ISHRAE

Guideline document to ISO 5149

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Indian Society of Heating, Refrigerating
and Air Conditioning Engineers

Acknowledgement

On behalf of ISHRAE I wish to thank and acknowledge the efforts of Mr Maniam and M/s Danfoss along with the standards subcommittee of the IRC for their efforts in preparation of this document.

Wish to appeal to readers to give their opinions to enable ISHRAE to come out with more enhanced versions of this document for the benefit of the Refrigeration and Cold Chain industry

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History

Many years the professional refrigeration society have been working on Standards for building and
maintaining refrigeration equipment in a safe and environmental responsible way. ISO 5149 was for decades the reference for the refrigeration industry. End of last century the ISO 5149 was lacking the connection to the state of the art technology in Europe. As a result the European Standard EN378 was introduced around 1995 and reworked in 2010 and 2016. As a matter of fact any Standard will have a limited lifecycle as technology and environmental requirements will develop constantly. So, from certain parts of society there will always be the demand to update Standards. As an example it can be mentioned that flammable hydrocarbon refrigerants are covered but the technology is running faster, so field-experts push already for modifications.

In 2014 the fully reworked ISO 5149 got the green light. Although the ISO 5149 is mainly based on the EN 378 there are differences. Some minor, like the reference to harmonised norms. Some major, like the difference in calculation of pressure relief valves. There will be valid arguments for both systems.

It is up to the designer of a plant to choose for either following the EN 378 or the ISO 5147.

Brief description of ISO 5149

Basically any international standard consist of a number of agreements between all members of a certain technology. In this case hundreds of refrigeration specialists from suppliers, contractors, institutes, end users, etc. have been through each and every detail with the objective to create rules for a safe and reliable refrigeration plant with a minimum impact on the environment, including operation and disposal. The majority of the "rules" will be no surprise for the educated refrigeration engineer as they relate to common practice. New are the rules regarding the flammable refrigerants
ISO 5149 consist of 4 parts, each of them divided in chapters and sub-chapters.

Part 1: Definitions, classification and selection criteria

The list of definitions will make sure that everybody will have the same understanding when they use an expression. The remaining part 1 is directed to the safety of persons and property on or near the premises where refrigeration facilities are located. The safety is secured by charge limitations of the refrigerant based on the toxicity (class A or B) and the flammability (class 1, 2, 2L and 3) of the refrigerant.

Part 2: Design, construction, testing, marking and documentation

This part is applicable to the design, construction, and installation of refrigerating systems, including piping, components, materials, and ancillary equipment directly associated with such systems. It also specifies requirements for testing, commissioning, marking, and documentation. Beside the chapters with requirements for strength, tightness, maximum allowable pressures, etc. there are 7 Annexes with both normative and informative technical details.

Part 3: Installation site

This part specifies safety requirements for the plant site, depending on the location of the equipment, and for the machinery room. It applies to new refrigerating systems, extensions or modifications of existing systems, and for used systems being transferred to and operated on another site. This part of ISO 5149 also applies in the case of the conversion of a system for another refrigerant. Requirements for leak detection and alarms are given.

Part 4: Operation, maintenance, repair and recovery

Part 4 specifies requirements for safety and environmental aspects in relation to operation, maintenance, repair, recovery, reuse and disposal of all types of refrigerant, refrigerant oil, heat transfer fluid, refrigerating system and part thereof. These requirements are intended to minimize risks of injury to persons and damage to property and the environment.Frame work of more detailed info of the different parts of the standard

In the next pages for each Part of the ISO 5149 there will be detailed explanation with examples. The aim is the restrict it to max 4 pages.

ISO 5149-1

The tile of this part 1 is; **Definitions, classification and selection criteria**. *It gives basic information to be used in the following parts 2,3 and 4. Safety for persons and property are the drivers in this part 1.*

As mentioned in the SCOPE this part of the standard applies to all refrigeration systems except auto air-conditioning in cars. Even in the case of changing to another refrigerant or rebuilding a system on another location the Standard is applicable.

The first 10 pages in part 1 are used to describe all possible **terms and definition** *related to refrigeration plants. When not in this list it will be covered by ISO 817.*

The sub-chapters 3.1.to 3.10 give the definitions of System, Location, Pressure, Piping joints and fitting, Safety devices, Fluids, heat transfer system, Refrigerants disposal and Miscellaneous. Most of the definitions are quite self-explaining but sometimes things look alike but are different. Let us take the machine room. In a standard machine (3.2.5.) it is allowed to have other equipment like heating boilers together with the refrigeration parts, where the special machine room (3.2.8) only the refrigeration parts are allowed. Another example is e.g. the design pressure (3.3.1) and the maximum allowable pressure PS (3.3.3). The design pressure is related to components and used by the constructor to develop his product. It can be 5 times the maximum allowable working pressure which is related to the system .

To protect the public against any damage caused by the refrigerant the Standard describes in chapter 5 and 6 the maximum refrigerant charge based on;

- *Type of refrigerant (* **refrigerant classification, toxicity class***), (A, B , A2L, A2, A3)*
- *The way a building is used (***occupancy category***) (a, b, c,)*
- *Type and location of refrigeration system (***location classification***) (I, II, III, IV)*

It basically drills down to the possibility that leaking refrigerant can enter the area, even with indirect systems via the heat transfer fluid. The maximum allowable refrigerant charge in the system is calculated or taken from tables based on room volume, the nature of the room and the toxicity of the leaking refrigerant.

The refrigerant classification and the toxicity class follow from tables based on ISO 817 and are given in a so-called Practical limit. For R134a the value is 0,25 kg refrigerant per m3 room volume, for R410A is it 0,44 m3/kg. It will be no surprise that for the toxic NH3 the practical limit is only 0,00035 kg/m3

The occupancy category contains 3 different possibilities

- *General occupancy, like hotels, hospitals, prisons, restaurants, schools, theatres, etc., etc.*
- *Supervised occupancy, like offices, factories, laboratories, etc., etc., where some people are familiar with safety instructions*
- *Authorised occupancy, like production facilities with mainly authorised personnel.*

ISO 5149-1

The location classification is determined from both the type of system (direct, indirect, double
indirect, etc.) and the way the refrigerant containing parts are placed (direct in the room, in vented space, in machine room).

Direct en indirect systems used in occupancy category (a) will always have a charge limitation based on the volume of the smallest room cooled or heated by the system. Calculation of the room volume is described in part 7 **Space volume calculation.**

Indicative example;

*For a hotel with direct or indirect system, (occupancy category (a) and location classification I or II) with rooms of 150 m3 each, the charge limit with R410A (toxicity class A) is 150m3*0,44 kg/m3=66 kg of refrigerant in the total system. A small 50 m3 office (on the ground floor with free connection to an emergency exit) connected to the same system does not influence this figure of 66 kg as the office is for restricted personnel and is covered by occupancy category (b), having no charge restrictions for this type of refrigerant.*

In part 8 **Heat-transfer fluids**, *precautions and guidelines are given for the heat transfer fluid itself as well as the demands for the circulation system end piping*

ISO 5149-2

The tile of part is; part 2: Design, construction, testing, marking and documentation.

It covers the technical requirements for constructing refrigerating plants, including piping, and most of the items will be well recognized by refrigeration engineers.

Chapter 4 handles **Requirements for components and piping.**
This chapter 4 is typical mend for the manufacturers of components and cover the usual production processes like strengths test on 1.43 times the maximum working pressure and the tightness test to assure that the component does not leak refrigerant to the atmosphere. The results has to be documented and signed by an authorised person.

Chapter 5 refers to **Requirements for assemblies**

This chapter describes in 24 pages the design and construction for a reliable and safe operation of any refrigeration plant and should refer to common daily practice, not more-not less.

A logical demand is sufficient strength of the construction to withstand all external conditions, even earthquakes in area where there is a possible risk. Second major condition to decide is the **maximum working pressure (PS)** *of the plant as this is crucial for further selections. A table based on maximum ambient air temperature for the location of the new plant will give the maximum condensing temperature. Depending on the refrigerant a maximum working pressure for as well the high side as the low side of the installation are given.*

Example;
A plant with an aircooled condenser has to operate with ambient temperatures of maximum 45C. The calculation of the maximum working pressure PS should be based on a saturated pressure of the used refrigerant of 67C. If R134a is used it will be 18,6 bar , if R407C is used it will be 28,3 bar. The maximum working pressure on the suction side of the plant has to be based on 55 C id exposed to outdoor temperature and to 38 C if exposed to indoor temperature. This will give maximum working pressures of 13,9 and 8,6 bar for R134a. For R407C it will be 21,3 and 13,6 bar.

The maximum working pressure PS is related to the safety cut-outs and the pressure relief valves. The set point of the pressure relief valve is equal to PS and the relief capacity should be reached at a pressure below 1.2 PS.*

In 5.2.3 requirements of **pipe joints and fittings** *are described. The minimum support-spacing for copper and steel piping is given in a table. For a 22 mm half-hard copper tube the recommended spacing is 3 meter. For a DN 100 (4 “) steel pipe the distance between the support should minimum be 5 meter.*

In 5.2.4 is mentioned that sufficient **shut-off valves** *has to be mounted for proper service. If tightening or replacing the packing gland of a valve is not possible, special precautions have to be made to ensure the possibility of evacuating that part of the plant. Oil drain valves or alike has to be of the quick closing type.*

Chapter 5.2.5 is extensively covering all **safety devices**, *from the electro mechanical switches to the pressure relief valves. Electronic equipment can only be used as high pressure safety switch if it complies to ISO 13849-1. Formulas and refrigerant-connected constants are given to calculate the required mass flow of air in kg/s. However, selection programs of component suppliers will make this job easier. Special attention is asked for the piping selection from the outlet of the relief valve to the atmosphere as a too high pressure drop in this piping will influence the set-pressure of the relief valve. See also annex F.*

The chapter 5.2.9 **Application of the protection devices** *starts with 4* **flow diagrams** *that give the answer under which conditions pressure relief valves and/or safety switches are obligatory. It is not restricted to just excessive pressure in vessels or compressors but also explains how to act in the case of possible risk of rupture due to liquid expansion. Prevention of excessive pressure in secondary cooling and heating system can be found as well.*

The use of pressure indicators and liquid level indicators based on the liquid charge is given in
5.2.10/11. In most cases it is sufficient to have pressure-gauge connections on each pressure side. In case of manual defrost or cleaning with hot water/glycol the plant must be permanent equipped with a pressure-indicator. Liquid receivers containing more than 100 kg of A1 refrigerant (like R134a) must have a level indication to see the maximum level. For B2 refrigerants, like R717, this limit lies at 25 kg.

The remaining past of chapter 5.2 handles protection against all kind of possible injuries to people, like burning, touched by moving parts, etc. The last part. 5.2.17 **Requirements for ventilated enclosures** *is an important chapter if the refrigeration plant is operating with a flammable refrigerant. The needed air volume is based on the refrigerant charge in kg. The minimum negative pressure is 20 Pa.*

Chapter 5.3 is all about **Testing**

The overall requirements are given in 5.3.1 as follows;
Before putting into service any refrigerating system, all the components or the whole refrigerating system shall undergo the following tests:

a) strength-pressure test;
b) tightness test;
c) functional test of safety switching devices for limiting the pressure;
d) conformity test of the complete installation.

Joints shall be accessible for inspection while the strength-pressure testing and tightness testing are in progress. After strength-pressure testing and tightness testing and before the system is started up for the first time, functional testing of all the electrical safety circuits shall be carried out.

In the following chapters details are provided about how and at what levels the different test should be done. The described procedure will cover most of the standard activities carried out by a refrigeration engineer if he is checking a new plant before start-up.

The last chapter 5.4 **Marking and documentation** *describes which components in the plant has to be marked for easy identification, that pipelines should have a colour code and that a clearly readable identification plate shall be located near or on the refrigerating system.*

The **documentation** *which is part of the plant is given in 5.4.3 and applies to;*

- Certificates
- Documentation at operating site giving the basic installer data, refrigerant type and emergency procedure
- Instruction manual (in the language where the plant is to be used)
- Drawings in the case of complex installation
- Logbook if refrigerant charge is over 3 kg

This ISO 5149-2 now continues with Annexes A to G. They are "informative" or "normative". In case of Normative the rules in the appendix have to be followed. For instance in appendix B additional measurements are given for NH3 plants with charge-levels above 50 and 4500 kg.

If a manufacturer likes to label his equipment as "intrinsic save" the test procedure to proof this is described in annex D.

ISO 5149-3

This part of ISO 5149 is applicable to the **installation site** *(plant space and services). It specifies requirements for the site for safety, which could be needed because of, but not directly connected with, the refrigerating system and its ancillary components.*

The **location of the refrigerating machinery**, *chapter 4, is decisive for the necessary measurements to ensure the safety of people in case of refrigerant leakage. In the open air it is important that intake is not close to the refrigeration equipment. When placed in an area where people can be around, or connected to an area where people are, the rules for maximum refrigerant charge will be valid according occupied space category a.*

The requirements for a **machinery room** *are described in chapter 5 and cover amongst others minimum ventilation, air intake for boilers, lighting, emergency switches inside and outside, construction to be 1 hour fire resistive, etc. If the machine room is also used as regular place for maintenance it is marked as occupied space category c.*

For **flammable refrigerants** *extra requirements are given in 5.14. It is quite obvious that in this case the machinery room shall be located in accordance with local and national regulations, depending on the amount of charge. Special non-sparking emergency fans should be mounted.*

For **R-717** *additional requirements can be found in 5.14.2. where the liquid catchment system has to prevent spilling ammonia to surface water. For personnel treatment after exposure to Ammonia an eye wash and body shower should be present outside the machinery room.*

Machine room ventilation by either natural convection or by forced ventilation is described in
chapter 6.3 where the formulas are given for the required opening or required air volume.

To minimise the leak rate in an occupied space it can be helpful to install emergency **safety shut-off valves**. *Chapter 6.4 describes the location, the control and the design of this kind of valve.*

An important detail in chapter 7, **electrical installations**, *is the statement that in case of flammable 2L class refrigerants the electrical equipment does not need to conform to hazardous areas requirements.*

Chapter 8 covers alarms, where to use , how. Both for occupied spaces as for machine rooms.

Refrigerant detectors *play an important role in the safety procedure for people an personnel. In chapter 9 the location, the set values, delays, actions, etc. are given. Special focus is put on flammable refrigerants and on R-717.*

ISO 5149-3

The last chapter 10 describes the **Instruction manuals, notices, and inspections** *connected to the plant site. As a matter of fact it is nothing more than good housekeeping and always be aware of the fact that accidents can be prevented.*
In particular, the following shall be checked for correct installation and function (10.3):

a) escape and access routes for passage are free from obstruction;
b) openings for ventilation are free from obstruction;
c) mechanical ventilation of the machinery room;
d) refrigerant detectors;

Minimum once a year the correct function at the right detection levels has to be checked and be recorded in the logbook (10.4)

ISO 5149-4

Requirements for **Operation, maintenance, repair and recovery** *of the refrigerating equipment is given in part 4 of the ISO 5149.*

High focus is given on the skills of people that are, are will become, responsible for the refrigerating equipment. Proper instruction from the installer and/or involvement during erecting the plant are needed to achieve the knowledge for a day to day monitoring of the plant.

The **logbook** *plays a central role in documenting all activities connected to the plant. In 4.3 it is described what and how has to be documented in the logbook.*

Maintenance *has to be done by qualified personnel in a safe and responsible way, without spilling refrigerant to the atmosphere. In 5.1 and 5.2 the appropriate procedure is given. For trained refrigeration technicians this will be more or less the working standard.*

The same applies for 5.3, **repair***, with the extra clause that if other skilled personnel (such as welders, electricians, measuring and control specialists, etc. are needed) the work shall be carried out under the supervision of a person* **competent in refrigeration.**

In 5.4 the preconditions and actions are given if a refrigerant change has to be carried out, for
instance with lower GWP. Beside the compatibility of all components several other aspects have to be checked, like maximum working pressure, motor power, liquid receiver, setting of safetyswitches, etc.

Chapter 6.1 and 6.2 handles the **Requirements for recovery, reuse and disposal.** *These actions are from environmental point of view very important and covered by local regulations. A flowchart (6.2.1) assists the process what can be done with the refrigerant taken from the plant, reuse or dispose.*

Requirements for refrigerant transfer, transport and storage *are given in chapter 6.3. Most of the requirements relate to safety for personnel and minimising the escape of refrigerant and are related to local rules.*

The **recovery equipment***, as mentioned in 6.4, draws refrigerant/oil out of the refrigerating system and transfers it into a container in a safe manner, and shall be leak-tight. Performance requirements are given in 6.4.3*

Disposal *of refrigerant, oil, water ammonia mix, etc. has to be to local rules, mostly as chemical waste, as described in 6.5.1 and following . When necessary, a person competent in dealing with the disposal of refrigerants and oils should be consulted.*

Draining oil *from a refrigeration plant can result in unforeseen accidents. Annex A in this part describes the oil-draining procedure in a safe and reliable way.*