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Thermal containers — Safety standard for refrigerating systems using flammable refrigerants — Requirements for design and operation

Conteneurs thermiques — Norme de sécurité pour les systèmes réfrigérants utilisant des fluides frigorigènes inflammables — Exigences de conception et de fonctionnement

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Contents

Page

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 documents 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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 104, *Freight containers*, SC 2, *Specific purpose containers*.

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.

Introduction

This document has been developed to enable the use of flammable refrigerants in refrigerated thermal containers. This document enables container owners and operators to understand and validate the risks associated with operating refrigerating equipment using previously non-acceptable flammable refrigerants. The goal is to achieve an acceptable level of safety for container refrigerating systems using flammable refrigerants as for container refrigerating systems using non-flammable refrigerants.

The background for initiating the development of this document was the foreseeable impact of global and national regulations on hydrofluorocarbons (HFCs) currently used in thermal containers. Hydrofluorocarbons are listed in the Kigali Amendment to the Montreal Protocol from 2016 due to the high global warming potential (GWP) of HFCs and a phase down in the use and availability of R134a, R404A and, for low temperature, R23, is expected in intermodal transport refrigeration.

This document is intended to complement ISO 1496-2 but not to replace existing standards such as the ISO 5149 series. It provides minimum requirements for the design of a refrigerating system and follows a risk-based approach to reduce, but not eliminate, the risks to persons, assets and the environment.

The working group, which developed this document consisted of representatives from refrigerating system manufacturers, refrigerated container box manufacturers, shipping lines, classification societies, equipment owners and other interested industry experts.

Thermal containers — Safety standard for refrigerating systems using flammable refrigerants — Requirements for design and operation

1 Scope

This document describes the design of the mechanical refrigeration unit (MRU) and operation of container refrigerating systems in all anticipated operational modes and locations.

It describes the industry's best practices for the safe operation of flammable refrigerants in refrigerating systems used in thermal freight containers operated on board ships, in terminals, on road, on rail and on land.

This document addresses the use of flammable refrigerants with classifications defined in ISO 817, defined as 2L, 2 and 3, except R717 (Ammonia).

This document describes an operational mode risk assessment (OMRA) which uses methods such as HAZOP (Hazard and operability analysis), FMEA (Failure mode and effects analysis), or FTA (Fault tree analysis) or combination of methods.

This document specifies requirements for the validation and consideration of possible safety concepts and protective devices within the OMRA process, including charge release tests, simulation, and function tests of the associated protective equipment. It defines test requirements for shock, impact, and vibration. A validation procedure is given to demonstrate that risks from hazardous events are investigated and their severity and frequency are meaningfully reduced, with the aim of achieving tolerable risk values.

The obligations of the manufacturer, the container owner as well as the responsible operator are described, as well as how stakeholders can investigate and mitigate risks associated with the use of flammable refrigerants.

Finally, this document describes the requirements of service and maintenance when working with flammable refrigerants.

This document is restricted to refrigerating systems integrated with or mounted on ISO thermal containers according to ISO 1496-2. It provides minimum requirements for reducing the risk associated with the use of flammable refrigerants.

The scope is limited to container refrigerating systems operated in conjunction with the carriage of refrigerated cargo as operating reefer (OR) or when used as a non-operating reefer (NOR) or when empty for positioning — while in intermodal transit. Static land-based continuous operations are excluded.

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 817, *Refrigerants — Designation system*

ISO 1496-2, *Freight containers — Specification and testing — Thermal containers*

ISO 5149 (all parts), *Refrigerating systems and heat pumps — Safety and environmental requirements*

ISO 14903, *Refrigerating systems and heat pumps — Qualification of tightness of components and joints*

IEC 60068-2-6, *Environmental testing — Part 2-6: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-75, *Environmental testing — Part 2-75: Tests — Test Eh: Hammer tests*

IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*

IEC 60079-14, *Explosive atmospheres — Part 14: Electrical installations, design, selection and erection*

IEC 60079-15, *Explosive atmospheres — Part 15: Equipment protection by type of equipment "n"*

IEC 60335-2-40, *Household and similar electrical appliances — Safety — Part 2-40: Particular requirements for electrical heat pump, air-conditioners and dehumidifiers*

EN 1127-1, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*

EN 14624, *Performance of portable leak detectors and of room monitors for halogenated refrigerants*

3 Terms and definitions

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

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

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

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

3.1
alarm system
system constituting all electrical and electronic parts of the refrigerating system which monitor the correct function of the protective device(s) and/or give a warning in case of malfunctioning or refrigerant leakage

3.2
hazardous area
area in which a flammable or toxic atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for construction, installation or use of apparatus

[SOURCE: IEC-60079-10-1:2015, 3.3.1, modified — In the definition, the word "explosive" has been replaced with "flammable and toxic".]

3.2.1
non-hazardous area
area in which a flammable or toxic atmosphere is not expected to be present in quantities such as to require special precautions for construction, installation and use of equipment

[SOURCE: IEC-60079-10-1:2015, 3.3.2, modified — In the definition, the word "explosive" has been replaced with "flammable and toxic".]

3.2.2
temporary hazardous area
area which can be defined as a hazardous area for a short period of time as a consequence of an abnormal or accidental type leak

3.3
authorized service facility
service facility that is authorized by the manufacturer to repair and to maintain the container refrigerating system

3.4
condenser section
space of the container where all outside parts of the refrigeration circuit including condenser fan are located

Note 1 to entry: The condenser section is not a confined space.

Note 2 to entry: The condenser section corresponds to control volume II (see Annex A).

3.5
container refrigerating system
mechanically refrigerated container with a vapour compression refrigeration cycle using refrigerant as a working fluid

3.6
control volume
theoretical volume representing the space in which a flammable atmosphere can occur as a consequence of a refrigerant leak

Note 1 to entry: It can be delimited by the internal or external space of a container, and/or by specific component compartments.

Note 2 to entry: A description of control volumes is included in Annex A.

3.7
durably technically tight
sealed equipment with enhanced tightness which is equal or less than that of fugitive emissions accomplished by enhanced maintenance and supervision

Note 1 to entry: Clauses 8, 9 and especially Clause 10 provide information on design aspects and operational aspects to maintain tightness, permanently ensured by means of enhanced maintenance and supervision.

Note 2 to entry: Additional information can be found in EN 1127:2011, Annex B.

Note 3 to entry: ISO 5149-2 provides information on “sealed systems” and IEC 60335-2-40 on “enhanced tightness”.

3.8
evaporator space
space inside the container containing the evaporator and air ducts

Note 1 to entry: The evaporator space corresponds to control volume III (see Annex A).

3.9
flammable atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour, which after ignition, permits self-sustained flame propagation

Note 1 to entry: For example, a mixture of flammable refrigerant fluid with air under atmospheric conditions.

[SOURCE: IEC 60079-10-1:2015, 3.2]

3.10 flammable limit/explosive limit[1)]

3.10.1
LFL
lower flammable limit
minimum concentration of the refrigerant that is capable of propagating a flame through a homogeneous mixture of the refrigerant and air under the specified test conditions at 23,0 °C and 101,3 kPa

[SOURCE: ISO 817:2018, 3.1.24, modified — Notes 1 and 2 have been omitted.]

3.10.2
UFL
upper flammable limit
concentration of flammable gas or vapour in air, above which the gas atmosphere is not flammable

[SOURCE: IEC-60079-10-1:2015, 3.6.13, modified — In the definition, the words "or mist" have been removed after "vapour". Also, at the end, after "above which", "an explosive gas atmosphere will not be formed" has been changed to " the gas atmosphere is not flammable".]

3.11
flammable refrigerant
refrigerant with a classification of class 2L, 2 or 3 in compliance with ISO 817 classification, refrigerants excluding ammonia

3.11.1
AIT
auto-ignition temperature
lowest temperature of a substance at or above which a chemical can spontaneously ignite in a normal test atmosphere, without an external source of ignition, such as a flame or spark

Note 1 to entry: Refer to the manufacturer’s safety data sheet (SDS) of the chemical used.

[SOURCE: ISO 5149-1:2014, 3.7.7, modified — Note 1 to entry has been added.]

3.11.2
RTT
reaction threshold temperature
lowest temperature of a substance at or above which a chemical can be decomposed spontaneously in a normal atmosphere, in the presence of an external source of ignition, such as an open flame, hot surface or spark

Note 1 to entry: As an estimation, the following values may be used: RTT_{est} = AIT − 100 °C.

3.12
flammable substance
substance in the form of gas, vapour, liquid, or mixtures of these, able to propagate a flame from an ignition source

3.13
fresh air exchange mechanism
mechanism that opens the fresh air ducting to allow ventilation

1) The flammability limits are function of temperature and humidity. For refrigerants flammability, ISO 817:2014 defines test conditions of 50 % relative humidity at 23,0 °C and 101,3 kPa for burning velocity and LFL/UFL measurements. The effect of a reduced lower flammable limit and an increased upper flammable limit at higher operational humidity and temperature levels can be taken into account in the operational mode risk assessment.

3.14
fugitive emission
small release of refrigerant from pressurized equipment which does not result in malfunction of the cooling process in its typical operation time

Note 1 to entry: Fugitive emissions result from corrosion or shortcoming of components or joints which are durably technically tight during intermodal operation and do not result to a malfunction and/or need for repair on the refrigerating system in a period of months to years.

Note 2 to entry: Annex C gives information on leak type, size, frequencies and leak rates.

Note 3 to entry: For additional information, see IEC 60079-10-1:2015, C.4.6.

3.15
inside component
component of the refrigerating system which is located inside the internal dimensional envelope of the container

3.16
intended use
use in accordance with information provided with the container refrigerating system, or, in the absence of such information, by generally understood patterns of usage

Note 1 to entry: Intended use of a container refrigerating system is the carriage of cargo under temperature control and when the unit is not operating i.e. used as NOR (non-operating reefer) or waiting empty for loading and/or repositioning — while in intermodal transit.

[SOURCE: ISO Guide 51, 3.6, modified — The words "a product or system" have been replaced with " the container refrigerating system" and Note 1 to entry has been added.]

3.16.1
normal operation

condition where the equipment is operating within its design parameters

Note 1 to entry: Failures (such as the breakdown of components or ruptures) which involve shut-down and urgent repair are not considered to be part of normal operation.

Note 2 to entry: Normal operation includes start-up and shut-down conditions.

Note 3 to entry: Normal operation can include occurrence of fugitive emissions. Normal operation does not include larger leaks. Normal operation of the container refrigerating system requires a certain minimum refrigerant charge. Larger leaks result in system failure.

[SOURCE: IEC 60079-10-1:2015, 3.7.1]

3.16.2
special use
use of a container refrigerating system for cooling and storage of goods in stationary and temporary land operation — not permanently imported

Note 1 to entry: Local regulations and guidelines can apply to the use of a container refrigerating system as permanent storage place of cargo.

3.16.3
reasonably foreseeable misuse
use of the container or container refrigerating system in a way not intended by the supplier, but which can result from readily predictable human behaviour

[SOURCE: ISO Guide 51:2017, 3.7, modified — The words "a product or system" have been replaced with "the container or container refrigerating system" and Notes 1 and 2 to entry have been omitted.]

3.17
non-occupied space
space inside the container which is not occupied for a significant period of time by person(s)

Note 1 to entry: For unpacking and packing of goods, the container doors are open, see 9.5.

3.18
operating site
site or location of operation in which a container refrigerating system can be operated, repaired, or stored during the intended use

3.19
operational mode
combination of type of operation (such as transport mode and storage location) and state of operation (such normal operation, power ON, power OFF, empty container, packed container) in a container refrigerating system

EXAMPLE The container is located in a terminal, on a truck and with power on and empty.

3.20
operational mode risk assessment
OMRA
overall process comprising a risk analysis and risk evaluation of a container refrigerating system in different operational modes

3.21
outside part
component of the refrigerating system which is located outside the insulated walls and inside the external dimensional envelope

3.22
packing
stuffing
action of filling cargo/goods into the container within designed capacity

Note 1 to entry: After packing, the container is loaded with goods.

3.23
PTI
pre-trip inspection
inspection and testing of a container refrigerating system including checking for structural damage and assurance that the refrigerating system is operating according to the specifications

Note 1 to entry: A PTI can be carried out before a container is released for a new trip or after a repair.

3.24
power supply
condition where a connection to the three-phase power supply is present

3.25
refrigerant leak detection mechanism
mechanism which can recognize a refrigerant leakage or charge losses of the container refrigerating system

3.26
refrigerating system repair operation
service or maintenance of a refrigerating system in which the container refrigeration system pipework or components is or will be opened

3.27
repair shop
place in a terminal or service facility where container refrigerating systems are serviced and repaired

3.28
responsible operator
MRU operator
person or entity that has operational control of the container including the MRU at any particular time including, but not limited to, repair and storage depots, terminals, transport operators, shippers and consignees

3.29
safety principle
set of provisions which, together, ensure safe design and safe operation of a container refrigerating system

3.30
shut-off device
normally closed device separating parts of the refrigerating system to reduce the maximum amount of refrigerant that can be leaked into a control volume

3.31
service access point
connection used to service the refrigerating system, that enables the refrigerant circuit to be charged, discharged, evacuated and pressure checked

3.32
service facility
building or installation where maintenance and repair of container refrigerating systems is carried out

3.33
smallest inside free volume
remaining inside volume when the cargo compartment is packed to the maximum allowed volume

Note 1 to entry: This volume includes the T-floor space.

3.34
T-floor
specially designed floor with longitudinal channels to allow air to pass underneath the cargo

3.35
terminal
intermodal facility that allows the transport and transfer of containers between different transport modes

Note 1 to entry: In a terminal, intermodal containers are also loaded/unloaded, stored, operated, maintained, packed/unpacked.

3.36
toxic atmosphere
mixture of air, under atmospheric conditions, with toxic substances in the form of gas or vapour which can be harmful or lethal to humans

Note 1 to entry: For example, a mixture of toxic refrigerant fluid or decomposition products with air under atmospheric conditions.

Note 2 to entry: A toxic substance is understood to be a substance in the form of gas, vapour, liquid, or mixtures of these, which can be harmful or lethal, or can impair a person's ability to escape due to acute or chronic exposure by contact, inhalation, or ingestion.

3.37
unit end
front end where the refrigerating system is placed

3.38
unpacking
unstuffing
action of emptying the container

Note 1 to entry: After unpacking, the container is empty.

3.39
ventilation environment
environment capable of diluting releases of hazardous substances in normal operation to a non-hazardous concentration

3.39.1
open air
any unenclosed space, possibly but not necessarily roofed with, as a minimum, natural ventilation

Note 1 to entry: The ventilation environment "open air" refers to or represents areas or operating sites such as PTI, inspection, roofed repair areas, on vessel deck, truck and rail.

[SOURCE: ISO 5149-1:2014, 3.2.7, modified — The words "with, as a minimum, natural ventilation" and Note 1 to entry have been added.]

3.39.2
well-ventilated
area which is naturally or mechanically ventilated

Note 1 to entry: The ventilation environment "well-ventilated" refers or represent areas or operating sites such as vessel cargo hold, workshops, system repair areas.

3.39.3
non-well-ventilated
area other than open air or well-ventilated

Note 1 to entry: The ventilation environment "non-well-ventilated" should be considered if an artificial or forced ventilation system is not in operation (due to power failures or other type of malfunction).

Note 2 to entry: For release rate and accumulation time of hazardous substances in non-well-ventilated areas or operating sites see Annex C.

3.40
ventilation mechanism
means which promotes the replacement of an air volume

3.41
ventilation
movement of air and its replacement with fresh air, i.e. without dangerous substances

3.41.1
natural ventilation
movement of air and its replacement with fresh air due to effects of natural mixing, air movement, or temperature gradients

Note 1 to entry: For open air ventilation is normally based on an assumed minimum wind speed of 0,15 m/s for obstructed areas and 0,3 m/s for unobstructed areas, which will be present virtually continuously (see IEC 60079-10-1:2015, Table C.1).

3.41.2
artificial ventilation
forced ventilation
movement of air and its replacement with fresh air provided by artificial means

3.42
zone
hazardous area classification based upon the frequency of the occurrence and duration of an explosive atmosphere

[SOURCE: IEC-60079-10-1:2015, 3.3.2]

3.42.1
zone 2
area in which an explosive gas atmosphere is not likely to occur but, if it does occur, for example as a result of accidental type release of refrigerant, it can be defined as a temporary hazardous area

[SOURCE: IEC-60079-10-1:2015, 3.3.6, modified — The words "in normal operation" have been removed; the end part after "if it does occur" has been changed; and Note 1 to entry has been omitted.]

3.42.2
extent of zone
distance in any direction from the source of release to where a gas/air mixture will be diluted by air to a concentration below the lower flammable limit

[SOURCE: IEC-60079-10-1:2015, 3.3.7]

4 Symbols and abbreviated terms

FEU	Forty-foot equivalent unit
MRU	Mechanical refrigeration unit (the terms "MRU" and "unit" are considered to be synonymous at this document)
SOI	Source of ignition
SDS	Safety datasheet for chemicals

5 Safety requirements for the design of container refrigerating systems

5.1 General

The safety requirements described in this clause cover the whole assembly of a container refrigerating system using flammable refrigerants: the refrigerating system and the container box and as well as the various operational modes.

5.2 Significant hazards of the refrigerating system

A container refrigerating system shall be designed to achieve the level of tightness as specified in ISO 5149-2 for sealed systems. ISO 14903 shall apply as it specifies qualification of tightness of components and joints for refrigerating systems and heat pumps.

In addition, the MRU design shall be such that a high degree of tightness can be maintained throughout its life with correct maintenance. According to EN 1127, a refrigerating system is classified as a durably technically tight system or as a sealed system with enhanced tightness accomplished by leak tight design and manufacturing procedures for components, joints and connections, implemented service procedures for maintenance and operation including inspection and monitoring of leak tightness.

An MRU is regarded as durably technically tight system or as a sealed system with enhanced tightness, if:

— it is constructed such that it remains technically tight due to its design, as described in this clause and Clause 6; and