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(54) **HEAT TRANSFER COMPOSITIONS**

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(57) **ABSTRACT**

The invention provides a heat transfer composition comprising (i) a first component selected from trans-1,3,3,3-tetrafluoropropene (R-1234ze(E)), cis-1,3,3,3-tetrafluoropropene (R-1234ze(Z)) and mixtures thereof; (ii) carbon dioxide (R-744); and (iii) a third component selected from difluoromethane (R-32) 1,1,1,2-tetrafluoroethane (R-134a) and mixtures thereof.

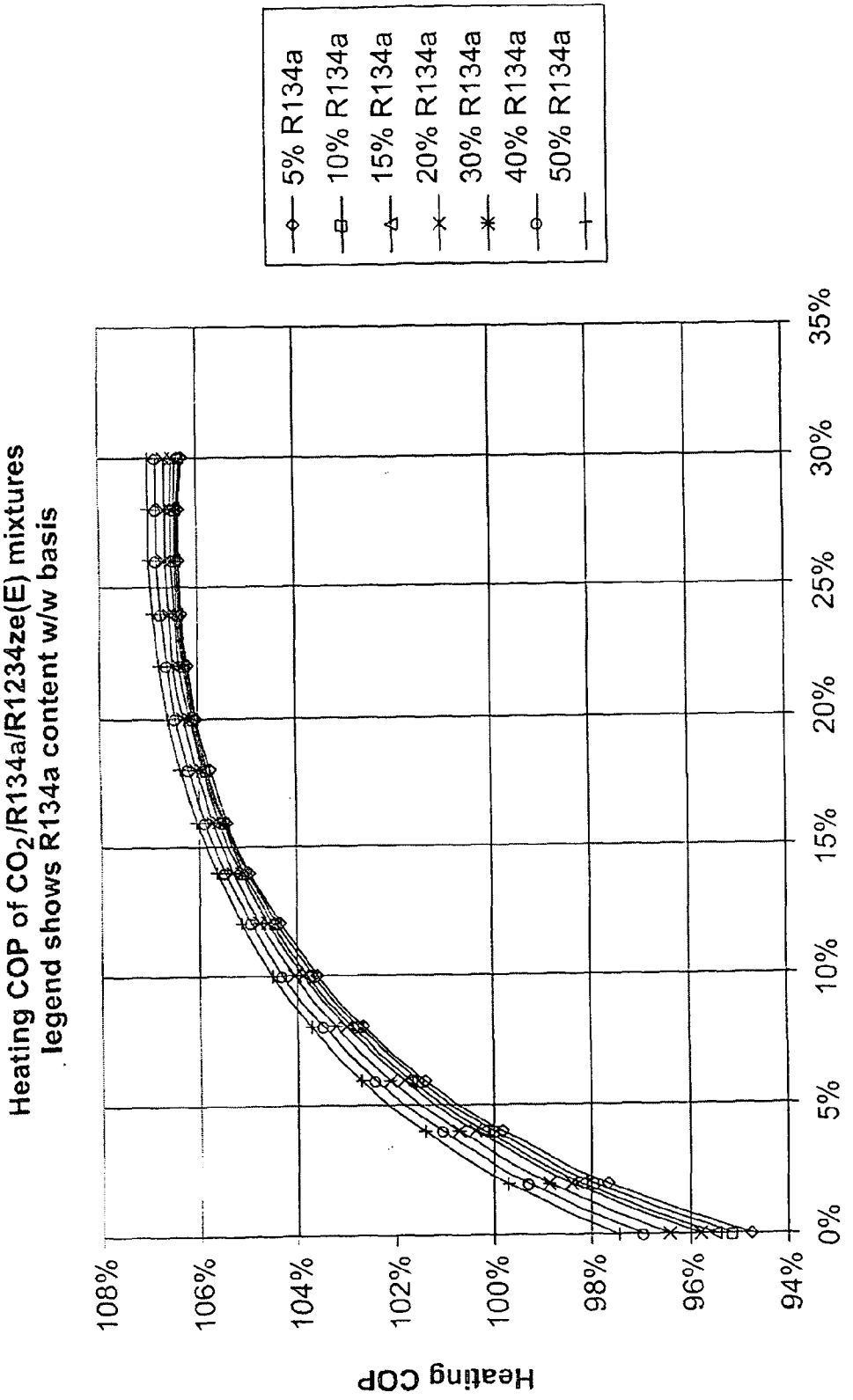
Heating COP of CO_2/R134a/R1234ze(E) mixtures
legend shows R134a content w/w basis
5% R134a
10% R134a
15% R134a
20% R134a
30% R134a
40% R134a
50% R134a
Heating COP
108%
106%
104%
102%
100%
98%
96%
94%
0%
5%
10%
15%
20%
25%
30%
35%
CO_2 content of blend w/w

Figure 1

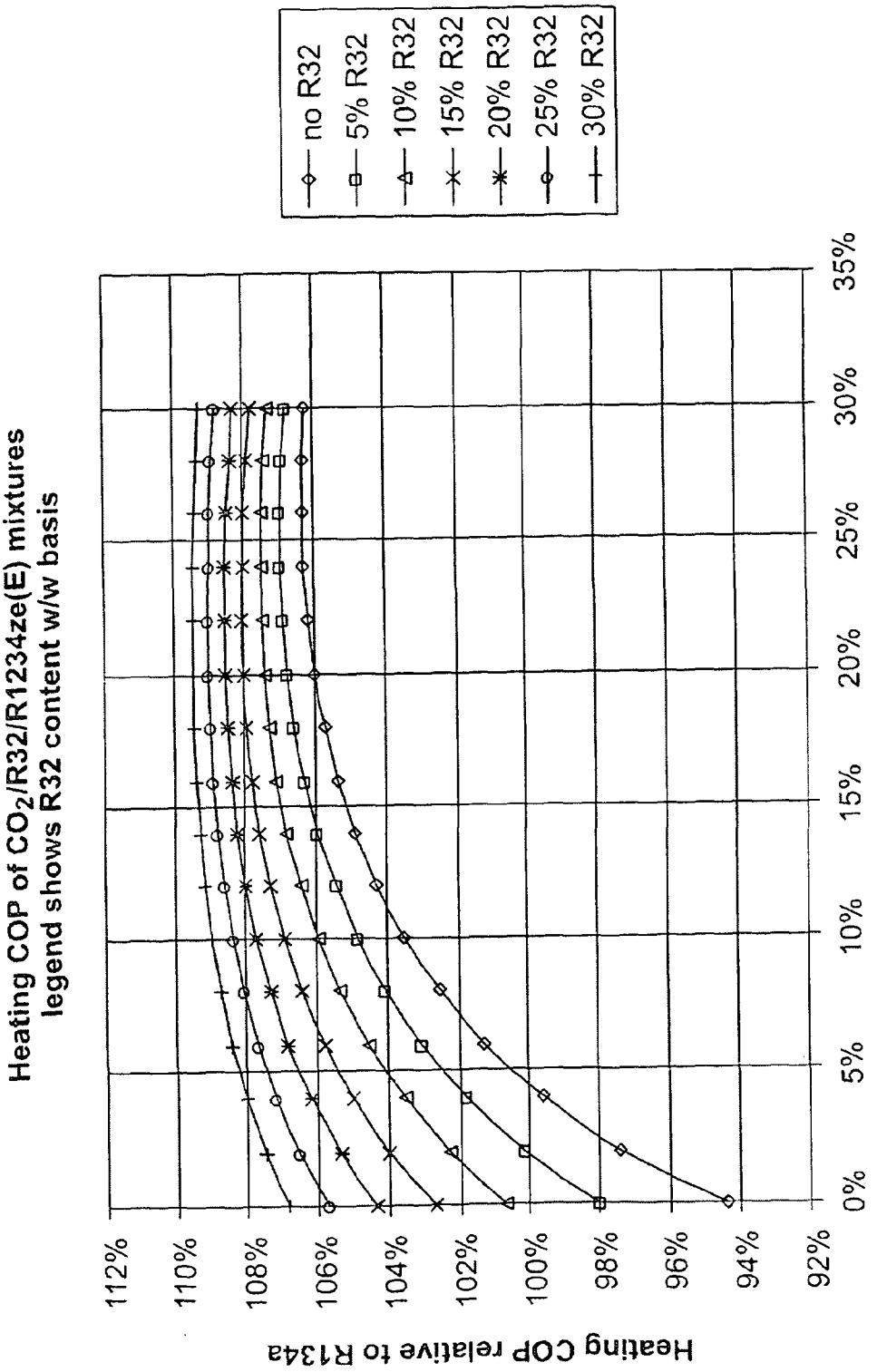
Heating COP of CO_2/R32/R1234ze(E) mixtures
legend shows R32 content w/w basis
no R32
5% R32
10% R32
15% R32
20% R32
25% R32
30% R32
Heating COP relative to R134a
112%
110%
108%
106%
104%
102%
100%
98%
96%
94%
92%
0%
5%
10%
15%
20%
25%
30%
35%
CO_2 content of mixture (w/w)

Figure 2

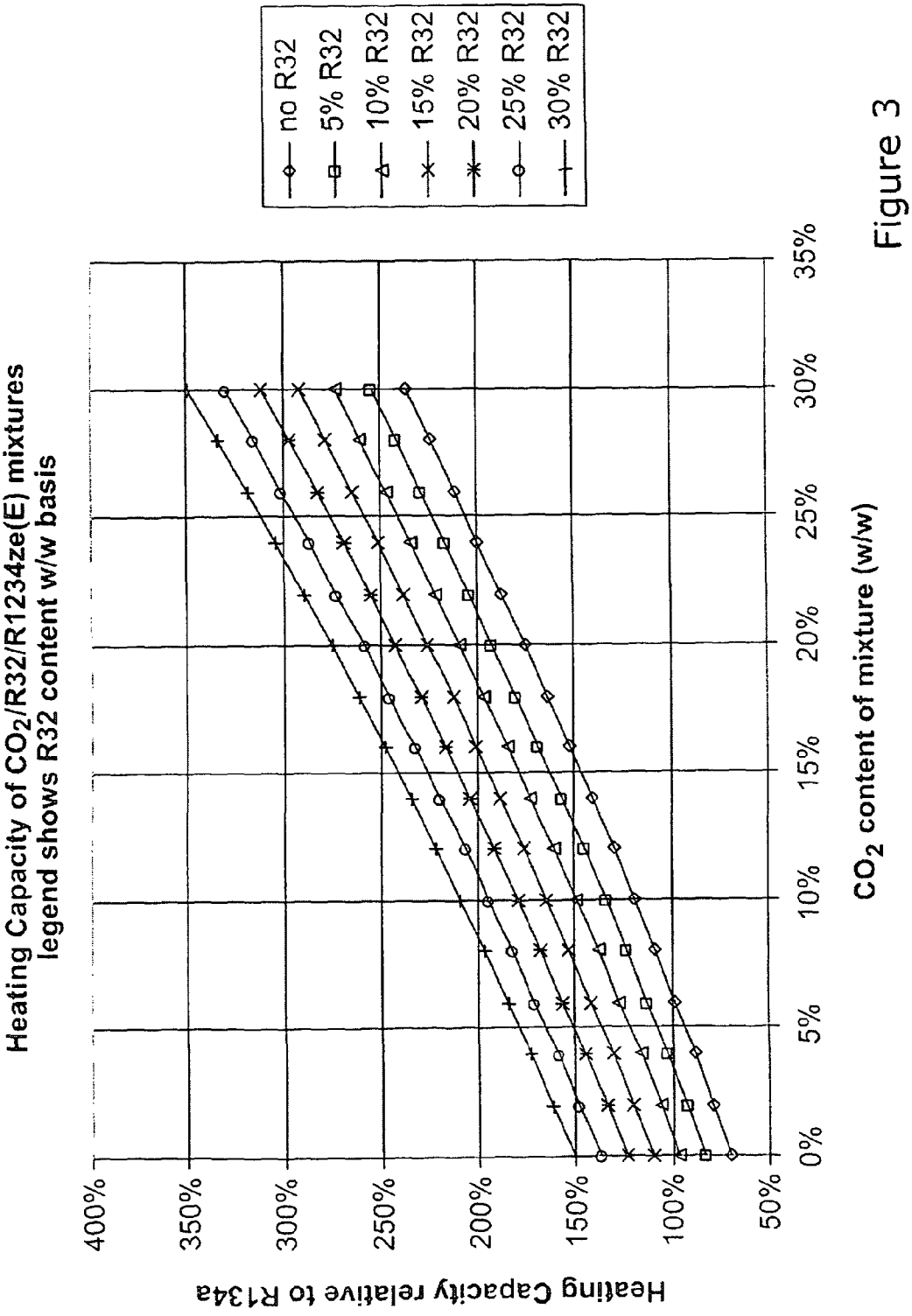
Heating Capacity of CO_2/R32/R1234ze(E) mixtures
legend shows R32 content w/w basis
Heating Capacity relative to R134a
400%
350%
300%
250%
200%
150%
100%
50%
0%
5%
10%
15%
20%
25%
30%
35%
CO_2 content of mixture (w/w)
no R32
5% R32
10% R32
15% R32
20% R32
25% R32
30% R32

Figure 3

HEAT TRANSFER COMPOSITIONS

[0001] The invention relates to heat transfer compositions, and in particular to heat transfer compositions which may be suitable as replacements for existing refrigerants such as R-134a, R-152a, R-1234yf, R-22, R-410A, R-407A, R-407B, R-407C, R507 and R-404a.

[0002] 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.

[0003] Mechanical refrigeration systems and related heat transfer devices such as heat pumps and air-conditioning systems are well known. In such systems, a refrigerant liquid evaporates at low pressure taking heat from the surrounding zone. The resulting vapour is then compressed and passed to a condenser where it condenses and gives off heat to a second zone, the condensate being returned through an expansion valve to the evaporator, so completing the cycle. Mechanical energy required for compressing the vapour and pumping the liquid is provided by, for example, an electric motor or an internal combustion engine.

[0004] In addition to having a suitable boiling point and a high latent heat of vaporisation, the properties preferred in a refrigerant include low toxicity, non-flammability, non-corrosivity, high stability and freedom from objectionable odour. Other desirable properties are ready compressibility at pressures below 25 bars, low discharge temperature on compression, high refrigeration capacity, high efficiency (high coefficient of performance) and an evaporator pressure in excess of 1 bar at the desired evaporation temperature.

[0005] Dichlorodifluoromethane (refrigerant R-12) possesses a suitable combination of properties and was for many years the most widely used refrigerant. Due to international concern that fully and partially halogenated chlorofluorocarbons were damaging the earth's protective ozone layer, there was general agreement that their manufacture and use should be severely restricted and eventually phased out completely. The use of dichlorodifluoromethane was phased out in the 1990's.

[0006] Chlorodifluoromethane (R-22) was introduced as a replacement for R-12 because of its lower ozone depletion potential. Following concerns that R-22 is a potent greenhouse gas, its use is also being phased out.

[0007] Whilst heat transfer devices of the type to which the present invention relates are essentially closed systems, loss of refrigerant to the atmosphere can occur due to leakage during operation of the equipment or during maintenance procedures. It is important, therefore, to replace fully and partially halogenated chlorofluorocarbon refrigerants by materials having zero ozone depletion potentials.

[0008] In addition to the possibility of ozone depletion, it has been suggested that significant concentrations of halocarbon refrigerants in the atmosphere might contribute to global warming (the so-called greenhouse effect). It is desirable, therefore, to use refrigerants which have relatively short atmospheric lifetimes as a result of their ability to react with other atmospheric constituents such as hydroxyl radicals, or as a result of ready degradation through photolytic processes.

[0009] R-410A and R-407 refrigerants (including R-407A, R-407B and R-407C) have been introduced as a replacement refrigerant for R-22. However, R-22, R-410A and the R-407 refrigerants all have a high global warming potential (GWP, also known as greenhouse warming potential).

[0010] 1,1,1,2-tetrafluoroethane (refrigerant R-134a) was introduced as a replacement refrigerant for R-12. R-134a is an energy efficient refrigerant, used currently for automotive air conditioning. However it is a greenhouse gas with a GWP of 1430 relative to CO_2 (GWP of CO_2 is 1 by definition). The proportion of the overall environmental impact of automotive air conditioning systems using this gas, which may be attributed to the direct emission of the refrigerant, is typically in the range 10-20%. Legislation has now been passed in the European Union to rule out use of refrigerants having GWP of greater than 150 for new models of car from 2011. The car industry operates global technology platforms, and in any event emission of greenhouse gas has global impact, thus there is a need to find fluids having reduced environmental impact (e.g. reduced GWP) compared to HFC-134a.

[0011] R-152a (1,1-difluoroethane) has been identified as an alternative to R-134a. It is somewhat more efficient than R-134a and has a greenhouse warming potential of 120. However the flammability of R-152a is judged too high, for example to permit its safe use in mobile air conditioning systems. In particular it is believed that its lower flammable limit in air is too low, its flame speeds are too high, and its ignition energy is too low.

[0012] Thus there is a need to provide alternative refrigerants having improved properties such as low flammability. Fluorocarbon combustion chemistry is complex and unpredictable. It is not always the case that mixing a non-flammable fluorocarbon with a flammable fluorocarbon reduces the flammability of the fluid or reduces the range of flammable compositions in air. For example, the inventors have found that if non-flammable R-134a is mixed with flammable R-152a, the lower flammable limit of the mixture alters in a manner which is not predictable. The situation is rendered even more complex and less predictable if ternary or quaternary compositions are considered.

[0013] There is also a need to provide alternative refrigerants that may be used in existing devices such as refrigeration devices with little or no modification.

[0014] R-1234yf (2,3,3,3-tetrafluoropropene) has been identified as a candidate alternative refrigerant to replace R-134a in certain applications, notably the mobile air conditioning or heat pumping applications. Its GWP is about 4. R-1234yf is flammable but its flammability characteristics are generally regarded as acceptable for some applications including mobile air conditioning or heat pumping. In particular, when compared with R-152a, its lower flammable limit is higher, its minimum ignition energy is higher and the flame speed in air is significantly lower than that of R-152a.

[0015] The environmental impact of operating an air conditioning or refrigeration system, in terms of the emissions of greenhouse gases, should be considered with reference not only to the so-called "direct" GWP of the refrigerant, but also with reference to the so-called "indirect" emissions, meaning those emissions of carbon dioxide resulting from consumption of electricity or fuel to operate the system. Several metrics of this total GWP impact have been developed, including those known as Total Equivalent Warming Impact (TEWI) analysis, or Life-Cycle Carbon Production (LCCP) analysis. Both of these measures include estimation of the effect of refrigerant GWP and energy efficiency on overall warming impact. Emissions of carbon dioxide associated with manufacture of the refrigerant and system equipment should also be considered.

[0016] The energy efficiency and refrigeration capacity of R-1234yf have been found to be significantly lower than those of R-134a and in addition the fluid has been found to exhibit increased pressure drop in system pipework and heat exchangers. A consequence of this is that to use R-1234yf and achieve energy efficiency and cooling performance equivalent to R-134a, increased complexity of equipment and increased size of pipework is required, leading to an increase in indirect emissions associated with equipment. Furthermore, the production of R-1234yf is thought to be more complex and less efficient in its use of raw materials (fluorinated and chlorinated) than R-134a. Current projections of long term pricing for R-1234yf is in the range 10-20 times greater than R-134a. This price differential and the need for extra expenditure on hardware will limit the rate at which refrigerants are changed and hence limit the rate at which the overall environmental impact of refrigeration or air conditioning may be reduced. In summary, the adoption of R-1234yf to replace R-134a will consume more raw materials and result in more indirect emissions of greenhouse gases than does R-134a.

[0017] Some existing technologies designed for R-134a may not be able to accept even the reduced flammability of some heat transfer compositions (any composition having a GWP of less than 150 is believed to be flammable to some extent).

[0018] A principal object of the present invention is therefore to provide a heat transfer composition which is usable in its own right or suitable as a replacement for existing refrigeration usages which should have a reduced GWP, yet have a capacity and energy efficiency (which may be conveniently expressed as the "Coefficient of Performance") ideally within 10% of the values, for example of those attained using existing refrigerants (e.g. R-134a, R-152a, R-1234yf, R-22, R-410A, R-407A, R-407B, R-407C, R507 and R-404a), and preferably within less than 10% (e.g. about 5%) of these values. It is known in the art that differences of this order between fluids are usually resolvable by redesign of equipment and system operational features. The composition should also ideally have reduced toxicity and acceptable flammability.

[0019] The subject invention addresses the above deficiencies by the provision of a heat transfer composition comprising (i) a first component selected from trans-1,3,3,3-tetrafluoropropene (R-1234ze(E)), cis-1,3,3,3-tetrafluoropropene (R-1234ze(Z)) and mixtures thereof; (ii) carbon dioxide (CO_2 or R-744); and (iii) a third component selected from difluoromethane (R-32), 1,1,1,2-tetrafluoroethane (R-134a), and mixtures thereof.

[0020] All of the chemicals herein described are commercially available. For example, the fluorochemicals may be obtained from Apollo Scientific (UK).

[0021] Typically, the compositions of the invention contain trans-1,3,3,3-tetrafluoropropene (R-1234ze(E)). The majority of the specific compositions described herein contain R-1234ze(E). It is to be understood, of course, that some or all of the R-1234ze(E) in such compositions can be replaced by R-1234ze(Z). The trans isomer is currently preferred, however.

[0022] Typically, the composition of the invention contain at least about 5% by weight R-1234ze(E), preferably at least about 15% by weight. In one embodiment, the compositions of the invention contain at least about 45% by weight R-1234ze(E), for example from about 50 to about 98% by weight.

[0023] The preferred amounts and choice of components for the invention are determined by a combination of properties:

[0024] (a) Flammability: non-flammable or weakly flammable compositions are preferred.

[0025] (b) Effective operating temperature of the refrigerant in an air conditioning system evaporator.

[0026] (c) Temperature "glide" of the mixture and its effect on heat exchanger performance.

[0027] (d) Critical temperature of the composition. This should be higher than the maximum expected condenser temperature.

[0028] The effective operating temperature in an air conditioning cycle, especially automotive air conditioning, is limited by the need to avoid ice formation on the air-side surface of the refrigerant evaporator. Typically air conditioning systems must cool and dehumidify humid air; so liquid water will be formed on the air-side surface. Most evaporators (without exception for the automotive application) have finned surfaces with narrow fin spacing. If the evaporator is too cold then ice can be formed between the fins, restricting the flow of air over the surface and reducing overall performance by reducing the working area of the heat exchanger.

[0029] It is known for automotive air-conditioning applications (*Modern Refrigeration and Air Conditioning* by A D Althouse et al, 1988 edition, Chapter 27, which is incorporated herein by reference) that refrigerant evaporation temperatures of −2° C. or higher are preferred to ensure that the problem of ice formation is thereby avoided.

[0030] It is also known that non-azeotropic refrigerant mixtures exhibit temperature "glide" in evaporation or condensation. In other words, as the refrigerant is progressively vaporised or condensed at constant pressure, the temperature rises (in evaporation) or drops (in condensation), with the total temperature difference (inlet to outlet) being referred to as the temperature glide. The effect of glide on evaporation and condensation temperature must also be considered.

[0031] The critical temperature of a heat transfer composition should be higher than the maximum expected condenser temperature. This is because the cycle efficiency drops as critical temperature is approached. As this happens, the latent heat of the refrigerant is reduced and so more of the heat rejection in the condenser takes place by cooling gaseous refrigerant; this requires more area per unit heat transferred.

[0032] R-410A is commonly used in building and domestic heat pump systems and by way of illustration its critical temperature of about 71° C. is higher than the highest normal condensing temperature required to deliver useful warm air at about 50° C. The automotive duty requires air at about 50° C. so the critical temperature of the fluids of the invention should be higher than this if a conventional vapour compression cycle is to be utilised. Critical temperature is preferably at least 15K higher than the maximum air temperature.

[0033] In one aspect, the compositions of the invention have a critical temperature of greater than about 65° C., preferably greater than about 70° C.

[0034] The carbon dioxide content of the compositions of the invention is limited primarily by considerations (b) and/or (c) and/or (d) above. Conveniently, the compositions of the invention typically contain up to about 35% by weight R-744, preferably up to about 30% by weight.

[0035] In a preferred aspect, the compositions of the invention contain from about 4 to about 30% R-744 by weight, preferably from about 4 to about 28% by weight, or from about 8 to about 30% by weight, or from about 10 to about 30% by weight.

[0036] The content of the third component, which may include flammable refrigerants such as R-32, is selected so that even in the absence of the carbon dioxide element of the composition, the residual fluorocarbon mixture has a lower flammable limit in air at ambient temperature (e.g. 23° C.) (as determined in the ASHRAE-34 12 litre flask test apparatus) which is greater than 5% v/v, preferably greater than 6% v/v, most preferably such that the mixture is non-flammable. The issue of flammability is discussed further later in this specification.

[0037] Typically, the compositions of the invention contain up to about 60% by weight of the third component. Preferably, the compositions of the invention contain up to about 50% by weight of the third component. Conveniently, the compositions of the invention contain up to about 45% by weight of the third component. In one aspect, the compositions of the invention contain from about 1 to about 40% by weight of the third component.

[0038] In one embodiment, the compositions of the invention comprise from about 10 to about 95% R-1234ze(E) by weight, from about 2 to about 30% by weight R-744, and from about 3 to about 60% by weight of the third component.

[0039] As used herein, all % amounts mentioned in compositions herein, including in the claims, are by weight based on the total weight of the compositions, unless otherwise stated.

[0040] For the avoidance of doubt, it is to be understood that the stated upper and lower values for ranges of amounts 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.

[0041] In one embodiment, the compositions of the invention consist essentially of (or consist of) the first component (e.g. R-1234ze(E)), R-744 and the third component.

[0042] By the term "consist essentially of", we mean 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. We include the term "consist of" within the meaning of "consist essentially of".

[0043] For the avoidance of doubt, any of the compositions of the invention described herein, including those with specifically defined compounds and amounts of compounds or components, may consist essentially of (or consist of) the compounds or components defined in those compositions.

[0044] The third component is selected from R-32, R-134a and mixtures thereof.

[0045] In one aspect, the third component contains only one of the listed components. For example, the third component may contain only one of difluoromethane (R-32) or 1,1,1,2-tetrafluoroethane (R-134a) Thus, the compositions of the invention may be ternary blends of R-1234ze(E), R-744 and one of the listed third components (e.g. R-32 or R-134a).

[0046] However, mixtures of R-32 and R-134a can be used as the third component. R-134a typically is included to reduce the flammability of the equivalent composition that does not contain R-134a.

[0047] The invention contemplates compositions in which additional compounds are included in the third component. Examples of such compounds include 2,3,3,3-tetrafluoropropene (R-1234yf), 3,3,3-trifluoropropene (R1243zf), 1,1-difluoroethane (R-152a), fluoroethane (R-161), 1,1,1-trifluoropropane (R-263fb), 1,1,1,2,3-pentafluoropropane (R-245eb), propylene (R-1270), propane (R-290), n-butane (R-600), isobutane (R-600a), ammonia (R-717) and mixtures thereof.

[0048] Preferably, the compositions of the invention which contain R-134a are non-flammable at a test temperature of 60° C. using the ASHRAE-34 methodology. Advantageously, the mixtures of vapour that exist in equilibrium with the compositions of the invention at any temperature between about −20° C. and 60° C. are also non-flammable.

[0049] In one preferred embodiment, the third component comprises R-134a. The third component may consist essentially of (or consist of) R-134a.

[0050] Compositions of the invention which contain R-134a typically contain it in an amount of from about 2 to about 50% by weight, for example from about 5 to about 40% by weight.

[0051] Typical compositions of the invention containing R-134a comprise from about 20 to about 93% by weight R-1234ze(E), from about 2 to about 30% by weight R-744 and from about 5 to about 50% by weight R-134a.

[0052] A relatively low GWP composition containing R-134a comprises from about 60 to about 92% R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 4 to about 10% by weight R-134a. A preferred such composition comprises from about 62 to about 86% R-1234ze(E), from about 10 to about 28% by weight R-744 and from about 4 to about 10% by weight R-134a.

[0053] A higher GWP composition containing R-134a comprises from about 20 to about 86% R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 10 to about 50% by weight R-134a. A preferred such composition comprises from about 22 to about 80% R-1234ze(E), from about 10 to about 28% by weight R-744 and from about 10 to about 50% by weight R-134a.

[0054] In one embodiment, the third component comprises R-32. The third component may consist essentially of (or consist of) R-32.

[0055] Compositions of the invention which contain R-32 typically contain it in an amount of from about 2 to about 30% by weight, conveniently in an amount of from about 2 to about 25% by weight, for example from about 5 to about 20% by weight.

[0056] Typical compositions of the invention containing R-32 comprise from about 60 to about 91% by weight R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 5 to about 30% by weight R-32.

[0057] A preferred composition comprises from about 58 to about 85% R-1234ze(E), from about 10 to about 28% by weight R-744 and from about 5 to about 30% by weight R-32.

[0058] Further advantageous compositions of the invention containing R-32 comprise from about 50 to about 88% by weight R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 2 to about 20% by weight R-32.

[0059] In one embodiment, the third component comprises R-32 and R-134a. The third component may consist essentially of (or consist of) R-32 and R-134a.

[0060] Compositions of the invention containing R-32 and R-134a typically contain from about 5 to about 95% by weight R-1234ze(E), from about 4 to about 30% by weight

R-744, from about 2 to about 30% by weight R-32 and from about 2 to about 50 by weight R-134a.

[0061] Preferred compositions comprise from about 5 to about 92% by weight R-1234ze(E), from about 4 to about 30% by weight R-744, from about 2 to about 25% by weight R-32 and from about 2 to about 40% by weight R-134a.

[0062] Advantageous compositions which have a relatively low GWP comprise from about 30 to about 81% by weight R-1234ze(E), from about 10 to about 30% by weight R-744, from about 5 to about 30% by weight R-32 and from about 4 to about 10 by weight R-134a. Preferably such compositions contain from about 37 to about 81% by weight R-1234ze(E), from about 10 to about 28% by weight R-744, from about 5 to about 25% by weight R-32 and from about 4 to about 10 by weight R-134a.

[0063] Yet further compositions of the invention containing R-32 and R-134a, and having a higher GWP, comprise from about 5 to about 75% by weight R-1234ze(E), from about 10 to about 30% by weight R-744, from about 5 to about 25% by weight R-32 and from about 10 to about 50 by weight R-134a. Preferred such compositions comprise from about 7 to about 75% by weight R-1234ze(E), from about 10 to about 28% by weight R-744, from about 5 to about 25% by weight R-32 and from about 10 to about 40 by weight R-134a.

[0064] Compositions according to the invention conveniently comprise substantially no R-1225 (pentafluoropropene), conveniently substantially no R-1225ye (1,2,3,3,3-pentafluoropropene) or R-1225zc (1,1,3,3,3-pentafluoropropene), which compounds may have associated toxicity issues.

[0065] By "substantially no", we include the meaning that the compositions of the invention contain 0.5% by weight or less of the stated component, preferably 0.1% or less, based on the total weight of the composition.

[0066] Certain compositions of the invention may contain substantially no:

[0067] (i) 2,3,3,3-tetrafluoropropene (R-1234yf),

[0068] (ii) cis-1,3,3,3-tetrafluoropropene (R-1234ze (Z)), and/or

[0069] (iii) 3,3,3-trifluoropropene (R-1243zf).

[0070] The compositions of the invention have zero ozone depletion potential.

[0071] Typically, the compositions of the invention have a GWP that is less than 1300, preferably less than 1000, more preferably less than 800, 500, 400, 300 or 200, especially less than 150 or 100, even less than 50 in some cases. Unless otherwise stated, IPCC (Intergovernmental Panel on Climate Change) TAR (Third Assessment Report) values of GWP have been used herein.

[0072] Advantageously, the compositions are of reduced flammability hazard when compared to the third component (s) alone, e.g. R-32. Preferably, the compositions are of reduced flammability hazard when compared to R-1234yf.

[0073] In one aspect, the compositions have one or more of (a) a higher lower flammable limit; (b) a higher ignition energy; or (c) a lower flame velocity compared to the third component(s), such as R-32, or compared to R-1234yf. In a preferred embodiment, the compositions of the invention are non-flammable. Advantageously, the mixtures of vapour that exist in equilibrium with the compositions of the invention at any temperature between about −20° C. and 60° C. are also non-flammable.

[0074] Flammability may be determined in accordance with ASHRAE Standard 34 incorporating the ASTM Standard E-681 with test methodology as per Addendum 34p dated 2004, the entire content of which is incorporated herein by reference.

[0075] In some applications it may not be necessary for the formulation to be classed as non-flammable by the ASHRAE-34 methodology; it is possible to develop fluids whose flammability limits will be sufficiently reduced in air to render them safe for use in the application, for example if it is physically not possible to make a flammable mixture by leaking the refrigeration equipment charge into the surrounds.

[0076] R-1234ze(E) is non-flammable in air at 23° C., although it exhibits flammability at higher temperatures in humid air. We have determined by experimentation that mixtures of R-1234ze(E) with flammable fluorocarbons such as R-32, R-152a or R-161 will remain non-flammable in air at 23° C. if the "fluorine ratio" R_f of the mixture is greater than about 0.57, where R_f is defined per gram-mole of the overall refrigerant mixture as:

$$R_f = (\text{gram-moles of fluorine})/(\text{gram-moles fluorine} + \text{gram-moles hydrogen})$$

[0077] Thus for R-161, $R_f = 1/(1+5) = 1/6$ (0.167) and it is flammable, in contrast R-1234ze(E) has $R_f = 4/6$ (0.667) and it is non-flammable. We found by experiment that a 20% v/v mixture of R-161 in R-1234ze(E) was similarly non-flammable. The fluorine ratio of this non-flammable mixture is $0.2*(1/6)+0.8*(4/6)=0.567$.

[0078] The validity of this relationship between flammability and fluorine ratio of 0.57 or higher has thusfar been experimentally proven for HFC-32, HFC-152a and mixtures of HFC-32 with HFC-152a.

[0079] Takizawa et al, *Reaction Stoichiometry for Combustion of Fluoroethane Blends*, ASHRAE Transactions 112(2) 2006 (which is incorporated herein by reference), shows that there exists a near-linear relationship between this ratio and the flame speed of mixtures comprising R-152a, with increasing fluorine ratio resulting in lower flame speeds. The data in this reference teach that the fluorine ratio needs to be greater than about 0.65 for the flame speed to drop to zero, in other words, for the mixture to be non-flammable.

[0080] Similarly, Minor et al (Du Pont Patent Application WO2007/053697) provide teaching on the flammability of many hydrofluoroolefins, showing that such compounds could be expected to be non-flammable if the fluorine ratio is greater than about 0.7.

[0081] In view of this prior art teaching, it is unexpected that that mixtures of R-1234ze(E) with flammable fluorocarbons such as R-32 will remain non-flammable in air at 23° C. if the fluorine ratio R_f of the mixture is greater than about 0.57.

[0082] Furthermore, we identified that if the fluorine ratio is greater than about 0.46 then the composition can be expected to have a lower flammable limit in air of greater than 6% v/v at room temperature.

[0083] By producing low- or non-flammable R-744/third component/R-1234ze(E) blends containing unexpectedly low amounts of R-1234ze(E), the amounts of the third component, in particular, in such compositions are increased. This is believed to result in heat transfer compositions exhibiting increased cooling capacity and/or decreased pressure drop, compared to equivalent compositions containing higher amounts of (e.g. almost 100%) R-1234ze(E).

[0084] Thus, the compositions of the invention exhibit a completely unexpected combination of low-/non-flammability, low GWP and improved refrigeration performance prop-

erties. Some of these refrigeration performance properties are explained in more detail below.

[0085] Temperature glide, which can be thought of as the difference between bubble point and dew point temperatures of a zeotropic (non-azeotropic) mixture at constant pressure, is a characteristic of a refrigerant; if it is desired to replace a fluid with a mixture then it is often preferable to have similar or reduced glide in the alternative fluid. In an embodiment, the compositions of the invention are zeotropic.

[0086] Advantageously, the volumetric refrigeration capacity of the compositions of the invention is at least 85% of the existing refrigerant fluid it is replacing, preferably at least 90% or even at least 95%.

[0087] The compositions of the invention typically have a volumetric refrigeration capacity that is at least 90% of that of R-1234yf. Preferably, the compositions of the invention have a volumetric refrigeration capacity that is at least 95% of that of R-1234yf, for example from about 95% to about 120% of that of R-1234yf.

[0088] In one embodiment, the cycle efficiency (Coefficient of Performance, COP) of the compositions of the invention is within about 5% or even better than the existing refrigerant fluid it is replacing

[0089] Conveniently, the compressor discharge temperature of the compositions of the invention is within about 15K of the existing refrigerant fluid it is replacing, preferably about 10K or even about 5K.

[0090] The compositions of the invention preferably have energy efficiency at least 95% (preferably at least 98%) of R-134a under equivalent conditions, while having reduced or equivalent pressure drop characteristics and cooling capacity at 95% or higher of R-134a values. Advantageously the compositions have higher energy efficiency and lower pressure drop characteristics than R-134a under equivalent conditions. The compositions also advantageously have better energy efficiency and pressure drop characteristics than R-1234yf alone.

[0091] The heat transfer compositions of the invention are 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.

[0092] Preferably, when used in heat transfer equipment, the composition of the invention is combined with a lubricant.

[0093] 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.

[0094] Advantageously, the lubricant further comprises a stabiliser.

[0095] Preferably, the stabiliser is selected from the group consisting of diene-based compounds, phosphates, phenol compounds and epoxides, and mixtures thereof.

[0096] Conveniently, the composition of the invention may be combined with a flame retardant.

[0097] Advantageously, the flame retardant is selected from the group consisting of tri-(2-chloroethyl)-phosphate, (chloropropyl)phosphate, tri-(2,3-dibromopropyl)-phosphate, tri-(1,3-dichloropropyl)-phosphate, diammonium phosphate, various halogenated aromatic compounds, antimony oxide, aluminium trihydrate, polyvinyl chloride, a fluorinated iodocarbon, a fluorinated bromocarbon, trifluoro iodomethane, perfluoroalkyl amines, bromo-fluoroalkyl amines and mixtures thereof.

[0098] Preferably, the heat transfer composition is a refrigerant composition.

[0099] In one embodiment, the invention provides a heat transfer device comprising a composition of the invention.

[0100] Preferably, the heat transfer device is a refrigeration device.

[0101] Conveniently, the heat transfer device is selected from the group consisting of automotive air conditioning systems, residential air conditioning systems, commercial air conditioning systems, residential refrigerator systems, residential freezer systems, commercial refrigerator systems, commercial freezer systems, chiller air conditioning systems, chiller refrigeration systems, and commercial or residential heat pump systems. Preferably, the heat transfer device is a refrigeration device or an air-conditioning system.

[0102] The compositions of the invention are particularly suitable for use in mobile air-conditioning applications, such as automotive air-conditioning systems (e.g. heat pump cycle for automotive air-conditioning).

[0103] Advantageously, the heat transfer device contains a centrifugal-type compressor.

[0104] The invention also provides the use of a composition of the invention in a heat transfer device as herein described.

[0105] According to a further aspect of the invention, there is provided a blowing agent comprising a composition of the invention.

[0106] According to another aspect of the invention, there is provided a foamable composition comprising one or more components capable of forming foam and a composition of the invention.

[0107] Preferably, the one or more components capable of forming foam are selected from polyurethanes, thermoplastic polymers and resins, such as polystyrene, and epoxy resins.

[0108] According to a further aspect of the invention, there is provided a foam obtainable from the foamable composition of the invention.

[0109] Preferably the foam comprises a composition of the invention.

[0110] According to another aspect of the invention, there is provided a sprayable composition comprising a material to be sprayed and a propellant comprising a composition of the invention.

[0111] According to a further aspect of the invention, there is provided a method for cooling an article which comprises condensing a composition of the invention and thereafter evaporating said composition in the vicinity of the article to be cooled.

[0112] According to another aspect of the invention, there is provided a method for heating an article which comprises condensing a composition of the invention in the vicinity of the article to be heated and thereafter evaporating said composition.

[0113] According to a further aspect of the invention, there is provided a method for extracting a substance from biomass comprising contacting the biomass with a solvent comprising a composition of the invention, and separating the substance from the solvent.

[0114] According to another aspect of the invention, there is provided a method of cleaning an article comprising contacting the article with a solvent comprising a composition of the invention.

[0115] According to a further aspect of the invention, there is provided a method for extracting a material from an aqueous solution comprising contacting the aqueous solution with a solvent comprising a composition of the invention, and separating the material from the solvent.

[0116] According to another aspect of the invention, there is provided a method for extracting a material from a particulate solid matrix comprising contacting the particulate solid matrix with a solvent comprising a composition of the invention, and separating the material from the solvent.

[0117] According to a further aspect of the invention, there is provided a mechanical power generation device containing a composition of the invention.

[0118] Preferably, the mechanical power generation device is adapted to use a Rankine Cycle or modification thereof to generate work from heat.

[0119] According to another aspect of the invention, there is provided a method of retrofitting a heat transfer device comprising the step of removing an existing heat transfer fluid, and introducing a composition of the invention. Preferably, the heat transfer device is a refrigeration device or (a static) air conditioning system. Advantageously, the method further comprises the step of obtaining an allocation of greenhouse gas (e.g. carbon dioxide) emission credit.

[0120] In accordance with the retrofitting method described above, an existing heat transfer fluid can be fully removed from the heat transfer device before introducing a composition of the invention. An existing heat transfer fluid can also be partially removed from a heat transfer device, followed by introducing a composition of the invention.

[0121] In another embodiment wherein the existing heat transfer fluid is R-134a, and the composition of the invention contains R134a, R-1234ze(E), R-744, the third component and any R-125 present (and optional components such as a lubricant, a stabiliser or an additional flame retardant), R-1234ze(E) and R-744, etc, can be added to the R-134a in the heat transfer device, thereby forming the compositions of the invention, and the heat transfer device of the invention, in situ. Some of the existing R-134a may be removed from the heat transfer device prior to adding the R-1234ze(E), R-744, etc, to facilitate providing the components of the compositions of the invention in the desired proportions.

[0122] Thus, the invention provides a method for preparing a composition and/or heat transfer device of the invention comprising introducing R-1234ze(E), R-744, the third component, any R-125 desired, and optional components such as a lubricant, a stabiliser or an additional flame retardant, into a heat transfer device containing an existing heat transfer fluid which is R-134a. Optionally, at least some of the R-134a is removed from the heat transfer device before introducing the R-1234ze(E), R-744, etc.

[0123] Of course, the compositions of the invention may also be prepared simply by mixing the R-1234ze(E), R-744, the third component, any R-125 desired (and optional components such as a lubricant, a stabiliser or an additional flame retardant) in the desired proportions. The compositions can then be added to a heat transfer device (or used in any other way as defined herein) that does not contain R-134a or any other existing heat transfer fluid, such as a device from which R-134a or any other existing heat transfer fluid have been removed.

[0124] In a further aspect of the invention, there is provided a method for reducing the environmental impact arising from operation of a product comprising an existing compound or composition, the method comprising replacing at least partially the existing compound or composition with a composition of the invention. Preferably, this method comprises the step of obtaining an allocation of greenhouse gas emission credit.

[0125] By environmental impact we include the generation and emission of greenhouse warming gases through operation of the product.

[0126] As mentioned above, this environmental impact can be considered as including not only those emissions of compounds or compositions having a significant environmental impact from leakage or other losses, but also including the emission of carbon dioxide arising from the energy consumed by the device over its working life. Such environmental impact may be quantified by the measure known as Total Equivalent Warming Impact (TEWI). This measure has been used in quantification of the environmental impact of certain stationary refrigeration and air conditioning equipment, including for example supermarket refrigeration systems (see, for example, http://en.wikipedia.org/wiki/Total_equivalent_warming_impact).

[0127] The environmental impact may further be considered as including the emissions of greenhouse gases arising from the synthesis and manufacture of the compounds or compositions. In this case the manufacturing emissions are added to the energy consumption and direct loss effects to yield the measure known as Life-Cycle Carbon Production (LCCP, see for example http://www.sae.org/events/aars/presentations/2007papasavva.pdf). The use of LCCP is common in assessing environmental impact of automotive air conditioning systems.

[0128] Emission credit(s) are awarded for reducing pollutant emissions that contribute to global warming and may, for example, be banked, traded or sold. They are conventionally expressed in the equivalent amount of carbon dioxide. Thus if the emission of 1 kg of R-134a is avoided then an emission credit of $1 \times 1300 = 1300$ kg CO_2 equivalent may be awarded.

[0129] In another embodiment of the invention, there is provided a method for generating greenhouse gas emission credit(s) comprising (i) replacing an existing compound or composition with a composition of the invention, wherein the composition of the invention has a lower GWP than the existing compound or composition; and (ii) obtaining greenhouse gas emission credit for said replacing step.

[0130] In a preferred embodiment, the use of the composition of the invention results in the equipment having a lower Total Equivalent Warming Impact, and/or a lower Life-Cycle Carbon Production than that which would be attained by use of the existing compound or composition.

[0131] These methods may be carried out on any suitable product, for example in the fields of air-conditioning, refrigeration (e.g. low and medium temperature refrigeration), heat transfer, blowing agents, aerosols or sprayable propellants, gaseous dielectrics, cryosurgery, veterinary procedures, dental procedures, fire extinguishing, flame suppression, solvents (e.g. carriers for flavorings and fragrances), cleaners, air horns, pellet guns, topical anesthetics, and expansion applications. Preferably, the field is air-conditioning or refrigeration.

[0132] Examples of suitable products include heat transfer devices, blowing agents, foamable compositions, sprayable compositions, solvents and mechanical power generation

devices. In a preferred embodiment, the product is a heat transfer device, such as a refrigeration device or an air-conditioning unit.

[0133] The existing compound or composition has an environmental impact as measured by GWP and/or TEWI and/or LCCP that is higher than the composition of the invention which replaces it. The existing compound or composition may comprise a fluorocarbon compound, such as a perfluoro-, hydrofluoro-, chlorofluoro- or hydrochlorofluoro-carbon compound or it may comprise a fluorinated olefin

[0134] Preferably, the existing compound or composition is a heat transfer compound or composition such as a refrigerant. Examples of refrigerants that may be replaced include R-134a, R-152a, R-1234yf, R-410A, R-407A, R-407B, R-407C, R507, R-22 and R-404A. The compositions of the invention are particularly suited as replacements for R-134a, R-152a or R-1234yf, especially R-134a or R-1234yf.

[0135] Any amount of the existing compound or composition may be replaced so as to reduce the environmental impact. This may depend on the environmental impact of the existing compound or composition being replaced and the environmental impact of the replacement composition of the invention. Preferably, the existing compound or composition in the product is fully replaced by the composition of the invention.

[0136] The invention is illustrated by the following non-limiting examples.

EXAMPLES

Flammability

[0137] The flammability of certain compositions of the invention in air at atmospheric pressure and controlled humidity was studied in a flame tube test as follows.

[0138] The test vessel was an upright glass cylinder having a diameter of 2 inches. The ignition electrodes were placed 60 mm above the bottom of the cylinder. The cylinder was fitted with a pressure-release opening. The apparatus was shielded to restrict any explosion damage. A standing induction spark of 0.5 second duration was used as the ignition source.

[0139] The test was performed at 23 or 35° C. (see below). A known concentration of fuel in air was introduced into the glass cylinder. A spark was passed through the mixture and it was observed whether or not a flame detached itself from the ignition source and propagated independently. The gas concentration was increased in steps of 1% vol. until ignition occurred (if at all). The results are shown below (all compositions are v/v basis unless otherwise stated).

Fuel	Temperature (° C.)	Humidity	Results[b]
R134a/R1234ze(E) 10/90	23	50% RH/23° C.	Non flammable
CO2/R134a/R1234ze 10/10/80[a]	23	50% RH/23° C.	Non flammable
R134a/R1234yf 10/90	35	50% RH/23° C.	LFL 6% UFL 11%
R134a/R1234ze(E) 10/90	35	50% RH/23° C.	LFL 8% UFL 12%

-continued

Fuel	Temperature (° C.)	Humidity	Results[b]
CO2/R134a/R1234ze 10/10/80[a]	35	50% RH/23° C.	LFL 10% UFL 11%[c]

[a]This corresponds to about 4% CO_2, 10% R-134a and 86% R-1234ze(E) by weight.
[b]LFL = lower flammable limit and UFL = upper flammable limit
[c]Incomplete propagation

[0140] The ternary composition 4% CO_2, 10% R-134a and 86% R-1234ze(E) by weight was shown to be non-flammable at 23° C. At 35° C., it was significantly less flammable than corresponding R134a/R1234yf and R134a/R1234ze(E) mixtures.

Modelled Performance Data

Generation of Accurate Physical Property Model

[0141] The physical properties of R-1234yf and R-1234ze (E) required to model refrigeration cycle performance, namely critical point, vapour pressure, liquid and vapour enthalpy, liquid and vapour density and heat capacities of vapour and liquid were accurately determined by experimental methods over the pressure range 0-200 bar and temperature range −40 to 200° C., and the resulting data used to generate Helmholtz free energy equation of state models of the Span-Wagner type for the fluid in the NIST REFPROP Version 8.0 software, which is more fully described in the user guide www.nist.gov/srd/PDFfiles/REFPROP8.PDF, and is incorporated herein by reference. The variation of ideal gas enthalpy of both fluids with temperature was estimated using molecular modelling software Hyperchem v7.5 (which is incorporated herein by reference) and the resulting ideal gas enthalpy function was used in the regression of the equation of state for these fluids. The predictions of this model for R1234yf and R1234ze(E) were compared to the predictions yielded by use of the standard files for R1234yf and R1234ze (E) included in REFPROP Version 9.0 (incorporated herein by reference). It was found that close agreement was obtained for each fluid's properties.

[0142] The vapour liquid equilibrium behaviour of R-1234ze(E) was studied in a series of binary pairs with carbon dioxide, R-32, R-125, R-134a, R-152a, R-161, propane and propylene over the temperature range −40 to +60° C., which encompasses the practical operating range of most refrigeration and air conditioning systems. The composition was varied over the full compositional space for each binary in the experimental programme, Mixture parameters for each binary pair were regressed to the experimentally obtained data and the parameters were also incorporated into the REFPROP software model. The academic literature was next searched for data on the vapour liquid equilibrium behaviour of carbon dioxide with the hydrofluorocarbons R-32, R-125, R-152a, R-161 and R-152a. The VLE data obtained from sources referenced in the article *Applications of the simple multi-fluid model to correlations of the vapour-liquid equilibrium of refrigerant mixtures containing carbon dioxide*, by R. Akasaka, Journal of Thermal Science and Technology, 159-168, 4, 1, 2009 (which is incorporated herein by reference) were then used to generate mixing parameters for the relevant binary mixtures and these were then also incorporated into the REFPROP model. The standard REFPROP mixing parameters for carbon dioxide with propane and propylene were also incorporated to this model.

[0143] The resulting software model was used to compare the performance of selected fluids of the invention with R-134a in a heat pumping cycle application.

Heat Pumping Cycle Comparison

[0144] In a first comparison the behaviour of the fluids was assessed for a simple vapour compression cycle with conditions typical of automotive heat pumping duty in low winter ambient temperatures. In this comparison pressure drop effects were included in the model by assignation of a representative expected pressure drop to the reference fluid (R-134a) followed by estimation of the equivalent pressure drop for the mixed refrigerant of the invention in the same equipment at the same heating capacity. The comparison was made on the basis of equal heat exchanger area for the reference fluid (R-134a) and for the mixed fluids of the invention. The methodology used for this model was derived using the assumptions of equal effective overall heat transfer coefficient for refrigerant condensation, refrigerant evaporation, refrigerant liquid subcooling and refrigerant vapour superheating processes to derive a so-called UA model for the process. The derivation of such a model for nonazeotropic refrigerant mixtures in heat pump cycles is more fully explained in the reference text *Vapor Compression Heat Pumps with refrigerant mixtures* by R Radermacher & Y Hwang (pub Taylor & Francis 2005) Chapter 3, which is incorporated herein by reference.

[0145] Briefly, the model starts with an initial estimate of the condensing and evaporating pressures for the refrigerant mixture and estimates the corresponding temperatures at the beginning and end of the condensation process in the condenser and the evaporation process in the evaporator. These temperatures are then used in conjunction with the specified changes in air temperatures over condenser and evaporator to estimate a required overall heat exchanger area for each of the condenser and evaporator. This is an iterative calculation: the condensing and evaporating pressures are adjusted to ensure that the overall heat exchanger areas are the same for reference fluid and for the mixed refrigerant.

[0146] For the comparison the worst case for heat pumping in automotive application was assumed with the following assumptions for air temperature and for R-134a cycle conditions.

Cycle Conditions

[0147]

Ambient air temperature on to condenser and evaporator	−15° C.
Air temperature leaving evaporator:	−25° C.
Air temperature leaving condenser (passenger air)	+45° C.
R134a evaporating temperature	−30° C.
R-134a condensing temperature	+50° C.
Subcooling of refrigerant in condenser	1 K
Superheating of refrigerant in evaporator	5 K
Compressor suction temperature	0° C.
Compressor isentropic efficiency	66%
Passenger air heating load	2 kW
Pressure drop in evaporator for R-134a	0.03 bar
Pressure drop in condenser for R-134a	0.03 bar
Pressure drop in suction line for R-134a	0.03 bar

[0148] The model assumed countercurrent flow for each heat exchanger in its calculation of effective temperature differences for each of the heat transfer processes.

[0149] Condensing and evaporating temperatures for compositions was adjusted to give equivalent usage of heat exchange area as reference fluid. The following input parameters were used.

Parameter		Reference
Refrigerant		R134a
Mean condenser temperature	° C.	50
Mean evaporator temperature	° C.	−30
Condenser subcooling	K	1
Evaporator superheat	K	5
Suction diameter	mm	16.2
Heating capacity	kW	2
Evaporator pressure drop	bar	0.03
Suction line pressure drop	bar	0.03
Condenser pressure drop	bar	0.03
Compressor suction temperature	° C.	0
Isentropic efficiency		66%
Evaporator air on	° C.	−15.00
Evaporator air off	° C.	−25.00
Condenser air on	° C.	−15.00
Condenser air off	° C.	45.00
Condenser area	100.0%	100.0%
Evaporator area	100.0%	100.0%

[0150] Using the above model, the performance data for the reference R-134a is shown below.

COP (heating)		2.11
COP (heating) relative to Reference		100.0%
Volumetric heating capacity at suction	kJ/m^3	879
Capacity relative to Reference		100.0%
Critical temperature	° C.	101.06
Critical pressure	bar	40.59
Condenser enthalpy change	kJ/kg	237.1
Pressure ratio		16.36
Refrigerant mass flow	kg/hr	30.4
Compressor discharge temperature	° C.	125.5
Evaporator inlet pressure	bar	0.86
Condenser inlet pressure	bar	13.2
Evaporator inlet temperature	° C.	−29.7
Evaporator dewpoint	° C.	−30.3
Evaporator exit gas temperature	° C.	−25.3
Evaporator mean temperature	° C.	−30.0
Evaporator glide (out-in)	K	−0.6
Compressor suction pressure	bar	0.81
Compressor discharge pressure	bar	13.2
Suction line pressure drop	Pa/m	292
Pressure drop relative to reference		100.0%
Condenser dew point	° C.	50.0
Condenser bubble point	° C.	50.0
Condenser exit liquid temperature	° C.	49.0
Condenser mean temperature	° C.	50.0
Condenser glide (in-out)	K	0.1

[0151] The generated performance data for selected compositions of the invention is set out in the following Tables. The tables show key parameters of the heat pump cycle, including operating pressures, volumetric heating capacity, energy efficiency (expressed as coefficient of performance for heating COP) compressor discharge temperature and pressure drops in pipework. The volumetric heating capacity of a refrigerant is a measure of the amount of heating which can be obtained for a given size of compressor operating at fixed speed. The coefficient of performance (COP) is the ratio of the amount of heat energy delivered in the condenser of the heat pump cycle to the amount of work consumed by the compressor.

[0152] The performance of R-134a is taken as the reference point for comparison of heating capacity, energy efficiency and pressure drop. This fluid is used as a reference for comparison of the ability of the fluids of the invention to be used

in the heat pump mode of an automotive combined air conditioning and heat pump system.

[0153] It should be noted in passing that the utility of fluids of the invention is not limited to automotive systems. Indeed these fluids can be used in so-called stationary (residential or commercial) equipment. Currently the main fluids used in such stationary equipment are R-410A (having a GWP of 2100) or R22 (having a GWP of 1800 and an ozone depletion potential of 0.05). The use of the fluids of the invention in such stationary equipment offers the ability to realise similar utility but with fluids having no ozone depletion potential and significantly reduced GWP compared to R410A.

[0154] It is evident that fluids of the invention can provide improved energy efficiency compared to R-134a or R-410A. It is unexpectedly found that the addition of carbon dioxide to the refrigerants of the invention can increase the COP of the resulting cycle above that of R-134a, even in case where admixture of the other mixture components would result in a fluid having worse energy efficiency than R-134a.

[0155] It is further found for all the fluids of the invention that compositions up to about 30% w/w of CO_2 can be used which yield refrigerant fluids whose critical temperature is about 70° C. or higher. This is particularly significant for stationary heat pumping applications where R-410A is currently used. The fundamental thermodynamic efficiency of a vapour compression process is affected by proximity of the critical temperature to the condensing temperature. R-410A has gained acceptance and can be considered an acceptable fluid for this application; its critical temperature is 71° C. It has unexpectedly been found that significant quantities of CO_2 (critical temperature 31° C.) can be incorporated in fluids of the invention to yield mixtures having similar or higher critical temperature to R-410A. Preferred compositions of the invention therefore have critical temperatures are about 70° C. or higher.

[0156] The heating capacity of the preferred fluids of the invention typically exceeds that of R134a. It is thought that R-134a alone, operated in an automotive a/c and heat pump system, cannot provide all of the potential passenger air heating demand in heat pump mode. Therefore higher heating capacities than R-134a are preferred for potential use in an automotive a/c and heat pump application. The fluids of the invention offer the ability to optimise fluid capacity and energy efficiency for both air conditioning and cooling modes so as to provide an improved overall energy efficiency for both duties.

[0157] For reference, the heating capacity of R-410A in the same cycle conditions was estimated at about 290% of the R-134a value and the corresponding energy efficiency was found to be about 106% of the R-134a reference value.

[0158] It is evident by inspection of the tables that fluids of the invention have been discovered having comparable heating capacities and energy efficiencies to R-410A, allowing adaption of existing R-410A technology to use the fluids of the invention if so desired.

[0159] Some further benefits of the fluids of the invention are described in more detail below.

[0160] At equivalent cooling capacity the compositions of the invention offer reduced pressure drop compared to R-134a. This reduced pressure drop characteristic is believed to result in further improvement in energy efficiency (through reduction of pressure losses) in a real system. Pressure drop effects are of particular significance for automotive air conditioning and heat pump applications so these fluids offer particular advantage for this application.

[0161] The compositions containing CO_2/R-134a/R-1234ze(E) are especially attractive since they have non-flammable liquid and vapour phases at 23° C. and selected compositions are also wholly non-flammable at 60° C.

[0162] The performance of fluids of the invention were compared to binary mixtures of CO_2/R1234ze(E). For all the ternary and quaternary compositions of the invention apart from CO_2/R1234yf/R1234ze(E) the energy efficiency of the ternary or quaternary mixtures was increased relative to the binary mixture having equivalent CO_2 content. These mixtures therefore represent an improved solution relative to the CO_2/R1234ze(E) binary refrigerant mixture, at least for CO_2 content less than 30% w/w.

TABLE 1

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 5% R-134

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/5/95	2/5/93	4/5/91	6/5/89	8/5/87	10/5/85	12/5/83	14/5/81
COP (heating)		2.00	2.06	2.10	2.14	2.16	2.18	2.20	2.21
COP (heating) relative to Reference		94.8%	97.7%	99.8%	101.4%	102.7%	103.6%	104.3%	104.9%
Volumetric heating capacity at suction	kJ/m^3	634	715	799	886	976	1069	1166	1265
Capacity relative to Reference		72.1%	81.3%	90.9%	100.8%	111.1%	121.7%	132.7%	143.9%
Critical temperature	° C.	109.40	105.47	101.78	98.30	95.02	91.91	88.98	86.19
Critical pressure	bar	37.08	37.84	38.60	39.36	40.12	40.88	41.64	42.39
Condenser enthalpy change	kJ/kg	211.5	224.7	235.8	245.4	253.6	261.0	267.5	273.5
Pressure ratio		18.55	18.78	18.82	18.71	18.47	18.15	17.77	17.36
Refrigerant mass flow	kg/hr	34.0	32.0	30.5	29.3	28.4	27.6	26.9	26.3
Compressor discharge temperature	° C.	113.3	117.6	121.5	125.1	128.3	131.3	134.1	136.8
Evaporator inlet pressure	bar	0.67	0.71	0.76	0.82	0.89	0.97	1.05	1.14
Condenser inlet pressure	bar	10.9	12.1	13.3	14.5	15.7	16.9	18.0	19.2
Evaporator inlet temperature	° C.	−29.0	−29.7	−30.4	−31.1	−31.9	−32.7	−33.6	−34.5
Evaporator dewpoint	° C.	−30.2	−29.6	−29.0	−28.2	−27.4	−26.6	−25.8	−25.1
Evaporator exit gas temperature	° C.	−25.2	−24.6	−24.0	−23.2	−22.4	−21.6	−20.8	−20.1
Evaporator mean temperature	° C.	−29.6	−29.7	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8
Evaporator glide (out-in)	K	−1.2	0.1	1.4	2.9	4.5	6.1	7.8	9.5
Compressor suction pressure	bar	0.59	0.64	0.71	0.77	0.85	0.93	1.01	1.10
Compressor discharge pressure	bar	10.9	12.1	13.3	14.5	15.7	16.9	18.0	19.2
Suction line pressure drop	Pa/m	447	378	327	286	253	226	204	185
Pressure drop relative to reference		152.9%	129.6%	111.8%	97.9%	86.6%	77.4%	69.7%	63.2%

TABLE 1-continued

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 5% R-134

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/5/95	2/5/93	4/5/91	6/5/89	8/5/87	10/5/85	12/5/83	14/5/81
Condenser dew point	° C.	53.1	55.0	56.5	57.8	58.8	59.6	60.2	60.5
Condenser bubble point	° C.	52.7	47.0	42.5	39.0	36.2	34.0	32.1	30.6
Condenser exit liquid temperature	° C.	51.7	46.0	41.5	38.0	35.2	33.0	31.1	29.6
Condenser mean temperature	° C.	52.9	51.0	49.5	48.4	47.5	46.8	46.1	45.6
Condenser glide (in-out)	K	0.4	7.9	14.0	18.8	22.6	25.7	28.1	29.9

TABLE 2

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 16-30% R-744 and 5% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		16/5/79	18/5/77	20/5/75	22/5/73	24/5/71	26/5/69	28/5/67	30/5/65
COP (heating)		2.22	2.23	2.24	2.24	2.24	2.24	2.24	2.24
COP (heating) relative to Reference		105.4%	105.8%	106.0%	106.2%	106.3%	106.4%	106.4%	106.3%
Volumetric heating capacity at suction	kJ/m^3	1366	1469	1575	1681	1789	1897	2007	2116
Capacity relative to Reference		155.5%	167.2%	179.2%	191.3%	203.6%	215.9%	228.4%	240.8%
Critical temperature	° C.	83.54	81.03	78.63	76.35	74.17	72.09	70.10	68.20
Critical pressure	bar	43.15	43.91	44.66	45.42	46.17	46.93	47.68	48.43
Condenser enthalpy change	kJ/kg	279.0	284.2	289.1	293.7	298.2	302.6	306.8	310.9
Pressure ratio		16.93	16.51	16.09	15.68	15.29	14.92	14.57	14.24
Refrigerant mass flow	kg/hr	25.8	25.3	24.9	24.5	24.1	23.8	23.5	23.2
Compressor discharge temperature	° C.	139.3	141.7	144.0	146.3	148.6	150.8	153.0	155.2
Evaporator inlet pressure	bar	1.23	1.32	1.42	1.53	1.63	1.74	1.85	1.97
Condenser inlet pressure	bar	20.3	21.4	22.5	23.6	24.6	25.7	26.7	27.7
Evaporator inlet temperature	° C.	−35.5	−36.5	−37.5	−38.6	−39.6	−40.6	−41.7	−42.6
Evaporator dewpoint	° C.	−24.4	−23.7	−23.1	−22.6	−22.1	−21.6	−21.3	−21.0
Evaporator exit gas temperature	° C.	−19.4	−18.7	−18.1	−17.6	−17.1	−16.6	−16.3	−16.0
Evaporator mean temperature	° C.	−29.9	−30.1	−30.3	−30.6	−30.8	−31.1	−31.5	−31.8
Evaporator glide (out-in)	K	11.1	12.8	14.4	16.0	17.5	19.0	20.4	21.7
Compressor suction pressure	bar	1.20	1.30	1.40	1.50	1.61	1.72	1.83	1.95
Compressor discharge pressure	bar	20.3	21.4	22.5	23.6	24.6	25.7	26.7	27.7
Suction line pressure drop	Pa/m	168	154	142	132	122	114	107	100
Pressure drop relative to reference		57.6%	52.8%	48.7%	45.1%	41.9%	39.0%	36.5%	34.3%
Condenser dew point	° C.	60.7	60.8	60.7	60.6	60.3	59.9	59.5	59.0
Condenser bubble point	° C.	29.3	28.3	27.4	26.6	25.9	25.4	24.9	24.4
Condenser exit liquid temperature	° C.	28.3	27.3	26.4	25.6	24.9	24.4	23.9	23.4
Condenser mean temperature	° C.	45.0	44.5	44.0	43.6	43.1	42.6	42.2	41.7
Condenser glide (in-out)	K	31.4	32.5	33.4	34.0	34.3	34.6	34.6	34.6

TABLE 3

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 10% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/10/90	2/10/88	4/10/86	6/10/84	8/10/82	10/10/80	12/10/78	14/10/76
COP (heating)		2.01	2.07	2.11	2.14	2.17	2.19	2.20	2.21
COP (heating) relative to Reference		95.1%	97.9%	100.0%	101.6%	102.8%	103.7%	104.4%	105.0%
Volumetric heating capacity at suction	kJ/m^3	652	734	819	906	998	1092	1190	1290
Capacity relative to Reference		74.2%	83.5%	93.2%	103.2%	113.6%	124.3%	135.4%	146.8%
Critical temperature	° C.	108.91	105.03	101.37	97.92	94.66	91.58	88.67	85.90
Critical pressure	bar	37.56	38.31	39.07	39.82	40.58	41.33	42.09	42.84
Condenser enthalpy change	kJ/kg	212.7	225.6	236.6	246.0	254.2	261.4	268.0	273.9
Pressure ratio		18.37	18.57	18.61	18.49	18.24	17.93	17.55	17.15
Refrigerant mass flow	kg/hr	33.9	31.9	30.4	29.3	28.3	27.5	26.9	26.3
Compressor discharge temperature	° C.	113.9	118.1	121.9	125.5	128.7	131.7	134.5	137.1
Evaporator inlet pressure	bar	0.68	0.73	0.78	0.84	0.91	0.99	1.07	1.16
Condenser inlet pressure	bar	11.1	12.3	13.5	14.7	15.9	17.1	18.2	19.4
Evaporator inlet temperature	° C.	−29.1	−29.8	−30.5	−31.2	−31.9	−32.8	−33.6	−34.5
Evaporator dewpoint	° C.	−30.1	−29.6	−28.9	−28.2	−27.4	−26.6	−25.8	−25.1
Evaporator exit gas temperature	° C.	−25.1	−24.6	−23.9	−23.2	−22.4	−21.6	−20.8	−20.1

TABLE 3-continued

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 10% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/10/90	2/10/88	4/10/86	6/10/84	8/10/82	10/10/80	12/10/78	14/10/76
Evaporator mean temperature	° C.	−29.6	−29.7	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8
Evaporator glide (out-in)	K	−1.0	0.2	1.6	3.0	4.6	6.2	7.8	9.4
Compressor suction pressure	bar	0.61	0.66	0.73	0.80	0.87	0.95	1.04	1.13
Compressor discharge pressure	bar	11.1	12.3	13.5	14.7	15.9	17.1	18.2	19.4
Suction line pressure drop	Pa/m	432	367	318	279	247	221	199	181
Pressure drop relative to reference		147.9%	125.8%	108.8%	95.4%	84.6%	75.7%	68.2%	61.9%
Condenser dew point	° C.	53.0	54.8	56.3	57.6	58.5	59.3	59.8	60.1
Condenser bubble point	° C.	52.4	46.9	42.5	39.1	36.3	34.1	32.3	30.8
Condenser exit liquid temperature	° C.	51.4	45.9	41.5	38.1	35.3	33.1	31.3	29.8
Condenser mean temperature	° C.	52.7	50.9	49.4	48.3	47.4	46.7	46.0	45.5
Condenser glide (in-out)	K	0.6	7.9	13.8	18.5	22.2	25.2	27.5	29.3

TABLE 4

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 16-30% R-744 and 10% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		16/10/74	18/10/72	20/10/70	22/10/68	24/10/66	26/10/64	28/10/62	30/10/60
COP (heating)		2.22	2.23	2.24	2.24	2.24	2.24	2.24	2.24
COP (heating) relative to Reference		105.5%	105.8%	106.1%	106.3%	106.4%	106.4%	106.4%	106.4%
Volumetric heating capacity at suction	kJ/m^3	1393	1498	1604	1712	1822	1933	2044	2156
Capacity relative to Reference		158.5%	170.4%	182.6%	194.9%	207.4%	219.9%	232.6%	245.4%
Critical temperature	° C.	83.28	80.78	78.40	76.13	73.97	71.90	69.93	68.03
Critical pressure	bar	43.59	44.35	45.10	45.85	46.61	47.36	48.11	48.86
Condenser enthalpy change	kJ/kg	279.4	284.5	289.3	293.9	298.4	302.7	306.8	310.9
Pressure ratio		16.73	16.31	15.89	15.49	15.10	14.74	14.39	14.06
Refrigerant mass flow	kg/hr	25.8	25.3	24.9	24.5	24.1	23.8	23.5	23.2
Compressor discharge temperature	° C.	139.6	142.0	144.3	146.6	148.8	151.0	153.2	155.4
Evaporator inlet pressure	bar	1.25	1.35	1.45	1.56	1.67	1.78	1.89	2.01
Condenser inlet pressure	bar	20.5	21.6	22.7	23.8	24.9	25.9	27.0	28.0
Evaporator inlet temperature	° C.	−35.5	−36.5	−37.5	−38.5	−39.5	−40.5	−41.4	−42.4
Evaporator dewpoint	° C.	−24.4	−23.7	−23.2	−22.6	−22.1	−21.7	−21.4	−21.1
Evaporator exit gas temperature	° C.	−19.4	−18.7	−18.2	−17.6	−17.1	−16.7	−16.4	−16.1
Evaporator mean temperature	° C.	−29.9	−30.1	−30.3	−30.5	−30.8	−31.1	−31.4	−31.7
Evaporator glide (out-in)	K	11.1	12.7	14.3	15.8	17.3	18.8	20.1	21.3
Compressor suction pressure	bar	1.23	1.33	1.43	1.54	1.65	1.76	1.87	1.99
Compressor discharge pressure	bar	20.5	21.6	22.7	23.8	24.9	25.9	27.0	28.0
Suction line pressure drop	Pa/m	165	151	139	129	120	112	105	98
Pressure drop relative to reference		56.5%	51.8%	47.8%	44.2%	41.1%	38.3%	35.9%	33.7%
Condenser dew point	° C.	60.3	60.4	60.3	60.1	59.8	59.5	59.0	58.5
Condenser bubble point	° C.	29.5	28.5	27.6	26.8	26.2	25.6	25.1	24.7
Condenser exit liquid temperature	° C.	28.5	27.5	26.6	25.8	25.2	24.6	24.1	23.7
Condenser mean temperature	° C.	44.9	44.4	44.0	43.5	43.0	42.6	42.1	41.6
Condenser glide (in-out)	K	30.8	31.9	32.7	33.3	33.6	33.8	33.9	33.8

TABLE 5

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 15% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/15/85	2/15/83	4/15/81	6/15/79	8/15/77	10/15/75	12/15/73	14/15/71
COP (heating)		2.01	2.07	2.11	2.14	2.17	2.19	2.20	2.22
COP (heating) relative to Reference		95.5%	98.2%	100.2%	101.7%	102.9%	103.8%	104.5%	105.1%
Volumetric heating capacity at suction	kJ/m^3	670	753	838	927	1020	1115	1214	1315
Capacity relative to Reference		76.3%	85.7%	95.4%	105.5%	116.0%	126.9%	138.1%	149.7%
Critical temperature	° C.	108.44	104.58	100.96	97.54	94.31	91.26	88.36	85.62
Critical pressure	bar	38.00	38.75	39.50	40.25	41.00	41.76	42.51	43.26
Condenser enthalpy change	kJ/kg	213.8	226.6	237.4	246.7	254.8	262.0	268.5	274.3
Pressure ratio		18.19	18.38	18.40	18.28	18.03	17.72	17.35	16.95
Refrigerant mass flow	kg/hr	33.7	31.8	30.3	29.2	28.3	27.5	26.8	26.2

TABLE 5-continued

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 15% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/15/85	2/15/83	4/15/81	6/15/79	8/15/77	10/15/75	12/15/73	14/15/71
Compressor discharge temperature	° C.	114.4	118.6	122.4	125.9	129.1	132.1	134.9	137.5
Evaporator inlet pressure	bar	0.69	0.74	0.80	0.86	0.93	1.01	1.10	1.18
Condenser inlet pressure	bar	11.3	12.5	13.7	14.9	16.1	17.3	18.4	19.6
Evaporator inlet temperature	° C.	−29.2	−29.8	−30.5	−31.2	−32.0	−32.8	−33.6	−34.5
Evaporator dewpoint	° C.	−30.1	−29.5	−28.9	−28.1	−27.4	−26.6	−25.8	−25.1
Evaporator exit gas temperature	° C.	−25.1	−24.5	−23.9	−23.1	−22.4	−21.6	−20.8	−20.1
Evaporator mean temperature	° C.	−29.6	−29.7	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8
Evaporator glide (out-in)	K	−0.9	0.3	1.6	3.1	4.6	6.2	7.8	9.4
Compressor suction pressure	bar	0.62	0.68	0.74	0.81	0.89	0.97	1.06	1.15
Compressor discharge pressure	bar	11.3	12.5	13.7	14.9	16.1	17.3	18.4	19.6
Suction line pressure drop	Pa/m	419	357	310	272	241	216	195	177
Pressure drop relative to reference		143.4%	122.3%	106.0%	93.1%	82.6%	74.0%	66.8%	60.6%
Condenser dew point	° C.	52.9	54.6	56.1	57.3	58.2	58.9	59.4	59.8
Condenser bubble point	° C.	52.2	46.8	42.5	39.2	36.4	34.3	32.5	31.0
Condenser exit liquid temperature	° C.	51.2	45.8	41.5	38.2	35.4	33.3	31.5	30.0
Condenser mean temperature	° C.	52.5	50.7	49.3	48.2	47.3	46.6	46.0	45.4
Condenser glide (in-out)	K	0.8	7.8	13.6	18.1	21.8	24.7	27.0	28.8

TABLE 6

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 16-30% R-744 and 15% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		16/15/69	18/15/67	20/15/65	22/15/63	24/15/61	26/15/59	28/15/57	30/15/55
COP (heating)		2.22	2.23	2.24	2.24	2.24	2.25	2.24	2.24
COP (heating) relative to Reference		105.5%	105.9%	106.1%	106.3%	106.4%	106.5%	106.5%	106.4%
Volumetric heating capacity at suction	kJ/m^3	1419	1525	1633	1743	1855	1967	2081	2196
Capacity relative to Reference		161.5%	173.6%	185.9%	198.4%	211.1%	223.9%	236.8%	249.9%
Critical temperature	° C.	83.01	80.53	78.17	75.92	73.77	71.71	69.75	67.87
Critical pressure	bar	44.01	44.76	45.52	46.27	47.02	47.77	48.52	49.27
Condenser enthalpy change	kJ/kg	279.8	284.9	289.7	294.2	298.6	302.8	306.9	310.9
Pressure ratio		16.54	16.12	15.71	15.31	14.93	14.56	14.21	13.88
Refrigerant mass flow	kg/hr	25.7	25.3	24.9	24.5	24.1	23.8	23.5	23.2
Compressor discharge temperature	° C.	140.0	142.3	144.6	146.9	149.1	151.3	153.4	155.5
Evaporator inlet pressure	bar	1.28	1.38	1.48	1.59	1.70	1.81	1.93	2.05
Condenser inlet pressure	bar	20.7	21.8	22.9	24.0	25.1	26.2	27.2	28.3
Evaporator inlet temperature	° C.	−35.4	−36.4	−37.4	−38.3	−39.3	−40.3	−41.2	−42.2
Evaporator dewpoint	° C.	−24.4	−23.8	−23.2	−22.7	−22.2	−21.8	−21.4	−21.1
Evaporator exit gas temperature	° C.	−19.4	−18.8	−18.2	−17.7	−17.2	−16.8	−16.4	−16.1
Evaporator mean temperature	° C.	−29.9	−30.1	−30.3	−30.5	−30.8	−31.0	−31.3	−31.6
Evaporator glide (out-in)	K	11.0	12.6	14.2	15.7	17.1	18.5	19.8	21.0
Compressor suction pressure	bar	1.25	1.35	1.46	1.57	1.68	1.80	1.91	2.04
Compressor discharge pressure	bar	20.7	21.8	22.9	24.0	25.1	26.2	27.2	28.3
Suction line pressure drop	Pa/m	162	148	137	127	118	110	103	97
Pressure drop relative to reference		55.4%	50.8%	46.9%	43.4%	40.3%	37.6%	35.2%	33.1%
Condenser dew point	° C.	59.9	60.0	59.9	59.7	59.4	59.0	58.6	58.1
Condenser bubble point	° C.	29.7	28.7	27.8	27.1	26.4	25.9	25.4	25.0
Condenser exit liquid temperature	° C.	28.7	27.7	26.8	26.1	25.4	24.9	24.4	24.0
Condenser mean temperature	° C.	44.8	44.3	43.9	43.4	42.9	42.5	42.0	41.6
Condenser glide (in-out)	K	30.2	31.3	32.1	32.6	33.0	33.2	33.2	33.1

TABLE 7

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 20% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/20/80	2/20/78	4/20/76	6/20/74	8/20/72	10/20/70	12/20/68	14/20/66
COP (heating)		2.02	2.08	2.12	2.15	2.17	2.19	2.20	2.22
COP (heating) relative to Reference		95.8%	98.4%	100.4%	101.8%	103.0%	103.9%	104.6%	105.1%
Volumetric heating capacity at suction	kJ/m^3	688	771	857	947	1041	1137	1237	1339

TABLE 7-continued

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 20% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/20/80	2/20/78	4/20/76	6/20/74	8/20/72	10/20/70	12/20/68	14/20/66
Capacity relative to Reference		78.3%	87.7%	97.6%	107.8%	118.4%	129.4%	140.7%	152.4%
Critical temperature	° C.	107.96	104.14	100.55	97.16	93.96	90.93	88.06	85.34
Critical pressure	bar	38.40	39.15	39.90	40.65	41.40	42.15	42.91	43.66
Condenser enthalpy change	kJ/kg	215.0	227.5	238.2	247.5	255.5	262.6	269.0	274.9
Pressure ratio		18.02	18.19	18.21	18.08	17.84	17.53	17.16	16.76
Refrigerant mass flow	kg/hr	33.5	31.6	30.2	29.1	28.2	27.4	26.8	26.2
Compressor discharge temperature	° C.	114.9	119.1	122.9	126.4	129.6	132.5	135.3	137.9
Evaporator inlet pressure	bar	0.71	0.76	0.81	0.88	0.95	1.03	1.12	1.21
Condenser inlet pressure	bar	11.5	12.7	13.9	15.1	16.3	17.5	18.6	19.8
Evaporator inlet temperature	° C.	−29.2	−29.9	−30.5	−31.3	−32.0	−32.8	−33.6	−34.5
Evaporator dewpoint	° C.	−30.0	−29.5	−28.8	−28.1	−27.4	−26.6	−25.9	−25.2
Evaporator exit gas temperature	° C.	−25.0	−24.5	−23.8	−23.1	−22.4	−21.6	−20.9	−20.2
Evaporator mean temperature	° C.	−29.6	−29.7	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8
Evaporator glide (out-in)	K	−0.8	0.4	1.7	3.1	4.6	6.2	7.8	9.3
Compressor suction pressure	bar	0.64	0.70	0.76	0.83	0.91	1.00	1.08	1.18
Compressor discharge pressure	bar	11.5	12.7	13.9	15.1	16.3	17.5	18.6	19.8
Suction line pressure drop	Pa/m	406	348	302	266	236	212	191	174
Pressure drop relative to reference		139.1%	119.0%	103.4%	91.0%	80.8%	72.5%	65.4%	59.4%
Condenser dew point	° C.	52.8	54.5	55.9	57.0	57.9	58.6	59.1	59.4
Condenser bubble point	° C.	52.0	46.7	42.5	39.2	36.5	34.4	32.6	31.1
Condenser exit liquid temperature	° C.	51.0	45.7	41.5	38.2	35.5	33.4	31.6	30.1
Condenser mean temperature	° C.	52.4	50.6	49.2	48.1	47.2	46.5	45.9	45.3
Condenser glide (in-out)	K	0.8	7.7	13.3	17.8	21.4	24.2	26.5	28.2

TABLE 8

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 16-30% R-744 and 20% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		16/20/64	18/20/62	20/20/60	22/20/58	24/20/56	26/20/54	28/20/52	30/20/50
COP (heating)		2.23	2.23	2.24	2.24	2.25	2.25	2.25	2.25
COP (heating) relative to Reference		105.6%	105.9%	106.2%	106.4%	106.5%	106.5%	106.5%	106.5%
Volumetric heating capacity at suction	kJ/m^3	1445	1552	1662	1774	1887	2002	2117	2235
Capacity relative to Reference		164.4%	176.7%	189.2%	201.9%	214.8%	227.8%	241.0%	254.3%
Critical temperature	° C.	82.75	80.29	77.94	75.70	73.57	71.53	69.57	67.70
Critical pressure	bar	44.41	45.16	45.91	46.66	47.41	48.16	48.91	49.66
Condenser enthalpy change	kJ/kg	280.3	285.3	290.1	294.6	298.9	303.1	307.1	311.1
Pressure ratio		16.36	15.94	15.54	15.14	14.76	14.40	14.05	13.72
Refrigerant mass flow	kg/hr	25.7	25.2	24.8	24.4	24.1	23.8	23.4	23.1
Compressor discharge temperature	° C.	140.3	142.7	145.0	147.2	149.4	151.5	153.7	155.7
Evaporator inlet pressure	bar	1.31	1.41	1.51	1.62	1.73	1.85	1.97	2.09
Condenser inlet pressure	bar	20.9	22.0	23.1	24.2	25.3	26.4	27.5	28.5
Evaporator inlet temperature	° C.	−35.4	−36.3	−37.3	−38.2	−39.2	−40.1	−41.0	−41.9
Evaporator dewpoint	° C.	−24.5	−23.8	−23.3	−22.7	−22.3	−21.9	−21.5	−21.2
Evaporator exit gas temperature	° C.	−19.5	−18.8	−18.3	−17.7	−17.3	−16.9	−16.5	−16.2
Evaporator mean temperature	° C.	−29.9	−30.1	−30.3	−30.5	−30.7	−31.0	−31.3	−31.6
Evaporator glide (out-in)	K	10.9	12.5	14.0	15.5	16.9	18.3	19.5	20.7
Compressor suction pressure	bar	1.28	1.38	1.49	1.60	1.71	1.83	1.95	2.08
Compressor discharge pressure	bar	20.9	22.0	23.1	24.2	25.3	26.4	27.5	28.5
Suction line pressure drop	Pa/m	159	146	134	124	116	108	101	95
Pressure drop relative to reference		54.3%	49.9%	46.0%	42.6%	39.6%	37.0%	34.6%	32.5%
Condenser dew point	° C.	59.5	59.6	59.5	59.3	59.0	58.6	58.2	57.7
Condenser bubble point	° C.	29.9	28.9	28.0	27.3	26.7	26.1	25.6	25.2
Condenser exit liquid temperature	° C.	28.9	27.9	27.0	26.3	25.7	25.1	24.6	24.2
Condenser mean temperature	° C.	44.7	44.2	43.8	43.3	42.8	42.4	41.9	41.5
Condenser glide (in-out)	K	29.6	30.7	31.5	32.0	32.3	32.5	32.5	32.4

TABLE 9

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 30% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/30/70	2/30/68	4/30/66	6/30/64	8/30/62	10/30/60	12/30/58	14/30/56
COP (heating)		2.03	2.08	2.12	2.15	2.18	2.19	2.21	2.22
COP (heating) relative to Reference		96.4%	98.9%	100.7%	102.1%	103.2%	104.1%	104.7%	105.3%
Volumetric heating capacity at suction	kJ/m^3	721	806	894	985	1081	1179	1281	1387
Capacity relative to Reference		82.1%	91.7%	101.7%	112.1%	123.0%	134.2%	145.8%	157.8%
Critical temperature	° C.	107.03	103.28	99.75	96.42	93.27	90.29	87.47	84.78
Critical pressure	bar	39.11	39.86	40.61	41.37	42.12	42.87	43.62	44.37
Condenser enthalpy change	kJ/kg	217.3	229.6	240.1	249.1	257.0	264.1	270.4	276.1
Pressure ratio		17.70	17.85	17.86	17.73	17.49	17.18	16.82	16.43
Refrigerant mass flow	kg/hr	33.1	31.4	30.0	28.9	28.0	27.3	26.6	26.1
Compressor discharge temperature	° C.	116.0	120.2	123.9	127.4	130.5	133.5	136.2	138.8
Evaporator inlet pressure	bar	0.74	0.79	0.85	0.91	0.99	1.07	1.16	1.25
Condenser inlet pressure	bar	11.9	13.0	14.2	15.4	16.6	17.8	19.0	20.1
Evaporator inlet temperature	° C.	−29.3	−30.0	−30.6	−31.3	−32.0	−32.8	−33.6	−34.4
Evaporator dewpoint	° C.	−30.0	−29.5	−28.8	−28.1	−27.4	−26.7	−25.9	−25.2
Evaporator exit gas temperature	° C.	−25.0	−24.5	−23.8	−23.1	−22.4	−21.7	−20.9	−20.2
Evaporator mean temperature	° C.	−29.7	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8	−29.8
Evaporator glide (out-in)	K	−0.7	0.5	1.8	3.2	4.6	6.1	7.6	9.2
Compressor suction pressure	bar	0.67	0.73	0.80	0.87	0.95	1.04	1.13	1.23
Compressor discharge pressure	bar	11.9	13.0	14.2	15.4	16.6	17.8	19.0	20.1
Suction line pressure drop	Pa/m	384	330	288	254	226	203	184	167
Pressure drop relative to reference		131.6%	113.1%	98.6%	87.0%	77.5%	69.6%	62.9%	57.2%
Condenser dew point	° C.	52.5	54.1	55.4	56.5	57.3	58.0	58.4	58.7
Condenser bubble point	° C.	51.6	46.6	42.5	39.3	36.7	34.6	32.9	31.4
Condenser exit liquid temperature	° C.	50.6	45.6	41.5	38.3	35.7	33.6	31.9	30.4
Condenser mean temperature	° C.	52.1	50.3	49.0	47.9	47.0	46.3	45.6	45.1
Condenser glide (in-out)	K	0.9	7.5	12.9	17.2	20.6	23.4	25.6	27.3

TABLE 10

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 16-30% R-744 and 30% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		16/30/54	18/30/52	20/30/50	22/30/48	24/30/46	26/30/44	28/30/42	30/30/40
COP (heating)		2.23	2.24	2.24	2.25	2.25	2.25	2.25	2.25
COP (heating) relative to Reference		105.7%	106.0%	106.3%	106.5%	106.6%	106.7%	106.7%	106.6%
Volumetric heating capacity at suction	kJ/m^3	1494	1605	1718	1833	1949	2068	2188	2309
Capacity relative to Reference		170.1%	182.7%	195.5%	208.6%	221.9%	235.3%	249.0%	262.8%
Critical temperature	° C.	82.23	79.80	77.49	75.28	73.17	71.16	69.23	67.38
Critical pressure	bar	45.12	45.88	46.63	47.38	48.13	48.88	49.63	50.38
Condenser enthalpy change	kJ/kg	281.5	286.4	291.1	295.5	299.8	303.8	307.8	311.6
Pressure ratio		16.03	15.63	15.23	14.84	14.46	14.10	13.75	13.42
Refrigerant mass flow	kg/hr	25.6	25.1	24.7	24.4	24.0	23.7	23.4	23.1
Compressor discharge temperature	° C.	141.2	143.5	145.8	148.0	150.1	152.2	154.2	156.3
Evaporator inlet pressure	bar	1.35	1.46	1.57	1.68	1.80	1.92	2.05	2.18
Condenser inlet pressure	bar	21.3	22.4	23.5	24.6	25.7	26.8	27.9	29.0
Evaporator inlet temperature	° C.	−35.3	−36.2	−37.1	−38.0	−38.9	−39.8	−40.7	−41.5
Evaporator dewpoint	° C.	−24.6	−24.0	−23.4	−22.9	−22.4	−22.0	−21.6	−21.3
Evaporator exit gas temperature	° C.	−19.6	−19.0	−18.4	−17.9	−17.4	−17.0	−16.6	−16.3
Evaporator mean temperature	° C.	−29.9	−30.1	−30.2	−30.4	−30.7	−30.9	−31.2	−31.4
Evaporator glide (out-in)	K	10.7	12.2	13.7	15.1	16.5	17.8	19.0	20.2
Compressor suction pressure	bar	1.33	1.43	1.55	1.66	1.78	1.90	2.03	2.16
Compressor discharge pressure	bar	21.3	22.4	23.5	24.6	25.7	26.8	27.9	29.0
Suction line pressure drop	Pa/m	153	140	130	120	112	104	98	92
Pressure drop relative to reference		52.3%	48.1%	44.4%	41.1%	38.3%	35.7%	33.4%	31.4%
Condenser dew point	° C.	58.8	58.8	58.7	58.5	58.2	57.9	57.4	56.9
Condenser bubble point	° C.	30.2	29.2	28.4	27.6	27.0	26.5	26.0	25.7
Condenser exit liquid temperature	° C.	29.2	28.2	27.4	26.6	26.0	25.5	25.0	24.7
Condenser mean temperature	° C.	44.5	44.0	43.6	43.1	42.6	42.2	41.7	41.3
Condenser glide (in-out)	K	28.6	29.6	30.4	30.9	31.2	31.4	31.4	31.3

TABLE 11

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 40% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/40/60	2/40/58	4/40/56	6/40/54	8/40/52	10/40/50	12/40/48	14/40/46
COP (heating)		2.04	2.09	2.13	2.16	2.18	2.20	2.21	2.22
COP (heating) relative to Reference		96.9%	99.3%	101.1%	102.4%	103.4%	104.3%	104.9%	105.4%
Volumetric heating capacity at suction	kJ/m^3	752	838	928	1021	1118	1220	1323	1431
Capacity relative to Reference		85.6%	95.4%	105.6%	116.2%	127.3%	138.8%	150.6%	162.8%
Critical temperature	° C.	106.12	102.44	98.97	95.70	92.60	89.66	86.88	84.24
Critical pressure	bar	39.69	40.45	41.21	41.96	42.72	43.48	44.23	44.99
Condenser enthalpy change	kJ/kg	219.7	231.7	242.1	251.0	258.9	265.8	272.1	277.8
Pressure ratio		17.41	17.56	17.56	17.42	17.19	16.88	16.53	16.15
Refrigerant mass flow	kg/hr	32.8	31.1	29.7	28.7	27.8	27.1	26.5	25.9
Compressor discharge temperature	° C.	117.2	121.3	125.1	128.5	131.6	134.5	137.2	139.8
Evaporator inlet pressure	bar	0.76	0.81	0.88	0.95	1.02	1.11	1.20	1.30
Condenser inlet pressure	bar	12.2	13.3	14.6	15.8	17.0	18.2	19.3	20.5
Evaporator inlet temperature	° C.	−29.4	−30.0	−30.6	−31.3	−32.0	−32.7	−33.5	−34.3
Evaporator dewpoint	° C.	−30.0	−29.5	−28.9	−28.2	−27.5	−26.7	−26.0	−25.3
Evaporator exit gas temperature	° C.	−25.0	−24.5	−23.9	−23.2	−22.5	−21.7	−21.0	−20.3
Evaporator mean temperature	° C.	−29.7	−29.7	−29.8	−29.7	−29.7	−29.7	−29.8	−29.8
Evaporator glide (out-in)	K	−0.6	0.5	1.8	3.1	4.6	6.0	7.5	9.0
Compressor suction pressure	bar	0.70	0.76	0.83	0.90	0.99	1.08	1.17	1.27
Compressor discharge pressure	bar	12.2	13.3	14.6	15.8	17.0	18.2	19.3	20.5
Suction line pressure drop	Pa/m	366	315	276	244	217	196	177	161
Pressure drop relative to reference		125.2%	108.0%	94.4%	83.5%	74.5%	66.9%	60.6%	55.2%
Condenser dew point	° C.	52.2	53.7	54.9	56.0	56.8	57.4	57.8	58.1
Condenser bubble point	° C.	51.4	46.4	42.5	39.3	36.8	34.7	33.0	31.6
Condenser exit liquid temperature	° C.	50.4	45.4	41.5	38.3	35.8	33.7	32.0	30.6
Condenser mean temperature	° C.	51.8	50.1	48.7	47.7	46.8	46.1	45.4	44.8
Condenser glide (in-out)	K	0.8	7.2	12.4	16.6	20.0	22.7	24.8	26.5

TABLE 12

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 16-30% R-744 and 40% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		16/40/44	18/40/42	20/40/40	22/40/38	24/40/36	26/40/34	28/40/32	30/40/30
COP (heating)		2.23	2.24	2.24	2.25	2.25	2.25	2.25	2.25
COP (heating) relative to Reference		105.9%	106.2%	106.4%	106.6%	106.7%	106.8%	106.8%	106.8%
Volumetric heating capacity at suction	kJ/m^3	1541	1654	1770	1888	2008	2130	2253	2379
Capacity relative to Reference		175.4%	188.3%	201.5%	214.9%	228.5%	242.4%	256.5%	270.7%
Critical temperature	° C.	81.72	79.33	77.05	74.87	72.78	70.79	68.89	67.06
Critical pressure	bar	45.74	46.50	47.26	48.01	48.77	49.52	50.27	51.03
Condenser enthalpy change	kJ/kg	283.0	287.9	292.5	296.9	301.0	305.0	308.8	312.5
Pressure ratio		15.76	15.36	14.97	14.58	14.21	13.85	13.50	13.17
Refrigerant mass flow	kg/hr	25.4	25.0	24.6	24.3	23.9	23.6	23.3	23.0
Compressor discharge temperature	° C.	142.2	144.5	146.7	148.8	150.9	153.0	155.0	157.0
Evaporator inlet pressure	bar	1.40	1.51	1.62	1.74	1.86	1.98	2.11	2.25
Condenser inlet pressure	bar	21.6	22.8	23.9	25.0	26.1	27.2	28.3	29.4
Evaporator inlet temperature	° C.	−35.2	−36.1	−36.9	−37.8	−38.7	−39.6	−40.4	−41.2
Evaporator dewpoint	° C.	−24.7	−24.1	−23.5	−23.0	−22.5	−22.1	−21.8	−21.5
Evaporator exit gas temperature	° C.	−19.7	−19.1	−18.5	−18.0	−17.5	−17.1	−16.8	−16.5
Evaporator mean temperature	° C.	−29.9	−30.1	−30.2	−30.4	−30.6	−30.8	−31.1	−31.3
Evaporator glide (out-in)	K	10.5	12.0	13.4	14.8	16.1	17.4	18.6	19.7
Compressor suction pressure	bar	1.37	1.48	1.60	1.72	1.84	1.97	2.10	2.23
Compressor discharge pressure	bar	21.6	22.8	23.9	25.0	26.1	27.2	28.3	29.4
Suction line pressure drop	Pa/m	148	136	125	116	108	101	95	89
Pressure drop relative to reference		50.5%	46.5%	42.9%	39.8%	37.0%	34.6%	32.4%	30.4%
Condenser dew point	° C.	58.2	58.2	58.1	57.9	57.6	57.2	56.8	56.3
Condenser bubble point	° C.	30.4	29.4	28.6	27.9	27.3	26.8	26.3	26.0
Condenser exit liquid temperature	° C.	29.4	28.4	27.6	26.9	26.3	25.8	25.3	25.0
Condenser mean temperature	° C.	44.3	43.8	43.3	42.9	42.4	42.0	41.6	41.1
Condenser glide (in-out)	K	27.8	28.8	29.5	30.0	30.3	30.4	30.4	30.3

TABLE 13

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 0-14% R-744 and 50% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		0/50/50	2/50/48	4/50/46	6/50/44	8/50/42	10/50/40	12/50/38	14/50/36
COP (heating)		2.05	2.10	2.14	2.17	2.19	2.20	2.22	2.23
COP (heating) relative to Reference		97.5%	99.7%	101.4%	102.7%	103.7%	104.5%	105.1%	105.6%
Volumetric heating capacity at suction	kJ/m^3	780	868	959	1054	1153	1256	1362	1472
Capacity relative to Reference		88.8%	98.7%	109.1%	120.0%	131.2%	143.0%	155.0%	167.5%
Critical temperature	° C.	105.23	101.62	98.21	94.99	91.94	89.05	86.31	83.70
Critical pressure	bar	40.15	40.91	41.68	42.45	43.21	43.98	44.74	45.51
Condenser enthalpy change	kJ/kg	222.2	234.1	244.4	253.2	261.0	267.9	274.1	279.7
Pressure ratio		17.16	17.30	17.30	17.17	16.94	16.64	16.30	15.92
Refrigerant mass flow	kg/hr	32.4	30.8	29.5	28.4	27.6	26.9	26.3	25.7
Compressor discharge temperature	° C.	118.4	122.5	126.3	129.7	132.8	135.7	138.4	140.9
Evaporator inlet pressure	bar	0.78	0.84	0.90	0.97	1.05	1.14	1.23	1.33
Condenser inlet pressure	bar	12.4	13.6	14.8	16.1	17.3	18.5	19.6	20.8
Evaporator inlet temperature	° C.	−29.5	−30.1	−30.7	−31.3	−32.0	−32.7	−33.5	−34.3
Evaporator dewpoint	° C.	−30.0	−29.5	−28.9	−28.2	−27.5	−26.8	−26.1	−25.4
Evaporator exit gas temperature	° C.	−25.0	−24.5	−23.9	−23.2	−22.5	−21.8	−21.1	−20.4
Evaporator mean temperature	° C.	−29.7	−29.8	−29.8	−29.8	−29.8	−29.8	−29.8	−29.9
Evaporator glide (out-in)	K	−0.6	0.5	1.8	3.1	4.5	5.9	7.4	8.9
Compressor suction pressure	bar	0.72	0.79	0.86	0.93	1.02	1.11	1.21	1.31
Compressor discharge pressure	bar	12.4	13.6	14.8	16.1	17.3	18.5	19.6	20.8
Suction line pressure drop	Pa/m	349	302	265	235	210	189	171	156
Pressure drop relative to reference		119.7%	103.5%	90.7%	80.3%	71.8%	64.6%	58.6%	53.4%
Condenser dew point	° C.	51.8	53.2	54.5	55.5	56.3	56.9	57.3	57.5
Condenser bubble point	° C.	51.1	46.3	42.4	39.3	36.8	34.8	33.1	31.7
Condenser exit liquid temperature	° C.	50.1	45.3	41.4	38.3	35.8	33.8	32.1	30.7
Condenser mean temperature	° C.	51.5	49.8	48.5	47.4	46.5	45.8	45.2	44.6
Condenser glide (in-out)	K	0.7	6.9	12.1	16.2	19.5	22.1	24.2	25.9

TABLE 14

Theoretical Performance Data of Selected R-744/R-134a/R-1234ze(E) blends containing 16-30% R-744 and 50% R-134a

		Composition CO_2/R-134a/R-1234ze(E) % by weight							
		16/50/34	18/50/32	20/50/32	22/50/28	24/50/26	26/50/24	28/50/22	30/50/20
COP (heating)		2.24	2.24	2.25	2.25	2.25	2.26	2.26	2.26
COP (heating) relative to Reference		106.1%	106.4%	106.6%	106.8%	106.9%	107.0%	107.0%	107.0%
Volumetric heating capacity at suction	kJ/m^3	1585	1700	1818	1939	2061	2186	2312	2441
Capacity relative to Reference		180.3%	193.5%	206.9%	220.7%	234.6%	248.8%	263.2%	277.8%
Critical temperature	° C.	81.22	78.86	76.61	74.46	72.40	70.44	68.55	66.75
Critical pressure	bar	46.27	47.03	47.80	48.56	49.32	50.08	50.84	51.60
Condenser enthalpy change	kJ/kg	284.9	289.7	294.3	298.6	302.7	306.6	310.4	314.0
Pressure ratio		15.53	15.14	14.75	14.37	14.00	13.64	13.30	12.97
Refrigerant mass flow	kg/hr	25.3	24.9	24.5	24.1	23.8	23.5	23.2	22.9
Compressor discharge temperature	° C.	143.3	145.6	147.7	149.9	151.9	153.9	155.9	157.9
Evaporator inlet pressure	bar	1.44	1.55	1.67	1.79	1.91	2.04	2.17	2.31
Condenser inlet pressure	bar	22.0	23.1	24.3	25.4	26.5	27.6	28.7	29.8
Evaporator inlet temperature	° C.	−35.1	−36.0	−36.8	−37.7	−38.5	−39.4	−40.2	−41.0
Evaporator dewpoint	° C.	−24.8	−24.2	−23.6	−23.1	−22.6	−22.2	−21.9	−21.6
Evaporator exit gas temperature	° C.	−19.8	−19.2	−18.6	−18.1	−17.6	−17.2	−16.9	−16.6
Evaporator mean temperature	° C.	−29.9	−30.1	−30.2	−30.4	−30.6	−30.8	−31.0	−31.3
Evaporator glide (out-in)	K	10.3	11.8	13.2	14.6	15.9	17.2	18.3	19.4
Compressor suction pressure	bar	1.41	1.53	1.64	1.77	1.89	2.02	2.16	2.30
Compressor discharge pressure	bar	22.0	23.1	24.3	25.4	26.5	27.6	28.7	29.8
Suction line pressure drop	Pa/m	143	131	121	113	105	98	92	86
Pressure drop relative to reference		48.9%	45.0%	41.6%	38.6%	35.9%	33.6%	31.4%	29.5%
Condenser dew point	° C.	57.7	57.7	57.5	57.3	57.0	56.7	56.2	55.8
Condenser bubble point	° C.	30.5	29.5	28.7	28.0	27.4	26.9	26.5	26.2
Condenser exit liquid temperature	° C.	29.5	28.5	27.7	27.0	26.4	25.9	25.5	25.2
Condenser mean temperature	° C.	44.1	43.6	43.1	42.7	42.2	41.8	41.4	41.0
Condenser glide (in-out)	K	27.1	28.1	28.8	29.3	29.6	29.7	29.7	29.6

TABLE 15

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 0-14% R-744 and 5% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		0/5/95	2/5/93	4/5/91	6/5/89	8/5/87	10/5/85	12/5/83	14/5/81
COP (heating)		2.07	2.11	2.15	2.17	2.19	2.21	2.22	2.23
COP (heating) relative to Reference		98.0%	100.2%	101.8%	103.1%	104.0%	104.8%	105.4%	105.9%
Volumetric heating capacity at suction	kJ/m3	729	813	900	990	1083	1179	1278	1379
Capacity relative to Reference		83.0%	92.5%	102.4%	112.7%	123.3%	134.2%	145.4%	156.9%
Critical temperature	° C.	106.60	103.13	99.78	96.58	93.54	90.65	87.91	85.29
Critical pressure	bar	39.06	39.91	40.71	41.47	42.23	42.98	43.73	44.48
Condenser enthalpy change	kJ/kg	226.5	237.7	247.3	255.7	263.2	269.9	276.1	281.7
Pressure ratio		17.96	17.98	17.89	17.68	17.40	17.07	16.71	16.33
Refrigerant mass flow	kg/hr	31.8	30.3	29.1	28.2	27.4	26.7	26.1	25.6
Compressor discharge temperature	° C.	118.1	121.9	125.4	128.6	131.6	134.4	137.1	139.6
Evaporator inlet pressure	bar	0.73	0.78	0.84	0.91	0.99	1.07	1.15	1.25
Condenser inlet pressure	bar	12.0	13.1	14.2	15.4	16.5	17.7	18.8	19.9
Evaporator inlet temperature	° C.	−29.9	−30.5	−31.3	−32.1	−32.9	−33.7	−34.6	−35.6
Evaporator dewpoint	° C.	−29.4	−28.8	−28.1	−27.3	−26.5	−25.8	−25.1	−24.4
Evaporator exit gas temperature	° C.	−24.4	−23.8	−23.1	−22.3	−21.5	−20.8	−20.1	−19.4
Evaporator mean temperature	° C.	−29.6	−29.7	−29.7	−29.7	−29.7	−29.8	−29.9	−30.0
Evaporator glide (out-in)	K	0.4	1.8	3.2	4.8	6.3	8.0	9.6	11.2
Compressor suction pressure	bar	0.67	0.73	0.80	0.87	0.95	1.03	1.12	1.22
Compressor discharge pressure	bar	12.0	13.1	14.2	15.4	16.5	17.7	18.8	19.9
Suction line pressure drop	Pa/m	368	319	280	248	222	200	181	166
Pressure drop relative to reference		126.2%	109.2%	95.8%	84.9%	75.9%	68.4%	62.1%	56.7%
Condenser dew point	° C.	53.8	55.3	56.6	57.6	58.3	58.9	59.3	59.5
Condenser bubble point	° C.	48.6	44.2	40.6	37.8	35.4	33.5	31.9	30.5
Condenser exit liquid temperature	° C.	47.6	43.2	39.6	36.8	34.4	32.5	30.9	29.5
Condenser mean temperature	° C.	51.2	49.7	48.6	47.7	46.9	46.2	45.6	45.0
Condenser glide (in-out)	K	5.2	11.1	15.9	19.8	22.9	25.4	27.4	29.0

TABLE 16

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 16-30% R-744 and 5% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		16/5/79	18/5/77	20/5/75	22/5/73	24/5/71	26/5/69	28/5/67	30/5/65
COP (heating)		2.24	2.25	2.25	2.25	2.25	2.25	2.25	2.25
COP (heating) relative to Reference		106.3%	106.6%	106.8%	106.9%	106.9%	106.9%	106.9%	106.8%
Volumetric heating capacity at suction	kJ/m3	1482	1586	1692	1799	1907	2015	2125	2236
Capacity relative to Reference		168.6%	180.5%	192.5%	204.7%	217.0%	229.4%	241.8%	254.4%
Critical temperature	° C.	82.80	80.43	78.16	75.99	73.92	71.94	70.04	68.22
Critical pressure	bar	45.22	45.96	46.71	47.45	48.19	48.93	49.66	50.40
Condenser enthalpy change	kJ/kg	287.1	292.1	296.9	301.5	306.0	310.3	314.5	318.6
Pressure ratio		15.95	15.57	15.21	14.86	14.52	14.20	13.89	13.59
Refrigerant mass flow	kg/hr	25.1	24.6	24.2	23.9	23.5	23.2	22.9	22.6
Compressor discharge temperature	° C.	142.1	144.5	146.8	149.1	151.3	153.6	155.8	158.0
Evaporator inlet pressure	bar	1.34	1.44	1.54	1.65	1.75	1.86	1.98	2.09
Condenser inlet pressure	bar	21.0	22.0	23.1	24.2	25.2	26.2	27.2	28.2
Evaporator inlet temperature	° C.	−36.5	−37.5	−38.5	−39.5	−40.4	−41.4	−42.3	−43.1
Evaporator dewpoint	° C.	−23.7	−23.2	−22.6	−22.2	−21.8	−21.4	−21.1	−20.9
Evaporator exit gas temperature	° C.	−18.7	−18.2	−17.6	−17.2	−16.8	−16.4	−16.1	−15.9
Evaporator mean temperature	° C.	−30.1	−30.3	−30.6	−30.8	−31.1	−31.4	−31.7	−32.0
Evaporator glide (out-in)	K	12.8	14.4	15.9	17.3	18.7	20.0	21.1	22.2
Compressor suction pressure	bar	1.31	1.42	1.52	1.63	1.73	1.85	1.96	2.08
Compressor discharge pressure	bar	21.0	22.0	23.1	24.2	25.2	26.2	27.2	28.2
Suction line pressure drop	Pa/m	152	140	130	121	113	105	99	93
Pressure drop relative to reference		52.0%	48.0%	44.4%	41.3%	38.5%	36.1%	33.9%	31.9%
Condenser dew point	° C.	59.6	59.6	59.5	59.3	59.0	58.6	58.1	57.6
Condenser bubble point	° C.	29.4	28.4	27.6	26.9	26.3	25.7	25.3	24.9
Condenser exit liquid temperature	° C.	28.4	27.4	26.6	25.9	25.3	24.7	24.3	23.9
Condenser mean temperature	° C.	44.5	44.0	43.5	43.1	42.6	42.1	41.7	41.2
Condenser glide (in-out)	K	30.2	31.2	31.9	32.4	32.7	32.8	32.9	32.8

TABLE 17

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 0-14% R-744 and 10% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		0/10/90	2/10/88	4/10/86	6/10/84	8/10/82	10/10/80	12/10/78	14/10/76
COP (heating)		2.12	2.16	2.18	2.20	2.22	2.23	2.24	2.25
COP (heating) relative to Reference		100.6%	102.3%	103.5%	104.5%	105.3%	106.0%	106.4%	106.8%
Volumetric heating capacity at suction	kJ/m3	847	934	1024	1118	1215	1314	1415	1518
Capacity relative to Reference		96.3%	106.3%	116.6%	127.3%	138.2%	149.5%	161.0%	172.8%
Critical temperature	° C.	103.66	100.50	97.45	94.53	91.74	89.08	86.53	84.10
Critical pressure	bar	41.28	42.13	42.93	43.70	44.47	45.22	45.97	46.71
Condenser enthalpy change	kJ/kg	240.3	249.9	258.3	265.9	272.8	279.1	284.9	290.4
Pressure ratio		17.03	16.94	16.77	16.52	16.25	15.93	15.61	15.27
Refrigerant mass flow	kg/hr	30.0	28.8	27.9	27.1	26.4	25.8	25.3	24.8
Compressor discharge temperature	° C.	122.7	126.1	129.3	132.3	135.2	137.8	140.4	142.9
Evaporator inlet pressure	bar	0.82	0.88	0.95	1.03	1.11	1.20	1.29	1.38
Condenser inlet pressure	bar	13.1	14.2	15.3	16.4	17.5	18.6	19.7	20.8
Evaporator inlet temperature	° C.	−30.7	−31.4	−32.2	−33.0	−33.8	−34.7	−35.5	−36.4
Evaporator dewpoint	° C.	−28.6	−27.9	−27.2	−26.5	−25.8	−25.1	−24.5	−23.9
Evaporator exit gas temperature	° C.	−23.6	−22.9	−22.2	−21.5	−20.8	−20.1	−19.5	−18.9
Evaporator mean temperature	° C.	−29.7	−29.7	−29.7	−29.7	−29.8	−29.9	−30.0	−30.2
Evaporator glide (out-in)	K	2.1	3.5	5.0	6.5	8.0	9.6	11.1	12.5
Compressor suction pressure	bar	0.77	0.84	0.91	0.99	1.08	1.17	1.26	1.36
Compressor discharge pressure	bar	13.1	14.2	15.3	16.4	17.5	18.6	19.7	20.8
Suction line pressure drop	Pa/m	304	267	238	213	193	175	160	147
Pressure drop relative to reference		104.0%	91.6%	81.4%	73.0%	65.9%	59.9%	54.8%	50.3%
Condenser dew point	° C.	53.9	55.0	56.0	56.8	57.3	57.7	58.0	58.1
Condenser bubble point	° C.	45.9	42.3	39.4	37.0	35.1	33.4	32.0	30.8
Condenser exit liquid temperature	° C.	44.9	41.3	38.4	36.0	34.1	32.4	31.0	29.8
Condenser mean temperature	° C.	49.9	48.7	47.7	46.9	46.2	45.6	45.0	44.4
Condenser glide (in-out)	K	8.0	12.7	16.6	19.7	22.3	24.3	26.0	27.3

TABLE 18

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 16-30% R-744 and 10% R-32

		Composition CO_2/R-32/R-1234ze(E) %by weight							
		16/10/74	18/10/72	20/10/70	22/10/68	24/10/66	26/10/64	28/10/62	30/10/60
COP (heating)		2.26	2.26	2.27	2.27	2.27	2.27	2.26	2.26
COP (heating) relative to Reference		107.1%	107.3%	107.4%	107.5%	107.5%	107.5%	107.4%	107.3%
Volumetric heating capacity at suction	kJ/m3	1623	1730	1838	1947	2057	2169	2283	2397
Capacity relative to Reference		184.7%	196.9%	209.1%	221.6%	234.1%	246.8%	259.8%	272.8%
Critical temperature	° C.	81.78	79.56	77.44	75.40	73.45	71.58	69.78	68.05
Critical pressure	bar	47.46	48.20	48.93	49.67	50.41	51.14	51.88	52.61
Condenser enthalpy change	kJ/kg	295.5	300.4	305.1	309.6	314.0	318.2	322.3	326.2
Pressure ratio		14.94	14.62	14.30	13.99	13.69	13.40	13.12	12.85
Refrigerant mass flow	kg/hr	24.4	24.0	23.6	23.3	22.9	22.6	22.3	22.1
Compressor discharge temperature	° C.	145.3	147.6	149.9	152.1	154.4	156.6	158.7	160.8
Evaporator inlet pressure	bar	1.48	1.59	1.69	1.80	1.91	2.03	2.15	2.27
Condenser inlet pressure	bar	21.8	22.9	23.9	24.9	26.0	27.0	28.0	29.0
Evaporator inlet temperature	° C.	−37.3	−38.2	−39.1	−39.9	−40.8	−41.5	−42.3	−43.0
Evaporator dewpoint	° C.	−23.3	−22.9	−22.4	−22.0	−21.7	−21.4	−21.1	−20.9
Evaporator exit gas temperature	° C.	−18.3	−17.9	−17.4	−17.0	−16.7	−16.4	−16.1	−15.9
Evaporator mean temperature	° C.	−30.3	−30.5	−30.7	−31.0	−31.2	−31.5	−31.7	−31.9
Evaporator glide (out-in)	K	14.0	15.4	16.7	17.9	19.1	20.1	21.1	22.0
Compressor suction pressure	bar	1.46	1.56	1.67	1.78	1.90	2.01	2.13	2.26
Compressor discharge pressure	bar	21.8	22.9	23.9	24.9	26.0	27.0	28.0	29.0
Suction line pressure drop	Pa/m	136	126	117	109	102	96	90	85
Pressure drop relative to reference		46.4%	43.1%	40.1%	37.4%	35.0%	32.9%	31.0%	29.2%
Condenser dew point	° C.	58.1	58.0	57.8	57.6	57.2	56.8	56.3	55.8
Condenser bubble point	° C.	29.7	28.9	28.1	27.4	26.9	26.4	25.9	25.6
Condenser exit liquid temperature	° C.	28.7	27.9	27.1	26.4	25.9	25.4	24.9	24.6
Condenser mean temperature	° C.	43.9	43.4	43.0	42.5	42.0	41.6	41.1	40.7
Condenser glide (in-out)	K	28.4	29.1	29.7	30.1	30.3	30.4	30.4	30.3

TABLE 19

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 0-14% R-744 and 15% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		0/15/85	2/15/83	4/15/81	6/15/79	8/15/77	10/15/75	12/15/73	14/15/71
COP (heating)		2.17	2.19	2.21	2.23	2.24	2.25	2.26	2.27
COP (heating) relative to Reference		102.7%	104.0%	105.0%	105.8%	106.4%	106.9%	107.3%	107.6%
Volumetric heating capacity at suction	kJ/m3	965	1056	1150	1247	1346	1447	1551	1656
Capacity relative to Reference		109.9%	120.2%	130.9%	141.9%	153.2%	164.7%	176.5%	188.5%
Critical temperature	° C.	101.02	98.12	95.32	92.63	90.05	87.59	85.23	82.97
Critical pressure	bar	43.26	44.09	44.90	45.68	46.45	47.21	47.96	48.71
Condenser enthalpy change	kJ/kg	252.5	261.1	268.8	275.8	282.2	288.2	293.8	299.1
Pressure ratio		16.11	15.97	15.76	15.52	15.25	14.97	14.68	14.38
Refrigerant mass flow	kg/hr	28.5	27.6	26.8	26.1	25.5	25.0	24.5	24.1
Compressor discharge temperature	° C.	126.9	130.1	133.1	135.9	138.6	141.2	143.7	146.2
Evaporator inlet pressure	bar	0.92	0.99	1.07	1.15	1.24	1.33	1.42	1.52
Condenser inlet pressure	bar	14.1	15.2	16.3	17.3	18.4	19.5	20.5	21.6
Evaporator inlet temperature	° C.	−31.6	−32.3	−33.0	−33.8	−34.6	−35.4	−36.2	−37.0
Evaporator dewpoint	° C.	−27.9	−27.2	−26.5	−25.9	−25.2	−24.6	−24.1	−23.6
Evaporator exit gas temperature	° C.	−22.9	−22.2	−21.5	−20.9	−20.2	−19.6	−19.1	−18.6
Evaporator mean temperature	° C.	−29.7	−29.7	−29.8	−29.8	−29.9	−30.0	−30.2	−30.3
Evaporator glide (out-in)	K	3.7	5.1	6.5	7.9	9.4	10.7	12.1	13.4
Compressor suction pressure	bar	0.88	0.95	1.03	1.12	1.21	1.30	1.40	1.50
Compressor discharge pressure	bar	14.1	15.2	16.3	17.3	18.4	19.5	20.5	21.6
Suction line pressure drop	Pa/m	257	229	206	186	169	155	143	132
Pressure drop relative to reference		87.9%	78.4%	70.4%	63.7%	58.0%	53.1%	48.8%	45.1%
Condenser dew point	° C.	53.6	54.5	55.2	55.8	56.2	56.5	56.6	56.6
Condenser bubble point	° C.	44.1	41.1	38.7	36.6	34.9	33.4	32.1	31.1
Condenser exit liquid temperature	° C.	43.1	40.1	37.7	35.6	33.9	32.4	31.1	30.1
Condenser mean temperature	° C.	48.8	47.8	47.0	46.2	45.5	44.9	44.4	43.9
Condenser glide (in-out)	K	9.5	13.4	16.5	19.1	21.3	23.0	24.5	25.6

TABLE 20

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 16-30% R-744 and 15% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		16/15/69	18/15/67	20/15/65	22/15/63	24/15/61	26/15/59	28/15/57	30/15/55
COP (heating)		2.27	2.28	2.28	2.28	2.28	2.28	2.28	2.27
COP (heating) relative to Reference		107.8%	107.9%	108.0%	108.1%	108.0%	108.0%	107.9%	107.8%
Volumetric heating capacity at suction	kJ/m3	1763	1872	1983	2095	2209	2324	2442	2562
Capacity relative to Reference		200.7%	213.1%	225.6%	238.4%	251.4%	264.5%	277.9%	291.5%
Critical temperature	° C.	80.80	78.72	76.73	74.82	72.98	71.21	69.51	67.88
Critical pressure	bar	49.46	50.20	50.94	51.68	52.42	53.16	53.90	54.63
Condenser enthalpy change	kJ/kg	304.1	308.9	313.4	317.8	322.0	326.1	330.0	333.8
Pressure ratio		14.09	13.80	13.52	13.23	12.96	12.70	12.44	12.19
Refrigerant mass flow	kg/hr	23.7	23.3	23.0	22.7	22.4	22.1	21.8	21.6
Compressor discharge temperature	° C.	148.5	150.8	153.1	155.2	157.4	159.5	161.6	163.6
Evaporator inlet pressure	bar	1.63	1.73	1.84	1.96	2.08	2.20	2.32	2.45
Condenser inlet pressure	bar	22.6	23.6	24.7	25.7	26.7	27.7	28.7	29.7
Evaporator inlet temperature	° C.	−37.8	−38.6	−39.3	−40.1	−40.7	−41.4	−42.0	−42.5
Evaporator dewpoint	° C.	−23.1	−22.7	−22.3	−22.0	−21.7	−21.5	−21.3	−21.1
Evaporator exit gas temperature	° C.	−18.1	−17.7	−17.3	−17.0	−16.7	−16.5	−16.3	−16.1
Evaporator mean temperature	° C.	−30.5	−30.6	−30.8	−31.0	−31.2	−31.4	−31.6	−31.8
Evaporator glide (out-in)	K	14.7	15.9	17.0	18.0	19.0	19.9	20.7	21.4
Compressor suction pressure	bar	1.61	1.71	1.83	1.94	2.06	2.18	2.31	2.44
Compressor discharge pressure	bar	22.6	23.6	24.7	25.7	26.7	27.7	28.7	29.7
Suction line pressure drop	Pa/m	122	114	106	100	93	88	83	78
Pressure drop relative to reference		41.9%	39.0%	36.4%	34.1%	32.0%	30.1%	28.4%	26.9%
Condenser dew point	° C.	56.6	56.4	56.2	55.9	55.5	55.1	54.6	54.1
Condenser bubble point	° C.	30.1	29.3	28.6	28.0	27.5	27.0	26.6	26.3
Condenser exit liquid temperature	° C.	29.1	28.3	27.6	27.0	26.5	26.0	25.6	25.3
Condenser mean temperature	° C.	43.4	42.9	42.4	41.9	41.5	41.1	40.6	40.2
Condenser glide (in-out)	K	26.5	27.1	27.6	27.9	28.1	28.1	28.0	27.9

TABLE 21

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 0-14% R-744 and 20% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		0/20/80	2/20/78	4/20/76	6/20/74	8/20/72	10/20/70	12/20/68	14/20/66
COP (heating)		2.20	2.22	2.24	2.25	2.26	2.27	2.28	2.28
COP (heating) relative to Reference		104.4%	105.4%	106.2%	106.8%	107.3%	107.7%	108.0%	108.2%
Volumetric heating capacity at suction	kJ/m3	1085	1179	1275	1375	1476	1580	1685	1793
Capacity relative to Reference		123.5%	134.1%	145.1%	156.4%	168.0%	179.8%	191.8%	204.1%
Critical temperature	° C.	98.64	95.95	93.36	90.88	88.49	86.20	84.00	81.89
Critical pressure	bar	45.03	45.86	46.66	47.44	48.22	48.98	49.75	50.50
Condenser enthalpy change	kJ/kg	263.9	271.7	278.9	285.5	291.6	297.4	302.8	307.9
Pressure ratio		15.25	15.09	14.88	14.65	14.40	14.15	13.88	13.62
Refrigerant mass flow	kg/hr	27.3	26.5	25.8	25.2	24.7	24.2	23.8	23.4
Compressor discharge temperature	° C.	130.9	134.0	136.8	139.6	142.2	144.7	147.1	149.5
Evaporator inlet pressure	bar	1.03	1.10	1.18	1.27	1.36	1.46	1.56	1.66
Condenser inlet pressure	bar	15.1	16.1	17.2	18.2	19.3	20.3	21.3	22.4
Evaporator inlet temperature	° C.	−32.3	−33.0	−33.7	−34.4	−35.2	−35.9	−36.6	−37.3
Evaporator dewpoint	° C.	−27.2	−26.6	−26.0	−25.4	−24.9	−24.4	−23.9	−23.5
Evaporator exit gas temperature	° C.	−22.2	−21.6	−21.0	−20.4	−19.9	−19.4	−18.9	−18.5
Evaporator mean temperature	° C.	−29.8	−29.8	−29.9	−29.9	−30.0	−30.1	−30.3	−30.4
Evaporator glide (out-in)	K	5.1	6.4	7.7	9.0	10.3	11.5	12.7	13.9
Compressor suction pressure	bar	0.99	1.07	1.15	1.24	1.34	1.43	1.54	1.64
Compressor discharge pressure	bar	15.1	16.1	17.2	18.2	19.3	20.3	21.3	22.4
Suction line pressure drop	Pa/m	221	199	180	164	151	139	128	119
Pressure drop relative to reference		75.6%	68.1%	61.7%	56.3%	51.6%	47.5%	43.9%	40.8%
Condenser dew point	° C.	53.0	53.7	54.3	54.7	55.0	55.2	55.2	55.2
Condenser bubble point	° C.	42.9	40.3	38.2	36.4	34.8	33.5	32.4	31.4
Condenser exit liquid temperature	° C.	41.9	39.3	37.2	35.4	33.8	32.5	31.4	30.4
Condenser mean temperature	° C.	47.9	47.0	46.2	45.5	44.9	44.3	43.8	43.3
Condenser glide (in-out)	K	10.2	13.4	16.1	18.3	20.1	21.6	22.9	23.8

TABLE 22

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 16-30% R-744 and 20% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		16/20/64	18/20/62	20/20/60	22/20/58	24/20/56	26/20/54	28/20/52	30/20/50
COP (heating)		2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.28
COP (heating) relative to Reference		108.4%	108.5%	108.5%	108.6%	108.5%	108.5%	108.4%	108.3%
Volumetric heating capacity at suction	kJ/m3	1903	2014	2127	2243	2360	2481	2603	2729
Capacity relative to Reference		216.5%	229.2%	242.1%	255.2%	268.6%	282.3%	296.3%	310.6%
Critical temperature	° C.	79.87	77.92	76.05	74.25	72.52	70.86	69.25	67.70
Critical pressure	bar	51.26	52.01	52.76	53.51	54.25	55.00	55.75	56.49
Condenser enthalpy change	kJ/kg	312.7	317.4	321.8	326.1	330.1	334.0	337.8	341.3
Pressure ratio		13.36	13.09	12.84	12.58	12.33	12.08	11.84	11.60
Refrigerant mass flow	kg/hr	23.0	22.7	22.4	22.1	21.8	21.6	21.3	21.1
Compressor discharge temperature	° C.	151.8	154.0	156.2	158.4	160.4	162.5	164.5	166.4
Evaporator inlet pressure	bar	1.77	1.88	2.00	2.12	2.24	2.37	2.50	2.64
Condenser inlet pressure	bar	23.4	24.4	25.4	26.4	27.4	28.4	29.5	30.5
Evaporator inlet temperature	° C.	−38.0	−38.7	−39.3	−39.9	−40.5	−41.0	−41.4	−41.8
Evaporator dewpoint	° C.	−23.1	−22.7	−22.4	−22.1	−21.9	−21.7	−21.5	−21.3
Evaporator exit gas temperature	° C.	−18.1	−17.7	−17.4	−17.1	−16.9	−16.7	−16.5	−16.3
Evaporator mean temperature	° C.	−30.5	−30.7	−30.9	−31.0	−31.2	−31.3	−31.5	−31.6
Evaporator glide (out-in)	K	14.9	16.0	16.9	17.8	18.6	19.3	19.9	20.5
Compressor suction pressure	bar	1.75	1.86	1.98	2.10	2.23	2.35	2.49	2.63
Compressor discharge pressure	bar	23.4	24.4	25.4	26.4	27.4	28.4	29.5	30.5
Suction line pressure drop	Pa/m	111	104	97	91	86	81	77	72
Pressure drop relative to reference		38.0%	35.5%	33.2%	31.2%	29.4%	27.7%	26.2%	24.8%
Condenser dew point	° C.	55.1	54.9	54.6	54.3	53.9	53.5	53.0	52.5
Condenser bubble point	° C.	30.5	29.8	29.1	28.5	28.0	27.6	27.3	27.0
Condenser exit liquid temperature	° C.	29.5	28.8	28.1	27.5	27.0	26.6	26.3	26.0
Condenser mean temperature	° C.	42.8	42.3	41.9	41.4	41.0	40.6	40.2	39.8
Condenser glide (in-out)	K	24.6	25.1	25.5	25.8	25.9	25.9	25.8	25.6

TABLE 23

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 0-14% R-744 and 25% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		0/25/75	2/25/73	4/25/71	6/25/69	8/25/67	10/25/65	12/25/63	14/25/61
COP (heating)		2.23	2.25	2.26	2.27	2.28	2.29	2.29	2.29
COP (heating) relative to Reference		105.7%	106.5%	107.2%	107.7%	108.1%	108.4%	108.6%	108.8%
Volumetric heating capacity at suction	kJ/m3	1205	1301	1399	1500	1604	1710	1818	1928
Capacity relative to Reference		137.1%	148.0%	159.2%	170.8%	182.5%	194.6%	206.9%	219.4%
Critical temperature	° C.	96.47	93.97	91.57	89.26	87.04	84.91	82.86	80.89
Critical pressure	bar	46.62	47.44	48.24	49.03	49.81	50.59	51.36	52.13
Condenser enthalpy change	kJ/kg	274.8	282.1	288.9	295.2	301.1	306.6	311.8	316.8
Pressure ratio		14.48	14.31	14.12	13.91	13.68	13.45	13.21	12.96
Refrigerant mass flow	kg/hr	26.2	25.5	24.9	24.4	23.9	23.5	23.1	22.7
Compressor discharge temperature	° C.	134.9	137.8	140.5	143.2	145.7	148.2	150.6	152.9
Evaporator inlet pressure	bar	1.14	1.22	1.30	1.39	1.49	1.59	1.69	1.80
Condenser inlet pressure	bar	16.0	17.0	18.0	19.0	20.1	21.1	22.1	23.1
Evaporator inlet temperature	° C.	−32.9	−33.6	−34.2	−34.9	−35.5	−36.2	−36.8	−37.4
Evaporator dewpoint	° C.	−26.8	−26.2	−25.7	−25.2	−24.7	−24.3	−23.9	−23.5
Evaporator exit gas temperature	° C.	−21.8	−21.2	−20.7	−20.2	−19.7	−19.3	−18.9	−18.5
Evaporator mean temperature	° C.	−29.8	−29.9	−30.0	−30.0	−30.1	−30.2	−30.3	−30.4
Evaporator glide (out-in)	K	6.1	7.3	8.5	9.7	10.8	11.9	12.9	13.9
Compressor suction pressure	bar	1.10	1.19	1.28	1.37	1.47	1.57	1.67	1.78
Compressor discharge pressure	bar	16.0	17.0	18.0	19.0	20.1	21.1	22.1	23.1
Suction line pressure drop	Pa/m	193	175	160	147	135	125	116	108
Pressure drop relative to reference		66.1%	60.0%	54.8%	50.3%	46.4%	42.9%	39.8%	37.1%
Condenser dew point	° C.	52.3	52.8	53.2	53.5	53.7	53.8	53.8	53.8
Condenser bubble point	° C.	42.0	39.8	37.9	36.3	34.9	33.7	32.6	31.7
Condenser exit liquid temperature	° C.	41.0	38.8	36.9	35.3	33.9	32.7	31.6	30.7
Condenser mean temperature	° C.	47.2	46.3	45.6	44.9	44.3	43.8	43.2	42.7
Condenser glide (in-out)	K	10.3	13.0	15.3	17.3	18.9	20.2	21.2	22.1

TABLE 24

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 16-30% R-744 and 25% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		16/25/59	18/25/57	20/25/55	22/25/53	24/25/51	26/25/49	28/25/47	30/25/45
COP (heating)		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.29
COP (heating) relative to Reference		108.9%	109.0%	109.0%	109.0%	109.0%	108.9%	108.9%	108.8%
Volumetric heating capacity at suction	kJ/m3	2040	2155	2272	2391	2513	2638	2766	2898
Capacity relative to Reference		232.2%	245.2%	258.5%	272.1%	286.0%	300.3%	314.8%	329.8%
Critical temperature	° C.	78.99	77.17	75.41	73.72	72.08	70.51	68.99	67.53
Critical pressure	bar	52.89	53.65	54.41	55.17	55.93	56.69	57.45	58.20
Condenser enthalpy change	kJ/kg	321.5	326.0	330.3	334.4	338.3	342.0	345.5	348.9
Pressure ratio		12.72	12.48	12.24	12.00	11.76	11.53	11.29	11.06
Refrigerant mass flow	kg/hr	22.4	22.1	21.8	21.5	21.3	21.1	20.8	20.6
Compressor discharge temperature	° C.	155.1	157.3	159.4	161.5	163.5	165.4	167.3	169.1
Evaporator inlet pressure	bar	1.91	2.03	2.15	2.28	2.41	2.54	2.68	2.83
Condenser inlet pressure	bar	24.1	25.1	26.1	27.1	28.1	29.1	30.2	31.2
Evaporator inlet temperature	° C.	−38.0	−38.5	−39.1	−39.6	−40.0	−40.4	−40.8	−41.1
Evaporator dewpoint	° C.	−23.1	−22.8	−22.6	−22.3	−22.1	−21.9	−21.8	−21.7
Evaporator exit gas temperature	° C.	−18.1	−17.8	−17.6	−17.3	−17.1	−16.9	−16.8	−16.7
Evaporator mean temperature	° C.	−30.6	−30.7	−30.8	−30.9	−31.1	−31.2	−31.3	−31.4
Evaporator glide (out-in)	K	14.8	15.7	16.5	17.2	17.9	18.5	19.0	19.4
Compressor suction pressure	bar	1.90	2.01	2.14	2.26	2.39	2.53	2.67	2.82
Compressor discharge pressure	bar	24.1	25.1	26.1	27.1	28.1	29.1	30.2	31.2
Suction line pressure drop	Pa/m	101	95	89	84	79	75	71	67
Pressure drop relative to reference		34.7%	32.5%	30.5%	28.7%	27.1%	25.6%	24.2%	23.0%
Condenser dew point	° C.	53.6	53.4	53.1	52.8	52.4	52.0	51.5	51.0
Condenser bubble point	° C.	30.9	30.2	29.6	29.1	28.6	28.2	27.9	27.6
Condenser exit liquid temperature	° C.	29.9	29.2	28.6	28.1	27.6	27.2	26.9	26.6
Condenser mean temperature	° C.	42.3	41.8	41.4	40.9	40.5	40.1	39.7	39.3
Condenser glide (in-out)	K	22.7	23.2	23.5	23.7	23.8	23.7	23.6	23.4

TABLE 25

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 0-14% R-744 and 30% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		0/30/70	2/30/68	4/30/66	6/30/64	8/30/62	10/30/60	12/30/58	14/30/56
COP (heating)		2.25	2.27	2.28	2.29	2.29	2.30	2.30	2.30
COP (heating) relative to Reference		106.8%	107.5%	108.0%	108.4%	108.7%	109.0%	109.2%	109.3%
Volumetric heating capacity at suction	kJ/m3	1323	1421	1522	1625	1730	1838	1949	2062
Capacity relative to Reference		150.5%	161.7%	173.2%	184.9%	196.9%	209.2%	221.8%	234.7%
Critical temperature	° C.	94.49	92.17	89.93	87.77	85.70	83.71	81.79	79.95
Critical pressure	bar	48.05	48.86	49.66	50.46	51.25	52.03	52.82	53.60
Condenser enthalpy change	kJ/kg	285.4	292.4	298.9	304.9	310.6	315.9	321.0	325.8
Pressure ratio		13.81	13.64	13.46	13.26	13.05	12.84	12.61	12.39
Refrigerant mass flow	kg/hr	25.2	24.6	24.1	23.6	23.2	22.8	22.4	22.1
Compressor discharge temperature	° C.	138.8	141.6	144.3	146.8	149.3	151.7	154.1	156.3
Evaporator inlet pressure	bar	1.25	1.33	1.42	1.52	1.62	1.72	1.83	1.94
Condenser inlet pressure	bar	16.8	17.8	18.8	19.8	20.8	21.8	22.8	23.8
Evaporator inlet temperature	° C.	−33.3	−33.9	−34.5	−35.1	−35.7	−36.2	−36.8	−37.3
Evaporator dewpoint	° C.	−26.5	−26.0	−25.6	−25.1	−24.7	−24.3	−24.0	−23.6
Evaporator exit gas temperature	° C.	−21.5	−21.0	−20.6	−20.1	−19.7	−19.3	−19.0	−18.6
Evaporator mean temperature	° C.	−29.9	−30.0	−30.0	−30.1	−30.2	−30.3	−30.4	−30.5
Evaporator glide (out-in)	K	6.8	7.9	9.0	10.0	11.0	11.9	12.8	13.7
Compressor suction pressure	bar	1.22	1.30	1.40	1.49	1.59	1.70	1.81	1.92
Compressor discharge pressure	bar	16.8	17.8	18.8	19.8	20.8	21.8	22.8	23.8
Suction line pressure drop	Pa/m	171	156	144	132	123	114	106	99
Pressure drop relative to reference		58.5%	53.5%	49.1%	45.3%	42.0%	39.0%	36.4%	34.0%
Condenser dew point	° C.	51.4	51.8	52.2	52.4	52.5	52.5	52.5	52.4
Condenser bubble point	° C.	41.4	39.4	37.7	36.3	35.0	33.9	32.9	32.0
Condenser exit liquid temperature	° C.	40.4	38.4	36.7	35.3	34.0	32.9	31.9	31.0
Condenser mean temperature	° C.	46.4	45.6	44.9	44.3	43.7	43.2	42.7	42.2
Condenser glide (in-out)	K	10.0	12.4	14.4	16.1	17.5	18.7	19.6	20.4

TABLE 26

Theoretical Performance Data of Selected R-744/R-32/R-1234ze(E) blends containing 16-30% R-744 and 30% R-32

		Composition CO_2/R-32/R-1234ze(E) % by weight							
		16/30/54	18/30/52	20/3/50	22/30/48	24/30/46	26/30/44	28/30/42	30/30/40
COP (heating)		2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.30
COP (heating) relative to Reference		109.4%	109.4%	109.5%	109.5%	109.4%	109.4%	109.4%	109.3%
Volumetric heating capacity at suction	kJ/m3	2177	2296	2416	2540	2667	2797	2931	3068
Capacity relative to Reference		247.8%	261.3%	275.0%	289.1%	303.5%	318.3%	333.5%	349.2%
Critical temperature	° C.	78.17	76.45	74.80	73.21	71.67	70.18	68.75	67.36
Critical pressure	bar	54.37	55.15	55.92	56.70	57.47	58.24	59.01	59.78
Condenser enthalpy change	kJ/kg	330.3	334.7	338.8	342.7	346.4	350.0	353.3	356.5
Pressure ratio		12.16	11.93	11.70	11.48	11.25	11.03	10.80	10.58
Refrigerant mass flow	kg/hr	21.8	21.5	21.3	21.0	20.8	20.6	20.4	20.2
Compressor discharge temperature	° C.	158.5	160.6	162.6	164.6	166.5	168.3	170.1	171.7
Evaporator inlet pressure	bar	2.06	2.18	2.31	2.44	2.57	2.72	2.87	3.02
Condenser inlet pressure	bar	24.8	25.8	26.8	27.8	28.8	29.8	30.8	31.9
Evaporator inlet temperature	° C.	−37.8	−38.2	−38.7	−39.1	−39.4	−39.7	−40.0	−40.2
Evaporator dewpoint	° C.	−23.3	−23.1	−22.8	−22.6	−22.4	−22.3	−22.2	−22.1
Evaporator exit gas temperature	° C.	−18.3	−18.1	−17.8	−17.6	−17.4	−17.3	−17.2	−17.1
Evaporator mean temperature	° C.	−30.6	−30.7	−30.8	−30.8	−30.9	−31.0	−31.1	−31.1
Evaporator glide (out-in)	K	14.4	15.2	15.8	16.4	17.0	17.4	17.8	18.2
Compressor suction pressure	bar	2.04	2.16	2.29	2.42	2.56	2.71	2.86	3.01
Compressor discharge pressure	bar	24.8	25.8	26.8	27.8	28.8	29.8	30.8	31.9
Suction line pressure drop	Pa/m	93	87	82	78	73	69	66	62
Pressure drop relative to reference		31.9%	29.9%	28.2%	26.6%	25.1%	23.7%	22.5%	21.3%
Condenser dew point	° C.	52.2	52.0	51.7	51.3	51.0	50.5	50.1	49.6
Condenser bubble point	° C.	31.3	30.6	30.1	29.6	29.2	28.8	28.5	28.3
Condenser exit liquid temperature	° C.	30.3	29.6	29.1	28.6	28.2	27.8	27.5	27.3
Condenser mean temperature	° C.	41.7	41.3	40.9	40.5	40.1	39.7	39.3	38.9
Condenser glide (in-out)	K	20.9	21.3	21.6	21.7	21.8	21.7	21.6	21.3

TABLE 27

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 5% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/5/5/90	2/5/5/88	4/5/5/86	6/5/5/84	8/5/5/82	10/5/5/80	12/5/5/78	14/5/5/76
COP (heating)		2.07	2.12	2.15	2.18	2.20	2.21	2.22	2.23
COP (heating) relative to Reference		98.2%	100.3%	101.9%	103.2%	104.1%	104.9%	105.5%	106.0%
Volumetric heating capacity at suction	kJ/m^3	748	833	920	1012	1106	1203	1302	1405
Capacity relative to Reference		85.2%	94.8%	104.7%	115.1%	125.8%	136.9%	148.2%	159.8%
Critical temperature	° C.	106.20	102.70	99.37	96.19	93.18	90.31	87.59	84.99
Critical pressure	bar	39.52	40.32	41.10	41.86	42.62	43.37	44.11	44.86
Condenser enthalpy change	kJ/kg	227.4	238.4	247.9	256.2	263.7	270.3	276.5	282.1
Pressure ratio		17.76	17.77	17.68	17.47	17.19	16.87	16.51	16.14
Refrigerant mass flow	kg/hr	31.7	30.2	29.0	28.1	27.3	26.6	26.0	25.5
Compressor discharge temperature	° C.	118.5	122.3	125.8	129.0	132.0	134.8	137.5	140.0
Evaporator inlet pressure	bar	0.75	0.80	0.86	0.93	1.01	1.09	1.18	1.27
Condenser inlet pressure	bar	12.1	13.3	14.4	15.6	16.7	17.9	19.0	20.1
Evaporator inlet temperature	° C.	−29.9	−30.6	−31.3	−32.1	−32.9	−33.7	−34.6	−35.5
Evaporator dewpoint	° C.	−29.4	−28.7	−28.0	−27.3	−26.5	−25.8	−25.1	−24.4
Evaporator exit gas temperature	° C.	−24.4	−23.7	−23.0	−22.3	−21.5	−20.8	−20.1	−19.4
Evaporator mean temperature	° C.	−29.6	−29.7	−29.7	−29.7	−29.7	−29.8	−29.9	−30.0
Evaporator glide (out-in)	K	0.5	1.9	3.3	4.8	6.3	7.9	9.5	11.1
Compressor suction pressure	bar	0.68	0.75	0.82	0.89	0.97	1.06	1.15	1.24
Compressor discharge pressure	bar	12.1	13.3	14.4	15.6	16.7	17.9	19.0	20.1
Suction line pressure drop	Pa/m	358	311	273	242	217	196	178	162
Pressure drop relative to reference		122.7%	106.4%	93.5%	83.0%	74.3%	67.0%	60.9%	55.6%
Condenser dew point	° C.	53.6	55.1	56.3	57.2	58.0	58.5	58.9	59.1
Condenser bubble point	° C.	48.6	44.2	40.7	37.9	35.6	33.7	32.1	30.8
Condenser exit liquid temperature	° C.	47.6	43.2	39.7	36.9	34.6	32.7	31.1	29.8
Condenser mean temperature	° C.	51.1	49.7	48.5	47.6	46.8	46.1	45.5	44.9
Condenser glide (in-out)	K	5.0	10.8	15.5	19.3	22.4	24.9	26.8	28.4

TABLE 28

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 5% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/5/5/74	18/5/5/72	20/5/5/70	22/5/5/68	24/5/5/66	26/5/5/64	28/5/5/62	30/5/5/60
COP (heating)		2.24	2.25	2.25	2.25	2.26	2.26	2.25	2.25
COP (heating) relative to Reference		106.3%	106.6%	106.8%	106.9%	107.0%	107.0%	106.9%	106.8%
Volumetric heating capacity at suction	kJ/m^3	1509	1615	1722	1831	1941	2052	2164	2277
Capacity relative to Reference		171.7%	183.7%	196.0%	208.4%	220.9%	233.5%	246.2%	259.1%
Critical temperature	° C.	82.52	80.17	77.92	75.76	73.71	71.74	69.85	68.04
Critical pressure	bar	45.60	46.34	47.08	47.82	48.56	49.30	50.04	50.78
Condenser enthalpy change	kJ/kg	287.4	292.4	297.2	301.7	306.1	310.4	314.5	318.5
Pressure ratio		15.77	15.40	15.03	14.68	14.35	14.02	13.72	13.42
Refrigerant mass flow	kg/hr	25.1	24.6	24.2	23.9	23.5	23.2	22.9	22.6
Compressor discharge temperature	° C.	142.4	144.8	147.1	149.3	151.6	153.8	155.9	158.1
Evaporator inlet pressure	bar	1.37	1.47	1.57	1.68	1.79	1.90	2.02	2.14
Condenser inlet pressure	bar	21.2	22.2	23.3	24.4	25.4	26.5	27.5	28.5
Evaporator inlet temperature	° C.	−36.5	−37.4	−38.4	−39.3	−40.2	−41.1	−42.0	−42.8
Evaporator dewpoint	° C.	−23.8	−23.2	−22.7	−22.3	−21.9	−21.5	−21.2	−21.0
Evaporator exit gas temperature	° C.	−18.8	−18.2	−17.7	−17.3	−16.9	−16.5	−16.2	−16.0
Evaporator mean temperature	° C.	−30.1	−30.3	−30.5	−30.8	−31.0	−31.3	−31.6	−31.9
Evaporator glide (out-in)	K	12.7	14.2	15.6	17.0	18.4	19.6	20.8	21.8
Compressor suction pressure	bar	1.34	1.45	1.55	1.66	1.77	1.89	2.00	2.12
Compressor discharge pressure	bar	21.2	22.2	23.3	24.4	25.4	26.5	27.5	28.5
Suction line pressure drop	Pa/m	149	137	127	118	111	103	97	91
Pressure drop relative to reference		51.0%	47.1%	43.6%	40.5%	37.8%	35.4%	33.3%	31.3%
Condenser dew point	° C.	59.2	59.2	59.0	58.8	58.5	58.1	57.7	57.2
Condenser bubble point	° C.	29.6	28.7	27.9	27.1	26.5	26.0	25.5	25.2
Condenser exit liquid temperature	° C.	28.6	27.7	26.9	26.1	25.5	25.0	24.5	24.2
Condenser mean temperature	° C.	44.4	43.9	43.5	43.0	42.5	42.1	41.6	41.2
Condenser glide (in-out)	K	29.6	30.5	31.2	31.7	32.0	32.1	32.1	32.0

TABLE 29

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 5% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/5/10/85	2/5/10/83	4/5/10/81	6/5/10/79	8/5/10/77	10/5/10/75	12/5/10/73	14/5/10/71
COP (heating)		2.08	2.12	2.15	2.18	2.20	2.21	2.23	2.24
COP (heating) relative to Reference		98.5%	100.5%	102.0%	103.3%	104.2%	105.0%	105.5%	106.0%
Volumetric heating capacity at suction	kJ/m^3	766	852	940	1032	1127	1226	1326	1430
Capacity relative to Reference		87.2%	96.9%	107.0%	117.5%	128.3%	139.5%	151.0%	162.7%
Critical temperature	° C.	105.78	102.29	98.97	95.82	92.83	89.99	87.28	84.71
Critical pressure	bar	39.92	40.71	41.48	42.23	42.99	43.73	44.48	45.22
Condenser enthalpy change	kJ/kg	228.3	239.1	248.6	256.8	264.2	270.9	276.9	282.5
Pressure ratio		17.57	17.58	17.48	17.27	17.00	16.68	16.33	15.97
Refrigerant mass flow	kg/hr	31.5	30.1	29.0	28.0	27.3	26.6	26.0	25.5
Compressor discharge temperature	° C.	119.0	122.7	126.2	129.4	132.4	135.2	137.8	140.3
Evaporator inlet pressure	bar	0.76	0.82	0.88	0.95	1.03	1.11	1.20	1.30
Condenser inlet pressure	bar	12.3	13.5	14.6	15.8	16.9	18.0	19.2	20.3
Evaporator inlet temperature	° C.	−30.0	−30.6	−31.4	−32.1	−32.9	−33.7	−34.6	−35.5
Evaporator dewpoint	° C.	−29.4	−28.7	−28.0	−27.3	−26.6	−25.8	−25.1	−24.5
Evaporator exit gas temperature	° C.	−24.4	−23.7	−23.0	−22.3	−21.6	−20.8	−20.1	−19.5
Evaporator mean temperature	° C.	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8	−29.9	−30.0
Evaporator glide (out-in)	K	0.6	1.9	3.3	4.8	6.3	7.9	9.4	11.0
Compressor suction pressure	bar	0.70	0.77	0.84	0.91	0.99	1.08	1.17	1.27
Compressor discharge pressure	bar	12.3	13.5	14.6	15.8	16.9	18.0	19.2	20.3
Suction line pressure drop	Pa/m	349	303	267	237	212	192	174	159
Pressure drop relative to reference		119.4%	103.8%	91.3%	81.1%	72.7%	65.7%	59.7%	54.5%
Condenser dew point	° C.	53.4	54.8	56.0	56.9	57.6	58.2	58.5	58.7
Condenser bubble point	° C.	48.6	44.3	40.8	38.0	35.7	33.9	32.3	31.0
Condenser exit liquid temperature	° C.	47.6	43.3	39.8	37.0	34.7	32.9	31.3	30.0
Condenser mean temperature	° C.	51.0	49.6	48.4	47.5	46.7	46.0	45.4	44.8
Condenser glide (in-out)	K	4.9	10.5	15.2	18.9	21.9	24.3	26.2	27.8

TABLE 30

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 5% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/5/10/69	18/5/10/67	20/5/10/65	22/5/10/63	24/5/10/61	26/5/10/59	28/5/10/57	30/5/10/55
COP (heating)		2.24	2.25	2.25	2.26	2.26	2.26	2.26	2.25
COP (heating) relative to Reference		106.4%	106.7%	106.8%	107.0%	107.0%	107.0%	107.0%	106.9%
Volumetric heating capacity at suction	kJ/m^3	1535	1643	1752	1862	1974	2088	2202	2318
Capacity relative to Reference		174.7%	187.0%	199.4%	212.0%	224.7%	237.6%	250.6%	263.8%
Critical temperature	° C.	82.25	79.91	77.68	75.54	73.50	71.55	69.67	67.87
Critical pressure	bar	45.96	46.71	47.45	48.19	48.93	49.67	50.40	51.14
Condenser enthalpy change	kJ/kg	287.8	292.8	297.5	302.0	306.3	310.5	314.6	318.5
Pressure ratio		15.60	15.23	14.87	14.52	14.18	13.86	13.55	13.25
Refrigerant mass flow	kg/hr	25.0	24.6	24.2	23.8	23.5	23.2	22.9	22.6
Compressor discharge temperature	° C.	142.8	145.1	147.4	149.6	151.8	154.0	156.1	158.2
Evaporator inlet pressure	bar	1.40	1.50	1.60	1.71	1.83	1.94	2.06	2.19
Condenser inlet pressure	bar	21.4	22.5	23.5	24.6	25.6	26.7	27.7	28.8
Evaporator inlet temperature	° C.	−36.4	−37.3	−38.2	−39.1	−40.0	−40.9	−41.7	−42.5
Evaporator dewpoint	° C.	−23.9	−23.3	−22.8	−22.4	−22.0	−21.6	−21.3	−21.1
Evaporator exit gas temperature	° C.	−18.9	−18.3	−17.8	−17.4	−17.0	−16.6	−16.3	−16.1
Evaporator mean temperature	° C.	−30.1	−30.3	−30.5	−30.7	−31.0	−31.2	−31.5	−31.8
Evaporator glide (out-in)	K	12.5	14.0	15.4	16.8	18.1	19.3	20.4	21.4
Compressor suction pressure	bar	1.37	1.47	1.58	1.69	1.81	1.93	2.05	2.17
Compressor discharge pressure	bar	21.4	22.5	23.5	24.6	25.6	26.7	27.7	28.8
Suction line pressure drop	Pa/m	146	135	125	116	109	102	95	90
Pressure drop relative to reference		50.1%	46.2%	42.8%	39.8%	37.2%	34.8%	32.7%	30.7%
Condenser dew point	° C.	58.8	58.8	58.6	58.4	58.1	57.7	57.2	56.7
Condenser bubble point	° C.	29.9	28.9	28.1	27.4	26.8	26.3	25.8	25.4
Condenser exit liquid temperature	° C.	28.9	27.9	27.1	26.4	25.8	25.3	24.8	24.4
Condenser mean temperature	° C.	44.3	43.8	43.4	42.9	42.4	42.0	41.5	41.1
Condenser glide (in-out)	K	29.0	29.9	30.5	31.0	31.3	31.4	31.4	31.3

TABLE 31

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 5% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/5/20/75	2/5/20/73	4/5/20/71	6/5/20/69	8/5/20/67	10/5/20/65	12/5/20/63	14/5/20/61
COP (heating)		2.08	2.13	2.16	2.18	2.20	2.22	2.23	2.24
COP (heating) relative to Reference		98.9%	100.8%	102.3%	103.5%	104.4%	105.1%	105.7%	106.1%
Volumetric heating capacity at suction	kJ/m^3	801	888	978	1072	1170	1270	1373	1479
Capacity relative to Reference		91.2%	101.1%	111.3%	122.0%	133.1%	144.5%	156.2%	168.3%
Critical temperature	° C.	104.94	101.49	98.21	95.11	92.16	89.36	86.70	84.16
Critical pressure	bar	40.64	41.40	42.16	42.91	43.66	44.41	45.15	45.90
Condenser enthalpy change	kJ/kg	230.1	240.7	250.0	258.2	265.5	272.1	278.1	283.6
Pressure ratio		17.21	17.22	17.12	16.93	16.65	16.35	16.00	15.65
Refrigerant mass flow	kg/hr	31.3	29.9	28.8	27.9	27.1	26.5	25.9	25.4
Compressor discharge temperature	° C.	120.0	123.7	127.1	130.3	133.3	136.1	138.7	141.2
Evaporator inlet pressure	bar	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35
Condenser inlet pressure	bar	12.7	13.8	14.9	16.1	17.3	18.4	19.5	20.6
Evaporator inlet temperature	° C.	−30.0	−30.7	−31.4	−32.1	−32.8	−33.6	−34.5	−35.3
Evaporator dewpoint	° C.	−29.3	−28.7	−28.1	−27.3	−26.6	−25.9	−25.3	−24.6
Evaporator exit gas temperature	° C.	−24.3	−23.7	−23.1	−22.3	−21.6	−20.9	−20.3	−19.6
Evaporator mean temperature	° C.	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8	−29.9	−30.0
Evaporator glide (out-in)	K	0.7	2.0	3.3	4.7	6.2	7.7	9.2	10.7
Compressor suction pressure	bar	0.74	0.80	0.87	0.95	1.04	1.13	1.22	1.32
Compressor discharge pressure	bar	12.7	13.8	14.9	16.1	17.3	18.4	19.5	20.6
Suction line pressure drop	Pa/m	332	289	255	227	204	185	168	154
Pressure drop relative to reference		113.6%	99.0%	87.4%	77.8%	69.9%	63.2%	57.5%	52.6%
Condenser dew point	° C.	53.0	54.3	55.4	56.3	57.0	57.5	57.8	58.0
Condenser bubble point	° C.	48.5	44.4	41.0	38.3	36.0	34.2	32.6	31.3
Condenser exit liquid temperature	° C.	47.5	43.4	40.0	37.3	35.0	33.2	31.6	30.3
Condenser mean temperature	° C.	50.8	49.3	48.2	47.3	46.5	45.8	45.2	44.7
Condenser glide (in-out)	K	4.5	9.9	14.4	18.0	20.9	23.3	25.2	26.7

TABLE 32

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 5% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/5/20/59	18/5/20/57	20/5/20/55	22/5/20/53	24/5/20/51	26/5/20/49	28/5/20/47	30/5/20/45
COP (heating)		2.24	2.25	2.25	2.26	2.26	2.26	2.26	2.26
COP (heating) relative to Reference		106.5%	106.7%	106.9%	107.1%	107.1%	107.2%	107.1%	107.1%
Volumetric heating capacity at suction	kJ/m^3	1587	1697	1810	1924	2040	2158	2277	2398
Capacity relative to Reference		180.6%	193.2%	206.0%	219.0%	232.2%	245.6%	259.1%	272.9%
Critical temperature	° C.	81.74	79.43	77.23	75.12	73.11	71.18	69.32	67.55
Critical pressure	bar	46.64	47.38	48.12	48.86	49.61	50.35	51.09	51.83
Condenser enthalpy change	kJ/kg	288.8	293.7	298.3	302.7	307.0	311.0	315.0	318.8
Pressure ratio		15.28	14.92	14.57	14.22	13.89	13.56	13.25	12.95
Refrigerant mass flow	kg/hr	24.9	24.5	24.1	23.8	23.5	23.1	22.9	22.6
Compressor discharge temperature	° C.	143.6	145.9	148.1	150.3	152.4	154.5	156.6	158.6
Evaporator inlet pressure	bar	1.45	1.55	1.66	1.78	1.90	2.02	2.14	2.27
Condenser inlet pressure	bar	21.7	22.8	23.9	25.0	26.1	27.1	28.2	29.2
Evaporator inlet temperature	° C.	−36.2	−37.0	−37.9	−38.8	−39.6	−40.4	−41.2	−41.9
Evaporator dewpoint	° C.	−24.0	−23.5	−23.0	−22.5	−22.1	−21.8	−21.5	−21.2
Evaporator exit gas temperature	° C.	−19.0	−18.5	−18.0	−17.5	−17.1	−16.8	−16.5	−16.2
Evaporator mean temperature	° C.	−30.1	−30.3	−30.4	−30.6	−30.9	−31.1	−31.3	−31.6
Evaporator glide (out-in)	K	12.1	13.5	14.9	16.2	17.4	18.6	19.7	20.7
Compressor suction pressure	bar	1.42	1.53	1.64	1.76	1.88	2.00	2.13	2.26
Compressor discharge pressure	bar	21.7	22.8	23.9	25.0	26.1	27.1	28.2	29.2
Suction line pressure drop	Pa/m	141	130	121	112	105	98	92	87
Pressure drop relative to reference		48.3%	44.6%	41.4%	38.5%	35.9%	33.6%	31.6%	29.7%
Condenser dew point	° C.	58.0	58.0	57.8	57.6	57.3	56.9	56.4	55.9
Condenser bubble point	° C.	30.2	29.3	28.5	27.8	27.2	26.7	26.3	25.9
Condenser exit liquid temperature	° C.	29.2	28.3	27.5	26.8	26.2	25.7	25.3	24.9
Condenser mean temperature	° C.	44.1	43.6	43.2	42.7	42.3	41.8	41.4	40.9
Condenser glide (in-out)	K	27.8	28.7	29.4	29.8	30.1	30.2	30.2	30.0

TABLE 33

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 5% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/5/30/65	2/5/30/63	4/5/30/61	6/5/30/59	8/5/30/57	10/2/30/55	12/5/30/53	14/5/30/51
COP (heating)		2.09	2.13	2.16	2.19	2.20	2.22	2.23	2.24
COP (heating) relative to Reference		99.2%	101.1%	102.5%	103.7%	104.5%	105.2%	105.8%	106.2%
Volumetric heating capacity at suction	kJ/m^3	833	922	1014	1109	1209	1311	1417	1525
Capacity relative to Reference		94.9%	104.9%	115.4%	126.3%	137.6%	149.2%	161.2%	173.6%
Critical temperature	° C.	104.11	100.71	97.48	94.43	91.52	88.76	86.14	83.64
Critical pressure	bar	41.22	41.98	42.74	43.49	44.24	44.99	45.74	46.49
Condenser enthalpy change	kJ/kg	232.0	242.5	251.7	259.9	267.1	273.6	279.5	285.0
Pressure ratio		16.90	16.91	16.81	16.63	16.36	16.06	15.72	15.37
Refrigerant mass flow	kg/hr	31.0	29.7	28.6	27.7	27.0	26.3	25.8	25.3
Compressor discharge temperature	° C.	121.0	124.7	128.2	131.3	134.3	137.0	139.6	142.1
Evaporator inlet pressure	bar	0.82	0.88	0.95	1.03	1.11	1.20	1.29	1.39
Condenser inlet pressure	bar	13.0	14.1	15.3	16.4	17.6	18.7	19.9	21.0
Evaporator inlet temperature	° C.	−30.1	−30.7	−31.4	−32.1	−32.8	−33.5	−34.3	−35.1
Evaporator dewpoint	° C.	−29.4	−28.8	−28.1	−27.4	−26.7	−26.1	−25.4	−24.8
Evaporator exit gas temperature	° C.	−24.4	−23.8	−23.1	−22.4	−21.7	−21.1	−20.4	−19.8
Evaporator mean temperature	° C.	−29.7	−29.7	−29.7	−29.7	−29.8	−29.8	−29.9	−30.0
Evaporator glide (out-in)	K	0.7	1.9	3.2	4.6	6.0	7.5	8.9	10.4
Compressor suction pressure	bar	0.77	0.83	0.91	0.99	1.07	1.17	1.26	1.37
Compressor discharge pressure	bar	13.0	14.1	15.3	16.4	17.6	18.7	19.9	21.0
Suction line pressure drop	Pa/m	317	277	245	219	197	178	162	148
Pressure drop relative to reference		108.5%	94.9%	83.9%	74.8%	67.3%	60.9%	55.5%	50.8%
Condenser dew point	° C.	52.6	53.8	54.9	55.7	56.3	56.8	57.1	57.3
Condenser bubble point	° C.	48.5	44.4	41.1	38.4	36.2	34.4	32.9	31.6
Condenser exit liquid temperature	° C.	47.5	43.4	40.1	37.4	35.2	33.4	31.9	30.6
Condenser mean temperature	° C.	50.5	49.1	48.0	47.1	46.3	45.6	45.0	44.4
Condenser glide (in-out)	K	4.1	9.4	13.7	17.3	20.1	22.4	24.3	25.7

TABLE 34

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 5% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/5/30/49	18/5/30/47	20/5/30/45	22/5/30/43	24/5/30/41	26/5/30/39	28/5/30/37	30/5/30/35
COP (heating)		2.25	2.25	2.26	2.26	2.26	2.26	2.26	2.26
COP (heating) relative to Reference		106.6%	106.9%	107.1%	107.2%	107.3%	107.3%	107.3%	107.3%
Volumetric heating capacity at suction	kJ/m^3	1636	1749	1865	1983	2102	2224	2347	2473
Capacity relative to Reference		186.2%	199.1%	212.3%	225.6%	239.3%	253.1%	267.1%	281.4%
Critical temperature	° C.	81.25	78.98	76.80	74.72	72.73	70.82	68.99	67.24
Critical pressure	bar	47.24	47.98	48.73	49.47	50.22	50.96	51.71	52.45
Condenser enthalpy change	kJ/kg	290.1	294.9	299.5	303.8	308.0	311.9	315.7	319.4
Pressure ratio		15.02	14.66	14.31	13.96	13.63	13.30	12.99	12.69
Refrigerant mass flow	kg/hr	24.8	24.4	24.0	23.7	23.4	23.1	22.8	22.5
Compressor discharge temperature	° C.	144.5	146.7	148.9	151.1	153.1	155.2	157.2	159.2
Evaporator inlet pressure	bar	1.50	1.61	1.72	1.84	1.96	2.09	2.22	2.35
Condenser inlet pressure	bar	22.1	23.2	24.3	25.4	26.5	27.6	28.6	29.7
Evaporator inlet temperature	° C.	−36.0	−36.8	−37.6	−38.4	−39.2	−40.0	−40.7	−41.4
Evaporator dewpoint	° C.	−24.2	−23.7	−23.2	−22.7	−22.3	−22.0	−21.7	−21.4
Evaporator exit gas temperature	° C.	−19.2	−18.7	−18.2	−17.7	−17.3	−17.0	−16.7	−16.4
Evaporator mean temperature	° C.	−30.1	−30.2	−30.4	−30.6	−30.8	−31.0	−31.2	−31.4
Evaporator glide (out-in)	K	11.8	13.1	14.4	15.7	16.9	18.0	19.1	20.0
Compressor suction pressure	bar	1.47	1.58	1.70	1.82	1.94	2.07	2.20	2.34
Compressor discharge pressure	bar	22.1	23.2	24.3	25.4	26.5	27.6	28.6	29.7
Suction line pressure drop	Pa/m	136	126	117	109	102	95	89	84
Pressure drop relative to reference		46.7%	43.2%	40.0%	37.2%	34.8%	32.6%	30.6%	28.8%
Condenser dew point	° C.	57.4	57.3	57.1	56.9	56.6	56.2	55.8	55.2
Condenser bubble point	° C.	30.5	29.6	28.8	28.1	27.6	27.1	26.7	26.3
Condenser exit liquid temperature	° C.	29.5	28.6	27.8	27.1	26.6	26.1	25.7	25.3
Condenser mean temperature	° C.	43.9	43.4	43.0	42.5	42.1	41.6	41.2	40.8
Condenser glide (in-out)	K	26.9	27.7	28.3	28.8	29.0	29.1	29.1	28.9

TABLE 35

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 5% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/5/40/55	2/5/40/53	4/5/40/51	6/5/40/49	8/5/40/47	10/5/40/45	12/5/40/43	14/5/40/41
COP (heating)		2.10	2.14	2.17	2.19	2.21	2.22	2.23	2.24
COP (heating) relative to Reference		99.6%	101.4%	102.8%	103.9%	104.7%	105.4%	106.0%	106.4%
Volumetric heating capacity at suction	kJ/m^3	863	953	1047	1144	1245	1350	1457	1568
Capacity relative to Reference		98.2%	108.5%	119.1%	130.2%	141.7%	153.7%	165.9%	178.5%
Critical temperature	° C.	103.30	99.95	96.78	93.77	90.91	88.19	85.60	83.14
Critical pressure	bar	41.67	42.44	43.21	43.97	44.73	45.49	46.24	47.00
Condenser enthalpy change	kJ/kg	234.1	244.6	253.7	261.8	269.0	275.4	281.3	286.8
Pressure ratio		16.63	16.64	16.55	16.37	16.11	15.81	15.49	15.14
Refrigerant mass flow	kg/hr	30.8	29.4	28.4	27.5	26.8	26.1	25.6	25.1
Compressor discharge temperature	° C.	122.1	125.8	129.3	132.5	135.4	138.1	140.7	143.1
Evaporator inlet pressure	bar	0.85	0.91	0.98	1.06	1.14	1.23	1.33	1.43
Condenser inlet pressure	bar	13.2	14.4	15.5	16.7	17.9	19.0	20.2	21.3
Evaporator inlet temperature	° C.	−30.1	−30.7	−31.3	−32.0	−32.7	−33.4	−34.2	−35.0
Evaporator dewpoint	° C.	−29.4	−28.9	−28.2	−27.6	−26.9	−26.2	−25.5	−24.9
Evaporator exit gas temperature	° C.	−24.4	−23.9	−23.2	−22.6	−21.9	−21.2	−20.5	−19.9
Evaporator mean temperature	° C.	−29.8	−29.8	−29.8	−29.8	−29.8	−29.8	−29.9	−30.0
Evaporator glide (out-in)	K	0.7	1.8	3.1	4.5	5.8	7.2	8.6	10.0
Compressor suction pressure	bar	0.79	0.86	0.94	1.02	1.11	1.20	1.30	1.41
Compressor discharge pressure	bar	13.2	14.4	15.5	16.7	17.9	19.0	20.2	21.3
Suction line pressure drop	Pa/m	304	266	236	211	190	172	157	144
Pressure drop relative to reference		104.0%	91.2%	80.8%	72.2%	65.0%	58.9%	53.7%	49.2%
Condenser dew point	° C.	52.1	53.3	54.3	55.1	55.8	56.2	56.5	56.7
Condenser bubble point	° C.	48.5	44.5	41.2	38.5	36.4	34.5	33.0	31.8
Condenser exit liquid temperature	° C.	47.5	43.5	40.2	37.5	35.4	33.5	32.0	30.8
Condenser mean temperature	° C.	50.3	48.9	47.8	46.8	46.1	45.4	44.8	44.2
Condenser glide (in-out)	K	3.6	8.8	13.1	16.6	19.4	21.7	23.5	24.9

TABLE 36

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 5% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/5/40/39	18/5/40/37	20/5/40/35	22/5/40/33	24/5/40/31	26/5/40/29	28/5/40/27	30/5/40/25
COP (heating)		2.25	2.26	2.26	2.26	2.27	2.27	2.27	2.27
COP (heating) relative to Reference		106.7%	107.0%	107.2%	107.3%	107.4%	107.5%	107.5%	107.4%
Volumetric heating capacity at suction	kJ/m^3	1682	1798	1916	2037	2160	2284	2411	2540
Capacity relative to Reference		191.4%	204.6%	218.1%	231.8%	245.8%	260.0%	274.4%	289.1%
Critical temperature	° C.	80.79	78.54	76.39	74.34	72.38	70.49	68.68	66.95
Critical pressure	bar	47.75	48.51	49.26	50.01	50.76	51.51	52.26	53.01
Condenser enthalpy change	kJ/kg	291.8	296.6	301.0	305.3	309.4	313.2	317.0	320.6
Pressure ratio		14.79	14.44	14.09	13.74	13.41	13.09	12.78	12.48
Refrigerant mass flow	kg/hr	24.7	24.3	23.9	23.6	23.3	23.0	22.7	22.5
Compressor discharge temperature	° C.	145.5	147.7	149.9	152.0	154.0	156.0	158.0	159.9
Evaporator inlet pressure	bar	1.54	1.65	1.77	1.89	2.02	2.15	2.29	2.43
Condenser inlet pressure	bar	22.4	23.6	24.7	25.8	26.9	27.9	29.0	30.1
Evaporator inlet temperature	° C.	−35.8	−36.6	−37.4	−38.2	−38.9	−39.7	−40.4	−41.1
Evaporator dewpoint	° C.	−24.4	−23.8	−23.3	−22.9	−22.5	−22.1	−21.8	−21.6
Evaporator exit gas temperature	° C.	−19.4	−18.8	−18.3	−17.9	−17.5	−17.1	−16.8	−16.6
Evaporator mean temperature	° C.	−30.1	−30.2	−30.4	−30.5	−30.7	−30.9	−31.1	−31.3
Evaporator glide (out-in)	K	11.4	12.8	14.1	15.3	16.5	17.6	18.6	19.5
Compressor suction pressure	bar	1.52	1.63	1.75	1.87	2.00	2.13	2.27	2.41
Compressor discharge pressure	bar	22.4	23.6	24.7	25.8	26.9	27.9	29.0	30.1
Suction line pressure drop	Pa/m	132	122	113	106	99	92	87	82
Pressure drop relative to reference		45.3%	41.8%	38.8%	36.1%	33.7%	31.6%	29.7%	27.9%
Condenser dew point	° C.	56.7	56.7	56.5	56.3	56.0	55.6	55.2	54.7
Condenser bubble point	° C.	30.7	29.8	29.0	28.3	27.8	27.3	26.9	26.6
Condenser exit liquid temperature	° C.	29.7	28.8	28.0	27.3	26.8	26.3	25.9	25.6
Condenser mean temperature	° C.	43.7	43.2	42.8	42.3	41.9	41.5	41.0	40.6
Condenser glide (in-out)	K	26.1	26.9	27.5	28.0	28.2	28.3	28.3	28.1

TABLE 37

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 5% R-32 and 50% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/5/50/45	2/5/50/43	4/5/50/41	6/5/50/39	8/5/50/37	10/5/50/35	12/5/50/33	14/5/50/31
COP (heating)		2.11	2.15	2.17	2.20	2.21	2.23	2.24	2.25
COP (heating) relative to Reference		100.0%	101.7%	103.1%	104.1%	105.0%	105.6%	106.2%	106.6%
Volumetric heating capacity at suction	kJ/m^3	890	981	1076	1176	1278	1385	1495	1607
Capacity relative to Reference		101.3%	111.7%	122.5%	133.8%	145.5%	157.6%	170.1%	182.9%
Critical temperature	° C.	102.50	99.21	96.09	93.13	90.31	87.63	85.09	82.66
Critical pressure	bar	42.02	42.80	43.58	44.35	45.12	45.89	46.66	47.43
Condenser enthalpy change	kJ/kg	236.4	246.8	256.0	264.0	271.2	277.6	283.5	288.9
Pressure ratio		16.40	16.42	16.33	16.15	15.91	15.61	15.30	14.95
Refrigerant mass flow	kg/hr	30.5	29.2	28.1	27.3	26.6	25.9	25.4	24.9
Compressor discharge temperature	° C.	123.3	127.1	130.5	133.7	136.6	139.3	141.9	144.3
Evaporator inlet pressure	bar	0.87	0.93	1.01	1.08	1.17	1.26	1.36	1.47
Condenser inlet pressure	bar	13.4	14.6	15.8	17.0	18.1	19.3	20.5	21.6
Evaporator inlet temperature	° C.	−30.1	−30.7	−31.3	−32.0	−32.6	−33.3	−34.1	−34.9
Evaporator dewpoint	° C.	−29.5	−29.0	−28.3	−27.7	−27.0	−26.3	−25.7	−25.1
Evaporator exit gas temperature	° C.	−24.5	−24.0	−23.3	−22.7	−22.0	−21.3	−20.7	−20.1
Evaporator mean temperature	° C.	−29.8	−29.8	−29.8	−29.8	−29.8	−29.8	−29.9	−30.0
Evaporator glide (out-in)	K	0.6	1.7	3.0	4.3	5.6	7.0	8.4	9.8
Compressor suction pressure	bar	0.82	0.89	0.97	1.05	1.14	1.24	1.34	1.44
Compressor discharge pressure	bar	13.4	14.6	15.8	17.0	18.1	19.3	20.5	21.6
Suction line pressure drop	Pa/m	293	257	228	204	184	167	152	139
Pressure drop relative to reference		100.2%	87.9%	78.0%	69.8%	62.9%	57.0%	52.0%	47.7%
Condenser dew point	° C.	51.6	52.8	53.8	54.6	55.3	55.7	56.0	56.2
Condenser bubble point	° C.	48.5	44.5	41.2	38.6	36.4	34.6	33.1	31.8
Condenser exit liquid temperature	° C.	47.5	43.5	40.2	37.6	35.4	33.6	32.1	30.8
Condenser mean temperature	° C.	50.0	48.6	47.5	46.6	45.8	45.1	44.5	44.0
Condenser glide (in-out)	K	3.2	8.3	12.6	16.1	18.9	21.1	22.9	24.4

TABLE 38

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 5% R-32 and 50% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/5/50/29	18/5/50/27	20/5/50/25	22/5/50/23	24/5/50/21	26/5/50/19	28/5/50/17	30/5/50/15
COP (heating)		2.25	2.26	2.26	2.27	2.27	2.27	2.27	2.27
COP (heating) relative to Reference		106.9%	107.2%	107.4%	107.5%	107.6%	107.7%	107.7%	107.6%
Volumetric heating capacity at suction	kJ/m^3	1723	1841	1962	2085	2211	2338	2467	2599
Capacity relative to Reference		196.1%	209.6%	223.3%	237.3%	251.6%	266.1%	280.8%	295.8%
Critical temperature	° C.	80.34	78.12	76.00	73.98	72.04	70.17	68.39	66.67
Critical pressure	bar	48.19	48.96	49.72	50.48	51.24	52.00	52.76	53.52
Condenser enthalpy change	kJ/kg	293.9	298.6	303.0	307.2	311.2	315.1	318.7	322.3
Pressure ratio		14.61	14.26	13.91	13.57	13.24	12.93	12.62	12.32
Refrigerant mass flow	kg/hr	24.5	24.1	23.8	23.4	23.1	22.9	22.6	22.3
Compressor discharge temperature	° C.	146.6	148.9	151.0	153.1	155.1	157.1	159.0	160.9
Evaporator inlet pressure	bar	1.58	1.69	1.81	1.94	2.07	2.20	2.34	2.48
Condenser inlet pressure	bar	22.7	23.9	25.0	26.1	27.2	28.3	29.4	30.4
Evaporator inlet temperature	° C.	−35.6	−36.4	−37.2	−38.0	−38.8	−39.5	−40.2	−40.9
Evaporator dewpoint	° C.	−24.5	−23.9	−23.4	−23.0	−22.6	−22.2	−21.9	−21.6
Evaporator exit gas temperature	° C.	−19.5	−18.9	−18.4	−18.0	−17.6	−17.2	−16.9	−16.6
Evaporator mean temperature	° C.	−30.1	−30.2	−30.3	−30.5	−30.7	−30.9	−31.1	−31.3
Evaporator glide (out-in)	K	11.2	12.5	13.8	15.0	16.2	17.3	18.3	19.2
Compressor suction pressure	bar	1.56	1.67	1.80	1.92	2.05	2.19	2.33	2.47
Compressor discharge pressure	bar	22.7	23.9	25.0	26.1	27.2	28.3	29.4	30.4
Suction line pressure drop	Pa/m	128	119	110	103	96	90	84	79
Pressure drop relative to reference		43.9%	40.6%	37.7%	35.1%	32.8%	30.7%	28.9%	27.2%
Condenser dew point	° C.	56.2	56.2	56.0	55.8	55.5	55.1	54.7	54.2
Condenser bubble point	° C.	30.8	29.9	29.1	28.4	27.9	27.4	27.0	26.7
Condenser exit liquid temperature	° C.	29.8	28.9	28.1	27.4	26.9	26.4	26.0	25.7
Condenser mean temperature	° C.	43.5	43.0	42.6	42.1	41.7	41.3	40.9	40.4
Condenser glide (in-out)	K	25.5	26.3	26.9	27.4	27.6	27.7	27.7	27.5

TABLE 39

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 10% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/10/5/85	2/10/5/83	4/10/5/81	6/10/5/79	8/10/5/77	10/10/5/75	12/10/5/73	14/10/5/71
COP (heating)		2.13	2.16	2.18	2.21	2.22	2.23	2.25	2.25
COP (heating) relative to Reference		100.8%	102.4%	103.6%	104.6%	105.4%	106.0%	106.5%	106.9%
Volumetric heating capacity at suction	kJ/m^3	865	953	1044	1139	1237	1337	1439	1544
Capacity relative to Reference		98.4%	108.5%	118.9%	129.7%	140.7%	152.1%	163.8%	175.7%
Critical temperature	° C.	103.31	100.13	97.08	94.18	91.40	88.76	86.23	83.82
Critical pressure	bar	41.66	42.48	43.26	44.03	44.79	45.54	46.28	47.03
Condenser enthalpy change	kJ/kg	240.9	250.5	258.9	266.5	273.3	279.6	285.4	290.8
Pressure ratio		16.85	16.76	16.59	16.35	16.07	15.77	15.44	15.12
Refrigerant mass flow	kg/hr	29.9	28.7	27.8	27.0	26.3	25.8	25.2	24.8
Compressor discharge temperature	° C.	123.1	126.5	129.7	132.7	135.6	138.2	140.8	143.2
Evaporator inlet pressure	bar	0.84	0.90	0.97	1.05	1.13	1.22	1.31	1.41
Condenser inlet pressure	bar	13.2	14.3	15.5	16.6	17.7	18.8	19.9	20.9
Evaporator inlet temperature	° C.	−30.8	−31.5	−32.2	−33.0	−33.8	−34.6	−35.4	−36.3
Evaporator dewpoint	° C.	−28.6	−27.9	−27.2	−26.5	−25.8	−25.2	−24.6	−24.0
Evaporator exit gas temperature	° C.	−23.6	−22.9	−22.2	−21.5	−20.8	−20.2	−19.6	−19.0
Evaporator mean temperature	° C.	−29.7	−29.7	−29.7	−29.7	−29.8	−29.9	−30.0	−30.1
Evaporator glide (out-in)	K	2.2	3.5	5.0	6.4	7.9	9.4	10.9	12.3
Compressor suction pressure	bar	0.79	0.86	0.93	1.01	1.10	1.19	1.29	1.39
Compressor discharge pressure	bar	13.2	14.3	15.5	16.6	17.7	18.8	19.9	20.9
Suction line pressure drop	Pa/m	297	262	233	209	189	172	157	144
Pressure drop relative to reference		101.6%	89.6%	79.7%	71.5%	64.7%	58.8%	53.8%	49.4%
Condenser dew point	° C.	53.6	54.7	55.7	56.4	56.9	57.3	57.6	57.7
Condenser bubble point	° C.	46.0	42.5	39.6	37.2	35.2	33.6	32.2	31.0
Condenser exit liquid temperature	° C.	45.0	41.5	38.6	36.2	34.2	32.6	31.2	30.0
Condenser mean temperature	° C.	49.8	48.6	47.6	46.8	46.1	45.5	44.9	44.3
Condenser glide (in-out)	K	7.7	12.3	16.1	19.2	21.7	23.7	25.4	26.7

TABLE 40

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 10% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/10/5/69	18/10/5/67	20/10/5/65	22/10/5/63	24/10/5/61	26/10/5/59	28/10/5/57	30/10/5/55
COP (heating)		2.26	2.26	2.27	2.27	2.27	2.27	2.27	2.26
COP (heating) relative to Reference		107.1%	107.3%	107.5%	107.5%	107.6%	107.5%	107.5%	107.4%
Volumetric heating capacity y at suction	kJ/m^3	1650	1758	1868	1979	2092	2206	2323	2440
Capacity relative to Reference		187.8%	200.1%	212.6%	225.3%	238.1%	251.1%	264.3%	277.7%
Critical temperature	° C.	81.51	79.31	77.20	75.17	73.24	71.38	69.59	67.88
Critical pressure	bar	47.77	48.51	49.25	49.99	50.72	51.46	52.19	52.93
Condenser enthalpy change	kJ/kg	295.9	300.8	305.4	309.9	314.1	318.3	322.3	326.1
Pressure ratio		14.79	14.46	14.14	13.84	13.54	13.25	12.96	12.69
Refrigerant mass flow	kg/hr	24.3	23.9	23.6	23.2	22.9	22.6	22.3	22.1
Compressor discharge temperature	° C.	145.6	147.9	150.2	152.4	154.6	156.7	158.8	160.9
Evaporator inlet pressure	bar	1.51	1.62	1.72	1.84	1.95	2.07	2.19	2.32
Condenser inlet pressure	bar	22.0	23.1	24.1	25.1	26.2	27.2	28.2	29.3
Evaporator inlet temperature	° C.	−37.2	−38.0	−38.9	−39.7	−40.5	−41.2	−41.9	−42.6
Evaporator dewpoint	° C.	−23.4	−23.0	−22.5	−22.1	−21.8	−21.5	−21.3	−21.0
Evaporator exit gas temperature	° C.	−18.4	−18.0	−17.5	−17.1	−16.8	−16.5	−16.3	−16.0
Evaporator mean temperature	° C.	−30.3	−30.5	−30.7	−30.9	−31.1	−31.4	−31.6	−31.8
Evaporator glide (out-in)	K	13.7	15.1	16.3	17.5	18.7	19.7	20.7	21.5
Compressor suction pressure	bar	1.49	1.59	1.70	1.82	1.93	2.05	2.18	2.30
Compressor discharge pressure	bar	22.0	23.1	24.1	25.1	26.2	27.2	28.2	29.3
Suction line pressure drop	Pa/m	133	124	115	107	101	94	89	84
Pressure drop relative to reference		45.6%	42.3%	39.4%	36.8%	34.4%	32.3%	30.4%	28.7%
Condenser dew point	° C.	57.7	57.6	57.4	57.1	56.8	56.4	55.9	55.4
Condenser bubble point	° C.	30.0	29.1	28.3	27.7	27.1	26.6	26.2	25.9
Condenser exit liquid temperature	° C.	29.0	28.1	27.3	26.7	26.1	25.6	25.2	24.9
Condenser mean temperature	° C.	43.8	43.3	42.9	42.4	42.0	41.5	41.1	40.6
Condenser glide (in-out)	K	27.7	28.5	29.1	29.4	29.7	29.7	29.7	29.5

TABLE 41

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 10% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/10/10/80	2/10/10/78	4/10/10/76	6/10/10/74	8/10/10/72	10/10/10/70	12/10/10/68	14/10/10/66
COP (heating)		2.13	2.16	2.19	2.21	2.22	2.24	2.25	2.25
COP (heating) relative to Reference		100.9%	102.5%	103.7%	104.7%	105.4%	106.0%	106.5%	106.9%
Volumetric heating capacity at suction	kJ/m^3	883	972	1064	1160	1258	1359	1463	1569
Capacity relative to Reference		100.5%	110.6%	121.1%	132.0%	143.2%	154.7%	166.5%	178.6%
Critical temperature	° C.	102.94	99.76	96.73	93.84	91.08	88.45	85.94	83.55
Critical pressure	bar	42.01	42.80	43.57	44.34	45.09	45.84	46.59	47.33
Condenser enthalpy change	kJ/kg	241.7	251.1	259.6	267.1	273.9	280.1	285.9	291.3
Pressure ratio		16.67	16.58	16.42	16.18	15.91	15.61	15.29	14.97
Refrigerant mass flow	kg/hr	29.8	28.7	27.7	27.0	26.3	25.7	25.2	24.7
Compressor discharge temperature	° C.	123.6	127.0	130.2	133.2	136.0	138.6	141.2	143.6
Evaporator inlet pressure	bar	0.85	0.92	0.99	1.07	1.15	1.24	1.34	1.44
Condenser inlet pressure	bar	13.4	14.5	15.6	16.7	17.8	18.9	20.0	21.1
Evaporator inlet temperature	° C.	−30.8	−31.5	−32.2	−32.9	−33.7	−34.5	−35.3	−36.2
Evaporator dewpoint	° C.	−28.6	−28.0	−27.3	−26.6	−25.9	−25.3	−24.7	−24.1
Evaporator exit gas temperature	° C.	−23.6	−23.0	−22.3	−21.6	−20.9	−20.3	−19.7	−19.1
Evaporator mean temperature	° C.	−29.7	−29.7	−29.7	−29.8	−29.8	−29.9	−30.0	−30.1
Evaporator glide (out-in)	K	2.2	3.5	4.9	6.3	7.8	9.2	10.7	12.1
Compressor suction pressure	bar	0.80	0.87	0.95	1.03	1.12	1.21	1.31	1.41
Compressor discharge pressure	bar	13.4	14.5	15.6	16.7	17.8	18.9	20.0	21.1
Suction line pressure drop	Pa/m	290	256	228	205	185	169	154	142
Pressure drop relative to reference		99.3%	87.7%	78.1%	70.1%	63.4%	57.7%	52.8%	48.6%
Condenser dew point	° C.	53.4	54.4	55.3	56.0	56.6	57.0	57.2	57.3
Condenser bubble point	° C.	46.1	42.6	39.7	37.4	35.4	33.8	32.4	31.2
Condenser exit liquid temperature	° C.	45.1	41.6	38.7	36.4	34.4	32.8	31.4	30.2
Condenser mean temperature	° C.	49.7	48.5	47.5	46.7	46.0	45.4	44.8	44.2
Condenser glide (in-out)	K	7.3	11.9	15.6	18.7	21.2	23.2	24.8	26.1

TABLE 42

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 10% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/10/10/64	18/10/10/62	20/10/10/60	22/10/10/58	24/10/10/56	26/10/10/54	28/10/10/52	30/10/10/50
COP (heating)		2.26	2.26	2.27	2.27	2.27	2.27	2.27	2.27
COP (heating) relative to Reference		107.2%	107.4%	107.5%	107.6%	107.6%	107.6%	107.6%	107.5%
Volumetric heating capacity at suction	kJ/m^3	1677	1787	1898	2011	2126	2243	2362	2483
Capacity relative to Reference		190.8%	203.3%	216.0%	228.9%	242.0%	255.3%	268.8%	282.5%
Critical temperature	° C.	81.26	79.07	76.97	74.96	73.03	71.19	69.41	67.71
Critical pressure	bar	48.07	48.81	49.55	50.29	51.03	51.76	52.50	53.23
Condenser enthalpy change	kJ/kg	296.3	301.2	305.8	310.2	314.4	318.5	322.4	326.2
Pressure ratio		14.64	14.32	14.00	13.69	13.39	13.10	12.81	12.54
Refrigerant mass flow	kg/hr	24.3	23.9	23.5	23.2	22.9	22.6	22.3	22.1
Compressor discharge temperature	° C.	146.0	148.3	150.5	152.7	154.9	157.0	159.0	161.1
Evaporator inlet pressure	bar	1.54	1.64	1.76	1.87	1.99	2.11	2.24	2.37
Condenser inlet pressure	bar	22.2	23.3	24.3	25.4	26.4	27.4	28.5	29.5
Evaporator inlet temperature	° C.	−37.0	−37.8	−38.6	−39.4	−40.2	−40.9	−41.6	−42.2
Evaporator dewpoint	° C.	−23.6	−23.1	−22.6	−22.3	−21.9	−21.6	−21.4	−21.2
Evaporator exit gas temperature	° C.	−18.6	−18.1	−17.6	−17.3	−16.9	−16.6	−16.4	−16.2
Evaporator mean temperature	° C.	−30.3	−30.5	−30.6	−30.8	−31.1	−31.3	−31.5	−31.7
Evaporator glide (out-in)	K	13.5	14.8	16.0	17.2	18.3	19.3	20.2	21.1
Compressor suction pressure	bar	1.52	1.62	1.74	1.85	1.97	2.09	2.22	2.35
Compressor discharge pressure	bar	22.2	23.3	24.3	25.4	26.4	27.4	28.5	29.5
Suction line pressure drop	Pa/m	131	122	113	106	99	93	87	82
Pressure drop relative to reference		44.9%	41.6%	38.7%	36.1%	33.8%	31.8%	29.9%	28.2%
Condenser dew point	° C.	57.3	57.2	57.0	56.7	56.4	56.0	55.5	55.0
Condenser bubble point	° C.	30.2	29.3	28.6	27.9	27.4	26.9	26.5	26.1
Condenser exit liquid temperature	° C.	29.2	28.3	27.6	26.9	26.4	25.9	25.5	25.1
Condenser mean temperature	° C.	43.7	43.3	42.8	42.3	41.9	41.4	41.0	40.6
Condenser glide (in-out)	K	27.1	27.9	28.4	28.8	29.0	29.1	29.0	28.9

TABLE 43

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 10% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/10/20/70	2/10/20/68	4/10/20/66	6/10/20/64	8/10/20/62	10/10/20/60	12/10/20/58	14/10/20/56
COP (heating)		2.13	2.17	2.19	2.21	2.23	2.24	2.25	2.26
COP (heating) relative to Reference		101.2%	102.7%	103.9%	104.8%	105.6%	106.2%	106.6%	107.0%
Volumetric heating capacity at suction	kJ/m^3	917	1007	1101	1198	1299	1403	1509	1617
Capacity relative to Reference		104.3%	114.6%	125.3%	136.4%	147.9%	159.7%	171.7%	184.1%
Critical temperature	° C.	102.20	99.05	96.05	93.19	90.47	87.87	85.40	83.03
Critical pressure	bar	42.60	43.37	44.14	44.89	45.65	46.39	47.14	47.89
Condenser enthalpy change	kJ/kg	243.2	252.7	261.0	268.5	275.2	281.4	287.1	292.5
Pressure ratio		16.35	16.27	16.12	15.89	15.62	15.33	15.02	14.70
Refrigerant mass flow	kg/hr	29.6	28.5	27.6	26.8	26.2	25.6	25.1	24.6
Compressor discharge temperature	° C.	124.5	127.9	131.1	134.1	136.9	139.5	142.1	144.5
Evaporator inlet pressure	bar	0.89	0.95	1.03	1.11	1.19	1.29	1.38	1.48
Condenser inlet pressure	bar	13.7	14.8	15.9	17.0	18.2	19.3	20.4	21.5
Evaporator inlet temperature	° C.	−30.8	−31.4	−32.1	−32.8	−33.6	−34.3	−35.1	−35.9
Evaporator dewpoint	° C.	−28.7	−28.0	−27.4	−26.7	−26.1	−25.4	−24.8	−24.3
Evaporator exit gas temperature	° C.	−23.7	−23.0	−22.4	−21.7	−21.1	−20.4	−19.8	−19.3
Evaporator mean temperature	° C.	−29.7	−29.7	−29.8	−29.8	−29.8	−29.9	−30.0	−30.1
Evaporator glide (out-in)	K	2.1	3.4	4.7	6.1	7.5	8.9	10.3	11.6
Compressor suction pressure	bar	0.84	0.91	0.99	1.07	1.16	1.26	1.36	1.46
Compressor discharge pressure	bar	13.7	14.8	15.9	17.0	18.2	19.3	20.4	21.5
Suction line pressure drop	Pa/m	278	246	220	197	179	163	149	137
Pressure drop relative to reference		95.2%	84.2%	75.2%	67.6%	61.2%	55.8%	51.1%	47.0%
Condenser dew point	° C.	52.8	53.9	54.7	55.4	55.9	56.2	56.5	56.6
Condenser bubble point	° C.	46.2	42.8	40.0	37.7	35.7	34.1	32.7	31.5
Condenser exit liquid temperature	° C.	45.2	41.8	39.0	36.7	34.7	33.1	31.7	30.5
Condenser mean temperature	° C.	49.5	48.3	47.4	46.5	45.8	45.2	44.6	44.1
Condenser glide (in-out)	K	6.6	11.0	14.7	17.7	20.2	22.2	23.8	25.0

TABLE 44

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 10% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/10/20/54	18/10/20/52	20/10/20/50	22/10/20/48	24/10/20/46	26/10/20/44	28/10/20/42	30/10/20/40
COP (heating)		2.26	2.27	2.27	2.27	2.27	2.27	2.27	2.27
COP (heating) relative to Reference		107.3%	107.5%	107.6%	107.7%	107.7%	107.7%	107.7%	107.7%
Volumetric heating capacity at suction	kJ/m^3	1728	1841	1956	2073	2193	2314	2438	2563
Capacity relative to Reference		196.7%	209.5%	222.6%	236.0%	249.5%	263.3%	277.4%	291.7%
Critical temperature	° C.	80.77	78.61	76.54	74.56	72.66	70.83	69.08	67.39
Critical pressure	bar	48.63	49.37	50.12	50.86	51.60	52.34	53.08	53.82
Condenser enthalpy change	kJ/kg	297.5	302.2	306.7	311.0	315.1	319.1	322.9	326.5
Pressure ratio		14.38	14.06	13.74	13.43	13.13	12.84	12.55	12.27
Refrigerant mass flow	kg/hr	24.2	23.8	23.5	23.2	22.8	22.6	22.3	22.1
Compressor discharge temperature	° C.	146.8	149.1	151.3	153.4	155.5	157.5	159.5	161.5
Evaporator inlet pressure	bar	1.59	1.70	1.82	1.94	2.06	2.19	2.32	2.46
Condenser inlet pressure	bar	22.6	23.6	24.7	25.8	26.8	27.9	28.9	30.0
Evaporator inlet temperature	° C.	−36.7	−37.5	−38.2	−39.0	−39.7	−40.4	−41.0	−41.6
Evaporator dewpoint	° C.	−23.8	−23.3	−22.9	−22.5	−22.1	−21.9	−21.6	−21.4
Evaporator exit gas temperature	° C.	−18.8	−18.3	−17.9	−17.5	−17.1	−16.9	−16.6	−16.4
Evaporator mean temperature	° C.	−30.2	−30.4	−30.6	−30.7	−30.9	−31.1	−31.3	−31.5
Evaporator glide (out-in)	K	12.9	14.2	15.4	16.5	17.6	18.5	19.4	20.2
Compressor suction pressure	bar	1.57	1.68	1.80	1.92	2.04	2.17	2.30	2.44
Compressor discharge pressure	bar	22.6	23.6	24.7	25.8	26.8	27.9	28.9	30.0
Suction line pressure drop	Pa/m	127	118	109	102	96	90	85	80
Pressure drop relative to reference		43.4%	40.3%	37.5%	35.0%	32.8%	30.8%	28.9%	27.3%
Condenser dew point	° C.	56.6	56.4	56.3	56.0	55.6	55.2	54.8	54.3
Condenser bubble point	° C.	30.5	29.7	28.9	28.3	27.8	27.3	26.9	26.6
Condenser exit liquid temperature	° C.	29.5	28.7	27.9	27.3	26.8	26.3	25.9	25.6
Condenser mean temperature	° C.	43.5	43.1	42.6	42.1	41.7	41.3	40.8	40.4
Condenser glide (in-out)	K	26.0	26.8	27.3	27.7	27.9	27.9	27.9	27.7

TABLE 45

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 10% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/10/30/60	2/10/30/58	4/10/30/56	6/10/30/54	8/10/30/52	10/10/30/50	12/10/30/48	14/10/30/46
COP (heating)		2.14	2.17	2.19	2.21	2.23	2.24	2.25	2.26
COP (heating) relative to Reference		101.5%	102.9%	104.1%	105.0%	105.7%	106.3%	106.7%	107.1%
Volumetric heating capacity at suction	kJ/m^3	948	1040	1135	1234	1337	1443	1551	1662
Capacity relative to Reference		107.8%	118.3%	129.2%	140.5%	152.2%	164.2%	176.5%	189.2%
Critical temperature	° C.	101.47	98.35	95.39	92.57	89.89	87.33	84.88	82.55
Critical pressure	bar	43.07	43.84	44.60	45.36	46.12	46.87	47.63	48.38
Condenser enthalpy change	kJ/kg	245.0	254.4	262.7	270.2	276.9	283.0	288.7	294.0
Pressure ratio		16.08	16.00	15.85	15.64	15.38	15.09	14.79	14.47
Refrigerant mass flow	kg/hr	29.4	28.3	27.4	26.6	26.0	25.4	24.9	24.5
Compressor discharge temperature	° C.	125.6	129.0	132.2	135.2	137.9	140.6	143.1	145.5
Evaporator inlet pressure	bar	0.91	0.98	1.06	1.14	1.23	1.32	1.42	1.53
Condenser inlet pressure	bar	14.0	15.1	16.2	17.3	18.5	19.6	20.7	21.8
Evaporator inlet temperature	° C.	−30.8	−31.4	−32.0	−32.7	−33.4	−34.1	−34.9	−35.6
Evaporator dewpoint	° C.	−28.8	−28.2	−27.5	−26.9	−26.3	−25.6	−25.0	−24.5
Evaporator exit gas temperature	° C.	−23.8	−23.2	−22.5	−21.9	−21.3	−20.6	−20.0	−19.5
Evaporator mean temperature	° C.	−29.8	−29.8	−29.8	−29.8	−29.8	−29.9	−30.0	−30.1
Evaporator glide (out-in)	K	2.0	3.2	4.5	5.8	7.2	8.5	9.8	11.2
Compressor suction pressure	bar	0.87	0.94	1.02	1.11	1.20	1.30	1.40	1.51
Compressor discharge pressure	bar	14.0	15.1	16.2	17.3	18.5	19.6	20.7	21.8
Suction line pressure drop	Pa/m	267	237	212	191	173	158	144	133
Pressure drop relative to reference		91.6%	81.1%	72.5%	65.3%	59.2%	54.0%	49.5%	45.5%
Condenser dew point	° C.	52.3	53.3	54.1	54.8	55.3	55.6	55.8	55.9
Condenser bubble point	° C.	46.4	43.0	40.2	37.9	35.9	34.3	33.0	31.8
Condenser exit liquid temperature	° C.	45.4	42.0	39.2	36.9	34.9	33.3	32.0	30.8
Condenser mean temperature	° C.	49.3	48.1	47.2	46.3	45.6	45.0	44.4	43.8
Condenser glide (in-out)	K	5.9	10.3	13.9	16.9	19.3	21.3	22.9	24.1

TABLE 46

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 10% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/10/30/44	18/10/30/42	20/10/30/40	22/10/30/38	24/10/30/36	26/10/30/34	28/10/30/32	30/10/30/30
COP (heating)		2.26	2.27	2.27	2.27	2.27	2.28	2.27	2.27
COP (heating) relative to Reference		107.4%	107.6%	107.7%	107.8%	107.9%	107.9%	107.9%	107.8%
Volumetric heating capacity at suction	kJ/m^3	1776	1892	2011	2131	2254	2379	2507	2637
Capacity relative to Reference		202.1%	215.4%	228.8%	242.6%	256.5%	270.8%	285.3%	300.1%
Critical temperature	° C.	80.32	78.19	76.15	74.19	72.31	70.50	68.77	67.11
Critical pressure	bar	49.13	49.88	50.62	51.37	52.12	52.87	53.61	54.36
Condenser enthalpy change	kJ/kg	298.9	303.6	308.0	312.2	316.3	320.1	323.8	327.3
Pressure ratio		14.15	13.83	13.52	13.21	12.91	12.61	12.33	12.05
Refrigerant mass flow	kg/hr	24.1	23.7	23.4	23.1	22.8	22.5	22.2	22.0
Compressor discharge temperature	° C.	147.8	150.0	152.1	154.2	156.3	158.2	160.2	162.1
Evaporator inlet pressure	bar	1.64	1.75	1.87	1.99	2.12	2.26	2.39	2.54
Condenser inlet pressure	bar	22.9	24.0	25.0	26.1	27.2	28.3	29.3	30.4
Evaporator inlet temperature	° C.	−36.4	−37.1	−37.9	−38.6	−39.3	−39.9	−40.5	−41.1
Evaporator dewpoint	° C.	−24.0	−23.5	−23.1	−22.7	−22.4	−22.1	−21.8	−21.6
Evaporator exit gas temperature	° C.	−19.0	−18.5	−18.1	−17.7	−17.4	−17.1	−16.8	−16.6
Evaporator mean temperature	° C.	−30.2	−30.3	−30.5	−30.6	−30.8	−31.0	−31.2	−31.3
Evaporator glide (out-in)	K	12.4	13.6	14.8	15.9	16.9	17.9	18.8	19.5
Compressor suction pressure	bar	1.62	1.73	1.85	1.98	2.11	2.24	2.38	2.52
Compressor discharge pressure	bar	22.9	24.0	25.0	26.1	27.2	28.3	29.3	30.4
Suction line pressure drop	Pa/m	123	114	106	99	93	87	82	77
Pressure drop relative to reference		42.1%	39.0%	36.3%	33.9%	31.8%	29.8%	28.1%	26.5%
Condenser dew point	° C.	55.9	55.8	55.6	55.3	55.0	54.6	54.2	53.7
Condenser bubble point	° C.	30.8	29.9	29.2	28.6	28.1	27.6	27.2	26.9
Condenser exit liquid temperature	° C.	29.8	28.9	28.2	27.6	27.1	26.6	26.2	25.9
Condenser mean temperature	° C.	43.3	42.9	42.4	42.0	41.5	41.1	40.7	40.3
Condenser glide (in-out)	K	25.1	25.8	26.4	26.7	26.9	27.0	26.9	26.8

TABLE 47

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 10% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/10/40/50	2/10/40/48	4/10/40/46	6/10/40/44	8/10/40/42	10/10/40/40	12/10/40/38	14/10/40/36
COP (heating)		2.14	2.17	2.20	2.22	2.23	2.24	2.25	2.26
COP (heating) relative to Reference		101.7%	103.2%	104.3%	105.1%	105.9%	106.4%	106.9%	107.2%
Volumetric heating capacity at suction	kJ/m^3	976	1069	1167	1267	1372	1480	1591	1704
Capacity relative to Reference		111.1%	121.7%	132.8%	144.2%	156.1%	168.4%	181.1%	193.9%
Critical temperature	° C.	100.75	97.68	94.76	91.98	89.33	86.81	84.40	82.10
Critical pressure	bar	43.42	44.20	44.97	45.74	46.51	47.27	48.04	48.80
Condenser enthalpy change	kJ/kg	247.0	256.4	264.8	272.2	278.9	285.0	290.6	295.9
Pressure ratio		15.84	15.77	15.63	15.43	15.18	14.89	14.59	14.28
Refrigerant mass flow	kg/hr	29.1	28.1	27.2	26.5	25.8	25.3	24.8	24.3
Compressor discharge temperature	° C.	126.7	130.1	133.3	136.3	139.1	141.7	144.2	146.6
Evaporator inlet pressure	bar	0.94	1.01	1.09	1.17	1.26	1.36	1.46	1.57
Condenser inlet pressure	bar	14.2	15.3	16.4	17.6	18.7	19.8	21.0	22.1
Evaporator inlet temperature	° C.	−30.7	−31.3	−31.9	−32.6	−33.3	−34.0	−34.7	−35.4
Evaporator dewpoint	° C.	−28.9	−28.3	−27.7	−27.1	−26.4	−25.8	−25.2	−24.7
Evaporator exit gas temperature	° C.	−23.9	−23.3	−22.7	−22.1	−21.4	−20.8	−20.2	−19.7
Evaporator mean temperature	° C.	−29.8	−29.8	−29.8	−29.8	−29.9	−29.9	−30.0	−30.1
Evaporator glide (out-in)	K	1.8	3.0	4.2	5.5	6.9	8.2	9.5	10.8
Compressor suction pressure	bar	0.90	0.97	1.05	1.14	1.23	1.33	1.44	1.55
Compressor discharge pressure	bar	14.2	15.3	16.4	17.6	18.7	19.8	21.0	22.1
Suction line pressure drop	Pa/m	258	229	205	185	168	153	140	129
Pressure drop relative to reference		88.4%	78.4%	70.2%	63.3%	57.4%	52.3%	48.0%	44.2%
Condenser dew point	° C.	51.7	52.7	53.5	54.2	54.7	55.0	55.2	55.3
Condenser bubble point	° C.	46.5	43.1	40.3	38.0	36.1	34.5	33.1	31.9
Condenser exit liquid temperature	° C.	45.5	42.1	39.3	37.0	35.1	33.5	32.1	30.9
Condenser mean temperature	° C.	49.1	47.9	46.9	46.1	45.4	44.7	44.2	43.6
Condenser glide (in-out)	K	5.3	9.6	13.2	16.2	18.6	20.6	22.1	23.4

TABLE 48

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 10% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/10/40/34	18/10/40/32	20/10/40/30	22/10/40/28	24/10/40/26	26/10/40/24	28/10/40/22	30/10/40/20
COP (heating)		2.27	2.27	2.27	2.28	2.28	2.28	2.28	2.28
COP (heating) relative to Reference		107.5%	107.7%	107.9%	108.0%	108.1%	108.1%	108.1%	108.0%
Volumetric heating capacity at suction	kJ/m^3	1820	1939	2060	2184	2309	2437	2569	2701
Capacity relative to Reference		207.2%	220.7%	234.5%	248.5%	262.8%	277.4%	292.3%	307.4%
Critical temperature	° C.	79.90	77.79	75.77	73.84	71.98	70.20	68.49	66.84
Critical pressure	bar	49.56	50.32	51.07	51.83	52.59	53.34	54.10	54.85
Condenser enthalpy change	kJ/kg	300.8	305.4	309.8	313.9	317.9	321.6	325.2	328.7
Pressure ratio		13.97	13.65	13.34	13.03	12.73	12.44	12.15	11.87
Refrigerant mass flow	kg/hr	23.9	23.6	23.2	22.9	22.7	22.4	22.1	21.9
Compressor discharge temperature	° C.	148.8	151.0	153.1	155.2	157.2	159.2	161.0	162.9
Evaporator inlet pressure	bar	1.68	1.80	1.92	2.05	2.18	2.31	2.46	2.60
Condenser inlet pressure	bar	23.2	24.3	25.4	26.5	27.5	28.6	29.7	30.8
Evaporator inlet temperature	° C.	−36.2	−36.9	−37.6	−38.3	−39.0	−39.6	−40.2	−40.8
Evaporator dewpoint	° C.	−24.2	−23.7	−23.3	−22.9	−22.5	−22.2	−21.9	−21.7
Evaporator exit gas temperature	° C.	−19.2	−18.7	−18.3	−17.9	−17.5	−17.2	−16.9	−16.7
Evaporator mean temperature	° C.	−30.2	−30.3	−30.4	−30.6	−30.8	−30.9	−31.1	−31.2
Evaporator glide (out-in)	K	12.0	13.2	14.3	15.4	16.5	17.4	18.3	19.1
Compressor suction pressure	bar	1.66	1.78	1.90	2.03	2.16	2.30	2.44	2.59
Compressor discharge pressure	bar	23.2	24.3	25.4	26.5	27.5	28.6	29.7	30.8
Suction line pressure drop	Pa/m	119	111	103	96	90	85	80	75
Pressure drop relative to reference		40.9%	37.9%	35.3%	33.0%	30.9%	29.0%	27.3%	25.8%
Condenser dew point	° C.	55.3	55.2	55.1	54.8	54.5	54.1	53.6	53.2
Condenser bubble point	° C.	31.0	30.1	29.4	28.8	28.3	27.8	27.4	27.1
Condenser exit liquid temperature	° C.	30.0	29.1	28.4	27.8	27.3	26.8	26.4	26.1
Condenser mean temperature	° C.	43.1	42.7	42.2	41.8	41.4	40.9	40.5	40.1
Condenser glide (in-out)	K	24.4	25.1	25.7	26.0	26.2	26.3	26.2	26.1

TABLE 49

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 10% R-32 and 50% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/10/50/40	2/10/50/38	4/10/50/36	6/10/50/34	8/10/50/32	10/10/50/30	12/10/50/28	14/10/50/26
COP (heating)		2.15	2.18	2.20	2.22	2.24	2.25	2.26	2.26
COP (heating) relative to Reference		102.0%	103.4%	104.5%	105.4%	106.1%	106.6%	107.1%	107.4%
Volumetric heating capacity at suction	kJ/m^3	1001	1096	1195	1297	1403	1513	1626	1741
Capacity relative to Reference		113.9%	124.7%	136.0%	147.6%	159.7%	172.2%	185.0%	198.1%
Critical temperature	° C.	100.04	97.02	94.14	91.41	88.80	86.31	83.94	81.67
Critical pressure	bar	43.67	44.47	45.25	46.04	46.82	47.60	48.37	49.15
Condenser enthalpy change	kJ/kg	249.3	258.7	267.1	274.5	281.2	287.3	293.0	298.2
Pressure ratio		15.64	15.58	15.45	15.26	15.01	14.74	14.44	14.13
Refrigerant mass flow	kg/hr	28.9	27.8	27.0	26.2	25.6	25.1	24.6	24.1
Compressor discharge temperature	° C.	127.9	131.4	134.6	137.6	140.4	143.0	145.4	147.8
Evaporator inlet pressure	bar	0.96	1.03	1.11	1.20	1.29	1.39	1.49	1.60
Condenser inlet pressure	bar	14.4	15.5	16.6	17.8	18.9	20.1	21.2	22.3
Evaporator inlet temperature	° C.	−30.7	−31.3	−31.9	−32.5	−33.2	−33.9	−34.6	−35.3
Evaporator dewpoint	° C.	−29.0	−28.5	−27.8	−27.2	−26.6	−26.0	−25.4	−24.8
Evaporator exit gas temperature	° C.	−24.0	−23.5	−22.8	−22.2	−21.6	−21.0	−20.4	−19.8
Evaporator mean temperature	° C.	−29.9	−29.9	−29.9	−29.9	−29.9	−29.9	−30.0	−30.1
Evaporator glide (out-in)	K	1.6	2.8	4.0	5.3	6.6	7.9	9.2	10.4
Compressor suction pressure	bar	0.92	0.99	1.08	1.17	1.26	1.36	1.47	1.58
Compressor discharge pressure	bar	14.4	15.5	16.6	17.8	18.9	20.1	21.2	22.3
Suction line pressure drop	Pa/m	250	222	199	179	163	149	136	126
Pressure drop relative to reference		85.6%	76.0%	68.1%	61.4%	55.8%	50.9%	46.7%	43.0%
Condenser dew point	° C.	51.2	52.2	53.0	53.7	54.2	54.5	54.8	54.9
Condenser bubble point	° C.	46.6	43.2	40.4	38.1	36.1	34.5	33.1	32.0
Condenser exit liquid temperature	° C.	45.6	42.2	39.4	37.1	35.1	33.5	32.1	31.0
Condenser mean temperature	° C.	48.9	47.7	46.7	45.9	45.2	44.5	43.9	43.4
Condenser glide (in-out)	K	4.7	9.0	12.7	15.6	18.1	20.0	21.6	22.9

TABLE 50

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 10% R-32 and 50% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/10/50/24	18/10/50/22	20/10/50/20	22/10/50/18	24/10/50/16	26/10/50/14	28/10/50/12	30/10/50/10
COP (heating)		2.27	2.28	2.28	2.28	2.28	2.28	2.28	2.28
COP (heating) relative to Reference		107.7%	107.9%	108.1%	108.2%	108.2%	108.3%	108.3%	108.2%
Volumetric heating capacity at suction	kJ/m^3	1859	1980	2103	2229	2357	2487	2620	2755
Capacity relative to Reference		211.6%	225.4%	239.4%	253.7%	268.2%	283.1%	298.2%	313.5%
Critical temperature	° C.	79.50	77.42	75.43	73.52	71.69	69.93	68.24	66.61
Critical pressure	bar	49.92	50.69	51.46	52.23	53.00	53.77	54.53	55.30
Condenser enthalpy change	kJ/kg	303.0	307.6	311.9	316.0	320.0	323.7	327.3	330.7
Pressure ratio		13.82	13.50	13.19	12.89	12.59	12.31	12.02	11.75
Refrigerant mass flow	kg/hr	23.8	23.4	23.1	22.8	22.5	22.2	22.0	21.8
Compressor discharge temperature	° C.	150.1	152.2	154.3	156.4	158.3	160.3	162.1	164.0
Evaporator inlet pressure	bar	1.72	1.84	1.96	2.09	2.22	2.36	2.51	2.66
Condenser inlet pressure	bar	23.4	24.5	25.6	26.7	27.8	28.9	30.0	31.1
Evaporator inlet temperature	° C.	−36.0	−36.7	−37.4	−38.1	−38.8	−39.4	−40.0	−40.6
Evaporator dewpoint	° C.	−24.3	−23.8	−23.4	−23.0	−22.6	−22.3	−22.0	−21.8
Evaporator exit gas temperature	° C.	−19.3	−18.8	−18.4	−18.0	−17.6	−17.3	−17.0	−16.8
Evaporator mean temperature	° C.	−30.2	−30.3	−30.4	−30.6	−30.7	−30.9	−31.0	−31.2
Evaporator glide (out-in)	K	11.7	12.9	14.0	15.1	16.2	17.1	18.0	18.8
Compressor suction pressure	bar	1.70	1.82	1.94	2.07	2.21	2.35	2.49	2.64
Compressor discharge pressure	bar	23.4	24.5	25.6	26.7	27.8	28.9	30.0	31.1
Suction line pressure drop	Pa/m	116	108	101	94	88	83	78	73
Pressure drop relative to reference		39.8%	36.9%	34.4%	32.2%	30.1%	28.3%	26.7%	25.2%
Condenser dew point	° C.	54.9	54.8	54.6	54.4	54.0	53.7	53.2	52.8
Condenser bubble point	° C.	31.0	30.2	29.4	28.8	28.3	27.9	27.5	27.2
Condenser exit liquid temperature	° C.	30.0	29.2	28.4	27.8	27.3	26.9	26.5	26.2
Condenser mean temperature	° C.	42.9	42.5	42.0	41.6	41.2	40.8	40.4	40.0
Condenser glide (in-out)	K	23.9	24.6	25.2	25.5	25.7	25.8	25.8	25.6

TABLE 51

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 15% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/15/5/80	2/15/5/78	4/15/5/76	6/15/5/74	8/15/5/72	10/15/5/70	12/15/5/68	14/15/5/66
COP (heating)		2.17	2.19	2.21	2.23	2.24	2.26	2.26	2.27
COP (heating) relative to Reference		102.8%	104.0%	105.0%	105.8%	106.5%	107.0%	107.3%	107.6%
Volumetric heating capacity at suction	kJ/m^3	983	1075	1170	1267	1368	1471	1575	1682
Capacity relative to Reference		111.9%	122.3%	133.1%	144.2%	155.7%	167.4%	179.2%	191.4%
Critical temperature	° C.	100.70	97.79	94.99	92.31	89.74	87.29	84.94	82.70
Critical pressure	bar	43.58	44.39	45.17	45.95	46.71	47.47	48.22	48.97
Condenser enthalpy change	kJ/kg	253.1	261.7	269.4	276.4	282.8	288.7	294.3	299.5
Pressure ratio		15.94	15.80	15.61	15.37	15.11	14.82	14.54	14.25
Refrigerant mass flow	kg/hr	28.4	27.5	26.7	26.1	25.5	24.9	24.5	24.0
Compressor discharge temperature	° C.	127.4	130.5	133.5	136.4	139.1	141.6	144.1	146.5
Evaporator inlet pressure	bar	0.94	1.01	1.09	1.17	1.26	1.35	1.45	1.55
Condenser inlet pressure	bar	14.3	15.3	16.4	17.5	18.6	19.6	20.7	21.8
Evaporator inlet temperature	° C.	−31.5	−32.2	−33.0	−33.7	−34.5	−35.3	−36.0	−36.8
Evaporator dewpoint	° C.	−27.9	−27.2	−26.6	−26.0	−25.3	−24.8	−24.2	−23.7
Evaporator exit gas temperature	° C.	−22.9	−22.2	−21.6	−21.0	−20.3	−19.8	−19.2	−18.7
Evaporator mean temperature	° C.	−29.7	−29.7	−29.8	−29.8	−29.9	−30.0	−30.1	−30.3
Evaporator glide (out-in)	K	3.7	5.0	6.4	7.8	9.1	10.5	11.8	13.1
Compressor suction pressure	bar	0.89	0.97	1.05	1.14	1.23	1.32	1.42	1.53
Compressor discharge pressure	bar	14.3	15.3	16.4	17.5	18.6	19.6	20.7	21.8
Suction line pressure drop	Pa/m	251	224	202	183	166	152	140	130
Pressure drop relative to reference		86.1%	76.8%	69.1%	62.6%	57.0%	52.2%	48.0%	44.4%
Condenser dew point	° C.	53.3	54.2	54.9	55.4	55.8	56.1	56.2	56.2
Condenser bubble point	° C.	44.2	41.3	38.9	36.8	35.1	33.6	32.4	31.3
Condenser exit liquid temperature	° C.	43.2	40.3	37.9	35.8	34.1	32.6	31.4	30.3
Condenser mean temperature	° C.	48.8	47.7	46.9	46.1	45.4	44.8	44.3	43.8
Condenser glide (in-out)	K	9.0	12.8	16.0	18.6	20.7	22.5	23.9	25.0

TABLE 52

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 15% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/15/5/64	18/15/5/62	20/15/5/60	22/15/5/58	24/15/5/56	26/15/5/54	28/15/5/52	30/15/5/50
COP (heating)		2.27	2.28	2.28	2.28	2.28	2.28	2.28	2.28
COP (heating) relative to Reference		107.8%	108.0%	108.1%	108.1%	108.1%	108.1%	108.0%	107.9%
Volumetric heating capacity at suction	kJ/m^3	1790	1901	2014	2128	2244	2362	2483	2606
Capacity relative to Reference		203.8%	216.4%	229.2%	242.2%	255.4%	268.9%	282.6%	296.5%
Critical temperature	° C.	80.54	78.48	76.50	74.60	72.77	71.02	69.33	67.70
Critical pressure	bar	49.71	50.46	51.20	51.94	52.68	53.42	54.16	54.90
Condenser enthalpy change	kJ/kg	304.5	309.2	313.7	318.1	322.2	326.2	330.1	333.8
Pressure ratio		13.96	13.67	13.38	13.10	12.83	12.56	12.30	12.05
Refrigerant mass flow	kg/hr	23.6	23.3	22.9	22.6	22.3	22.1	21.8	21.6
Compressor discharge temperature	° C.	148.9	151.1	153.3	155.5	157.6	159.7	161.7	163.7
Evaporator inlet pressure	bar	1.65	1.76	1.88	1.99	2.11	2.24	2.37	2.50
Condenser inlet pressure	bar	22.8	23.8	24.9	25.9	26.9	27.9	29.0	30.0
Evaporator inlet temperature	° C.	−37.6	−38.3	−39.1	−39.8	−40.4	−41.0	−41.6	−42.1
Evaporator dewpoint	° C.	−23.3	−22.8	−22.5	−22.1	−21.9	−21.6	−21.4	−21.2
Evaporator exit gas temperature	° C.	−18.3	−17.8	−17.5	−17.1	−16.9	−16.6	−16.4	−16.2
Evaporator mean temperature	° C.	−30.4	−30.6	−30.8	−30.9	−31.1	−31.3	−31.5	−31.7
Evaporator glide (out-in)	K	14.3	15.5	16.6	17.6	18.5	19.4	20.2	20.9
Compressor suction pressure	bar	1.63	1.74	1.86	1.98	2.10	2.22	2.35	2.49
Compressor discharge pressure	bar	22.8	23.8	24.9	25.9	26.9	27.9	29.0	30.0
Suction line pressure drop	Pa/m	120	112	105	98	92	87	82	77
Pressure drop relative to reference		41.2%	38.3%	35.8%	33.5%	31.5%	29.6%	28.0%	26.4%
Condenser dew point	° C.	56.2	56.0	55.8	55.5	55.1	54.7	54.3	53.7
Condenser bubble point	° C.	30.3	29.5	28.8	28.2	27.7	27.3	26.9	26.5
Condenser exit liquid temperature	° C.	29.3	28.5	27.8	27.2	26.7	26.3	25.9	25.5
Condenser mean temperature	° C.	43.3	42.8	42.3	41.9	41.4	41.0	40.6	40.1
Condenser glide (in-out)	K	25.8	26.5	27.0	27.3	27.4	27.5	27.4	27.2

TABLE 53

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 15% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/15/10/75	2/15/10/73	4/15/10/71	6/15/10/69	8/15/10/67	10/15/10/65	12/15/10/63	14/15/10/61
COP (heating)		2.17	2.20	2.22	2.23	2.25	2.26	2.26	2.27
COP (heating) relative to Reference		102.9%	104.1%	105.1%	105.9%	106.5%	107.0%	107.4%	107.7%
Volumetric heating capacity at suction	kJ/m^3	1001	1093	1188	1287	1389	1493	1599	1707
Capacity relative to Reference		113.9%	124.4%	135.2%	146.5%	158.0%	169.9%	182.0%	194.3%
Critical temperature	° C.	100.38	97.46	94.67	92.00	89.45	87.01	84.68	82.44
Critical pressure	bar	43.87	44.66	45.43	46.20	46.96	47.71	48.47	49.22
Condenser enthalpy change	kJ/kg	253.8	262.3	270.0	277.0	283.4	289.3	294.9	300.1
Pressure ratio		15.79	15.65	15.47	15.24	14.97	14.70	14.41	14.12
Refrigerant mass flow	kg/hr	28.4	27.4	26.7	26.0	25.4	24.9	24.4	24.0
Compressor discharge temperature	° C.	127.8	131.0	134.0	136.8	139.5	142.1	144.5	146.9
Evaporator inlet pressure	bar	0.95	1.03	1.10	1.19	1.28	1.37	1.47	1.57
Condenser inlet pressure	bar	14.4	15.5	16.6	17.6	18.7	19.8	20.9	21.9
Evaporator inlet temperature	° C.	−31.5	−32.2	−32.9	−33.6	−34.4	−35.1	−35.9	−36.6
Evaporator dewpoint	° C.	−28.0	−27.3	−26.7	−26.1	−25.5	−24.9	−24.3	−23.8
Evaporator exit gas temperature	° C.	−23.0	−22.3	−21.7	−21.1	−20.5	−19.9	−19.3	−18.8
Evaporator mean temperature	° C.	−29.7	−29.8	−29.8	−29.8	−29.9	−30.0	−30.1	−30.2
Evaporator glide (out-in)	K	3.6	4.9	6.2	7.6	8.9	10.2	11.5	12.8
Compressor suction pressure	bar	0.91	0.99	1.07	1.16	1.25	1.35	1.45	1.55
Compressor discharge pressure	bar	14.4	15.5	16.6	17.6	18.7	19.8	20.9	21.9
Suction line pressure drop	Pa/m	247	220	198	180	164	150	138	128
Pressure drop relative to reference		84.5%	75.4%	67.9%	61.5%	56.0%	51.3%	47.2%	43.7%
Condenser dew point	° C.	53.0	53.8	54.5	55.0	55.4	55.7	55.8	55.9
Condenser bubble point	° C.	44.4	41.5	39.0	37.0	35.3	33.8	32.5	31.5
Condenser exit liquid temperature	° C.	43.4	40.5	38.0	36.0	34.3	32.8	31.5	30.5
Condenser mean temperature	° C.	48.7	47.6	46.8	46.0	45.4	44.7	44.2	43.7
Condenser glide (in-out)	K	8.6	12.3	15.5	18.0	20.2	21.9	23.3	24.4

TABLE 54

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 15% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/15/10/59	18/15/10/57	20/15/10/55	22/15/10/53	24/15/10/51	26/15/10/49	28/15/10/47	30/15/10/45
COP (heating)		2.27	2.28	2.28	2.28	2.28	2.28	2.28	2.28
COP (heating) relative to Reference		107.9%	108.0%	108.1%	108.2%	108.2%	108.1%	108.1%	108.0%
Volumetric heating capacity at suction	kJ/m^3	1817	1930	2044	2161	2279	2400	2523	2648
Capacity relative to Reference		206.8%	219.6%	232.7%	245.9%	259.4%	273.1%	287.1%	301.4%
Critical temperature	° C.	80.30	78.25	76.28	74.40	72.58	70.84	69.16	67.54
Critical pressure	bar	49.96	50.71	51.45	52.19	52.94	53.68	54.42	55.16
Condenser enthalpy change	kJ/kg	305.0	309.7	314.1	318.4	322.5	326.4	330.2	333.8
Pressure ratio		13.83	13.54	13.25	12.97	12.70	12.43	12.17	11.91
Refrigerant mass flow	kg/hr	23.6	23.3	22.9	22.6	22.3	22.1	21.8	21.6
Compressor discharge temperature	° C.	149.3	151.5	153.7	155.8	157.9	159.9	161.9	163.9
Evaporator inlet pressure	bar	1.68	1.79	1.91	2.03	2.15	2.28	2.41	2.55
Condenser inlet pressure	bar	23.0	24.0	25.1	26.1	27.1	28.2	29.2	30.2
Evaporator inlet temperature	° C.	−37.4	−38.1	−38.8	−39.5	−40.1	−40.7	−41.2	−41.7
Evaporator dewpoint	° C.	−23.4	−23.0	−22.6	−22.3	−22.0	−21.7	−21.5	−21.4
Evaporator exit gas temperature	° C.	−18.4	−18.0	−17.6	−17.3	−17.0	−16.7	−16.5	−16.4
Evaporator mean temperature	° C.	−30.4	−30.5	−30.7	−30.9	−31.1	−31.2	−31.4	−31.5
Evaporator glide (out-in)	K	14.0	15.1	16.2	17.2	18.1	18.9	19.7	20.4
Compressor suction pressure	bar	1.66	1.77	1.89	2.01	2.14	2.27	2.40	2.54
Compressor discharge pressure	bar	23.0	24.0	25.1	26.1	27.1	28.2	29.2	30.2
Suction line pressure drop	Pa/m	118	110	103	96	90	85	80	76
Pressure drop relative to reference		40.5%	37.7%	35.2%	33.0%	31.0%	29.2%	27.5%	26.0%
Condenser dew point	° C.	55.8	55.6	55.4	55.1	54.8	54.3	53.9	53.4
Condenser bubble point	° C.	30.5	29.7	29.0	28.4	27.9	27.5	27.1	26.8
Condenser exit liquid temperature	° C.	29.5	28.7	28.0	27.4	26.9	26.5	26.1	25.8
Condenser mean temperature	° C.	43.2	42.7	42.2	41.8	41.3	40.9	40.5	40.1
Condenser glide (in-out)	K	25.3	25.9	26.4	26.7	26.8	26.9	26.8	26.6

TABLE 55

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 15% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/15/20/65	2/15/20/63	4/15/20/61	6/15/20/59	8/15/20/57	10/15/20/55	12/15/20/53	14/15/20/51
COP (heating)		2.17	2.20	2.22	2.23	2.25	2.26	2.27	2.27
COP (heating) relative to Reference		103.1%	104.3%	105.2%	106.0%	106.6%	107.1%	107.4%	107.7%
Volumetric heating capacity at suction	kJ/m^3	1033	1127	1224	1325	1428	1534	1643	1755
Capacity relative to Reference		117.6%	128.3%	139.3%	150.7%	162.5%	174.6%	187.0%	199.7%
Critical temperature	° C.	99.72	96.82	94.05	91.41	88.89	86.48	84.18	81.97
Critical pressure	bar	44.35	45.12	45.89	46.65	47.41	48.17	48.92	49.67
Condenser enthalpy change	kJ/kg	255.3	263.9	271.6	278.5	284.9	290.8	296.3	301.4
Pressure ratio		15.52	15.39	15.22	14.99	14.74	14.46	14.18	13.89
Refrigerant mass flow	kg/hr	28.2	27.3	26.5	25.9	25.3	24.8	24.3	23.9
Compressor discharge temperature	° C.	128.8	132.0	135.0	137.8	140.5	143.0	145.5	147.8
Evaporator inlet pressure	bar	0.99	1.06	1.14	1.23	1.32	1.41	1.52	1.62
Condenser inlet pressure	bar	14.7	15.7	16.8	17.9	19.0	20.1	21.2	22.2
Evaporator inlet temperature	° C.	−31.4	−32.1	−32.8	−33.4	−34.1	−34.8	−35.6	−36.3
Evaporator dewpoint	° C.	−28.1	−27.5	−26.9	−26.3	−25.7	−25.1	−24.6	−24.1
Evaporator exit gas temperature	° C.	−23.1	−22.5	−21.9	−21.3	−20.7	−20.1	−19.6	−19.1
Evaporator mean temperature	° C.	−29.8	−29.8	−29.8	−29.9	−29.9	−30.0	−30.1	−30.2
Evaporator glide (out-in)	K	3.3	4.6	5.9	7.2	8.4	9.7	11.0	12.2
Compressor suction pressure	bar	0.94	1.02	1.11	1.20	1.29	1.39	1.49	1.60
Compressor discharge pressure	bar	14.7	15.7	16.8	17.9	19.0	20.1	21.2	22.2
Suction line pressure drop	Pa/m	238	213	192	174	158	145	134	124
Pressure drop relative to reference		81.4%	72.8%	65.6%	59.5%	54.3%	49.7%	45.8%	42.3%
Condenser dew point	° C.	52.4	53.2	53.8	54.4	54.7	55.0	55.1	55.2
Condenser bubble point	° C.	44.7	41.8	39.3	37.3	35.6	34.1	32.9	31.8
Condenser exit liquid temperature	° C.	43.7	40.8	38.3	36.3	34.6	33.1	31.9	30.8
Condenser mean temperature	° C.	48.5	47.5	46.6	45.8	45.2	44.6	44.0	43.5
Condenser glide (in-out)	K	7.7	11.4	14.5	17.1	19.2	20.9	22.3	23.4

TABLE 56

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 15% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/15/20/49	18/15/20/47	20/15/20/45	22/15/20/43	24/15/20/41	26/15/20/39	28/15/20/37	30/15/20/35
COP (heating)		2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
COP (heating) relative to Reference		108.0%	108.1%	108.2%	108.3%	108.3%	108.3%	108.3%	108.2%
Volumetric heating capacity at suction	kJ/m^3	1868	1984	2102	2222	2345	2470	2598	2729
Capacity relative to Reference		212.6%	225.8%	239.2%	252.9%	266.9%	281.1%	295.7%	310.5%
Critical temperature	° C.	79.86	77.83	75.88	74.02	72.22	70.50	68.84	67.24
Critical pressure	bar	50.42	51.17	51.92	52.67	53.42	54.16	54.91	55.65
Condenser enthalpy change	kJ/kg	306.2	310.8	315.2	319.4	323.4	327.2	330.8	334.3
Pressure ratio		13.60	13.31	13.02	12.74	12.47	12.20	11.93	11.67
Refrigerant mass flow	kg/hr	23.5	23.2	22.8	22.5	22.3	22.0	21.8	21.5
Compressor discharge temperature	° C.	150.1	152.3	154.4	156.5	158.5	160.5	162.4	164.3
Evaporator inlet pressure	bar	1.73	1.85	1.97	2.09	2.22	2.36	2.49	2.64
Condenser inlet pressure	bar	23.3	24.4	25.4	26.5	27.5	28.6	29.6	30.7
Evaporator inlet temperature	° C.	−37.0	−37.7	−38.3	−39.0	−39.6	−40.1	−40.6	−41.1
Evaporator dewpoint	° C.	−23.7	−23.2	−22.9	−22.5	−22.3	−22.0	−21.8	−21.6
Evaporator exit gas temperature	° C.	−18.7	−18.2	−17.9	−17.5	−17.3	−17.0	−16.8	−16.6
Evaporator mean temperature	° C.	−30.3	−30.5	−30.6	−30.8	−30.9	−31.1	−31.2	−31.3
Evaporator glide (out-in)	K	13.3	14.4	15.5	16.4	17.3	18.1	18.9	19.5
Compressor suction pressure	bar	1.71	1.83	1.95	2.08	2.21	2.34	2.48	2.63
Compressor discharge pressure	bar	23.3	24.4	25.4	26.5	27.5	28.6	29.6	30.7
Suction line pressure drop	Pa/m	115	107	100	93	88	83	78	74
Pressure drop relative to reference		39.3%	36.6%	34.2%	32.0%	30.0%	28.3%	26.7%	25.2%
Condenser dew point	° C.	55.1	54.9	54.7	54.4	54.1	53.7	53.2	52.7
Condenser bubble point	° C.	30.9	30.1	29.4	28.8	28.3	27.9	27.5	27.2
Condenser exit liquid temperature	° C.	29.9	29.1	28.4	27.8	27.3	26.9	26.5	26.2
Condenser mean temperature	° C.	43.0	42.5	42.1	41.6	41.2	40.8	40.4	40.0
Condenser glide (in-out)	K	24.2	24.9	25.3	25.6	25.8	25.8	25.7	25.5

TABLE 57

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 15% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/15/30/55	2/15/30/53	4/15/30/51	6/15/30/49	8/15/30/47	10/15/30/45	12/15/30/43	14/15/30/41
COP (heating)		2.18	2.20	2.22	2.24	2.25	2.26	2.27	2.27
COP (heating) relative to Reference		103.2%	104.4%	105.3%	106.1%	106.7%	107.2%	107.5%	107.8%
Volumetric heating capacity at suction	kJ/m^3	1063	1158	1257	1359	1465	1573	1685	1799
Capacity relative to Reference		120.9%	131.8%	143.1%	154.7%	166.7%	179.0%	191.7%	204.7%
Critical temperature	° C.	99.07	96.20	93.47	90.86	88.37	85.99	83.71	81.53
Critical pressure	bar	44.72	45.49	46.26	47.03	47.79	48.55	49.31	50.07
Condenser enthalpy change	kJ/kg	257.1	265.7	273.4	280.3	286.7	292.5	298.0	303.1
Pressure ratio		15.28	15.17	15.00	14.79	14.54	14.27	13.99	13.70
Refrigerant mass flow	kg/hr	28.0	27.1	26.3	25.7	25.1	24.6	24.2	23.8
Compressor discharge temperature	° C.	129.9	133.1	136.1	138.9	141.6	144.1	146.5	148.9
Evaporator inlet pressure	bar	1.01	1.09	1.17	1.26	1.35	1.45	1.56	1.67
Condenser inlet pressure	bar	14.9	16.0	17.1	18.2	19.3	20.4	21.5	22.5
Evaporator inlet temperature	° C.	−31.3	−32.0	−32.6	−33.3	−33.9	−34.6	−35.3	−36.0
Evaporator dewpoint	° C.	−28.3	−27.7	−27.1	−26.5	−25.9	−25.4	−24.8	−24.4
Evaporator exit gas temperature	° C.	−23.3	−22.7	−22.1	−21.5	−20.9	−20.4	−19.8	−19.4
Evaporator mean temperature	° C.	−29.8	−29.8	−29.8	−29.9	−29.9	−30.0	−30.1	−30.2
Evaporator glide (out-in)	K	3.1	4.3	5.5	6.7	8.0	9.2	10.4	11.6
Compressor suction pressure	bar	0.97	1.05	1.14	1.23	1.33	1.43	1.53	1.65
Compressor discharge pressure	bar	14.9	16.0	17.1	18.2	19.3	20.4	21.5	22.5
Suction line pressure drop	Pa/m	230	206	186	169	154	141	130	120
Pressure drop relative to reference		78.8%	70.5%	63.6%	57.7%	52.7%	48.3%	44.5%	41.1%
Condenser dew point	° C.	51.8	52.6	53.2	53.7	54.1	54.4	54.5	54.5
Condenser bubble point	° C.	44.9	42.0	39.6	37.5	35.8	34.3	33.1	32.0
Condenser exit liquid temperature	° C.	43.9	41.0	38.6	36.5	34.8	33.3	32.1	31.0
Condenser mean temperature	° C.	48.3	47.3	46.4	45.6	45.0	44.3	43.8	43.3
Condenser glide (in-out)	K	6.9	10.6	13.7	16.2	18.3	20.0	21.4	22.5

TABLE 58

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 15% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/15/30/39	18/15/30/37	20/15/30/35	22/15/30/33	24/15/30/31	26/15/30/29	28/15/30/27	30/15/30/25
COP (heating)		2.28	2.28	2.28	2.29	2.29	2.29	2.29	2.29
COP (heating) relative to Reference		108.1%	108.2%	108.4%	108.4%	108.5%	108.5%	108.4%	108.4%
Volumetric heating capacity at suction	kJ/m^3	1915	2034	2155	2279	2405	2534	2665	2800
Capacity relative to Reference		218.0%	231.5%	245.3%	259.4%	273.7%	288.4%	303.3%	318.6%
Critical temperature	° C.	79.44	77.44	75.52	73.68	71.90	70.20	68.56	66.98
Critical pressure	bar	50.83	51.59	52.34	53.10	53.85	54.61	55.36	56.12
Condenser enthalpy change	kJ/kg	307.9	312.4	316.7	320.8	324.7	328.4	332.0	335.4
Pressure ratio		13.41	13.12	12.83	12.55	12.28	12.01	11.74	11.49
Refrigerant mass flow	kg/hr	23.4	23.0	22.7	22.4	22.2	21.9	21.7	21.5
Compressor discharge temperature	° C.	151.1	153.3	155.4	157.4	159.4	161.3	163.2	165.0
Evaporator inlet pressure	bar	1.78	1.90	2.02	2.15	2.28	2.42	2.57	2.72
Condenser inlet pressure	bar	23.6	24.7	25.8	26.8	27.9	28.9	30.0	31.0
Evaporator inlet temperature	° C.	−36.6	−37.3	−37.9	−38.5	−39.1	−39.7	−40.2	−40.6
Evaporator dewpoint	° C.	−23.9	−23.5	−23.1	−22.8	−22.5	−22.2	−22.0	−21.8
Evaporator exit gas temperature	° C.	−18.9	−18.5	−18.1	−17.8	−17.5	−17.2	−17.0	−16.8
Evaporator mean temperature	° C.	−30.3	−30.4	−30.5	−30.7	−30.8	−30.9	−31.1	−31.2
Evaporator glide (out-in)	K	12.7	13.8	14.8	15.8	16.7	17.5	18.2	18.8
Compressor suction pressure	bar	1.76	1.88	2.01	2.14	2.27	2.41	2.55	2.70
Compressor discharge pressure	bar	23.6	24.7	25.8	26.8	27.9	28.9	30.0	31.0
Suction line pressure drop	Pa/m	112	104	97	91	85	80	76	72
Pressure drop relative to reference		38.2%	35.6%	33.2%	31.1%	29.2%	27.5%	25.9%	24.5%
Condenser dew point	° C.	54.5	54.3	54.1	53.8	53.5	53.1	52.7	52.2
Condenser bubble point	° C.	31.1	30.3	29.6	29.1	28.6	28.1	27.8	27.5
Condenser exit liquid temperature	° C.	30.1	29.3	28.6	28.1	27.6	27.1	26.8	26.5
Condenser mean temperature	° C.	42.8	42.3	41.9	41.4	41.0	40.6	40.2	39.8
Condenser glide (in-out)	K	23.4	24.0	24.5	24.8	25.0	25.0	24.9	24.7

TABLE 59

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 15% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/15/40/45	2/15/40/43	4/15/40/41	6/15/40/39	8/15/40/37	10/15/40/35	12/15/40/33	14/15/40/31
COP (heating)		2.18	2.21	2.22	2.24	2.25	2.26	2.27	2.28
COP (heating) relative to Reference		103.4%	104.6%	105.5%	106.2%	106.8%	107.3%	107.7%	108.0%
Volumetric heating capacity at suction	kJ/m^3	1089	1186	1286	1390	1498	1608	1722	1838
Capacity relative to Reference		124.0%	135.0%	146.4%	158.2%	170.4%	183.0%	196.0%	209.2%
Critical temperature	° C.	98.43	95.60	92.90	90.33	87.87	85.52	83.27	81.12
Critical pressure	bar	44.98	45.76	46.54	47.32	48.10	48.87	49.64	50.41
Condenser enthalpy change	kJ/kg	259.2	267.8	275.5	282.5	288.8	294.7	300.1	305.1
Pressure ratio		15.09	14.98	14.82	14.61	14.37	14.11	13.83	13.54
Refrigerant mass flow	kg/hr	27.8	26.9	26.1	25.5	24.9	24.4	24.0	23.6
Compressor discharge temperature	° C.	131.0	134.2	137.3	140.1	142.8	145.3	147.7	150.0
Evaporator inlet pressure	bar	1.04	1.11	1.20	1.29	1.38	1.48	1.59	1.70
Condenser inlet pressure	bar	15.1	16.2	17.3	18.4	19.5	20.6	21.7	22.8
Evaporator inlet temperature	° C.	−31.3	−31.8	−32.5	−33.1	−33.7	−34.4	−35.0	−35.7
Evaporator dewpoint	° C.	−28.5	−27.9	−27.3	−26.7	−26.1	−25.6	−25.1	−24.6
Evaporator exit gas temperature	° C.	−23.5	−22.9	−22.3	−21.7	−21.1	−20.6	−20.1	−19.6
Evaporator mean temperature	° C.	−29.9	−29.9	−29.9	−29.9	−29.9	−30.0	−30.1	−30.1
Evaporator glide (out-in)	K	2.8	4.0	5.1	6.4	7.6	8.8	10.0	11.1
Compressor suction pressure	bar	1.00	1.08	1.17	1.26	1.36	1.46	1.57	1.68
Compressor discharge pressure	bar	15.1	16.2	17.3	18.4	19.5	20.6	21.7	22.8
Suction line pressure drop	Pa/m	223	200	180	164	150	137	126	117
Pressure drop relative to reference		76.4%	68.5%	61.8%	56.1%	51.2%	47.0%	43.3%	40.0%
Condenser dew point	° C.	51.2	52.0	52.7	53.2	53.6	53.8	54.0	54.0
Condenser bubble point	° C.	45.0	42.1	39.7	37.6	35.9	34.4	33.2	32.1
Condenser exit liquid temperature	° C.	44.0	41.1	38.7	36.6	34.9	33.4	32.2	31.1
Condenser mean temperature	° C.	48.1	47.1	46.2	45.4	44.7	44.1	43.6	43.1
Condenser glide (in-out)	K	6.1	9.9	13.0	15.5	17.7	19.4	20.8	21.9

TABLE 60

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 15% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/15/40/29	18/15/40/27	20/15/40/25	22/15/40/23	24/15/40/21	26/15/40/19	28/15/40/17	30/15/40/15
COP (heating)		2.28	2.29	2.29	2.29	2.29	2.29	2.29	2.29
COP (heating) relative to Reference		108.2%	108.4%	108.5%	108.6%	108.6%	108.7%	108.6%	108.6%
Volumetric heating capacity at suction	kJ/m^3	1957	2078	2202	2329	2457	2589	2723	2859
Capacity relative to Reference		222.7%	236.5%	250.6%	265.0%	279.7%	294.6%	309.9%	325.4%
Critical temperature	° C.	79.06	77.08	75.19	73.36	71.61	69.93	68.31	66.75
Critical pressure	bar	51.18	51.95	52.72	53.48	54.25	55.02	55.78	56.54
Condenser enthalpy change	kJ/kg	309.9	314.4	318.6	322.6	326.5	330.2	333.7	337.1
Pressure ratio		13.26	12.97	12.68	12.40	12.13	11.86	11.60	11.35
Refrigerant mass flow	kg/hr	23.2	22.9	22.6	22.3	22.1	21.8	21.6	21.4
Compressor discharge temperature	° C.	152.2	154.4	156.4	158.4	160.4	162.3	164.1	165.9
Evaporator inlet pressure	bar	1.82	1.94	2.07	2.20	2.34	2.48	2.62	2.78
Condenser inlet pressure	bar	23.9	25.0	26.0	27.1	28.2	29.2	30.3	31.4
Evaporator inlet temperature	° C.	−36.4	−37.0	−37.6	−38.3	−38.8	−39.4	−39.9	−40.3
Evaporator dewpoint	° C.	−24.1	−23.7	−23.3	−23.0	−22.6	−22.4	−22.1	−21.9
Evaporator exit gas temperature	° C.	−19.1	−18.7	−18.3	−18.0	−17.6	−17.4	−17.1	−16.9
Evaporator mean temperature	° C.	−30.2	−30.3	−30.5	−30.6	−30.7	−30.9	−31.0	−31.1
Evaporator glide (out-in)	K	12.3	13.3	14.3	15.3	16.2	17.0	17.7	18.4
Compressor suction pressure	bar	1.80	1.92	2.05	2.19	2.32	2.46	2.61	2.76
Compressor discharge pressure	bar	23.9	25.0	26.0	27.1	28.2	29.2	30.3	31.4
Suction line pressure drop	Pa/m	109	101	95	89	83	78	74	70
Pressure drop relative to reference		37.2%	34.6%	32.4%	30.3%	28.5%	26.8%	25.3%	23.9%
Condenser dew point	° C.	54.0	53.8	53.6	53.4	53.0	52.7	52.2	51.8
Condenser bubble point	° C.	31.2	30.4	29.8	29.2	28.7	28.3	27.9	27.6
Condenser exit liquid temperature	° C.	30.2	29.4	28.8	28.2	27.7	27.3	26.9	26.6
Condenser mean temperature	° C.	42.6	42.1	41.7	41.3	40.9	40.5	40.1	39.7
Condenser glide (in-out)	K	22.8	23.4	23.9	24.2	24.4	24.4	24.3	24.1

TABLE 61

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 20% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/20/5/75	2/20/5/73	4/20/5/71	6/20/5/69	8/20/5/67	10/20/5/65	12/20/5/63	14/20/5/61
COP (heating)		2.20	2.22	2.24	2.25	2.26	2.27	2.28	2.28
COP (heating) relative to Reference		104.4%	105.4%	106.2%	106.8%	107.3%	107.7%	108.0%	108.3%
Volumetric heating capacity at suction	kJ/m^3	1103	1197	1294	1394	1497	1602	1709	1818
Capacity relative to Reference		125.5%	136.2%	147.3%	158.7%	170.4%	182.3%	194.5%	206.9%
Critical temperature	° C.	98.35	95.65	93.07	90.59	88.21	85.93	83.74	81.64
Critical pressure	bar	45.29	46.10	46.88	47.66	48.43	49.20	49.96	50.71
Condenser enthalpy change	kJ/kg	264.5	272.4	279.5	286.1	292.2	298.0	303.3	308.4
Pressure ratio		15.11	14.95	14.76	14.53	14.29	14.03	13.77	13.50
Refrigerant mass flow	kg/hr	27.2	26.4	25.8	25.2	24.6	24.2	23.7	23.3
Compressor discharge temperature	° C.	131.4	134.4	137.3	140.0	142.6	145.1	147.5	149.9
Evaporator inlet pressure	bar	1.04	1.12	1.20	1.29	1.38	1.48	1.58	1.69
Condenser inlet pressure	bar	15.2	16.3	17.3	18.4	19.4	20.5	21.5	22.5
Evaporator inlet temperature	° C.	−32.2	−32.9	−33.6	−34.3	−35.0	−35.7	−36.4	−37.1
Evaporator dewpoint	° C.	−27.3	−26.7	−26.2	−25.6	−25.0	−24.5	−24.1	−23.6
Evaporator exit gas temperature	° C.	−22.3	−21.7	−21.2	−20.6	−20.0	−19.5	−19.1	−18.6
Evaporator mean temperature	° C.	−29.8	−29.8	−29.9	−29.9	−30.0	−30.1	−30.2	−30.4
Evaporator glide (out-in)	K	4.9	6.2	7.5	8.7	10.0	11.2	12.3	13.5
Compressor suction pressure	bar	1.01	1.09	1.17	1.26	1.36	1.46	1.56	1.67
Compressor discharge pressure	bar	15.2	16.3	17.3	18.4	19.4	20.5	21.5	22.5
Suction line pressure drop	Pa/m	217	196	177	162	148	137	126	117
Pressure drop relative to reference		74.3%	67.0%	60.7%	55.4%	50.8%	46.8%	43.3%	40.2%
Condenser dew point	° C.	52.7	53.4	53.9	54.3	54.6	54.8	54.8	54.8
Condenser bubble point	° C.	43.0	40.5	38.4	36.6	35.0	33.7	32.6	31.6
Condenser exit liquid temperature	° C.	42.0	39.5	37.4	35.6	34.0	32.7	31.6	30.6
Condenser mean temperature	° C.	47.9	46.9	46.2	45.5	44.8	44.2	43.7	43.2
Condenser glide (in-out)	K	9.6	12.8	15.5	17.7	19.6	21.1	22.3	23.2

TABLE 62

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 20% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/20/5/59	18/20/5/57	20/20/5/55	22/20/5/53	24/20/5/51	26/20/5/49	28/20/5/47	30/20/5/45
COP (heating)		2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
COP (heating) relative to Reference		108.4%	108.5%	108.6%	108.6%	108.6%	108.6%	108.5%	108.4%
Volumetric heating capacity at suction	kJ/m^3	1930	2043	2159	2276	2396	2519	2645	2773
Capacity relative to Reference		219.6%	232.5%	245.7%	259.1%	272.7%	286.7%	301.0%	315.6%
Critical temperature	° C.	79.63	77.69	75.84	74.05	72.33	70.67	69.07	67.53
Critical pressure	bar	51.47	52.22	52.97	53.72	54.47	55.22	55.96	56.71
Condenser enthalpy change	kJ/kg	313.2	317.8	322.2	326.4	330.4	334.2	337.9	341.4
Pressure ratio		13.24	12.98	12.72	12.46	12.21	11.96	11.71	11.47
Refrigerant mass flow	kg/hr	23.0	22.7	22.3	22.1	21.8	21.5	21.3	21.1
Compressor discharge temperature	° C.	152.2	154.4	156.5	158.6	160.7	162.7	164.6	166.5
Evaporator inlet pressure	bar	1.80	1.91	2.03	2.15	2.28	2.41	2.55	2.69
Condenser inlet pressure	bar	23.6	24.6	25.6	26.6	27.6	28.7	29.7	30.7
Evaporator inlet temperature	° C.	−37.8	−38.4	−39.0	−39.6	−40.1	−40.6	−41.1	−41.4
Evaporator dewpoint	° C.	−23.2	−22.9	−22.6	−22.3	−22.0	−21.8	−21.6	−21.5
Evaporator exit gas temperature	° C.	−18.2	−17.9	−17.6	−17.3	−17.0	−16.8	−16.6	−16.5
Evaporator mean temperature	° C.	−30.5	−30.6	−30.8	−30.9	−31.1	−31.2	−31.3	−31.5
Evaporator glide (out-in)	K	14.5	15.5	16.5	17.3	18.1	18.8	19.4	20.0
Compressor suction pressure	bar	1.78	1.89	2.01	2.14	2.26	2.40	2.53	2.68
Compressor discharge pressure	bar	23.6	24.6	25.6	26.6	27.6	28.7	29.7	30.7
Suction line pressure drop	Pa/m	109	102	96	90	85	80	75	71
Pressure drop relative to reference		37.4%	34.9%	32.7%	30.7%	28.9%	27.3%	25.8%	24.4%
Condenser dew point	° C.	54.7	54.5	54.3	53.9	53.6	53.1	52.7	52.2
Condenser bubble point	° C.	30.7	30.0	29.3	28.8	28.3	27.9	27.5	27.2
Condenser exit liquid temperature	° C.	29.7	29.0	28.3	27.8	27.3	26.9	26.5	26.2
Condenser mean temperature	° C.	42.7	42.2	41.8	41.3	40.9	40.5	40.1	39.7
Condenser glide (in-out)	K	24.0	24.5	24.9	25.2	25.3	25.3	25.2	25.0

TABLE 63

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 20% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/20/10/70	2/20/10/68	4/20/10/66	6/20/10/64	8/20/10/64	10/20/10/60	12/20/10/58	14/20/10/56
COP (heating)		2.20	2.22	2.24	2.25	2.26	2.27	2.28	2.28
COP (heating) relative to Reference		104.5%	105.5%	106.2%	106.9%	107.4%	107.8%	108.1%	108.3%
Volumetric heating capacity at suction	kJ/m^3	1119	1214	1312	1413	1517	1624	1732	1843
Capacity relative to Reference		127.4%	138.2%	149.3%	160.9%	172.7%	184.8%	197.1%	209.7%
Critical temperature	° C.	98.06	95.36	92.78	90.31	87.94	85.67	83.49	81.41
Critical pressure	bar	45.53	46.31	47.09	47.87	48.63	49.40	50.16	50.91
Condenser enthalpy change	kJ/kg	265.2	273.1	280.3	286.8	292.9	298.6	304.0	309.0
Pressure ratio		14.98	14.83	14.64	14.42	14.17	13.92	13.66	13.39
Refrigerant mass flow	kg/hr	27.1	26.4	25.7	25.1	24.6	24.1	23.7	23.3
Compressor discharge temperature	° C.	131.9	134.9	137.8	140.5	143.1	145.6	148.0	150.3
Evaporator inlet pressure	bar	1.06	1.14	1.22	1.31	1.40	1.50	1.61	1.71
Condenser inlet pressure	bar	15.3	16.4	17.4	18.5	19.5	20.6	21.6	22.7
Evaporator inlet temperature	° C.	−32.2	−32.8	−33.5	−34.2	−34.8	−35.5	−36.2	−36.9
Evaporator dewpoint	° C.	−27.4	−26.9	−26.3	−25.7	−25.2	−24.7	−24.2	−23.8
Evaporator exit gas temperature	° C.	−22.4	−21.9	−21.3	−20.7	−20.2	−19.7	−19.2	−18.8
Evaporator mean temperature	° C.	−29.8	−29.8	−29.9	−29.9	−30.0	−30.1	−30.2	−30.3
Evaporator glide (out-in)	K	4.7	6.0	7.2	8.4	9.7	10.8	12.0	13.1
Compressor suction pressure	bar	1.02	1.10	1.19	1.28	1.38	1.48	1.58	1.69
Compressor discharge pressure	bar	15.3	16.4	17.4	18.5	19.5	20.6	21.6	22.7
Suction line pressure drop	Pa/m	213	192	175	159	146	135	124	116
Pressure drop relative to reference		73.1%	65.9%	59.8%	54.5%	50.0%	46.1%	42.6%	39.6%
Condenser dew point	° C.	52.4	53.0	53.6	54.0	54.2	54.4	54.5	54.4
Condenser bubble point	° C.	43.2	40.7	38.6	36.8	35.2	33.9	32.7	31.8
Condenser exit liquid temperature	° C.	42.2	39.7	37.6	35.8	34.2	32.9	31.7	30.8
Condenser mean temperature	° C.	47.8	46.9	46.1	45.4	44.7	44.1	43.6	43.1
Condenser glide (in-out)	K	9.1	12.3	15.0	17.2	19.0	20.5	21.7	22.7

TABLE 64

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 20% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/20/10/54	18/20/10/52	20/20/10/50	22/20/10/48	24/20/10/46	26/20/10/44	28/20/10/42	30/20/10/40
COP (heating)		2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
COP (heating) relative to Reference		108.5%	108.6%	108.6%	108.7%	108.7%	108.6%	108.6%	108.5%
Volumetric heating capacity at suction	kJ/m^3	1956	2071	2189	2309	2431	2556	2684	2816
Capacity relative to Reference		222.6%	235.7%	249.1%	262.8%	276.7%	290.9%	305.5%	320.4%
Critical temperature	° C.	79.40	77.48	75.63	73.85	72.14	70.50	68.91	67.38
Critical pressure	bar	51.67	52.42	53.17	53.93	54.68	55.43	56.18	56.93
Condenser enthalpy change	kJ/kg	313.8	318.3	322.6	326.8	330.7	334.5	338.1	341.5
Pressure ratio		13.13	12.87	12.60	12.35	12.09	11.84	11.59	11.35
Refrigerant mass flow	kg/hr	22.9	22.6	22.3	22.0	21.8	21.5	21.3	21.1
Compressor discharge temperature	° C.	152.6	154.8	156.9	159.0	161.0	162.9	164.8	166.6
Evaporator inlet pressure	bar	1.83	1.94	2.06	2.19	2.32	2.45	2.59	2.74
Condenser inlet pressure	bar	23.7	24.8	25.8	26.8	27.8	28.9	29.9	30.9
Evaporator inlet temperature	° C.	−37.5	−38.1	−38.7	−39.3	−39.8	−40.3	−40.7	−41.1
Evaporator dewpoint	° C.	−23.4	−23.0	−22.7	−22.4	−22.2	−22.0	−21.8	−21.6
Evaporator exit gas temperature	° C.	−18.4	−18.0	−17.7	−17.4	−17.2	−17.0	−16.8	−16.6
Evaporator mean temperature	° C.	−30.4	−30.6	−30.7	−30.9	−31.0	−31.1	−31.2	−31.4
Evaporator glide (out-in)	K	14.1	15.1	16.0	16.9	17.6	18.3	18.9	19.5
Compressor suction pressure	bar	1.81	1.92	2.05	2.17	2.30	2.44	2.58	2.73
Compressor discharge pressure	bar	23.7	24.8	25.8	26.8	27.8	28.9	29.9	30.9
Suction line pressure drop	Pa/m	108	101	94	88	83	78	74	70
Pressure drop relative to reference		36.9%	34.4%	32.2%	30.3%	28.5%	26.9%	25.4%	24.0%
Condenser dew point	° C.	54.3	54.1	53.9	53.6	53.2	52.8	52.3	51.8
Condenser bubble point	° C.	30.9	30.2	29.5	29.0	28.5	28.1	27.7	27.4
Condenser exit liquid temperature	° C.	29.9	29.2	28.5	28.0	27.5	27.1	26.7	26.4
Condenser mean temperature	° C.	42.6	42.2	41.7	41.3	40.9	40.4	40.0	39.6
Condenser glide (in-out)	K	23.4	24.0	24.4	24.6	24.7	24.7	24.6	24.4

TABLE 65

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 20% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/20/20/60	2/20/20/58	4/20/20/56	6/20/20/54	8/20/20/52	10/20/20/50	12/20/20/48	14/20/20/46
COP (heating)		2.20	2.23	2.24	2.25	2.27	2.27	2.28	2.29
COP (heating) relative to Reference		104.6%	105.5%	106.3%	106.9%	107.4%	107.8%	108.1%	108.4%
Volumetric heating capacity at suction	kJ/m^3	1150	1247	1347	1449	1556	1664	1776	1890
Capacity relative to Reference		130.9%	141.9%	153.3%	165.0%	177.0%	189.4%	202.1%	215.1%
Critical temperature	° C.	97.47	94.79	92.23	89.78	87.43	85.19	83.03	80.97
Critical pressure	bar	45.91	46.68	47.46	48.23	48.99	49.76	50.52	51.28
Condenser enthalpy change	kJ/kg	266.8	274.7	281.9	288.5	294.5	300.2	305.5	310.5
Pressure ratio		14.75	14.61	14.42	14.21	13.98	13.72	13.46	13.20
Refrigerant mass flow	kg/hr	27.0	26.2	25.5	25.0	24.4	24.0	23.6	23.2
Compressor discharge temperature	° C.	132.9	135.9	138.8	141.5	144.1	146.6	149.0	151.3
Evaporator inlet pressure	bar	1.09	1.17	1.25	1.35	1.44	1.54	1.65	1.76
Condenser inlet pressure	bar	15.6	16.6	17.7	18.7	19.8	20.9	21.9	23.0
Evaporator inlet temperature	° C.	−32.0	−32.6	−33.2	−33.9	−34.5	−35.2	−35.8	−36.4
Evaporator dewpoint	° C.	−27.7	−27.1	−26.5	−26.0	−25.5	−25.0	−24.5	−24.1
Evaporator exit gas temperature	° C.	−22.7	−22.1	−21.5	−21.0	−20.5	−20.0	−19.5	−19.1
Evaporator mean temperature	° C.	−29.8	−29.9	−29.9	−29.9	−30.0	−30.1	−30.2	−30.3
Evaporator glide (out-in)	K	4.3	5.5	6.7	7.9	9.1	10.2	11.3	12.4
Compressor suction pressure	bar	1.05	1.14	1.23	1.32	1.42	1.52	1.63	1.74
Compressor discharge pressure	bar	15.6	16.6	17.7	18.7	19.8	20.9	21.9	23.0
Suction line pressure drop	Pa/m	207	187	169	155	142	131	121	112
Pressure drop relative to reference		70.8%	63.9%	58.0%	53.0%	48.6%	44.8%	41.4%	38.5%
Condenser dew point	° C.	51.7	52.4	52.9	53.3	53.6	53.7	53.8	53.8
Condenser bubble point	° C.	43.5	41.0	38.9	37.1	35.5	34.2	33.0	32.0
Condenser exit liquid temperature	° C.	42.5	40.0	37.9	36.1	34.5	33.2	32.0	31.0
Condenser mean temperature	° C.	47.6	46.7	45.9	45.2	44.5	44.0	43.4	42.9
Condenser glide (in-out)	K	8.2	11.3	14.0	16.2	18.1	19.6	20.8	21.7

TABLE 66

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 20% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/20/20/44	18/20/20/42	20/20/20/40	22/20/20/38	24/20/20/38	26/20/20/34	28/20/20/32	30/20/20/30
COP (heating)		2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
COP (heating) relative to Reference		108.6%	108.7%	108.8%	108.8%	108.8%	108.8%	108.8%	108.7%
Volumetric heating capacity at suction	kJ/m^3	2006	2125	2246	2370	2496	2626	2758	2894
Capacity relative to Reference		228.3%	241.8%	255.6%	269.7%	284.1%	298.8%	313.9%	329.3%
Critical temperature	° C.	78.99	77.09	75.26	73.50	71.81	70.18	68.61	67.10
Critical pressure	bar	52.04	52.80	53.56	54.32	55.07	55.83	56.59	57.34
Condenser enthalpy change	kJ/kg	315.2	319.6	323.8	327.9	331.7	335.4	338.9	342.2
Pressure ratio		12.93	12.67	12.41	12.15	11.89	11.64	11.39	11.14
Refrigerant mass flow	kg/hr	22.8	22.5	22.2	22.0	21.7	21.5	21.2	21.0
Compressor discharge temperature	° C.	153.5	155.6	157.7	159.7	161.6	163.5	165.4	167.1
Evaporator inlet pressure	bar	1.88	2.00	2.12	2.25	2.39	2.53	2.67	2.82
Condenser inlet pressure	bar	24.0	25.1	26.1	27.2	28.2	29.2	30.3	31.3
Evaporator inlet temperature	° C.	−37.1	−37.6	−38.2	−38.8	−39.3	−39.7	−40.1	−40.5
Evaporator dewpoint	° C.	−23.7	−23.3	−23.0	−22.7	−22.5	−22.2	−22.0	−21.9
Evaporator exit gas temperature	° C.	−18.7	−18.3	−18.0	−17.7	−17.5	−17.2	−17.0	−16.9
Evaporator mean temperature	° C.	−30.4	−30.5	−30.6	−30.7	−30.9	−31.0	−31.1	−31.2
Evaporator glide (out-in)	K	13.4	14.3	15.2	16.0	16.8	17.5	18.1	18.6
Compressor suction pressure	bar	1.86	1.98	2.11	2.24	2.37	2.51	2.66	2.81
Compressor discharge pressure	bar	24.0	25.1	26.1	27.2	28.2	29.2	30.3	31.3
Suction line pressure drop	Pa/m	105	98	92	86	81	76	72	68
Pressure drop relative to reference		35.8%	33.5%	31.3%	29.4%	27.7%	26.1%	24.7%	23.3%
Condenser dew point	° C.	53.7	53.5	53.3	53.0	52.6	52.2	51.8	51.3
Condenser bubble point	° C.	31.2	30.5	29.8	29.3	28.8	28.4	28.1	27.8
Condenser exit liquid temperature	° C.	30.2	29.5	28.8	28.3	27.8	27.4	27.1	26.8
Condenser mean temperature	° C.	42.4	42.0	41.5	41.1	40.7	40.3	39.9	39.5
Condenser glide (in-out)	K	22.5	23.0	23.4	23.7	23.8	23.8	23.7	23.5

TABLE 67

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 20% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/20/30/50	2/20/30/48	4/20/30/46	6/20/30/44	8/20/30/42	10/20/30/40	12/20/30/38	14/20/30/36
COP (heating)		2.21	2.23	2.24	2.26	2.27	2.28	2.28	2.29
COP (heating) relative to Reference		104.7%	105.7%	106.4%	107.0%	107.5%	107.9%	108.3%	108.5%
Volumetric heating capacity at suction	kJ/m^3	1178	1276	1378	1482	1590	1702	1815	1932
Capacity relative to Reference		134.1%	145.2%	156.8%	168.7%	181.0%	193.6%	206.6%	219.9%
Critical temperature	° C.	96.89	94.24	91.70	89.28	86.96	84.74	82.61	80.57
Critical pressure	bar	46.18	46.96	47.74	48.51	49.29	50.06	50.83	51.60
Condenser enthalpy change	kJ/kg	268.7	276.6	283.8	290.4	296.5	302.1	307.4	312.3
Pressure ratio		14.56	14.42	14.24	14.04	13.81	13.56	13.30	13.04
Refrigerant mass flow	kg/hr	26.8	26.0	25.4	24.8	24.3	23.8	23.4	23.1
Compressor discharge temperature	° C.	134.0	137.1	139.9	142.7	145.3	147.7	150.1	152.3
Evaporator inlet pressure	bar	1.12	1.20	1.28	1.38	1.48	1.58	1.69	1.80
Condenser inlet pressure	bar	15.8	16.8	17.9	19.0	20.0	21.1	22.2	23.2
Evaporator inlet temperature	° C.	−31.8	−32.4	−33.0	−33.6	−34.3	−34.9	−35.5	−36.1
Evaporator dewpoint	° C.	−27.9	−27.4	−26.8	−26.3	−25.7	−25.2	−24.8	−24.3
Evaporator exit gas temperature	° C.	−22.9	−22.4	−21.8	−21.3	−20.7	−20.2	−19.8	−19.3
Evaporator mean temperature	° C.	−29.9	−29.9	−29.9	−30.0	−30.0	−30.1	−30.1	−30.2
Evaporator glide (out-in)	K	3.9	5.1	6.2	7.4	8.5	9.6	10.7	11.8
Compressor suction pressure	bar	1.08	1.17	1.26	1.35	1.45	1.56	1.67	1.78
Compressor discharge pressure	bar	15.8	16.8	17.9	19.0	20.0	21.1	22.2	23.2
Suction line pressure drop	Pa/m	201	181	165	151	138	127	118	109
Pressure drop relative to reference		68.8%	62.1%	56.4%	51.5%	47.3%	43.6%	40.3%	37.4%
Condenser dew point	° C.	51.1	51.7	52.3	52.7	53.0	53.1	53.2	53.2
Condenser bubble point	° C.	43.8	41.2	39.1	37.3	35.7	34.4	33.2	32.2
Condenser exit liquid temperature	° C.	42.8	40.2	38.1	36.3	34.7	33.4	32.2	31.2
Condenser mean temperature	° C.	47.4	46.5	45.7	45.0	44.3	43.8	43.2	42.7
Condenser glide (in-out)	K	7.3	10.5	13.2	15.4	17.3	18.8	20.0	21.0

TABLE 68

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 20% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/20/30/34	18/20/20/32	20/20/30/30	22/20/30/28	24/20/30/26	26/20/30/24	28/20/30/22	30/20/30/20
COP (heating)		2.29	2.29	2.30	2.30	2.30	2.30	2.30	2.30
COP (heating) relative to Reference		108.7%	108.8%	108.9%	109.0%	109.0%	109.0%	109.0%	108.9%
Volumetric heating capacity at suction	kJ/m^3	2051	2173	2297	2424	2554	2686	2822	2961
Capacity relative to Reference		233.4%	247.3%	261.4%	275.9%	290.7%	305.7%	321.2%	336.9%
Critical temperature	° C.	78.61	76.73	74.93	73.19	71.52	69.91	68.36	66.86
Critical pressure	bar	52.37	53.14	53.91	54.67	55.44	56.21	56.97	57.74
Condenser enthalpy change	kJ/kg	316.9	321.3	325.5	329.5	333.2	336.8	340.3	343.5
Pressure ratio		12.77	12.51	12.24	11.98	11.73	11.48	11.23	10.99
Refrigerant mass flow	kg/hr	22.7	22.4	22.1	21.9	21.6	21.4	21.2	21.0
Compressor discharge temperature	° C.	154.5	156.6	158.6	160.6	162.5	164.4	166.2	167.9
Evaporator inlet pressure	bar	1.92	2.04	2.17	2.31	2.45	2.59	2.74	2.89
Condenser inlet pressure	bar	24.3	25.4	26.4	27.5	28.5	29.6	30.6	31.7
Evaporator inlet temperature	° C.	−36.7	−37.3	−37.8	−38.3	−38.8	−39.3	−39.7	−40.1
Evaporator dewpoint	° C.	−23.9	−23.6	−23.2	−22.9	−22.7	−22.5	−22.3	−22.1
Evaporator exit gas temperature	° C.	−18.9	−18.6	−18.2	−17.9	−17.7	−17.5	−17.3	−17.1
Evaporator mean temperature	° C.	−30.3	−30.4	−30.5	−30.6	−30.8	−30.9	−31.0	−31.1
Evaporator glide (out-in)	K	12.8	13.7	14.6	15.4	16.2	16.8	17.4	18.0
Compressor suction pressure	bar	1.90	2.03	2.16	2.29	2.43	2.58	2.73	2.88
Compressor discharge pressure	bar	24.3	25.4	26.4	27.5	28.5	29.6	30.6	31.7
Suction line pressure drop	Pa/m	102	95	89	84	79	74	70	66
Pressure drop relative to reference		34.9%	32.6%	30.5%	28.7%	27.0%	25.4%	24.0%	22.7%
Condenser dew point	° C.	53.1	53.0	52.7	52.4	52.1	51.7	51.3	50.8
Condenser bubble point	° C.	31.4	30.7	30.0	29.5	29.0	28.6	28.3	28.0
Condenser exit liquid temperature	° C.	30.4	29.7	29.0	28.5	28.0	27.6	27.3	27.0
Condenser mean temperature	° C.	42.3	41.8	41.4	41.0	40.6	40.2	39.8	39.4
Condenser glide (in-out)	K	21.7	22.3	22.7	23.0	23.1	23.1	23.0	22.8

TABLE 69

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 20% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/20/40/40	2/20/40/38	4/20/40/36	6/20/40/34	8/20/40/32	10/20/40/30	12/20/40/28	14/20/40/26
COP (heating)		2.21	2.23	2.24	2.26	2.27	2.28	2.28	2.29
COP (heating) relative to Reference		104.9%	105.7%	106.4%	107.0%	107.5%	107.9%	108.3%	108.5%
Volumetric heating capacity at suction	kJ/m^3	1202	1276	1378	1482	1590	1702	1815	1932
Capacity relative to Reference		136.8%	145.2%	156.8%	168.7%	181.0%	193.6%	206.6%	219.9%
Critical temperature	° C.	96.33	94.24	91.70	89.28	86.96	84.74	82.61	80.57
Critical pressure	bar	46.37	46.96	47.74	48.51	49.29	50.06	50.83	51.60
Condenser enthalpy change	kJ/kg	270.8	276.6	283.8	290.4	296.5	302.1	307.4	312.3
Pressure ratio		14.39	14.42	14.24	14.04	13.81	13.56	13.30	13.04
Refrigerant mass flow	kg/hr	26.6	26.0	25.4	24.8	24.3	23.8	23.4	23.1
Compressor discharge temperature	° C.	135.2	137.1	139.9	142.7	145.3	147.7	150.1	152.3
Evaporator inlet pressure	bar	1.14	1.20	1.28	1.38	1.48	1.58	1.69	1.80
Condenser inlet pressure	bar	15.9	16.8	17.9	19.0	20.0	21.1	22.2	23.2
Evaporator inlet temperature	° C.	−31.7	−32.4	−33.0	−33.6	−34.3	−34.9	−35.5	−36.1
Evaporator dewpoint	° C.	−28.1	−27.4	−26.8	−26.3	−25.7	−25.2	−24.8	−24.3
Evaporator exit gas temperature	° C.	−23.1	−22.4	−21.8	−21.3	−20.7	−20.2	−19.8	−19.3
Evaporator mean temperature	° C.	−29.9	−29.9	−29.9	−30.0	−30.0	−30.1	−30.1	−30.2
Evaporator glide (out-in)	K	3.6	5.1	6.2	7.4	8.5	9.6	10.7	11.8
Compressor suction pressure	bar	1.11	1.17	1.26	1.35	1.45	1.56	1.67	1.78
Compressor discharge pressure	bar	15.9	16.8	17.9	19.0	20.0	21.1	22.2	23.2
Suction line pressure drop	Pa/m	196	181	165	151	138	127	118	109
Pressure drop relative to reference		67.0%	62.1%	56.4%	51.5%	47.3%	43.6%	40.3%	37.4%
Condenser dew point	° C.	50.5	51.7	52.3	52.7	53.0	53.1	53.2	53.2
Condenser bubble point	° C.	44.0	41.3	39.1	37.3	35.7	34.4	33.2	32.2
Condenser exit liquid temperature	° C.	43.0	40.3	38.1	36.3	34.7	33.4	32.2	31.2
Condenser mean temperature	° C.	47.2	46.5	45.7	45.0	44.3	43.8	43.2	42.7
Condenser glide (in-out)	K	6.5	10.5	13.2	15.4	17.3	18.8	20.0	21.0

TABLE 70

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 20% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/20/40/24	18/20/40/22	20/20/40/20	22/20/40/18	24/20/40/16	26/20/40/14	28/20/40/12	30/20/40/10
COP (heating)		2.29	2.29	2.30	2.30	2.30	2.30	2.30	2.30
COP (heating) relative to Reference		108.7%	108.8%	108.9%	109.0%	109.0%	109.0%	109.0%	108.9%
Volumetric heating capacity at suction	kJ/m^3	2051	2173	2297	2424	2554	2686	2822	2961
Capacity relative to Reference		233.4%	247.3%	261.4%	275.9%	290.7%	305.7%	321.2%	336.9%
Critical temperature	° C.	78.61	76.73	74.93	73.19	71.52	69.91	68.36	66.86
Critical pressure	bar	52.37	53.14	53.91	54.67	55.44	56.21	56.97	57.74
Condenser enthalpy change	kJ/kg	316.9	321.3	325.5	329.5	333.2	336.8	340.3	343.5
Pressure ratio		12.77	12.51	12.24	11.98	11.73	11.48	11.23	10.99
Refrigerant mass flow	kg/hr	22.7	22.4	22.1	21.9	21.6	21.4	21.2	21.0
Compressor discharge temperature	° C.	154.5	156.6	158.6	160.6	162.5	164.4	166.2	167.9
Evaporator inlet pressure	bar	1.92	2.04	2.17	2.31	2.45	2.59	2.74	2.89
Condenser inlet pressure	bar	24.3	25.4	26.4	27.5	28.5	29.6	30.6	31.7
Evaporator inlet temperature	° C.	−36.7	−37.3	−37.8	−38.3	−38.8	−39.3	−39.7	−40.1
Evaporator dewpoint	° C.	−23.9	−23.6	−23.2	−22.9	−22.7	−22.5	−22.3	−22.1
Evaporator exit gas temperature	° C.	−18.9	−18.6	−18.2	−17.9	−17.7	−17.5	−17.3	−17.1
Evaporator mean temperature	° C.	−30.3	−30.4	−30.5	−30.6	−30.8	−30.9	−31.0	−31.1
Evaporator glide (out-in)	K	12.8	13.7	14.6	15.4	16.2	16.8	17.4	18.0
Compressor suction pressure	bar	1.90	2.03	2.16	2.29	2.43	2.58	2.73	2.88
Compressor discharge pressure	bar	24.3	25.4	26.4	27.5	28.5	29.6	30.6	31.7
Suction line pressure drop	Pa/m	102	95	89	84	79	74	70	66
Pressure drop relative to reference		34.9%	32.6%	30.5%	28.7%	27.0%	25.4%	24.0%	22.7%
Condenser dew point	° C.	53.1	53.0	52.7	52.4	52.1	51.7	51.3	50.8
Condenser bubble point	° C.	31.4	30.7	30.0	29.5	29.0	28.6	28.3	28.0
Condenser exit liquid temperature	° C.	30.4	29.7	29.0	28.5	28.0	27.6	27.3	27.0
Condenser mean temperature	° C.	42.3	41.8	41.4	41.0	40.6	40.2	39.8	39.4
Condenser glide (in-out)	K	21.7	22.3	22.7	23.0	23.1	23.1	23.0	22.8

TABLE 71

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 25% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/25/5/70	2/25/5/68	4/25/5/66	6/25/5/64	8/25/5/62	10/25/5/60	12/25/5/58	14/25/5/56
COP (heating)		2.23	2.25	2.26	2.27	2.28	2.29	2.29	2.29
COP (heating) relative to Reference		105.7%	106.5%	107.2%	107.7%	108.1%	108.4%	108.7%	108.8%
Volumetric heating capacity at suction	kJ/m^3	1221	1318	1418	1520	1624	1732	1841	1953
Capacity relative to Reference		139.0%	150.0%	161.3%	172.9%	184.9%	197.1%	209.5%	222.3%
Critical temperature	° C.	96.21	93.71	91.30	89.00	86.78	84.66	82.62	80.65
Critical pressure	bar	46.83	47.63	48.42	49.20	49.98	50.75	51.52	52.29
Condenser enthalpy change	kJ/kg	275.4	282.8	289.6	295.9	301.8	307.3	312.5	317.4
Pressure ratio		14.37	14.20	14.01	13.80	13.58	13.34	13.10	12.86
Refrigerant mass flow	kg/hr	26.1	25.5	24.9	24.3	23.9	23.4	23.0	22.7
Compressor discharge temperature	° C.	135.4	138.2	141.0	143.7	146.2	148.7	151.0	153.3
Evaporator inlet pressure	bar	1.15	1.23	1.32	1.41	1.51	1.61	1.72	1.83
Condenser inlet pressure	bar	16.1	17.1	18.1	19.2	20.2	21.2	22.2	23.3
Evaporator inlet temperature	° C.	−32.8	−33.4	−34.0	−34.7	−35.3	−35.9	−36.5	−37.1
Evaporator dewpoint	° C.	−26.9	−26.4	−25.9	−25.4	−24.9	−24.5	−24.0	−23.7
Evaporator exit gas temperature	° C.	−21.9	−21.4	−20.9	−20.4	−19.9	−19.5	−19.0	−18.7
Evaporator mean temperature	° C.	−29.9	−29.9	−30.0	−30.0	−30.1	−30.2	−30.3	−30.4
Evaporator glide (out-in)	K	5.9	7.0	8.2	9.3	10.4	11.5	12.5	13.5
Compressor suction pressure	bar	1.12	1.20	1.29	1.39	1.49	1.59	1.70	1.81
Compressor discharge pressure	bar	16.1	17.1	18.1	19.2	20.2	21.2	22.2	23.3
Suction line pressure drop	Pa/m	190	173	158	145	133	124	115	107
Pressure drop relative to reference		65.1%	59.1%	54.0%	49.6%	45.7%	42.3%	39.3%	36.6%
Condenser dew point	° C.	51.9	52.5	52.9	53.2	53.4	53.5	53.5	53.4
Condenser bubble point	° C.	42.2	40.0	38.1	36.5	35.1	33.9	32.8	31.9
Condenser exit liquid temperature	° C.	41.2	39.0	37.1	35.5	34.1	32.9	31.8	30.9
Condenser mean temperature	° C.	47.1	46.2	45.5	44.8	44.2	43.7	43.1	42.6
Condenser glide (in-out)	K	9.7	12.5	14.8	16.7	18.3	19.6	20.7	21.5

TABLE 72

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 25% R-32 and 5% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/25/5/54	18/25/5/52	20/25/5/50	22/25/5/48	24/25/5/46	26/25/5/44	28/25/5/42	30/25/5/40
COP (heating)		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
COP (heating) relative to Reference		109.0%	109.0%	109.1%	109.1%	109.1%	109.0%	109.0%	108.9%
Volumetric heating capacity at suction	kJ/m^3	2067	2184	2303	2425	2549	2677	2808	2942
Capacity relative to Reference		235.3%	248.6%	262.1%	276.0%	290.1%	304.6%	319.5%	334.8%
Critical temperature	° C.	78.77	76.95	75.20	73.52	71.90	70.33	68.83	67.37
Critical pressure	bar	53.05	53.82	54.58	55.34	56.10	56.86	57.62	58.38
Condenser enthalpy change	kJ/kg	322.0	326.5	330.7	334.7	338.6	342.2	345.7	349.0
Pressure ratio		12.62	12.37	12.13	11.89	11.65	11.41	11.18	10.95
Refrigerant mass flow	kg/hr	22.4	22.1	21.8	21.5	21.3	21.0	20.8	20.6
Compressor discharge temperature	° C.	155.5	157.7	159.7	161.8	163.7	165.6	167.4	169.2
Evaporator inlet pressure	bar	1.94	2.06	2.18	2.31	2.45	2.58	2.73	2.88
Condenser inlet pressure	bar	24.3	25.3	26.3	27.3	28.3	29.4	30.4	31.4
Evaporator inlet temperature	° C.	−37.7	−38.2	−38.8	−39.2	−39.7	−40.0	−40.4	−40.7
Evaporator dewpoint	° C.	−23.3	−23.0	−22.7	−22.5	−22.3	−22.1	−22.0	−21.8
Evaporator exit gas temperature	° C.	−18.3	−18.0	−17.7	−17.5	−17.3	−17.1	−17.0	−16.8
Evaporator mean temperature	° C.	−30.5	−30.6	−30.7	−30.9	−31.0	−31.1	−31.2	−31.3
Evaporator glide (out-in)	K	14.4	15.2	16.0	16.7	17.4	17.9	18.4	18.9
Compressor suction pressure	bar	1.92	2.04	2.17	2.30	2.43	2.57	2.72	2.87
Compressor discharge pressure	bar	24.3	25.3	26.3	27.3	28.3	29.4	30.4	31.4
Suction line pressure drop	Pa/m	100	94	88	83	78	74	70	66
Pressure drop relative to reference		34.2%	32.0%	30.1%	28.3%	26.7%	25.2%	23.9%	22.6%
Condenser dew point	° C.	53.3	53.0	52.8	52.4	52.1	51.7	51.2	50.7
Condenser bubble point	° C.	31.1	30.4	29.8	29.3	28.8	28.5	28.1	27.9
Condenser exit liquid temperature	° C.	30.1	29.4	28.8	28.3	27.8	27.5	27.1	26.9
Condenser mean temperature	° C.	42.2	41.7	41.3	40.9	40.5	40.1	39.7	39.3
Condenser glide (in-out)	K	22.2	22.6	23.0	23.2	23.2	23.2	23.1	22.8

TABLE 73

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 25% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/25/10/65	2/25/10/63	4/25/10/61	6/25/10/59	8/25/10/57	10/25/10/55	12/25/10/53	14/25/10/51
COP (heating)		2.23	2.25	2.26	2.27	2.28	2.29	2.29	2.30
COP (heating) relative to Reference		105.8%	106.6%	107.2%	107.7%	108.1%	108.4%	108.7%	108.9%
Volumetric heating capacity at suction	kJ/m^3	1237	1335	1435	1538	1644	1753	1864	1977
Capacity relative to Reference		140.8%	151.9%	163.3%	175.0%	187.1%	199.5%	212.1%	225.1%
Critical temperature	° C.	95.95	93.44	91.04	88.74	86.54	84.42	82.39	80.44
Critical pressure	bar	47.01	47.80	48.58	49.36	50.14	50.91	51.68	52.45
Condenser enthalpy change	kJ/kg	276.2	283.6	290.4	296.7	302.5	308.0	313.2	318.0
Pressure ratio		14.26	14.10	13.91	13.71	13.48	13.25	13.01	12.77
Refrigerant mass flow	kg/hr	26.1	25.4	24.8	24.3	23.8	23.4	23.0	22.6
Compressor discharge temperature	° C.	135.9	138.8	141.5	144.2	146.7	149.1	151.5	153.7
Evaporator inlet pressure	bar	1.17	1.25	1.34	1.43	1.53	1.63	1.74	1.85
Condenser inlet pressure	bar	16.2	17.2	18.3	19.3	20.3	21.4	22.4	23.4
Evaporator inlet temperature	° C.	−32.7	−33.3	−33.9	−34.5	−35.1	−35.7	−36.3	−36.9
Evaporator dewpoint	° C.	−27.1	−26.5	−26.0	−25.5	−25.1	−24.6	−24.2	−23.8
Evaporator exit gas temperature	° C.	−22.1	−21.5	−21.0	−20.5	−20.1	−19.6	−19.2	−18.8
Evaporator mean temperature	° C.	−29.9	−29.9	−30.0	−30.0	−30.1	−30.2	−30.3	−30.4
Evaporator glide (out-in)	K	5.6	6.7	7.9	9.0	10.0	11.1	12.1	13.0
Compressor suction pressure	bar	1.14	1.22	1.31	1.41	1.51	1.61	1.72	1.83
Compressor discharge pressure	bar	16.2	17.2	18.3	19.3	20.3	21.4	22.4	23.4
Suction line pressure drop	Pa/m	187	170	155	143	132	122	113	105
Pressure drop relative to reference		64.1%	58.3%	53.2%	48.9%	45.1%	41.7%	38.7%	36.1%
Condenser dew point	° C.	51.6	52.1	52.5	52.8	53.0	53.1	53.1	53.1
Condenser bubble point	° C.	42.4	40.2	38.3	36.6	35.2	34.0	33.0	32.1
Condenser exit liquid temperature	° C.	41.4	39.2	37.3	35.6	34.2	33.0	32.0	31.1
Condenser mean temperature	° C.	47.0	46.1	45.4	44.7	44.1	43.6	43.0	42.6
Condenser glide (in-out)	K	9.2	11.9	14.2	16.2	17.8	19.1	20.2	21.0

TABLE 74

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 25% R-32 and 10% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/25/10/49	18/25/10/47	20/25/10/45	22/25/10/43	24/25/10/41	26/25/10/39	28/25/10/37	30/25/10/35
COP (heating)		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
COP (heating) relative to Reference		109.0%	109.1%	109.1%	109.2%	109.2%	109.1%	109.1%	109.0%
Volumetric heating capacity at suction	kJ/m^3	2093	2212	2333	2457	2584	2714	2847	2983
Capacity relative to Reference		238.3%	251.7%	265.5%	279.6%	294.1%	308.8%	324.0%	339.5%
Critical temperature	° C.	78.56	76.75	75.02	73.34	71.73	70.17	68.67	67.22
Critical pressure	bar	53.21	53.98	54.74	55.51	56.27	57.03	57.80	58.56
Condenser enthalpy change	kJ/kg	322.6	327.0	331.2	335.2	339.0	342.6	346.0	349.2
Pressure ratio		12.52	12.28	12.03	11.79	11.55	11.31	11.08	10.84
Refrigerant mass flow	kg/hr	22.3	22.0	21.7	21.5	21.2	21.0	20.8	20.6
Compressor discharge temperature	° C.	155.9	158.0	160.1	162.1	164.0	165.9	167.7	169.4
Evaporator inlet pressure	bar	1.97	2.09	2.22	2.35	2.48	2.62	2.77	2.93
Condenser inlet pressure	bar	24.4	25.5	26.5	27.5	28.5	29.5	30.6	31.6
Evaporator inlet temperature	° C.	−37.4	−38.0	−38.5	−38.9	−39.3	−39.7	−40.1	−40.3
Evaporator dewpoint	° C.	−23.5	−23.2	−22.9	−22.7	−22.4	−22.3	−22.1	−22.0
Evaporator exit gas temperature	° C.	−18.5	−18.2	−17.9	−17.7	−17.4	−17.3	−17.1	−17.0
Evaporator mean temperature	° C.	−30.5	−30.6	−30.7	−30.8	−30.9	−31.0	−31.1	−31.2
Evaporator glide (out-in)	K	13.9	14.8	15.6	16.3	16.9	17.5	18.0	18.4
Compressor suction pressure	bar	1.95	2.07	2.20	2.33	2.47	2.61	2.76	2.91
Compressor discharge pressure	bar	24.4	25.5	26.5	27.5	28.5	29.5	30.6	31.6
Suction line pressure drop	Pa/m	98	92	87	82	77	73	69	65
Pressure drop relative to reference		33.7%	31.6%	29.7%	27.9%	26.3%	24.9%	23.5%	22.3%
Condenser dew point	° C.	52.9	52.7	52.4	52.1	51.8	51.3	50.9	50.4
Condenser bubble point	° C.	31.3	30.6	30.0	29.5	29.0	28.6	28.3	28.1
Condenser exit liquid temperature	° C.	30.3	29.6	29.0	28.5	28.0	27.6	27.3	27.1
Condenser mean temperature	° C.	42.1	41.6	41.2	40.8	40.4	40.0	39.6	39.2
Condenser glide (in-out)	K	21.7	22.1	22.5	22.7	22.7	22.7	22.6	22.4

TABLE 75

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 25% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/25/20/55	2/25/20/53	4/25/20/51	6/25/20/49	8/25/20/47	10/25/20/45	12/25/20/43	14/25/20/41
COP (heating)		2.23	2.25	2.26	2.27	2.28	2.29	2.29	2.30
COP (heating) relative to Reference		105.8%	106.6%	107.3%	107.8%	108.2%	108.5%	108.8%	109.0%
Volumetric heating capacity at suction	kJ/m^3	1266	1365	1468	1573	1681	1792	1906	2023
Capacity relative to Reference		144.1%	155.4%	167.0%	179.0%	191.3%	204.0%	217.0%	230.2%
Critical temperature	° C.	95.42	92.93	90.55	88.26	86.08	83.98	81.97	80.04
Critical pressure	bar	47.30	48.08	48.86	49.64	50.41	51.19	51.96	52.74
Condenser enthalpy change	kJ/kg	277.9	285.3	292.1	298.4	304.2	309.7	314.8	319.6
Pressure ratio		14.07	13.91	13.73	13.53	13.32	13.08	12.84	12.60
Refrigerant mass flow	kg/hr	25.9	25.2	24.6	24.1	23.7	23.2	22.9	22.5
Compressor discharge temperature	° C.	136.9	139.8	142.6	145.2	147.8	150.2	152.5	154.7
Evaporator inlet pressure	bar	1.20	1.28	1.37	1.47	1.57	1.67	1.78	1.90
Condenser inlet pressure	bar	16.4	17.4	18.5	19.5	20.6	21.6	22.6	23.7
Evaporator inlet temperature	° C.	−32.4	−33.0	−33.6	−34.2	−34.8	−35.3	−35.9	−36.4
Evaporator dewpoint	° C.	−27.4	−26.9	−26.3	−25.9	−25.4	−25.0	−24.5	−24.2
Evaporator exit gas temperature	° C.	−22.4	−21.9	−21.3	−20.9	−20.4	−20.0	−19.5	−19.2
Evaporator mean temperature	° C.	−29.9	−29.9	−30.0	−30.0	−30.1	−30.1	−30.2	−30.3
Evaporator glide (out-in)	K	5.1	6.2	7.2	8.3	9.4	10.4	11.3	12.3
Compressor suction pressure	bar	1.16	1.25	1.34	1.44	1.54	1.65	1.76	1.88
Compressor discharge pressure	bar	16.4	17.4	18.5	19.5	20.6	21.6	22.6	23.7
Suction line pressure drop	Pa/m	182	166	151	139	128	119	110	103
Pressure drop relative to reference		62.4%	56.7%	51.8%	47.6%	43.9%	40.6%	37.7%	35.1%
Condenser dew point	° C.	50.9	51.4	51.9	52.2	52.4	52.5	52.5	52.5
Condenser bubble point	° C.	42.7	40.5	38.6	36.9	35.5	34.3	33.2	32.3
Condenser exit liquid temperature	° C.	41.7	39.5	37.6	35.9	34.5	33.3	32.2	31.3
Condenser mean temperature	° C.	46.8	46.0	45.2	44.5	43.9	43.4	42.9	42.4
Condenser glide (in-out)	K	8.2	11.0	13.3	15.2	16.9	18.2	19.3	20.1

TABLE 76

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 25% R-32 and 20% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/25/20/39	18/25/20/37	20/25/20/35	22/25/20/33	24/25/20/31	26/25/20/29	28/25/20/27	30/25/20/25
COP (heating)		2.30	2.30	2.30	2.30	2.31	2.30	2.30	2.30
COP (heating) relative to Reference		109.1%	109.2%	109.3%	109.3%	109.3%	109.3%	109.3%	109.2%
Volumetric heating capacity at suction	kJ/m^3	2142	2264	2389	2516	2647	2780	2917	3058
Capacity relative to Reference		243.8%	257.7%	271.9%	286.4%	301.2%	316.4%	332.0%	348.0%
Critical temperature	° C.	78.18	76.39	74.67	73.02	71.42	69.88	68.40	66.96
Critical pressure	bar	53.51	54.28	55.05	55.82	56.59	57.36	58.13	58.90
Condenser enthalpy change	kJ/kg	324.2	328.5	332.6	336.5	340.2	343.7	347.0	350.2
Pressure ratio		12.35	12.10	11.86	11.62	11.37	11.14	10.90	10.67
Refrigerant mass flow	kg/hr	22.2	21.9	21.6	21.4	21.2	20.9	20.7	20.6
Compressor discharge temperature	° C.	156.9	158.9	160.9	162.9	164.7	166.6	168.3	170.0
Evaporator inlet pressure	bar	2.02	2.14	2.27	2.41	2.55	2.70	2.85	3.01
Condenser inlet pressure	bar	24.7	25.8	26.8	27.8	28.9	29.9	30.9	32.0
Evaporator inlet temperature	° C.	−37.0	−37.5	−38.0	−38.4	−38.8	−39.2	−39.5	−39.8
Evaporator dewpoint	° C.	−23.8	−23.5	−23.2	−23.0	−22.7	−22.5	−22.4	−22.2
Evaporator exit gas temperature	° C.	−18.8	−18.5	−18.2	−18.0	−17.7	−17.5	−17.4	−17.2
Evaporator mean temperature	° C.	−30.4	−30.5	−30.6	−30.7	−30.8	−30.9	−30.9	−31.0
Evaporator glide (out-in)	K	13.2	14.0	14.8	15.5	16.1	16.7	17.1	17.6
Compressor suction pressure	bar	2.00	2.13	2.26	2.40	2.54	2.68	2.84	3.00
Compressor discharge pressure	bar	24.7	25.8	26.8	27.8	28.9	29.9	30.9	32.0
Suction line pressure drop	Pa/m	96	90	84	79	75	71	67	63
Pressure drop relative to reference		32.8%	30.8%	28.9%	27.2%	25.6%	24.2%	22.9%	21.7%
Condenser dew point	° C.	52.3	52.1	51.9	51.6	51.2	50.8	50.4	49.9
Condenser bubble point	° C.	31.5	30.8	30.2	29.7	29.3	28.9	28.6	28.3
Condenser exit liquid temperature	° C.	30.5	29.8	29.2	28.7	28.3	27.9	27.6	27.3
Condenser mean temperature	° C.	41.9	41.5	41.1	40.6	40.3	39.9	39.5	39.1
Condenser glide (in-out)	K	20.8	21.3	21.6	21.8	21.9	21.9	21.8	21.6

TABLE 77

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 25% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/25/30/45	2/25/30/43	4/25/30/41	6/25/30/39	8/25/30/37	10/25/30/35	12/25/30/33	14/25/30/31
COP (heating)		2.23	2.25	2.26	2.27	2.28	2.29	2.30	2.30
COP (heating) relative to Reference		105.9%	106.7%	107.4%	107.9%	108.3%	108.6%	108.9%	109.1%
Volumetric heating capacity at suction	kJ/m^3	1292	1393	1497	1604	1714	1828	1944	2063
Capacity relative to Reference		147.0%	158.5%	170.3%	182.6%	195.1%	208.0%	221.2%	234.8%
Critical temperature	° C.	94.91	92.44	90.08	87.82	85.65	83.58	81.59	79.68
Critical pressure	bar	47.50	48.28	49.07	49.85	50.63	51.42	52.20	52.98
Condenser enthalpy change	kJ/kg	279.9	287.3	294.2	300.5	306.3	311.8	316.8	321.6
Pressure ratio		13.91	13.76	13.59	13.39	13.18	12.94	12.71	12.46
Refrigerant mass flow	kg/hr	25.7	25.1	24.5	24.0	23.5	23.1	22.7	22.4
Compressor discharge temperature	° C.	138.1	141.0	143.8	146.4	149.0	151.3	153.6	155.8
Evaporator inlet pressure	bar	1.22	1.31	1.40	1.50	1.60	1.71	1.82	1.94
Condenser inlet pressure	bar	16.6	17.6	18.7	19.7	20.8	21.8	22.9	23.9
Evaporator inlet temperature	° C.	−32.2	−32.8	−33.3	−33.9	−34.4	−35.0	−35.6	−36.1
Evaporator dewpoint	° C.	−27.7	−27.1	−26.6	−26.2	−25.7	−25.2	−24.8	−24.4
Evaporator exit gas temperature	° C.	−22.7	−22.1	−21.6	−21.2	−20.7	−20.2	−19.8	−19.4
Evaporator mean temperature	° C.	−29.9	−30.0	−30.0	−30.0	−30.1	−30.1	−30.2	−30.3
Evaporator glide (out-in)	K	4.6	5.6	6.7	7.7	8.8	9.8	10.7	11.7
Compressor suction pressure	bar	1.19	1.28	1.37	1.47	1.58	1.69	1.80	1.92
Compressor discharge pressure	bar	16.6	17.6	18.7	19.7	20.8	21.8	22.9	23.9
Suction line pressure drop	Pa/m	178	162	148	136	125	116	108	100
Pressure drop relative to reference		60.8%	55.3%	50.5%	46.4%	42.8%	39.6%	36.8%	34.3%
Condenser dew point	° C.	50.3	50.8	51.3	51.6	51.8	51.9	52.0	51.9
Condenser bubble point	° C.	43.0	40.7	38.8	37.1	35.7	34.4	33.4	32.5
Condenser exit liquid temperature	° C.	42.0	39.7	37.8	36.1	34.7	33.4	32.4	31.5
Condenser mean temperature	° C.	46.6	45.8	45.0	44.4	43.7	43.2	42.7	42.2
Condenser glide (in-out)	K	7.3	10.1	12.5	14.5	16.1	17.5	18.6	19.5

TABLE 78

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 25% R-32 and 30% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/25/30/29	18/25/30/27	20/25/30/25	22/25/30/23	24/25/30/21	26/25/30/19	28/25/30/17	30/25/30/15
COP (heating)		2.30	2.31	2.31	2.31	2.31	2.31	2.31	2.31
COP (heating) relative to Reference		109.2%	109.4%	109.4%	109.5%	109.5%	109.5%	109.5%	109.4%
Volumetric heating capacity at suction	kJ/m^3	2185	2310	2437	2567	2700	2837	2976	3119
Capacity relative to Reference		248.7%	262.9%	277.4%	292.2%	307.3%	322.8%	338.7%	354.9%
Critical temperature	° C.	77.84	76.07	74.37	72.73	71.15	69.63	68.16	66.75
Critical pressure	bar	53.77	54.55	55.33	56.11	56.89	57.67	58.45	59.24
Condenser enthalpy change	kJ/kg	326.1	330.4	334.4	338.3	341.9	345.4	348.7	351.9
Pressure ratio		12.21	11.97	11.72	11.48	11.24	11.01	10.77	10.54
Refrigerant mass flow	kg/hr	22.1	21.8	21.5	21.3	21.1	20.8	20.6	20.5
Compressor discharge temperature	° C.	157.9	160.0	162.0	163.9	165.7	167.5	169.2	170.9
Evaporator inlet pressure	bar	2.06	2.19	2.32	2.46	2.60	2.75	2.91	3.07
Condenser inlet pressure	bar	25.0	26.0	27.0	28.1	29.1	30.2	31.2	32.3
Evaporator inlet temperature	° C.	−36.6	−37.1	−37.6	−38.0	−38.4	−38.8	−39.2	−39.5
Evaporator dewpoint	° C.	−24.1	−23.7	−23.5	−23.2	−23.0	−22.7	−22.6	−22.4
Evaporator exit gas temperature	° C.	−19.1	−18.7	−18.5	−18.2	−18.0	−17.7	−17.6	−17.4
Evaporator mean temperature	° C.	−30.3	−30.4	−30.5	−30.6	−30.7	−30.8	−30.9	−30.9
Evaporator glide (out-in)	K	12.5	13.4	14.1	14.8	15.5	16.1	16.6	17.0
Compressor suction pressure	bar	2.04	2.17	2.31	2.45	2.59	2.74	2.90	3.06
Compressor discharge pressure	bar	25.0	26.0	27.0	28.1	29.1	30.2	31.2	32.3
Suction line pressure drop	Pa/m	94	88	82	78	73	69	65	62
Pressure drop relative to reference		32.0%	30.0%	28.2%	26.5%	25.0%	23.6%	22.4%	21.2%
Condenser dew point	° C.	51.8	51.6	51.4	51.1	50.8	50.4	50.0	49.5
Condenser bubble point	° C.	31.7	31.0	30.4	29.9	29.4	29.1	28.7	28.5
Condenser exit liquid temperature	° C.	30.7	30.0	29.4	28.9	28.4	28.1	27.7	27.5
Condenser mean temperature	° C.	41.7	41.3	40.9	40.5	40.1	39.7	39.4	39.0
Condenser glide (in-out)	K	20.2	20.7	21.0	21.2	21.3	21.3	21.2	21.0

TABLE 79

Theoretical Performance Data of Selected R-744/R-32/R-134a/R-1234ze(E) blends containing 0-14% R-744, 25% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		0/25/40/35	2/25/40/33	4/25/40/31	6/25/40/29	8/25/40/27	10/25/40/25	12/25/40/23	14/25/40/21
COP (heating)		2.24	2.25	2.27	2.28	2.29	2.29	2.30	2.30
COP (heating) relative to Reference		106.1%	106.9%	107.5%	108.0%	108.4%	108.8%	109.0%	109.2%
Volumetric heating capacity at suction	kJ/m^3	1314	1416	1522	1631	1742	1858	1976	2097
Capacity relative to Reference		149.5%	161.2%	173.2%	185.6%	198.3%	211.4%	224.9%	238.7%
Critical temperature	° C.	94.41	91.96	89.63	87.40	85.26	83.21	81.24	79.35
Critical pressure	bar	47.61	48.41	49.20	50.00	50.80	51.60	52.40	53.19
Condenser enthalpy change	kJ/kg	282.2	289.7	296.6	302.9	308.8	314.2	319.3	324.0
Pressure ratio		13.77	13.63	13.47	13.27	13.07	12.84	12.60	12.36
Refrigerant mass flow	kg/hr	25.5	24.9	24.3	23.8	23.3	22.9	22.6	22.2
Compressor discharge temperature	° C.	139.4	142.3	145.1	147.7	150.3	152.6	154.9	157.1
Evaporator inlet pressure	bar	1.24	1.33	1.42	1.52	1.62	1.73	1.85	1.97
Condenser inlet pressure	bar	16.7	17.7	18.8	19.9	20.9	22.0	23.0	24.1
Evaporator inlet temperature	° C.	−32.1	−32.6	−33.1	−33.7	−34.2	−34.8	−35.3	−35.8
Evaporator dewpoint	° C.	−27.9	−27.4	−26.9	−26.4	−25.9	−25.5	−25.1	−24.7
Evaporator exit gas temperature	° C.	−22.9	−22.4	−21.9	−21.4	−20.9	−20.5	−20.1	−19.7
Evaporator mean temperature	° C.	−30.0	−30.0	−30.0	−30.0	−30.1	−30.1	−30.2	−30.2
Evaporator glide (out-in)	K	4.1	5.2	6.2	7.2	8.3	9.3	10.2	11.2
Compressor suction pressure	bar	1.21	1.30	1.40	1.50	1.60	1.71	1.83	1.95
Compressor discharge pressure	bar	16.7	17.7	18.8	19.9	20.9	22.0	23.0	24.1
Suction line pressure drop	Pa/m	174	158	144	133	122	113	105	98
Pressure drop relative to reference		59.4%	54.0%	49.4%	45.4%	41.9%	38.8%	36.0%	33.6%
Condenser dew point	° C.	49.8	50.3	50.8	51.1	51.3	51.5	51.5	51.5
Condenser bubble point	° C.	43.2	40.9	38.9	37.2	35.8	34.5	33.4	32.5
Condenser exit liquid temperature	° C.	42.2	39.9	37.9	36.2	34.8	33.5	32.4	31.5
Condenser mean temperature	° C.	46.5	45.6	44.8	44.2	43.5	43.0	42.5	42.0
Condenser glide (in-out)	K	6.6	9.5	11.9	13.9	15.6	17.0	18.1	19.0

TABLE 80

Theoretical Performance Data of Selected R-7447R-32/R-134a/R-1234ze(E) blends containing 16-30% R-744, 25% R-32 and 40% R-134a

		Composition CO_2/R-32/R-134a/R-1234ze(E) % by weight							
		16/25/40/19	28/25/40/17	20/25/40/15	22/25/40/13	24/25/40/11	26/25/40/9	28/25/40/7	30/25/40/5
COP (heating)		2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31
COP (heating) relative to Reference		109.4%	109.5%	109.6%	109.7%	109.7%	109.7%	109.7%	109.6%
Volumetric heating capacity at suction	kJ/m^3	2221	2348	2477	2609	2743	2881	3021	3165
Capacity relative to Reference		252.8%	267.2%	281.9%	296.9%	312.2%	327.9%	343.8%	360.2%
Critical temperature	° C.	77.54	75.79	74.11	72.49	70.93	69.43	67.98	66.57
Critical pressure	bar	53.99	54.79	55.58	56.38	57.17	57.97	58.76	59.56
Condenser enthalpy change	kJ/kg	328.5	332.8	336.8	340.7	344.3	347.8	351.1	354.2
Pressure ratio		12.12	11.87	11.63	11.39	11.15	10.92	10.69	10.47
Refrigerant mass flow	kg/hr	21.9	21.6	21.4	21.1	20.9	20.7	20.5	20.3
Compressor discharge temperature	° C.	159.2	161.2	163.2	165.1	166.9	168.7	170.4	172.1
Evaporator inlet pressure	bar	2.09	2.22	2.36	2.50	2.64	2.79	2.95	3.11
Condenser inlet pressure	bar	25.2	26.2	27.3	28.3	29.3	30.4	31.4	32.5
Evaporator inlet temperature	° C.	−36.4	−36.9	−37.3	−37.8	−38.2	−38.6	−39.0	−39.3
Evaporator dewpoint	° C.	−24.3	−23.9	−23.6	−23.3	−23.1	−22.9	−22.7	−22.5
Evaporator exit gas temperature	° C.	−19.3	−18.9	−18.6	−18.3	−18.1	−17.9	−17.7	−17.5
Evaporator mean temperature	° C.	−30.3	−30.4	−30.5	−30.6	−30.7	−30.8	−30.8	−30.9
Evaporator glide (out-in)	K	12.1	12.9	13.7	14.5	15.1	15.8	16.3	16.8
Compressor suction pressure	bar	2.08	2.21	2.34	2.48	2.63	2.78	2.94	3.10
Compressor discharge pressure	bar	25.2	26.2	27.3	28.3	29.3	30.4	31.4	32.5
Suction line pressure drop	Pa/m	92	86	81	76	72	68	64	61
Pressure drop relative to reference		31.4%	29.4%	27.6%	26.0%	24.5%	23.2%	21.9%	20.8%
Condenser dew point	° C.	51.4	51.3	51.0	50.8	50.4	50.1	49.7	49.2
Condenser bubble point	° C.	31.7	31.0	30.4	29.9	29.4	29.1	28.7	28.5
Condenser exit liquid temperature	° C.	30.7	30.0	29.4	28.9	28.4	28.1	27.7	27.5
Condenser mean temperature	° C.	41.6	41.1	40.7	40.3	39.9	39.6	39.2	38.9
Condenser glide (in-out)	K	19.7	20.3	20.6	20.9	21.0	21.0	20.9	20.8

TABLE 81

Theoretical Performance Data of Selected R-744/R-1234ze(E) blends containing 0-14% R-744

		Composition CO_2/R-1234ze(E) % by weight							
		0/100	2/98	4/96	6/94	8/92	10/90	12/88	14/86
COP (heating)		1.99	2.05	2.10	2.14	2.16	2.18	2.20	2.21
COP (heating) relative to Reference		94.4%	97.4%	99.6%	101.3%	102.5%	103.5%	104.3%	104.9%
Volumetric heating capacity at suction	kJ/m3	615	695	778	864	953	1046	1141	1239
Capacity relative to Reference		70.0%	79.1%	88.6%	98.3%	108.5%	119.0%	129.8%	141.0%
Critical temperature	° C.	109.89	105.93	102.20	98.69	95.38	92.25	89.29	86.48
Critical pressure	bar	36.57	37.34	38.10	38.87	39.63	40.40	41.16	41.92
Condenser enthalpy change	kJ/kg	210.2	223.7	235.1	244.8	253.2	260.5	267.2	273.2
Pressure ratio		18.75	18.99	19.05	18.95	18.71	18.39	18.00	17.58
Refrigerant mass flow	kg/hr	34.2	32.2	30.6	29.4	28.4	27.6	27.0	26.4
Compressor discharge temperature	° C.	112.8	117.1	121.1	124.7	127.9	131.0	133.8	136.5
Evaporator inlet pressure	bar	0.65	0.69	0.74	0.80	0.87	0.95	1.03	1.11
Condenser inlet pressure	bar	10.7	11.9	13.1	14.3	15.5	16.7	17.8	19.0
Evaporator inlet temperature	° C.	−28.9	−29.6	−30.3	−31.1	−31.9	−32.7	−33.6	−34.5
Evaporator dewpoint	° C.	−30.3	−29.7	−29.0	−28.3	−27.5	−26.6	−25.8	−25.1
Evaporator exit gas temperature	° C.	−25.3	−24.7	−24.0	−23.3	−22.5	−21.6	−20.8	−20.1
Evaporator mean temperature	° C.	−29.6	−29.7	−29.7	−29.7	−29.7	−29.7	−29.7	−29.8
Evaporator glide (out-in)	K	−1.3	−0.1	1.3	2.8	4.4	6.0	7.7	9.4
Compressor suction pressure	bar	0.57	0.63	0.69	0.75	0.83	0.91	0.99	1.08
Compressor discharge pressure	bar	10.7	11.9	13.1	14.3	15.5	16.7	17.8	19.0
Suction line pressure drop	Pa/m	462	390	336	294	259	231	208	189
Pressure drop relative to reference		158.3%	133.6%	115.0%	100.5%	88.8%	79.2%	71.3%	64.6%
Condenser dew point	° C.	53.1	55.1	56.7	58.1	59.2	60.0	60.5	60.9
Condenser bubble point	° C.	53.0	47.1	42.6	38.9	36.1	33.8	31.9	30.4
Condenser exit liquid temperature	° C.	52.0	46.1	41.6	37.9	35.1	32.8	30.9	29.4
Condenser mean temperature	° C.	53.1	51.1	49.7	48.5	47.6	46.9	46.2	45.7
Condenser glide (in-out)	K	0.1	7.9	14.2	19.1	23.1	26.2	28.6	30.6

TABLE 82

Theoretical Performance Data of Selected R-744/R-1234ze(E) blends containing 16-30% R-744

		Composition CO_2/R-1234ze(E) % by weight							
		16/84	18/82	20/80	22/78	24/76	26/74	28/72	30/70
COP (heating)		2.22	2.23	2.23	2.24	2.24	2.24	2.24	2.24
COP (heating) relative to Reference		105.4%	105.7%	106.0%	106.2%	106.3%	106.3%	106.3%	106.2%
Volumetric heating capacity at suction	kJ/m3	1339	1441	1545	1650	1756	1862	1969	2076
Capacity relative to Reference		152.4%	164.0%	175.8%	187.7%	199.8%	211.9%	224.1%	236.3%
Critical temperature	° C.	83.81	81.28	78.87	76.57	74.38	72.28	70.28	68.37
Critical pressure	bar	42.68	43.44	44.20	44.96	45.72	46.47	47.23	47.98
Condenser enthalpy change	kJ/kg	278.7	283.9	288.9	293.6	298.1	302.5	306.8	311.0
Pressure ratio		17.15	16.72	16.29	15.88	15.49	15.12	14.77	14.44
Refrigerant mass flow	kg/hr	25.8	25.4	24.9	24.5	24.2	23.8	23.5	23.1
Compressor discharge temperature	° C.	139.0	141.4	143.8	146.1	148.4	150.6	152.9	155.1
Evaporator inlet pressure	bar	1.20	1.29	1.39	1.49	1.60	1.70	1.81	1.92
Condenser inlet pressure	bar	20.1	21.2	22.3	23.3	24.4	25.4	26.5	27.5
Evaporator inlet temperature	° C.	−35.5	−36.5	−37.6	−38.7	−39.7	−40.8	−41.9	−42.9
Evaporator dewpoint	° C.	−24.4	−23.7	−23.1	−22.5	−22.0	−21.6	−21.2	−20.9
Evaporator exit gas temperature	° C.	−19.4	−18.7	−18.1	−17.5	−17.0	−16.6	−16.2	−15.9
Evaporator mean temperature	° C.	−29.9	−30.1	−30.3	−30.6	−30.9	−31.2	−31.5	−31.9
Evaporator glide (out-in)	K	11.2	12.9	14.5	16.2	17.7	19.2	20.7	22.0
Compressor suction pressure	bar	1.17	1.27	1.37	1.47	1.57	1.68	1.79	1.90
Compressor discharge pressure	bar	20.1	21.2	22.3	23.3	24.4	25.4	26.5	27.5
Suction line pressure drop	Pa/m	172	157	145	134	125	116	109	102
Pressure drop relative to reference		58.8%	53.9%	49.7%	45.9%	42.7%	39.8%	37.2%	35.0%
Condenser dew point	° C.	61.2	61.2	61.2	61.0	60.8	60.4	60.0	59.5
Condenser bubble point	° C.	29.1	28.0	27.1	26.3	25.7	25.1	24.6	24.1
Condenser exit liquid temperature	° C.	28.1	27.0	26.1	25.3	24.7	24.1	23.6	23.1
Condenser mean temperature	° C.	45.1	44.6	44.1	43.7	43.2	42.7	42.3	41.8
Condenser glide (in-out)	K	32.1	33.2	34.1	34.7	35.1	35.3	35.4	35.3

Further Performance Data

[0163] The performance of a composition containing 6% by weight CO_2, 10% by weight R-134a and 84% by weight R-1234ze(E) was tested in an automotive air conditioning system suitable for use with R-134a. This composition is denoted "Blend" in the results shown below.

[0164] The test conditions used were as described in SAE Standard J2765, which is incorporated herein by reference. These conditions are summarised below.

[0165] Ambient air condition 35° C. and 40% relative humidity (RH)

[0166] Air off temperature from evaporator controlled to 3° C.

[0167] Compressor displacement variable 0-175 cc per stroke

[0168] Conventional R-134a expansion valve was replaced with an electronic expansion valve to allow for ease of superheat adjustment

[0169] System used without internal heat exchanger and with equivalent superheat at evaporator exit for all fluids

[0170] The results are shown below, in which I, L, M and H refer to idle, low, medium and high speed, and wherein 35 and 45 refer to the ambient temperature in ° C.

	Measured cooling capacity (kW)		Relative to R-134a
Test point	R134a	Blend	Blend
I35	4.67	4.5	96%
L35	5.86	5.66	97%
M35	6.43	6.18	96%
H35	6.65	6.5	98%
I45	3.81	3.64	96%
L45	4.76	4.61	97%
M45	5.2	5.05	97%
H45	5.41	5.33	99%

Measured Energy Efficiency Test point	(expressed as COP) R134a	Blend	COP relative to R-134a Blend
I35	2.87	2.62	91%
L35	1.98	1.89	95%
M35	1.79	1.7	95%
H35	1.4	1.36	97%
I45	2.3	2.18	95%
L45	1.64	1.62	99%

-continued

Measured Energy Efficiency Test point	(expressed as COP) R134a	Blend	COP relative to R-134a Blend
M45	1.48	1.45	98%
H45	1.18	1.16	98%

[0171] The Blend composition of the invention represents a good match of capacity and efficiency for R-134a in an R-134a air-conditioning system across a range of conditions.

Lubricant Miscibility Data

[0172] The miscibility of a composition of the invention containing about 6% by weight CO_2, about 10% by weight R-134a and about 84% by weight R-1234ze(E) (referred to below as Blend) was tested with the polyalkylene glycol (PAG) lubricant YN12 and the polyol ester (POE) lubricant 32H. The results of these experiments were compared to the miscibility of pure R-1234yf with the same lubricants. The results are shown below.

Miscibility Results for Blend with 32H

[0173]

Temperature	Lubricant Concentration wt %					
deg C.	4	7	10	20	30	50
−20	miscible	miscible	miscible	miscible	miscible	miscible
−10	miscible	miscible	miscible	miscible	miscible	miscible
0	miscible	miscible	miscible	miscible	miscible	miscible
10	miscible	miscible	miscible	miscible	miscible	miscible
20	miscible	miscible	miscible	miscible	miscible	miscible
30	miscible	miscible	miscible	miscible	miscible	miscible
40	miscible	miscible	miscible	miscible	miscible	miscible
50	miscible	miscible	miscible	miscible	miscible	miscible
60	miscible	miscible	miscible	miscible	miscible	miscible
70	miscible	miscible	miscible	miscible	miscible	miscible
80	miscible	miscible	miscible	miscible	miscible	miscible

Miscibility Results for 1234yf with 32H

[0174]

Temperature	Lubricant Concentration wt %					
deg C.	4	7	10	20	30	50
−20	miscible	miscible	miscible	miscible	miscible	miscible
−10	miscible	miscible	miscible	miscible	miscible	miscible
0	miscible	miscible	miscible	miscible	miscible	miscible
10	slightly opaque	slightly opaque	miscible	miscible	miscible	miscible
20	slightly opaque	slightly opaque	miscible	miscible	miscible	miscible
30	slightly opaque	slightly opaque	miscible	miscible	miscible	miscible
40	slightly opaque	slightly opaque	miscible	miscible	miscible	miscible
50	slightly opaque	slightly opaque	miscible	miscible	slightly opaque	slightly opaque
60	slightly opaque	slightly opaque	miscible	miscible	slightly opaque	slightly opaque
70	slightly opaque	slightly opaque	miscible	miscible	slightly opaque	slightly opaque
80	Miscible	slightly opaque	miscible	Opaque 2 layers	Opaque 2 layers	Opaque

Miscibility Results for Blend with YN12

[0175]

Temp	Lubricant Concentration wt %					
deg C.	4	7	10	20	30	50
−20	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque
−10	Opaque	Opaque	Opaque	Opaque	slightly opaque	slightly opaque
0	Opaque	Opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque
10	Opaque	Opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque
20	Opaque	Opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque
30	slightly opaque	Opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque
40	slightly opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque
50	very Slighty opaque	very Slighty opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque
60	very Slighty opaque	very Slighty opaque	slightly opaque	slightly opaque	slightly opaque	slightly opaque
70	very Slighty opaque	very Slighty opaque	2 layers	2 layers	2 layers	slightly opaque
80	2 layers	2 layers	2 layers	2 layers	2 layers	2 layers

Miscibility Results for 1234yf with YN12

[0176]

Temperature	Lubricant Concentration wt %					
deg C.	4	7	10	20	30	50
−20	opaque	opaque	2 layers	opaque	2 layers	2 layers
−10	slightly opaque	slightly opaque	2 layers	opaque	2 layers	2 layers
0	slightly opaque	opaque	2 layers	opaque	opaque	opaque
10	slightly opaque	opaque	2 layers opaque	2 layers opaque	2 layers opaque	2 layers opaque
20	opaque	slightly opaque 2 layers	2 layers opaque	2 layers	2 layers opaque	2 layers opaque
30	opaque	opaque	2 layers opaque	2 layers	2 layers opaque	2 layers opaque
40	clear 2 layers	clear 2 layers	2 layers clear	2 layers	2 layers clear	2 layers clear
50	clear 2 layers	clear 2 layers	2 layers clear	2 layers	2 layers clear	2 layers clear
60	clear 2 layers	clear 2 layers	2 layers clear	2 layers	2 layers clear	2 layers clear
70	clear 2 layers	clear 2 layers	2 layers clear	2 layers	2 layers clear	2 layers clear
80	clear 2 layers	clear 2 layers	2 layers clear	2 layers	2 layers clear	2 layers clear

[0177] The miscibility of further compositions of the invention were tested with the polyalkylene glycol (PAG) lubricant YN12. The lubricant was present in a concentration of 4% w/w. This concentration is representative of the typical oil concentration present in an air conditioning system. The results of these experiments were compared to the miscibility of pure R-1234yf. The results are shown below.

	Temperature/° C.				
	0	10	20	30	40
R-1234yf (comparative)	opaque	opaque	opaque	very opaque	opaque
CO_2/R-134a/R-1234ze (15/10/75% by weight)	slightly opaque	slightly opaque	slightly opaque	very slightly opaque	slightly opaque
CO_2/R-134a/R-1234ze (25/10/65% by weight)	opaque	slightly opaque	very slightly opaque	ok	
CO_2/R-32/R-1234ze (4/7/89% by weight)	opaque	slightly opaque	very slightly opaque	ok	

[0178] The results show that the compositions of the invention have improved miscibility with lubricants compared to the pure fluid R-1234yf.

[0179] In summary, the invention provides new compositions that exhibit a surprising combination of advantageous properties including good refrigeration performance, low flammability, low GWP, and/or miscibility with lubricants compared to existing refrigerants such as R-134a and the proposed refrigerant R-1234yf.

[0180] The invention is defined by the following claims.

1. A heat transfer composition comprising:

(i) a first component selected from R-1234ze(E), R-1234ze (Z), or mixtures thereof;

(ii) a second component that is R 744; and

(iii) a third component selected from R-32, R-134a, or mixtures thereof.

2. A composition according to claim **1** wherein the first component is R-1234ze(E) or a mixture of R-1234ze(E) and R-1234ze(Z).

3. A composition according to claim **1** comprising at least about 15% by weight R-1234ze(E).

4. A composition according to claim **1** comprising up to about 35% by weight R 744.

5. A composition according to claim **4** comprising from about 4 to about 30% R-744 by weight.

6. A composition according to claim **1** comprising up to about 60% by weight of the third component.

7. A composition according to claim **1** comprising from about 10 to about 95% R-1234ze(E) by weight, from about 2 to about 30% by weight R-744, and from about 3 to about 60% by weight of the third component.

8. A composition according to claim **1** wherein the composition has a critical temperature of greater than about 65° C.

9. A composition according to claim **1** wherein the third component is R-134a or a mixture of R-134a and R-32.

10. A composition according to claim **1** comprising from about 20 to about 94% by weight R-1234ze(E), from about 2 to about 30% by weight R-744 and from about 4 to about 50% by weight R-134a.

11. A composition according to claim **10** comprising from about 60 to about 92% R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 4 to about 10% by weight R-134a.

12. A composition according to claim **10** comprising from about 20 to about 86% R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 10 to about 50% by weight R-134a.

13. A composition according to claim **1** wherein the third component is R-32 or a mixture of R-32 and R-134a.

14. A composition according to claim **13** comprising from about 60 to about 91% by weight R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 5 to about 30% by weight R-32.

15. A composition according to claim **13** comprising from about 50 to about 88% by weight R-1234ze(E), from about 4 to about 30% by weight R-744 and from about 2 to about 20% by weight R-32.

16. A composition according to claim **1** wherein the third component is a mixture of R-134a and R-32.

17. A composition according to claim **16** comprising from about 5 to about 95% by weight R-1234ze(E), from about 4 to about 30% by weight R-744, from about 2 to about 30% by weight R-32 and from about 2 to about 50 by weight R-134a.

18. A composition according to claim **17** comprising from about 30 to about 81% by weight R-1234ze(E), from about 10 to about 30% by weight R-744, from about 5 to about 30% by weight R-32 and from about 4 to about 10 by weight R-134a.

19. A composition according to claim **17** comprising from about 5 to about 75% by weight R-1234ze(E), from about 10 to about 30% by weight R-744, from about 5 to about 25% by weight R-32 and from about 10 to about 50 by weight R-134a.

20. A composition according to claim **1** consisting essentially of R-1234ze(E), R-744 and the third component.

21. A composition according to claim **1**, further comprising R-125.

22. A composition consisting essentially of from about 4 to about 34% by weight R-744 and from about 66 to about 96% by weight R-1234ze(E).

23. A composition according to claim **22** consisting essentially of from about 4 to about 30% by weight R-744 and from about 70 to about 96% by weight R-1234ze(E).

24. A composition according to claim **23** consisting essentially of from about 6 to about 30% by weight R-744 and from about 70 to about 94% by weight R-1234ze(E).

25. A composition according to claim **22** wherein the composition has a critical temperature of greater than about 70° C.

26. A composition according to claim **1**, wherein the composition has a GWP of less than 1000.

27. A composition according to claim **1**, wherein the composition has a volumetric refrigeration capacity within about 15%, of an existing refrigerant that the composition is intended to replace.

28. A composition according to claim **1**, wherein the composition is less flammable than R-32 alone or R-1234yf alone.

29. A composition according to claim **28** wherein the composition has at least one of:

(a) a higher flammable limit;

(b) a higher ignition energy; or

(c) a lower flame velocity

compared to R-32 alone or R-1234yf alone.

30. A composition according to claim **1** wherein the composition has a fluorine ratio (F/(F+H)) of from about 0.42 to about 0.7.

31. A composition according to claim **1** wherein the composition is non-flammable.

32. A composition according to claim **1**, wherein the composition has a cycle efficiency within about 5% of an existing refrigerant that the composition is intended to replace.

33. A composition according to claim **1**, wherein the composition has a compressor discharge temperature within about 15K, of an existing refrigerant that the composition is intended to replace.

34. A composition comprising a lubricant and the composition according to claim **1**.

35. A composition according to claim **34**, wherein the lubricant is selected from mineral oil, silicone oil, PABs, POEs, PAGs, PAG esters, PVEs, poly (alpha-olefins) and combinations thereof.

36. A composition according to claim **34** further comprising a stabilizer.

37. A composition according to claim **36**, wherein the stabilizer is selected from diene-based compounds, phosphates, phenol compounds and epoxides, and mixtures thereof.

38. A composition comprising a flame retardant and the composition according to claim **1**.

39. A composition according to claim **38**, wherein the flame retardant is selected from the group consisting of tri-(2-chloroethyl)-phosphate, (chloropropyl)phosphate, tri-(2,3-dibromopropyl)-phosphate, tri-(1,3-dichloropropyl)-phosphate, diammonium phosphate, various halogenated aromatic compounds, antimony oxide, aluminium trihydrate, polyvinyl chloride, a fluorinated iodocarbon, a fluorinated bromocarbon, trifluoro iodomethane, perfluoroalkyl amines, bromo-fluoroalkyl amines and mixtures thereof.

40. A composition according to claim **1** wherein the composition is a refrigerant composition.

41. A heat transfer device containing the composition of claim **1**.

42. (canceled)

43. A heat transfer device according to claim **41** wherein the heat transfer device is a refrigeration device.

44. A heat transfer device according to claim **43** wherein the heat transfer device is selected from group consisting of automotive air conditioning systems, residential air conditioning systems, commercial air conditioning systems, residential refrigerator systems, residential freezer systems, commercial refrigerator systems, commercial freezer systems, chiller air conditioning systems, chiller refrigeration systems, and commercial or residential heat pump systems.

45. A heat transfer device according to claim **43** wherein the heat transfer device contains a compressor.

46. A blowing agent comprising the composition of claim **1**.

47. A foamable composition comprising one or more components capable of forming foam and the composition of claim **1**, wherein the one or more components capable of forming foam are selected from polyurethanes, thermoplastic polymers and resins, and mixtures thereof.

48. (canceled)

49. A foam comprising the composition of claim **1**.

50. A sprayable composition comprising material to be sprayed and a propellant comprising the composition of claim **1**.

51. A method for cooling an article comprising condensing the composition of claim **1** and thereafter evaporating the composition in the vicinity of the article to be cooled.

52. A method for heating an article comprising condensing the composition of claim **1** in the vicinity of the article to be heated and thereafter evaporating the composition.

53. A method for extracting a substance from biomass comprising contacting biomass with a solvent comprising the composition of claim **1**, and separating the substance from the solvent.

54. A method of cleaning an article comprising contacting the article with a solvent comprising the composition of claim **1**.

55. A method of extracting a material from an aqueous solution comprising contacting the aqueous solution with a solvent comprising the composition of claim **1**, and separating the material from the solvent.

56. A method for extracting a material from a particulate solid matrix comprising contacting the particulate solid matrix with a solvent comprising the composition of claim **1**, and separating the material from the solvent.

57. A mechanical power generation device containing the composition of claim **1**.

58. A mechanical power generating device according to claim **57** wherein the mechanical power generating device is adapted to use a Rankine Cycle or modification thereof to generate work from heat.

59. A method of retrofitting a heat transfer device comprising the step of removing an existing heat transfer fluid, and introducing the composition of claim **1**.

60. A method of claim **59** wherein the heat transfer device is a refrigeration device.

61. A method according to claim **60** wherein the heat transfer device is an air conditioning system.

62. A method for reducing the environmental impact arising from the operation of a product comprising an existing compound or composition, the method comprising replacing at least partially the existing compound or composition with the composition of claim **1**.

63. A method for preparing the composition of claim **1**, wherein the composition comprises R-134a, the method comprising introducing R-1234ze(E), R-744, and the third component into a heat transfer device containing an existing heat transfer fluid which is R-134a.

64. A method according to claim **63** further comprising removing at least some of the existing R-134a from the heat transfer device before introducing the R-1234ze(E), R-744, and the third component.

65. A method for generating greenhouse gas emission credit comprising (i) replacing an existing compound or composition with the composition of claim **1**, wherein the composition has a lower GWP than the existing compound or composition; and (ii) obtaining greenhouse gas emission credit for said replacing step.

66. A method of claim **65** wherein the use of the composition results in at least one of a lower Total Equivalent Warming Impact, or a lower Life-Cycle Carbon Production than is attained by use of the existing compound or composition.

67. A method of claim **65** carried out on a product from at least one field of air-conditioning, refrigeration, heat transfer, blowing agents, aerosols or sprayable propellants, gaseous dielectrics, cryosurgery, veterinary procedures, dental procedures, fire extinguishing, flame suppression, solvents, cleaners, air horns, pellet guns, topical anesthetics, or expansion applications.

68. A method according to claim **62** wherein the product is selected from a heat transfer device, a blowing agent, a foamable composition, a sprayable composition, a solvent or a mechanical power generation device.

69. A method according to claim **68** wherein the product is a heat transfer device.

70. A method according to claim **65** wherein the existing compound or composition is a heat transfer composition.

71. A method according to claim **70** wherein the heat transfer composition is a refrigerant selected from R-134a, R-1234yf, R-152a, R-404A, R-410A, R-507, R-407A, R-407B, R-407D, R-407E and R-407F.

72. (canceled)

73. A composition according to claim **10** comprising from about 62 to about 86% R-1234ze(E), from about 10 to about 28% by weight R-744 and from about 4 to about 10% by weight R-134a.

74. A composition according to claim **10** comprising from about 22 to about 80% R-1234ze(E), from about 10 to about 28% by weight R-744 and from about 10 to about 50% by weight R-134a.

75. A composition according to claim **13** comprising from about 58 to about 85% R-1234ze(E), from about 10 to about 28% by weight R-744 and from about 5 to about 30% by weight R-32.

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