INTERNATIONAL STANDARD

IEC 60335-2-40

2002

AMENDMENT 1
2005-03

Amendment 1

Household and similar electrical appliances – Safety –

Part 2-40: Particular requirements for electrical heat pumps, air conditioners and dehumidifiers

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FOREWORD

This amendment has been prepared by subcommittee 61D: Appliances for air-conditioning for household and similar purposes, of IEC technical committee 61: Safety of household and similar electrical appliances.

The text of this amendment is based on the following documents:

FDIS	Report on voting
61D/138/FDIS	61D/140/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of May 2006 have been included in this copy.

CONTENTS

Add the titles of new Annexes BB to GG as follows:

1 Scope

Delete the word "sealed" from the first paragraph.

Add, after the second paragraph, the following new paragraph:

This standard also applies to electric **heat pumps**, **air conditioners** and **dehumidifiers** containing **flammable refrigerant**. **Flammable refrigerants** are defined in 3.120.

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Replace the existing Note 101 by the following:

NOTE 101 A definition of 'motor-compressor' is given in IEC60335-2-34, which includes the statement that the term motor-compressor is be used to designate either a hermetic motor-compressor or semi-hermetic motor-compressor.

Add, after Note 102, the following new paragraph:

This standard does not take into account chemicals other than group A1, A2, or A3 as defined by 3.121.

Replace the existing Note 103 by the following:

NOTE 103 This standard specifies particular requirements for the use of flammable refrigerants. Unless specifications are covered by this standard, including the annexes, requirements for refrigerating safety are covered by ISO 5149.

The sections and clauses in ISO 5149 of particular concern to this standard are as follows:

– Section 3: Design and construction of equipment applies to all appliances and systems.

– Section 4: Requirements for utilization applies to appliances and systems which are for "similar electrical appliances", i.e. commercial and light industrial.

– Section 5: Operating procedures applies to appliances and systems which are for "similar electrical appliances", i.e. commercial and light industrial.

Replace, in Note 4, the last dashed item by the following:

– In many countries additional requirements are specified, for example, by the national health authorities responsible for the protection of labour and the national authorities responsible for storage, transportation, building constructions and installations.

2 Normative references

The clause of Part 1 is applicable except as follows.

Add to the existing list the titles of the following standards:

IEC 60079-14, *Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations in hazardous areas (other than mines)*

IEC 60079-15:2001, *Electrical apparatus for explosive atmospheres – Part 15: Type of protection "n"*

ISO 817:1974, *Organic refrigerants – number designation*

ISO 3864:1984, *Safety colours and safety signs*[1)]

ISO 5149:1993 *Mechanical refrigerating systems used for cooling and heating – Safety requirements*

ISO 7000: Graphical symbols for use on equipment – Index synopsis

ANSI/ASHRAE 34:2001, *Designation and safety classification of refrigerants*

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1) ISO 3864:1984 has been replaced by ISO 3864-1 2002, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs in workplaces and public areas* and ISO 7010:2003, *Graphical symbols – Safety colours and safety signs -- Safety signs used in workplaces and public areas.* However the safety sign referred to here in ISO 3864 (symbol B.3.2, Caution, risk of fire) is no longer contained in either ISO 3864-1 or ISO 7010.

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3 Definitions

Add the following new definitions:

3.121
flammable refrigerant
refrigerant with a classification of class A2 or A3 in compliance with ANSI/ASHRAE 34-2001 [ISO817] classification.

3.122
refrigerating system
combination of interconnected refrigerant containing parts constituting one closed refrigerant circuit in which refrigerant is circulated for the purpose of extracting heat at the low temperature side to reject heat at the high temperature side by changing the state of the refrigerant

3.123
maximum allowable pressure
a limit to the refrigerating system operating pressure, generally the maximum pressure for which the equipment is designed, as specified by the manufacturer

NOTE Maximum allowable pressure constitutes a limit to the operating pressure whether the equipment is working or not, see Clause 21.

3.124
low-pressure side
the part(s) of a refrigerating system operating at the evaporator pressure

3.125
high-pressure side
the part(s) of a refrigerating system operating at the condenser pressure

3.126
service port
a means to access the refrigerant in a refrigerating system for the purpose of charging or servicing the system, typically a valve, tube extension or entry location

5 General conditions for the tests

Add the following subclause:

5.2 *Addition:*

The testing of Clause 21 may be carried out on separate samples. The testing of Clauses 11, 19 and 21 shall require that pressure measurements be made at various points in the ***refrigerating system***

At least one additional specially prepared sample is required for the tests of Annex FF (Leak simulation tests), if that test option is selected.

The temperatures on the refrigerant piping should be measured during the test of Clause 11.

NOTE Due to the potentially hazardous nature of the tests of Clause 21 and Annexes EE and FF, special precautions need to be taken when carrying out the tests.

5.102 *Motor compressors that are tested and comply with IEC 60335-2-34 need not be additionally tested for Clause 21.*

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7 Marking and instructions

7.1 *Modification:*

Add the following paragraphs to the existing addition:

The flame symbol and the instruction manual symbol of 7.6 shall be visible when a **flammable refrigerant** is employed and the following conditions exist:

– accessing parts expected to be subjected to maintenance or repair;

– observing the appliance under sale or installed conditions;

– observing the appliance packaging, if the appliance is charged with refrigerant.

If a flammable refrigerant is used, the symbols for “read operator’s manual”, “operator’s manual; operating instructions” and “service indicator; read technical manual” (symbols 0790, 1641 and 1659 of ISO 7000) shall be placed on the appliance in a location visible to the persons required to know the information. The perpendicular height shall be at least 10 mm.

An additional warning symbol (flame symbol: B.3.2 of ISO 3864) shall be placed on the nameplate of the unit near the declaration of the refrigerant type and charge information. The perpendicular height shall be at least 10 mm, and the symbol need not be in colour.

NOTE 101 When installed, the marking should be visible after removing a **detachable** part.

The following warning shall also be applied to the appliance when a **flammable refrigerant** is employed.

WARNING **Appliance** shall be installed, operated and stored in a room with a floor area larger than ‘X’ m^2 (only applies to **appliances** that are not **fixed appliances**).

For **appliances,** which are not **fixed appliances**, the minimum room size X shall be specified on the appliance. The X in the marking shall be determined in m^2 by the procedure described in paragraph 2 of Annex GG for unventilated areas and the X in the marking shall be 4 if the refrigerant charge of the appliance is less than m_1 (see Annex GG, paragraph 1.1).

The maximum allowable pressure for the low-pressure side and the high-pressure side shall be marked on the product.

NOTE 102 For the **refrigerating system**; if the **maximum allowable pressure** of the **low-pressure side** and the **high-pressure side** is the same, a single indication is permitted.

If not already visible when accessing a **service port** and if a **service port** is provided, the **service port** shall be marked to identify the type of refrigerant. If the refrigerant is flammable, symbol B.3.2 of ISO 3864, shall be included, without specifying the colour.

Add the following subclause:

7.6 *Addition:*

When a **flammable refrigerant** is employed, a warning symbol B.3.2 of ISO 3864, including colour and format, shall be permanently placed on the appliance. The perpendicular height of the triangle containing the "Caution, risk of fire" symbol shall be at least 30 mm.

When a **flammable refrigerant** is employed, a symbol requiring reference to the manual [0790 of ISO 7000], including colour and format, shall be permanently placed on the appliance.

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7.12 *Addition*:

For **appliances** using **flammable refrigerants**, an installation, service and operation manual, either separate or combined manuals, shall be provided and include the information given in Annex DD.

19 Abnormal operation

Add the following subclause after subclause 19.10

19.10.1 *The test of 19.10 is repeated on class 01 appliances and class 1 appliances incorporating tubular sheathed or embedded heating elements. However, controls are not short-circuited but one end of the element is connected to the sheath of the heating element.*

The test is repeated with the polarity of the supply to the appliance reversed and with the other end of the element connected to the sheath.

The test is not carried out on appliances intended to be permanently connected to fixed wiring and on appliances where **all-pole disconnection** occurs during the test of 19.10.

19.14 *Amend the opening of the first sentence to read:*

"During the tests of 19.2 to 19.10.1 and 19.11..."

21 Mechanical strength

Add the following paragraph:

Safety requirements specified in Annex EE shall apply. The pressure test in Annex EE applies to parts other than pressure vessels.

22 Construction

Add the following new subclauses:

22.112 The construction of the **refrigerating system** shall comply with the requirements of Section 3 of ISO 5149.

22.113 When a **flammable refrigerant** is used, refrigerant tubing shall be protected or enclosed to avoid mechanical damage. The tubing shall be protected to the extent that it will not be handled or used for carrying during moving of the product. Tubing located within the confines of the cabinet is considered to be protected from mechanical damage.

Compliance is checked by inspection.

22.114 When a **flammable refrigerant** is used, low temperature solder alloys, such as lead/tin alloys, are not acceptable for pipe connections.

22.115 The total refrigerant mass (*M*) of all **refrigerating systems** within the appliance employing **flammable refrigerants,** shall not exceed m_3 as defined in Annex GG.

22.116 Appliances using **flammable refrigerants** shall be constructed so that any leaked refrigerant will not flow or stagnate so as to cause a fire or explosion hazard in areas within the appliance where electrical components, which could be a source of ignition and which could function under normal conditions or in the event of a leak, are fitted.

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Separate components, such as thermostats, which are charged with less than 0,5 g of a flammable gas are not considered to cause a fire or explosion hazard in the event of leakage of the gas within the component itself.

All electrical components that could be a source of ignition and which could function under normal conditions or in the event of a leak, shall comply with one of the following.

– IEC 60079-15:2001, Clauses 9 to 26, for group IIA gases or the refrigerant used or an applicable standard that makes electrical components suitable for use in Zone 2, 1 or 0 as defined in IEC 60079-14.
– Not be located in an area where a potentially flammable gas mixture will accumulate as demonstrated by the test of Annex FF
– Be located in an enclosure. The enclosure containing the electrical components shall comply with IEC 60079-15:2001 for enclosures suitable for use with group IIA gases or the refrigerant used.

NOTE The test current for a switching component is the rated current of the component or the actual load to be switched, whichever is greater.

22.117 Temperatures on surfaces that may be exposed to leakage of **flammable refrigerants** shall not exceed the auto-ignition temperature of the refrigerant reduced by 100 K; some typical values are given in Annex BB.

Compliance is checked by measuring the appropriate surface temperatures during the tests of Clauses 11 and 19, except those which during the tests of Clause 19 are terminated in a non-self-resetting way.

22.118 When a **flammable refrigerant** is used, all appliances shall be charged with refrigerant at the manufacturing location or charged on site as recommended by the manufacturer.

A part of an appliance that is charged on site, which requires brazing or welding in the installation shall not be shipped with a **flammable refrigerant** charge. Joints made in the installation between parts of the **refrigerating system**, with at least one part charged, shall be made in accordance with the following.

– A brazed, welded, or mechanical connection shall be made before opening the valves to permit refrigerant to flow between the refrigerating system parts. A vacuum valve shall be provided to evacuate the interconnecting pipe and/or any uncharged refrigerating system part.
– Reusable mechanical connectors and flared joints are not allowed indoors.
– Refrigerant tubing shall be protected or enclosed to avoid damage.

Flexible refrigerant connectors (such as connecting lines between the indoor and outdoor unit) that may be displaced during normal operations shall be protected against mechanical damage.

Compliance is checked according to the manufacturer's installation instructions and a trial installation if necessary.

Annexes

Add the following new annexes:

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Annex BB
(normative)
Selected information about refrigerants

The normative component of this annex involves the “Lower limit” column of Table BB.1. The rest of the annex is informative.

Refrigerant designation[1]	Description	Formula	Auto-ignition temperatures °C	Density (2),(5) kg/m³	Molar mass[3] kg/kmol	Lower flammability limit[2]	
						kg/m³[4]	% v/v
R32	Difluoromethane	CH_2F_2	648	2,13	52,0	0,306	14,4[7]
R50	Methane	CH_4	645	0,65	16,0	0,032	4,9[8]
R143a	1,1,1 – Trifluoroethane	CF_3CH_3	750	3,43	84,0	0,282	8,2[7]
R152a	1, 1 – Difluoroethane	CHF_2CH_3	455	2,70	66,0	0,130	4,8[7]
R170	Ethane	CH_3CH_3	515	1,23	30,1	0,038	3,1[7]
R290	Propane	$CH_3CH_2CH_3$	470	1,80	44,1	0,038	2,1[7]
R600	n-Butane	$CH_3CH_2CH_2CH_3$	365	2,37	58,1	0,043	1,8[9]
R600a	Isobutane	$CH(CH_3)_3$	460	2,37	58,1	0,043	1,8[10]
R1150	Ethylene	$CH_2=CH_2$	425	1,15	28,1	0,036	3,1[7]
R1270	Propylene	$CH_2=CHCH_3$	455	1,72	42,1	0,040	2,3[11]
E170	Dimethylether	CH_3 °CH_3	235	1,88	46,1	0,064	3,4[12]
R142b	1-chloro-1,1-difluoroethane	CH_3CClF_2	750[6]	4,11	100,5	0,329	8,0[7]

(1) The refrigerant designations are in accordance with ISO 817

(2) These values are at 25°C and at 1013,2 mbar

(3) For comparison, the molecular mass of air is taken equal to 28,8 kg/kmol

(4) Multiply % v/v by the corresponding molar mass * 0,000409 to give the flammability limit in kg/m³

(5) Divide molar mass by 24,465 to give the density in kg/m3

(6) Estimated from molecular structure

(7) WILSON, DP. and Richard, RG. Determination of Refrigerant Lower Flammability Limits in Compliance with Proposed Addendum p to Standard 34. *ASHRAE Transactions:* 2002 V. 108, Pt. 2.

(8) BURRELL, GA. and OBERFELL, GG. U.S. Bur. Mines, Tech. Paper 119, (1915)

(9) LAFFITTE, P. and DELBOURGO, R. *4th Symp. on Combust.*, p.114(1953)

(10) ZABETAKIS, MG., SCOTT, GS., JONES, GW. *Ind. Eng. Chem.*, 43, 2120, (1951)

(11) Estimated from LFL for propane analogs and data from JABBOUR, T., CLODIC, D. Burning Vel °City and Refrigerant Flammability Classification, Ecole de Mines, Paris, France, *ASHRAE Transactions* 2004.

(12) Atofina application to ASHRAE for safety classification of R-E170, 13 December 2001

Annex CC
(informative)

Transportation, marking and storage for units that employ flammable refrigerants

The following information is provided for units that employ flammable refrigerants:

CC.1 Transport of equipment containing flammable refrigerants

Attention is drawn to the fact that additional transportation regulations may exist with respect to equipment containing flammable gas. The maximum number of pieces of equipment or the configuration of the equipment, permitted to be transported together will be determined by the applicable transport regulations.

CC.2 Marking of equipment using signs

Signs for similar appliances used in a work area generally are addressed by local regulations and give the minimum requirements for the provision of safety and/or health signs for a work location.

All required signs are to be maintained and employers should ensure that employees receive suitable and sufficient instruction and training on the meaning of appropriate safety signs and the actions that need to be taken in connection with these signs.

The effectiveness of signs should not be diminished by too many signs being placed together.

Any pictograms used should be as simple as possible and contain only essential details.

CC.3 Disposal of equipment using flammable refrigerants

See National Regulations.

CC.4 Storage of equipment/appliances

The storage of equipment should be in accordance with the manufacturer's instructions.

CC.5 Storage of packed (unsold) equipment

Storage package protection should be constructed such that mechanical damage to the equipment inside the package will not cause a leak of the refrigerant charge.

The maximum number of pieces of equipment permitted to be stored together will be determined by local regulations.

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Annex DD
(normative)

Service operations

DD.1 General

For appliances using **flammable refrigerants**, an installation, service and operation manual, in the form of either separate or combined manuals, shall be provided and shall include the following information.

DD.2 Symbols

The symbol referred to in 7.6 (without colours is permitted) and the information of the warning marking shall be provided as follows:

WARNING

Do not use means to accelerate the defrosting process or to clean, other than those recommended by the manufacturer.

The appliance shall be stored in a room without continuously operating ignition sources (for example: open flames, an operating gas appliance or an operating electric heater.

Do not pierce or burn.

Be aware that refrigerants may not contain an odour,

Appliance shall be installed, operated and stored in a room with a floor area larger than X m^2.

NOTE The manufacturer may provide other suitable examples or may provide additional information about the refrigerant odour.

DD.3 Information in manual

DD.3.1 The following information shall be specified in the manual where the information is needed for the function of the manual and as applicable to the appliance:

– information for spaces where pipes containing flammable refrigerant are allowed, including statements
  - that the installation of pipe-work shall be kept to a minimum;
  - that pipe-work shall be protected from physical damage and shall not be installed in an unventilated space, if that space is smaller than A_{min} in Annex GG;
  - that compliance with national gas regulations shall be observed;
  - that mechanical connections made in accordance with 22.118, shall be accessible for maintenance purposes;
  - that the minimum floor area of the room shall be mentioned in the form of a table or a single figure without reference to a formula;
– the maximum refrigerant charge amount (M);
– the minimum rated airflow, if required by Annex GG;
– information for handling, installation, cleaning, servicing and disposal of refrigerant;
– the minimum floor area of the room or the special requirements for the room in which the appliance can be located as defined in Annex GG, except where the refrigerant charge (M) is less than or equal to m_1 ($M \leq m_1$);

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– a warning to keep ventilation openings clear of obstruction;
– a notice that servicing shall be performed only as recommended by the manufacturer.

DD.3.2 The manual shall include a statement advising that an unventilated area where the appliance using **flammable refrigerants** is installed shall be so constructed that should any refrigerant leak, it will not stagnate so as to create a fire or explosion hazard. This shall include:

– a warning that the appliance shall be stored in a well-ventilated area where the room size corresponds to the room area as specified for operation;
– a warning that the appliance shall be stored in a room without continuously operating open flames (for example an operating gas appliance) and ignition sources (for example an operating electric heater).

NOTE The manufacturer should specify other potential continuously operating sources known to cause ignition of the refrigerant used.

The appliance shall be stored so as to prevent mechanical damage from occurring.

DD.3.3 The manual shall contain specific information about the credentials of qualified service personnel as follows.

– Any person who is involved with working on or breaking into a refrigerant circuit should hold a current valid certificate from an industry-accredited assessment authority, which authorises their competence to handle refrigerants safely in accordance with an industry recognised assessment specification.
– Servicing shall only be performed as recommended by the equipment manufacturer. Maintenance and repair requiring the assistance of other skilled personnel shall be carried out under the supervision of the person competent in the use of flammable refrigerants.

DD.4 Information on servicing

The manual shall contain specific information for service personnel who shall be instructed to undertake the following when servicing an appliance that employs a flammable refrigerant.

DD.4.1 Checks to the area

Prior to beginning work on systems containing flammable refrigerants, safety checks are necessary to ensure that the risk of ignition is minimised. For repair to the refrigerating system, the following precautions shall be complied with prior to conducting work on the system.

DD.4.2 Work procedure

Work shall be undertaken under a controlled procedure so as to minimise the risk of a flammable gas or vapour being present while the work is being performed.

DD.4.3 General work area

All maintenance staff and others working in the local area shall be instructed on the nature of work being carried out. Work in confined spaces shall be avoided. The area around the workspace shall be sectioned off. Ensure that the conditions within the area have been made safe by control of flammable material.

DD.4.4 Checking for presence of refrigerant

The area shall be checked with an appropriate refrigerant detector prior to and during work, to ensure the technician is aware of potentially flammable atmospheres. Ensure that the leak detection equipment being used is suitable for use with flammable refrigerants, i.e. non-sparking, adequately sealed or intrinsically safe.

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DD.4.5 Presence of fire extinguisher

If any hot work is to be conducted on the refrigeration equipment or any associated parts, appropriate fire extinguishing equipment shall be available to hand. Have a dry powder or CO_2 fire extinguisher adjacent to the charging area.

DD.4.6 No ignition sources

No person carrying out work in relation to a refrigeration system which involves exposing any pipe work that contains or has contained flammable refrigerant shall use any sources of ignition in such a manner that it may lead to the risk of fire or explosion. All possible ignition sources, including cigarette smoking, should be kept sufficiently far away from the site of installation, repairing, removing and disposal, during which flammable refrigerant can possibly be released to the surrounding space. Prior to work taking place, the area around the equipment is to be surveyed to make sure that there are no flammable hazards or ignition risks. “No Smoking” signs shall be displayed.

DD.4.7 Ventilated area

Ensure that the area is in the open or that it is adequately ventilated before breaking into the system or conducting any hot work. A degree of ventilation shall continue during the period that the work is carried out. The ventilation should safely disperse any released refrigerant and preferably expel it externally into the atmosphere.

DD.4.8 Checks to the refrigeration equipment

Where electrical components are being changed, they shall be fit for the purpose and to the correct specification. At all times the manufacturer's maintenance and service guidelines shall be followed. If in doubt consult the manufacturer's technical department for assistance.

The following checks shall be applied to installations using flammable refrigerants:

- *the charge size is in accordance with the room size within which the refrigerant containing parts are installed;*
- *the ventilation machinery and outlets are operating adequately and are not obstructed;*
- *if an indirect refrigerating circuit is being used, the secondary circuit shall be checked for the presence of refrigerant;*
- *marking to the equipment continues to be visible and legible. Markings and signs that are illegible shall be corrected;*
- *refrigeration pipe or components are installed in a position where they are unlikely to be exposed to any substance which may corrode refrigerant containing components, unless the components are constructed of materials which are inherently resistant to being corroded or are suitably protected against being so corroded.*

DD.4.9 Checks to electrical devices

Repair and maintenance to electrical components shall include initial safety checks and component inspection procedures. If a fault exists that could compromise safety, then no electrical supply shall be connected to the circuit until it is satisfactorily dealt with. If the fault cannot be corrected immediately but it is necessary to continue operation, an adequate temporary solution shall be used. This shall be reported to the owner of the equipment so all parties are advised.

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Initial safety checks shall include:

- that capacitors are discharged: this shall be done in a safe manner to avoid possibility of sparking;
- that there no live electrical components and wiring are exposed while charging, recovering or purging the system;
- that there is continuity of earth bonding.

DD.5 Repairs to sealed components

DD.5.1 During repairs to sealed components, all electrical supplies shall be disconnected from the equipment being worked upon prior to any removal of sealed covers, etc. If it is absolutely necessary to have an electrical supply to equipment during servicing, then a permanently operating form of leak detection shall be located at the most critical point to warn of a potentially hazardous situation.

DD.5.2 Particular attention shall be paid to the following to ensure that by working on electrical components, the casing is not altered in such a way that the level of protection is affected. This shall include damage to cables, excessive number of connections, terminals not made to original specification, damage to seals, incorrect fitting of glands, etc.

Ensure that apparatus is mounted securely.

Ensure that seals or sealing materials have not degraded such that they no longer serve the purpose of preventing the ingress of flammable atmospheres. Replacement parts shall be in accordance with the manufacturer's specifications.

NOTE The use of silicon sealant may inhibit the effectiveness of some types of leak detection equipment. Intrinsically safe components do not have to be isolated prior to working on them.

DD.6 Repair to intrinsically safe components

Do not apply any permanent inductive or capacitance loads to the circuit without ensuring that this will not exceed the permissible voltage and current permitted for the equipment in use.

Intrinsically safe components are the only types that can be worked on while live in the presence of a flammable atmosphere. The test apparatus shall be at the correct rating.

Replace components only with parts specified by the manufacturer. Other parts may result in the ignition of refrigerant in the atmosphere from a leak.

DD.7 Cabling

Check that cabling will not be subject to wear, corrosion, excessive pressure, vibration, sharp edges or any other adverse environmental effects. The check shall also take into account the effects of aging or continual vibration from sources such as compressors or fans.

DD.8 Detection of flammable refrigerants

Under no circumstances shall potential sources of ignition be used in the searching for or detection of refrigerant leaks. A halide torch (or any other detector using a naked flame) shall not be used.

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DD.9 Leak detection methods

The following leak detection methods are deemed acceptable for systems containing flammable refrigerants.

Electronic leak detectors shall be used to detect flammable refrigerants, but the sensitivity may not be adequate, or may need re-calibration. (Detection equipment shall be calibrated in a refrigerant-free area.) Ensure that the detector is not a potential source of ignition and is suitable for the refrigerant used. Leak detection equipment shall be set at a percentage of the LFL of the refrigerant and shall be calibrated to the refrigerant employed and the appropriate percentage of gas (25 % maximum) is confirmed.

Leak detection fluids are suitable for use with most refrigerants but the use of detergents containing chlorine shall be avoided as the chlorine may react with the refrigerant and corrode the copper pipe-work.

If a leak is suspected, all naked flames shall be removed/extinguished.

If a leakage of refrigerant is found which requires brazing, all of the refrigerant shall be recovered from the system, or isolated (by means of shut off valves) in a part of the system remote from the leak. Oxygen free nitrogen (OFN) shall then be purged through the system both before and during the brazing process.

DD.10 Removal and evacuation

When breaking into the refrigerant circuit to make repairs – or for any other purpose – conventional procedures shall be used. However, it is important that best practice is followed since flammability is a consideration. The following procedure shall be adhered to:

- remove refrigerant;
- purge the circuit with inert gas;
- evacuate;
- purge again with inert gas;
- open the circuit by cutting or brazing.

The refrigerant charge shall be recovered into the correct recovery cylinders. The system shall be "flushed" with OFN to render the unit safe. This process may need to be repeated several times. Compressed air or oxygen shall not be used for this task.

Flushing shall be achieved by breaking the vacuum in the system with OFN and continuing to fill until the working pressure is achieved, then venting to atmosphere, and finally pulling down to a vacuum. This process shall be repeated until no refrigerant is within the system. When the final OFN charge is used, the system shall be vented down to atmospheric pressure to enable work to take place. This operation is absolutely vital if brazing operations on the pipe-work are to take place.

Ensure that the outlet for the vacuum pump is not close to any ignition sources and there is ventilation available.

DD.11 Charging procedures

In addition to conventional charging procedures, the following requirements shall be followed.

– Ensure that contamination of different refrigerants does not occur when using charging equipment. Hoses or lines shall be as short as possible to minimise the amount of refrigerant contained in them.

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– Cylinders shall be kept upright.
– Ensure that the refrigeration system is earthed prior to charging the system with refrigerant.
– Label the system when charging is complete (if not already).
– Extreme care shall be taken not to overfill the refrigeration system.

Prior to recharging the system it shall be pressure tested with OFN. The system shall be leak tested on completion of charging but prior to commissioning. A follow up leak test shall be carried out prior to leaving the site.

DD.12 Decommissioning

Before carrying out this procedure, it is essential that the technician is completely familiar with the equipment and all its detail. It is recommended good practice that all refrigerants are recovered safely. Prior to the task being carried out, an oil and refrigerant sample shall be taken in case analysis is required prior to re-use of reclaimed refrigerant. It is essential that electrical power is available before the task is commenced.

a) Become familiar with the equipment and its operation.
b) Isolate system electrically.
c) Before attempting the procedure ensure that:
   - mechanical handling equipment is available, if required, for handling refrigerant cylinders;
   - all personal protective equipment is available and being used correctly;
   - the recovery process is supervised at all times by a competent person;
   - recovery equipment and cylinders conform to the appropriate standards.
d) Pump down refrigerant system, if possible.
e) If a vacuum is not possible, make a manifold so that refrigerant can be removed from various parts of the system.
f) Make sure that cylinder is situated on the scales before recovery takes place.
g) Start the recovery machine and operate in accordance with manufacturer's instructions.
h) Do not overfill cylinders. (No more than 80 % volume liquid charge).
i) Do not exceed the maximum working pressure of the cylinder, even temporarily.
j) When the cylinders have been filled correctly and the process completed, make sure that the cylinders and the equipment are removed from site promptly and all isolation valves on the equipment are closed off.
k) Recovered refrigerant shall not be charged into another refrigeration system unless it has been cleaned and checked.

DD.13 Labelling

Equipment shall be labelled stating that it has been de-commissioned and emptied of refrigerant. The label shall be dated and signed. Ensure that there are labels on the equipment stating the equipment contains flammable refrigerant.

DD.14 Recovery

When removing refrigerant from a system, either for servicing or decommissioning, it is recommended good practice that all refrigerants are removed safely.

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When transferring refrigerant into cylinders, ensure that only appropriate refrigerant recovery cylinders are employed. Ensure that the correct number of cylinders for holding the total system charge are available. All cylinders to be used are designated for the recovered refrigerant and labelled for that refrigerant (i.e. special cylinders for the recovery of refrigerant). Cylinders shall be complete with pressure relief valve and associated shut-off valves in good working order. Empty recovery cylinders are evacuated and, if possible, cooled before recovery occurs.

The recovery equipment shall be in good working order with a set of instructions concerning the equipment that is at hand and shall be suitable for the recovery of flammable refrigerants. In addition, a set of calibrated weighing scales shall be available and in good working order. Hoses shall be complete with leak-free disconnect couplings and in good condition. Before using the recovery machine, check that it is in satisfactory working order, has been properly maintained and that any associated electrical components are sealed to prevent ignition in the event of a refrigerant release. Consult manufacturer if in doubt.

The recovered refrigerant shall be returned to the refrigerant supplier in the correct recovery cylinder, and the relevant Waste Transfer Note arranged. Do not mix refrigerants in recovery units and especially not in cylinders.

If compressors or compressor oils are to be removed, ensure that they have been evacuated to an acceptable level to make certain that flammable refrigerant does not remain within the lubricant. The evacuation process shall be carried out prior to returning the compressor to the suppliers. Only electric heating to the compressor body shall be employed to accelerate this process. When oil is drained from a system, it shall be carried out safely.

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Annex EE
(normative)

Pressure Tests

EE.1 General

All **refrigerating system** parts shall withstand the maximum pressure expected in normal operation, abnormal operation, and standstill.

A compressor tested for compliance with IEC 60335-2-34 need not be additionally tested.

Compliance is checked by the following tests.

For all tests of Clause 21, if the refrigerant is a blend, the test pressure of EE.4.7 shall be carried out at the highest pressure under the specified temperature.

The test value that is the maximum of Clauses EE.2, EE.3 or EE.4 shall be used for the test of EE.4.1, respectively, for the high side and the low side components.

EE.2 Pressure test value determined under testing carried out in Clause 11

A **refrigerating system** component that is exposed to pressure shall be subjected to measurement of the maximum pressure developed in the **refrigerating system** when tested under the conditions specified in Clause 11.

The pressure test value shall be at least three times the maximum pressure developed during operation under Clause 11.

EE.3 Pressure test value determined under testing carried out in Clause 19.

A **refrigerating system** component that is exposed to pressure shall be subjected to measurement of the maximum pressure developed in the **refrigerating system** when tested under the conditions specified in Clause 19.

The pressure test value shall be at least three times the maximum pressure developed during abnormal operation (Clause 19).

EE.4 Pressure test value determined under testing carried out under standstill conditions

In order to determine the standstill pressure, the appliance shall be soaked in the highest operating temperature specified by the manufacturer for 1 h with power off.

A **refrigerating system** component that is exposed only to low side pressure shall be subjected to measurement of the maximum pressure developed in the **refrigerating system** under the condition of standstill.

The pressure test value shall be at least three times the maximum pressure developed during standstill.

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Pressure gauges and control mechanisms need not be subjected to the test, provided the parts meet the requirements of the component.

EE.4.1 The pressure test shall be carried out on three samples of each component. The test samples are filled with a liquid, such as water, to exclude air and are connected in a hydraulic pump system. The pressure is raised gradually until the required test pressure is reached. The pressure is maintained for at least 1 min, during which time the sample shall not leak.

Where gaskets are employed for sealing parts under pressure, leakage at gaskets is acceptable, provided the leakage only occurs at a value greater than 120 % of the **maximum allowable pressure** and the test pressure is still reached for the specified time.

EE.5 Fatigue test option for Clauses EE.1 and EE.4.1

The components shall be subjected to a test at 2/3 times the test pressure determined by Clauses EE.2, EE.3 or EE.4, provided the components comply with the fatigue test in Clause EE.5. This test is conducted on a separate sample.

EE.5.1 Three samples of each refrigerant-containing part shall be tested at the cyclic pressure values specified in EE.5.6 and EE.5.7 for the number of cycles specified in EE.5.5. as described in EE.5.3

EE.5.2 The samples shall be considered to comply with EE.5.4 on completion of the test and if they do not rupture, burst, or leak.

EE.5.3 The test samples shall be filled with fluid, and shall be connected to a pressure-driving source. The pressure shall be raised and lowered between the upper and lower cyclic values at a rate specified by the manufacturer. The pressure shall reach the specified upper and lower values during each cycle. The shape of the pressure cycle shall be such that the upper and lower pressure values shall be maintained for at least 0,1 s.

NOTE For safety purposes, it is suggested that a non-compressible fluid be used. The fluid shall completely fill the part, displacing all of the air.

If the operating temperatures of the appliance under the conditions of steady state operation of Clause 11 are less than or equal to 125 °C for copper or aluminum, or 200 °C for steel, the test temperature of the component part or assembly shall be at least 20 °C. If the continuous operating temperature of the component exceeds 125 °C for copper or aluminum, or 200 °C for steel, the test temperature of the parts or assemblies that are at these temperatures, and subjected to the pressure, shall be at least 25 °C greater than the temperature of the part measured during the test of Clause 11 for copper or aluminum and 60 °C higher for steel. For other materials, the effects of temperature on the material fatigue characteristics shall be evaluated by conducting the test at the higher temperatures and considering the material characteristics at the higher temperatures.

EE.5.4 The pressure for the first cycle shall be the maximum evaporating pressure for **low-pressure side** components or the maximum condensing pressure for the **high-pressure side** components.

EE.5.5 The total number of cycles shall be 250 000. The test pressures shall be determined by 5.7 (except the first and last cycles as noted in EE.5.4 and EE.5.7).

EE.5.6 The pressure for the test cycles shall be as follows:

a) For components subject to high side pressures, the upper pressure value shall not be less than the saturated vapour pressure of the refrigerant at 50 °C and the lower pressure value shall not be greater than the saturated vapour pressure of the refrigerant at 5 °C. For hot water heat pumps, the upper pressure shall not be less than 80 % of the maximum pressure under the conditions of Clause 11.

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b) For components subjected to only low side pressures, the upper pressure value shall be not less than the saturated vapour pressure of the refrigerant at 30 °C and the lower pressure value shall be between 0 bar and the greater of 4,0 bar or the saturated vapour pressure of the refrigerant at –13 °C.

EE.5.7 For the final test cycle, the test pressure shall be increased to two times the minimum upper pressure specified in EE.5.6.

NOTE The objective is to avoid a test value that is a negative pressure but to require a lower pressure value of the saturated vapour pressure at –13 °C or 4.0 bar whichever is greater.

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Annex FF
(normative)

Leak simulation tests

FF.1 General

A leakage of refrigerant is simulated at the most critical point in the refrigeration system. The method to simulate a leakage at the most critical point is to inject refrigerant vapour through a suitable capillary tube at that point. A critical point is a joint in the refrigerant system tubing, a bend of more than 90°, or other point judged to be a weak point in the refrigerant containing system due to the thickness of the metal, exposure to damage, sharpness of a bend or the manufacturing process. A quantity of refrigerant leaked is equal to the rated charge amount or the amount that will leak as determined by test. The refrigerant is injected at the most critical point and the most unfavourable direction at ambient temperature (20 °C – 25 °C).

FF.2 Test methods

FF.2.1 The appliance is modified by introducing a simulated leak through a capillary tube. The leak rate shall be maintained at 25 % ± 5 % of the total appliance charge in 1 min.

FF.2.2 During this test the appliance is switched off or operated under **normal operation** at **rated voltage**, whichever gives the most unfavourable result unless a prepurge is activated prior to energizing any loads, in which case the test shall be conducted with the appliance operating. During a test where the appliance is operating, refrigerant gas injection is started at the same time as the appliance is switched on.

FF.2.3 If a blend refrigerant is used that can fractionate, the test is carried out using the worst fractionated formulation that has the smallest value of LFL (Lower Flammable Limit) defined in ANSI/ASHRAE 34-2001.

NOTE If a zeotropic blend is used, the test is conducted maintaining the composition within a reasonable range. Liquid phase of the blend may be extracted from the bottle then evaporated. Gas phase release with the pressure regulator from a large mixed gas tank is the best method.

FF.2.4 The test is conducted in a room that is draft free and of sufficient size to conduct the test.

The minimum volume (V) is:

$$V = (4*m)/LFL,$$

where

$V = m^3$ considering a ceiling height not less than 2.2 m.

m = the refrigerant charge mass in kg.

LFL = the lower flammable limit in kg/m^3 from Annex BB.

NOTE 1 The quantity of gas injected should preferably be measured by weighing the bottle.

NOTE 2 Care should be taken that the installation of the capillary tube does not unduly influence the results of the test and that the structure of the appliance is not in a position to unduly influence the results of the test.

NOTE 3 The instrument used for monitoring the refrigerant gas concentration should have a fast response to the gas concentration, typically 2 s to 3 s and should be located so as to not unduly influence the results of the test.

NOTE 4 If gas chromatography is used to measure the refrigerant gas concentrations the gas sampling in confined areas should not exceed 2 ml in every 30 s.

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FF.2.5 The measured concentration of refrigerant gas surrounding the component shall not exceed 75 % of the LFL of the refrigerant gas, and shall not exceed 50 % of the LFL of the refrigerant gas for a time period of 5 min or the duration of the test if less than 5 min during and after the amount has been injected. The measured concentration of refrigerant gas surrounding a component that will not function during the prepurge time may exceed the 75 % of the LFL during the prepurge time. The LFL is as specified in Annex BB for the refrigerant used.

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Annex GG
(normative)

Charge limits, ventilation requirements and requirements for secondary circuits

GG.1 Requirements for charge limits in ventilated areas

When a **flammable refrigerant** is used, the requirements for ventilation of the **appliance** or the space where the appliance functions are presented according to the mass charge amount (M) used in the appliance, the installation location and the type of ventilation of the location or the appliance, see Table GG.1

GG.1.1 Determine the case applicable based on the relationship of the mass charge amount employed and m_1, m_2, m_3, defined as follows:

m_1 = (4 m^3) * *LFL*:
m_2 = (26 m^3) * *LFL*:
m_3 = (130 m^3) * LFL:

where LFL is the lower flammable limit in kg/m^3 from Annex BB for the refrigerant used.

GG.1.2 Determine the column for indoor or outdoor application. The requirements are identified in the appropriate box and the product and installation requirements are identified.

NOTE 1 The factors in the formulas (4, 26, 130) are in cubic meters and are the incremental room sizes that relate to increasing charge amounts and the type of ventilation permitted or required for the room that avoid reaching the lower flammable limit, if the entire charge is released and mixed with the room air. The formulas governing the charge amount are based on a consideration of non-uniform mixing, if the refrigerant is heavier or lighter than air.

NOTE 2 The method to determine the *LFL* of a blend refrigerant is under consideration by ASHRAE 34 [ISO 817]. For the *LFL* of a refrigerant not included in ANNEX BB, it must be referred to ASHRAE 34 [ISO 817].

Table GG.1 – Mass of refrigerants

Maximum mass of refrigerants	Outdoor all installations	Indoor installed or stored below or above ground level
$M \leq m_1$	Shall comply with 22.116 and 22.117.	Shall comply with 22.116 and 22.117.
$m_1 < M \leq m_2$	Shall comply with 22.116 and 22.117.	Shall comply with 22.116 and 22.117. The installation for unventilated and mechanical ventilation shall comply with 2) or 3) below.
$m_2 < M \leq m_3$	Shall comply with 22.116 and 22.117.	Shall comply with 22.116 and 22.117. The installation for mechanical ventilation shall comply with 3) below.
$M > m_3$	National standards apply	National standards apply

NOTE The requirements applicable to a higher charge amount are permitted for each range in Table GG.1.

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GG.2 Requirements for charge limits in unventilated areas

This is applicable for appliances with a charge amount $m_1 < M \leq m_2$:

Reference Figure GG.1.

For appliances with a charge amount $m_1 < M \leq m_2$:

The maximum charge in a room shall be in accordance with the following:

$$m_{max} = 2{,}5 \times (LFL)^{(5/4)} \times h_0 \times (A)^{1/2}$$

or the required minimum floor area A_{min} to install an appliance with refrigerant charge M (kg) shall be in accordance with following;

$$A_{min} = (M / (2{,}5 \times (LFL)^{(5/4)} \times h_0))^2$$

where:

m_{max} = allowable maximum charge in a room in kg;

M = refrigerant charge amount in appliance in kg;

A_{min} = required minimum room area in m^2;

A = room area in m^2;

LFL = Lower Flammable Limit (LFL) in kg/m^3;

h_0 = installation height of the appliance in m:

0,6 m for floor location;

1,8 m for wall mounted;

1,0 m for window mounted;

2,2 m for ceiling mounted.

where the LFL is in kg/m^3 from Annex BB and the molecular weight of the refrigerant is greater than 42.

NOTE 1 This formula cannot be used for refrigerants lighter than 42 kg/kmol.

NOTE 2 Some examples of the results of the calculations according to the above formula are given in Tables GG.2 and GG.3.

GG.3 Requirements for charge limits in areas with mechanical ventilation

NOTE This is applicable for appliances with a charge amount of $m_1 < M \leq m_3$

Reference Figure GG.2.

Mechanical ventilation applies to **fixed appliances** only.

Mechanical ventilation occurs when the appliance enclosure or the room is provided with a ventilating system that, in the event of a leak, is intended to vent refrigerant into an area where there is not an ignition source and the gas can be readily dispersed. The appliance enclosure shall have a ventilation system that produces airflow within the appliance enclosure and meets the requirements of 3.1 or is intended to be installed in a room that meets the requirements of 3.2.

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GG.4 Requirements for mechanical ventilation within the appliance enclosure

The refrigerating circuit is provided with a separate enclosure that does not communicate with the room. The appliance enclosure shall have a ventilation system that produces airflow from the appliance interior to the outside through a ventilation shaft. The manufacturer shall specify the ventilation shaft width and height, the maximum length and number of bends. The appliance shall provide for airflow between the room and the interior of the appliance enclosure. The negative pressure measurement in the interior of the appliance enclosure shall be 20 Pa or more and the flow rate to the exterior shall be at least Q_{min}. The ventilation duct does not contain any components.

$$Q_{min} = S \times 15\ (m_c/\rho)\ \text{(with a minimum of 2 m}^3\text{/h)}$$

where

S = 4 (safety factor)

ρ = Density of the refrigerant at atmospheric pressure at 25 °C, kg/m^3

Q_{min} = minimum required volume flow of the ventilation, m^3/h

m_c = refrigerant charge mass, kg

NOTE The constant, 15, above is based on the assumptions used for the charge size formulas, i.e. releasing the full charge amount within 4 min.

Compliance for the appliance ventilation system is checked by the following tests.

GG.4.1 *The appliance shall be installed in accordance with the manufacturer's instructions and the ventilation shaft shall not exceed the maximum length and number of bends specified by the manufacturer.*

GG.4.2 *The room shall be at least 10 times the volume of the appliance and with sufficient make-up air to replace any air exhausted during the test. The air pressure differential is measured between the interior of the appliance enclosure and the room. The airflow rate shall be measured at the outside end of the ventilation shaft.*

GG.4.3 *Ventilation shall be to the outside or to a room with a minimum volume as specified under the unventilated area case.*

GG.4.4 *The airflow is detected continuously or monitored continuously and the appliance or the motor compressor is switched off within 10 s in the event that the airflow is reduced below Q_{min},, or GG.4.5 applies.*

GG.4.5 *The ventilation is switched on by a refrigerant gas sensor before 25 % of the LFL (lower flammable limit) is obtained. The sensor shall be suitably located considering the density of the refrigerant and periodically proved in accordance to the manufacturer's instructions. The airflow is periodically checked and detected and the appliance or the motor compressor is switched off within 10 s in the event that the airflow is reduced below Q_{min}.*

GG.5 Requirements for mechanical ventilation for rooms complying with ISO 5149

The appliance shall be designed to meet the requirements of ISO 5149.

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