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ISO TC 104/SC 2 N496

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

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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](http://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](http://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.

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# 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

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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]

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### 3.10 flammable limit/explosive limit<sup>1</sup>

#### 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:  $RTT_{est} = AIT - 100\text{ °C}$ .

#### 3.12

##### flammable substance

<sup>1</sup> 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.

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

### 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**