

Table BB.1 Continued

Refrigerant designation ^a	Description	Formula (nominal composition mass fraction %)	Safety group ^f	Auto ignition temperature	Hot surface ignition temperature ^g	Maximum allowable surface temperature ^g	Density ^b	Molar mass ^c at nominal composition ^h	Molar mass ^c at worst case formulation	Lower flammable limit ^{b,d} at nominal composition ^h	Lower flammability limit ^{b,d} at worst case formulation
				°C	°C (A2L only)	°C	kg/m ³	kg/kmol	kg/kmol	kg/m ³	kg/m ³
R-444B	R-32/152a/1234ze(E)	(41.5/10/48.5)	A2L	ND	> 800	700	3,02	72,8	73,0	0,277	0,277
R-447A	R-32/125/1234ze(E)	(68/3.5/28.5)	A2L	ND			2,61	63,0	63,1	0,304	0,330
R-447B	R-32/125/1234ze(E)	(68/8/24)	A2L	ND	> 800	700	2,58	63,1	63,1	0,312	0,312
R-451A	R-1234yf/134a	(89.8/10.2)	A2L	ND	> 800	700	4,61	112,7	112,7	0,322	0,346
R-451B	R-1234yf/134a	(88.8/11.2)	A2L	ND	> 800	700	4,60	112,6	112,6	0,322	0,341
R-452B	R-32/125/1234yf	(67/7/26)	A2L	ND	> 800	700	2,60	63,5	63,7	0,309	0,310
R-454A	R-32/1234yf	(35/65)	A2L	ND	> 800	700	3,29	80,5	81,8	0,273	0,278
R-454B	R-32/1234yf	(68.9/31.1)	A2L	ND	> 800	700	2,56	62,6	63,0	0,307	0,301
R-454C	R-32/1234yf	(21.5/78.5)	A2L	ND	> 800	700	3,71	90,8	92,5	0,286	0,291
R-457A	R-32/1234yf/152a	(18/70/12)	A2L	ND			3,58	87,6	88,0	0,215	0,216

If any data in this table is missing or in conflict with the data in ISO 817 then the value in ISO 817 shall take precedence.

ND means non-determined. Consult the safety data sheet of the manufacturer.

NA means not applicable.

^a The refrigerant designations are in accordance with ISO 817.

^b These values are at 25 °C and at 1 013,2 mbar.

^c For comparison, the molecular mass of air is taken equal to 28,8 kg/kmol.

^d Multiply % v/v by the corresponding molar mass × 0,000 409 to give the flammability limit in kg/m³.

^e Estimated from molecular structure.

^f Safety group of refrigerants based upon ISO 817.

^g For FLAMMABLE REFRIGERANTS, the maximum allowable surface temperature is determined by AIT reduced by 100 K.

For A2L REFRIGERANTS, the maximum allowable surface temperature is determined by the highest of AIT reduced by 100 K or if tested per Annex [KK](#), the HOT SURFACE IGNITION TEMPERATURE reduced by 100 K, but not higher than 700 °C.

^h Nominal composition means design composition as stated in the refrigerant blend application, excluding any tolerances.

ⁱ Worst case formulation means the composition that results from application of the tolerances to the nominal composition resulting in the most toxic or most flammable formulation.

Table BBDV.1 D2 *Modification of Table BB.1 of Annex BB of the Part 2 as follows:*

In note (g) to Table BB.1, delete “, but not higher than 700°C”.

Annex CC (informative)

Transportation, marking and storage for units that employ flammable refrigerants

CC.1 General

The following information is provided for units that employ FLAMMABLE REFRIGERANTS.

CC.2 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.3 Marking of equipment using signs

Signs for similar appliances used in a work area are generally 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.4 Disposal of equipment using flammable refrigerants

See national regulations.

CC.5 Storage of equipment/appliances

The storage of the appliance should be in accordance with the applicable regulations or instructions, whichever is more stringent.

CC.6 Storage of packed (unsold) equipment

Storage package protection should be constructed such a way 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.

Annex DD (normative)

Requirements for operation, service and installation manuals of appliances using flammable refrigerants

DD.1 General

Each service manual shall include requirements of clauses according to [Table DD.1 – Mandatory clauses in each manual](#). Different manuals can be combined into one manual.

Table DD.1 – Mandatory clauses in each manual

Clause	Installation	Maintenance and repair	Decommissioning	Note
DD.2	Yes	Yes	Yes	
DD.3.1	Yes	Yes	No	
DD.3.2	Yes	Yes	No	User manual also
DD.3.3	Yes	Yes	Yes	
DD.4	No	Yes	Yes	
DD.4.1	No	Yes	Yes	
DD.4.2	No	Yes	Yes	
DD.4.3	No	Yes	Yes	
DD.4.4	No	Yes	Yes	
DD.4.5	No	Yes	Yes	
DD.4.6	No	Yes	Yes	
DD.4.7	No	Yes	Yes	
DD.4.8	Yes	Yes	No	
DD.4.9	No	Yes	No	
DD.5.1	No	Yes	No	
DD.5.2	No	Yes	No	
DD.6	No	Yes	No	
DD.7	Yes	Yes	No	
DD.8	Yes	Yes	Yes	
DD.9	Yes	Yes	Yes	
DD.10	Yes	Yes	No	
DD.11	No	No	Yes	
12	No	No	Yes	
DD.13	Yes	Yes	Yes	

DD.1DV DR Modification of Clause DD.1 of the Part 2 by adding the following:

For appliances that are not intended to be serviced, the following shall apply:

- a) Maintenance and repair manuals and decommissioning manuals are not required.
- b) Installation instructions do not need to include content of DD.9, DD.10, or DD.13.

DD.2 Symbols

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

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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.

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

DD.3 Information in manual**DD.3.1 General**

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 refrigerant pipes 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, in the case of FLAMMABLE REFRIGERANTS, shall not be installed in an unventilated space, if that space is smaller than A_{\min} in Annex GG, except for A2L REFRIGERANTS where the installed pipes comply with 22.116. In case of field charge, the effect on REFRIGERANT CHARGE caused by the different pipe length has to be quantified;
- 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, for appliances containing FLAMMABLE REFRIGERANTS, 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 (m_{\max});

– instructions how to determine the additional REFRIGERANT CHARGE and how to complete the REFRIGERANT CHARGE on the label provided by the manufacturer considering the requirements in 7.107;

– the minimum rated airflow, if required by Annex GG;

– information for handling, installation, cleaning, servicing and disposal of refrigerant;

– the appliance using FLAMMABLE REFRIGERANTS, instructions shall include the minimum INSTALLED HEIGHT h_{inst} (when required to calculate A_{\min}), REFRIGERANT CHARGE m_c and minimum room area of the space A_{\min} or a minimum room area of conditioned space TA_{\min} where applicable. Additional minimum room area data may be provided based on other INSTALLED HEIGHTS and/or charge levels.

- detailed instructions on how to install the appliance to ensure that the release height h_0 as determined in Clause [GG.2](#) of the installed appliance is not lower than h_0 used for the calculation of A_{\min} ;
- a warning to keep any required ventilation openings clear of obstruction;
- a notice that servicing shall be performed only as recommended by the manufacturer;
- a warning that ducts connected to an appliance shall not contain a POTENTIAL IGNITION SOURCE;
- instructions for wiring to external zoning dampers and/or mechanical ventilation, if required to comply with Clause [GG.9](#), to ensure that upon detection of a leak, the zoning dampers are driven fully open and additional mechanical ventilation is activated;
- for appliances relying on safety measures according to [GG.8.3](#) instructions for wiring to external ventilation;
- when a remote located refrigerant sensor is specified by the manufacturer, the instructions shall state when it is required and how to install and connect the sensor;
- for appliances using A2L REFRIGERANTS, connected via an air duct system to one or more rooms, the supply and return air shall be directly ducted to the space. Open areas such as false ceilings shall not be used as a return air duct;
- the following information requirements apply for ENHANCED TIGHTNESS REFRIGERATING SYSTEMS using A2L REFRIGERANTS:
 - Equipment piping in the occupied space shall be installed in such a way to protect against accidental damage in operation and service.
 - Precautions shall be taken to avoid excessive vibration or pulsation to refrigerating piping.
 - Protection devices, piping and fittings shall be protected as far as possible against adverse environmental effects, for example, the danger of water collecting and freezing in relief pipes or the accumulation of dirt and debris.
 - Provision shall be made for expansion and contraction of long runs of piping.
 - Piping in REFRIGERATING SYSTEMS shall be so designed and installed to minimize the likelihood hydraulic shock damaging the system.
 - Solenoid valves shall be correctly positioned in the piping to avoid hydraulic shock.
 - Solenoid valves shall not block in liquid refrigerant unless adequate relief is provided to the refrigerant system low pressure side.
 - Steel pipes and components shall be protected against corrosion with a rustproof coating before applying any insulation.
 - Flexible pipe elements shall be protected against mechanical damage, excessive stress by torsion, or other forces. They should be checked for mechanical damage annually.
 - The indoor equipment and pipes shall be securely mounted and guarded such that accidental rupture of equipment cannot occur from such events as moving furniture or reconstruction activities.
 - Where safety shut off valves are specified, the minimum room area may be determined based on the maximum amount of refrigerant that can be leaked as determined in [GG.12.2](#).
 - Where safety shut off valves are specified, the location of the valve in the REFRIGERATING SYSTEM relative to the occupied spaces shall be as described in [GG.12.1](#).

- Field-made refrigerant joints indoors shall be tightness tested. The test method shall have a sensitivity of 5 grams per year of refrigerant or better under a pressure of at least 0,25 times the MAXIMUM ALLOWABLE PRESSURE. No leak shall be detected.
- For mechanical ventilation as specified in [GG.8.3](#), the air extraction opening from the room shall be located equal or below the refrigerant release point. For floor mounted units, it shall be as low as practicable. The air extraction openings shall be located in a sufficient distance from the air intake openings to prevent re-circulation to the space.

DD.3.1DV.1 D1 Modification of Clause DD.3.1 of the Part 2 by addition of the following:

All installation instruction information required to comply with Annex [GG](#) shall be provided in the form of a table or a single figure without reference to a formula;

DD.3.1DV.2 D1 Modification of Clause DD.3.1 of the Part 2 by replacing the first dashed item with the following:

– information for spaces where refrigerant pipes are allowed, including statements

- that piping material, pipe routing, and installation shall include protection from physical damage in operation and service, and be in compliance with national and local codes and standards, such as ASHRAE 15, IAPMO Uniform Mechanical Code, ICC International Mechanical Code, or CSA B52. All field joints shall be accessible for inspection prior to being covered or enclosed.
- that the installation of pipe-work shall be kept to a minimum.
- that pipe-work in the case of flammable refrigerants shall not be installed in an unventilated space, if that space is smaller than A_{\min} in Annex [GG](#), except for A2L refrigerants where the installed pipes comply with Clause [22.116](#). In case of field charge, the effect on refrigerant charge caused by the different pipe length shall be quantified.
- that mechanical connections made in accordance with Clause [22.118](#) shall be accessible for maintenance purposes;
- that provision shall be made for expansion and contraction of long runs of piping;
- that protection devices, piping, and fittings shall be protected as far as possible against adverse environmental effects, for example, the danger of water collecting and freezing in relief pipes or the accumulation of dirt and debris;
- that piping in refrigeration systems shall be so designed and installed to minimize the likelihood of hydraulic shock damaging the system;
- that steel pipes and components shall be protected against corrosion with a rustproof coating before applying any insulation;
- that flexible pipe elements shall be protected against mechanical damage, excessive stress by torsion, or other forces, and that they should be checked for mechanical damage annually;
- that precautions shall be taken to avoid excessive vibration or pulsation;
- that, for appliances containing flammable refrigerants, 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;

- that after completion of field piping for split systems, the field pipework shall be pressure tested with an inert gas and then vacuum tested prior to refrigerant charging, according to the following requirements:

The minimum test pressure for the low side of the system shall be the low side design pressure and the minimum test pressure for the high side of the system shall be the high side design pressure, unless the high side of the system, cannot be isolated from the low side of the system in which case the entire system shall be pressure tested to the low side design pressure.

The test pressure after removal of pressure source shall be maintained for at least 1 h with no decrease of pressure indicated by the test gauge, with test gauge resolution not exceeding 5% of the test pressure.

During the evacuation test, after achieving a vacuum level specified in the manual or less, the refrigeration system shall be isolated from the vacuum pump and the pressure shall not rise above 1500 microns within 10 min. The vacuum pressure level shall be specified in the manual, and shall be the lessor of 500 microns or the value required for compliance with national and local codes and standards, which may vary between residential, commercial, and industrial buildings.

- that field-made refrigerant joints indoors shall be tightness tested according to the following requirements: The test method shall have a sensitivity of 5 grams per year of refrigerant or better under a pressure of at least 0,25 times the maximum allowable pressure. No leak shall be detected.

DD.3.1DV.3 D1 Modification of Clause DD.3.1 of the Part 2 as follows:

Delete the second dashed item.

DD.3.1DV.4 D1 Modification of Clause DD.3.1 of this Part 2 by adding the following to the fifth dashed item:

Instructions shall include how to correct the minimum room area of the space A_{\min} or a minimum room area of conditioned space TA_{\min} , as applicable from Annex [GG](#), by multiplying by the altitude adjustment factor (AF) factor in [Table DD.3.1DV](#) based on for building site ground level altitude (H_{alt}) in meters.

Table DD.3.1DV
Altitude Adjustment Factor

H_{alt}	0	200	400	600	800	1000	1200	1400	1600
AF	1.00	1.00	1.00	1.00	1.02	1.05	1.07	1.10	1.12
H_{alt}	1600	1800	2000	2200	2400	2600	2800	3000	3200
AF	1.12	1.15	1.18	1.21	1.25	1.28	1.32	1.36	1.40

DD.3.1DV.5 D1 Modification of Clause DD.3.1 of the Part 2 as follows:

Adding “All dimensional data shall be provided in both SI and IP units” at end of the sixth dashed item.

DD.3.1DV.6 D1 Modification of Clause DD.3.1 of the Part 2 as follows:

Deleting the 15th dashed item.

DD.3.1DV.7 D1 Modification of Clause DD.3.1 of the Part 2 by replacing the last dashed item with the following;

- For mechanical ventilation as specified in Clause [GG.8.3](#), the lower edge of the air extraction opening where air is exhausted from the room shall not be more than 100 mm above the floor.

The location where the mechanical ventilation air extracted from the space is discharged shall be separated by a sufficient distance, but not less than 3 m, from the mechanical ventilation air intake openings, to prevent re-circulation to the space.

DD.3.1DV.8 D1 Modification of Clause DD.3.1 of the Part 2 by addition of the following:

For add on heatpumps with flammable refrigerants, the instructions shall include the following:

- Instruction for installation of the critical-to-safety wiring connection of the leak detection sensor or leak detection system to the furnace assembly. The wiring shall be not less than 18 AWG with a minimum insulation thickness of 1.58 mm or protected from damage. Critical-to-safety wiring is any field installed wiring necessary to fulfill the requirements of Annex [GG](#) in the event of detection of a leak.
- Shall not be installed on furnaces with an inductive electrical greater than L_e as calculated in [22.116](#).
- Detection of a leak shall turn on the indoor fan at the highest available speed or turn it on to not less Q_{min} as determined in Annex [GG](#). (Consult furnace manufacturer.)

DD.3.1DV.9 D1 Modification of Clause DD.3.1 of the Part 2 by addition of the following:

The following additional information shall be specified in the manual for multi-split system using safety shut off valves in installation of appliances using A2L refrigerants where the information is needed for the function of the manual and as applicable to the appliance:

- Safety shut off valves installation shall avoid hydraulic shock.
- Safety shut off valves shall not block in liquid refrigerant unless adequate relief is provided to the refrigerant system low pressure side.
- Where safety shut off valves are specified, the minimum room area may be determined based on the maximum amount of refrigerant that can be leaked as determined in Clause 101.DVG.7.
- Where safety shut off valves are specified, the location of the valve in the REFRIGERATING SYSTEM, relative to the occupied spaces shall be as described in Clause 101.DVG.6.2.

DD.3.1DV.10 D1 Modification of Clause DD.3.1 of the Part 2 by addition of the following:

For appliances with REFRIGERANT DETECTION SYSTEMS, the instructions shall include the following:

- For REFRIGERANT DETECTION SYSTEMS, the function and operation and required servicing measures.
- For LIMITED LIFE REFRIGERANT SENSORS used in REFRIGERANT DETECTION SYSTEMS, the specified end of life and instructions for replacement.
- REFRIGERANT SENSORS for REFRIGERANT DETECTION SYSTEMS shall only be replaced with sensors specified by the appliance manufacture.

DD.3.1DV.11 D1 Modification of Clause DD.3.1 of the Part 2 by addition of the following dashed item:

- Instruction to verify actuation of mitigation actions per Annex [GG](#).

DD.3.2 Unventilated areas

For appliances containing more than m_1 for any refrigerating circuit, 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 non-FIXED APPLIANCE shall be stored in an area where the room size corresponds to the room area as specified for operation;
- a warning that the non-FIXED APPLIANCE shall be stored in a room without continuously operating open flames (for example an operating gas appliance) or other POTENTIAL IGNITION SOURCES (for example an operating electric heater, hot surfaces);
- a warning that if appliances connected via an air duct system to one or more rooms with A2L REFRIGERANTS are installed in a room with an area less than A_{min} as determined in Clause [GG.2](#), that room shall be without continuously operating open flames (for example an operating gas appliance) or other POTENTIAL IGNITION SOURCES (for example an operating electric heater, hot surfaces). A flame-producing device may be installed in the same space if the device is provided with an effective flame arrest;
- for appliances using A2L REFRIGERANTS connected via an air duct system to one or more rooms, a warning with the substance of the following: “Auxiliary devices which may be a POTENTIAL IGNITION SOURCE shall not be installed in the duct work. Examples of such POTENTIAL IGNITION SOURCES are hot surfaces with a temperature exceeding X°C and electric switching devices”;

NOTE X is the maximum allowable surface temperature as defined in [22.117](#).

- for appliances using A2L REFRIGERANTS connected via an air duct system to one or more rooms, a warning that only auxiliary devices approved by the appliance manufacturer or declared suitable with the refrigerant shall be installed in connecting ductwork. The manufacturer can list in the instructions all approved auxiliary devices by the manufacturer and model number for use with the specific appliance, if those devices have a potential to become an ignition source.

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.3.2DV.1 D1 Modification of Clause DD.3.2 of the Part 2 by replacing the fifth dashed item with the following;

– for appliances using A2L refrigerants connected via an air duct system to one or more rooms, a warning that only auxiliary devices approved by the appliance manufacturer or declared suitable with the refrigerant shall be installed in connecting ductwork. The manufacturer shall list in the instructions all approved auxiliary devices by manufacturer and model number for use with the specific appliance, if those devices have a potential to become an ignition source.

DD.3.2DV.2 D1 Modification of Clause DD.3.2 of the Part 2 by adding the following dashed items:

– Non-duct connected appliances containing A2L refrigerants with the supply and return air openings in the conditioned space may have the body of the appliance may be installed in open areas such as false ceilings not being used as return air plenums, as long as the conditioned air does not directly communicate with the air of the false ceiling.

– For duct connected appliances, false ceilings or drop ceilings may be used as a return air plenum if a REFRIGERANT DETECTION SYSTEM detection is provided in both the appliance and any external connections are also provided with a sensor immediately below the joint.

DD.3.3 Qualification of workers

The manual shall contain specific information about the required qualification of the working personnel for maintenance, service and repair operations. Every working procedure that affects safety means shall only be carried out by competent persons according to Annex [HH](#).

Examples for such working procedures are:

- breaking into the refrigerating circuit;
- opening of sealed components;
- opening of ventilated enclosures.

DD.4 Information on servicing

DD.4.1 General

The manual shall contain specific information for service personnel according to [DD.4.2](#) to [DD.4.10](#).

DD.4.2 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, [DD.4.3](#) to [DD.4.7](#) shall be completed prior to conducting work on the system.