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COMPOSITIONS

The present invention relates to a refrigerant composition and more particularly to a refrigerant composition comprising 1,1-difluoroethylene (R-1132a), difluoromethane (R-32) and 2,3,3,3-tetrafluoropropene (R-1234yf) that is useful in mobile or automotive thermal management systems, such as heat pump and air-conditioning systems, especially systems for electric vehicles.

The listing or discussion of a prior-published document or any background in the specification should not necessarily be taken as an acknowledgement that a document or background is part of the state of the art or is common general knowledge.

Unless otherwise stated, it is to be understood that the term “electric vehicle” as used herein refers to both purely electric vehicles as well as vehicles which use electricity as one of several means of propulsion, such as hybrid vehicles.

Cars fitted with internal combustion engines (ICEs) as primary propulsion systems often also have air-conditioning systems to provide passenger comfort by cooling and dehumidifying air. Such cars provide passenger heating in low-temperature environments by using waste heat from the engine to heat cabin air.

In contrast, electric vehicles (EVs) have no high-temperature source of heat in sufficient quantity to provide similar cabin heating. Instead, passenger heating must be achieved either by using battery energy in a resistive heating system or by recycling and upgrading heat from other sources using a heat pump. As EV passengers also require cooling in warm temperatures, a common strategy is to use the air conditioning system in reverse as a heat pump to provide some or all of the required heat at the appropriate temperature to the cabin air. Although the use of a heat pump architecture is more expensive, it can help reduce the overall power draw for passenger heating.

Despite this, it is known that passenger thermal comfort requirements can significantly reduce the effective driving range of EVs both in winter (from providing heating) and in summer (from providing air conditioning). Thus, improving energy efficiency of heating and air-conditioning of the vehicle would help reduce so-called “range anxiety” amongst EV users.

The existing refrigerants used for mobile air conditioning are: 1,1,1,2-tetrafluoroethane (R-134a), 2,3,3,3-tetrafluoropropene (R-1234yf) and carbon dioxide (CO₂, R-744).

R-134a has a Global Warming Potential (GWP) of 1430 and is gradually being phased out in favour of R-1234yf (GWP of about 1) in order to meet new EU F-Gas regulations, which mandate that new mobile air-conditioning (MAC) systems should use a refrigerant with GWP less than 150. Although both R-134a and R-1234yf offer good and energy efficient performance in air conditioning systems (whether for ICE or EV vehicles), they are limited in their ability to work in a “heat pump mode” for EVs.

Ambient air temperature can be as low as -25°C to -30°C . The use of R-134a and/or R-1234yf can be advantageous if the ambient temperature is above about -10°C ; however, below this temperature their relatively low vapour pressure reduces the capacity of the system and also reduces the energy efficiency of the heat pump.

Carbon dioxide is only used in a few ICE vehicles at present because it requires high-pressure equipment (leading to higher cost than that for system components using R-1234yf) and it offers poor energy efficiency in air-conditioning operation at higher ambient temperatures.

The use of highly flammable refrigerants such as 1,1-difluoroethane (R-152a) or propane, coupled with a “secondary loop” architecture to provide passenger safety has also been advocated. Whilst this technology is conceptually suited to some EV thermal management systems where a chiller moves heat between reservoirs of hot and cold liquid (said liquids then being used to perform cabin air heating or air conditioning), it is not likely to be universally adopted in EVs or ICE vehicles.

Car manufacturers anticipate rapid growth in electric vehicles but a continued presence of significant numbers of ICE vehicles for the next 10 to 15 years. Thus, the use of a single refrigerant composition across all platforms would offer production benefits and simpler manufacturing and maintenance operations.

Therefore, there is a need to provide a refrigerant composition that offers the following characteristics:

(a) acceptable performance (ideally better than that of R-1234yf) in both air-conditioning and heat pump modes;

(b) flammability characteristics similar to those of R-1234yf;

(c) a GWP of below about 150

At the same time, such compositions preferably should achieve satisfactory performance when operating in a heat pump mode at ambient temperatures as low as from about -25°C to about -30°C .

WO 2019/030508 discloses composition comprising 1,1-difluoroethene (R-1132a), difluoromethane (R-32), 2,3,3,3-tetrafluoropropene (R-1234yf), and optionally carbon dioxide (CO_2 , R-744) and 1,1,2-trifluoroethene (R-1123).

WO 2020/035690 discloses compositions comprising from 1 to 20% by weight 1,1-difluoroethylene (R-1132a), from 59 to 98% by weight 2,3,3,3-tetrafluoropropene (R-1234yf) and from 1 to 21% by weight difluoromethane (R-32).

EP3825381A1 discloses a composition comprising 15 to 24% by weight difluoromethane (HFC-32), 2,3,3,3-tetrafluoropropene (HFO-1234yf), and from 1 to 7% by weight 1,1-difluoroethylene (HFO-1132a).

The present invention addresses the above and other deficiencies, and the above needs, by the provision of a composition comprising 1,1-difluoroethylene (R-1132a), difluoromethane (R-32) and 2,3,3,3-tetrafluoropropene (R-1234yf) in particular amounts. Such compositions are referred to hereinafter as "the compositions of the (present) invention".

The present inventors have found that the compositions disclosed herein offer improved performance relative to R-1234yf both in air-conditioning and heat pump modes of operation. This renders these fluids suitable for use in the air-conditioning systems of conventional ICE platforms and also in the thermal management systems of EV platforms.

This finding is unexpected at least because the critical temperatures of these compositions are lower than those of R-1234yf. It is known that the efficiency of a vapour compression air-conditioning cycle reduces as the condensation temperature approaches the critical temperature. One might therefore anticipate that the performance of these compositions would be worse when compared to R-1234yf, especially at higher condensing temperatures which are required when operating the car in hot climates. However, it has been found that the compositions of the invention offer improved efficiencies in equipment as compared to R-1234yf. Consequently, the obtained performance is higher in both cooling capacity and energy

efficiency (described as "Coefficient of Performance", which is the ratio of useful cooling power to work input to the system).

Furthermore, the compositions of the invention have higher vapour pressures than that of R-1234yf and hence allow operation at lower external ambient temperatures in a heat pump mode. Thus, the compositions offer improved energy consumption and heating capacity in heating mode as well as cooling mode.

A further benefit of the compositions is that they are zeotropic and exhibit moderate "temperature glides".

The compositions of the invention will now be described in detail.

The compositions of the present invention comprise from about 6 to about 12 weight % R-1132a, from about 7 to about 13 weight % R-32 and from about 55 to about 87 weight % R-1234yf.

Conveniently, such compositions comprise from about 7 to about 12 weight % R-1132a, for example from about 7 to about 10 weight %.

Typically, the compositions of the present invention comprise from about 8 to about 13 weight % R-32, preferably from about 9 to about 13 weight %.

Advantageously, such compositions comprise from about 60 to about 87 weight % R-1234yf, for example from about 75 to about 85 weight %, preferably from about 78 to about 84 weight %.

The compositions of the present invention conveniently comprise from about 6 to about 10 weight % R-1132a, such as from 6 to about 7 weight %.

The compositions of the invention comprise from about 55 to about 87 weight % R-1234yf, such as from about 60 to about 84 weight %, preferably from about 75 to about 84 weight %.

For example, one of the preferred compositions of the present invention comprises about 8 weight % R-1132a, about 11 weight % R-32 and about 81 weight % R-1234yf.

Alternatively, the compositions of the invention may comprise from about 6 to about 9 weight % R-1132a, such as from about 6 to about 8 weight %.

5 Typically, the compositions of the present invention may comprise from about 63 to about 85 weight % R-1234yf, for example from about 67 to about 83 weight %, preferably from about 69 to about 82 weight %, even more preferably from about 72 to about 81 weight %.

10 Preferably, the tolerances (preferably manufacturing tolerances) for the compositions of the present invention are about ± 0.5 weight % for R-1132a, about ± 1 weight % for R-32 and about ± 1.5 weight % for R-1234yf.

In one embodiment, the compositions of the present invention consist essentially of the stated
15 components. By the term "consist essentially of", we include the meaning that the compositions of the invention contain substantially no other components, particularly no further (hydro)(fluoro)compounds (e.g. (hydro)(fluoro)alkanes or (hydro)(fluoro)alkenes)) known to be used in heat transfer compositions. The term "consist of" is included within the meaning of "consist essentially of".

20 In one embodiment, the compositions of the invention are substantially free of any component that has heat transfer properties (other than the components specified). For instance, the compositions of the invention may be substantially free of any other hydrofluorocarbon compound.

25 By "substantially no" and "substantially free of" we include the meaning that the compositions of the invention contain 0.5% by weight or less of the stated component, preferably 0.4%, 0.3%, 0.2%, 0.1% or less, based on the total weight of the compositions.

30 As used herein, all % amounts mentioned in the compositions herein, including in the claims, are by weight based on the total weight of the composition, unless otherwise stated.

By the term "about", as used in connection with numerical values of amounts of component in % by weight, we include the meaning of ± 0.5 weight %, for example ± 0.2 weight %.

35 For the avoidance of doubt, it is to be understood that the stated upper and lower values for ranges of amount of components in the compositions of the invention described herein may

be interchanged in any way, provided that the resulting ranges fall within the broadest scope of the invention.

The compositions of the present invention have zero ozone depletion potential.

5

Conveniently, the compositions of the invention have a Global Warming Potential (GWP) of less than about 400, such as less than about 150, preferably less than about 140 or less than about 125.

10 Typically, the compositions of the invention are of reduced flammability hazard when compared to R-1132a.

Flammability may be determined in accordance with ASHRAE Standard 34 (e.g. ASHRAE Standard 34:2019) incorporating the ASTM Standard E-681, the entire content of which is
15 incorporated herein by reference.

In one aspect, the compositions have one or more of (a) a higher lower flammable limit; (b) a higher ignition energy (c) a higher auto-ignition temperature; or (d) a lower burning velocity compared to R-1132a alone.

20

Preferably, the compositions of the invention are less flammable compared to R-1132a in one or more of the following respects: lower flammable limit at 23°C; lower flammable limit at 60°C; breadth of flammable range at 23°C or 60°C; auto-ignition temperature (thermal decomposition temperature); minimum ignition energy in dry air or burning velocity. The flammable limits and
25 burning velocity being determined according to the methods specified in ASHRAE-34 and the auto-ignition temperature being determined in a 500ml glass flask by the method of ASTM E659-78.

Conveniently, the compositions of the present invention have a burning velocity of less than
30 about 10 cm/s as determined in accordance with ASHRAE Standard 34:2019, such as less than about 9 cm/s, for example less than about 8 cm/s.

In one embodiment, the compositions of the invention are classified as weakly flammable ("class 2L") as determined in accordance with ASHRAE Standard 34:2019.

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It is believed that the compositions of the invention exhibit a completely unexpected combination of low/non-flammability, low GWP, improved lubricant miscibility and improved

performance properties when used in heat pump and/or air-conditioning systems of vehicles, especially electric vehicles. Some of these properties are explained in more detail below.

For example, the compositions of the present invention have a temperature glide in an evaporator or condenser of less than about 12K, such as less than about 10K, for example less than about 5K

Advantageously, the compositions of the present invention can operate in a heat pump mode at a temperature of less than about -15°C , such as less than about -20°C , preferably whilst still having an evaporation pressure and compressor suction pressure above atmospheric pressure

Typically, the compositions of the invention have heating capacity which is greater than or about equal to that of R-1234yf.

Conveniently, the compositions of the present invention have a volumetric cooling capacity which is greater than or about equal to that of R-1234yf.

Advantageously, the compositions of the present invention have a cycle efficiency (coefficient of performance (COP)) which is greater than or about equal to that of R-1234yf.

Typically, the compositions of the present invention evaporate at a temperature of below about -30°C when in operation. This enables heat pump operation at ambient air temperatures as low as -25°C to -30°C .

Conveniently, the compositions of the present invention condense at a temperature of above about 40°C when in operation. This is particularly desirable, since passenger air flow from the vent into the cabin is ideally heated to a temperature of from about 40°C to about 50°C .

Typically, the compressor discharge temperature of the compositions of the present invention is within about 15K of the existing refrigerant fluid (such as R-1234yf) they are replacing, preferably within about 10K or about 5K.

The compositions of the invention are typically suitable for use in existing designs of equipment and are compatible with all classes of lubricant currently used with established HFC refrigerants. They may be optionally stabilized or compatibilized with mineral oils by the use of appropriate additives.

Preferably, when used in a heat transfer equipment, the composition of the present invention is combined with a lubricant.

5 Conveniently, the lubricant is selected from the group consisting of mineral oil, silicone oil, polyalkyl benzenes (PABs), polyol esters (POEs), polyalkylene glycols (PAGs), polyalkylene glycol esters (PAG esters), polyvinyl ethers (PVEs), poly (alpha-olefins) and combinations thereof, such as wherein the lubricant is selected from the group consisting of polyol esters (POEs), polyalkylene glycols (PAGs) and combinations thereof.

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In one embodiment, the compositions of the invention contain substantially no trifluoriodomethane (CF₃I).

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All the chemicals described herein are commercially available. For example, fluorochemicals may be obtained from Apollo Scientific (UK).

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The compositions of the invention may be prepared by simply mixing R-1132a, R-32 and R-1234yf (and optional components, such as a lubricant) in the desired proportions. The compositions can then be added to a heat transfer device or used in any other way as described herein.

25

According to another aspect of the present invention, there is provided a use of a composition of the invention as a working fluid in a heat pump system of a vehicle (such as an electric vehicle).

In another aspect of the invention, there is provided a use of a composition of the present invention as a working fluid in an air-conditioning system of a vehicle (e.g. an electric vehicle).

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In a further aspect of the present invention, there is provided a use of a compositions of the invention as a replacement for an existing heat transfer fluid in a refrigeration or air-conditioning system, preferably wherein the existing fluid is R-407C or R-22.

According to a further aspect of the invention, there is provided a heat transfer device comprising a composition according to the present invention.

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Conveniently, the heat transfer device is a refrigeration device or an air-conditioning device.

In one embodiment, the heat transfer device comprises a residential or commercial air conditioning system, an air-conditioning system for a train or bus, a heat pump or a commercial or industrial refrigeration system.

- 5 According to another aspect of the invention, there is provided a method for cooling an article which comprises condensing a composition of the present invention and thereafter evaporating said composition in the vicinity of the article to be cooled.

- 10 According to another aspect of the invention, there is provided a method for heating an article which comprises condensing a composition according to the present invention in the vicinity of the article to be heated and thereafter evaporating said composition.

The present invention is illustrated by the following non-limiting examples.

15 EXAMPLES

- A thermodynamic model of the R-1132a/R-32/R-1234yf fluid system was built using the Span-Wagner equation of state as implemented in NIST REFPROP9.1 software. A pure fluid model for R-1132a was derived by measuring its vapour pressure from boiling point to critical point, 20 determining the critical point, measuring compressed liquid and vapour densities and measuring enthalpy content and heat capacity of the fluid in liquid and vapour states. Next, the vapour-liquid equilibrium behaviour of the binary mixtures of R-1132a with R-32 and R-1234yf was measured using constant-volume apparatus to measure the vapour pressure of a series of binary compositions over a range of temperatures and pressures from about -50°C 25 to $+70^{\circ}\text{C}$. These data were then regressed to provide binary interaction parameters suitable for use in modelling performance of ternary mixtures as refrigerants using standard cycle modelling techniques.

- Subsequently, a refrigeration/heat pump cycle was constructed in Microsoft Excel, linked to 30 the REFPROP software to provide thermodynamic property data for the mixtures. This model was used to estimate the performance of R-1234yf in air-conditioning mode and heat pump mode. The model was then used to estimate the performance of the fluids of the invention at the same delivered cooling or heating capacities.

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Example 1: Cooling mode performance

The compositions of the invention were modelled in cooling mode with R-1234yf as a reference. The cycle conditions used were as follows:

5

Data Input Section		R1234yf
Target cooling capacity	kW	6
Compressor displacement	m ³ /hr	11.35
Mean condenser temperature	°C	45.0
Mean evaporator temperature	°C	5.0
Condenser subcooling	K	3.0
Evaporator superheat	K	1.0
Evaporator pressure drop	bar	0.40
Suction line pressure drop	bar	0.20
Condenser pressure drop	bar	0.20
Compressor suction superheat	K	10.0
Isentropic efficiency		65.0%

Table 1: Cycle modelling conditions (Cooling Mode)

The performance of selected compositions of the invention in cooling mode is given in Tables 1 to 8 below. In the modelling, the anticipated pressure drops in the components for the compositions was estimated by reference to the specified pressure drops for R-1234yf. The compressor displacement required to deliver the stated cooling capacity was calculated for each fluid and compared to R-1234yf.

It can be seen from the performance data that the compositions of the invention offer the following:

- (a) Improved energy efficiency (expressed as Coefficient of Performance) as compared to that of R-1234yf;
- (b) Higher volumetric cooling capacity than that of R-1234yf. This makes it possible to either use a smaller displacement of compressor (thus saving weight and/or space) or use a compressor running at a lower speed. The ability to run air-conditioning with a low compressor speed is an important benefit for EV systems, because lower compressor speeds translate to lower transmitted noise of the air-conditioning system in the passenger cabin, thereby further improving the passengers' comfort;

- (c) Moderate temperature glide in an evaporator and condenser.

Example 2: Heating Mode Performance

- 5 The model was then used to simulate performance of selected compositions of the invention using the following cycle input conditions

Data Input Section		R1234yf
Target heating capacity	kW	5
Compressor displacement	m ³ /hr	20.38
Mean condenser temperature	°C	55.0
Mean evaporator temperature	°C	-15.0
Condenser subcooling	K	3.0
Evaporator superheat	K	1.0
Evaporator pressure drop	bar	0.50
Suction line pressure drop	bar	0.30
Condenser pressure drop	bar	0.30
Compressor suction superheat	K	10.0
Isentropic efficiency		65.0%

Table 2: Cycle modelling conditions (Heating Mode)

- 10 The chosen evaporator and condenser temperatures correspond to operation with external ambient air at about -10°C and a desired air delivery temperature for the cabin of about 50°C.

The performance of selected compositions of the invention in heating mode is shown in Tables 9 to 16 below.

- 15 It can be seen from the performance data that the compositions of the invention offer the following benefits:

- (a) Much higher heating capacities than that of R-1234yf;
 (b) Improved energy efficiency (expressed as COP) as compared to that of R-1234yf;
 20 (c) Higher suction pressures, thereby making it possible to operate the heat pump at lower ambient temperatures than is feasible/practicable with R-1234yf;
 (d) Moderate temperature glides (generally less than about 10K).

Example 3: Experimental testing

A composition comprising 8 weight % R-1132a, 11 weight % R-32 and 81 weight % R-1234yf was tested in the air-conditioner/heat pump system of a Nissan Leaf electric vehicle over a range of cooling mode and heating mode conditions. This system has been designed for use with R-1234yf. The testing was conducted according to the SAE J2765 standard for evaluation of performance of mobile air-conditioning systems. Testing was run for the blend in two states: firstly, with the same compressor speed as used for R-1234yf; secondly, with the compressor speed adjusted so that the blend gave equivalent cooling or heating capacity.

The performance in cooling and heating modes is shown in Figures 1 and 2. The legend notation shows the compressor speed (Idle/Medium/High) and the ambient temperature for each test point. Ambient temperatures in cooling mode were from 25°C to 60°C; in heating mode from –20°C to 0°C.

It can be seen that the blend gave significantly increased energy efficiency in cooling mode and significantly increased heating capacity at low ambient temperatures in heating mode, in line with the modelled results from Examples 1 and 2.

Table 1 (Cooling mode): Compositions comprising 3 weight % R-1132a (Reference examples)

Results		R1234yf																				
			3%	8%	89%	3%	10%	87%	3%	12%	85%	3%	14%	16%	18%	3%	3%	3%	3%	3%	3%	3%
R1132a R32 R1234yf	Cooling COP	2.97	3.13	3.14	3.16	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17
	Cooling COP relative to Reference	100.0%	105.4%	105.9%	106.3%	106.6%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%	106.8%
	Volumetric cooling capacity	1902	2712	2839	2959	3073	3182	3182	3182	3182	3182	3182	3182	3182	3182	3182	3182	3182	3182	3182	3182	3182
	Cooling Capacity relative to Reference	100.0%	142.6%	149.2%	155.6%	161.6%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%	167.3%
	Heating COP	3.97	4.13	4.14	4.16	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17
	Volumetric heating Capacity	2715	3798	3968	4130	4283	4430	4430	4430	4430	4430	4430	4430	4430	4430	4430	4430	4430	4430	4430	4430	4430
	Heating Capacity relative to Reference	100.0%	139.9%	146.2%	152.1%	157.8%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%	163.2%
	Cooling capacity	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	Heating capacity	8.56	8.40	8.39	8.37	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36
	Refrigeration effect	109.1	123.6	125.8	128.0	130.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0
	Pressure ratio	3.49	3.33	3.30	3.27	3.24	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22
	Compressor discharge temperature	65.2	72.9	74.0	75.0	75.9	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
	Discharge temp. difference from reference																					
	Evaporator inlet pressure	K	7.8	8.8	9.8	10.8	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
	Condenser inlet pressure	bar	5.04	5.25	5.45	5.64	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83
	Evaporator inlet temperature	bar	15.55	16.15	16.72	17.27	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80
	Evaporator dewpoint	°C	3.1	2.8	2.5	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	Evaporator exit gas temperature	°C	6.9	7.2	7.5	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Evaporator glide (out-in)	°C	7.9	8.2	8.5	8.7	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
	Compressor suction pressure	K	3.7	4.4	4.9	5.3	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
	Compressor discharge pressure	bar	4.67	4.90	5.12	5.33	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53
	Condenser dew point	bar	15.6	16.1	16.7	17.3	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8
	Condenser bubble point	°C	49.2	49.3	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4
	Condenser exit liquid temperature	°C	40.8	40.7	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6
	Condenser glide (in-out)	K	37.8	37.7	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6
			8.4	8.7	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8

Table 2 (Cooling mode): Compositions comprising 4 weight % R-1132a (Reference examples)

Results		R1132a R32 R1234yf										R1234yf	
Cooling COP		3.13	3.14	3.15	3.16	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17
Cooling COP relative to Reference		105.4%	105.8%	106.2%	106.5%	106.7%	106.8%	106.8%	106.8%	106.8%	106.8%	106.9%	106.9%
Volumetric cooling capacity	kJ/m3	2779	2905	3025	3138	3247	3350	3449	3449	3449	3449	3497	3497
Cooling Capacity relative to Reference		146.1%	152.7%	159.0%	165.0%	170.7%	176.1%	181.3%	181.3%	181.3%	181.3%	183.9%	183.9%
Heating COP		4.13	4.14	4.15	4.16	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17
Volumetric heating Capacity	kJ/m3	3891	4061	4222	4375	4522	4662	4797	4797	4797	4797	4862	4862
Heating Capacity relative to Reference		143.3%	149.6%	155.5%	161.1%	166.5%	171.7%	176.7%	176.7%	176.7%	176.7%	179.1%	179.1%
Cooling capacity	kW	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Heating capacity	kW	8.40	8.39	8.37	8.36	8.35	8.35	8.34	8.34	8.34	8.34	8.35	8.35
Refrigeration effect	kJ/kg	124.2	126.4	128.4	130.4	132.3	134.2	136.1	136.1	136.1	136.1	137.0	137.0
Pressure ratio		3.32	3.29	3.26	3.23	3.21	3.19	3.17	3.17	3.17	3.17	3.16	3.16
Compressor discharge temperature	°C	73.5	74.6	75.5	76.4	77.3	78.1	78.9	78.9	78.9	78.9	79.3	79.3
Discharge temp. difference from reference		8.3	9.4	10.4	11.3	12.1	12.9	13.7	13.7	13.7	13.7	14.1	14.1
Evaporator inlet pressure	bar	5.16	5.36	5.57	5.76	5.95	6.14	6.32	6.32	6.32	6.32	6.41	6.41
Condenser inlet pressure	bar	15.93	16.53	17.10	17.65	18.18	18.69	19.18	19.18	19.18	19.18	19.42	19.42
Evaporator inlet temperature	°C	2.8	2.5	2.3	2.1	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Evaporator dewpoint	°C	7.2	7.5	7.7	7.9	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Evaporator exit gas temperature	°C	8.2	8.5	8.7	8.9	9.0	9.1	9.1	9.1	9.1	9.1	9.1	9.1
Evaporator glide (out-in)	K	4.3	4.9	5.4	5.8	6.0	6.1	6.2	6.2	6.2	6.2	6.2	6.2
Compressor suction pressure	bar	4.80	5.02	5.24	5.46	5.66	5.86	6.05	6.05	6.05	6.05	6.15	6.15
Compressor discharge pressure	bar	15.9	16.5	17.1	17.6	18.2	18.7	19.2	19.2	19.2	19.2	19.4	19.4
Condenser dew point	°C	49.5	49.6	49.7	49.7	49.6	49.5	49.4	49.4	49.4	49.4	49.3	49.3
Condenser bubble point	°C	40.5	40.4	40.3	40.3	40.4	40.5	40.6	40.6	40.6	40.6	40.7	40.7
Condenser exit liquid temperature	°C	37.5	37.4	37.3	37.3	37.4	37.5	37.6	37.6	37.6	37.6	37.7	37.7
Condenser glide (in-out)	K	9.0	9.3	9.3	9.3	9.2	9.0	8.7	8.7	8.7	8.7	8.6	8.6

Table 3 (Cooling mode): Compositions comprising 5 weight % R-1132a (Reference examples)

Results		R1234yf												
			R1132a			R32			R1234yf					
Cooling COP		2.97												
Cooling COP relative to Reference		100.0%												
Volumetric cooling capacity	kJ/m ³	1902												
Cooling Capacity relative to Reference		100.0%												
Heating COP		3.97												
Volumetric heating Capacity	kJ/m ³	2715												
Heating Capacity relative to Reference		100.0%												
Cooling capacity	kW	6.00												
Heating capacity	kW	8.56												
Refrigeration effect	kJ/kg	109.1												
Pressure ratio		3.49												
Compressor discharge temperature	°C	65.2												
Discharge temp. difference from reference	K	0.0												
Evaporator inlet pressure	bar	3.93												
Condenser inlet pressure	bar	11.64												
Evaporator inlet temperature	°C	6.6												
Evaporator dewpoint	°C	3.4												
Evaporator exit gas temperature	°C	4.4												
Evaporator glide (out-in)	K	-3.3												
Compressor suction pressure	bar	3.33												
Compressor discharge pressure	bar	11.6												
Condenser dew point	°C	45.4												
Condenser bubble point	°C	44.6												
Condenser exit liquid temperature	°C	41.6												
Condenser glide (in-out)	K	0.7												

	3.13	3.14	3.15	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.17
	105.4%	105.8%	106.1%	106.3%	106.3%	106.5%	106.5%	106.6%	106.6%	106.6%	106.6%	106.6%	106.6%	106.6%
	2846	2971	3091	3203	3203	3311	3311	3414	3414	3414	3414	3512	3561	3561
	149.6%	156.2%	162.5%	168.4%	168.4%	174.0%	174.0%	179.4%	179.4%	179.4%	179.4%	184.6%	187.2%	187.2%
	4.13	4.14	4.15	4.16	4.16	4.16	4.16	4.16	4.16	4.16	4.16	4.16	4.17	4.17
	3984	4153	4314	4467	4467	4613	4613	4753	4753	4753	4753	4887	4953	4953
	146.8%	153.0%	158.9%	164.5%	164.5%	169.9%	169.9%	175.0%	175.0%	175.0%	175.0%	180.0%	182.4%	182.4%
	6.00	6.00	5.99	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	8.40	8.39	8.36	8.36	8.36	8.35	8.35	8.36	8.36	8.36	8.36	8.35	8.35	8.35
	124.8	126.9	128.9	130.8	130.8	132.7	132.7	134.5	134.5	134.5	134.5	136.4	137.3	137.3
	3.31	3.28	3.25	3.23	3.23	3.20	3.20	3.18	3.18	3.18	3.18	3.16	3.15	3.15
	74.1	75.1	76.0	76.9	76.9	77.8	77.8	78.6	78.6	78.6	78.6	79.3	79.7	79.7
	8.9	9.9	10.9	11.8	11.8	12.6	12.6	13.4	13.4	13.4	13.4	14.2	14.5	14.5
	5.27	5.48	5.69	5.88	5.88	6.08	6.08	6.27	6.27	6.27	6.27	6.45	6.54	6.54
	16.31	16.91	17.48	18.03	18.03	18.56	18.56	19.07	19.07	19.07	19.07	19.57	19.81	19.81
	2.6	2.3	2.1	1.9	1.9	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	7.4	7.7	7.9	8.1	8.1	8.2	8.2	8.3	8.3	8.3	8.3	8.3	8.3	8.3
	8.4	8.7	8.9	9.1	9.1	9.2	9.2	9.3	9.3	9.3	9.3	9.3	9.3	9.3
	4.9	5.4	5.9	6.2	6.2	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	4.92	5.15	5.37	5.59	5.59	5.79	5.79	5.99	5.99	5.99	5.99	6.19	6.28	6.28
	16.3	16.9	17.5	18.0	18.0	18.6	18.6	19.1	19.1	19.1	19.1	19.6	19.8	19.8
	49.8	49.9	49.9	49.9	49.9	49.8	49.8	49.7	49.7	49.7	49.7	49.6	49.5	49.5
	40.2	40.1	40.1	40.1	40.1	40.2	40.2	40.3	40.3	40.3	40.3	40.4	40.5	40.5
	37.2	37.1	37.1	37.1	37.1	37.2	37.2	37.3	37.3	37.3	37.3	37.4	37.5	37.5
	9.6	9.8	9.8	9.8	9.8	9.6	9.6	9.4	9.4	9.4	9.4	9.1	9.0	9.0

Table 4 (Cooling mode): Compositions comprising 6 weight % R-1132a

Results		R1234yf	R1132a R32 R1234yf												(Reference example)	(Reference example)	(Reference example)	(Reference example)	(Reference example)
			6%	8%	86%	6%	10%	84%	6%	12%	82%	6%	14%	80%	(Reference example)	(Reference example)	(Reference example)	(Reference example)	(Reference example)
Cooling COP		2.97	3.13			3.14	3.15		3.15	3.15		3.15	3.15		3.15	3.16	3.16	3.16	6%
Cooling COP relative to Reference		100.0%	105.3%			105.7%	106.0%		106.1%	106.3%		106.3%	106.3%		106.3%	106.3%	106.3%	106.4%	6%
Volumetric cooling capacity	kJ/m ³	1902	2913			3038	3155		3267	3375		3375	3375		3375	3477	3575	3624	20%
Cooling Capacity relative to Reference		100.0%	153.1%			159.7%	165.9%		171.8%	177.4%		177.4%	177.4%		177.4%	182.8%	188.0%	190.5%	73%
Heating COP		3.97	4.13			4.14	4.15		4.15	4.15		4.15	4.15		4.15	4.16	4.16	4.16	
Volumetric heating Capacity	kJ/m ³	2715	4078			4246	4405		4557	4703		4703	4703		4703	4843	4978	5043	
Heating Capacity relative to Reference		100.0%	150.2%			156.4%	162.3%		167.9%	173.2%		173.2%	173.2%		173.2%	178.4%	183.3%	185.8%	
Cooling capacity	kW	6.00	6.00			6.00	6.00		6.01	6.01		6.01	6.01		6.01	6.00	6.01	6.00	
Heating capacity	kW	8.56	8.40			8.39	8.38		8.38	8.37		8.37	8.37		8.37	8.35	8.37	8.35	
Refrigeration effect	kJ/kg	109.1	125.3			127.4	129.3		131.2	133.0		133.0	133.0		133.0	134.8	136.6	137.5	
Pressure ratio		3.49	3.30			3.27	3.25		3.22	3.20		3.20	3.20		3.20	3.18	3.16	3.15	
Compressor discharge temperature	°C	65.2	74.6			75.6	76.5		77.4	78.2		78.2	78.2		78.2	79.0	79.8	80.1	
Discharge temp. difference from reference																			
Evaporator inlet pressure	K	0.0	9.4			10.4	11.4		12.2	13.1		13.1	13.1		13.1	13.8	14.6	15.0	
Condenser inlet pressure	bar	3.93	5.39			5.60	5.81		6.01	6.20		6.20	6.20		6.20	6.39	6.58	6.67	
Evaporator inlet temperature	bar	11.64	16.69			17.29	17.86		18.41	18.95		18.95	18.95		18.95	19.46	19.96	20.20	
Evaporator dewpoint	°C	6.6	2.3			2.0	1.8		1.7	1.6		1.6	1.6		1.6	1.6	1.6	1.6	
Evaporator exit gas temperature	°C	3.4	7.7			8.0	8.2		8.3	8.4		8.4	8.4		8.4	8.4	8.4	8.4	
Evaporator glide (out-in)	°C	4.4	8.7			9.0	9.2		9.3	9.4		9.4	9.4		9.4	9.4	9.4	9.4	
Compressor suction pressure	K	-3.3	5.4			5.9	6.3		6.6	6.8		6.8	6.8		6.8	6.9	6.9	6.8	
Compressor discharge pressure	bar	3.33	5.05			5.28	5.50		5.72	5.93		5.93	5.93		5.93	6.13	6.32	6.42	
Condenser dew point	bar	11.6	16.7			17.3	17.9		18.4	18.9		18.9	18.9		18.9	19.5	20.0	20.2	
Condenser bubble point	°C	45.4	50.1			50.1	50.1		50.1	50.1		50.1	50.1		50.1	49.9	49.7	49.6	
Condenser exit liquid temperature	°C	44.6	39.9			39.9	39.9		39.9	39.9		39.9	39.9		39.9	40.1	40.3	40.4	
Condenser glide (in-out)	°C	41.6	36.9			36.9	36.9		36.9	36.9		36.9	36.9		36.9	37.1	37.3	37.4	
	K	0.7	10.2			10.3	10.3		10.2	10.0		10.2	10.2		10.2	9.7	9.4	9.3	

Table 5 (Cooling mode): Compositions comprising 7 weight % R-1132a

	Results		R1234yf																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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Table 6 (Cooling mode): Compositions comprising 8 weight % R-1132a

	Results		R1234yf																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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Table 7 (Cooling mode): Compositions comprising 9 weight % R-1132a

Results		R1132a R32 R1234yf									
		3.12	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13
Cooling COP		105.1%	105.4%	105.5%	105.6%	105.6%	105.6%	105.6%	105.6%	105.5%	105.5%
Cooling COP relative to Reference		3111	3233	3349	3459	3459	3459	3459	3459	3763	3808
Volumetric cooling capacity	kJ/m3	163.6%	170.0%	176.0%	181.8%	181.8%	181.8%	181.8%	181.8%	197.8%	200.2%
Cooling Capacity relative to Reference		4.12	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13
Heating COP		2715	4356	4679	4831	4831	4831	4831	4831	5248	5311
Volumetric heating Capacity	kJ/m3	100.0%	166.6%	172.4%	177.9%	177.9%	177.9%	177.9%	177.9%	193.3%	195.6%
Heating Capacity relative to Reference		6.00	6.00	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.05
Cooling capacity	kW	8.41	8.39	8.40	8.39	8.39	8.39	8.39	8.39	8.38	8.44
Heating capacity	kW										
Refrigeration effect	kJ/kg	109.1	128.5	130.3	132.1	132.1	132.1	132.1	132.1	137.2	138.0
Pressure ratio		3.49	3.25	3.22	3.20	3.20	3.20	3.20	3.20	3.14	3.13
Compressor discharge temperature	°C	65.2	76.1	77.1	77.9	78.8	78.8	78.8	79.5	81.0	81.4
Discharge temp. difference from reference											
Evaporator inlet pressure	K	0.0	10.9	11.9	12.8	13.6	13.6	13.6	14.4	15.8	16.2
Condenser inlet pressure	bar	3.93	5.76	5.97	6.19	6.39	6.39	6.39	6.59	6.98	7.07
Evaporator inlet temperature	bar	11.64	17.83	18.43	19.01	19.57	19.57	19.57	20.11	21.13	21.38
Evaporator dewpoint	°C	6.6	1.6	1.4	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Evaporator exit gas temperature	°C	3.4	8.4	8.6	8.8	8.9	8.9	8.9	8.9	8.9	8.9
Evaporator glide (out-in)	°C	4.4	9.4	9.6	9.8	9.9	9.9	9.9	9.9	9.9	9.9
Compressor suction pressure	K	-3.3	6.9	7.3	7.6	7.8	7.8	7.8	7.9	7.8	7.8
Compressor discharge pressure	bar	3.33	5.44	5.68	5.90	6.12	6.12	6.12	6.33	6.73	6.83
Condenser dew point	bar	11.6	17.8	18.4	19.0	19.6	19.6	19.6	20.1	21.1	21.4
Condenser bubble point	°C	45.4	50.8	50.8	50.7	50.6	50.6	50.6	50.5	50.2	50.1
Condenser exit liquid temperature	°C	44.6	39.2	39.2	39.3	39.4	39.4	39.4	39.5	39.8	39.9
Condenser glide (in-out)	°C	41.6	36.2	36.2	36.3	36.4	36.4	36.4	36.5	36.8	36.9
	K	0.7	11.6	11.6	11.5	11.3	11.3	11.3	11.0	10.3	10.1

Table 8 (Cooling mode): Compositions comprising 10 weight % R-1132a

Results		R1132a R32 R1234yf										R1234yf	
Cooling COP		3.12	3.12	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.12
Cooling COP relative to Reference		105.0%	105.2%	105.3%	105.4%	105.4%	105.4%	105.4%	105.3%	105.3%	105.3%	105.2%	105.2%
Volumetric cooling capacity	kJ/m3	3177	3298	3413	3522	3522	3627	3627	3728	3728	3825	3871	3871
Cooling Capacity relative to Reference		167.0%	173.4%	179.4%	185.2%	185.2%	190.7%	190.7%	195.9%	195.9%	201.0%	203.5%	203.5%
Heating COP		4.12	4.12	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.12	4.12
Volumetric heating Capacity	kJ/m3	4449	4613	4771	4921	4921	5065	5065	5204	5204	5338	5402	5402
Heating Capacity relative to Reference		163.8%	169.9%	175.7%	181.3%	181.3%	186.6%	186.6%	191.7%	191.7%	196.6%	199.0%	199.0%
Cooling capacity	kW	6.00	6.01	6.00	6.01	6.01	6.00	6.00	6.01	6.01	6.00	6.02	6.02
Heating capacity	kW	8.40	8.41	8.39	8.39	8.39	8.39	8.39	8.38	8.38	8.38	8.40	8.40
Refrigeration effect	kJ/kg	127.1	128.9	130.6	132.3	132.3	134.0	134.0	135.7	135.7	137.3	138.1	138.1
Pressure ratio		3.27	3.24	3.21	3.19	3.19	3.17	3.17	3.15	3.15	3.13	3.12	3.12
Compressor discharge temperature	°C	76.6	77.5	78.4	79.2	79.2	79.9	79.9	80.7	80.7	81.4	81.7	81.7
Discharge temp. difference from reference													
Evaporator inlet pressure	K	11.4	12.3	13.2	14.0	14.0	14.8	14.8	15.5	15.5	16.2	16.6	16.6
Condenser inlet pressure	bar	5.88	6.10	6.32	6.52	6.52	6.73	6.73	6.92	6.92	7.11	7.21	7.21
Evaporator inlet temperature	bar	18.21	18.82	19.40	19.96	19.96	20.50	20.50	21.02	21.02	21.53	21.77	21.77
Evaporator dewpoint	°C	1.3	1.1	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0
Evaporator exit gas temperature	°C	8.7	8.9	9.0	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.0	9.0
Evaporator glide (out-in)	°C	9.7	9.9	10.0	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.0	10.0
Compressor suction pressure	K	7.3	7.7	8.0	8.1	8.1	8.2	8.2	8.2	8.2	8.1	8.0	8.0
Compressor discharge pressure	bar	5.57	5.81	6.04	6.26	6.26	6.47	6.47	6.67	6.67	6.87	6.97	6.97
Condenser dew point	bar	18.2	18.8	19.4	20.0	20.0	20.5	20.5	21.0	21.0	21.5	21.8	21.8
Condenser bubble point	°C	51.0	51.0	50.9	50.8	50.8	50.6	50.6	50.5	50.5	50.3	50.2	50.2
Condenser exit liquid temperature	°C	39.0	39.0	39.1	39.2	39.2	39.4	39.4	39.5	39.5	39.7	39.8	39.8
Condenser glide (in-out)	°C	36.0	36.0	36.1	36.2	36.2	36.4	36.4	36.5	36.5	36.7	36.8	36.8
	K	12.0	12.0	11.8	11.6	11.6	11.3	11.3	10.9	10.9	10.5	10.4	10.4

Table 9 (Heating mode): Compositions comprising 3 weight % R-1132a (Reference examples)

Results		R1132a	3 weight % R-1132a (Reference examples)						R1234yf
			3%	3%	3%	3%	3%	3%	
Cooling COP			1.26	1.27	1.28	1.29	1.30	1.31	1.32
Cooling COP relative to Reference			113.1%	114.3%	115.5%	116.4%	117.2%	117.9%	118.6%
Volumetric cooling capacity	kl/m3		926	986	1044	1101	1156	1210	1263
Cooling Capacity relative to Reference			165.4%	176.1%	186.6%	196.8%	206.6%	216.1%	225.6%
Heating COP			2.26	2.27	2.28	2.29	2.30	2.31	2.32
Volumetric heating Capacity	kl/m3		1755	1857	1958	2055	2150	2242	2333
Heating Capacity relative to Reference			155.4%	164.5%	173.4%	182.0%	190.4%	198.5%	206.6%
Cooling capacity	kW		2.64	2.66	2.67	2.68	2.69	2.70	2.71
Heating capacity	kW		5.00	5.00	5.00	5.00	5.00	5.00	5.00
Refrigeration effect	kl/kg		93.6	95.9	98.1	100.2	102.2	104.2	106.2
Pressure ratio			9.56	9.36	9.17	8.99	8.84	8.70	8.57
Compressor discharge temperature	°C		95.2	96.8	98.4	99.9	101.4	102.9	104.3
Discharge temp. difference from reference	K		8.2	9.8	11.4	13.0	14.5	16.0	17.4
Evaporator inlet pressure	bar		2.51	2.60	2.70	2.79	2.89	2.98	3.07
Condenser inlet pressure	bar		19.56	20.30	21.02	21.71	22.37	23.01	23.63
Evaporator inlet temperature	°C		-14.9	-15.3	-15.7	-15.9	-16.2	-16.4	-16.5
Evaporator dewpoint	°C		-15.1	-14.7	-14.3	-14.1	-13.8	-13.6	-13.5
Evaporator exit gas temperature	°C		-14.1	-13.7	-13.3	-13.1	-12.8	-12.6	-12.5
Evaporator glide (out-in)	K		-0.1	0.6	1.3	1.9	2.4	2.7	3.0
Compressor suction pressure	bar		2.05	2.17	2.29	2.41	2.53	2.64	2.76
Compressor discharge pressure	bar		19.6	20.3	21.0	21.7	22.4	23.0	23.6
Condenser dew point	°C		58.9	59.0	59.0	59.0	59.0	58.9	58.7
Condenser bubble point	°C		51.1	51.0	51.0	51.0	51.0	51.1	51.2
Condenser exit liquid temperature	°C		48.1	48.0	48.0	48.0	48.0	48.1	48.2
Condenser glide (in-out)	K		7.7	8.0	8.1	8.1	8.0	7.8	7.6
									7.4
									1.32
									118.9%
									1288
									230.1%
									2.32
									2376
									210.4%
									2.71
									5.00
									107.2
									8.51
									105.1
									18.1
									3.12
									23.93
									-16.6
									-13.4
									-12.4
									3.1
									2.81
									23.9
									58.7
									51.3
									48.3
									7.4

Table 10 (Heating mode): Compositions comprising 4 weight % R-1132a (Reference examples)

Results		R1234yf											
Cooling COP		1.11											
Cooling COP relative to Reference		100.0%											
Volumetric cooling capacity	kl/m3	560											
Cooling Capacity relative to Reference		100.0%											
Heating COP		2.11											
Volumetric heating Capacity	kl/m3	1129											
Heating Capacity relative to Reference		100.0%											
Cooling capacity	kW	2.48											
Heating capacity	kW	5.00											
Refrigeration effect	kl/kg	79.7											
Pressure ratio		11.38											
Compressor discharge temperature	°C	86.9											
Discharge temp. difference from reference	K	0.0											
Evaporator inlet pressure	bar	2.10											
Condenser inlet pressure	bar	14.80											
Evaporator inlet temperature	°C	-11.5											
Evaporator dewpoint	°C	-18.5											
Evaporator exit gas temperature	°C	-17.5											
Evaporator glide (out-in)	K	-7.1											
Compressor suction pressure	bar	1.30											
Compressor discharge pressure	bar	14.8											
Condenser dew point	°C	55.4											
Condenser bubble point	°C	54.6											
Condenser exit liquid temperature	°C	51.6											
Condenser glide (in-out)	K	0.9											

R1132a	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
R32	8%	10%	12%	14%	16%	18%	20%	21%	20%	18%	16%	14%	12%
R1234yf	88%	86%	84%	82%	80%	78%	76%	75%	76%	78%	80%	82%	84%

1.26	1.27	1.28	1.29	1.30	1.31	1.31	1.31	1.32
113.1%	114.3%	115.4%	116.2%	117.0%	117.7%	117.7%	118.2%	118.6%
951	1011	1069	1126	1180	1235	1235	1286	1313
169.9%	180.6%	191.0%	201.2%	210.9%	220.6%	220.6%	229.8%	234.6%
2.26	2.27	2.28	2.29	2.30	2.31	2.31	2.31	2.32
1802	1904	2005	2102	2196	2290	2290	2379	2425
159.5%	168.6%	177.5%	186.2%	194.5%	202.8%	202.8%	210.6%	214.7%
2.64	2.66	2.67	2.68	2.69	2.70	2.70	2.72	2.70
5.00	5.01	5.01	5.00	5.02	5.00	5.00	5.02	4.98
94.1	96.3	98.5	100.5	102.5	104.5	104.5	106.4	107.4
9.50	9.30	9.12	8.95	8.81	8.66	8.66	8.54	8.48
95.8	97.4	99.0	100.5	102.1	103.5	103.5	105.0	105.7
8.9	10.5	12.1	13.6	15.1	16.6	16.6	18.0	18.7
2.56	2.65	2.75	2.84	2.94	3.04	3.04	3.13	3.18
20.01	20.76	21.47	22.16	22.83	23.47	23.47	24.09	24.39
-15.1	-15.5	-15.8	-16.1	-16.3	-16.5	-16.5	-16.7	-16.7
-14.9	-14.5	-14.2	-13.9	-13.7	-13.5	-13.5	-13.3	-13.3
-13.9	-13.5	-13.2	-12.9	-12.7	-12.5	-12.5	-12.3	-12.3
0.3	1.0	1.7	2.2	2.7	3.0	3.0	3.3	3.4
2.11	2.23	2.35	2.48	2.59	2.71	2.71	2.82	2.88
20.0	20.8	21.5	22.2	22.8	23.5	23.5	24.1	24.4
59.1	59.2	59.3	59.2	59.2	59.1	59.1	58.9	58.9
50.9	50.8	50.7	50.8	50.8	50.9	50.9	51.1	51.1
47.9	47.8	47.7	47.8	47.8	47.9	47.9	48.1	48.1
8.3	8.5	8.5	8.5	8.3	8.1	8.1	7.9	7.7

Table 11 (Heating mode): Compositions comprising 5 weight % R-1132a (Reference examples)

Results		R1132a										R1234yf									
Cooling COP		1.11											1.31								
Cooling COP relative to Reference		100.0%											117.9%								
Volumetric cooling capacity	kJ/m ³	560											1310								
Cooling Capacity relative to Reference		100.0%											234.1%								
Heating COP		2.11											2.31								
Volumetric heating Capacity	kJ/m ³	1129											2427								
Heating Capacity relative to Reference		100.0%											214.9%								
Cooling capacity	kW	2.48											2.71								
Heating capacity	kW	5.00											5.00								
Refrigeration effect	kJ/kg	79.7											106.6								
Pressure ratio		11.38											8.51								
Compressor discharge temperature	°C	86.9											106.3								
Discharge temp. difference from reference	K	0.0											19.3								
Evaporator inlet pressure	bar	2.10											3.24								
Condenser inlet pressure	bar	14.80											24.86								
Evaporator inlet temperature	°C	-11.5											-16.8								
Evaporator dewpoint	°C	-18.5											-13.2								
Evaporator exit gas temperature	°C	-17.5											-12.2								
Evaporator glide (out-in)	K	-7.1											3.7								
Compressor suction pressure	bar	1.30											2.94								
Compressor discharge pressure	bar	14.8											24.9								
Condenser dew point	°C	55.4											59.1								
Condenser bubble point	°C	54.6											51.0								
Condenser exit liquid temperature	°C	51.6											48.0								
Condenser glide (in-out)	K	0.9											8.2								

R1132a 5% 5% 5% 5% 5% 5% 5%

R32 8% 10% 12% 14% 16% 18% 20% 21%

R1234yf 87% 85% 83% 81% 79% 77% 75% 74%

Table 12 (Heating mode): Compositions comprising 6 weight % R-1132a

	Results	R1234yf										
		1.11	100.0%	560	100.0%	2.11	1129	100.0%	2.48	5.00		
	Cooling COP											
	Cooling COP relative to Reference											
	Volumetric cooling capacity	kl/m3										
	Cooling Capacity relative to Reference											
	Heating COP											
	Volumetric heating Capacity	kl/m3										
	Heating Capacity relative to Reference											
	Cooling capacity	kW										
	Heating capacity	kW										
	Refrigeration effect	kl/kg										
	Pressure ratio											
	Compressor discharge temperature	°C										
	Discharge temp. difference from reference	K										
	Evaporator inlet pressure	bar										
	Condenser inlet pressure	bar										
	Evaporator inlet temperature	°C										
	Evaporator dewpoint	°C										
	Evaporator exit gas temperature	°C										
	Evaporator glide (out-in)	K										
	Compressor suction pressure	bar										
	Compressor discharge pressure	bar										
	Condenser dew point	°C										
	Condenser bubble point	°C										
	Condenser exit liquid temperature	°C										
	Condenser glide (in-out)	K										

R1132a	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
	8%	10%	12%	14%	16%	18%	20%	21%	21%	21%	21%	21%
	86%	84%	82%	80%	78%	76%	74%	73%	73%	73%	73%	73%
	1.26	1.27	1.28	1.28	1.28	1.29	1.30	1.31	1.31	1.31	1.31	1.31
	113.2%	114.2%	115.1%	115.1%	115.1%	115.8%	117.1%	117.6%	117.6%	117.6%	117.6%	117.6%
	1002	1062	1119	1119	1119	1175	1283	1335	1335	1335	1361	1361
	179.1%	189.7%	199.9%	199.9%	199.9%	210.0%	229.3%	238.6%	238.6%	238.6%	243.1%	243.1%
	2.26	2.27	2.28	2.28	2.28	2.29	2.30	2.31	2.31	2.31	2.31	2.31
	1898	2000	2100	2100	2100	2197	2385	2475	2475	2475	2520	2520
	168.0%	177.1%	185.9%	185.9%	185.9%	194.6%	211.2%	219.2%	219.2%	219.2%	223.1%	223.1%
R32	2.64	2.65	2.67	2.66	2.66	2.67	2.69	2.70	2.70	2.70	2.70	2.70
	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	95.0	97.1	99.1	99.1	99.1	101.1	104.9	106.8	106.8	106.8	107.7	107.7
	9.38	9.19	9.03	9.03	9.03	8.87	8.59	8.47	8.47	8.47	8.42	8.42
	97.1	98.7	100.3	100.3	100.3	101.8	104.7	106.1	106.1	106.1	106.9	106.9
	10.1	11.7	13.3	13.3	13.3	14.8	17.8	19.2	19.2	19.2	19.9	19.9
	2.66	2.75	2.85	2.85	2.85	2.95	3.15	3.25	3.25	3.25	3.30	3.30
	20.91	21.67	22.39	22.39	22.39	23.08	24.40	25.03	25.03	25.03	25.33	25.33
	-15.6	-15.9	-16.2	-16.2	-16.2	-16.5	-16.8	-16.9	-16.9	-16.9	-17.0	-17.0
	-14.4	-14.1	-13.8	-13.8	-13.8	-13.5	-13.2	-13.1	-13.1	-13.1	-13.0	-13.0
R1234yf	-13.4	-13.1	-12.8	-12.8	-12.8	-12.5	-12.2	-12.1	-12.1	-12.1	-12.0	-12.0
	1.2	1.9	2.4	2.4	2.4	2.9	3.6	3.9	3.9	3.9	4.0	4.0
	2.23	2.36	2.48	2.48	2.48	2.60	2.84	2.95	2.95	2.95	3.01	3.01
	20.9	21.7	22.4	22.4	22.4	23.1	24.4	25.0	25.0	25.0	25.3	25.3
	59.6	59.7	59.7	59.7	59.7	59.6	59.4	59.2	59.2	59.2	59.1	59.1
	50.4	50.3	50.3	50.3	50.3	50.4	50.6	50.8	50.8	50.8	50.9	50.9
	47.4	47.3	47.3	47.3	47.3	47.4	47.6	47.8	47.8	47.8	47.9	47.9
	9.2	9.3	9.3	9.3	9.3	9.2	8.7	8.4	8.4	8.4	8.3	8.3
	11.38	86.9	0.0	2.10	14.80	-11.5	-18.5	-17.5	-7.1	1.30	14.8	55.4
	54.6	51.6	0.9									

Table 13 (continued): Compositions comprising 7 weight % R-1132a

			R1132a	7%	7%	7%	7%	7%	7%	7%	7%	7%
			R32	8%	10%	12%	14%	16%	18%	20%	21%	
			R1234yf	85%	83%	81%	79%	77%	75%	73%	72%	
Results		34yf		(Reference example)	(Reference example)	(Reference example)	(Reference example)	(Reference example)	(Reference example)	(Reference example)	(Reference example)	
Cooling COP		11	1.26	1.27	1.28	1.28	1.29	1.30	1.30	1.30	1.30	
Cooling COP relative to Reference		.0%	113.2%	114.1%	114.9%	115.6%	116.2%	116.7%	117.2%	117.4%	117.4%	
Volumetric cooling capacity	kJ/m3	10	1028	1087	1144	1200	1254	1307	1359	1385	1385	
Cooling Capacity relative to Reference		.0%	183.6%	194.1%	204.4%	214.3%	224.1%	233.6%	242.8%	247.4%	247.4%	
Heating COP		11	2.26	2.27	2.28	2.28	2.29	2.30	2.30	2.30	2.30	
Volumetric heating Capacity	kJ/m3	29	1945	2048	2147	2245	2340	2432	2523	2567	2567	
Heating Capacity relative to Reference		.0%	172.2%	181.3%	190.1%	198.8%	207.2%	215.4%	223.4%	227.3%	227.3%	
Cooling capacity	kW	18	2.64	2.65	2.66	2.67	2.68	2.69	2.69	2.70	2.70	
Heating capacity	kW	30	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	
Refrigeration effect	kJ/kg	79.7	95.4	97.4	99.4	101.3	103.2	105.0	106.9	107.8	107.8	
Pressure ratio		11.38	9.32	9.14	8.98	8.83	8.69	8.56	8.44	8.39	8.39	
Compressor discharge temperature	°C	86.9	97.7	99.3	100.9	102.4	103.9	105.3	106.7	107.4	107.4	
Discharge temp. difference from reference	K	0.0	10.8	12.4	13.9	15.4	16.9	18.4	19.8	20.5	20.5	
Evaporator inlet pressure	bar	2.10	2.71	2.81	2.91	3.01	3.11	3.21	3.31	3.36	3.36	
Condenser inlet pressure	bar	14.80	21.37	22.12	22.85	23.54	24.22	24.87	25.49	25.80	25.80	
Evaporator inlet temperature	°C	-11.5	-15.8	-16.1	-16.4	-16.6	-16.8	-17.0	-17.1	-17.1	-17.1	
Evaporator dewpoint	°C	-18.5	-14.2	-13.9	-13.6	-13.4	-13.2	-13.0	-12.9	-12.9	-12.9	
Evaporator exit gas temperature	°C	-17.5	-13.2	-12.9	-12.6	-12.4	-12.2	-12.0	-11.9	-11.9	-11.9	
Evaporator glide (out-in)	K	-7.1	1.6	2.2	2.8	3.3	3.6	3.9	4.1	4.2	4.2	
Compressor suction pressure	bar	1.30	2.29	2.42	2.54	2.67	2.79	2.91	3.02	3.08	3.08	
Compressor discharge pressure	bar	14.8	21.4	22.1	22.8	23.5	24.2	24.9	25.5	25.8	25.8	
Condenser dew point	°C	55.4	59.8	59.9	59.8	59.7	59.6	59.5	59.3	59.3	59.3	
Condenser bubble point	°C	54.6	50.2	50.1	50.2	50.3	50.4	50.5	50.7	50.7	50.7	
Condenser exit liquid temperature	°C	51.6	47.2	47.1	47.2	47.3	47.4	47.5	47.7	47.7	47.7	
Condenser glide (in-out)	K	0.9	9.7	9.7	9.6	9.5	9.3	9.0	8.7	8.5	8.5	

Table 14 (Heating mode): Compositions comprising 8 weight % R-1132a

Results		R1234yf	R1132a								R1234yf							
			8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Cooling COP		1.11	1.26	1.27	1.27	1.27	1.27	1.27	1.28	1.29	1.29	1.29	1.29	1.29	1.30	1.30	1.30	8%
Cooling COP relative to Reference		100.0%	113.1%	114.0%	114.7%	114.7%	114.7%	114.7%	115.3%	115.9%	115.9%	115.9%	116.3%	116.8%	117.0%	117.0%	117.0%	21%
Volumetric cooling capacity	kJ/m3	560	1053	1111	1168	1168	1168	1168	1224	1278	1278	1278	1331	1383	1408	1408	1408	20%
Cooling Capacity relative to Reference		100.0%	188.1%	198.6%	208.7%	208.7%	208.7%	208.7%	218.7%	228.4%	228.4%	228.4%	237.8%	247.1%	251.6%	251.6%	251.6%	71%
Heating COP		2.11	2.26	2.27	2.27	2.27	2.27	2.27	2.28	2.29	2.29	2.29	2.29	2.30	2.30	2.30	2.30	8%
Volumetric heating Capacity	kJ/m3	1129	1993	2095	2195	2195	2195	2195	2292	2387	2387	2387	2480	2571	2615	2615	2615	20%
Heating Capacity relative to Reference		100.0%	176.4%	185.5%	194.3%	194.3%	194.3%	194.3%	203.0%	211.4%	211.4%	211.4%	219.6%	227.6%	231.6%	231.6%	231.6%	71%
Cooling capacity	kW	2.48	2.64	2.65	2.66	2.66	2.66	2.66	2.67	2.68	2.68	2.68	2.68	2.69	2.69	2.69	2.69	20%
Heating capacity	kW	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	71%
Refrigeration effect	kJ/kg	79.7	95.7	97.7	99.6	99.6	99.6	99.6	101.5	103.3	103.3	103.3	105.2	107.0	107.9	107.9	107.9	20%
Pressure ratio		11.38	9.27	9.09	8.93	8.93	8.93	8.93	8.78	8.65	8.65	8.65	8.52	8.41	8.36	8.36	8.36	71%
Compressor discharge temperature	°C	86.9	98.3	99.9	101.5	101.5	101.5	101.5	103.0	104.4	104.4	104.4	105.9	107.3	108.0	108.0	108.0	20%
Discharge temp. difference from reference	K	0.0	11.4	13.0	14.5	14.5	14.5	14.5	16.0	17.5	17.5	17.5	18.9	20.4	21.1	21.1	21.1	71%
Evaporator inlet pressure	bar	2.10	2.76	2.86	2.96	2.96	2.96	2.96	3.07	3.17	3.17	3.17	3.27	3.37	3.42	3.42	3.42	20%
Condenser inlet pressure	bar	14.80	21.83	22.58	23.31	23.31	23.31	23.31	24.01	24.68	24.68	24.68	25.34	25.97	26.27	26.27	26.27	71%
Evaporator inlet temperature	°C	-11.5	-16.0	-16.3	-16.6	-16.6	-16.6	-16.6	-16.8	-17.0	-17.0	-17.0	-17.1	-17.2	-17.2	-17.2	-17.2	20%
Evaporator dewpoint	°C	-18.5	-14.0	-13.7	-13.4	-13.4	-13.4	-13.4	-13.2	-13.0	-13.0	-13.0	-12.9	-12.8	-12.8	-12.8	-12.8	71%
Evaporator exit gas temperature	°C	-17.5	-13.0	-12.7	-12.4	-12.4	-12.4	-12.4	-12.2	-12.0	-12.0	-12.0	-11.9	-11.8	-11.8	-11.8	-11.8	20%
Evaporator glide (out-in)	K	-7.1	2.0	2.6	3.1	3.1	3.1	3.1	3.6	3.9	3.9	3.9	4.2	4.4	4.5	4.5	4.5	71%
Compressor suction pressure	bar	1.30	2.36	2.48	2.61	2.61	2.61	2.61	2.73	2.85	2.85	2.85	2.97	3.09	3.14	3.14	3.14	20%
Compressor discharge pressure	bar	14.8	21.8	22.6	23.3	23.3	23.3	23.3	24.0	24.7	24.7	24.7	25.3	26.0	26.3	26.3	26.3	71%
Condenser dew point	°C	55.4	60.0	60.0	60.0	60.0	60.0	60.0	59.9	59.8	59.8	59.8	59.6	59.4	59.4	59.4	59.4	20%
Condenser bubble point	°C	54.6	50.0	50.0	50.0	50.0	50.0	50.0	50.1	50.2	50.2	50.2	50.4	50.6	50.6	50.6	50.6	71%
Condenser exit liquid temperature	°C	51.6	47.0	47.0	47.0	47.0	47.0	47.0	47.1	47.2	47.2	47.2	47.4	47.6	47.6	47.6	47.6	20%
Condenser glide (in-out)	K	0.9	10.1	10.1	10.0	10.0	10.0	10.0	9.8	9.5	9.5	9.5	9.2	8.9	8.7	8.7	8.7	71%

Table 15 (Heating mode): Compositions comprising 9 weight % R-1132a

R1132a R32 R1234yf	Results		R1234yf																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
	Cooling COP	Cooling COP relative to Reference	Volumetric cooling capacity kJ/m3	Cooling Capacity relative to Reference	Heating COP	Volumetric heating Capacity kJ/m3	Heating Capacity relative to Reference	Cooling capacity kW	Heating capacity kW	Refrigeration effect kJ/kg	Pressure ratio °C	Compressor discharge temperature K	Discharge temp. difference from reference bar	Evaporator inlet pressure bar	Condenser inlet pressure °C	Evaporator inlet temperature °C	Evaporator dewpoint °C	Evaporator exit gas temperature K	Evaporator glide (out-in) bar	Compressor suction pressure bar	Compressor discharge pressure °C	Condenser dew point °C	Condenser bubble point °C	Condenser exit liquid temperature K	(Reference example)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
																									1.25	1.26	1.27	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1

Table 16 (Heating mode): Compositions comprising 10 weight % R-1132a

	Results		R1234yf																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
R1132a R32 R1234yf	Cooling COP		1.11																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

SAMMENSÆTNINGER

PATENTKRAV

1. En sammensætning, der omfatter:
 - (a) fra ca. 6 til ca. 12 vægtprocent R-1132a
 - (b) fra ca. 7 til ca. 13 vægtprocent R-32
 - (c) fra ca. 55 til ca. 87 vægtprocent R-1234yf.
2. Sammensætningen ifølge krav 1, der omfatter fra ca. 7 til ca. 12 vægtprocent R-1132a, for eksempel fra ca. 7 til ca. 10 vægtprocent.
3. Sammensætningen ifølge krav 1 eller 2, der omfatter fra ca. 8 til ca. 13 vægtprocent R-32, fortrinsvis fra ca. 9 til ca. 13 vægtprocent.
4. Sammensætningen ifølge et hvilket som helst af kravene 1 til 3, der omfatter fra ca. 60 til ca. 87 vægtprocent R-1234yf, for eksempel fra ca. 75 til ca. 85 vægtprocent, fortrinsvis fra ca. 78 til ca. 84 vægtprocent.
5. Sammensætningen ifølge et hvilket som helst af kravene 1 til 4, hvilken sammensætning omfatter fra ca. 6 til ca. 10 vægtprocent R-1132a, såsom fra 6 til ca. 7 vægtprocent.
6. Sammensætningen ifølge et hvilket som helst af kravene 1 til 5, hvilken sammensætning omfatter fra ca. 60 til ca. 84 vægtprocent R-1234yf, fortrinsvis fra ca. 75 til ca. 84 vægtprocent.
7. Sammensætningen ifølge krav 1, hvilken sammensætning omfatter fra ca. 6 til ca. 9 vægtprocent R-1132a, såsom fra ca. 6 til ca. 8 vægtprocent.
8. Sammensætningen ifølge krav 1, hvilken sammensætning omfatter fra ca. 63 til ca. 85 vægtprocent R-1234yf, for eksempel fra ca. 67 til ca. 83 vægtprocent, fortrinsvis fra ca. 69 til ca. 82 vægtprocent, mere fortrinsvist fra ca. 72 til ca. 81 vægtprocent.
9. Sammensætningen ifølge et hvilket som helst af de foregående krav, der i det væsentlige består af de angivne bestanddele.

10. Sammensætningen ifølge et hvilket som helst af de foregående krav, hvilken sammensætning har:

(a) en højere nedre antændelsesgrænse, (b) en højere antændelsesenergi, (c) en højere selv-antændelsestemperatur, og/eller (d) en lavere forbrændingshastighed sammenlignet med R-1132a alene, og/eller hvor sammensætningen har en forbrændingshastighed på mindre end ca. 10 cm/s som bestemt i overensstemmelse med ASHRAE-standard 34:2019, såsom mindre end ca. 9 cm/s, for eksempel mindre end ca. 8 cm/s, og/eller hvor sammensætningen er klassificeret som svagt brandfarlig ("klasse 2L") som bestemt i overensstemmelse med ASHRAE-standard 34:2019.

11. En sammensætning, der omfatter et smøremiddel og sammensætningen ifølge et hvilket som helst af de foregående krav, fortrinsvis hvor smøremidlet er valgt fra gruppen bestående af mineralolie, silikoneolie, polyalkylbenzener (PAB'er), polyolestere (POE'er), polyalkylenglycoler (PAG'er), polyalkylenglycolestere (PAG-estere), polyvinylethere (PVE'er), poly(alfa-olefiner) og kombinationer deraf, såsom hvor smøremidlet er valgt fra gruppen bestående af polyolestere (POE'er), polyalkylenglycoler (PAG'er) og kombinationer deraf.

12. Sammensætningen ifølge et hvilket som helst af de foregående krav, hvilken sammensætning har en temperaturglidning i en fordamper eller kondensator på mindre end ca. 12 K, såsom mindre end ca. 10 K, for eksempel mindre end ca. 5 K, og/eller hvilken sammensætning kan fungere i en varmepumpetilstand ved en temperatur på mindre end ca. -15 °C, såsom mindre end ca. -20 °C.

13. Sammensætningen ifølge et hvilket som helst af de foregående krav, der har en varmekapacitet, som er større end eller omtrent lig med R-1234yf, og/eller hvilken sammensætning har en volumetrisk kølekapacitet, der er større end eller omtrent lig med R-1234yf, og/eller hvilken sammensætning har en cykluseffektivitet (effektfaktor (COP)), som er større end eller omtrent lig med R-1234yf; og/eller hvilken sammensætnings kompressorafgangstemperatur er inden for ca. 15 K af den eksisterende kølemiddelvæske, den erstatter, fortrinsvis ca. 10 K eller ca. 5 K, eventuelt hvor den eksisterende kølemiddelvæske er R-1234yf.

14. Sammensætningen ifølge et hvilket som helst af de foregående krav, hvilken sammensætning fordamper ved en temperatur på under ca. -30 °C, og/eller hvilken sammensætning kondenserer ved en temperatur på over ca. 40 °C.

15. Anvendelse af sammensætningen ifølge et hvilket som helst af de foregående krav som

arbejdsfluid i et varmepumpesystem af et køretøj, eventuelt hvor køretøjet er et elektrisk køretøj.

16. Anvendelse af sammensætningen som defineret i et hvilket som helst af kravene 1 til 14 som arbejdsfluid i et klimaanlæg af et køretøj, såsom et elektrisk køretøj eller et køretøj, der kører ved hjælp af en forbrændingsmotor (ICE).

17. Anvendelse af sammensætningen som defineret i et hvilket som helst af kravene 1 til 14 som erstatning for et eksisterende varmeoverførselsfluid i et kølesystem eller klimaanlæg, fortrinsvis hvor det eksisterende fluid er R-407C.

18. En varmeoverførselsindretning, der omfatter sammensætningen som defineret i et hvilket som helst af kravene 1 til 14, fortrinsvis hvor varmeoverførselsindretningen er en køleindretning eller en luftkonditioneringsindretning, såsom hvor varmeoverførselsindretningen omfatter et klimaanlæg til boliger eller erhverv, et klimaanlæg til et tog eller en bus, en varmepumpe eller et kommercielt eller industrielt kølesystem.

19. En fremgangsmåde til afkøling af en genstand, hvilken fremgangsmåde omfatter kondensering af sammensætningen ifølge et hvilket som helst af kravene 1 til 14 og derefter fordampning af nævnte sammensætning i nærheden af den genstand, der skal afkøles.

20. En fremgangsmåde til opvarmning af en genstand, hvilken fremgangsmåde omfatter kondensering af sammensætningen ifølge et hvilket som helst af kravene 1 til 14 i nærheden af den genstand, der skal opvarmes, og derefter fordampning af nævnte sammensætning.