UDC 621.56/.59 : 614.8 – 084

Ref. No. : ISO/R 1662-1971 (E)

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 1662

REFRIGERATING PLANTS

SAFETY REQUIREMENTS

1st EDITION

January 1971

Printed in Switzerland

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 1662, *Refrigerating plants – Safety requirements*, was drawn up by Technical Committee ISO/TC 86, *Refrigeration*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question led to the adoption of Draft ISO Recommendation No. 1662, which was circulated to all the ISO Member Bodies for enquiry in October 1968. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Greece	South Africa, Rep. of
Austria	Hungary	Spain
Belgium	India	Sweden
Chile	Israel	Switzerland
Czechoslovakia	Italy	Thailand
Denmark	Japan	Turkey
France	Netherlands	U.A.R.
Germany	Poland	U.S.S.R.

The following Member Bodies opposed the approval of the Draft :

New Zealand
United Kingdom
U.S.A.

This Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided to accept it as an ISO RECOMMENDATION.

CONTENTS

ISO Recommendation R 1662 January 1971

REFRIGERATING PLANTS

SAFETY REQUIREMENTS

INTRODUCTION

This ISO Recommendation concerning the safety of refrigerating plants has been made taking into account regulations already in force, or existing in draft form, in a number of countries. The provisions represent minimum requirements for the design, construction, installation, and operation of a refrigerating plant; however, in particular cases, more severe requirements may be necessary. Where national regulations are in force, full account should be taken of them.

In accordance with ISO regulations, the present document is restricted to recommendations. It is evident, however, that amongst these are some which could not be neglected without grave danger, and others which only illustrate good practice. It is therefore recommended that, when using the present document as a basis for a standard or a national regulation, a distinction should be made between these two categories of recommendations as only the first could be considered to have an obligatory character.*

Reference is made in the document to pressure vessel codes, electrical codes and the like, and in many countries such codes exist and are mandatory. In the absence of such mandatory rules in any particular country, an acceptable substitute becomes necessary. It is recommended therefore that a relevant document that has received national or international recognition should be used. However, such regulations must be acceptable to and be accepted by all the parties concerned in each transaction.**

These recommendations are intended solely to minimize possible hazards in refrigerating plants; they do not constitute a technical design manual. These hazards are associated essentially with the physical and chemical characteristics of refrigerants as well as the pressures and temperatures occurring in refrigeration cycles. Inadequate precautions may result in

- rupture of a part or even an explosion, with risk from flying pieces of metal;
- escape of refrigerant following a fracture or simply due to leakage, or to incorrect operation during running or repair or during charging;
- burning or explosion of escaping refrigerant, with consequent risk of fire.

---

* A proposed basis for this distinction is given in Annex A.

** See Chapter 5 of *Practical guide to refrigerating storage*, published by the International Institute of Refrigeration (IIR), Paris XVII^{ème}, 117 Boulevard Malesherbes.

Refrigerants, on the one hand, affect a refrigerating plant internally according to the nature of the materials used and the pressures and temperatures and, on the other hand, they may have external effects when they are toxic, flammable or explosive and may present risks to personnel, goods or materials (from burns, poisoning, asphyxiation, deterioration and corrosion).

Dangers due to the states of pressure and temperature in refrigeration cycles are essentially due to the simultaneous presence of the liquid and vapour phases, from which certain consequences follow. Furthermore, the state of the refrigerant and the stresses that it exerts on the various components do not depend solely on the processes and functions inside the plant, but also on external causes.

The following are dangers worthy of noting :

(*a*) *from the direct effect of temperature*

- brittleness of metals at low temperatures;
- freezing of heat-transferring liquids (for example water, brine) in closed spaces;
- thermal stresses;
- damage to buildings resulting from freezing of the ground beneath them;
- injurious effects to persons caused by low temperatures.

(*b*) *from excessive pressure due to*

- increase in the pressure of condensation, caused by inadequate cooling or the partial pressure of non-condensable gases or an accumulation of oil or liquid refrigerant;
- increase in the pressure of saturated vapour due to excessive external heating, for example of a liquid cooler, or when defrosting an air cooler or high ambient temperature when the plant is at a standstill;
- expansion of liquid refrigerant in a closed space without the presence of vapour, caused by a rise in external temperature;
- fire.

(*c*) *from the direct effect of the liquid phase*

- excessive charge or flooding of apparatus;
- presence of liquid in compressors, caused by siphoning, or condensation in the compressor;
- loss of lubrication due to emulsification of oil.

(*d*) *from the escape of refrigerants*

- fire;
- explosion;
- toxicity;
- panic.

No reference is made to dangers common to all compression plants, such as : excessive temperature at discharge, erroneous operation (for example, discharge valve closed while running) or reduction in mechanical strength caused by corrosion, erosion or vibration. Corrosion, however, should have special consideration as conditions peculiar to refrigerating plants arise due to alternate frosting and defrosting or the covering of apparatus by insulation.

The above analysis of the risks applying to refrigerating installations explains the plan on which the present ISO Recommendation has been based.

After general considerations (Part I), definitions (Part II) and a classification of the occupancies, the cooling systems and the refrigerants (Part III), Part IV defines the precautions to be considered at the design, construction and assembly stages, in the choice of working and test pressures, in the use of materials and in the disposition of safety devices in the various parts of the installation. Part V provides rules for the application of refrigerating equipment in the various types of occupancy for exits and ventilation in terms of the number of persons involved and also miscellaneous precautions. Finally, Part VI describes instructions necessary to safeguard personnel, to secure correct operation of the plant and to prevent its deterioration.

Small refrigerating equipment, such as refrigerators, commercial refrigerated cabinets and unit air conditioners, having specific safety aspects may require appropriate additional recommendations. Taking into account, however, that, on the one hand, such special recommendations are not yet available and that, on the other hand, a number of general requirements included in this ISO Recommendation also apply to small equipment, the clauses including requirements of the latter nature are accordingly given (see clause 2.2).

PART I

GENERAL

1. SCOPE

1.1 This ISO Recommendation is drawn up for the protection of life and limb and the health of the individual and also for the prevention of damage to property.

1.2 In order to attain these objectives, good design, construction, installation, operation and management are necessary.

1.3 This ISO Recommendation is applicable to new refrigerating plants, extensions and modifications of already existing plants, and for used plants on being transferred to and operated on another site. Deviations are permissible only if equivalent protection is ensured.

1.4 This ISO Recommendation also applies in the case of the conversion of a plant for another refrigerant, for example R 40 to R 12 or ammonia to R 22.

1.5 Conversions of and changes to existing plant should be carried out only by the manufacturer or a competent installer.

2. FIELD OF APPLICATION

2.1 This ISO Recommendation, when pertinent, applies to all kinds of refrigerating systems in which the refrigerant is evaporated and condensed in a closed circuit, including heat pumps and absorption systems but excluding systems using water or air as the refrigerant. If special regulations exist as, for example, for mines or transport (rail or road vehicles, ships and aeroplanes), they will supersede this ISO Recommendation insofar as they are more stringent.

2.2 In the case of small refrigerating equipment and factory assembled units, such as household refrigerators, commercial refrigerated cabinets, unit air conditioners, etc., with only a small charge of refrigerant, only some of the clauses are in general applicable. To facilitate the use of this ISO Recommendation, the clauses involved are listed separately in Annex B. Due consideration should also be given to any Recommendation issued by ISO or IEC relating to these small equipments.

PART II

DEFINITIONS

For the purpose of this ISO Recommendation, the following definitions apply.

3. **Refrigerating system**. A combination of interconnected, refrigerant-containing parts constituting one closed refrigerant circuit in which a refrigerant is circulated for the purpose of extracting and rejecting heat.

4. **Refrigerating plant or installation**. An assembly of components of a refrigerating system and all the apparatus necessary for its utilization.

5. **Absorption or adsorption refrigerating system**. A system in which refrigeration is effected by evaporation of a refrigerant, the vapour then being absorbed or adsorbed by an absorbent or adsorbent medium respectively, from which it is subsequently expelled at a higher partial vapour pressure by heating and liquefied by cooling.

6. **Limited charge refrigerating system**. A system in which the internal volume and total refrigerant charge are such that with the system idle, the maximum working pressure will not be exceeded if complete evaporation of the refrigerant charge occurs.

7. **Refrigerating unit**. See *Condensing unit*, *Compressor unit* and *Unit system*, below.

8. **Condensing unit**. A specific refrigerating machine combination for a given refrigerant, consisting of one or more power-driven compressors, condensers, liquid receivers (when required) and the regularly furnished accessories.

9. **Compressor unit**. A condensing unit less the condenser and liquid receiver.

10. **Unit system**. A complete factory-assembled, factory-charged and factory-tested system with a suitable frame or enclosure requiring no refrigerant-containing parts to be connected on site.

11. **Machinery**. The refrigerating equipment forming a part of the refrigerating system including any or all or the following : compressor, condenser, generator, absorber (adsorber), liquid receiver, connecting pipe, evaporator.

12. **Refrigerant compressor**. A mechanical component of a refrigerating system that withdraws refrigerant vapour – generally from the evaporator – and discharges it at a higher pressure.

13. **Positive displacement compressor**. A compressor in which increase in vapour pressure is attained by changing the internal volume of the compression chamber.

14. **Non-positive displacement compressor**. A compressor in which increase in vapour pressure is attained without changing the internal volume of the compression chamber.

15. **Condenser**. A heat exchanger in which the refrigerant, after compression to a suitable pressure, is condensed by rejection of heat to an appropriate external cooling medium.

16. **Receiver**. A vessel permanently connected to a system by inlet and outlet pipes for storage of a liquid refrigerant.

17. **Evaporator**. A heat exchanger in which liquid refrigerant, after reduction of its pressure (expansion), is evaporated by absorption of heat from the medium to be cooled.

18. **Coil or Grid**. A part of the refrigerating system constructed from bent or straight pipes or tubes suitably connected and serving as a heat exchanger (evaporator or condenser).

19. **Pressure relief valve**. A pressure-actuated valve held shut by a spring or other means and designed to relieve automatically pressure in excess of its setting.

20. **Bursting disc**. A disc or foil which bursts at a pre-determined pressure.

21. **Fusible plug**. A device containing a material melting at a pre-determined temperature.

22. **High pressure limiting device**. A pressure-actuated adjustable instrument (for example, a high pressure switch) designed to stop the operation of the pressure-imposing element and which may also operate an alarm.

23. **Piping**. The pipes or tubes for interconnecting the various parts of a refrigerating system.

24. **Header**. A pipe or tube component of a refrigerating circuit to which several other pipes or tubes are connected.

25. **Refrigerant**. A fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and rejects heat at a higher temperature and a higher pressure of the fluid, usually involving changes of state of the fluid.

26. **Heat-transferring liquid (brine, water)**. Any liquid for the transmission of heat without any change in its liquid state and having no flash point or a flash point above 65 °C.

27. **Gauge pressure**. That part of the pressure exceeding the atmospheric pressure. Generally it is assumed to be 1 bar less than the absolute pressure.

28. **High pressure side**. That part of a refrigerating system subject to the pressure of condensation.

29. **Low pressure side**. That part of a refrigerating system subject to the pressure of evaporation.

30. **Internal gross volume**. Volume calculated from the internal dimensions of the container, no account being taken of the volume of the internal parts.

31. **Internal net volume**. Volume calculated from the internal dimensions of the container, after deduction of the volume of the internal parts.

32. **Critical density**. Density at critical temperature and critical pressure.

33. **Machinery room**. A room specially intended to contain components of the refrigerating system for reasons connected with safety.

34. **Humanly occupied space**. Space normally frequented or occupied by people with the exception of machinery rooms and of cold rooms used for storage purposes.

35. **Hallway**. A corridor for the passage of people.

36. **Lobby**. An entrance hall or large hallway serving as a waiting room.

37. **Exit**. A passage-way immediately in the vicinity of the door through which people leave a building.

38. **Vestibule with doors (air lock)**. An isolating chamber provided with separate entrance and exit doors allowing passage from one place to another whilst isolating one from the other.

39. **Changeover device**. A valve controlling two protection devices and so arranged that only one can be rendered inoperative at any given moment.

40. **Abnormal fire risk**. Danger arising from fires which cannot be controlled by the usual methods of protection against fire.

PART III

CLASSIFICATION

41. OCCUPANCIES

Considerations of safety in refrigerating systems take into account the site, the number of people occupying the site and the category of occupancy.

The categories are listed in Table 1. They refer to that part of a property and adjoining property where an installation would affect safety.

TABLE 1 – List of categories

Category	General characteristics	Examples
A	where persons are restricted in their movement	hospitals, court houses, prisons with cells
B	where people may freely assemble	theatres, dance rooms, department stores, passenger stations, schools, churches, lecture halls, restaurants
C	where sleeping accommodation is provided	homes, hotels, residential apartments, clubs, colleges
D	where any number of people may be assembled, a limited number being necessarily acquainted with the general safety precautions of the establishment	business or professional offices, small shops and small restaurants, laboratories, places for general manufacturing and the performance of work, markets with unrestricted entry
E	where only authorized persons have access and where manufacturing, processing or storage of materials or products takes place	plants manufacturing chemicals, food, beverages, ice cream and ice, refineries, cold stores, dairies, abattoirs

41.1 In establishments with more than one category of occupancy, the most stringent requirements apply, unless the different occupancies are separated and cut off from the rest of the building by tightly sealed partitions, floors and ceilings, in which case the requirements of the individual occupancies apply.

41.2 When installing plants in locations adjacent to property classified in categories defined in this section, due regard should be paid to the safety of adjacent property.

42. COOLING SYSTEMS

Cooling systems can be classified, as shown in Table 2, according to the method of extracting heat from the air or substance to be cooled.

42.1 Direct cooling system

The evaporator of the refrigerating system is in direct communication with the air or the substance to be cooled.

42.2 Indirect cooling systems

The evaporator of the refrigerating system, located externally to the space where the heat is extracted from the air or substance to be cooled, cools a heat-transferring liquid (see Part II – Definitions) which is circulated to cool the air or substance concerned.

42.2.1 *Indirect open system*. The evaporator cools the heat-transferring liquid which is brought into direct communication with the air or substance to be cooled by sprays or similar means.

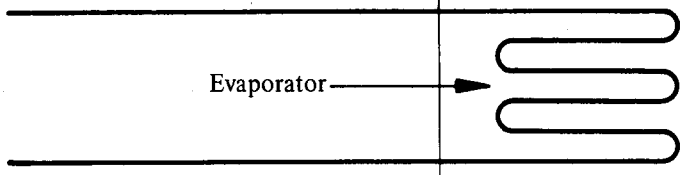
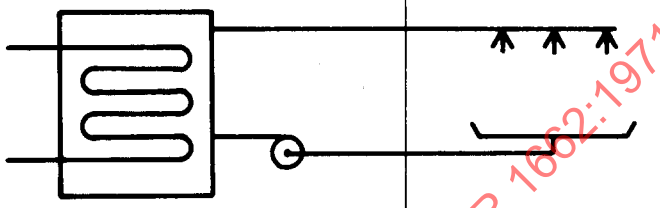
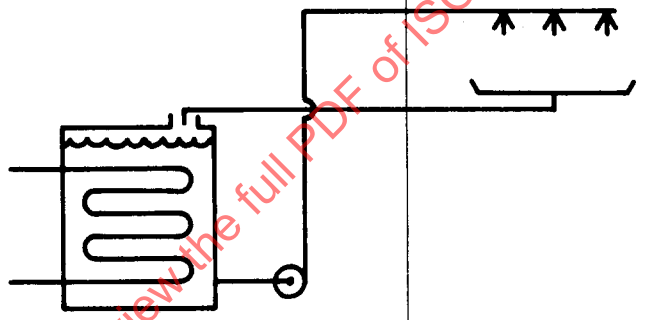
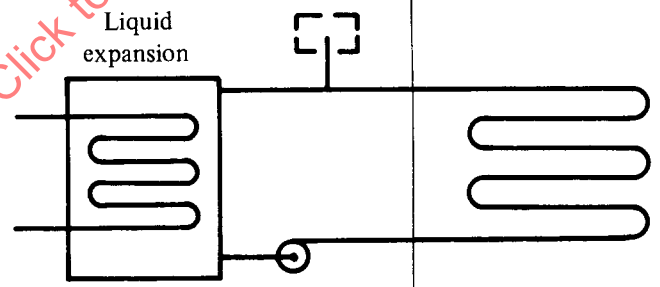
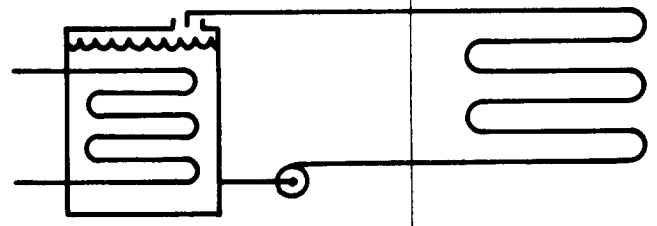
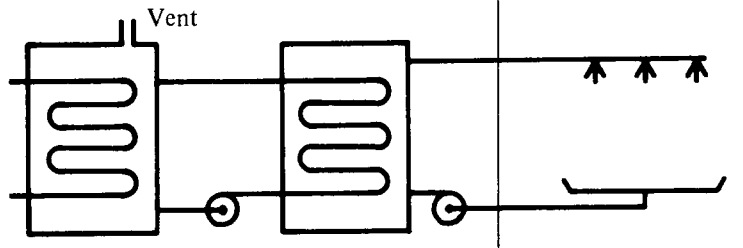
42.2.2 *Indirect vented open system*. This system is similar to that of clause 42.2.1, except that the evaporator is placed in an open tank or appropriately vented with comparable effet.

42.2.3 *Indirect closed system*. The evaporator cools the heat-transferring liquid which passes through a closed circuit in direct communication with the air or substance to be cooled.

42.2.4 *Indirect vented closed system*. This system is similar to that of clause 42.2.3, except that the evaporator is placed in an open tank or appropriately vented with comparable effect.

42.2.5 *Double indirect system*. This system is similar to that of clause 42.2.4, except that the cooled heat-transferring liquid passes through a second heat exchanger located externally to the space as mentioned in clause 42.2 and cools a second heat-transferring liquid which is brought into direct communication with the air or substance to be cooled by sprays or similar means.

TABLE 2 – Classification of cooling systems

Clause	Designation	Refrigerating system	Air or substance to be cooled
42.1	Direct system		
42.2.1	Indirect open system		
42.2.2	Indirect vented open system		
42.2.3	Indirect closed system		
42.2.4	Indirect vented closed system		
42.2.5	Double indirect system		

43. REFRIGERANTS

43.1 For the purpose of this ISO Recommendation, refrigerants are classified in three groups (see Table 3) :

43.1.1 *Group 1* comprises refrigerants that are non-flammable and may be used in direct systems where the total charge, adequate in quantity for the refrigeration requirements of the spaces concerned, could escape into the related spaces (except machinery rooms) without creating undue hazards.

43.1.2 *Group 2* comprises refrigerants that have toxicity as a dominant characteristic. It is almost impossible to make a functioning refrigerating plant with the quantity of the refrigerant that would be below toxic concentration if it escaped into the spaces concerned. A few refrigerants in this group are flammable but with a lower ignition limit of 3.5 % or more by volume. Appropriate additional restrictions are required for these.

NOTE. – For ammonia see also clause 51.2.3.

43.1.3 *Group 3* comprises refrigerants that have their explosive or flammable characteristics dominant with a lower ignition limit below 3.5 % by volume. They are, in general, non-toxic but lend themselves to special application where, because of other circumstances, they are generally valid and special regulations apply.

43.2 The application of direct system cooling to humanly occupied space is a major safety matter and, for this reason, consideration of the permitted amounts relates particularly to group 1.

Table 4 shows the comparative results of laboratory tests for various periods of exposure in various concentrations of refrigerant in air. The conditions visualized apply only to refrigerating requirements; in other words, no significant concentration can occur in refrigeration usage except as an abnormal or untoward occurrence. The information on toxicity data has been extended so as to apply to group 2 refrigerants for comparison only, as these refrigerants, for other reasons, are not permitted for general application in the various occupancies.

Some of the gases tested showed no lasting, harmful effects at 25 % concentration but there remains the problem that toxic decomposition products might result from contact with flames or hot surfaces under certain conditions. Among these, hydrochloric acid, chlorine and phosgene are toxic, but they provide an automatic and definite warning by their exceedingly irritant smell even at concentrations too low to produce harmful effects.

To provide a sufficient margin for safety, a top limit is set in Table 5 for the use of group 1 refrigerants at 10 % by volume of the smallest humanly occupied space concerned, machinery rooms excepted. In the case of these refrigerants where a 10 % concentration has shown harmful effects, this figure has been halved (carbon dioxide) or halved again (R 21, R 113) to establish a safe basis for use.

The total volume of all rooms cooled by air from one system may be used as the criterion if the air supply to each room cannot be restricted below 25 % of the full supply to each.

43.3 The following refrigerants of group 2,

– methyl chloride
– methyl formate
– ethyl chloride
– dichloroethylene

and all refrigerants of group 3 are flammable. Where the quantity in any refrigerating system exceeds the amount given in Table 5 in any room in which any part of the system is installed, then no flame-producing devices or surfaces above 400 °C should be permitted and all electrical equipment should comply with the requirements for hazardous areas. Notwithstanding the foregoing, quantities in excess of 500 kg should not be used without authorization.

NOTE. – For ammonia see clause 51.2.3.

TABLE 3 – Physical properties of refrigerants

Group	Refrigerant number	Chemical name	Chemical formula	Molecular mass	Gas constant	Boiling point at 1.013 bar		Freezing point		Critical temperature		Critical pressure (absolute)		Combustibility			
														Ignition temperature		Explosive range : Concentration in air	
	R				J/(kg·K)	°C	°F	°C	°F	°C	°F	bar*	lbf/in²	°C	°F	Low limit % by volume	Upper limit % by volume
1	11	Trichlorofluoromethane	CCl_3F	137.4	60.5	23.8	75	−111	−168	198	388	43.7	634				
	12	Dichlorodifluoromethane	CCl_2F_2	120.9	68.64	− 29.8	− 22	−158	−252	112	234	41.2	597				
	13	Chlorotrifluoromethane	$CClF_3$	104.5	79.64	− 81.5	−115	−181	−294	28.8	84	38.6	560				
	13B1	Bromotrifluoromethane	$CBrF_3$	148.9	55.9	− 58	− 72	−168	−270	67	153	39.6	575				
	21	Dichlorofluoromethane	$CHCl_2F$	102.9	80.79	8.92	48	−135	−211	178.3	353	51.7	750				
	22	Chlorodifluoromethane	$CHClF_2$	86.5	96.2	− 40.8	− 41	−160	−256	96	205	49.3	716				
	113	Trichlorotrifluoroethane	CCl_2FCClF_2	187.4	44.44	47.7	118	− 35	− 31	214.1	417	34.1	495				
	114	Dichlorotetrafluoroethane	$CClF_2CClF_2$	170.9	48.64	3.5	38	− 94	−137	145.7	294	32.8	475				
	115	Chloropentafluoroethane	$CClF_2CF_3$	154.5	53.84	− 38.7	− 37	−106	−159	80	176	31.2	453				
	C318	Octofluorocyclobutane	C_4F_8	200	41.59	− 5.9	21.5	− 41.4	− 42.5	115	240	27.9	403.6				
	500	R 12 (73.8 %) + R 152 (26.2 %)	CCl_2F_2 / CH_3CHF_2	99.29	83.75	− 28	−159	−159	−254	105	221	43.4	631				
	502	R 22 (48.8 %) + R 115 (51.2 %)	$CHClF_2$ / $CClF_2CF_3$	112	74.52	− 45.6	− 50	–	–	90	194	42.7	619				
		Carbon dioxide	CO_2	44	189	− 78.5	−109	− 56.6	− 70	31	88	73.8	1070				
2		Ammonia	NH_3	17	488.3	− 33.3	− 28	− 77.9	−108	132.4	270	113	1638	630	1166	15	28
	30	Methylene chloride	CH_2Cl_2	84.9	978.6	40.1	104	− 96.7	−142	250	480	46.1	670	–	–	–	–
	40	Methyl chloride	CH_3Cl	50.5	164.7	− 24	− 11	− 97.6	−143	143	290	66.8	969	625	1155	7.1	18.5
		Methyl formate	$C_2H_4O_2$	60	138.6	31.2	88	−104.4	−149	214	417	60	870.5	456	853	4.5	20
		Sulphur dioxide	SO_2	64	129.8	− 10.0	14	− 75.5	−104	157.5	315	78.8	1144	–	–	–	–
	160	Ethyl chloride	CH_3CH_2Cl	64.5	128.9	12.5	54.5	−138.7	−218	187.2	369	52.7	764	510	950	3.6	14.8
	1130	Dichloroethylene	$CHCl=CHCl$	96.9	85.8	48.5	119	− 56.7	− 70	243	469	53.3	774	458	857	6.2	16
3	170	Ethane	CH_3CH_3	30	276.5	− 88.6	−128	−183	−297	32.1	90	49	711	515	959	3.0	15.5
	290	Propane	$CH_3CH_2CH_3$	44	188.6	− 42.8	− 44.5	−188	−307	96.8	206	42.6	617	470	878	2.1	9.5
	600	Butane	$CH_3CH_2CH_2CH_3$	58.1	143.2	0.5	33	−135	−211	152.8	307	35.5	515	365	689	1.5	8.5
	600a	Isobutane	$CH(CH_3)_3$	58.1	143.2	− 10.2	14	−145	−229	133.7	273	37	536	460	860	1.8	8.5
	1150	Ethylene	$CH_2=CH_2$	28	296.1	−103.7	−154	−169.4	−273	9.5	50	50.6	730	425	797	2.7	34

* 1 bar = 10^5 N/m²

TABLE 4 – Physiological properties of refrigerants

Group	Refrigerant number R	Chemical name	Chemical formula	Lethal or serious injury within a few minutes	Dangerous within 30 to 60 minutes	No injury within 1 to 2 hours	See Note (last column)	Caution	Notes
				% by volume concentration in air					
1	11	Trichloro-fluoromethane	CCl_3F			10	*a*	Toxic decomposition products may be found in the presence of open flames. Their intense smell, however, provides an unmistakable warning before dangerous concentrations arise.	*a*) Higher concentrations are slightly narcotic.
	12	Dichloro-difluoromethane	CCl_2F_2			20 to 30	*b*		
	13	Chloro-trifluoromethane	$CClF_3$			20 to 30	*b*		*b*) Higher concentrations cause deficiency of oxygen leading to suffocation.
	13B1	Bromo-trifluoromethane	$CBrF_3$			20 to 30	*b*		
	21	Dichloro-fluoromethane	$CHCl_2F$		10	5	*a*		
	22	Chloro-difluoromethane	$CHClF_2$			20	*b*		
	113	Trichloro-trifluoroethane	CCl_2FCClF_2		5 to 10	2.5	*a*		
	114	Dichloro-tetrafluoroethane	$CClF_2CClF_2$			20 to 30	*b*		*c*) No warning smell but exceptionally narrow range between non-toxic and lethal conditions.
	115	Chloro-pentafluoroethane	$CClF_2CF_3$			20 to 30	*b*		
	C318	Octofluoro-cyclobutane	C_4F_8			20 to 30	*b*		
	500	R 12 (73.8 %) + R 152 (26.2 %)	CCl_2F_2 / CH_3CHF_2			20	*b*		
	502	R 22 (48.8 %) + R 115 (51.2 %)	$CHClF_2$ / $CClF_2CF_3$			20	*b*		*d*) Warning smell at very low concentrations.
		Carbon dioxide	CO_2	8	5 to 6	2 to 4	*c*		
2		Ammonia	NH_3	0.5 to 1.0	0.2 to 0.3	0.01 to 0.03	*d*, *e*	Corrosive	*e*) Irritant at very low concentrations.
	30	Methylene chloride	CH_2Cl_2	5 to 5.4	2 to 2.4	0.2	*a*	Toxic decomposition products (see above)	
	40	Methyl chloride	CH_3Cl	15 to 30	2 to 4	0.05 to 0.1	*f*		
		Methyl formate	$C_2H_4O_2$	2 to 2.5	0.9 to 1.0		*c*		
		Sulphur dioxide	SO_2	0.2 to 1.0	0.04 to 0.05	0.005 to 0.004	*d*, *e*	Corrosive	
	160	Ethyl chloride	CH_3CH_2Cl	15 to 30	6 to 10	2.0 to 4.0	*f*	Toxic decomposition products (see above)	*f*) Very narcotic.
	1130	Dichloroethylene	$CHCl=CHCl$		2 to 2.5		*f*		
3	170	Ethane	CH_3CH_3		6.3	4.7 to 5.5	*g*	Highly flammable	*g*) No lethal or serious injury at concentrations below lower explosion limits. Virtually non-toxic.
	290	Propane	$CH_3CH_2CH_3$			4.7 to 5.5	*g*		
	600	Butane	$CH_3CH_2CH_2CH_3$			5.0 to 5.6	*g*		
	600a	Isobutane	$CH(CH_3)_3$			4.7 to 5.5	*g*		
	1150	Ethylene	$CH_2=CH_2$				*g*		

TABLE 5 – Practical limits of concentration of refrigerants

Group	Refrigerant number	Chemical name	Chemical formula	Practical limits (see clauses 43.2 and 43.3)	
	R			% by volume	g/m³
1	11	Trichloro-fluoromethane	CCl_3F	10	570
	12	Dichloro-difluoromethane	CCl_2F_2	10	500
	13	Chloro-trifluoromethane	$CClF_3$	10	440
	13B1	Bromo-trifluoromethane	$CBrF_3$	10	610
	21	Dichloro-fluoromethane	$CHCl_2F$	2.5	100
	22	Chloro-difluoromethane	$CHClF_2$	10	360
	113	Trichloro-trifluoroethane	CCl_2FCClF_2	2.5	185
	114	Dichloro-tetrafluoroethane	$CClF_2CClF_2$	10	720
	115	Chloro-pentafluoroethane	$CClF_2CF_3$	10	640
	C318	Octofluoro-cyclobutane	C_4F_8	10	800
	500	R 12 (73.8 %) + R 152 (26.2 %)	CCl_2F_2 / CH_3CHF_2	10	410
	502	R 22 (48.8 %) + R 115 (51.2 %)	$CHClF_2$ / $CClF_2CF_3$	10	460
		Carbon dioxide	CO_2	5	95
2		Ammonia	NH_3	*	
	30	Methylene chloride	CH_2Cl_2		
	40	Methyl chloride	CH_3Cl	4	90
		Methyl formate	$C_2H_4O_2$	2.2	58.8
		Sulphur dioxide	SO_2	–	–
	160	Ethyl chloride	CH_3CH_2Cl	1.8	51.8
	1130	Dichloroethylene	$CHCl=CHCl$	2.8	122
3	170	Ethane	CH_3CH_3	1.6	21.45
	290	Propane	$CH_3CH_2CH_3$	1.2	23.65
	600	Butane	$CH_3CH_2CH_2CH_3$	0.9	23.35
	600a	Isobutane	$CH(CH_3)_3$	0.9	23.35
	1150	Ethylene	$CH_2=CH_2$	1.4	17.5

* For ammonia see clause 51.2.3.

PART IV

REFRIGERATION MACHINES AND PLANTS

44. WORKING AND TEST PRESSURE

In this ISO Recommendation, the word "pressure" is used to mean "gauge pressure".* On pressure gauges, identification plates, etc., pressures should always be given as gauge pressures. Pressures below atmospheric pressure should be appropriately indicated, for example "vacuum".

44.1 Maximum working pressure

The maximum working pressure is the pressure which may not be exceeded either in operation or at rest except within the operating range (see clause 50.1.1.1) of the pressure relief device. It represents the basis of all other pressures in this ISO Recommendation and the pressure at which the relief device begins to operate should not exceed it.

44.1.1 The maximum working pressure depends on the highest temperature which may occur in the plant during operation or when at rest, on the content of non-condensable gases, on the methods of defrosting, etc. It may be differently specified for the high and low pressure side and for any necessary interstage pressure.

44.1.1.1 On the low pressure side, the pressure is mainly affected by the maximum temperature of this part of the system influenced, for example, by the ambient temperature or the defrosting system.

44.1.1.2 On the high pressure side, the determining factor is normally the temperature of condensation which may occur under the least favourable conditions. The pressure may, however, be influenced remarkably by other factors, for example the amount of non-condensable gases present, and intense radiation from the sun.

44.1.2 Where an interstage pressure is necessary to the design it will be stipulated by the designer. It may be equal to that of the high pressure side or of the low pressure side or between the two.

44.2 Design pressure

The design pressure, used to determine the constructional characteristics of the apparatus, should not be less than the maximum working pressure.

44.3 Test pressure

The test pressure is the pressure which is applied to test the strength of a refrigerating system and/or of any part of it. It should invariably be higher than the maximum working pressure. No permanent deformation should result from these tests.

44.3.1 *Manufacturer's test of the components*. Every component should be subjected to a strength test followed by a leakage test at the manufacturer's premises before delivery or on site if not previously tested. The pressure should be applied gradually and carefully.

44.3.1.1 The strength test is generally but not necessarily carried out with liquids (for example, water or oil); except for pressure gauges and control devices constructed so that they cannot withstand the pressure without permanent distortion, the test pressure should be

(*a*) for iron castings and castings in other materials; at least 1.5 times the maximum working pressure;

(*b*) for steel construction and other rolled or drawn materials, at least 1.3 times the maximum working pressure.

Higher test pressures may be used if they do not cause permanent distortion.

* except for Table 3.

44.3.1.2 The leakage test should be carried out with a non-dangerous gas (for example, air) at a pressure not less than the maximum working pressure but not exceeding 1.1 times the maximum working pressure.*

For hermetically sealed units in series production, a higher leakage test pressure may be used if it does not cause permanent distortion.

44.3.1.3 In all cases where pneumatic pressure is applied to a component as a strength test or leakage test, adequate precautions should be taken to prevent completely danger to people and to minimize the risk of damage to property.

44.3.2 *Leakage test after erection or assembly*. Before putting into service, the complete system should be subjected to a pressure test with a suitable gas (for example air, nitrogen or other inert gas) to at least the maximum working pressure of the plant. The use of oxygen is very dangerous and is prohibited. In this test some refrigerant may be added to enable any leakages to be more easily detected, but explosive or flammable refrigerants other than ammonia should not be used.*

NOTE. – The means for building up a pressure for testing purposes should have a pressure limiting device, reducing valve (with gauge) or other device for preventing any pressure being imposed over that prescribed.

A certificate to the effect that the pressure test has been carried out should be drawn up for the user of the equipment by the competent person responsible for the erection of the plant or the assembly of the unit.

44.3.3 *Leakage test for small equipment*. For testing small installations defined in clause 2.2, the use of the refrigerant intended for operation at a pressure lower than the maximum working pressure is allowed.

For small installations, the certification may take the form of the inspection clearance mark, stamp or docket of a competent person or the manufacturer's name and data plate, this data plate preferably showing the test pressure applied.

45. MATERIALS

In selecting constructional, welding and brazing materials for refrigerating plants, care should be taken that they will bear the chemical, mechanical and thermal stresses. They should be resistant to refrigerants to be used, to the refrigerant and oil mixtures with possible impurities and contaminants and to the heat-transferring liquids. For pressure vessels, the special references under section 46 should be followed.

For parts under pressure (including connecting pipes), materials with strength values tested and certified by the manufacturer should be used. For use at low temperatures they should have adequate impact strength.

45.1 Ferrous materials

45.1.1 *Cast iron and malleable iron* of dense and good quality may be used for machines and fittings of the refrigerant circuit as well as for heat-transferring liquid circuits. Parts connected to castings (for example, pipe conduits) should not cause unacceptable stresses.

45.1.2 *Steel and cast steel, unalloyed and low-alloyed*, of good quality may be used for all parts carrying refrigerant and also for heat-transferring liquid circuits. In low temperature installations, steel should be used with an adequate impact strength paying regard to thickness, the lowest service temperature and the test procedure.

45.1.3 *High-alloyed steel and cast steel*. The use of these special materials may be required at lower temperatures, higher pressures and where corrosion risks are present. The impact strength should be adequate for the particular duty, and the material suitable for welding.

* Oil/air mixtures should be avoided during the test.

45.2 Non-ferrous metals and their alloys (cast, forged, rolled and drawn)

45.2.1 *Copper and copper alloys*

45.2.1.1 COPPER. If copper is used in contact with refrigerants, it should be oxygen-free or deoxidized. However, for parts carrying the refrigerants ammonia and methyl formate, copper and alloys with a high percentage of copper should in general not be used.

45.2.1.2 COPPER ALLOYS (for example brass and bronze) may be used after carefully testing their compatibility with the materials coming into contact with them.

45.2.2 *Aluminium*. For the refrigerant methyl chloride, aluminium and its alloys should not be used.

If used as a material for gaskets in connection with other refrigerants, aluminium of adequate purity should be used.

45.2.3 *Magnesium* should not be used, except for special cases where alloys with a low percentage of magnesium may be used after carefully testing their ability to resist the materials coming into contact with them.

45.2.4 *Zinc* should not be used for the refrigerants ammonia and methyl chloride or for fluorinated refrigerants.

45.2.5 *Lead* should not be used for fluorinated refrigerants, except for packing purposes.

45.2.6 *Tin and lead/tin alloys* are corroded by fluorinated hydrocarbons. Their use at working temperatures under −10 °C is not recommended.

45.2.7 *Soldering and brazing alloys**

45.2.7.1 SOFT SOLDERING ALLOYS with tin as their basis may be used where mechanical stresses are low, but for working temperatures below −10 °C their use is not recommended.

The effect of the alloy components, for example lead (see clause 45.2.5) and tin (see clause 45.2.6) should not be disregarded.

45.2.7.2 BRAZING ALLOYS are used for higher stresses and for lower working temperatures.

The alloy components should be examined for their compatibility with refrigerants.

NOTE. – Due to the development of new soldering materials and methods, in particular for joining aluminium parts, recommendations are not given. Soldering materials containing zinc or other metals normally not compatible with certain refrigerants should, however, only be allowed after the manufacturer of the refrigerating equipment has proved conclusively that such soldering materials may be safely used.

45.3 Non-metallic materials

45.3.1 *Packing materials* for sealing joints and for sealing stuffing-boxes on fittings, etc., should be resistant to the refrigerants and refrigerating machine oils used and should also be suitable for the pressures and temperatures occurring. No erosion should occur which might cause leakages and risks.

45.3.2 *Glass* may be used in the refrigerant circuits and in the heat-transferring liquid circuits of machines, apparatus and pipes for fluid gauges and for observation ports. It should be of special quality resistant to the pressure, temperatures and chemical actions which may occur.

45.3.3 *Plastics* may be used provided they are adequate for the mechanical, thermal, chemical and long-term creep stresses occurring and provided they do not increase risks from fire. Reference should be made to national and/or international codes as referred to in the Introduction.

* See ISO Recommendation R 857, *Definitions of welding processes.*

46. PRESSURE VESSELS

Pressure vessels should be designed and tested in accordance with national and/or international codes as referred to in the Introduction.

46.1 Parts considered as pressure vessels

A pressure vessel is any refrigerant-containing part of a refrigerating system other than

- compressors;
- evaporators each separate section of which does not exceed 15 litres of refrigerant-containing volume;
- coils and grids;
- headers of not more than 150 mm nominal internal diameter;
- pipes and their fittings;
- controls.

46.2 Compulsory testing and marking of pressure vessels

Pressure vessels in accordance with clause 46.1 should be tested by a competent person. Those pressure vessels whose maximum working pressure exceeds 0.5 bar and in which the product of the internal net volume of the vessels in litres and the maximum working pressure in bars exceeds the figure 200, require marking in accordance with clause 46.5.

46.3 Pressure relief devices for pressure vessels

Pressure relief devices, as defined in clause 50.1.1, should be arranged according to clause 50.2.5.

46.4 Testing pressure vessels

Pressure tests should be carried out in accordance with the provisions of section 44, under the supervision of a competent person and having regard to the appropriate safety measures.

46.5 Marking

All pressure vessels which require marking in accordance with clause 46.2 should be provided with an identification plate bearing at least the following data :

- manufacturer's or supplier's name;
- serial number;
- year of manufacture;
- maximum working pressure;
- internal net volume;
- designation of refrigerant;
- hydraulic test pressure factor; ,
- date of pressure test;

and, for low temperature vessels :

- minimum permissible temperature.

The identification plate should be permanently connected to the vessel. If the plate is not readily visible, a second plate marked with the word "DUPLICATE" should be fixed in the most convenient adjacent position.

46.6 Certificates

Pressure test certificates and any necessary copies should be prepared on behalf of and signed by the persons witnessing and responsible for the tests.

46.7 Repeat test

This should be carried out on pressure vessels of refrigerating plant when apparatus has been taken out of service, emptied and subjected to considerable repair work. The working parts should not be interfered with thereby. It is not necessary to remove the insulation for external inspection unless this appears essential for special reasons.

In the case of removal of a plant to another working site or when using a pressure vessel in another installation, a repeat test should be carried out.

47. REFRIGERANT PIPING AND FITTINGS

47.1 General

For piping, piping connections, fittings and accessories, national and/or international codes as referred to in the Introduction should apply.

47.2 Materials

Tubes, connections and fittings should be made of such materials as may be used for pressure vessels. It is particularly important to keep those materials under observation when they are exposed to the refrigerants used and to the temperatures encountered in service (see section 45).

47.3 Tubes

The use of seamless steel or copper tubes, or welded steel or copper tubes of comparable strength, is recommended. The tubes should satisfy the pressure and temperature stress conditions. Works' certificates should be provided if requested.

47.4 Tube connections

These may be welded, brazed, soldered or flanged, or screw couplings may be used. The connections should be gas- and liquid-tight.

47.4.1 *Flanges* should be adequate for the maximum working pressure and should be in accordance with the calculations specified in the regulations for pressure vessels. The construction and choice of materials should be such as to prevent the packing being forced out. The packing material should be resistant to refrigerant and oil.

47.4.2 *Screw couplings* may be used for certain applications, for example, for copper tubing, screw couplings or single or double-flared screw couplings and for steel tubing, cutting-ring screw couplings and the like.

47.4.3 *Welded, brazed and soldered joints*. All joints obtained by welding, brazing or soldering should be perfectly gas-tight. For brazed and soldered joints, reference should be made to clause 45.2.7.

In view of its increased resistance to stresses caused by pressure, temperature and vibration and for gas-tightness, brazing is preferred to soldering. In all cases, the possibility of corrosion should be considered.

47.5 Shut-off devices (valves, cocks, gate valves)

These should be in accordance with current standards. It should be possible to tighten or to remove gland packing while under pressure. Unintentional turning out of valve spindles should be prevented.

47.5.1 *Shut-off devices for operation at any time* should be provided with a handwheel or some other rigidly mounted operating element.

47.5.2 *Shut-off devices without any duty during the operation of the plant*, used for example for facilitating repairing and maintenance, should not be provided with operating handles or with devices which can be operated without the use of appropriate tools.

A shut-off valve with a screwed cap complies with this requirement if the cap cannot be used to operate the valve.

Refrigerant under pressure that might be present under the cap should be vented rapidly when starting to remove the cap.

47.5.3 *Arrangement of shut-off devices* (see clause 50.2.4). To minimize danger and loss of refrigerant, it is recommended that machines and apparatus be equipped individually or in groups with isolating valves with handwheels for immediate operation or other quick-acting valves, for example "fail-safe" solenoid valves. Shut-off devices which do not require to be operated when the plant is running or in emergency are preferably selected according to clause 47.5.2 and fitted with a cap. Facilities for emptying should be provided on machines and apparatus.

47.5.4 *Numbering*. It is recommended that all shut-off devices should be identified, for example with a number (see also clause 55.1.2).

47.6 **Pipelines installed on site** (see also section 54)

Refrigerant circuits should be securely fixed. The distance between the holders depends on the size and service mass of the pipeline. The free clearance around the pipeline should be sufficient to allow any necessary checking, and subsequent repacking of flanges, screw joints, and fittings, etc. Free passage should not be obstructed.

Pipes passing through fireproof walls and ceilings should be so sealed as not to allow spreading of fire to neighbouring rooms. Pipe ducts and shafts should be shut off from other rooms in such a way as to be fireproof.

In the case of long runs of pipelines, provisions should be made for expansion.

Flexible hoses, as for example those used in plate freezers, should be well protected against any possibility of mechanical damage.

47.7 **Marking or pipes installed on site**

It is recommended that pipes be marked in different colours, preferably according to a suitable colour code, in order to indicate the substance flowing through them.

48. MISCELLANEOUS PARTS

Parts of refrigerating systems other than control mechanisms or pressure gauges and not governed by national and/or international codes as referred to in the Introduction should be designed, constructed and assembled so as to be capable of withstanding the "erection and assembly test" without being stressed beyond the limits as set out in the relevant national and/or international codes for pressure vessels (see clause 44.3.1).

49. INDICATING AND MEASURING INSTRUMENTS

Refrigerating plants should be equipped with the indicating and measuring instruments necessary for adequate service and operation.

49.1 **Refrigerant pressure gauges**

49.1.1 *Calibration and marking*. The dials of these pressure gauges are calibrated in pressures with the corresponding saturation vapour temperatures.

The gauges should be marked to show the refrigerants for which they are suitable. The maximum working pressure should be indicated by a red mark. The requirements of this clause only apply to permanently mounted gauges.

49.1.2 *Arrangement*

49.1.2.1 COMPRESSORS should be equipped with pressure gauges when the charge mass of the system with refrigerant of group 1 exceeds 50 kg and, with refrigerant of group 2, 25 kg. Below these limits, pressure gauge connections should be provided, but the fitting of permanent pressure gauges is optional. When using refrigerants of group 3, and also carbon dioxide, pressure gauges should always be fitted.

49.1.2.2 POSITIVE DISPLACEMENT LIQUID PUMPS should be fitted with pressure gauges on the discharge side. A suitable gauge-damping device or a self-closing valve should be included to prevent leakage of dangerous fluid.

49.1.2.3 PRESSURE VESSELS REQUIRING TESTING should be provided with a pressure gauge connection which is separate and remote from the test pressure connection, unless the person responsible for the supervision of the test (see clause 46.4) has taken steps to ensure that the vessel is, in fact, subjected to the pressure indicated by the pressure gauge.

49.1.2.4 HEATING JACKETS of pressure vessels should be equipped with a pressure gauge and a thermometer.

49.1.2.5 APPARATUS which is cleaned or defrosted in the warm or hot state and is under manual control should be equipped with pressure gauges.

49.2 Liquid level indicators

The test pressure of liquid level indicators should be at least equal to the test pressure applied to those parts of the system to which they are fitted. Top and bottom connections of glass tube type indicators should have automatic shut-off devices. Such glass tube indicators should have adequate guards against wanton or accidental damage and to prevent injury to observers in the event of glass breakage.

50. PROTECTION AGAINST EXCESSIVE PRESSURE (see also section 46)

50.1 Protection devices

50.1.1 *Pressure relief devices*

50.1.1.1 PRESSURE RELIEF VALVES. The adjustment of the valve should be sealed after testing and setting, the seal having the identifying mark of a competent person. The set pressure should be marked on the seal or on the valve body.

The pressure at which a pressure relief valve is fully opened should not exceed 1.1 times the pressure at which the valve begins to open.

50.1.1.2 BURSTING DISCS AND HOLDERS. The disc should be firmly clamped in its holder. The inner circular cross-section of the holder serves as the free aperture cross-section for the disc. Not less than this free aperture cross-section should be maintained throughout the body of the device.

Each disc or foil should bear the name of the manufacturer and the bursting pressure in such a manner that the operation is not affected.

50.1.1.3 FUSIBLE PLUGS. The melting temperature of the material should be stamped on the plug. For the intended protection, the charge in the system or vessel protected by a fusible plug should not exceed the amount corresponding to critical density.

50.1.2 *High pressure limiting devices*. This type of device cannot prevent a rise in pressure when the machine is at a standstill. A service valve that cannot readily be operated (in accordance with clause 47.5.2) may be fitted to a high pressure limiting device if there is an alternative safeguard against high pressure.

50.2 Application of the protection devices

50.2.1 *Protection of the system*. Every refrigerating system should be protected by a pressure relief device, except insofar as a soldered joint can safely work as a fusible plug or unless it is otherwise so constructed that pressure due to fire conditions will be safely relieved.

50.2.1.1 This pressure relief device should be so fitted as to protect the high pressure side of the refrigerating system (see also clause 50.2.3).

50.2.1.2 This pressure relief device can discharge into the atmosphere or, in accordance with clause 50.2.5.4, into the low pressure side of the system.

50.2.1.3 If the high pressure side of the system is protected by means of a pressure relief valve blowing into the low pressure side, the low pressure side should be fitted with a pressure relief valve or bursting disc of adequate capacity discharging into the atmosphere.

50.2.2 *Protection of machinery components*

50.2.2.1 POSITIVE DISPLACEMENT COMPRESSORS absorbing more than 10 kW prime-mover power or having more than 23.6 l/s of swept volume should be equipped with a pressure relief valve or bursting disc between the compressor and discharge stop valve, if any, adequate to prevent a rise in pressure which could endanger the compressor. The discharge from the device may be vented to atmosphere or into the low pressure side of the refrigerating system.

Moreover, compressors absorbing more than 10 kW prime-mover power should be protected by means of a pressure-limiting device, the set pressure of which should be lower than the maximum working pressure of the high pressure side. This also applies to smaller compressors which can be shut off on the high pressure side.

50.2.2.2 NON-POSITIVE DISPLACEMENT COMPRESSORS need not have a pressure relief device on condition that it is not possible to exceed the maximum working pressure.

50.2.2.3 POSITIVE DISPLACEMENT PUMPS in any circuit of a refrigerating system should be protected by a pressure relief valve or bursting disc on the discharge side. The discharge from the device may be vented to atmosphere or into the low pressure side of the refrigerating system.

50.2.3 *Pressure vessels* (see also section 46)

Pressure vessels which may contain liquid refrigerant and which may be shut off from other parts of the refrigerating system should be protected by a pressure relief device of adequate capacity and in a manner defined as follows :

- pressure vessels with an internal net volume of 100 litres or more should be protected by means of a pressure relief valve or a bursting disc;
- pressure vessels of less than 100 litres internal net volume should be protected by means of a pressure relief valve, a bursting disc or, if on the high pressure side, by means of a fusible plug, with a further relaxation that a pressure relief device may be omitted from vessels of less than 150 mm internal diameter.

The foregoing requirements may be relaxed insofar as evaporators or parts of evaporators have inside diameters of less than 150 mm.

50.2.4 *Other parts of the plant*. Due consideration should be given to the danger of liquid refrigerant being locked up in pipes or fittings between shut-off devices. Depending on circumstances (for example size of pipe, kind of refrigerant, surroundings and occupancy) a pressure relief device in accordance with clause 50.1.1.1 or 50.1.1.2, or other special safety arrangements, may be used.

50.2.5 *Arrangement of protection devices*

50.2.5.1 All protection devices should be mounted on, or in proximity to, a pressure vessel or other parts of a refrigerating system which they protect. They should be easily accessible and be placed, except for fusible plugs, above the level of the liquid refrigerant.

50.2.5.2 No stop valve should be inserted between the apparatus to be protected and the pressure relief device. A changeover device may, however, be used in order to facilitate testing and repairs.

50.2.5.3 In order to prevent loss of refrigerant, the bursting disc may be used in combination with a relief valve. Care should be taken that the pressure in the vessel can in no circumstances, such as leakage in the protection device, exceed the maximum working pressure.

50.2.5.4 Pressure relief devices may discharge into the low pressure side of the system provided that they are of a type not appreciably affected by back pressure and provided that the low pressure side of the system is equipped with protection devices of sufficient capacity to protect all connected vessels subjected to excess pressure simultaneously, calculated in accordance with the formulae applying to the protection devices for pressure vessels.

50.2.6 *Application of high pressure limiting devices*. A high pressure limiting device should be set so that it stops the pressure-imposing element at a pressure not higher than the maximum working pressure or, if a pressure relief device is provided, before the latter comes into action.

No stop valve that can readily be operated should be imposed between the pressure limiting device and the pressure-imposing element (see clause 50.1.2).

50.3 Discharge from pressure relief devices

50.3.1 The rated capacity of the protection device as well as the cross-section and the length of the discharge line should comply with national and/or international codes as referred to in the Introduction.

50.3.2 Discharge from pressure relief devices should take place in such a manner that persons are not endangered by the escaping refrigerant. It may be diffused into the air by adequate means, or discharged into an adequate absorbing liquid.

50.3.3 Two or more devices in parallel may be considered as a single device for the purpose indicated in clause 50.3.1.

50.3.4 Two pressure relief valves or bursting discs controlled by a changeover device should each be of the size required for the protection of the apparatus.

50.3.5 All protection devices and pipelines should be protected against adverse climatic effects.

50.4 Protection against abnormal fire risk

To protect plants against risks caused by abnormal fires, plants may have emergency discharge lines controlled by stop valves to facilitate rapid discharge of the refrigerant. The connection of such lines should be above the liquid level. The stop valves should be protected against improper use by enclosure in a locked box with a "break glass" access to its key and labelled "For emergency use in case of fire". The address and telephone number of the fire authority concerned should be marked on the box. Special care should be taken to prevent freezing of water (for example in evaporators) and to ensure a safe discharge of large volumes of refrigerant suddenly released. The discharge line should be calculated according to national and/or international codes as referred to in the Introduction and which take into account the heat load caused by fire.

51. ELECTRICAL INSTALLATIONS

The design, construction, installation, testing and use of electrical equipment should be in accordance with national and/or international codes as referred to in the Introduction.

51.1 General arrangements

51.1.1 *Main power supply*. The electrical power supply to refrigerating systems should be arranged so that it can be switched on or off independently of the electricity supply to other items of plant and equipment in general and, in particular, to any refrigerating plant lighting system, warning system and mechanical ventilation unit.

51.1.2 *Auxiliary electrical supply*

51.1.2.1 MECHANICAL VENTILATION. Fans for the ventilation of spaces containing refrigerating machinery should be so arranged that they can be controlled by switching arrangements both inside and outside the space and, if the space is not at ground level, by a further switch at ground level (see section 52).

51.1.2.2 LIGHTING. The brightness and disposition of the lighting appliances for normal use should allow free circulation of personnel in complete safety.

An emergency safe lighting system should be provided adequate to allow urgent operation of controls and evacuation of personnel. This lighting may be of portable type.

51.1.2.3 WARNING. An independent, low-voltage supply permanently available (for example battery) should be provided for use with warning systems installed in accordance with national and/or international codes as referred to in the Introduction and particularly with the IIF *Practical guide to refrigerating storage.*

51.2 Special arrangements

51.2.1 *Rooms containing machinery* (see also Part II, Definitions). Except in cases where condensation may occur due to the presence of cold elements, electrical installations in machinery rooms may be of a type suitable for dry spaces.

51.2.2 *Refrigerants of group 1* do not, in principle, require other special arrangements.

51.2.3 *Refrigerants of group 2 and group 3.* For the flammable refrigerants (see Table 3) the requirements as given in clause 43.3 apply.

NOTE. – Ammonia/air mixtures can be explosive but only at the unusually high concentration of 15 to 28 % by volume if ignited by a high temperature source. Taking into account, however, that 0.05 % or less is readily detected by smell and 2 % or less by suitable detectors, the following precautions (*a*) and (*b*) are recommended.

(*a*) In areas or enclosed spaces housing compressors or other non-static parts of refrigerating systems containing ammonia, isolation of electrical circuits should be effected by circuit breaker(s) installed in a safe place. The circuit breaker(s) should be controlled either

- by one or more detector devices operative at a predetermined low level of concentration, say 1 % or 2 %, fixed over non-static items of equipment from which a leakage might occur and arranged to give visual and audible alarm, to switch on equipment for increased ventilation (if installed) and flame-proof lighting (if installed); or
- if the area or enclosed space is continuously manned and occupied, by push buttons immediately outside. The push stop buttons should be of the "breakglass" type and located outside exit doors on a similar basis to the provision of fire alarm push buttons for hazardous areas.

(*b*) In cases where mechanical ventilation is used for normal purposes, it is recommended that two-speed fans should be installed for changing over to high speed (or additional fans installed and arranged to operate) when any ammonia detector operates or an emergency push stop button is pressed.

Where the fan motors and associated electrical equipment may be required to operate in flammable concentrations of gas, they should be of "flame-proof" construction. The construction and materials of the fans should not be conducive to fire or sparking.

The installation of one or more emergency push stop buttons remote from the area or enclosed space should be considered.

PART V

REQUIREMENTS FOR UTILIZATION

52. MACHINERY ROOMS

Machinery rooms (see Part II – Definitions) serve for accommodating refrigerating machinery. They need not serve exclusively for this machinery.

A machinery room should be so dimensioned that all parts are easily accessible with adequate space for proper service, maintenance, and operation.

There should be clear headroom of not less than 2 m below equipment situated over gangways.

52.1 General requirements

Refrigerating machinery rooms should have well-fitting doors opening outwards, self-closing if they issue into the building, and adequate in number to ensure freedom for persons to escape in an emergency. There should be no partitions or openings that could permit passage of escaping refrigerant to other parts of the building.

Machinery rooms should be ventilated to the outer air by means of windows (and door openings), or mechanical ventilation.

Windows (together with door openings) for such ventilation should have an area related to the mass of refrigerant in the largest refrigerating system, any part of which is in the machinery room and in accordance with the formula given in clause 52.3.1.

Furthermore, the air passing through the windows should not be obstructed by area walls, shaft walls, surrounding buildings or similar obstructions paying due regard to the density of the refrigerant concerned.

The mechanical ventilation referred to should be by power-driven fans capable of exhausting from the machinery room the amount of air given by the formula in clause 52.3.2.

The air inlet to fans or inlet ducts should be near the machinery and suitably guarded, and the discharge of the air should be to the outside of the building in such a manner as not to cause inconvenience or danger. Provisions for distributing replacement fresh air throughout the room should be made, thereby preventing short circuits.

In machinery rooms without windows and those in basements or sub-basements, a sufficient proportion of the ventilation specified in the formula in clause 52.3.2 should be in continuous operation for the safety, health and comfort of persons concerned. The use of two-speed fans may provide a convenient solution.

According to circumstances, the use of water sprinkler devices for ammonia should be considered.

52.2 Special requirements

52.2.1 In certain cases, as specified in clauses 54.2.2.1 and 54.2.2.2, and Table 6, the machinery room should meet the following additional requirements besides those given in clause 52.1 :

(*a*) communication with adjacent rooms, permanently occupied or for general use, only by means of tight-fitting, self-closing, vestibule-type doors of not less than 1 hour fire-resistive construction;

(*b*) walls, floors and ceilings should be tightly sealed and of not less than 1 hour fire-resistive construction;

(*c*) all piping through walls, ceilings and floors tightly sealed to these;

(*d*) exterior openings not under emergency exits and staircases;

(*e*) at least one safe emergency exit should be assured, preferably giving ready access to the open air;

(*f*) remote switch for stopping the machinery, outside and near the machinery room door, as well as a second switch on the ground floor if the machinery room is on another level;

(*g*) independent mechanical ventilation with independent emergency control located outside near the machinery room and on the ground floor;

(*h*) no flame-producing equipment permanently installed and operated.

52.2.2 When using refrigerants of group 3, the machinery room should comply with national and/or international codes as referred to in the Introduction.

52.3 Ventilation

52.3.1 *Natural ventilation*. The free aperture cross-section for the ventilation of the machinery room should amount to at least

$$F = 0.14 \sqrt{G}$$

where

F is the free opening area, in square metres;

G is the mass of the refrigerant charge, in kilogrammes, in the largest plant, any part of which plant is located in the machinery room.

52.3.2 *Mechanical ventilation*. The output of the mechanical ventilation system should be at least

$$Q = 13.88 \sqrt[3]{G^2}$$

where

Q is the air flow in litres per second;

G is the mass of the refrigerant charge, in kilogrammes, in the largest plant, any part of which plant is located in the machinery room.

52.4 Machine surrounds

These are tight-closing, non-flammable coverings for sets of machines which can be partly or wholly removed for work thereon. It should not be possible to enter the surround. Every surround should have a vent, if necessary, leading into the open air.

53. MISCELLANEOUS SPECIAL PRECAUTIONS

53.1 Liquid hammer

Liquid hammer in compressor cylinders can severely damage the valves and, in extreme cases, cause a rupture of cylinder covers, pistons or other parts.

Care should be taken, both at start up and during running, to prevent any excessive quantity of liquid refrigerant or oil from entering the compression chamber of the compressor. The separation of liquid should be adequate to ensure dry aspiration, if required.

Condensation of refrigerant in or near the compressor, due to a low ambient temperature, should be prevented, for example by means of heating; this applies in particular when the compressor is not running. The suction and discharge lines may be fitted with check valves or so arranged that no dangerous accumulation of liquid refrigerant or oil can arise in the vicinity of the compressor.

53.2 Protection of fans and other moving machinery

Fans and all moving machinery should be guarded in accordance with factory regulations or national and/or international codes as referred to in the Introduction.

53.3 Permissible charge of refrigerant

Owing to the expansion of liquids with rising temperature, due observance should be given to the filling of any vessel or bottle with liquid refrigerant, taking into account its specific density at the filling temperature and the maximum temperature which can be expected.

Consideration should be given to the matter of the fusing temperature of a fusible plug as regards a particular refrigerant and its pressure, because the protection given by a fusible plug, if the plant or vessel contains more liquid than the amount corresponding to its critical density, may not obviate rupture by hydraulic pressure.

53.4 Influence of heating elements near evaporators

Direct expansion coils or evaporators in air ducts in occupancies A and B, which can be valved off and are within 0.5 m of a heating coil, or in the hot air stream leaving a heating coil, should be fitted with a pressure relief valve or bursting disc discharging to the outside of the building unless of a volume that will contain the refrigerant charge and remain below critical conditions of density and temperature.

53.5 Limited charge systems

Limited charge systems should always be equipped with a pressure relief valve or bursting disc, regardless of size of plant.

53.6 Unauthorized entry or operation

Cold rooms, rooms with a controlled (and not harmful) atmosphere, machinery rooms, auxiliary plant rooms, switch rooms, etc. should be clearly marked as such on the doors together with warning notices that unauthorized persons must not enter.

Additionally, warning notices should be displayed prohibiting unauthorized operation of the plant.

53.7 Safety of personnel in cold rooms

Attention is drawn to the danger of persons being unable to move due to an accident, or falling asleep or being inadvertently locked in cold rooms, especially in those having temperatures below 0 °C. Some measures to increase safety are given in the following clauses.

53.7.1 Generally a person should not work alone in a cold room. However, if this is unavoidable, this person's safety should be verified at least every hour.

53.7.2 In the event of a failure of the lighting, the ways towards the emergency call should be indicated either by other independent lighting or by luminous paint or by other approved means.

53.7.3 Several minutes after work ceases, a responsible person should make a duty round so as to ensure that no one has remained behind in the cold rooms and to lock them after it has been ascertained that they are clear of personnel.

53.7.4 It should be possible to leave cold rooms at any time. It should be ensured that persons locked in can attract the attention of others outside or free themselves. Therefore, a suitable choice of the following provisions should be made.

53.7.4.1 Doors that can be opened both from the inside and outside.

53.7.4.2 A warning light with a fixed or flashing signal or a buzzer or bell operated from within, near the door and visible or audible in a constantly manned place and operated by illuminated buttons or by chains hanging near the floor.

53.7.4.3 An axe inside each room near the door.

53.7.4.4 A telephone in every room which can also be used for the regular interval telephone routine as referred to in clause 53.7.1.

53.7.4.5 An electric light switch on the inside of every room (with an indicator lamp outside.)

53.7.4.6 In the case of electrically or pneumatically operated doors, a device to open the door by hand.

53.7.4.7 Unlocked insulated safety exit door(s) which can only be opened from the inside.

53.7.4.8 A panel to be removed from the door from the inside of the room, large enough for a man to pass through easily.

53.7.5 All emergency exit doors should be in good functional order, periodically tested and easily accessible at any time.

53.8 Sprinklers for use for ammonia leakage

Due to the high absorption capacity of ammonia in water, the use of water sprinkler devices and/or a water screen may be considered according to circumstances, for example as protection in case of leakages in ammonia-plate-freezers with flexible connections, or from evaporators serving cold storage rooms containing goods, etc.

53.9 Marking

53.9.1 *The refrigerating system*. Refrigerating systems should be provided with a clearly visible plate near or on the machines giving at least the following information :

- installer's name and address*;
- year of installation;
- designation of refrigerant;
- maximum working pressure(s);
- mass of refrigerant charge.

53.9.2 *Compressors*. Each compressor should be provided with a permanently connected plate giving at least the following information :

- manufacturer's name;
- type;
- serial number;
- year of manufacture;
- designation of refrigerant;
- maximum working pressure;
- maximum number of revolutions per minute.

* If there is no installer, the name of the manufacturer should be given.

53.9.3 *Small compressors and refrigerating units* (see clause 44.3.3). Small compressors or refrigerating units should be provided with a fixed plate giving the following information :

- manufacturer's name;
- type;
- year of manufacture (may be part of the serial number);
- designation of refrigerant;
- maximum working pressure (may be omitted in hermetic systems).

53.9.4 *Other parts*. Main stop valves and controls for services (gas, air, water, electricity), remote control devices and pressure limiting devices should be clearly marked. Exposed refrigerant piping outside machinery rooms should be marked in accordance with ISO Recommendation R 817, *Number designation of organic refrigerants* (see also clause 47.7).

53.10 Heat-transferring liquids

If refrigerated water or brine is used, due observance should be given to ensure its suitability as regards temperature, pressure, quantity, purity and freedom from contamination.

53.11 Water lines

Water lines should not connect directly to a fresh water supply or to a drain or a sewer if there is any possibility of contamination. Reference should be made to national and/or international codes as referred to in the Introduction.

53.12 Air duct systems

When installed for air conditioning, especially for humanly occupied space, air duct systems should comply with fire department regulations and national and/or international codes as referred to in the Introduction.

53.13 Low ambient temperatures

Due to the danger of low temperatures as referred to in clauses 53.1 and 55.1.2, due observance should be given to the adequate heating of the machinery room.

Furthermore, danger from the effect of low temperatures on oil/refrigerant mixtures should be prevented by means of adequate heating of compressors.

53.14 Charging

Charging connections should preferably be on the low pressure side and above the level of the liquid.

53.15 Supports for units

Foundations or supports for machinery should be substantial and adequate to control vibration. For the foundations or supports, combustibility of the material should not be disregarded.

54. USE OF COOLING SYSTEMS AND REFRIGERANTS IN RELATION TO OCCUPANCIES

When selecting a refrigerant (see section 43) and a cooling system (see section 42), due attention should be paid to the occupancy (see section 41 and clause 54.1.1.1 (*b*)) relevant to the premises for which the refrigerant is utilised.

For each category of occupancy, certain cooling systems and certain locations of machinery and pipelines in combination with certain refrigerants are prohibited or subjected to restrictions, or are permitted free from restrictions.

Table 6 shows whether combinations are permitted or not. Combinations which are permitted but subjected to restrictions are indicated by the number(s) of the clause(s) specifying the restrictions.

In Table 6 the refrigerant groups 1 and 2 are each combined with two sections, one for cooling systems and one for the location of machinery. For refrigerant group 3, see clause 54.3.

TABLE 6 – **Requirements for the use of refrigerating systems in relation to occupancies** (see section 54)

Refrigerant group	Occupancy / Location of refrigerating machinery / Refrigerating systems**	A B C D		E	
		in a machinery room*	in a humanly occupied space	in a machinery room*	in a humanly occupied space
1	direct indirect open	54.1.1.1 54.1.2.2	54.1.1.1 54.1.2	54.1.1.1	54.1.1.1
	indirect vented open indirect closed indirect vented closed double indirect	54.1.1.2 54.1.2.2	54.1.1.2 54.1.2	no restrictions	

Refrigerant group	Occupancy / Location of refrigerating machinery / Refrigerating systems**	A B C		D		E	
		in a machinery room*	in a humanly occupied space	in a machinery room*	in a humanly occupied space	in a machinery room*	in a humanly occupied space
2	direct	54.2.1.1 54.2.2.1 54.2.2.3	54.2.1.1 54.2.2.2 54.2.2.3	54.2.1.2 54.2.2.1 54.2.2.3	54.2.1.2 54.2.2.2 54.2.2.3	54.2.1.2 43.3	54.2.1.2 54.2.2.2
	indirect open indirect vented open indirect closed	not permitted		54.2.1.2 54.2.2.1 54.2.2.3	54.2.1.2 54.2.2.2 54.2.2.3	54.2.1.2 43.3	54.2.1.2 54.2.2.2
	indirect vented closed double indirect	54.2.1.3 54.2.2.1 54.2.2.3	54.2.1.3 54.2.2.2 54.2.2.3	54.2.1.3 54.2.2.1 54.2.2.3	54.2.1.3 54.2.2.2 54.2.2.3	43.3	43.3 54.2.2.2
3	54.3						

* See section 52.
** See Table 2.

54.1 Refrigerants of group 1

54.1.1 *Requirements for the use of cooling systems*

54.1.1.1 DIRECT AND INDIRECT OPEN SYSTEMS (see clauses 42.1 and 42.2.1)

OCCUPANCY CATEGORIES A, B, C, D

The use of these systems is permitted under the following conditions.

The refrigerant charge, in kilogrammes, contained in the system should not exceed the product of

(*a*) the concentration allowed for the refrigerant, in kilogrammes per cubic metre (see Table 5), and

(*b*) the volume, in cubic metres, of the smallest humanly occupied space of the occupancy in which refrigerant-containing machinery is located.

The total volume of all the rooms cooled by air from one system may be used as the criterion if the air supply to each room cannot be restricted below 25 % of the full supply to each.

Due to possible danger of decomposition products, occupancies of category A in which open flames are present should always be sufficiently vented; otherwise the cooling systems in accordance with clauses 42.1 and 42.2.1 should not be used.

OCCUPANCY CATEGORY E

No restrictions, except on upper floors which do not have adequate emergency exits taking into account the number of persons normally present, in which case the restrictions of occupancy categories A, B, C, D should apply.

54.1.1.2 INDIRECT VENTED OPEN SYSTEM (see clause 42.2.2),

INDIRECT CLOSED SYSTEM (see clause 42.2.3),

INDIRECT VENTED CLOSED SYSTEM (see clause 42.2.4),

DOUBLE INDIRECT SYSTEM (see clause 42.2.5)

OCCUPANCY CATEGORIES A, B, C, D

No restrictions if all machinery is located in a machinery room in accordance with clause 52.1; otherwise the charge of refrigerant should be restricted in accordance with clause 54.1.1.1.

54.1.2 *Location of refrigerating systems*

54.1.2.1 REFRIGERATING SYSTEMS OR PARTS THEREOF NOT IN A MACHINERY ROOM

OCCUPANCY CATEGORIES A, B, C, D

In hallways, lobbies and sundry rooms of category A and in hallways and lobbies of categories B, C and D, only unit systems may be installed, containing not more refrigerant than allowed by clause 54.1.1.1. The free movement of persons should not be obstructed.

No refrigerating system or part thereof should be installed in or on public stairways, entrances or exits, or on landings if it may hinder free passage.

These units should always be fitted with machine surrounds (see clause 52.4) which prevent unauthorized access.

Spaces of occupancies of category A in which open flames or comparable hot surfaces are present should always be adequately ventilated in order to avoid danger of decomposition products (see clause 43.2); otherwise no refrigerating system or part thereof should be installed.

54.1.2.2 REFRIGERANT PIPING NOT IN A MACHINERY ROOM

OCCUPANCY CATEGORIES A, B, C, D

Inside the rooms, the connecting refrigerant-containing pipelines should be as short as possible and should be protected to prevent persons from touching them.

In hallways, lobbies and stairways, pipelines should be fixed as near as possible to the ceiling. Pipelines situated lower than 2.20 m above the floor should be protected to prevent persons from touching them.

For occupancies of categories A, B and C, pipelines crossing rooms not served by the system or served by the system indirectly should be laid in fire-resistant ducts vented to atmosphere, or to a space where parts of the refrigerating system are located. In these ducts no other pipelines or electric wires should be laid, unless they are adequately guarded. Vertical pipelines not otherwise guarded should be adequately protected to a height of not less than 2.20 m above the floor.

Fittings such as shut-off and control devices should be protected.

54.2 Refrigerants of group 2

54.2.1 *Requirements for the use of cooling systems*

54.2.1.1 DIRECT SYSTEM (see clause 42.1)

OCCUPANCY CATEGORIES A, B, C

This system should not be permitted for air conditioning for human comfort, nor used in rooms of occupancy category A. For occupancy categories B and C, this system should be permitted only for small hermetically sealed units using the absorption system (see clause 2.2).

54.2.1.2 DIRECT SYSTEM (see clause 42.1),
INDIRECT OPEN SYSTEM (see clause 42.2.1),
INDIRECT VENTED OPEN SYSTEM (see clause 42.2.2),
INDIRECT CLOSED SYSTEM (see clause 42.2.3)

OCCUPANCY CATEGORY D

This system should not be permitted for air conditioning for human comfort. For other refrigerating purposes, the total amount of refrigerant in the plant should not exceed 30 kg.

OCCUPANCY CATEGORY E

The direct (see clause 42.1) and indirect open (see clause 42.2.1) systems should not be permitted for air conditioning for human comfort. Furthermore, the restrictions of clause 43.3 should apply and also those of category D if sufficient clearly indicated exits are not available when taking into account the number of persons normally present.

Otherwise, no restrictions apply.

54.2.1.3 INDIRECT VENTED CLOSED SYSTEM (see clause 42.2.4),
DOUBLE INDIRECT SYSTEM (see clause 42.2.5)

OCCUPANCY CATEGORIES A, B, C, D

These systems may be used up to the following refrigerant charge limits in the occupancy categories paying due regard to clause 43.3 :

- category A : 250 kg
- category B : 500 kg
- category C : no limit
- category D : no limit if all machinery is located in a machinery room in accordance with clause 52.2.1 or in the open air (see clause 54.5);

  250 kg if all machinery is located in a machinery room in accordance with clause 52.1.

54.2.2 *Location of refrigerating systems*

54.2.2.1 PARTS OF THE REFRIGERATING SYSTEM IN A MACHINERY ROOM

OCCUPANCY CATEGORIES A, B

The machinery room should meet the requirements of clause 52.2.1. Moreover, no direct communication should exist with any room open to the public.

OCCUPANCY CATEGORY C

The machinery room should meet the requirements of clause 52.2.1. Moreover, no direct communication should exist with any room concerned.

OCCUPANCY CATEGORY D

The machinery room should meet the requirements of clause 52.1 or 52.2.1.

54.2.2.2 PARTS OF REFRIGERATING SYSTEMS NOT IN A MACHINERY ROOM

OCCUPANCY CATEGORIES A, B, C, D

In hallways, lobbies and sundry rooms, only small, hermetically sealed units of the absorption type (see clause 2.2) may be installed, but not in rooms where persons are restricted in their movement.

No refrigerating system or part thereof should be installed in or on public stairways, entrances or exits, or on landings if it may hinder free passage.

OCCUPANCY CATEGORY E

There are no restrictions if the system contains not more than 500 kg of refrigerant.

In systems containing more than 500 kg of refrigerant, high pressure side components, except for parts outside the building and refrigerant lines, should be located in a machinery room in accordance with clause 52.2.1.

No refrigerating system or part thereof should be permitted in entrances or exits or on stairways or landings if it may hinder free passage.

54.2.2.3 REFRIGERANT PIPELINES NOT IN A MACHINERY ROOM

OCCUPANCY CATEGORY A

These are not permitted.

OCCUPANCY CATEGORIES B, C, D

Pipelines should not be laid in rooms of categories B and C.

In hallways and lobbies, horizontal pipelines should be laid as closely as possible underneath the ceiling.

All pipelines should be laid in fire-resistant ducts vented to the atmosphere. In these ducts, no other pipeline or electric wire should be laid, unless it is adequately guarded.

No detachable joint or any fitting or control should be permitted.

54.3 Refrigerants of group 3

In general, these refrigerants should not be permitted for occupancies of the categories A, B, C and D where people who do not form part of the specialised staff looking after the refrigerating plants are usually present. These refrigerants may be permitted, however, in laboratories in category D, in unit systems with total quantities not exceeding 2.5 kg taking into account clause 43.3.

In industrial occupancies, category E, refrigerants of group 3 may be used in special cases taking into account clause 43.3; refrigerating systems should be in accordance with national and/or international codes as referred to in the Introduction.

54.4 Skating rinks

54.4.1 *Indoor skating rinks.* The provisions of clause 41.1 apply to indoor skating rinks, it being understood that an adequate, reinforced, tightly sealed concrete floor separates the refrigerating system from the public area. A refrigerant receiver should be provided to accommodate the whole of the refrigerant charge. This receiver is not a requirement for refrigerants of group 1.

By these provisions, it is recognized that direct systems using ammonia can be applied.

54.4.2 *Outdoor skating rinks.* All provisions of clause 41.2 apply to outdoor skating rinks. All machinery, pipelines and fittings should be fully protected against unauthorized interference although so arranged that they are accessible for inspection. There should be adequate provision for escape of people in the event of an untoward occurrence. A refrigerant receiver should be provided as in clause 54.4.1.

By these provisions, it is recognized that direct cooling systems using ammonia can be applied.

54.5 Machinery and equipment in the open air

Machinery and equipment installed outdoors should be weatherproof. All requirements and restrictions stated in this section and in Table 6 should be met insofar as they can be applied. The machinery and equipment should not be accessible to unauthorized persons. In the case of installations on the roof, care should be taken that no refrigerant can enter the building.

54.6 Occupancies subject to explosion hazard

Reference should be made to national and/or international codes as referred to in the Introduction.