should be properly secured to prevent theft for illegal activity.
Security incidents such as successful or attempted theft or diversion (misuse of package or product) of product or equipment should be immediately reported to local management and, if warranted, to local law enforcement authorities.

11. References

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Appendix A: Example of a Checklist

TRANSPORT OF VACUUM INSULATED TANK CONTAINERS BY SEA

Nitrogen shield tank container check list

Portable Tank Number:		Contents:	
Route from:		To:	
Estimated Duration in days:			

If any action is required, consult the product supply company or their operator.
Normal condition column and responsibility box must be filled in in prior to departure from the filling location

		NORMAL CONDITION		ACTUAL CONDITION	
1.	**Product Filling**	Date:	Responsibility:	Executed by:	
1.1	Check vessel arrival pressure	bar g		bar g	
1.2	Check container condition and any damage	OK		OK	Not OK
1.3	Weight of product	kg		kg	
1.4	Check vessel pressure	bar g		bar g	
1.5	Check Nitrogen shield pressure	bar g		bar g	
1.6	Check product contents level				
1.7	Check Nitrogen shield contents level				
1.8	Set any "intransit" valves	open / closed		open / closed	
1.9	Check blanks fitted, required valves and cabinet door closed	OK		OK	Not OK
2	**Shipboard Loading**	Date:	Responsibility:	Executed by:	
2.1	Check vessel pressure	bar g		bar g	
2.2	Check Nitrogen shield pressure	bar g		bar g	
2.3	Check valves for leakage and cabinet door closed	OK		OK	Not OK
2.4	Check Nitrogen shield contents level				
3	**Landing**	Date:	Responsibility:	Executed by:	
3.1	Check vessel pressure on arrival	bar g		bar g	
3.2	Check Nitrogen shield pressure	bar g		bar g	
3.3	Check Nitrogen shield contents level				
3.4	Check valves for leakage and cabinet door closed	OK		OK	Not OK
4	**Onward Journey**	Date:	Responsibility:	Executed by:	
4.1	Check vessel pressure on arrival	bar g		bar g	
4.2	Check Nitrogen shield pressure	bar g		bar g	
4.3	Check Nitrogen shield contents level				
4.4	Check valves for leakage and cabinet door closed	OK		OK	Not OK
5	**Product Offloading**	Date:	Responsibility:	Executed by:	
5.1	Check satisfactory operation	OK		OK	Not OK
5.2	Check produt contents level				
5.3	Check Nitrogen shield contents level				
5.4	Blow down if required and check vessel pressure	bar g		bar g	
5.5	Set any "intransit" valves	open / closed		open / closed	
5.6	Check blanks fitted, required valves and cabinet door closed	OK		OK	Not OK

Appendix B: Example to determine the actual holding time of a vacuum insulated tank container

The following data has to be available to determine the actual holding time:

- Water capacity (V) of the tank in litres – from the tank plate
- Maximum allowable working pressure (MAWP) of the tank in bar (which is equal to the set pressure of the pressure relief device) – from the tank plate
- Gas vapour pressure in the tank in bar just after filling – from the filler of the tank and
- Heat leak performance of the tank in Joule per hour based on the expected average ambient air temperature. This value may be delivered by the manufacturer of the tank or may be calculated taking into account the heat leak by the insulation of the tank, the support system of the tank and the pipelines to the inner vessel.

Calculation of the hold time for a filled tank

Normally the tank container manufacturer will supply details of the hold time capability of the tank container for various fill ratios and products. This relies on the vacuum and insulation being well maintained. If these data are not supplied the following is a method that may be used.

The vapour phase in the tank can be neglected for the consideration of a filled tank
.
The following calculation has to be carried out to determine the holding time of a tank:

Take from a table of the thermodynamic properties of the gas filled in the tank:

- enthalpy, liquid (h_{sl})in kJ/kg at vapour pressure at filling

- enthalpy, liquid (h_{fl})in kJ/kg at vapour pressure of MAWP

NOTE: As an example table 1 shows the thermodynamic properties of saturated nitrous oxide

- Heat leak (Q) in kJ/h for the tank
- Mass (m_{sl}) in kg of liquid gas in the tank after filling
- Expected duration t_e (hours) of the journey

Calculate the holding time (t_c) in (h) until the PRDs (pressure relief valves) will open:

$$t_c = (h_{sl} - h_{fl})m_{sl}/Q$$

If t_c is smaller than the expected duration (t_e) in hours of the journey the vapour pressure of the tank may be reduced, e.g. by releasing vapour of the tank. If this will not be possible e.g. some gases are filled in under ambient pressure, the duration of the journey has to be reduced e.g. by using an intermediate stop where the tank can have its pressure released.

Sometimes it is necessary to calculate the maximum allowable vapour pressure of the gas in the tank after filling for an expected journey. Then the following formula shall be used to calculate h_{sl}

$$h_{sl} = h_{fl}+(Q^*t_e)/m_{sl}$$

and the vapour pressure that relates to h_{sl} has to be taken from the Table B-1

In addition it has to be verified that the tank will not be completely filled with liquid before the vapour pressure will reach a value that is equal to MAWP of the tank:

Take from the table:

- the density ρ_{sl} in kg/dm³ of the liquid at filling related to h_{sl}
- the density ρ_{fl} in kg/dm³ of the liquid at MAWP related to h_{fl}

Calculate the max allowable degree of filling in % for the expected journey by using the formula

$$\text{Degree of filling} = (\rho_{fl} / \rho_{sl})\ 100$$

In case of UN portable tanks this value is limited to 98% so that the following formula has to be used

$$\text{Degree of filling} = 0.98\ (\rho_{fl} / \rho_{sl})\ 100$$

Example for a nitrous oxide tank container:

For an ADR tank with MAWP of 20 bar, that will be filled with N_2O with a vapour pressure of 15 bar (which is a tank pressure of 14bar) the degree of filling should be less than (0.998/1.044)*100=95.6%.

For a UN portable tank with MAWP of 20 bar that will be filled with N_2O with a vapour pressure of 15 bar (which is a tank pressure of 14bar) the degree of filling should be less than:

$$0.98*(0.998/1.044)*100 = 93.7\%.$$

If the actual degree of filling is greater than the allowable value the degree of filling has to be reduced e.g. by discharging liquid nitrous oxide.

Calculation for an empty tank

It is very important to consider also the journey of the discharged tank back to the filling station because discharging the liquid gas reduces the heat capacity of the load. For this consideration the liquid and the vapour phase of the transported gas has to be taken into account.
In addition to the information necessary for the consideration of a filled tank the following shall be available:

- Residual mass (m_{sl}) in kg of liquid gas in the tank
- Take from the table of the thermodynamic properties of the gas filled in the tank
  - enthalpy, vapour (h_{sg}) in kJ/kg at the vapour pressure of the discharged tank
  - enthalpy, vapour (h_{fg}) in kJ/kg at vapour pressure of MAWP
  - vapour density (ρ_{sg}) in kg/dm³ at the vapour pressure of the discharged tank

Calculate the mass (m_{sg}) in kg of gas vapour within the tank:

$$m_{sg} = [V-(m_{sl} / \rho_{sl})]\ \rho_{sg}$$

Then calculate the holding time (t_c) in (h) until the PRDs (Pressure relief valves) will open:

$$t_c = [(h_{sl} - h_{fl})m_{sl} + (h_{sg} - h_{fg})m_{sg}] / Q$$

If t_c is smaller than t_e either:

- the vapour pressure of the tank has to be reduced, e.g. by releasing vapour of the tank
- or the residual mass of liquid has to be increased,
- or the duration of the journey has to be reduced e.g. by using an intermediate stop where the tank can be pressure released.

Table 1: **Thermodynamic properties of saturated nitrous oxide**

Vapour pressure (bar, abs.)	Temperature (°C)	Density, liquid (kg/dm^3)	Density, vapour (kg/dm^3)	Enthalpy, liquid (kJ/kg)	Enthalpy, vapour (kJ/kg)
10	-38.50	1.085	0.028	-154.443	168.381
11	-35.79	1.077	0.030	-149.605	168.943
12	-33.30	1.069	0.032	-145.067	169.460
13	-31.05	1.059	0.035	-140.847	169.929
14	-28.79	1.049	0.038	-136.627	170.397
15	-26.64	1.044	0.040	-132.522	170.671
16	-24.48	1.039	0.042	-128.417	170.945
17	-22.45	1.032	0.045	-124.464	171.130
18	-20.56	1.024	0.048	-120.694	171.209
19	-18.67	1.015	0.051	-116.924	171.287
20	-16.95	1.007	0.054	-113.537	171.359
21	-15.42	0.998	0.056	-110.551	171.424
22	-13.88	0.989	0.058	-107.565	171.489
23	-12.35	0.981	0.061	-104.579	171.554
24	-10.79	0.972	0.064	-101.358	171.502

Appendix C—Examples of portable tanks and multiple element gas containers

Figure C-1—Portable tank for refrigerated liquefied gas
(20 ft cryogenic vacuum insulated tank container)

Figure C-2—Portable tank for refrigerated liquefied gas
(40 ft cryogenic vacuum insulated tank container for helium with a nitrogen shield)

Figure C-3—Portable tank for refrigerated liquefied gas
(20 ft thermally insulated tank container for carbon dioxide)

Figure C-4—Portable tank for liquefied gas
(20 ft non-insulated tank container with sunshield)

Figure C-5—Multiple element gas container (MEGC)
(20 ft for compressed and liquefied compressed gas)

Figure C-6—Multiple element gas container (MEGC)
(40 ft for compressed and liquefied compressed gas)