

TITLE OF THE INVENTION

LOW GWP COMPOSITIONS COMPRISING HFO-1252ZC AND USES THEREOF

FIELD

[0001] The present disclosure relates to compositions useful as refrigerants in refrigeration, air conditioning and heat pump systems. The compositions are useful in methods for producing cooling and heating, methods for replacing existing refrigerants, and refrigeration, air conditioning, heat pump, and chiller systems.

BACKGROUND

[0002] The fluorocarbon industry has been working for the past few decades to find replacement refrigerants for the ozone depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) being phased out as a result of the Montreal Protocol. The solution for many applications has been the commercialization of hydrofluorocarbon (HFC) compounds for use as refrigerants, solvents, fire extinguishing agents, blowing agents and propellants. These new compounds, such as HFC refrigerants, HFC-134a and HFC-125 being the most widely used at this time, have zero ozone depletion potential (ODP) and thus are not affected by the current regulatory phase-out as a result of the Montreal Protocol. In addition to ozone depleting concerns, global warming is another environmental concern in many of these applications. HFC refrigerants such as HFC-134a and HFC-125 respectively have global warming potentials (GWP) of 1,430 and 3,500 according to the UN's IPCC Fourth Assessment Report (AR4).

[0003] This regulatory landscape is continuously evolving, taking into consideration properties beyond just ODP and GWP. More particularly, there is a need for refrigerant compositions that not only meet low ODP standards and have low global warming potentials, but that also provide superior performance in a variety of applications and which meet the standards of evolving regulations.

[0004] The instant invention solves certain problems associated with conventional refrigerants and provides refrigerant blends containing 1,1-difluoropropene, which meet the evolving regulatory landscape.

SUMMARY

[0005] In one embodiment, compositions are provided comprising HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I.

[0006] According to the foregoing embodiment, the compositions comprise, consist of, or consist essentially of HFO-1252zc and are selected from:

HFO-1252zc and HFC-32;
HFO-1252zc and HFO-1132E;
HFO-1252zc and HFO-1132Z;
HFO-1252zc, HFO-1132E, and HFO-1132Z;
HFO-1252zc and HFC-134;
HFO-1252zc, HFO-1132E, and HFC-32;
HFO-1252zc, HFO-1132E, and HFC-134;
HFO-1252zc, HFC-32, and CF₃I;
HFO-1252zc, HFO-1132E, and CF₃I;
HFO-1252zc, HFC-134, and CF₃I;
HFO-1252zc, HFO-1132E, HFC-32, and CF₃I; or
HFO-1252zc, HFO-1132E, HFC-134, and CF₃I.

[0007] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 56 to 99 weight percent HFO-1252zc and about 1 to 44 weight percent HFC-32, or about 56 to 78 weight percent HFO-1252zc and about 22 to 44 weight percent HFC-32, or about 78 to 99 weight percent HFO-1252zc and about 1 to 22 weight percent HFC-32, or about 85 to 92 weight percent HFO-1252zc and about 8 to 15 weight percent HFC-32.

[0008] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132E, or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132E.

[0009] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132Z, or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132Z.

[0010] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132E and HFO-1132Z, or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132E and HFO-1132Z.

[0011] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 73 to 99 weight percent HFO-1252zc and about 1 to 27 weight percent HFC-134, or about 73 to 86 weight percent HFO-1252zc and about 14 to 27 weight percent HFC-134, or about 86 to 99 weight percent HFO-1252zc and about 1 to 14 weight percent HFC-134, or about 81 to 99 weight percent HFO-1252zc and about 1 to 19 weight percent HFC-134, or about 81 to 91 weight percent HFO-1252zc and about 9 to 19 weight percent HFC-134.

[0012] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 31 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 44 weight percent HFC-32, or about 31 to 53 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 22 to 44 weight percent HFC-32, or about 31 to 53 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 22 weight percent HFC-32, or about 53 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 22 weight percent HFC-32, or about 79 to 92 weight percent HFO-1252zc, about 1 to 21 weight percent HFO-1132E, and about 1 to 14 weight percent HFC-32.

[0013] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 46 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 26 weight percent HFC-134, or about 49 to 62 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 13 to 26 weight percent HFC-134, or about 49 to 62 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 13 weight percent HFC-134; or about 61 to 98 weight percent HFO-1252zc, about 1 to 25 weight

percent HFO-1132E, and about 1 to 13 weight percent HFC-134, or about 68 to 88 weight percent HFO-1252zc, about 11 to 22 weight percent HFO-1132E, and about 1 to 13 weight percent HFC-134.

[0014] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 36 to 98 weight percent HFO-1252zc, about 1 to 44 weight percent HFC-32, and about 1 to 30 weight percent CF₃I, or about 46 to 58 weight percent HFO-1252zc, about 22 to 44 weight percent HFC-32, and about 10 to 20 weight percent CF₃I, or about 58 to 98 weight percent HFO-1252zc, about 1 to 22 weight percent HFC-32, and about 1 to 30 weight percent CF₃I, or about 42 to 93 weight percent HFO-1252zc, about 6 to 15 weight percent HFC-32, and about 1 to 48 weight percent CF₃I, or about 24 to 97 weight percent HFO-1252zc, about 2 to 15 weight percent HFC-32, and about 1 to 73 weight percent CF₃I.

[0015] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 55 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 20 weight percent CF₃I, or about 55 to 65 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 10 to 20 weight percent CF₃I, or about 11 to 96 weight percent HFO-1252zc, about 3 to 23 weight percent HFO-1132E, and about 1 to 83 weight percent CF₃I, or about 29 to 89 weight percent HFO-1252zc, about 10 to 22 weight percent HFO-1132E, and about 1 to 61 weight percent CF₃I, or about 11 to 62 weight percent HFO-1252zc, about 4 to 16 weight percent HFO-1132E, and about 34 to 83 weight percent CF₃I, or about 29 to 56 weight percent HFO-1252zc, about 10 to 15 weight percent HFO-1132E, and about 34 to 61 weight percent CF₃I.

[0016] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 53 to 98 weight percent HFO-1252zc, about 1 to 27 weight percent HFC-134, and about 1 to 20 weight percent CF₃I, or about 53 to 77 weight percent HFO-1252zc, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF₃I, or about 66 to 98 weight percent HFO-1252zc, about 1 to 13 weight percent HFC-134, and about 1 to 30 weight percent CF₃I.

[0017] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 11 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 44 weight percent HFC-32, and about 1 to 20

weight percent CF₃I, or about 29 to 42 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF₃I, or about 33 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 22 weight percent HFC-32, and about 1 to 30 weight percent CF₃I.

[0018] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 29 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 27 weight percent HFC-134, and about 1 to 20 weight percent CF₃I, or about 29 to 42 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF₃I, or about 42 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 13.25 weight percent HFC-134, and about 1 to 30 weight percent CF₃I.

[0019] According to any of the foregoing embodiments, disclosed herein are compositions wherein the CF₃I is present at about 1 to 25 weight percent or about 1 to 20 weight percent.

[0020] According to any of the foregoing embodiments, disclosed herein are compositions wherein the HFC-32 is present at about 1 to 22 weight percent, or at about 10 to 22 weight percent, or at about 15 to 22 weight percent.

[0021] According to any of the foregoing embodiments, disclosed herein are compositions wherein the HFC-134 is present at about 1 to 13 weight percent, or at about 5 to 13 weight percent, or at about 8 to 13 weight percent.

[0022] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-1132E, or about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132E.

[0023] According to any of the foregoing embodiments, disclosed herein are compositions comprising from about 1 to 26 weight percent HFO-1252zc and HFO-1132E, HFO-1132Z, or a combination thereof.

[0024] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 1 to 50 HFO-1252zc and about 50 to 99 weight

percent HFO-1132Z, or about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132Z.

[0025] According to any of the foregoing embodiments, disclosed herein are compositions comprising about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-1132E and HFO-1132Z, or about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132E and HFO-1132Z.

[0026] According to any of the foregoing embodiments, disclosed herein are compositions that are classified as class 2 for flammability according to ASHRAE Standard 34.

[0027] According to any of the foregoing embodiments, disclosed herein are compositions further comprising at least one additional compound selected from the group consisting of methane, ethane, HFC-41, HCC-40, HFCF-22, HFC-23, HFO-1141, HFO-1132E, HFO-1132Z, HFC-161, HFC-152, HFC-143, HFC-143a, HFC-134a, PFC-116, HCFO-1122, HCFO-1122aE, HCFO-1122aZ, HCC-150, HCFC-151, CFO-1112E, CFO-1112Z, HCFC-142a, HCFC-132, HCFC-133, HCFC-133b, HCFC-123, HFO-1123, HFO-1132a, HCFO-1131E, HCFO-1131Z, ethylene, and acetylene.

[0028] According to any of the foregoing embodiments, disclosed herein are compositions further comprising from 0.1 to 200 ppm by weight of water; from about 10 ppm by volume to about 0.35 volume percent oxygen; and/or from about 100 ppm by volume to about 1.5 volume percent air or NAG.

[0029] According to any of the foregoing embodiments, disclosed herein are compositions further comprising a stabilizer.

[0030] According to any of the foregoing embodiments, disclosed herein are compositions, wherein the stabilizer is selected from the group consisting of nitromethane, ascorbic acid, terephthalic acid, azoles, phenolic compounds, cyclic monoterpenes, terpenes, phosphites, phosphates, phosphonates, thiols, and lactones.

[0031] According to any of the foregoing embodiments, disclosed herein are compositions, wherein the stabilizer is selected from toluotriazole, benzotriazole, tocopherol, hydroquinone, t-butyl hydroquinone, 2,6-di-terbutyl-4-methylphenol, fluorinated epoxides, n-butyl glycidyl ether, hexanediol diglycidyl ether, allyl glycidyl

ether, butylphenylglycidyl ether, d-limonene, a-terpinene, b-terpinene, a-pinene, b-pinene, or butylated hydroxytoluene.

[0032] According to any of the foregoing embodiments, disclosed herein are compositions, wherein the stabilizer is present in an amount from about 0.001 to 1.0 weight percent based on the weight of the refrigerant.

[0033] According to any of the foregoing embodiments, disclosed herein are compositions further comprising a lubricant.

[0034] According to any of the foregoing embodiments, the lubricant included in the compositions may be chosen from polyalkylene glycol, polyol ester, poly- α -olefin, and polyvinyl ether.

[0035] According to any of the foregoing embodiments, the lubricant included in the compositions may be chosen from polyol ester, and polyvinyl ether.

[0036] According to any of the foregoing embodiments, the lubricant included in the compositions, wherein said lubricant has at least one property selected from the group consisting of volume resistivity of greater than 10^{10} Ω -m at 20 °C; surface tension of from about 0.02 N/m to 0.04 N/m at 20 °C; kinematic viscosity of from about 20 cSt to about 500 cSt at 40 °C; a breakdown voltage of at least 25 kV; and a hydroxy value of at most 0.1 mg KOH/g.

[0037] According to any of the foregoing embodiments, disclosed herein are compositions further comprising at least one tracer.

[0038] According to any of the foregoing embodiments, disclosed herein are compositions wherein said tracer is present in an amount from about 1.0 ppm by weight to about 1000 ppm by weight.

[0039] According to any of the foregoing embodiments, disclosed herein are compositions wherein said at least one tracer is selected from the group consisting of hydrofluorocarbons, hydrofluoroolefins, hydrochlorocarbons, hydrochloroolefins, hydrochlorofluorocarbons, hydrochlorofluoroolefins, hydrochlorocarbons, hydrochloroolefins, chlorofluorocarbons, chlorofluoroolefins, hydrocarbons, perfluorocarbons, perfluoroolefins, and combinations thereof.

[0040] According to any of the foregoing embodiments, disclosed herein are compositions wherein said at least one tracer is selected from the group consisting of HFC-23, HCFC-31, HFC-41, HFC-161, HFC-143a, HFC-134a, HFC-125, HFC-236fa, HFC-236ea, HFC-245cb, HFC-245fa, HFC-254eb, HFC-263fb, HFC-272ca, HFC-281ea, HFC-281fa, HFC-329p, HFC-329mmz, HFC338mf, HFC-338pcc, CFC-12, CFC-11, CFC-114, CFC-114a, HCFC-22, HCFC-123, HCFC-124, HCFC-124a, HCFC-141b, HCFC-142b, HCFC-151a, HCFC-244bb, HCC-40, HFO-1141, HCFO-1130, HCFO-1130a, HCFO-1131, HCFO-1122, HFO-1123, HFO-1234yf, HFO-1234ye, HFO-1243zf, HFO-1225ye, HFO-1225zc, PFC-116, PFC-C216, PFC-218, PFC-C318, PFC-1216, PFC-31-10mc, PFC-31-10my, and combinations thereof.

[0041] According to any of the foregoing embodiments, disclosed herein are compositions wherein said composition provides average temperature glide less than 8 K, or less than 6 K, or less than 5 K, or less than 4 K, or less than 3 K, or less than 2 K, or less than 1 K.

[0042] According to any of the foregoing embodiments, disclosed herein are compositions wherein the composition is free of or substantially free of Group A Fluorinated Substances, and wherein degradation products of the composition are free of or substantially free of Group A Fluorinated Substances.

[0043] In some embodiments, disclosed herein are methods for cooling comprising evaporating a composition according to any of the foregoing embodiments in the vicinity of a body to be cooled and thereafter condensing said composition.

[0044] In other embodiments, disclosed herein are methods for heating comprising evaporating a composition according to any of the foregoing embodiments, and thereafter condensing said composition in the vicinity of a body to be heated.

[0045] In other embodiments, disclosed herein are systems for cooling or heating comprising a composition according to any of the foregoing embodiments. In other embodiments, the systems comprise an evaporator, compressor, condenser, and expansion device, each operably connected to perform a vapor compression cycle. In another embodiment, the system is a residential, light commercial, or industrial air-conditioner, heat pump, or chiller. In another embodiment, the system is a medium or low temperature refrigeration system, beverage cooler, supermarket display case, ice machine, or transport refrigeration system. In another embodiment, the system is

an automobile heat pump for cooling and heating the passenger compartment, battery or electronic systems of an electric or hybrid vehicle. In another embodiment, the system is a secondary loop system. In another embodiment, the system does not include a PTC heater.

[0046] In other embodiments, disclosed herein are methods of replacing at least one of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C, in refrigeration, air-conditioning, heat pump, or chiller systems comprising providing the composition of any of the foregoing embodiments to the system in place of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C.

[0047] In other embodiments, disclosed herein is the use of a composition of any of the foregoing embodiments as refrigerant in refrigeration, air conditioning, heat pump, or chiller systems. In another embodiment, the use is in a refrigeration, air conditioning, heat pump or chiller system comprising residential, light commercial, or industrial air-conditioner, residential, light commercial, or industrial heat pump, chiller, medium or low temperature refrigeration system, beverage cooler, supermarket display case, ice machine, or transport refrigeration system.

[0048] In another embodiment, the compositions according to any of the foregoing embodiments are used in an automobile heat pump for cooling and heating the passenger compartment, battery or electronic systems of an electric or hybrid vehicle. In another embodiment, the automobile heat pump includes a secondary loop.

[0049] In another embodiment, the compositions of any of the foregoing embodiments may be used to replace any of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C.

DETAILED DESCRIPTION

[0050] The present invention relates to compositions comprising Z-1,2-difluoroethylene (HFO-1252zc) and at least one compounds selected from the group consisting of E-1,2-difluoroethylene (HFO-1132E), Z-1,2-difluoroethylene (HFO-

1132Z), difluoromethane (HFC-32), 1,1,2,2-tetrafluoroethane (HFC-134), and iodotrifluoromethane (CF₃I). These compositions are expected to provide blends with low global warming potential (GWP), improved environmental fate, safety, and performance which meet evolving standards and regulations.

[0051] A refrigerant is defined as a heat transfer fluid that undergoes a phase change from liquid to gas and back again during a cycle used to transfer of heat.

[0052] A heat transfer system is the system (or apparatus) used to produce a heating or cooling effect in a particular space. A heat transfer system may be a mobile system or a stationary system.

[0053] Examples of heat transfer systems are any type of refrigeration systems and air conditioning systems including, but not limited to, stationary heat transfer systems, air conditioners, freezers, refrigerators, heat pumps, flooded evaporator heat pumps, direct expansion chiller heat pumps, chillers, flooded evaporator chillers, direct expansion chillers, walk-in coolers, mobile refrigerators, mobile heat transfer systems, mobile heat pumps (including heat pumps for cabin comfort cooling and heating in automobiles), mobile air conditioning units (for cooling of passenger compartments in automobiles), dehumidifiers, and combinations thereof.

[0054] Volumetric capacity is the amount of heat absorbed or rejected divided by the theoretical compressor displacement. Heat removed or absorbed is the enthalpy difference across a heat exchanger multiplied by the refrigerant mass flowrate. Theoretical compressor displacement is the refrigerant mass flowrate divided by the density of the gas entering the compressor (i.e., compressor suction density). More simply, volumetric capacity is the suction density multiplied by the heat exchanger enthalpy difference. Higher volumetric capacity allows the use of a smaller compressor for the same heat load. Herein, cooling capacity refers to the volumetric capacity in cooling mode and heating capacity refers to the volumetric capacity in heating mode.

[0055] Coefficient of performance (COP) is the amount of heat absorbed or rejected divided by the required energy input to operate the cycle (approximated by the compressor power). COP is specific to the mode of operation of a heat pump, thus COP for heating or COP for cooling. COP is directly related to the energy efficiency ratio (EER).

[0056] Subcooling refers to the reduction of the temperature of a liquid below that liquid's saturation point for a given pressure. The liquid saturation point is the temperature at which the vapor is completely condensed to a liquid. By cooling a liquid below the saturation temperature (or bubble point temperature), the net refrigeration effect can be increased. Subcooling thereby improves refrigeration capacity and energy efficiency of a system. The subcool amount is the amount of cooling below the saturation temperature (in degrees).

[0057] Superheating refers to the increase of the temperature of a vapor above that vapor's saturation point for a given pressure. The vapor saturation point is the temperature at which the liquid is completely evaporated to a vapor. Superheating continues to heat the vapor to a higher temperature vapor at the given pressure. By heating the vapor above the saturation temperature (or dew point temperature), the net refrigeration effect can be increased. Superheating thereby improves refrigeration capacity and energy efficiency of a system when it occurs in the evaporator. Suction line superheat does not add to the net refrigeration effect and can reduce efficiency and capacity. The superheat amount is the amount of heating above the saturation temperature (in degrees).

[0058] Temperature glide (sometimes referred to simply as "glide") is the absolute value of the difference between the starting and ending temperatures of a phase-change process by a refrigerant within a condenser of a refrigerant system, exclusive of any subcooling or superheating. For an evaporator, the glide is the difference in temperature between the dew point and the evaporator inlet. Glide may be used to describe condensation or evaporation of a near azeotrope or non-azeotropic composition. When referring to the temperature glide of an air conditioning or heat pump system, it is common to provide the average temperature glide being the average of the temperature glide in the evaporator and the temperature glide in the condenser. Glide is applicable to blend refrigerants, i.e., refrigerants that are composed of at least 2 components.

[0059] The net refrigeration effect is the quantity of heat that each kilogram of refrigerant absorbs in the evaporator to produce useful cooling.

[0060] The mass flow rate is the quantity of refrigerant in kilograms circulating through the refrigeration, heat pump or air conditioning system over a given period of time.

[0061] As used herein, the term “lubricant” means any material added to a composition or a compressor (and in contact with any heat transfer composition in use within any heat transfer system) that provides hydrodynamic lubrication to the compressor to aid in preventing parts from seizing.

[0062] Global warming potential (GWP) is an index for estimating relative global warming contribution due to atmospheric emission of a kilogram of a particular greenhouse gas compared to emission of a kilogram of carbon dioxide. GWP can be calculated for different time horizons showing the effect of atmospheric lifetime for a given gas. The GWP for the 100-year time horizon is commonly the value referenced. For mixtures, a weighted average can be calculated based on the individual GWPs for each component. Herein, the GWP values are those reported in the United Nations Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), for those compounds listed. The GWP used for each component is listed here.

Compound	GWP
HFO-1252zc	0.09
HFC-32	677
HFO-1132-E	0.0059
HFO-1132-Z	1.5
HFO-1234yf	1
HFC-152a	138
HFC-134	1120
CF ₃ I	0.4
HFC-134a	1300
propane	3

[0063] Ozone depletion potential (ODP) is a number that refers to the amount of ozone depletion caused by a substance. The ODP is the ratio of the impact on

ozone of a chemical compared to the impact of a similar mass of CFC-11 (fluorotrichloromethane). Thus, the ODP of CFC-11 is defined to be 1.0. Other CFCs and HCFCs have ODPs that range from 0.01 to 1.0. Hydrofluorocarbons (HFCs) and the hydrofluoro-olefins (HFO's) described herein have zero ODP because they do not contain chlorine, bromine or iodine, species known to contribute to ozone breakdown and depletion. HFO-1252zc and HFO-1132E have zero ozone depletion potential.

[0064] An azeotropic composition may refer to a constant-boiling mixture of two or more substances that behave as a single substance. One way to characterize an azeotropic composition is that the vapor produced by partial evaporation or distillation of the liquid has the same composition as the liquid from which it is evaporated or distilled. For example, the mixture distills/refluxes without compositional change. Constant-boiling compositions are characterized as azeotropic because they exhibit either a maximum or minimum boiling point, as compared with that of the non-azeotropic mixture of the same compounds. An azeotropic composition will not fractionate within a refrigeration or air conditioning system during operation. Additionally, an azeotropic composition will not fractionate upon leakage from a refrigeration or air conditioning system.

[0065] By "azeotrope-like" composition (sometimes referred to as "near-azeotrope") is meant essentially constant boiling, or substantially constant boiling, liquid mixture of two or more substances that behaves as a single substance. One way to characterize an azeotrope-like composition is that the vapor produced by partial evaporation or distillation of the liquid has substantially the same composition as the liquid from which it was evaporated or distilled, that is, the mixture distills/refluxes without substantial composition change. Another way to characterize an azeotrope-like composition is that the bubble point vapor pressure and the dew point vapor pressure of the composition at a particular temperature are substantially the same, for example within 3 percent. Another way to characterize an azeotrope-like composition is that the difference between the bubble point pressure ("BP") and dew point pressure ("DP") of the composition at a particular temperature is less than or equal to 5 percent based upon the bubble point pressure.

[0066] Another manner to characterize a near-azeotropic composition is that the bubble point vapor pressure and the dew point pressure of the composition at a particular temperature are substantially the same. A composition may be azeotrope-like if, after 50 weight percent (50 wt.%) of the composition is removed, such as by evaporation or boiling off, the difference in vapor pressure, between the original composition and the composition remaining after 50 weight percent of the original composition has been removed, is less than about 10 percent (10%).

[0067] Azeotropic and azeotrope-like compositions will have very low or zero temperature glide in the heat exchangers of a refrigerant system, including refrigeration, air conditioning, heat pump and chiller systems. Herein, a composition with an average temperature glide of 1.0 K or less will be considered to be azeotropic or azeotrope-like. A composition with zero average temperature glide will be considered to be azeotropic.

[0068] 1,1-Difluoropropene (HFO-1252zc or R-1252zc) may be prepared by hydrogenation of 3,3,3-trifluoropropene (HFO-1243zf) over palladium on carbon catalyst to form 1,1,1-trifluoropropane (HFC-263fb), followed by dehydrofluorination of the HFC-263fb over chrome catalyst or by pyrolysis at high temperatures (see U.S. Provisional Patent Application No. 63/527133, herein incorporated by reference).

[0069] The other components of the compositions as disclosed herein are available commercially from various fluorochemical manufacturers and/or specialty chemical suppliers, or can be made by methods known in the art.

[0070] As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a composition, process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such composition, process, method, article, or apparatus.

[0071] The transitional phrase “consisting of” excludes any element, step, or ingredient not specified. If in the claim such would close the claim to the inclusion of materials other than those recited except for impurities ordinarily associated therewith. When the phrase “consists of” appears in a clause of the body of a claim,

rather than immediately following the preamble, it limits only the element set forth in that clause; other elements are not excluded from the claim as a whole.

[0072] The transitional phrase "consisting essentially of" is used to define a composition, method or apparatus that includes materials, steps, features, components, or elements, in addition to those literally disclosed provided that these additional included materials, steps, features, components, or elements do not materially affect the basic and novel characteristic(s) of the claimed invention. The term 'consisting essentially of' occupies a middle ground between "comprising" and 'consisting of'. Typically, components of the refrigerant mixtures and the refrigerant mixtures themselves can contain minor amounts (e.g., less than about 0.5 weight percent total) of impurities and/or byproducts (e.g., from the manufacture of the refrigerant components or reclamation of the refrigerant components from other systems) which do not materially affect the novel and basic characteristics of the refrigerant mixture.

[0073] Also, use of "a" or "an" are employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

[0074] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the disclosed compositions, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety, unless a particular passage is cited. In case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

REFRIGERANT COMPOSITIONS

[0075] In one embodiment, compositions comprise, consist of, or consist essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFC-32, HFC-134, and CF₃I. These compositions provide low Global Warming Potential (GWP), improved environmental fate characteristics, and improved capacity and/or energy efficiency (COP).

[0076] In another embodiment, the compositions comprise, consist of, or consist essentially of HFO-1252zc and are selected from:

HFO-1252zc and HFC-32;
HFO-1252zc and HFO-1132E;
HFO-1252zc and HFO-1132Z;
HFO-1252zc, HFO-1132E, and HFO-1132Z;
HFO-1252zc and HFC-134;
HFO-1252zc, HFO-1132E, and HFC-32;
HFO-1252zc, HFO-1132E, and HFC-134;
HFO-1252zc, HFC-32, and CF₃I;
HFO-1252zc, HFO-1132E, and CF₃I;
HFO-1252zc, HFC-134, and CF₃I;
HFO-1252zc, HFO-1132E, HFC-32, and CF₃I; or
HFO-1252zc, HFO-1132E, HFC-134, and CF₃I.

[0077] In another embodiment, the compositions comprise, consist of, or consist essentially of about 56 to 99 weight percent HFO-1252zc and about 1 to 44 weight percent HFC-32, or about 56 to 78 weight percent HFO-1252zc and about 22 to 44 weight percent HFC-32, or about 78 to 99 weight percent HFO-1252zc and about 1 to 22 weight percent HFC-32, or about 85 to 92 weight percent HFO-1252zc and about 8 to 15 weight percent HFC-32.

[0078] In another embodiment, the compositions comprise, consist of, or consist essentially of about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132E, or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132E.

[0079] In another embodiment, the compositions comprise, consist of, or consist essentially of about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132Z, or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132Z.

[0080] In another embodiment, the compositions comprise, consist of, or consist essentially of about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132E and HFO-1132Z, or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132E and HFO-1132Z.

[0081] In another embodiment, the compositions comprise, consist of, or consist essentially of about 73.5 to 99 weight percent HFO-1252zc and about 1 to 26.5 weight percent HFC-134, or about 86.75 to 99 weight percent HFO-1252zc and about 1 to 13.25 weight percent HFC-134, or about 81 to 95 weight percent HFO-1252zc and about 1 to 19 weight percent HFC-134, or about 73 to 99 weight percent HFO-1252zc and about 1 to 27 weight percent HFC-134, or about 73 to 86 weight percent HFO-1252zc and about 14 to 27 weight percent HFC-134, or about 86 to 99 weight percent HFO-1252zc and about 1 to 14 weight percent HFC-134, or about 81 to 99 weight percent HFO-1252zc and about 1 to 19 weight percent HFC-134, or about 81 to 91 weight percent HFO-1252zc and about 9 to 19 weight percent HFC-134.

[0082] In another embodiment, the compositions comprise, consist of, or consist essentially of about 31 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 44 weight percent HFC-32, or about 31 to 53 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 22 to 44 weight percent HFC-32, or about 31 to 53 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 22 weight percent HFC-32, or about 53 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 22 weight percent HFC-32, or about 79 to 92 weight percent HFO-1252zc, about 1 to 21 weight percent HFO-1132E, and about 1 to 14 weight percent HFC-32.

[0083] In another embodiment, the compositions comprise, consist of, or consist essentially of about 46 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 26 weight percent HFC-134, or about 49 to 62 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about

13 to 26 weight percent HFC-134, or about 49 to 62 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 13 weight percent HFC-134; or about 61 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 13 weight percent HFC-134, or about 68 to 88 weight percent HFO-1252zc, about 11 to 22 weight percent HFO-1132E, and about 1 to 13 weight percent HFC-134.

[0084] In another embodiment, the compositions comprise, consist of, or consist essentially of about 36 to 98 weight percent HFO-1252zc, about 1 to 44 weight percent HFC-32, and about 1 to 30 weight percent CF₃I, or about 46 to 58 weight percent HFO-1252zc, about 22 to 44 weight percent HFC-32, and about 10 to 20 weight percent CF₃I, or about 58 to 98 weight percent HFO-1252zc, about 1 to 22 weight percent HFC-32, and about 1 to 30 weight percent CF₃I, or about 42 to 93 weight percent HFO-1252zc, about 6 to 15 weight percent HFC-32, and about 1 to 48 weight percent CF₃I, or about 24 to 97 weight percent HFO-1252zc, about 2 to 15 weight percent HFC-32, and about 1 to 73 weight percent CF₃I.

[0085] In another embodiment, the compositions comprise, consist of, or consist essentially of about 55 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 20 weight percent CF₃I, or about 55 to 65 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 10 to 20 weight percent CF₃I, or about 11 to 96 weight percent HFO-1252zc, about 3 to 23 weight percent HFO-1132E, and about 1 to 83 weight percent CF₃I, or about 29 to 89 weight percent HFO-1252zc, about 10 to 22 weight percent HFO-1132E, and about 1 to 61 weight percent CF₃I, or about 11 to 62 weight percent HFO-1252zc, about 4 to 16 weight percent HFO-1132E, and about 34 to 83 weight percent CF₃I, or about 29 to 56 weight percent HFO-1252zc, about 10 to 15 weight percent HFO-1132E, and about 34 to 61 weight percent CF₃I.

[0086] In another embodiment, the compositions comprise, consist of, or consist essentially of about 53 to 98 weight percent HFO-1252zc, about 1 to 27 weight percent HFC-134, and about 1 to 20 weight percent CF₃I, or about 53 to 77 weight percent HFO-1252zc, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF₃I, or about 66 to 98 weight percent HFO-1252zc, about 1 to 13 weight percent HFC-134, and about 1 to 30 weight percent CF₃I.

[0087] In another embodiment, the compositions comprise, consist of, or consist essentially of about 11 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 44 weight percent HFC-32, and about 1 to 20 weight percent CF₃I, or about 29 to 42 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF₃I, or about 33 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 22 weight percent HFC-32, and about 1 to 30 weight percent CF₃I.

[0088] In another embodiment, the compositions comprise, consist of, or consist essentially of about 29 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 27 weight percent HFC-134, and about 1 to 20 weight percent CF₃I, or about 29 to 42 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF₃I, or about 42 to 97 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 13 weight percent HFC-134, and about 1 to 30 weight percent CF₃I.

[0089] In another embodiment, for the compositions according to any of the foregoing embodiments containing CF₃I, the content of CF₃I is about 1 to 25 weight percent or about 1 to 20 weight percent.

[0090] In another embodiment, for the compositions according to any of the foregoing embodiments wherein the HFC-32 is present at about 1 to 22 weight percent, or at about 10 to 22 weight percent, or at about 15 to 22 weight percent.

[0091] In another embodiment, for the compositions according to any of the foregoing embodiments wherein the HFC-134 is present at about 1 to 13 weight percent, or at about 5 to 13 weight percent, or at about 8 to 13 weight percent.

[0092] In another embodiment, it is desirable to have flammability class 2 (or less flammable) for the compositions. Therefore, disclosed herein are compositions comprising, consisting of, or consisting essentially of about 1 to 26 weight percent HFO-1252zc and at least one of HFO-1132E, HFO-1132Z, or a combination thereof.

[0093] In another embodiment, the compositions comprise, consist of, or consist essentially of: about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-

1132E; or about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-1132Z; or about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-1132E and HFO-1132Z.

[0094] The compositions of the present invention may be classified by the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) as class 2, based on ASHRAE Standard 34. Thus, in another embodiment, wherein the compositions are classified as class 2 for flammability, the compositions comprise, consist of, or consist essentially of about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132E; or about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132Z; or about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132E and HFO-1132Z.

[0095] Flammability is a term used to mean the ability of a composition to ignite and/or propagate a flame. For refrigerants and other heat transfer compositions or working fluids, the lower flammability limit ("LFL") is the minimum concentration of the heat transfer composition in air that is capable of propagating a flame through a homogeneous mixture of the composition and air under test conditions specified in ASTM (American Society of Testing and Materials) E681. The upper flammability limit ("UFL") is the maximum concentration of the heat transfer composition in air that is capable of propagating a flame through a homogeneous mixture of the composition and air under the same test conditions.

[0096] In order for a refrigerant to be classified by ANSI/ASHRAE (ANSI = American National Standards Institute) as class 1 or non-flammable, it must have no flame propagation when tested at 140°F (60°C) and 14.7 psia (101.3 kPa).

[0097] In order for a refrigerant to be classified by ANSI/ASHRAE as low flammability (class 2L), it must: 1) exhibit flame propagation when tested at 140°F (60°C) and 14.7 psia (101.3 kPa); 2) have an LFL >0.0062 lb/ft³ (0.10 kg/m³); 3) have a heat of combustion <8169 Btu/lb (19,000 kJ/kg); and 4) have a maximum burning velocity of ≤3.9 in./s (10 cm/s) when tested at 73.4°F (23.0°C) and 14.7 psia (101.3 kPa) in dry air.

[0098] In order for a refrigerant to be classified by ANSI/ASHRAE as flammable (class 2), it must: 1) exhibit flame propagation when tested at 140°F (60°C) and 14.7

psia (101.3 kPa); 2) have an LFL $>0.0062 \text{ lb/ft}^3$ (0.10 kg/m^3); and 3) have a heat of combustion $<8169 \text{ Btu/lb}$ ($19,000 \text{ kJ/kg}$).

[0099] ASHRAE Standard 34 provides a methodology to calculate the heat of combustion for refrigerant blends using a balanced stoichiometric equation based on the complete combustion of one mole of refrigerant with enough oxygen for a stoichiometric reaction.

[0100] The compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF_3I , may further comprise at least one additional compound. The at least one additional compound may be selected from the group consisting of methane, ethane, HFC-41 (fluoromethane), HCC-40 (chloromethane), HFCF-22 (chlorodifluoromethane), HFC-23 (trifluoromethane), HFO-1141 (fluoroethylene), HFO-1132E (E-1,2-difluoroethylene), HFO-1132Z (Z-1,2-difluoroethylene), HFC-161 (fluoroethane), HFC-152 (1,2-difluoroethane), HFC-143 (1,1,2-trifluoroethane), HFC-143a (1,1,1-trifluoroethane), HFC-134a (1,1,1,2-tetrafluoroethane), PFC-116 (hexafluoroethane), HCFO-1122 (1-chloro-2,2-difluoroethylene), HCFO-1122aE (E-1-chloro-1,2-difluoroethylene), HCFO-1122aZ (Z-1-chloro-1,2-difluoroethylene), HCC-150 (1,2-dichloroethane), HCFC-151 (1-chloro-2-fluoroethane), CFO-1112E (E-1,2-dichloro-1,2-difluoroethylene), CFO-1112Z (Z-1,2-dichloro-1,2-difluoroethylene), HCFC-142a (1-chloro-1,2-difluoroethane), HCFC-132 (1,2-dichloro-1,2-difluoroethane), HCFC-133 (1-chloro-1,1,2-trifluoroethane), HCFC-133b (2-chloro-1,1,1-trifluoroethane), HCFC-123 (1,1-dichloro-2,2,2-trifluoroethane), HFO-1123 (trifluoroethylene), HFO-1132a (1,1-difluoroethylene), HCFO-1131E (E-1-chloro-2-fluoroethylene), HCFO-1131Z (Z-1-chloro-2-fluoroethylene), ethylene, and acetylene.

[0101] The amount of additional compounds present in any of the foregoing refrigerant compositions can be greater than 0 ppm and less than 5,000 ppm and, in particular, can range from greater than zero to about 1,000 ppm, about 5 to about 500 ppm and about 1 to about 100 ppm.

[0102] In one embodiment, the amount of additional compounds present in any of the foregoing refrigerant compositions can be greater than 0 and less than 1 wt% of

the refrigerant composition, preferably less than 0.5 weight percent, or more preferably less than 0.1 weight percent.

[0103] The compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I will perform more consistently and be more stable with only minor amounts of water present. Thus, the compositions may further comprise less than 100 ppm (by weight) water, preferably less than 20 ppm (by weight) water, and even more preferably less than 10 ppm (by weight) water.

[0104] Additionally, the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I will perform more consistently and be more stable with only minor amounts of oxygen or air present. Therefore, the presently claimed compositions may further comprise less than about 5 volume percent non-adsorbable gases (NAG), preferably less than 3 volume percent NAG, and more preferably less than 1.5 volume percent NAG. Further, the presently claimed compositions, due to the presence of air or NAG, will contain less than 1 volume percent oxygen, preferably less than 0.5 volume percent oxygen, and more preferably less than 0.3 volume percent oxygen.

[0105] In another embodiment, the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I may contain a stabilizer. Such stabilizer compounds are intended to be present in a small amount and prevent various types of chemical reactivity including decomposition due to the presence of water, air, NAG, or oxygen in a system while in use or while the composition is stored. HFO type refrigerants, due to the presence of a double bond, may be subject to thermal instability and decompose under extreme use, handling or storage situations also. Therefore, there may be advantages to adding stabilizers to HFO type refrigerants. Stabilizers may notably include nitromethane, ascorbic acid, terephthalic acid, azoles such as tolutriazole or benzotriazole, phenolic compounds such as tocopherol, hydroquinone, t-butyl hydroquinone, 2,6-di-tertbutyl-4-methylphenol, epoxides (possibly fluorinated or perfluorinated alkyl epoxides or

alkenyl or aromatic epoxides) such as n-butyl glycidyl ether, hexanediol diglycidyl ether, allyl glycidyl ether, butylphenylglycidyl ether, cyclic monoterpenes, terpenes, such as d-limonene, α -terpinene, β -terpinene, γ -terpinene, α -pinene, or β -pinene, phosphites, phosphates, phosphonates, thiols and lactones. Examples of suitable stabilizers are disclosed in WO2019213004, WO2020222864, and WO2020222865; the disclosures of which are hereby incorporated by reference.

[0106] If the composition does include a stabilizer, it may include any amount from 0.001 wt% up to 1 wt%, preferably from about 0.001 to about 0.5 weight percent, more preferably, from about 0.001 to about 0.3 weight percent of any of the stabilizers listed above.

[0107] In some embodiments, the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I may contain a tracer compound or tracers. The tracer may comprise two or more tracer compounds. In some embodiments, the tracer is present in the compositions at a total concentration of about 50 parts per million by weight (ppm) to about 1000 ppm, based on the weight of the total composition. In other embodiments, the tracer is present at a total concentration of about 50 ppm to about 500 ppm. Alternatively, the tracer is present at a total concentration of about 100 ppm to about 300 ppm.

[0108] The tracer may be present in compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I in predetermined quantities to allow detection of any dilution, contamination, or other alteration of the composition. The presence of certain compounds in the composition may indicate by what method or process one of the components has been produced. The tracer may also be added to the composition in a specified amount in order to identify the source of the composition. In this manner, detection of infringement on patent rights may be accomplished. The tracers may be refrigerant compounds but are present in the composition at levels that are unlikely to impact performance of the refrigerant component of the composition.

[0109] Tracer compounds may be hydrofluorocarbons, hydrofluoroolefins, hydrochlorocarbons, hydrochloroolefins, hydrochlorofluorocarbons, hydrochlorofluoroolefins, hydrochlorocarbons, hydrochloroolefins, chlorofluorocarbons, chlorofluoroolefins, hydrocarbons, perfluorocarbons, perfluoroolefins, and combinations thereof. Examples of tracer compounds include, but are not limited to HFC-23 (trifluoromethane), HCFC-31 (chlorofluoromethane), HFC-41 (fluoromethane), HFC-161 (fluoroethane), HFC-143a (1,1,1-trifluoroethane), HFC-134a (1,1,1,2-tetrafluoroethane), HFC-125 (pentafluoroethane), HFC-236fa (1,1,1,3,3,3-hexafluoropropane), HFC-236ea (1,1,1,2,3,3-hexafluoropropane), HFC-245cb (1,1,1,2,2-pentafluoropropane), HFC-245fa (1,1,1,3,3-pentafluoropropane), HFC-254eb (1,1,1,2-tetrafluoropropane), HFC-263fb (1,1,1 trifluoropropane), HFC-272ca (2,2-difluoropropane), HFC-281ea (2-fluoropropane), HFC-281fa (1-fluoropropane), HFC-329p (1,1,1,2,2,3,3,4,4-nonafluorobutane), HFC-329mmz (1,1,1-trifluoro-2-methylpropane), HFC-338mf (1,1,1,2,2,4,4,4-octafluorobutane), HFC-338pcc (1,1,2,2,3,3,4,4-octafluorobutane), CFC-12 (dichlorodifluoromethane), CFC-11 (trichlorofluoromethane), CFC-114 (1,2-dichloro-1,1,2,2-tetrafluoroethane), CFC-114a (1,1,-dichloro-1,2,2,2-tetrafluoroethane), HCFC-22 (chlorodifluoromethane), HCFC-123 (1,1-dichloro-2,2,2-trifluoroethane), HCFC-124 (2-chloro-1,1,1,2-tetrafluoroethane), HCFC-124a (1-chloro-1,1,2,2-tetrafluoroethane), HCFC-141b (1,1-dichloro-1-fluoroethane), HCFC-142b (1-chloro-1,1-difluoroethane), HCFC-151a (1-chloro-1-fluoroethane), HCFC-244bb (2-chloro-1,1,1,2-tetrafluoropropane), HCC-40 (chloromethane), HFO-1141 (fluoroethene), HCFO-1130 (1,2-dichloroethene), HCFO-1130a (1,1-dichloroethene), HCFO-1131 (1-chloro-2-fluoroethene), HCFO-1122 (2-chloro-1,1-difluoroethene), HFO-1123 (1,1,2-trifluoroethene), HFO-1234ye (1,2,3,3-tetrafluoropropene), HFO-1243zf (3,3,3-trifluoropropene), HFO-1225ye (1,2,3,3,3-pentafluoropropene), HFO-1225zc (1,1,3,3,3-pentafluoropropene), PFC-116 (hexafluoroethane), PFC-C216 (hexafluorocyclopropane), PFC-218 (octafluoropropane), PFC-C318 (octafluorocyclobutane), PFC-1216 (hexafluoroethane), PFC-31-10mc (1,1,1,2,2,3,3,4,4,4-decafluorobutane), PFC-31-10my (1,1,1,2,3,3,3-heptafluoro-2-trifluoromethylpropane), and combinations thereof.

[0110] In another embodiment of the present disclosure, the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I further comprise at least one lubricant. Lubricants may be selected from the group consisting of polyalkylene glycol (PAG), polyol ester (POE), poly- α -olefin (PAO), and polyvinyl ether (PVE). In another embodiment, compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I further comprise POE or PAG lubricants. Lubricants may also comprise those commonly known as “mineral oils” in the field of compression refrigeration lubrication. Mineral oils comprise paraffins (i.e. straight-chain and branched-carbon-chain, saturated hydrocarbons), naphthenes (i.e. cyclic or ring structure saturated hydrocarbons, which may be paraffins) and aromatics (i.e. unsaturated, cyclic hydrocarbons containing one or more rings characterized by alternating double bonds). Lubricants of the present invention further comprise those commonly known as “synthetic oils” in the field of compression refrigeration lubrication. Synthetic oils comprise alkylaryls (i.e. linear and branched alkyl alkylbenzenes), synthetic paraffins and naphthenes, silicones, and polyalphaolefins. Representative conventional lubricants of the present invention are the commercially available BVM 100 N (paraffinic mineral oil sold by BVA Oils), naphthenic mineral oil commercially available under the trademark from Suniso® 3GS and Suniso® 5GS by Crompton Co., naphthenic mineral oil commercially available from Pennzoil under the trademark Sontex® 372LT, naphthenic mineral oil commercially available from Calumet Lubricants under the trademark Calumet® RO-30, linear alkylbenzenes commercially available from Shrieve Chemicals under the trademarks Zerol® 75, Zerol® 150 and Zerol® 500 and branched alkylbenzene, sold by Nippon Oil as HAB 22.

[0111] Lubricants of the present invention further comprise those which have been designed for use with hydrofluorocarbon refrigerants and are miscible with refrigerants of the present invention under compression refrigeration and air-conditioning apparatus' operating conditions. Lubricants include, but are not limited to, polyol esters (POEs) such as Castrol® 100 (Castrol, United Kingdom),

polyalkylene glycols (PAGs) such as RL-488A from Dow (Dow Chemical, Midland, Mich.), and polyvinyl ethers (PVEs) such as PVE-FVC68D.

[0112] In one embodiment, the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I are combined with a PAG lubricant or a PVE lubricant or a POE lubricant for usage in a refrigeration system, air-conditioning system, heat pump system, or chiller system.

[0113] In the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I including a lubricant, the lubricant may be present in an amount of less than 80 weight percent of the total composition. The lubricant may further be present in an amount of less than 60 weight percent of the total composition. In other embodiments, the amount of lubricant may be between about 0.1 and 50 weight percent of the total composition. The lubricant may also be between about 0.1 and 20 weight percent of the total composition. The lubricant may also be between about 0.1 and 5 weight percent of the total composition.

[0114] In another aspect of the invention, the inventive composition comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I is used to introduce lubricant into the air-conditioning or heat pump system as well as or alternatively other additives, such as a) acid scavengers, b) performance enhancers, and c) flame suppressants. In one preferred embodiment, the present compositions comprise an acid scavenger.

[0115] Examples of the acid scavengers that may be included in the present compositions include, but are not limited, the stabilizers and/or the epoxide component of the stabilizers disclosed in U.S. Patent No. 8,535,555 and the acid scavengers disclosed in International Application Publication No. WO 2020/222864, the disclosure of each of which is incorporated herein by reference in its entirety.

[0116] In some embodiments, an acid scavenger may comprise one or more epoxides, one or more amines and/or one or more hindered amines, such as, for example but not limited to, epoxybutane.

[0117] The acid scavenger (e.g., the activated aromatic compound, the siloxane, or both) may be present in any concentration that results in a relatively low total acid number, a relatively low total halides concentration, a relatively low total organic acid concentration, or any combination thereof.

[0118] Preferably the acid scavenger is present at a concentration greater than about 0.0050 wt%, more preferably greater than about 0.05 wt% and even more preferably greater than about 0.1 wt% (e.g. greater than about 0.5 wt%) based on the total weight of the refrigerant composition. The acid scavenger preferably is present in a concentration less than about 5 wt%, less than about 4 wt%, less than about 3 wt%, more preferably less than about 2.5 wt% and most preferably greater than about 2 wt% (e. g. less than about 1.8 wt%) based on the total weight of the refrigerant composition.

[0119] Preferred additives include those described in U.S. Pat. Nos. 5,152,926; 4,755,316, which are hereby incorporated by reference. In particular, the preferred extreme pressure additives include mixtures of (A) tolyltriazole or substituted derivatives thereof, (B) an amine (e.g. Jeffamine M-600) and (C) a third component which is (i) an ethoxylated phosphate ester (e.g. Antara LP-700 type), or (ii) a phosphate alcohol (e.g. ZELEC 3337 type), or (iii) a Zinc dialkyldithiophosphate (e.g. Lubrizol 5139, 5604, 5178, or 5186 type), or (iv) a mercaptobenzothiazole, or (v) a 2,5-dimercapto-1,3,4-triadiazole derivative (e. g. Curvan 826) or a mixture thereof. Additional examples of additives which may be used are given in U.S. Pat. No. 5,976,399 (Schnur, 5:12-6:51, hereby incorporated by reference).

[0120] Acid number is measured according to ASTM D664-01 in units of mg KOH/g. The total halides concentration, the fluorine ion concentration, and the total organic acid concentration is measured by ion chromatography. Chemical stability of the refrigerant system is measured according to ASHRAE 97: 2007 (RA 2017) "Sealed Glass Tube Method to Test the Chemical Stability of Materials for Use within Refrigerant Systems". The viscosity of the lubricant is tested at 40°C according to ASTM D-7042.

[0121] Mouli et al. (WO 2008/027595 and WO 2009/042847) teach the use of alkyl silanes as a stabilizer in refrigerant compositions containing fluoroolefins. Phosphates, phosphites, epoxides, and phenolic additives also have been employed

in certain refrigerant compositions. These are described for example by Kaneko (U.S. patent application Ser. No. 11/575,256, published as U.S. Publication 2007/0290164) and Singh et al. (U.S. patent application Ser. No. 11/250,219, published as U.S. Publication 2006/0116310). All of these aforementioned applications are expressly incorporated herein by reference.

[0122] Preferred flame suppressants include the flame retardants described in patent application "Refrigerant compositions containing fluorine substituted olefins CA 2557873 A1" and incorporated by reference, as well as fluorinated products such as HFC-125, HFC-227ea, HFC-236fa, CF₃I, and/or Krytox® lubricants, also incorporated by reference and described in patent application "Refrigerant compositions comprising fluoroolefins and uses thereof WO2009018117A1."

[0123] In another embodiment, the compositions comprise, consist of, or consist essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I provide cooling and or heating performance, such that the average temperature glide is less than 8 K, or less than 6 K, or less than 5 K, or less than 4 K, or less than 3 K, or less than 2 K, or less than 1 K.

[0124] In one embodiment, as used herein, "Group A Fluorinated Substances" includes any substance that (i) contains at least one fully fluorinated methyl (–CF₃) or methylene (–CF₂–) carbon atom (without any H/Cl/Br/I attached to it); and (ii) meets the criterion for persistence in soil/sediment and water established in Annex XIII (Section 1.1.1) of the European Union's REACH Regulation (<https://reachonline.eu/reach/en/annex-xiii-1-1.1-1.1.1.html> as accessed on May 2, 2023) and referenced in the Annex XV Restriction Report dated March 22, 2023, the disclosure of which is hereby incorporated by reference (<https://echa.europa.eu/documents/10162/f605d4b5-7c17-7414-8823-b49b9fd43aea> as accessed on May 2, 2023). In one embodiment, Group A Fluorinated Substances include, but are not limited to, trifluoroacetic acid (TFA).

[0125] In another embodiment, as used herein, "Group A Fluorinated Substances" includes any substance that has a Henry's Law constant $\leq 250 \text{ Pa}\cdot\text{m}^3/\text{mol}$ and contains at least one fully fluorinated methyl (–CF₃) or methylene (–CF₂–) carbon

atom (without any H/Cl/Br/I attached to it). In one embodiment, Group A Fluorinated Substances include, but are not limited to, TFA.

[0126] Thus, according to some embodiments, compositions of the present invention which comprise, consist of, or consist essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, CF₃I, and CO₂ are free of or substantially free of Group A Fluorinated Substances, such as TFA. In one embodiment, the phrase "free of" as used herein with respect to the presence of Group A Fluorinated Substances in the present compositions means that the amount of such substances in the compositions is sufficiently low so as to not be detectable, including but not limited to 0%, when measured by gas chromatography with a flame ionization detector, gas chromatography with a mass detector by analysis of a gas sample or liquid sample, and/or ion chromatography by analysis of a water sample after bubbling the thermal fluid through water. Such methodologies are well known to those skilled in the art. In one embodiment, the phrase "substantially free of" as used herein with respect to the presence of Group A Fluorinated Substances in the present compositions means that the amount of such substances in the compositions is > 0 wt. % and ≤ 5 wt. %, or > 0 wt. % and ≤ 4 wt. %, or > 0 wt. % and ≤ 3 wt. %, or > 0 wt. % and ≤ 2 wt. %, or > 0 wt. % and ≤ 1 wt. %, and all values and ranges therebetween, when measured by gas chromatographic (GC) techniques, for example gas chromatography (GC) with a flame ionization or electron-capture detector, or GC coupled with a mass detector (gas chromatography/mass spectral (GC/MS) method), by ion chromatograph (IC) or ion chromatography mass spectrometry (IC-MS) techniques, or by high-performance liquid chromatography (HPLC) or high-performance liquid chromatography mass spectrometry (HPLC-MS) techniques. The TFA analytical standard may be used in either gas chromatography or ion chromatography and is available from, for example, Sigma Aldrich.

[0127] Further, in some embodiments, degradation products of such compositions of the present invention which comprise, consist of, or consist essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I are free of or substantially free of Group A Fluorinated Substances, such as TFA. In one embodiment, the phrase "free of" as used herein with respect to the formation of Group A Fluorinated

Substances by the present compositions means that the theoretical molar yield of such substances in environmental compartments of air, soil/sediment and water produced during tropospheric degradation of the compositions is sufficiently low so as to not be detectable, including but not limited to 0%, when measured by GC techniques, for example GC with a flame ionization or electron-capture detector or GC/MS method, by IC or IC-MS techniques, or by HPLC or HPLC-MS techniques. In one embodiment, the phrase "substantially free of" as used herein with respect to the formation of Group A Fluorinated Substances by the present compositions means that the theoretical molar yield of such substances in environmental compartments of air, soil/sediment and water produced during tropospheric degradation of the compositions is $> 0\%$ and $\leq 5\%$, or $> 0\%$ and $\leq 4\%$, or $> 0\%$ and $\leq 3\%$, or $> 0\%$ and $\leq 2\%$, or $> 0\%$ and $\leq 1\%$, and all values and ranges therebetween, when measured by GC techniques, for example GC with a flame ionization or electron-capture detector or GC/MS method, by IC or IC-MS techniques, or by HPLC or HPLC-MS techniques.

METHODS AND SYSTEMS

[0128] The compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I are useful in numerous methods and systems that provide cooling (e.g. air-conditioning or refrigeration) and heating.

[0129] In one embodiment, provided is a method of cooling comprising evaporating a composition comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I in the vicinity of a body to be cooled and thereafter condensing said composition, wherein said cooling is provided by a refrigeration system, air-conditioner, heat pump, or chiller.

[0130] In one embodiment, the refrigeration system may be a residential, commercial, or industrial refrigeration system. These may include, but are not limited to, supermarket and convenience store refrigerated cases for beverages, dairy, and produce and prepared foods. In one embodiment, the refrigeration system is a low or medium temperature refrigeration system, including supermarket and convenience store refrigerator and freezer cabinets and displays, ice machines,

self-contained coolers and freezers, such as beverage coolers, walk-in and reach-in coolers and freezers, supermarket rack and distributed systems, and refrigerated or frozen food transport.

[0131] In one embodiment, the air conditioner may be a residential, commercial, or industrial air-conditioning system. These may include, but are not limited to, window, ducted, ductless, packaged terminal, and those exterior to, but connected to the building, such as rooftop systems. These may also include residential heat pumps that provide comfort air-conditioning and heating.

[0132] In another embodiment, the cooling may be performed in a chiller. Chillers, including both flooded evaporator and direct expansion chillers, may be coupled with an air handling and distribution system to provide comfort air conditioning (cooling and dehumidifying the air) to large commercial buildings, including hotels, office buildings, hospitals, universities and the like. In another embodiment, chillers, most likely air-cooled direct expansion chillers, have found additional utility in naval submarines and surface vessels.

[0133] Chillers may be characterized by the compressor used. In one embodiment, the chiller may comprise a centrifugal compressor. In another embodiment, the chiller may comprise a scroll compressor. In another embodiment the chiller may comprise a screw compressor. In yet another embodiment, the chiller may comprise a reciprocating compressor.

[0134] The present method for cooling may be particularly useful in high ambient temperature regions, due to the high critical temperature of blends comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I.

[0135] In another embodiment, the method for producing cooling is particularly useful in regions where the ambient temperature can exceed at least 35°C.

[0136] In geographic areas with high ambient temperatures, where air conditioning becomes essential, refrigerant compositions with high critical temperatures and high thermal stability are desirable. Currently available hydrofluorocarbon (HFC) refrigerants such as R-410A, R-407C or R-32 have relatively low critical

temperatures. As a consequence, these refrigerants do not perform well in extreme hot environments. The energy efficiency of a refrigerant generally decreases as the condensing temperature approaches the refrigerant critical temperature during operation at high ambient temperatures. In hot climates, R-22 has remained the refrigerant of choice for much air conditioning and refrigeration applications as it is not flammable and has a higher critical temperature so that it delivers higher cooling capacity and higher energy efficiency in hot climates as compared to R-410A or R-32. However, R-22 is an ozone depleting substance in the Montreal Protocol to reduce ozone depletion. As such, R-22 has been mandated and legislated for phase out for manufacture for and use in air conditioning and refrigeration. There is interest in finding a refrigerant with the lowest possible direct GWP and also that performs well in hot climate (or high ambient) temperature regions.

[0137] In the method for producing cooling the body to be cooled may be defined as any space, location, object, or body for which it is desirable to provide cooling. Examples include spaces, open or enclosed, that require cooling such as a residence, such as an apartment or apartment building, university dormitory, townhouse or other attached house, or a single-family home; or the body to be cooled may be any other building, such as an office building, supermarket, college or university classroom or administration buildings.

[0138] In another embodiment, a method for producing air conditioning in high ambient temperatures is provided. The method comprises evaporating a composition comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I and thereafter condensing said composition. The method is particularly useful in regions where ambient temperatures can exceed 35°C or more.

[0139] In another embodiment, a method is provided for replacing HCFC-22 in high ambient air conditioning apparatus comprising providing a composition comprising, consisting essentially of, or consisting of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I to said apparatus. The method of replacing HCFC-22 is particularly useful in regions where ambient temperatures can exceed 35°C or more.

[0140] Similarly, in some industrial air conditioning applications heat must be released in high ambient temperature environments. HCFC-124 has been used as the working fluid in such applications. HCFC-124 is also controlled under the Montreal protocol as an ozone depleting substance and more environmentally sustainable replacements are desirable. Thus, a method is provided for replacing HCFC-124 in industrial air conditioning apparatus, comprising providing a composition comprising, consisting essentially of, or consisting of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I to said apparatus. The method of replacing HCFC-124 is particularly useful in regions where ambient temperatures can exceed 35°C or more.

[0141] In another embodiment, the method for producing cooling and method for replacing HCFC-22 or HCFC-124 are useful for systems operating in ambient temperatures of 40°C or higher. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures of 45°C or higher. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures of 50°C or higher. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures of 55°C or higher. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures of 60°C or higher. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures from 35-50°C. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures from 35-60°C. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures from 40- 60°C. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures from 45-60°C. In another embodiment, the method for producing cooling is useful for systems operating in ambient temperatures from 50-60°C.

[0142] In another embodiment, provided is a method of heating comprising evaporating a composition comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-

1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I and thereafter condensing said composition in the vicinity of a body to be heated.

[0143] In one embodiment, the heating is accomplished by a heat pump, which may be a residential, light commercial, commercial, or industrial heat pump system. These may include, but are not limited to, residential heat pumps that provide comfort air-conditioning and heating, hot water heat pumps for heating air (by secondary loop) or for heating water for residential or commercial use, heat pumps for heating manufacturing process equipment, and high temperature heat pumps (with condensing temperature of 50 deg C or higher).

[0144] Due to the high critical temperature of blends comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I it is possible to heat water to higher temperatures than propane or R-454C.

[0145] In another embodiment, is provided a system for cooling or heating comprising a composition comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I. The system comprises an evaporator, compressor, condenser, and expansion device, each operably connected to perform a vapor compression cycle. In another embodiment, the system may further comprise a lubricant. The lubricant may be selected from the group consisting of polyalkylene glycol, polyol ester, poly- α -olefin, and polyvinyl ether. In another embodiment, the lubricant is selected from POE or PVE.

[0146] The system for cooling or heating may be a refrigeration system, air-conditioner, heat pump, or chiller.

[0147] In one embodiment, the refrigeration system may be a residential, commercial, or industrial refrigeration system. These may include, but are not limited to, supermarket and convenience store refrigerated cases for beverages, dairy, and produce and prepared foods. In one embodiment, the refrigeration system is a low or medium temperature refrigeration system, including supermarket and convenience store refrigerator and freezer cabinets and displays, ice machines, self-contained coolers and freezers, such as beverage coolers, walk-in and reach-in

coolers and freezers, supermarket rack and distributed systems, and refrigerated or frozen food transport.

[0148] In one embodiment, the air conditioner may be a residential, commercial, or industrial air-conditioning system. These may include, but are not limited to, window, ducted, ductless, packaged terminal, and those exterior to, but connected to the building, such as rooftop systems. These may also include residential heat pumps that provide comfort air-conditioning and heating.

[0149] In one embodiment, the system is a heat pump, which may be a residential, light commercial, commercial, or industrial heat pump system. These may include, but are not limited to, residential heat pumps that provide comfort air-conditioning and heating, hot water heat pumps for heating air (by secondary loop) or for heating water for residential or commercial use, heat pumps for heating manufacturing process equipment, and high temperature heat pumps (with condensing temperature of 50 deg C or higher).

[0150] In another embodiment, the system is a chiller. Chillers, including both flooded evaporator and direct expansion chillers, may be coupled with an air handling and distribution system to provide comfort air conditioning (cooling and dehumidifying the air) to large commercial buildings, including hotels, office buildings, hospitals, universities and the like. In another embodiment, chillers, most likely air-cooled direct expansion chillers, have found additional utility in naval submarines and surface vessels.

[0151] Chillers may be characterized by the compressor used. In one embodiment, the chiller may comprise a centrifugal compressor. In another embodiment, the chiller may comprise a scroll compressor. In another embodiment the chiller may comprise a screw compressor. In yet another embodiment, the chiller may comprise a reciprocating compressor. When replacing a refrigerant in a chiller, the compressor, often designed for the refrigerant to be used, may need modification. Therefore, for centrifugal chillers, the impeller diameter or impeller tip speed for the new refrigerant must be similar or match that for the original refrigerant to be used as a drop-in replacement.

[0152] In another embodiment, the system containing the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I may be an automobile heat pump for cooling and heating the passenger compartment, battery or electronic systems of an electric or hybrid vehicle. Electric or hybrid vehicles include automobiles with no internal combustion engine (ICE) or those that maintain an ICE but also use electric power and are therefore hybrid electric vehicles (HEV) or plug-in hybrid electric vehicles (PHEV) or mild hybrid electric vehicles (MHEV). Additionally, electric or hybrid vehicles include full electric vehicles (EV), such as battery electric vehicles (BEV). All of these electric or hybrid vehicles use at least one electric motor, wherein the electric motor provides some form of propulsion for the vehicles normally provided by the ICE found in gasoline/diesel powered vehicles.

[0153] In one embodiment, the automobile heat pump is a secondary loop system. The secondary loop allows the separation of a flammable refrigerant from the passenger compartment, using a heat transfer fluid to produce cooling or heating in the passenger compartment.

[0154] In another embodiment, the automobile heat pump does not include a positive temperature coefficient (PTC) heater. The PTC heater often used in electric vehicles is needed in the absence of an ICE to provide adequate heating to the passenger compartment.

[0155] In another embodiment, the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I may be used in a method of replacing at least one of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C, in refrigeration, air-conditioning, heat pump, or chiller systems comprising providing any of the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I to the system in place of R-22, HFC-134a, propane, HFO-1234yf, R-407C,

R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C.

[0156] In one embodiment, the method for replacement may be a retrofit for existing equipment. Therefore, the method is specific to replacing a refrigerant in equipment that was designed for, or originally contained R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C. In another embodiment, the replacement is simply providing a new refrigerant for an application or use, wherein the new refrigerant can provide improved performance, or meet regulatory requirements that are not met by the incumbent refrigerant.

[0157] The compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I provide performance that would allow replacement of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C..

[0158] In another embodiment, the compositions comprising, consisting of, or consisting essentially of HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, and CF₃I provide performance that enables the use as refrigerant in refrigeration, air-conditioning, heat pump, or chiller systems. In particular, the refrigeration, air-conditioning, heat pump, or chiller systems comprise mobile or stationary air conditioning, mobile or stationary heat pumps, residential, light commercial, commercial, or industrial air-conditioner, residential, light commercial, commercial, or industrial heat pump, centrifugal chiller, screw chiller, scroll chiller, flooded evaporator chiller, direct expansion chiller, medium or low temperature refrigeration system, beverage cooler, supermarket display case, ice machine, or transport refrigeration or freezer system. Additionally, the compositions are useful wherein the system is an automobile heat pump for cooling and heating the passenger compartment of an electric or hybrid vehicle. Further, the compositions may be useful in replacing refrigerants such as R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C.

[0159] The following Examples are provided to illustrate certain aspects of the invention and shall not limit the scope of the appended claims.

EXAMPLES

Examples for Residential and EV heat pumps

[0160] In the examples to follow, the conditions for electric vehicle heat pumps in cooling mode are 0 °C and 40 °C as the average evaporator and condenser temperatures, 10 K of superheat and 0 K of subcooling and in heating mode are -30 °C and 50 °C as the average evaporator and condenser temperatures, 10 K of superheat and 0 K of subcooling.

Example 1: HFO-1252zc and HFC-32

[0161] Refrigerant performance is provided below for compositions containing HFO-1252zc and HFC-32 as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0162] **Table 1A and Table 1B:** Heat pump conditions in cooling mode.

TABLE 1A

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
R1252zc	R32	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.78	0.22	97.7	149.0	5.5	79.4	-7.0	4.2
0.77	0.23	97.2	155.8	5.6	79.8	-5.9	4.1
0.76	0.24	96.8	162.5	5.6	80.1	-4.8	4.0
0.75	0.25	96.4	169.3	5.7	80.5	-3.7	3.9
0.74	0.26	96.0	176.1	5.8	80.8	-2.7	3.8
0.73	0.27	95.6	182.9	5.8	81.2	-1.6	3.7
0.72	0.28	95.2	189.6	5.9	81.5	-0.5	3.6
0.71	0.29	94.8	196.4	5.9	81.8	0.5	3.6
0.70	0.30	94.4	203.2	5.9	82.1	1.6	3.5
0.69	0.31	94.0	209.9	5.9	82.4	2.7	3.4
0.68	0.32	93.7	216.7	5.9	82.7	3.7	3.3
0.67	0.33	93.3	223.5	5.9	83.1	4.8	3.2
0.66	0.34	92.9	230.2	5.9	83.3	5.8	3.1
0.65	0.35	92.5	237.0	5.9	83.6	6.8	3.0
0.64	0.36	92.2	243.8	5.9	83.9	7.9	2.9

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
0.63	0.37	91.8	250.5	5.9	84.2	8.9	2.8
0.62	0.38	91.5	257.3	5.8	84.5	9.9	2.7
0.61	0.39	91.1	264.1	5.8	84.8	11.0	2.7
0.60	0.40	90.8	270.9	5.7	85.0	12.0	2.6
0.59	0.41	90.4	277.6	5.7	85.3	13.0	2.5
0.58	0.42	90.1	284.4	5.6	85.5	14.0	2.4
0.57	0.43	89.7	291.2	5.5	85.8	15.1	2.3
0.56	0.44	89.4	297.9	5.5	86.1	16.1	2.2

TABLE 1B

Mass Fraction		Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
R1252zc	R32	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.78	0.22	-39.3	7.4	-13.7	9.6	46.1	3.0	39.0	-0.8
0.77	0.23	-38.6	7.3	-12.7	9.5	47.8	2.9	40.6	-0.9
0.76	0.24	-37.9	7.2	-11.7	9.4	49.5	2.8	42.3	-1.0
0.75	0.25	-37.2	7.1	-10.7	9.4	51.2	2.8	43.9	-1.1
0.74	0.26	-36.5	7.0	-9.7	9.3	52.9	2.7	45.5	-1.2
0.73	0.27	-35.8	6.9	-8.7	9.2	54.6	2.6	47.1	-1.2
0.72	0.28	-35.1	6.9	-7.7	9.1	56.3	2.5	48.7	-1.3
0.71	0.29	-34.4	6.8	-6.7	9.0	58.0	2.4	50.3	-1.4
0.70	0.30	-33.7	6.7	-5.7	8.9	59.6	2.3	51.9	-1.5
0.69	0.31	-33.0	6.6	-4.7	8.8	61.3	2.2	53.4	-1.6
0.68	0.32	-32.3	6.5	-3.7	8.7	62.9	2.2	55.0	-1.7
0.67	0.33	-31.6	6.4	-2.8	8.6	64.6	2.1	56.6	-1.7
0.66	0.34	-30.9	6.3	-1.8	8.5	66.2	2.0	58.1	-1.8
0.65	0.35	-30.3	6.2	-0.8	8.4	67.9	1.9	59.7	-1.9
0.64	0.36	-29.6	6.1	0.1	8.3	69.5	1.8	61.2	-2.0
0.63	0.37	-28.9	6.0	1.1	8.2	71.1	1.7	62.8	-2.1
0.62	0.38	-28.2	5.9	2.1	8.1	72.7	1.6	64.3	-2.2
0.61	0.39	-27.6	5.8	3.0	8.0	74.4	1.5	65.9	-2.3
0.60	0.40	-26.9	5.7	4.0	7.9	76.0	1.4	67.4	-2.4
0.59	0.41	-26.2	5.6	4.9	7.9	77.6	1.3	68.9	-2.4
0.58	0.42	-25.6	5.6	5.9	7.8	79.2	1.3	70.5	-2.5
0.57	0.43	-24.9	5.5	6.8	7.7	80.8	1.2	72.0	-2.6
0.56	0.44	-24.2	5.4	7.7	7.6	82.4	1.1	73.5	-2.7

[0163] Table 1C and Table 1D: Heat pump conditions in heating mode.

TABLE 1C

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
R1252zc	R32	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.78	0.22	97.7	149.0	4.5	122.9	0.5	10.9
0.77	0.23	97.2	155.8	4.6	123.7	1.8	10.8
0.76	0.24	96.8	162.5	4.6	124.5	3.2	10.8
0.75	0.25	96.4	169.3	4.7	125.3	4.6	10.7
0.74	0.26	96.0	176.1	4.8	126.0	5.9	10.6
0.73	0.27	95.6	182.9	4.8	126.8	7.3	10.6
0.72	0.28	95.2	189.6	4.9	127.5	8.7	10.5
0.71	0.29	94.8	196.4	4.9	128.3	10.1	10.4
0.70	0.30	94.4	203.2	4.9	129.0	11.5	10.3
0.69	0.31	94.0	209.9	5.0	129.8	12.9	10.3
0.68	0.32	93.7	216.7	5.0	130.5	14.3	10.2
0.67	0.33	93.3	223.5	5.0	131.2	15.7	10.1
0.66	0.34	92.9	230.2	5.0	131.9	17.1	10.1
0.65	0.35	92.5	237.0	5.0	132.6	18.5	10.0
0.64	0.36	92.2	243.8	5.0	133.3	19.9	9.9
0.63	0.37	91.8	250.5	5.0	134.0	21.3	9.8
0.62	0.38	91.5	257.3	5.0	134.7	22.7	9.8
0.61	0.39	91.1	264.1	4.9	135.4	24.1	9.7
0.60	0.40	90.8	270.9	4.9	136.1	25.5	9.6
0.59	0.41	90.4	277.6	4.9	136.7	26.9	9.5
0.58	0.42	90.1	284.4	4.8	137.4	28.3	9.5
0.57	0.43	89.7	291.2	4.8	138.1	29.7	9.4
0.56	0.44	89.4	297.9	4.7	138.7	31.1	9.3

TABLE 1D

Mass Fraction		Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
R1252zc	R32	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.78	0.22	-42.0	11.1	-5.4	25.2	46.1	3.0	39.0	-0.8
0.77	0.23	-41.2	11.0	-4.1	25.1	47.8	2.9	40.6	-0.9
0.76	0.24	-40.5	11.0	-2.8	25.1	49.5	2.8	42.3	-1.0
0.75	0.25	-39.7	10.9	-1.6	25.0	51.2	2.8	43.9	-1.1
0.74	0.26	-38.9	10.8	-0.3	24.9	52.9	2.7	45.5	-1.2
0.73	0.27	-38.1	10.8	1.0	24.8	54.6	2.6	47.1	-1.2
0.72	0.28	-37.3	10.7	2.3	24.8	56.3	2.5	48.7	-1.3
0.71	0.29	-36.5	10.6	3.6	24.7	58.0	2.4	50.3	-1.4
0.70	0.30	-35.7	10.6	4.9	24.6	59.6	2.3	51.9	-1.5

Mass Fraction		Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
0.69	0.31	-34.9	10.5	6.3	24.5	61.3	2.2	53.4	-1.6
0.68	0.32	-34.1	10.4	7.6	24.4	62.9	2.2	55.0	-1.7
0.67	0.33	-33.3	10.3	8.9	24.4	64.6	2.1	56.6	-1.7
0.66	0.34	-32.5	10.3	10.2	24.3	66.2	2.0	58.1	-1.8
0.65	0.35	-31.6	10.2	11.5	24.2	67.9	1.9	59.7	-1.9
0.64	0.36	-30.8	10.1	12.8	24.1	69.5	1.8	61.2	-2.0
0.63	0.37	-30.0	10.1	14.2	24.0	71.1	1.7	62.8	-2.1
0.62	0.38	-29.2	10.0	15.5	23.9	72.7	1.6	64.3	-2.2
0.61	0.39	-28.4	9.9	16.8	23.9	74.4	1.5	65.9	-2.3
0.60	0.40	-27.6	9.8	18.1	23.8	76.0	1.4	67.4	-2.4
0.59	0.41	-26.8	9.8	19.5	23.7	77.6	1.3	68.9	-2.4
0.58	0.42	-26.0	9.7	20.8	23.6	79.2	1.3	70.5	-2.5
0.57	0.43	-25.1	9.6	22.1	23.5	80.8	1.2	72.0	-2.6
0.56	0.44	-24.3	9.5	23.5	23.4	82.4	1.1	73.5	-2.7

[0164] The data indicate that compositions containing HFO-1252zc and HFC-32 will provide good replacements for R-454C, with capacity within 10%, in many cases, and improved COP. Additionally, the compositions have reasonable glide and GWP from just under 150 to 300 allowing use in many refrigerant applications.

Example 2: HFO-1252zc and HFO-1132E

[0165] Refrigerant performance is provided below for compositions containing HFO-1252zc and HFO-1132E as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0166] Table 2A and Table 2B: Heat pump conditions in cooling mode.

TABLE 2A

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
R1252zc	R1132E	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.75	0.25	100.9	0.1	3.9	73.3	-14.4	4.6

TABLE 2B

Composition, mass fraction		Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
R-1252zc	R1132E	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.75	0.25	-44.1	7.9	-20.5	10.1	34.5	3.5	28.0	-0.4

[0167] Table 2C and Table 2D: Heat pump conditions in heating mode.

TABLE 2C

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
R1252zc	R1132E	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.78	0.22	97.7	149.0	3.2	110.2	-7.6	10.6

TABLE 2D

Composition, mass fraction		Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
R-1252zc	R1132E	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.75	0.25	-44.1	7.9	-20.5	10.1	34.5	3.5	28.0	-0.4

Example 3: HFO-1252zc and HFC-134

[0168] Refrigerant performance is provided below for compositions containing HFO-1252zc and HFC-134 as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0169] Table 3A and Table 3B: Heat pump conditions in cooling mode.

TABLE 3A

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
R1252zc	R134	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.86	0.14	106.7	156.9	0.1	67.5	-30.3	6.2
0.85	0.15	106.7	168.1	0.1	67.4	-30.3	6.2
0.84	0.16	106.6	179.3	0.0	67.3	-30.2	6.2
0.83	0.17	106.6	190.5	0.0	67.2	-30.1	6.1
0.82	0.18	106.5	201.7	0.0	67.2	-30.1	6.1
0.81	0.19	106.5	212.9	0.0	67.1	-30.0	6.1

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
0.80	0.20	106.4	224.1	0.0	67.0	-30.0	6.1
0.79	0.21	106.4	235.3	0.0	67.0	-30.0	6.1
0.78	0.22	106.3	246.5	0.0	66.9	-29.9	6.1
0.77	0.23	106.3	257.7	0.0	66.9	-29.9	6.1
0.76	0.24	106.3	268.9	0.0	66.8	-29.9	6.1
0.75	0.25	106.2	280.1	0.0	66.7	-29.8	6.1
0.74	0.26	106.2	291.3	0.0	66.7	-29.8	6.1

TABLE 3B

Composition, mass fraction		Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
R-1252zc	R134	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.86	0.14	-54.5	9.5	-35.3	11.8	9.5	5.0	4.1	1.1
0.85	0.15	-54.5	9.5	-35.3	11.7	9.6	5.0	4.2	1.1
0.84	0.16	-54.4	9.4	-35.2	11.7	9.7	5.0	4.3	1.1
0.83	0.17	-54.4	9.4	-35.2	11.7	9.8	5.0	4.4	1.1
0.82	0.18	-54.4	9.4	-35.1	11.7	9.8	5.0	4.5	1.0
0.81	0.19	-54.3	9.4	-35.1	11.7	9.9	4.9	4.6	1.0
0.80	0.20	-54.3	9.4	-35.0	11.7	10.0	4.9	4.6	1.0
0.79	0.21	-54.3	9.4	-35.0	11.7	10.1	4.9	4.7	1.0
0.78	0.22	-54.3	9.4	-35.0	11.7	10.1	4.9	4.7	1.0
0.77	0.23	-54.2	9.4	-34.9	11.6	10.2	4.9	4.8	1.0
0.76	0.24	-54.2	9.4	-34.9	11.6	10.2	4.9	4.8	1.0
0.75	0.25	-54.2	9.3	-34.9	11.6	10.2	4.9	4.9	1.0
0.74	0.26	-54.2	9.3	-34.9	11.6	10.3	4.9	4.9	1.0

[0170] Table 3C and Table 3D: Heat pump conditions in heating mode.

TABLE 3C

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
R1252zc	R134	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.86	0.14	106.7	156.9	0.0	100.2	-26.1	11.8
0.85	0.15	106.7	168.1	0.0	100.1	-26.1	11.8
0.84	0.16	106.6	179.3	0.0	99.9	-26.0	11.8
0.83	0.17	106.6	190.5	0.0	99.8	-26.0	11.7
0.82	0.18	106.5	201.7	0.0	99.6	-25.9	11.7
0.81	0.19	106.5	212.9	0.0	99.5	-25.9	11.7
0.80	0.20	106.4	224.1	0.0	99.4	-25.9	11.6
0.79	0.21	106.4	235.3	0.0	99.2	-25.9	11.6

Mass Fraction		Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
0.78	0.22	106.3	246.5	0.0	99.1	-25.9	11.6
0.77	0.23	106.3	257.7	0.0	99.0	-25.9	11.5
0.76	0.24	106.3	268.9	0.0	98.9	-25.9	11.5
0.75	0.25	106.2	280.1	0.0	98.8	-25.9	11.5
0.74	0.26	106.2	291.3	0.0	98.6	-26.0	11.4

TABLE 3D

Composition, mass fraction		Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
R-1252zc	R134	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.86	0.14	-57.4	12.0	-30.5	26.3	24.0	15.7	14.9	2.6
0.85	0.15	-57.3	12.0	-30.4	26.2	24.1	15.7	15.0	2.5
0.84	0.16	-57.3	12.0	-30.4	26.2	24.2	15.7	15.1	2.5
0.83	0.17	-57.3	12.0	-30.3	26.2	24.3	15.6	15.2	2.5
0.82	0.18	-57.3	11.9	-30.3	26.1	24.3	15.6	15.2	2.5
0.81	0.19	-57.3	11.9	-30.3	26.1	24.4	15.6	15.2	2.4
0.80	0.20	-57.2	11.9	-30.2	26.1	24.4	15.5	15.3	2.4
0.79	0.21	-57.2	11.8	-30.2	26.0	24.4	15.5	15.3	2.4
0.78	0.22	-57.2	11.8	-30.2	26.0	24.4	15.5	15.3	2.3
0.77	0.23	-57.2	11.8	-30.2	26.0	24.4	15.4	15.3	2.3
0.76	0.24	-57.3	11.7	-30.3	25.9	24.4	15.4	15.3	2.3
0.75	0.25	-57.3	11.7	-30.3	25.9	24.4	15.4	15.2	2.3
0.74	0.26	-57.3	11.7	-30.3	25.9	24.3	15.3	15.2	2.2

[0171] The data indicate that the compositions containing HFO-1252zc and HFC-134 would serve well as replacement for HFC-134a and/or HFO-1234yf with improved capacity and COP for both heating and cooling. Additionally, these compositions are azeotropic or azeotrope-like with low to zero average temperature glide and have GWP less than 300.

Example 4: HFO-1252zc, HFO-1132E, and HFC-32

[0172] Refrigerant performance is provided below for compositions containing HFO-1252zc, HFO-1132E, and HFC-32 as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0173] Table 4A and Table 4B: Heat pump conditions in cooling mode.

TABLE 4A

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R404A	
1252zc	32	1132E	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.53	0.22	0.25	91.3	149.0	5.7	81.4	3.2	8.0
0.52	0.23	0.25	90.9	155.8	5.7	81.7	4.3	7.9
0.51	0.24	0.25	90.5	162.5	5.7	81.9	5.3	7.8
0.50	0.25	0.25	90.1	169.3	5.7	82.2	6.4	7.7
0.48	0.27	0.25	89.3	182.8	5.6	82.7	8.5	7.5
0.47	0.28	0.25	88.9	189.6	5.5	83.0	9.5	7.4
0.46	0.29	0.25	88.5	196.4	5.4	83.3	10.6	7.3
0.45	0.30	0.25	88.2	203.1	5.4	83.5	11.6	7.2
0.44	0.31	0.25	87.8	209.9	5.3	83.7	12.6	7.1
0.43	0.32	0.25	87.4	216.7	5.2	84.0	13.6	7.0
0.42	0.33	0.25	87.1	223.4	5.1	84.2	14.7	6.9
0.41	0.34	0.25	86.7	230.2	5.0	84.5	15.7	6.8
0.40	0.35	0.25	86.4	237.0	4.9	84.7	16.8	6.7
0.39	0.36	0.25	86.0	243.8	4.8	84.9	17.8	6.6
0.38	0.37	0.25	85.7	250.5	4.7	85.1	18.8	6.5
0.37	0.38	0.25	85.3	257.3	4.6	85.3	19.9	6.4
0.36	0.39	0.25	85.0	264.1	4.5	85.5	20.9	6.3
0.35	0.40	0.25	84.7	270.8	4.4	85.8	21.9	6.2
0.34	0.41	0.25	84.3	277.6	4.3	86.0	23.0	6.1
0.33	0.42	0.25	84.0	284.4	4.1	86.2	23.9	6.0
0.32	0.43	0.25	83.7	291.1	4.0	86.4	24.9	5.9
0.31	0.44	0.25	83.4	297.9	3.8	86.5	25.9	5.8

TABLE 4B

Composition, mass fraction			Relative to R410A		Relative to R454C		Relative to 1234yf		Relative to R134a	
1252zc	32	1132E	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.53	0.22	0.25	-27.4	5.8	11.2	2.6	74.7	1.5	66.2	-2.3
0.52	0.23	0.25	-26.7	5.7	12.4	2.5	76.5	1.4	67.9	-2.4
0.51	0.24	0.25	-25.9	5.6	13.5	2.4	78.3	1.3	69.6	-2.5
0.50	0.25	0.25	-25.2	5.5	14.6	2.3	80.1	1.2	71.3	-2.6
0.48	0.27	0.25	-23.7	5.3	16.9	2.1	83.6	1.0	74.7	-2.8
0.47	0.28	0.25	-23.0	5.2	17.9	2.0	85.3	0.9	76.3	-2.9
0.46	0.29	0.25	-22.2	5.1	19.1	1.9	87.2	0.8	78.0	-2.9
0.45	0.30	0.25	-21.5	5.0	20.2	1.8	88.9	0.7	79.7	-3.0
0.44	0.31	0.25	-20.8	4.9	21.4	1.7	90.7	0.6	81.4	-3.1

Composition, mass fraction			Relative to R410A		Relative to R454C		Relative to 1234yf		Relative to R134a	
0.43	0.32	0.25	-20.1	4.8	22.4	1.6	92.3	0.5	82.9	-3.3
0.42	0.33	0.25	-19.3	4.7	23.6	1.5	94.2	0.4	84.7	-3.3
0.41	0.34	0.25	-18.6	4.6	24.7	1.4	95.9	0.3	86.4	-3.4
0.40	0.35	0.25	-17.9	4.5	25.8	1.3	97.7	0.2	88.0	-3.5
0.39	0.36	0.25	-17.2	4.4	26.9	1.3	99.4	0.1	89.7	-3.6
0.38	0.37	0.25	-16.4	4.3	28.0	1.2	101.1	0.0	91.3	-3.7
0.37	0.38	0.25	-15.7	4.2	29.1	1.1	102.9	-0.1	93.0	-3.8
0.36	0.39	0.25	-15.0	4.1	30.2	1.0	104.6	-0.1	94.6	-3.9
0.35	0.40	0.25	-14.3	4.0	31.3	0.9	106.3	-0.2	96.3	-4.0
0.34	0.41	0.25	-13.5	3.9	32.5	0.8	108.2	-0.3	98.1	-4.0
0.33	0.42	0.25	-12.8	3.8	33.5	0.7	109.8	-0.4	99.6	-4.1
0.32	0.43	0.25	-12.1	3.7	34.6	0.6	111.5	-0.5	101.2	-4.2
0.31	0.44	0.25	-11.5	3.6	35.6	0.5	113.1	-0.6	102.7	-4.3

[0174] Table 4C and Table 4D: Heat pump conditions in heating mode.

TABLE 4C

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R404A	
1252zc	32	1132E	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.53	0.22	0.25	91.3	149.0	4.8	127.2	17.0	23.2
0.52	0.23	0.25	90.9	155.8	4.8	127.9	18.5	23.1
0.51	0.24	0.25	90.5	162.5	4.8	128.6	19.9	23.0
0.50	0.25	0.25	90.1	169.3	4.8	129.3	21.3	22.9
0.47	0.28	0.25	88.9	189.6	4.7	130.6	24.2	22.7
0.46	0.29	0.25	88.5	196.4	4.6	131.2	25.5	22.5
0.45	0.30	0.25	88.2	203.1	4.6	131.9	27.0	22.5
0.44	0.31	0.25	87.8	209.9	4.6	132.6	28.5	22.4
0.43	0.32	0.25	87.4	216.7	4.5	133.2	29.9	22.3
0.42	0.33	0.25	87.1	223.4	4.4	133.8	31.3	22.1
0.41	0.34	0.25	86.7	230.2	4.4	134.5	32.8	22.1
0.40	0.35	0.25	86.4	237.0	4.3	135.1	34.3	22.0
0.39	0.36	0.25	86.0	243.8	4.2	135.7	35.7	21.9
0.38	0.37	0.25	85.7	250.5	4.2	136.3	37.2	21.8
0.37	0.38	0.25	85.3	257.3	4.1	137.0	38.6	21.7
0.36	0.39	0.25	85.0	264.1	4.0	137.6	40.1	21.6
0.35	0.40	0.25	84.7	270.8	3.9	138.2	41.5	21.5
0.34	0.41	0.25	84.3	277.6	3.8	138.8	43.0	21.4
0.33	0.42	0.25	84.0	284.4	3.7	139.4	44.6	21.4
0.32	0.43	0.25	83.7	291.1	3.6	140.0	45.9	21.2
0.31	0.44	0.25	83.4	297.9	3.5	140.6	47.4	21.1

TABLE 4D

Composition, mass fraction			Relative to R410A		Relative to R454C		Relative to 1234yf		Relative to R134a	
1252zc	R32	1132E	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.53	0.22	0.25	-28.3	9.3	24.3	9.1	108.7	12.9	93.4	0.1
0.52	0.23	0.25	-27.4	9.2	25.8	9.0	111.3	12.8	95.8	0.0
0.51	0.24	0.25	-26.5	9.1	27.3	8.9	113.8	12.7	98.1	-0.1
0.50	0.25	0.25	-25.6	9.0	28.9	8.8	116.4	12.6	100.5	-0.2
0.47	0.28	0.25	-23.9	8.9	31.9	8.6	121.5	12.4	105.2	-0.4
0.46	0.29	0.25	-23.1	8.7	33.3	8.5	123.8	12.3	107.4	-0.5
0.45	0.30	0.25	-22.1	8.7	34.9	8.5	126.6	12.2	109.9	-0.5
0.44	0.31	0.25	-21.2	8.6	36.5	8.4	129.2	12.1	112.3	-0.6
0.43	0.32	0.25	-20.4	8.5	38.0	8.3	131.7	12.1	114.7	-0.7
0.42	0.33	0.25	-19.6	8.3	39.4	8.1	134.1	11.9	116.9	-0.8
0.41	0.34	0.25	-18.6	8.3	41.1	8.1	136.9	11.9	119.5	-0.9
0.40	0.35	0.25	-17.7	8.2	42.6	8.0	139.5	11.8	121.9	-0.9
0.39	0.36	0.25	-16.8	8.1	44.2	7.9	142.1	11.7	124.3	-1.0
0.38	0.37	0.25	-15.9	8.0	45.7	7.8	144.7	11.6	126.7	-1.1
0.37	0.38	0.25	-15.0	7.9	47.2	7.7	147.2	11.5	129.1	-1.2
0.36	0.39	0.25	-14.1	7.9	48.8	7.6	149.9	11.4	131.5	-1.3
0.35	0.40	0.25	-13.3	7.8	50.3	7.6	152.5	11.3	133.9	-1.3
0.34	0.41	0.25	-12.4	7.7	51.9	7.5	155.1	11.2	136.3	-1.4
0.33	0.42	0.25	-11.4	7.7	53.6	7.5	157.9	11.2	138.9	-1.4
0.32	0.43	0.25	-10.6	7.5	55.0	7.3	160.3	11.1	141.1	-1.6
0.31	0.44	0.25	-9.7	7.4	56.5	7.2	162.9	11.0	143.5	-1.6

[0175] The data indicate that the compositions containing HFO-1252zc, HFC-32, and HFO-1132E would serve well as replacement for HFC-134a and/or HFO-1234yf with improved capacity and COP for both heating and cooling as compared to 1234yf and only slight reductions in COP as compared to HFC-134a. Additionally, these compositions have reasonable average temperature glide and have GWP less than 300.

Example 5: HFO-1252zc, HFO-1132E, and HFC-134

[0176] Refrigerant performance is provided below for compositions containing HFO-1252zc, HFO-1132E, and HFC-134 as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0177] Table 5A and Table 5B: Heat pump conditions in cooling mode.

TABLE 5A

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	1132E	134	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.62	0.25	0.13	100.1	145.7	3.6	72.5	-13.1	4.5
0.61	0.25	0.14	100.0	156.9	3.6	72.4	-13.1	4.5
0.60	0.25	0.15	100.0	168.1	3.6	72.4	-13.0	4.5
0.58	0.25	0.17	99.9	190.5	3.6	72.3	-12.9	4.5
0.57	0.25	0.18	99.9	201.7	3.6	72.2	-12.8	4.4
0.56	0.25	0.19	99.8	212.9	3.6	72.2	-12.8	4.4
0.55	0.25	0.20	99.8	224.0	3.6	72.2	-12.7	4.4
0.54	0.25	0.21	99.8	235.2	3.6	72.1	-12.7	4.4
0.53	0.25	0.22	99.8	246.4	3.6	72.1	-12.6	4.4
0.52	0.25	0.23	99.8	257.6	3.5	72.0	-12.7	4.4
0.51	0.25	0.24	99.7	268.8	3.6	72.0	-12.6	4.4
0.50	0.25	0.25	99.7	280.0	3.6	72.0	-12.6	4.4
0.49	0.25	0.26	99.7	291.2	3.6	72.0	-12.6	4.4

TABLE 5B

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	1132E	134	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.62	0.25	0.13	-43.3	7.7	-19.4	10.0	36.5	3.3	29.9	-0.5
0.61	0.25	0.14	-43.3	7.7	-19.3	9.9	36.5	3.3	29.9	-0.5
0.60	0.25	0.15	-43.2	7.7	-19.2	10.0	36.7	3.3	30.1	-0.5
0.58	0.25	0.17	-43.1	7.7	-19.1	9.9	36.9	3.3	30.2	-0.6
0.57	0.25	0.18	-43.1	7.7	-19.1	9.9	37.0	3.3	30.3	-0.6
0.56	0.25	0.19	-43.1	7.7	-19.0	9.9	37.1	3.3	30.4	-0.6
0.55	0.25	0.20	-43.0	7.7	-19.0	9.9	37.1	3.3	30.5	-0.6
0.54	0.25	0.21	-43.0	7.6	-18.9	9.9	37.2	3.3	30.5	-0.6
0.53	0.25	0.22	-43.0	7.6	-18.9	9.9	37.2	3.2	30.6	-0.6
0.52	0.25	0.23	-43.0	7.6	-18.9	9.8	37.2	3.2	30.5	-0.6
0.51	0.25	0.24	-42.9	7.6	-18.9	9.9	37.3	3.2	30.7	-0.6
0.50	0.25	0.25	-42.9	7.6	-18.8	9.9	37.4	3.2	30.7	-0.6
0.49	0.25	0.26	-42.9	7.6	-18.8	9.8	37.4	3.2	30.7	-0.6

[0178] Table 5C and Table 5D: Heat pump conditions in heating mode.

TABLE 5C

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	1132E	134	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.62	0.25	0.13	100.1	145.7	2.9	108.6	-6.8	10.2
0.61	0.25	0.14	100.0	156.9	2.9	108.5	-6.9	10.1
0.60	0.25	0.15	100.0	168.1	2.9	108.4	-6.8	10.1
0.58	0.25	0.17	99.9	190.5	2.9	108.2	-6.8	10.0
0.57	0.25	0.18	99.9	201.7	2.9	108.2	-6.9	10.0
0.56	0.25	0.19	99.8	212.9	2.9	108.1	-6.9	10.0
0.55	0.25	0.20	99.8	224.0	2.9	108.1	-7.0	9.9
0.54	0.25	0.21	99.8	235.2	2.9	108.0	-7.0	9.9
0.53	0.25	0.22	99.8	246.4	2.9	108.0	-7.1	9.8
0.52	0.25	0.23	99.8	257.6	2.9	107.9	-7.2	9.7
0.51	0.25	0.24	99.7	268.8	2.9	107.9	-7.2	9.8
0.50	0.25	0.25	99.7	280.0	2.9	107.9	-7.3	9.7
0.49	0.25	0.26	99.7	291.2	2.9	107.8	-7.4	9.7

TABLE 5D

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	1132E	134	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.62	0.25	0.13	-46.2	10.4	-12.3	24.4	56.5	14.0	45.0	1.0
0.61	0.25	0.14	-46.3	10.3	-12.3	24.3	56.4	13.9	44.9	0.9
0.60	0.25	0.15	-46.2	10.3	-12.3	24.3	56.5	13.9	45.0	1.0
0.58	0.25	0.17	-46.2	10.2	-12.3	24.2	56.4	13.9	44.9	0.9
0.57	0.25	0.18	-46.3	10.2	-12.3	24.2	56.4	13.8	44.9	0.9
0.56	0.25	0.19	-46.3	10.2	-12.4	24.2	56.3	13.8	44.8	0.9
0.55	0.25	0.20	-46.3	10.1	-12.4	24.1	56.2	13.8	44.8	0.8
0.54	0.25	0.21	-46.3	10.1	-12.5	24.1	56.1	13.7	44.7	0.8
0.53	0.25	0.22	-46.4	10.1	-12.5	24.0	56.0	13.7	44.6	0.8
0.52	0.25	0.23	-46.5	10.0	-12.7	23.9	55.8	13.6	44.3	0.7
0.51	0.25	0.24	-46.5	10.0	-12.7	24.0	55.8	13.6	44.3	0.7
0.50	0.25	0.25	-46.5	10.0	-12.8	23.9	55.6	13.6	44.2	0.7
0.49	0.25	0.26	-46.6	9.9	-12.9	23.9	55.4	13.5	44.0	0.6

[0179] The data indicates that compositions containing HFO-1252zc, HFO-1132E, and HFC-134 provide capacity within 10% of that for R-454C in heating mode and improved COP. Additionally, these compositions have low average temperature glide and GWP from under 150 up to only 300.

Example 6: HFO-1252zc, CF₃I, and HFC-32

[0180] Refrigerant performance is provided below for compositions containing HFO-1252zc, CF₃I, and HFC-32 as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0181] Table 6A and Table 6B: Heat pump conditions in cooling mode.

TABLE 6A

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	32	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.58	0.22	0.20	96.5	149.1	6.3	80.7	-3.0	4.1
0.57	0.23	0.20	96.0	155.8	6.4	81.1	-1.8	4.0
0.56	0.24	0.20	95.5	162.6	6.4	81.5	-0.5	3.8
0.55	0.25	0.20	95.0	169.4	6.5	81.9	0.8	3.7
0.54	0.26	0.20	94.5	176.1	6.5	82.2	2.0	3.6
0.53	0.27	0.20	94.0	182.9	6.5	82.6	3.3	3.5
0.52	0.28	0.20	93.5	189.7	6.5	82.9	4.5	3.4
0.51	0.29	0.20	93.1	196.5	6.5	83.3	5.7	3.3
0.50	0.30	0.20	92.6	203.2	6.5	83.6	7.0	3.2
0.49	0.31	0.20	92.1	210.0	6.4	83.9	8.2	3.0
0.48	0.32	0.20	91.7	216.8	6.4	84.3	9.4	2.9
0.47	0.33	0.20	91.2	223.5	6.3	84.6	10.6	2.8
0.46	0.34	0.20	90.8	230.3	6.3	84.9	11.8	2.7
0.45	0.35	0.20	90.4	237.1	6.2	85.2	13.1	2.5
0.44	0.36	0.20	89.9	243.8	6.1	85.5	14.3	2.4
0.43	0.37	0.20	89.5	250.6	6.0	85.7	15.5	2.3
0.42	0.38	0.20	89.1	257.4	5.9	86.0	16.7	2.2
0.41	0.39	0.20	88.7	264.1	5.8	86.3	17.8	2.0
0.40	0.40	0.20	88.3	270.9	5.7	86.6	19.1	1.9
0.39	0.41	0.20	87.8	277.7	5.6	86.9	20.3	1.9
0.38	0.42	0.20	87.5	284.5	5.5	87.1	21.4	1.7
0.37	0.43	0.20	87.1	291.2	5.3	87.3	22.6	1.6
0.36	0.44	0.20	86.7	298.0	5.2	87.6	23.8	1.5
0.68	0.22	0.10	97.1	149.0	5.8	80.0	-5.1	4.1
0.67	0.23	0.10	96.7	155.8	5.9	80.3	-4.0	4.0
0.66	0.24	0.10	96.2	162.6	6.0	80.7	-2.8	3.9
0.65	0.25	0.10	95.8	169.3	6.0	81.1	-1.6	3.9
0.64	0.26	0.10	95.3	176.1	6.1	81.4	-0.5	3.8
0.63	0.27	0.10	94.9	182.9	6.2	81.8	0.8	3.7
0.62	0.28	0.10	94.4	189.7	6.2	82.1	1.8	3.6
0.61	0.29	0.10	94.0	196.4	6.2	82.5	3.0	3.5

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
0.60	0.30	0.10	93.6	203.2	6.2	82.8	4.2	3.4
0.59	0.31	0.10	93.2	210.0	6.2	83.1	5.3	3.2
0.58	0.32	0.10	92.8	216.7	6.1	83.4	6.4	3.1
0.57	0.33	0.10	92.3	223.5	6.1	83.7	7.5	3.0
0.56	0.34	0.10	91.9	230.3	6.1	84.0	8.7	2.9
0.55	0.35	0.10	91.5	237.0	6.1	84.3	9.8	2.8
0.54	0.36	0.10	91.1	243.8	6.0	84.6	10.9	2.7
0.53	0.37	0.10	90.7	250.6	5.9	84.9	12.0	2.6
0.51	0.39	0.10	90.0	264.1	5.8	85.5	14.2	2.4
0.50	0.40	0.10	89.6	270.9	5.8	85.8	15.4	2.3
0.49	0.41	0.10	89.2	277.7	5.7	86.0	16.4	2.2
0.48	0.42	0.10	88.9	284.4	5.6	86.3	17.5	2.1
0.47	0.43	0.10	88.5	291.2	5.5	86.5	18.6	2.0
0.46	0.44	0.10	88.1	298.0	5.3	86.7	19.6	1.9

TABLE 6B

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	R-32	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.58	0.22	0.20	-36.7	7.3	-10.0	9.5	52.4	2.9	44.9	-0.9
0.57	0.23	0.20	-35.9	7.2	-8.8	9.4	54.4	2.8	46.8	-1.0
0.56	0.24	0.20	-35.0	7.1	-7.6	9.3	56.3	2.7	48.7	-1.1
0.55	0.25	0.20	-34.2	7.0	-6.5	9.2	58.3	2.6	50.6	-1.2
0.54	0.26	0.20	-33.4	6.8	-5.3	9.1	60.3	2.5	52.5	-1.3
0.53	0.27	0.20	-32.6	6.7	-4.1	8.9	62.2	2.4	54.3	-1.5
0.52	0.28	0.20	-31.8	6.6	-3.0	8.8	64.2	2.3	56.2	-1.6
0.51	0.29	0.20	-31.0	6.5	-1.8	8.7	66.1	2.1	58.1	-1.7
0.50	0.30	0.20	-30.2	6.4	-0.7	8.6	68.1	2.0	59.9	-1.8
0.49	0.31	0.20	-29.4	6.2	0.4	8.4	70.0	1.9	61.7	-1.9
0.48	0.32	0.20	-28.6	6.1	1.6	8.3	71.9	1.8	63.6	-2.0
0.47	0.33	0.20	-27.8	6.0	2.7	8.2	73.8	1.7	65.4	-2.1
0.46	0.34	0.20	-27.0	5.9	3.8	8.1	75.7	1.5	67.2	-2.3
0.45	0.35	0.20	-26.2	5.7	4.9	7.9	77.6	1.4	69.0	-2.4
0.44	0.36	0.20	-25.4	5.6	6.1	7.8	79.7	1.3	70.9	-2.5
0.43	0.37	0.20	-24.6	5.5	7.2	7.7	81.4	1.2	72.6	-2.6
0.42	0.38	0.20	-23.8	5.4	8.3	7.6	83.3	1.1	74.4	-2.7
0.41	0.39	0.20	-23.1	5.2	9.3	7.4	85.1	0.9	76.1	-2.9
0.40	0.40	0.20	-22.3	5.1	10.5	7.3	87.1	0.8	78.0	-2.9
0.39	0.41	0.20	-21.4	5.0	11.7	7.2	89.1	0.7	79.9	-3.0
0.38	0.42	0.20	-20.7	4.9	12.7	7.1	90.8	0.6	81.5	-3.2
0.37	0.43	0.20	-19.9	4.8	13.8	6.9	92.7	0.5	83.3	-3.3
0.36	0.44	0.20	-19.2	4.6	14.9	6.8	94.6	0.4	85.1	-3.4
0.68	0.22	0.10	-38.1	7.4	-11.9	9.6	49.1	3.0	41.8	-0.9

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
0.67	0.23	0.10	-37.3	7.3	-10.8	9.5	50.9	2.9	43.6	-1.0
0.66	0.24	0.10	-36.5	7.2	-9.8	9.4	52.7	2.8	45.3	-1.0
0.65	0.25	0.10	-35.8	7.1	-8.7	9.3	54.6	2.7	47.0	-1.1
0.64	0.26	0.10	-35.0	7.0	-7.6	9.2	56.4	2.6	48.8	-1.2
0.63	0.27	0.10	-34.2	6.9	-6.5	9.1	58.3	2.5	50.6	-1.3
0.62	0.28	0.10	-33.5	6.8	-5.5	9.0	60.0	2.4	52.2	-1.4
0.61	0.29	0.10	-32.8	6.7	-4.4	8.9	61.8	2.3	53.9	-1.5
0.60	0.30	0.10	-32.0	6.6	-3.3	8.8	63.7	2.2	55.7	-1.6
0.59	0.31	0.10	-31.3	6.4	-2.3	8.7	65.4	2.1	57.3	-1.7
0.58	0.32	0.10	-30.5	6.3	-1.2	8.6	67.2	2.0	59.0	-1.8
0.57	0.33	0.10	-29.8	6.2	-0.2	8.5	68.9	1.9	60.7	-1.9
0.56	0.34	0.10	-29.1	6.1	0.9	8.3	70.7	1.8	62.4	-2.0
0.55	0.35	0.10	-28.3	6.0	1.9	8.2	72.5	1.7	64.1	-2.1
0.54	0.36	0.10	-27.6	5.9	2.9	8.1	74.2	1.6	65.7	-2.2
0.53	0.37	0.10	-26.9	5.8	4.0	8.0	76.0	1.5	67.4	-2.3
0.51	0.39	0.10	-25.4	5.6	6.0	7.8	79.5	1.3	70.7	-2.5
0.50	0.40	0.10	-24.7	5.5	7.1	7.7	81.3	1.2	72.5	-2.6
0.49	0.41	0.10	-24.0	5.4	8.1	7.6	82.9	1.1	74.0	-2.7
0.48	0.42	0.10	-23.3	5.3	9.1	7.5	84.6	1.0	75.7	-2.8
0.47	0.43	0.10	-22.6	5.2	10.1	7.4	86.4	0.9	77.3	-2.9
0.46	0.44	0.10	-21.9	5.0	11.0	7.2	88.0	0.8	78.8	-3.0

[0182] Table 6C and Table 6D: Heat pump conditions in heating mode.

TABLE 6C

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	32	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.58	0.22	0.20	96.5	149.1	5.2	125.4	7.1	11.3
0.57	0.23	0.20	96.0	155.8	5.3	126.2	8.7	11.2
0.56	0.24	0.20	95.5	162.6	5.3	127.1	10.4	11.1
0.55	0.25	0.20	95.0	169.4	5.4	128.0	12.0	11.0
0.54	0.26	0.20	94.5	176.1	5.4	128.8	13.7	10.9
0.53	0.27	0.20	94.0	182.9	5.4	129.6	15.3	10.8
0.52	0.28	0.20	93.5	189.7	5.4	130.5	17.0	10.7
0.51	0.29	0.20	93.1	196.5	5.5	131.3	18.6	10.6
0.50	0.30	0.20	92.6	203.2	5.4	132.1	20.3	10.5
0.49	0.31	0.20	92.1	210.0	5.4	132.9	21.9	10.4
0.48	0.32	0.20	91.7	216.8	5.4	133.7	23.6	10.3
0.47	0.33	0.20	91.2	223.5	5.4	134.5	25.2	10.1
0.46	0.34	0.20	90.8	230.3	5.3	135.3	26.9	10.0
0.45	0.35	0.20	90.4	237.1	5.3	136.0	28.6	9.9
0.44	0.36	0.20	89.9	243.8	5.3	136.8	30.3	9.9

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
0.43	0.37	0.20	89.5	250.6	5.2	137.5	31.9	9.7
0.42	0.38	0.20	89.1	257.4	5.1	138.3	33.5	9.6
0.41	0.39	0.20	88.7	264.1	5.0	139.0	35.1	9.4
0.40	0.40	0.20	88.3	270.9	4.9	139.8	36.9	9.3
0.39	0.41	0.20	87.8	277.7	4.9	140.6	38.7	9.3
0.38	0.42	0.20	87.5	284.5	4.7	141.2	40.2	9.1
0.37	0.43	0.20	87.1	291.2	4.6	142.0	41.9	9.0
0.36	0.44	0.20	86.7	298.0	4.5	142.7	43.6	8.9
0.68	0.22	0.10	97.1	149.0	4.8	124.0	3.7	11.1
0.67	0.23	0.10	96.7	155.8	4.9	124.8	5.2	11.1
0.66	0.24	0.10	96.2	162.6	5.0	125.6	6.6	11.0
0.65	0.25	0.10	95.8	169.3	5.0	126.4	8.1	10.9
0.64	0.26	0.10	95.3	176.1	5.1	127.2	9.6	10.8
0.63	0.27	0.10	94.9	182.9	5.1	128.1	11.2	10.8
0.62	0.28	0.10	94.4	189.7	5.1	128.8	12.6	10.6
0.61	0.29	0.10	94.0	196.4	5.2	129.6	14.2	10.5
0.60	0.30	0.10	93.6	203.2	5.2	130.4	15.8	10.5
0.59	0.31	0.10	93.2	210.0	5.2	131.1	17.2	10.4
0.58	0.32	0.10	92.8	216.7	5.2	131.9	18.7	10.3
0.57	0.33	0.10	92.3	223.5	5.2	132.6	20.2	10.2
0.56	0.34	0.10	91.9	230.3	5.2	133.4	21.7	10.1
0.55	0.35	0.10	91.5	237.0	5.1	134.1	23.2	10.0
0.54	0.36	0.10	91.1	243.8	5.1	134.9	24.8	9.9
0.53	0.37	0.10	90.7	250.6	5.1	135.6	26.3	9.8
0.51	0.39	0.10	90.0	264.1	5.0	137.0	29.4	9.6
0.50	0.40	0.10	89.6	270.9	5.0	137.8	31.0	9.6
0.49	0.41	0.10	89.2	277.7	4.9	138.4	32.4	9.4
0.48	0.42	0.10	88.9	284.4	4.8	139.1	33.9	9.4
0.47	0.43	0.10	88.5	291.2	4.7	139.8	35.5	9.3
0.46	0.44	0.10	88.1	298.0	4.6	140.5	36.9	9.1

TABLE 6D

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	R32	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.58	0.22	0.20	-38.2	11.6	0.8	25.7	79.9	15.2	66.6	2.1
0.57	0.23	0.20	-37.3	11.5	2.4	25.6	82.6	15.1	69.2	2.0
0.56	0.24	0.20	-36.3	11.4	3.9	25.5	85.3	15.0	71.7	1.9
0.55	0.25	0.20	-35.4	11.2	5.5	25.4	88.1	14.9	74.3	1.8
0.54	0.26	0.20	-34.4	11.1	7.0	25.3	90.8	14.8	76.8	1.7
0.53	0.27	0.20	-33.5	11.0	8.5	25.1	93.6	14.7	79.4	1.6
0.52	0.28	0.20	-32.5	10.9	10.1	25.0	96.4	14.6	81.9	1.5
0.51	0.29	0.20	-31.6	10.8	11.7	24.9	99.2	14.4	84.5	1.4

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
0.50	0.30	0.20	-30.6	10.7	13.2	24.8	101.9	14.3	87.1	1.3
0.49	0.31	0.20	-29.7	10.6	14.8	24.6	104.7	14.2	89.7	1.2
0.48	0.32	0.20	-28.7	10.5	16.3	24.5	107.5	14.1	92.2	1.1
0.47	0.33	0.20	-27.7	10.4	17.9	24.4	110.3	14.0	94.8	1.0
0.46	0.34	0.20	-26.8	10.2	19.4	24.2	113.1	13.9	97.4	0.9
0.45	0.35	0.20	-25.8	10.1	21.0	24.1	115.9	13.7	100.0	0.8
0.44	0.36	0.20	-24.8	10.1	22.7	24.1	118.9	13.7	102.8	0.8
0.43	0.37	0.20	-23.9	9.9	24.2	23.8	121.5	13.5	105.2	0.6
0.42	0.38	0.20	-22.9	9.8	25.7	23.7	124.2	13.4	107.8	0.5
0.41	0.39	0.20	-22.0	9.6	27.2	23.5	126.9	13.2	110.2	0.3
0.40	0.40	0.20	-21.0	9.5	28.9	23.5	129.9	13.1	113.0	0.3
0.39	0.41	0.20	-20.0	9.5	30.6	23.4	132.9	13.1	115.8	0.2
0.38	0.42	0.20	-19.1	9.3	32.0	23.2	135.5	12.9	118.2	0.1
0.37	0.43	0.20	-18.1	9.2	33.6	23.1	138.3	12.8	120.8	0.0
0.36	0.44	0.20	-17.1	9.1	35.2	23.0	141.1	12.7	123.4	-0.1
0.68	0.22	0.10	-40.2	11.4	-2.4	25.5	74.1	15.0	61.3	1.9
0.67	0.23	0.10	-39.3	11.3	-1.0	25.4	76.6	14.9	63.6	1.9
0.66	0.24	0.10	-38.5	11.2	0.4	25.3	79.1	14.8	65.9	1.8
0.65	0.25	0.10	-37.6	11.1	1.8	25.2	81.6	14.8	68.2	1.7
0.64	0.26	0.10	-36.7	11.0	3.2	25.1	84.1	14.7	70.6	1.6
0.63	0.27	0.10	-35.8	11.0	4.7	25.1	86.8	14.7	73.1	1.6
0.62	0.28	0.10	-35.0	10.9	6.0	24.9	89.1	14.5	75.2	1.5
0.61	0.29	0.10	-34.1	10.8	7.5	24.8	91.7	14.4	77.6	1.4
0.60	0.30	0.10	-33.2	10.7	9.0	24.8	94.4	14.4	80.1	1.4
0.59	0.31	0.10	-32.4	10.6	10.3	24.6	96.8	14.2	82.3	1.2
0.58	0.32	0.10	-31.5	10.5	11.7	24.5	99.3	14.1	84.6	1.1
0.57	0.33	0.10	-30.6	10.4	13.2	24.4	101.8	14.0	87.0	1.1
0.56	0.34	0.10	-29.8	10.3	14.6	24.3	104.4	13.9	89.4	1.0
0.55	0.35	0.10	-28.9	10.2	16.0	24.2	107.0	13.8	91.7	0.9
0.54	0.36	0.10	-28.0	10.1	17.5	24.1	109.5	13.7	94.1	0.8
0.53	0.37	0.10	-27.1	10.0	18.9	24.0	112.1	13.6	96.5	0.7
0.52	0.38	0.10	-26.7	11.6	16.3	25.7	107.5	15.2	92.3	2.1
0.51	0.39	0.10	-25.4	9.8	21.8	23.8	117.2	13.4	101.2	0.6
0.50	0.40	0.10	-24.4	9.8	23.3	23.8	120.0	13.4	103.8	0.5
0.49	0.41	0.10	-23.6	9.7	24.7	23.6	122.3	13.3	106.0	0.4
0.48	0.42	0.10	26.1	23.5	124.9	13.2	108.4	0.3	26.1	23.5
0.47	0.43	0.10	27.5	23.4	127.5	13.1	110.8	0.2	27.5	23.4
0.46	0.44	0.10	28.9	23.2	129.8	12.9	113.0	0.1	28.9	23.2

[0183] The data indicates that some of the compositions containing HFO-1252zc, CF₃I, and HFC-32 provide similar capacity and improved COP compared to R-454C. Additionally, the compositions provide reasonable average temperature glide and GWP less than 300.

Example 7: HFO-1252zc, HFO-1132E, and CF₃I

[0184] Refrigerant performance is provided below for compositions containing HFO-1252zc, CF₃I, and HFO-1132E as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0185] Table 7A and Table 7B: Heat pump conditions in cooling mode.

TABLE 7A

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	1132E	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.55	0.25	0.2	100.7	0.1	4.5	74.2	-12.6	4.7
0.65	0.25	0.1	100.8	0.1	4.1	73.7	-13.5	4.7

TABLE 7B

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	1132E	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.55	0.25	0.2	-42.9	7.9	-18.8	10.2	37.4	3.5	30.7	-0.3
0.65	0.25	0.1	-43.5	7.9	-19.7	10.2	35.9	3.5	29.3	-0.3

[0186] Table 7C and Table 7D: Heat pump conditions in heating mode.

TABLE 7C

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	1132E	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.55	0.25	0.2	100.7	0.1	3.6	111.8	-4.3	11.2
0.65	0.25	0.1	100.8	0.1	3.4	110.8	-5.9	10.9

TABLE 7D

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	1132E	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.55	0.25	0.2	-44.8	11.4	-9.9	25.6	60.7	15.1	48.8	2.0
0.65	0.25	0.1	-45.7	11.1	-11.5	25.3	57.9	14.8	46.3	1.7

[0187] The data indicates that the compositions containing HFO-1252zc, CF₃I, and HFO-1132E provide improved COP as compared to all the incumbent refrigerants and similar capacity to R-454C. Additionally the compositions have low average temperature glide and very low GWP (GWP<1).

Example 8: HFO-1252zc, HFO-134, and CF₃I

[0188] Refrigerant performance is provided below for compositions containing HFO-1252zc, HFC-134, and CF₃I as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0189] Table 8A and Table 8B: Heat pump conditions in cooling mode.

TABLE 8A

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	134	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.66	0.14	0.20	107.7	156.9	0.1	67.4	-31.2	6.5
0.65	0.15	0.20	107.7	168.1	0.1	67.3	-31.2	6.5
0.64	0.16	0.20	107.7	179.3	0.1	67.3	-31.1	6.4
0.63	0.17	0.20	107.6	190.5	0.1	67.2	-31.1	6.4
0.62	0.18	0.20	107.6	201.7	0.1	67.2	-31.0	6.4
0.61	0.19	0.20	107.6	212.9	0.1	67.1	-31.1	6.4
0.60	0.20	0.20	107.5	224.1	0.1	67.1	-31.1	6.4
0.59	0.21	0.20	107.5	235.3	0.1	67.0	-31.1	6.4
0.58	0.22	0.20	107.5	246.5	0.1	67.0	-31.1	6.4
0.57	0.23	0.20	107.5	257.7	0.1	66.9	-31.1	6.4
0.56	0.24	0.20	107.5	268.9	0.1	66.9	-31.1	6.3
0.55	0.25	0.20	107.5	280.1	0.2	66.9	-31.1	6.4
0.54	0.26	0.20	107.5	291.3	0.1	66.8	-31.1	6.3
0.77	0.13	0.10	107.3	145.7	0.1	67.4	-30.7	6.3
0.76	0.14	0.10	107.2	156.9	0.1	67.4	-30.7	6.3
0.75	0.15	0.10	107.2	168.1	0.1	67.3	-30.6	6.3
0.74	0.16	0.10	107.1	179.3	0.1	67.3	-30.6	6.3
0.73	0.17	0.10	107.1	190.5	0.1	67.2	-30.6	6.3
0.72	0.18	0.10	107.0	201.7	0.1	67.1	-30.5	6.3
0.71	0.19	0.10	107.0	212.9	0.1	67.1	-30.5	6.3
0.70	0.20	0.10	106.9	224.1	0.1	67.0	-30.5	6.3
0.69	0.21	0.10	106.9	235.3	0.0	66.9	-6.4	43.0
0.68	0.22	0.10	106.9	246.5	0.1	66.9	-30.4	6.2
0.67	0.23	0.10	106.8	257.7	0.1	66.9	-30.4	6.2
0.66	0.24	0.10	106.8	268.9	0.1	66.8	-30.4	6.2

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
0.65	0.25	0.10	106.8	280.1	0.1	66.8	-30.4	6.2
0.64	0.26	0.10	106.8	291.3	0.1	66.7	-30.4	6.2
0.63	0.27	0.10	106.8	302.5	0.1	66.7	-30.4	6.2

TABLE 8B

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	134	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.66	0.14	0.20	-55.1	9.8	-36.1	12.1	8.1	5.3	2.8	1.4
0.65	0.15	0.20	-55.1	9.8	-36.1	12.0	8.2	5.3	2.9	1.3
0.64	0.16	0.20	-55.0	9.7	-36.1	12.0	8.2	5.3	2.9	1.3
0.63	0.17	0.20	-55.0	9.7	-36.0	12.0	8.3	5.3	3.0	1.3
0.62	0.18	0.20	-55.0	9.7	-36.0	12.0	8.3	5.3	3.1	1.3
0.61	0.19	0.20	-55.0	9.7	-36.0	12.0	8.3	5.2	3.0	1.3
0.60	0.20	0.20	-55.0	9.7	-36.0	12.0	8.3	5.2	3.1	1.3
0.59	0.21	0.20	-55.0	9.7	-36.0	12.0	8.3	5.2	3.1	1.3
0.58	0.22	0.20	-55.0	9.7	-36.0	12.0	8.3	5.2	3.1	1.3
0.57	0.23	0.20	-55.0	9.7	-36.0	11.9	8.3	5.2	3.0	1.3
0.56	0.24	0.20	-55.0	9.6	-36.0	11.9	8.3	5.2	3.0	1.2
0.55	0.25	0.20	-55.0	9.7	-36.0	11.9	8.3	5.2	3.1	1.3
0.54	0.26	0.20	-55.0	9.6	-36.1	11.9	8.2	5.2	3.0	1.2
0.53	0.27	0.20	-55.1	9.6	-36.1	11.9	8.2	5.1	2.9	1.2
0.77	0.13	0.10	-54.8	9.6	-35.7	11.9	8.8	5.2	3.5	1.2
0.76	0.14	0.10	-54.8	9.6	-35.7	11.9	8.9	5.1	3.6	1.2
0.75	0.15	0.10	-54.7	9.6	-35.6	11.9	9.0	5.1	3.7	1.2
0.74	0.16	0.10	-54.7	9.6	-35.5	11.9	9.1	5.1	3.8	1.2
0.73	0.17	0.10	-54.7	9.6	-35.5	11.9	9.1	5.1	3.8	1.2
0.72	0.18	0.10	-54.6	9.6	-35.5	11.9	9.2	5.1	3.9	1.2
0.71	0.19	0.10	-54.6	9.6	-35.5	11.8	9.2	5.1	3.9	1.2
0.70	0.20	0.10	-54.6	9.5	-35.4	11.8	9.3	5.1	4.0	1.2
0.69	0.21	0.10	-38.9	47.4	-13.1	50.5	47.1	41.4	39.9	36.1
0.68	0.22	0.10	-54.6	9.5	-35.4	11.8	9.3	5.1	4.0	1.1
0.67	0.23	0.10	-54.6	9.5	-35.4	11.8	9.4	5.0	4.0	1.1
0.66	0.24	0.10	-54.6	9.5	-35.4	11.8	9.4	5.0	4.1	1.1
0.65	0.25	0.10	-54.6	9.5	-35.4	11.8	9.4	5.0	4.1	1.1
0.64	0.26	0.10	-54.6	9.5	-35.4	11.8	9.4	5.0	4.1	1.1
0.63	0.27	0.10	-54.6	9.5	-35.4	11.8	9.4	5.0	4.0	1.1

[0190] Table 8C and Table 8D: Heat pump conditions in heating mode.

TABLE 8C

Mass Fraction			Critical temp	GWP	Average Glide	Compressor Discharge temp	Relative to R454C	
1252zc	134	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.66	0.14	0.20	107.7	156.9	0.1	100.1	-25.9	12.7
0.65	0.15	0.20	107.7	168.1	0.1	100.0	-26.0	12.6
0.64	0.16	0.20	107.7	179.3	0.1	99.9	-26.0	12.6
0.63	0.17	0.20	107.6	190.5	0.1	99.8	-26.0	12.6
0.62	0.18	0.20	107.6	201.7	0.1	99.7	-26.0	12.6
0.61	0.19	0.20	107.6	212.9	0.1	99.6	-26.1	12.5
0.60	0.20	0.20	107.5	224.1	0.1	99.5	-26.2	12.4
0.59	0.21	0.20	107.5	235.3	0.1	99.4	-26.3	12.4
0.58	0.22	0.20	107.5	246.5	0.1	99.4	-26.3	12.4
0.57	0.23	0.20	107.5	257.7	0.1	99.3	-26.4	12.3
0.56	0.24	0.20	107.5	268.9	0.1	99.2	-26.5	12.3
0.55	0.25	0.20	107.5	280.1	0.2	99.2	-26.6	12.3
0.54	0.26	0.20	107.5	291.3	0.2	99.1	-26.8	12.2
0.77	0.13	0.10	107.3	145.7	0.1	100.2	-25.9	12.3
0.76	0.14	0.10	107.2	156.9	0.1	100.1	-25.9	12.2
0.75	0.15	0.10	107.2	168.1	0.1	99.9	-25.9	12.2
0.74	0.16	0.10	107.1	179.3	0.1	99.8	-25.8	12.2
0.73	0.17	0.10	107.1	190.5	0.1	99.7	-25.9	12.1
0.72	0.18	0.10	107.0	201.7	0.1	99.6	-25.9	12.1
0.71	0.19	0.10	107.0	212.9	0.1	99.4	-25.9	12.1
0.70	0.20	0.10	106.9	224.1	0.1	99.3	-25.9	12.0
0.68	0.22	0.10	106.9	246.5	0.1	99.1	-26.0	12.0
0.67	0.23	0.10	106.8	257.7	0.1	99.0	-26.0	11.9
0.66	0.24	0.10	106.8	268.9	0.1	98.9	-26.1	11.9
0.65	0.25	0.10	106.8	280.1	0.1	98.8	-26.2	11.9
0.64	0.26	0.10	106.8	291.3	0.1	98.8	-26.2	11.8

TABLE 8D

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	134	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.66	0.14	0.20	-57.3	12.9	-30.3	27.2	24.4	16.6	15.2	3.3
0.65	0.15	0.20	-57.3	12.9	-30.3	27.2	24.3	16.6	15.2	3.3
0.64	0.16	0.20	-57.3	12.8	-30.3	27.1	24.3	16.5	15.2	3.3
0.63	0.17	0.20	-57.3	12.8	-30.4	27.1	24.2	16.5	15.1	3.2
0.62	0.18	0.20	-57.3	12.8	-30.3	27.1	24.3	16.5	15.1	3.3
0.61	0.19	0.20	-57.4	12.7	-30.4	27.0	24.1	16.4	14.9	3.2
0.60	0.20	0.20	-57.4	12.7	-30.5	27.0	24.0	16.4	14.8	3.1

Composition, mass fraction			Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
0.59	0.21	0.20	-57.4	12.6	-30.6	26.9	23.8	16.3	14.7	3.1
0.58	0.22	0.20	-57.5	12.6	-30.7	26.9	23.7	16.3	14.6	3.1
0.57	0.23	0.20	-57.5	12.6	-30.7	26.8	23.5	16.2	14.5	3.0
0.56	0.24	0.20	-57.6	12.5	-30.8	26.8	23.4	16.2	14.3	3.0
0.55	0.25	0.20	-57.6	12.5	-30.9	26.8	23.3	16.2	14.2	3.0
0.54	0.26	0.20	-57.7	12.4	-31.1	26.7	23.0	16.1	13.9	2.9
0.53	0.27	0.20	-57.8	12.4	-31.2	26.7	22.8	16.1	13.7	2.9
0.77	0.13	0.10	-57.3	12.5	-30.3	26.8	24.4	16.2	15.2	3.0
0.76	0.14	0.10	-57.3	12.5	-30.3	26.7	24.4	16.2	15.3	2.9
0.75	0.15	0.10	-57.2	12.4	-30.2	26.7	24.4	16.1	15.3	2.9
0.74	0.16	0.10	-57.2	12.5	-30.2	26.7	24.6	16.2	15.4	2.9
0.73	0.17	0.10	-57.2	12.4	-30.2	26.6	24.5	16.0	15.3	2.9
0.72	0.18	0.10	-57.2	12.3	-30.2	26.6	24.5	16.0	15.3	2.8
0.71	0.19	0.10	-57.2	12.3	-30.2	26.6	24.4	16.0	15.3	2.8
0.70	0.20	0.10	-57.3	12.3	-30.3	26.5	24.4	15.9	15.3	2.8
0.68	0.22	0.10	-57.3	12.2	-30.3	26.4	24.3	15.9	15.2	2.7
0.67	0.23	0.10	-57.3	12.1	-30.4	26.4	24.2	15.8	15.1	2.7
0.66	0.24	0.10	-57.4	12.1	-30.4	26.4	24.1	15.8	15.0	2.6
0.65	0.25	0.10	-57.4	12.1	-30.5	26.3	24.0	15.8	14.9	2.6
0.64	0.26	0.10	-57.4	12.0	-30.5	26.3	23.9	15.7	14.8	2.6
0.63	0.27	0.10	-57.5	12.0	-30.6	26.2	23.7	15.7	14.6	2.5

[0191] The data indicate that the compositions containing HFO-1252zc, HFC-134, and CF₃I would serve well as replacement for HFC-134a and/or HFO-1234yf with improved capacity and COP for both heating and cooling. Additionally, these compositions are azeotropic or azeotrope-like with low to zero average temperature glide and have GWP less than 300.

Example 9: HFO-1252zc, HFC-32, HFO-1132E, and CF₃I

[0192] Refrigerant performance is provided below for compositions containing HFO-1252zc, HFC-32, HFO-1132E, and CF₃I as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0193] Table 9A and Table 9B: Heat pump conditions in cooling mode.

TABLE 9A

Mass Fraction				Critical temp	GWP	Avg Glide	Compr Disch temp	Relative to R454C	
1252zc	R-32	1132E	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.33	0.22	0.25	0.20	88.9	149.0	5.9	82.9	17.7	2.0
0.32	0.23	0.25	0.20	88.5	155.8	5.8	83.1	19.1	1.9
0.31	0.24	0.25	0.20	88.0	162.6	5.8	83.5	20.5	1.8
0.30	0.25	0.25	0.20	87.5	169.4	5.6	83.6	21.7	1.6
0.29	0.26	0.25	0.20	87.0	176.1	5.5	84.0	23.2	1.5
0.28	0.27	0.25	0.20	86.6	182.9	5.4	84.2	24.4	1.4
0.26	0.29	0.25	0.20	85.7	196.4	5.1	84.7	27.0	1.1
0.25	0.30	0.25	0.20	85.2	203.2	5.0	84.9	28.4	1.0
0.24	0.31	0.25	0.20	84.8	210.0	4.8	85.1	29.7	0.9
0.23	0.32	0.25	0.20	84.4	216.7	4.6	85.3	31.0	0.8
0.22	0.33	0.25	0.20	84.0	223.5	4.5	85.6	32.4	0.7
0.21	0.34	0.25	0.20	83.6	230.3	4.3	85.7	33.6	0.5
0.20	0.35	0.25	0.20	83.1	237.0	4.1	85.9	35.0	0.4
0.19	0.36	0.25	0.20	82.7	243.8	3.9	86.1	36.3	0.3
0.18	0.37	0.25	0.20	82.4	250.6	3.8	86.3	37.7	0.2
0.17	0.38	0.25	0.20	82.0	257.4	3.6	86.5	39.0	0.1
0.16	0.39	0.25	0.20	81.6	264.1	3.3	86.6	40.1	0.0
0.15	0.40	0.25	0.20	81.2	270.9	3.2	86.8	41.5	-0.1
0.13	0.42	0.25	0.20	80.5	284.4	2.8	87.2	44.2	-0.2
0.12	0.43	0.25	0.20	80.2	291.2	2.6	87.3	45.5	-0.3
0.11	0.44	0.25	0.20	79.8	298.0	2.4	87.5	46.8	-0.4
0.43	0.22	0.25	0.10	90.2	149.0	5.8	82.1	14.3	2.4
0.42	0.23	0.25	0.10	89.7	155.8	5.8	82.3	15.5	2.3
0.41	0.24	0.25	0.10	89.3	162.6	5.7	82.6	16.7	2.2
0.40	0.25	0.25	0.10	88.9	169.3	5.7	82.9	18.0	2.0
0.39	0.26	0.25	0.10	88.5	176.1	5.6	83.2	19.3	2.0
0.38	0.27	0.25	0.10	88.0	182.9	5.5	83.5	20.5	1.8
0.37	0.28	0.25	0.10	87.6	189.6	5.4	83.7	21.6	1.7
0.36	0.29	0.25	0.10	87.2	196.4	5.4	84.0	22.9	1.6
0.35	0.30	0.25	0.10	86.8	203.2	5.2	84.1	24.0	1.4
0.34	0.31	0.25	0.10	86.4	209.9	5.1	84.4	25.3	1.4
0.33	0.32	0.25	0.10	86.0	216.7	5.0	84.6	26.5	1.2
0.32	0.33	0.25	0.10	85.6	223.5	4.9	84.9	27.7	1.1
0.31	0.34	0.25	0.10	85.2	230.3	4.7	85.0	28.8	1.0
0.30	0.35	0.25	0.10	84.9	237.0	4.6	85.3	30.1	0.9
0.29	0.36	0.25	0.10	84.5	243.8	4.5	85.5	31.3	0.8
0.28	0.37	0.25	0.10	84.1	250.6	4.3	85.7	32.5	0.7
0.27	0.38	0.25	0.10	83.7	257.3	4.2	85.9	33.7	0.6

Mass Fraction				Critical temp	GWP	Avg Glide	Compr Disch temp	Relative to R454C	
0.26	0.39	0.25	0.10	83.4	264.1	4.0	86.1	34.8	0.5
0.25	0.40	0.25	0.10	83.0	270.9	3.8	86.3	36.0	0.4
0.24	0.41	0.25	0.10	82.7	277.6	3.7	86.5	37.2	0.3
0.23	0.42	0.25	0.10	82.4	284.4	3.6	86.7	38.6	0.3
0.22	0.43	0.25	0.10	82.0	291.2	3.3	86.8	39.6	0.2

TABLE 9B

Composition, mass fraction				Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	R-32	1132 E	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.33	0.22	0.25	0.20	-23.1	5.2	9.3	7.4	85.0	0.9	76.0	-2.8
0.32	0.23	0.25	0.20	-22.3	5.1	10.5	7.3	87.1	0.8	78.0	-3.0
0.31	0.24	0.25	0.20	-21.3	5.0	11.8	7.1	89.3	0.7	80.1	-3.1
0.30	0.25	0.25	0.20	-20.6	4.8	12.9	7.0	91.1	0.5	81.8	-3.3
0.29	0.26	0.25	0.20	-19.6	4.7	14.3	6.9	93.5	0.4	84.1	-3.3
0.28	0.27	0.25	0.20	-18.8	4.5	15.5	6.7	95.4	0.3	85.9	-3.5
0.26	0.29	0.25	0.20	-17.1	4.3	17.9	6.4	99.6	0.0	89.9	-3.7
0.25	0.30	0.25	0.20	-16.2	4.1	19.1	6.3	101.7	-0.1	91.9	-3.8
0.24	0.31	0.25	0.20	-15.3	4.0	20.4	6.2	103.8	-0.2	93.8	-4.0
0.23	0.32	0.25	0.20	-14.5	3.9	21.6	6.0	105.8	-0.4	95.8	-4.1
0.22	0.33	0.25	0.20	-13.6	3.8	22.9	6.0	108.0	-0.4	97.9	-4.2
0.21	0.34	0.25	0.20	-12.8	3.6	24.0	5.8	109.8	-0.6	99.6	-4.3
0.20	0.35	0.25	0.20	-11.9	3.5	25.3	5.7	112.1	-0.7	101.7	-4.4
0.19	0.36	0.25	0.20	-11.0	3.4	26.5	5.6	114.1	-0.8	103.7	-4.5
0.18	0.37	0.25	0.20	-10.1	3.3	27.8	5.5	116.3	-0.9	105.8	-4.6
0.17	0.38	0.25	0.20	-9.3	3.2	29.0	5.4	118.4	-1.0	107.8	-4.7
0.16	0.39	0.25	0.20	-8.5	3.1	30.1	5.3	120.2	-1.1	109.5	-4.8
0.15	0.40	0.25	0.20	-7.6	3.0	31.4	5.2	122.4	-1.2	111.6	-4.9
0.13	0.42	0.25	0.20	-5.9	2.9	33.8	5.0	126.5	-1.3	115.5	-5.0
0.12	0.43	0.25	0.20	-5.0	2.8	35.0	4.9	128.6	-1.4	117.4	-5.1
0.11	0.44	0.25	0.20	-4.2	2.7	36.2	4.9	130.6	-1.5	119.4	-5.1
0.43	0.22	0.25	0.10	-25.4	5.6	6.1	7.8	79.6	1.3	70.8	-2.5
0.42	0.23	0.25	0.10	-24.6	5.4	7.2	7.6	81.5	1.1	72.7	-2.6
0.41	0.24	0.25	0.10	-23.8	5.3	8.4	7.5	83.4	1.0	74.5	-2.7
0.40	0.25	0.25	0.10	-23.0	5.2	9.5	7.4	85.4	0.9	76.3	-2.9
0.39	0.26	0.25	0.10	-22.1	5.1	10.7	7.3	87.4	0.8	78.3	-2.9
0.38	0.27	0.25	0.10	-21.3	5.0	11.8	7.2	89.3	0.7	80.1	-3.0
0.37	0.28	0.25	0.10	-20.6	4.8	12.9	7.0	91.1	0.6	81.8	-3.2
0.36	0.29	0.25	0.10	-19.8	4.8	14.1	6.9	93.1	0.5	83.7	-3.3
0.35	0.30	0.25	0.10	-19.1	4.6	15.1	6.8	94.8	0.3	85.3	-3.4
0.34	0.31	0.25	0.10	-18.2	4.5	16.3	6.7	96.9	0.3	87.4	-3.5
0.33	0.32	0.25	0.10	-17.4	4.4	17.4	6.6	98.7	0.1	89.0	-3.6
0.32	0.33	0.25	0.10	-16.7	4.3	18.5	6.4	100.6	0.0	90.8	-3.7

Composition, mass fraction				Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
0.31	0.34	0.25	0.10	-15.9	4.1	19.6	6.3	102.4	-0.1	92.5	-3.8
0.30	0.35	0.25	0.10	-15.1	4.1	20.7	6.2	104.4	-0.2	94.4	-3.9
0.29	0.36	0.25	0.10	-14.3	3.9	21.9	6.1	106.3	-0.3	96.2	-4.0
0.28	0.37	0.25	0.10	-13.5	3.8	23.0	6.0	108.2	-0.4	98.0	-4.1
0.27	0.38	0.25	0.10	-12.7	3.7	24.1	5.9	110.1	-0.5	99.8	-4.2
0.26	0.39	0.25	0.10	-12.0	3.6	25.1	5.8	111.8	-0.6	101.5	-4.3
0.25	0.40	0.25	0.10	-11.2	3.5	26.2	5.7	113.7	-0.7	103.3	-4.4
0.24	0.41	0.25	0.10	-10.4	3.4	27.3	5.6	115.5	-0.8	105.1	-4.5
0.23	0.42	0.25	0.10	-9.5	3.4	28.6	5.6	117.7	-0.8	107.1	-4.5
0.22	0.43	0.25	0.10	-8.9	3.3	29.6	5.4	119.3	-1.0	108.6	-4.7

[0194] Table 9C and Table 9D: Heat pump conditions in heating mode.

TABLE 9C

Mass Fraction				Critical temp	GWP	Avg Glide	Compr Disch temp	Relative to R454C	
1252zc	R-32	1132E	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.33	0.22	0.25	0.20	88.9	149.0	5.0	130.6	34.0	8.7
0.32	0.23	0.25	0.20	88.5	155.8	5.0	131.4	35.9	8.6
0.31	0.24	0.25	0.20	88.0	162.6	4.9	132.1	37.8	8.5
0.30	0.25	0.25	0.20	87.5	169.4	4.8	132.8	39.4	8.2
0.29	0.26	0.25	0.20	87.0	176.1	4.8	133.6	41.5	8.2
0.28	0.27	0.25	0.20	86.6	182.9	4.6	134.2	43.2	8.0
0.26	0.29	0.25	0.20	85.7	196.4	4.4	135.6	46.9	7.7
0.25	0.30	0.25	0.20	85.2	203.2	4.3	136.2	48.7	7.6
0.24	0.31	0.25	0.20	84.8	210.0	4.1	136.9	50.6	7.5
0.23	0.32	0.25	0.20	84.4	216.7	4.0	137.6	52.4	7.4
0.22	0.33	0.25	0.20	84.0	223.5	3.9	138.3	54.4	7.3
0.21	0.34	0.25	0.20	83.6	230.3	3.7	138.8	56.0	7.0
0.20	0.35	0.25	0.20	83.1	237.0	3.6	139.5	58.0	7.0
0.19	0.36	0.25	0.20	82.7	243.8	3.4	140.1	59.9	6.9
0.18	0.37	0.25	0.20	82.4	250.6	3.3	140.8	62.0	6.9
0.17	0.38	0.25	0.20	82.0	257.4	3.1	141.4	63.8	6.8
0.16	0.39	0.25	0.20	81.6	264.1	2.9	141.9	65.4	6.5
0.15	0.40	0.25	0.20	81.2	270.9	2.8	142.6	67.5	6.5
0.13	0.42	0.25	0.20	80.5	284.4	2.4	143.8	71.3	6.3
0.12	0.43	0.25	0.20	80.2	291.2	2.2	144.3	73.2	6.2
0.11	0.44	0.25	0.20	79.8	298.0	2.1	144.9	75.1	6.2
0.43	0.22	0.25	0.10	90.2	149.0	4.9	128.8	28.9	9.0
0.42	0.23	0.25	0.10	89.7	155.8	4.9	129.5	30.6	8.8
0.41	0.24	0.25	0.10	89.3	162.6	4.9	130.2	32.2	8.7
0.40	0.25	0.25	0.10	88.9	169.3	4.8	130.9	33.9	8.6
0.39	0.26	0.25	0.10	88.5	176.1	4.8	131.6	35.7	8.6

Mass Fraction				Critical temp	GWP	Avg Glide	Compr Disch temp	Relative to R454C	
0.38	0.27	0.25	0.10	88.0	182.9	4.7	132.3	37.4	8.5
0.37	0.28	0.25	0.10	87.6	189.6	4.6	132.9	38.9	8.3
0.36	0.29	0.25	0.10	87.2	196.4	4.6	133.6	40.7	8.2
0.35	0.30	0.25	0.10	86.8	203.2	4.4	134.2	42.1	8.0
0.34	0.31	0.25	0.10	86.4	209.9	4.4	135.0	44.1	8.0
0.33	0.32	0.25	0.10	86.0	216.7	4.3	135.6	45.6	7.8
0.32	0.33	0.25	0.10	85.6	223.5	4.2	136.2	47.3	7.7
0.31	0.34	0.25	0.10	85.2	230.3	4.0	136.8	48.8	7.5
0.30	0.35	0.25	0.10	84.9	237.0	4.0	137.5	50.7	7.5
0.29	0.36	0.25	0.10	84.5	243.8	3.9	138.1	52.3	7.4
0.28	0.37	0.25	0.10	84.1	250.6	3.7	138.7	54.1	7.3
0.27	0.38	0.25	0.10	83.7	257.3	3.6	139.3	55.8	7.2
0.26	0.39	0.25	0.10	83.4	264.1	3.4	139.9	57.3	7.0
0.25	0.40	0.25	0.10	83.0	270.9	3.3	140.5	59.0	6.9
0.24	0.41	0.25	0.10	82.7	277.6	3.2	141.1	60.7	6.9
0.23	0.42	0.25	0.10	82.4	284.4	3.1	141.8	62.7	6.9
0.22	0.43	0.25	0.10	82.0	291.2	2.9	142.3	64.1	6.7

TABLE 9D

Composition, mass fraction				Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	R-32	1132E	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.33	0.22	0.25	0.20	-22.7	8.9	26.2	22.7	125.1	12.5	108.5	-0.3
0.32	0.23	0.25	0.20	-21.6	8.8	27.9	22.6	128.1	12.3	111.4	-0.4
0.31	0.24	0.25	0.20	-20.5	8.7	29.7	22.5	131.4	12.3	114.4	-0.5
0.30	0.25	0.25	0.20	-19.6	8.4	31.2	22.2	134.1	12.0	116.8	-0.8
0.29	0.26	0.25	0.20	-18.4	8.4	33.2	22.2	137.6	12.0	120.1	-0.7
0.28	0.27	0.25	0.20	-17.4	8.2	34.8	22.0	140.4	11.8	122.8	-0.9
0.26	0.29	0.25	0.20	-15.2	8.0	38.3	21.7	146.6	11.5	128.5	-1.2
0.25	0.30	0.25	0.20	-14.2	7.8	40.0	21.5	149.7	11.4	131.4	-1.3
0.24	0.31	0.25	0.20	-13.1	7.7	41.8	21.4	152.9	11.2	134.3	-1.4
0.23	0.32	0.25	0.20	-12.0	7.6	43.5	21.2	156.0	11.1	137.2	-1.5
0.22	0.33	0.25	0.20	-10.9	7.5	45.4	21.2	159.3	11.0	140.3	-1.6
0.21	0.34	0.25	0.20	-10.0	7.2	46.9	20.9	162.0	10.8	142.7	-1.8
0.20	0.35	0.25	0.20	-8.8	7.2	48.8	20.8	165.4	10.7	145.9	-1.9
0.19	0.36	0.25	0.20	-7.7	7.1	50.5	20.7	168.5	10.6	148.8	-2.0
0.18	0.37	0.25	0.20	-6.5	7.1	52.5	20.7	172.0	10.6	152.0	-2.0
0.17	0.38	0.25	0.20	-5.5	7.0	54.2	20.6	175.1	10.5	154.9	-2.1
0.16	0.39	0.25	0.20	-4.6	6.7	55.7	20.3	177.8	10.2	157.3	-2.3
0.15	0.40	0.25	0.20	-3.4	6.7	57.7	20.3	181.2	10.2	160.6	-2.3
0.14	0.41	0.25	0.20	0.8	11.6	64.4	25.7	193.3	15.2	171.7	2.1
0.13	0.42	0.25	0.20	-1.2	6.5	61.2	20.1	187.6	10.0	166.5	-2.5
0.12	0.43	0.25	0.20	-0.1	6.5	63.0	20.0	190.8	10.0	169.4	-2.5

Composition, mass fraction				Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
0.11	0.44	0.25	0.20	1.0	6.4	64.8	19.9	194.0	9.9	172.4	-2.6
0.43	0.22	0.25	0.10	-25.6	9.2	21.4	23.0	116.5	12.8	100.6	-0.1
0.42	0.23	0.25	0.10	-24.7	9.1	22.9	22.9	119.3	12.6	103.1	-0.2
0.41	0.24	0.25	0.10	-23.7	8.9	24.5	22.8	122.0	12.5	105.7	-0.3
0.40	0.25	0.25	0.10	-22.7	8.8	26.1	22.7	124.8	12.4	108.3	-0.4
0.39	0.26	0.25	0.10	-21.7	8.8	27.7	22.6	127.8	12.4	111.1	-0.4
0.38	0.27	0.25	0.10	-20.7	8.7	29.3	22.5	130.6	12.3	113.7	-0.5
0.37	0.28	0.25	0.10	-19.9	8.5	30.8	22.3	133.2	12.1	116.1	-0.7
0.36	0.29	0.25	0.10	-18.8	8.5	32.5	22.2	136.3	12.0	118.9	-0.7
0.35	0.30	0.25	0.10	-18.0	8.2	33.8	21.9	138.6	11.7	121.1	-1.0
0.34	0.31	0.25	0.10	-16.9	8.2	35.6	22.0	141.9	11.8	124.1	-0.9
0.33	0.32	0.25	0.10	-16.0	8.1	37.1	21.8	144.5	11.6	126.5	-1.1
0.32	0.33	0.25	0.10	-15.0	7.9	38.7	21.7	147.3	11.5	129.1	-1.2
0.31	0.34	0.25	0.10	-14.1	7.8	40.1	21.4	149.9	11.3	131.5	-1.4
0.30	0.35	0.25	0.10	-13.1	7.7	41.8	21.4	153.0	11.3	134.4	-1.4
0.29	0.36	0.25	0.10	-12.1	7.6	43.4	21.3	155.8	11.2	137.0	-1.5
0.28	0.37	0.25	0.10	-11.1	7.5	45.0	21.2	158.7	11.1	139.7	-1.6
0.27	0.38	0.25	0.10	-10.1	7.4	46.6	21.1	161.5	10.9	142.3	-1.7
0.26	0.39	0.25	0.10	-9.2	7.2	48.1	20.9	164.1	10.8	144.7	-1.8
0.25	0.40	0.25	0.10	-8.3	7.2	49.7	20.8	167.0	10.7	147.4	-1.9
0.24	0.41	0.25	0.10	-7.3	7.1	51.3	20.7	169.8	10.6	150.0	-2.0
0.23	0.42	0.25	0.10	-6.1	7.1	53.2	20.7	173.3	10.7	153.2	-1.9
0.22	0.43	0.25	0.10	-5.3	6.9	54.5	20.5	175.6	10.4	155.3	-2.1

[0195] The data indicate that the compositions containing HFO-1252zc, HFC-32, HFO-1132E, and CF₃I would serve well as replacement for HFC-134a and/or HFO-1234yf with improved capacity and COP for both heating and cooling. Additionally, these compositions provide reasonable average temperature glide and have GWP less than 300.

Example 10: HFO-1252zc, HFO-1132E, HFC-134, and CF₃I

[0196] Refrigerant performance is provided below for compositions containing HFO-1252zc, HFC-134, HFO-1132E, and CF₃I as compared to R-410A, R-404A, R-454C, R-1234yf and R-134a.

[0197] Table 10A and Table 10B: Heat pump conditions in cooling mode.

TABLE 10A

Mass Fraction				Critical temp	GWP	Avg Glide	Compr Disch temp	Relative to R454C	
1252zc	1132E	R-134	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.29	0.25	0.26	0.20	99.9	291.3	4.6	73.4	-11.3	4.4
0.30	0.25	0.25	0.20	99.9	280.1	4.5	73.4	-11.3	4.4
0.31	0.25	0.24	0.20	99.9	268.9	4.5	73.4	-11.2	4.4
0.32	0.25	0.23	0.20	99.8	257.7	4.5	73.4	-11.2	4.4
0.33	0.25	0.22	0.20	99.8	246.5	4.4	73.4	-11.3	4.4
0.35	0.25	0.20	0.20	99.8	224.1	4.4	73.4	-11.3	4.4
0.36	0.25	0.19	0.20	99.8	212.9	4.4	73.5	-11.2	4.5
0.37	0.25	0.18	0.20	99.8	201.7	4.4	73.4	-11.3	4.5
0.38	0.25	0.17	0.20	99.8	190.5	4.3	73.5	-11.3	4.5
0.39	0.25	0.16	0.20	99.8	179.3	4.4	73.5	-11.3	4.5
0.40	0.25	0.15	0.20	99.8	168.1	4.3	73.5	-11.4	4.5
0.41	0.25	0.14	0.20	99.9	156.9	4.3	73.5	-11.4	4.5
0.42	0.25	0.13	0.20	99.9	145.7	4.4	73.6	-11.4	4.5
0.39	0.25	0.26	0.10	99.8	291.3	4.1	72.7	-11.9	4.4
0.40	0.25	0.25	0.10	99.8	280.1	4.0	72.6	-11.9	4.4
0.41	0.25	0.24	0.10	99.8	268.9	4.0	72.6	-11.9	4.4
0.42	0.25	0.23	0.10	99.8	257.7	4.0	72.7	-11.9	4.4

TABLE 10B

Composition, mass fraction				Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	1132E	R-134	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.29	0.25	0.26	0.20	-42.1	7.6	-17.7	9.9	39.3	3.2	32.5	-0.6
0.30	0.25	0.25	0.20	-42.1	7.6	-17.7	9.9	39.4	3.2	32.6	-0.6
0.31	0.25	0.24	0.20	-42.0	7.7	-17.6	9.9	39.5	3.3	32.7	-0.6
0.32	0.25	0.23	0.20	-42.0	7.7	-17.6	9.9	39.5	3.3	32.7	-0.6
0.33	0.25	0.22	0.20	-42.1	7.6	-17.6	9.9	39.4	3.3	32.6	-0.6
0.35	0.25	0.20	0.20	-42.1	7.7	-17.6	9.9	39.4	3.3	32.6	-0.6
0.36	0.25	0.19	0.20	-42.0	7.7	-17.6	10.0	39.5	3.3	32.7	-0.5
0.37	0.25	0.18	0.20	-42.1	7.7	-17.6	9.9	39.4	3.3	32.6	-0.6
0.38	0.25	0.17	0.20	-42.1	7.7	-17.7	10.0	39.4	3.3	32.6	-0.5
0.39	0.25	0.16	0.20	-42.1	7.7	-17.6	10.0	39.4	3.3	32.6	-0.5
0.40	0.25	0.15	0.20	-42.2	7.7	-17.8	10.0	39.2	3.3	32.4	-0.5
0.41	0.25	0.14	0.20	-42.2	7.7	-17.8	10.0	39.2	3.3	32.4	-0.5
0.42	0.25	0.13	0.20	-42.2	7.8	-17.8	10.0	39.2	3.4	32.4	-0.5
0.39	0.25	0.26	0.10	-42.5	7.6	-18.2	9.9	38.4	3.2	31.7	-0.6
0.40	0.25	0.25	0.10	-42.5	7.6	-18.3	9.9	38.4	3.2	31.6	-0.6
0.41	0.25	0.24	0.10	-42.5	7.6	-18.3	9.9	38.4	3.2	31.6	-0.6
0.42	0.25	0.23	0.10	-42.5	7.6	-18.3	9.9	38.3	3.2	31.6	-0.6

[0198] Table 10C and Table 10D: Heat pump conditions in heating mode.

TABLE 10C

Mass Fraction				Critical temp	GWP	Avg Glide	Compr Disch temp	Relative to R454C	
1252zc	1132 E	R-134	CF ₃ I	(°C)	AR5	(K)	(°C)	Capacity (%)	COP (%)
0.29	0.25	0.26	0.20	99.9	291.3	3.8	110.6	-6.2	10.1
0.30	0.25	0.25	0.20	99.9	280.1	3.8	110.6	-6.0	10.1
0.31	0.25	0.24	0.20	99.9	268.9	3.8	110.6	-5.7	10.2
0.32	0.25	0.23	0.20	99.8	257.7	3.7	110.5	-5.5	10.3
0.33	0.25	0.22	0.20	99.8	246.5	3.7	110.5	-5.4	10.2
0.35	0.25	0.20	0.20	99.8	224.1	3.6	110.5	-5.1	10.3
0.36	0.25	0.19	0.20	99.8	212.9	3.6	110.5	-4.8	10.4
0.37	0.25	0.18	0.20	99.8	201.7	3.6	110.5	-4.8	10.4
0.38	0.25	0.17	0.20	99.8	190.5	3.5	110.5	-4.7	10.4
0.39	0.25	0.16	0.20	99.8	179.3	3.6	110.6	-4.5	10.6
0.40	0.25	0.15	0.20	99.8	168.1	3.5	110.5	-4.6	10.5
0.41	0.25	0.14	0.20	99.9	156.9	3.5	110.6	-4.4	10.6
0.42	0.25	0.13	0.20	99.9	145.7	3.5	110.7	-4.2	10.7
0.39	0.25	0.26	0.10	99.8	291.3	3.4	109.1	-6.7	10.0
0.40	0.25	0.25	0.10	99.8	280.1	3.3	109.0	-6.6	9.9
0.41	0.25	0.24	0.10	99.8	268.9	3.3	109.0	-6.5	10.0
0.42	0.25	0.23	0.10	99.8	257.7	3.2	109.1	-6.3	10.0

TABLE 10D

Composition, mass fraction				Relative to R410A		Relative to R404A		Relative to 1234yf		Relative to R134a	
1252zc	1132E	R-134	CF ₃ I	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)	Capacity (%)	COP (%)
0.29	0.25	0.26	0.20	-45.9	10.3	-11.7	24.3	57.5	13.9	46.0	1.0
0.30	0.25	0.25	0.20	-45.7	10.3	-11.5	24.4	57.9	14.0	46.3	1.0
0.31	0.25	0.24	0.20	-45.6	10.5	-11.2	24.5	58.4	14.1	46.7	1.1
0.32	0.25	0.23	0.20	-45.5	10.5	-11.0	24.5	58.7	14.1	47.0	1.1
0.33	0.25	0.22	0.20	-45.4	10.5	-10.9	24.5	58.9	14.1	47.2	1.1
0.35	0.25	0.20	0.20	-45.2	10.5	-10.6	24.6	59.4	14.2	47.7	1.2
0.36	0.25	0.19	0.20	-45.1	10.7	-10.4	24.7	59.8	14.3	48.0	1.3
0.37	0.25	0.18	0.20	-45.1	10.6	-10.4	24.7	59.9	14.3	48.1	1.3
0.38	0.25	0.17	0.20	-45.0	10.7	-10.3	24.7	60.1	14.3	48.3	1.3
0.39	0.25	0.16	0.20	-44.9	10.8	-10.1	24.9	60.4	14.4	48.6	1.4
0.40	0.25	0.15	0.20	-44.9	10.7	-10.2	24.7	60.3	14.3	48.5	1.3
0.41	0.25	0.14	0.20	-44.8	10.8	-10.0	24.9	60.5	14.4	48.7	1.4
0.42	0.25	0.13	0.20	-44.7	10.9	-9.8	25.0	60.8	14.6	49.0	1.5
0.39	0.25	0.26	0.10	-46.1	10.2	-12.1	24.2	56.7	13.8	45.2	0.9
0.40	0.25	0.25	0.10	-46.1	10.1	-12.1	24.1	56.8	13.8	45.3	0.8
0.41	0.25	0.24	0.10	-46.0	10.2	-11.9	24.2	57.1	13.8	45.5	0.9
0.42	0.25	0.23	0.10	-45.9	10.2	-11.8	24.2	57.3	13.8	45.7	0.9

[0199] The data indicates that compositions containing HFO-1252zc, HFO-1132E, HFC-134, and CF₃I provide capacity similar to R-454C and improved COP as compared to R-454C. Additionally, these compositions have low average temperature glide and GWP less than 300.

**Example 11: HFO-1252zc, and at least one of HFO-1132E or HFO-1132Z –
Flammability and refrigerant performance**

[0200] Flammability classification and cooling/heating performance is provided below in Table 11 for compositions containing HFO-1252zc and HFO-1132E (Composition A and C) and HFO-1252zc and HFO-1132E, and HFO-1132Z (Composition B). Refrigerant performance is determined using the same conditions as all the previous examples.

TABLE 11

Compositions	A	B	C
HFO-1132-E (wt%)	0.74	0.50	0.50
HFO-1252zc (wt%)	0.26	0.26	0.50
HFO-1132-Z (wt%)		0.24	
GWP (AR5)	0.028	0.386	0.048
T _{cr} (°C)	84.1	95.7	92.6
NBP (°C)	-49.8	-44.6	-45.9
Flammability class	2	2	3
	Cooling	Cooling	Cooling
Evaporator Glide (K)	3.7	5.1	4.9
Condenser Glide (K)	4.0	6.2	6.0
T _{Discharge} (°C)	77.8	80.0	76.7
COP	3.698	3.831	3.789
CAP (kJ/m ³)	3,959.6	3,215.1	3,293.3
	Heating	Heating	Heating
Evaporator Glide (K)	2.8	3.6	3.4
Condenser Glide (K)	3.7	5.8	5.7
T _{Discharge} (°C)	120.1	124.2	116.5
COP	1.288	1.367	1.333
CAP (kJ/m ³)	1,099.4	881.8	893.9

[0201] The data indicates that up to 26 weight percent HFO-1252zc and HFO-1132E or HFO-1132E and HFO-1132Z will provide a composition classified as class 2 for flammability. Additionally, these compositions provide cooling and heating with good capacity (CAP) and COP, with the composition containing HFO-1252zc, HFO-1132E and HFO-1132Z having the highest COP. The compositions also produce reasonable glide and have extremely low GWP (GWP<1)

Example 12a:

[0202] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, HFC-32 and HFC-134.

[0203] Broadly, for cooling mode, a composition range of 57.0% to 67.0% of HFO-1252ZC, 16.0% to 42.0% of R32, and 1.0% to 17.0% of R134 will have a GWP less than 299, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -8.8% to 23.8% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from 0.1% to 3.9% than that of the cooling COP of R-454C evaluated with the same conditions set. Table 4a lists example compositions within the GWP<299 range that have ASHRAE flammability classifications of 2.

[0204] Similarly, but a little less broadly for cooling mode, a composition range of 66.0% to 67.0% of HFO-1252ZC, 16.0% to 20.0% of R32, and 14.0% to 17.0% of R134 will have a GWP less than 299, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 2, a cooling capacity range has a deviation of -8.8% to -3.4% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of 3.5% to 3.9% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0205] The composition for the maximum cooling capacity, which is -3.4% than that of R-454C, is 66.0 wt-% HFO-1252ZC, 20.0 wt-% R32 and 14.0 wt-% R134, where the COP for cooling is 3.5% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 7.0 K and its ASHRAE flammability classification is 2.

[0206] The composition for the maximum cooling COP efficiency, which is 3.9% than that of R-454C, is 67.0 wt-% HFO-1252ZC, 16.0 wt-% R32 and 17.0 wt-%

R134, where the CAP for cooling is -8.8% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.3 K and its ASHRAE flammability classification is 2.

Table 12a: Compositions cited in Example 12a

W_HFO-1252ZC	W_R32	W_R134	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.67	0.16	0.17	299	6.3	2	-8.8	3.9
0.67	0.19	0.14	285	6.9	2	-4.7	3.6
0.57	0.42	0.01	296	6.4	2	23.8	0.1
0.58	0.41	0.01	289	6.6	2	22.7	0.2
0.66	0.2	0.14	292	7	2	-3.4	3.5
0.66	0.19	0.15	297	6.8	2	-4.8	3.6
0.67	0.17	0.16	294	6.5	2	-7.4	3.8
0.67	0.18	0.15	290	6.7	2	-6.1	3.7

Example 12b:

[0207] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, HFC-32 and HFC-134.

[0208] Broadly, for heating mode, a composition range of 57.0% to 98.0% of HFO-1252ZC, 1.0% to 42.0% of R32, and 1.0% to 26.0% of R134 will have a GWP less than 300, a maximum average glide of about 6.7 K, a heating capacity range that has a deviation range of -30.4% to 35.5% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from 3.1% to 6.7% than that of the heating COP of R-454C evaluated with the same conditions set. Table 4b lists example compositions within the GWP<300 range that have ASHRAE flammability classifications of 2 and 3.

[0209] Similarly, but a little less broadly for heating mode, a composition range of 57.0% to 68.0% of HFO-1252ZC, 16.0% to 42.0% of R32, and 1.0% to 17.0% of R134 will have a GWP less than 300, a maximum average glide of about 6.6 K, an ASHRAE flammability classification of 2, a heating capacity range has a deviation of -8.1% to 35.5% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of 3.1% to 5.5% than that of the heating COP of R-454C evaluated with the same conditions set.

[0210] Preferred blend composition ranges for heating mode within a composition range of 63.0% to 68.0% of HFO-1252ZC, 16.0% to 27.0% of R32, and 6.0% to 17.0% of R134 will have a GWP < 300, a maximum average heat exchanger glide of 6.4 K, an ASHRAE flammability classification of 2, the minimum and maximum heating capacities are -8.1% and 10.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 4.5% and 5.5% than that of R-454C evaluated at the same conditions set.

[0211] The composition for the preferred maximum heating capacity, which is 10.0% than that of R-454C, is 64.0 wt-% HFO-1252ZC, 27.0 wt-% R32 and 9.0 wt-% R134, where the COP for heating is 4.6% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.3 K and its ASHRAE flammability classification is 2.

[0212] The composition for the preferred maximum heating COP efficiency, which is 5.5% than that of R-454C, is 67.0 wt-% HFO-1252ZC, 16.0 wt-% R32 and 17.0 wt-% R134, where the CAP for heating is -8.1% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 5.1 K and its ASHRAE flammability classification is 2.

TABLE 12B

W_HFO-1252ZC	W_R32	W_R134	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.59	0.36	0.05	300	6.1	2	24.9	3.8
0.98	0.01	0.01	18	0.6	3	-28.9	6.7
0.57	0.42	0.01	296	5.6	2	35.5	3.1
0.9	0.01	0.09	108	0.6	3	-29.2	6.6
0.73	0.01	0.26	298	0.5	3	-30.4	6.4
0.63	0.36	0.01	255	6.3	2	26	3.5
0.71	0.28	0.01	201	6.7	3	13.1	4.1
0.67	0.28	0.05	246	6.5	2	12.3	4.3
0.8	0.13	0.07	166	4.9	3	-11.4	5.5
0.68	0.28	0.04	234	6.5	2	12.5	4.3
0.67	0.16	0.17	299	5.1	2	-8.1	5.5
0.68	0.31	0.01	221	6.6	2	17.9	3.8
0.68	0.27	0.05	239	6.5	2	10.7	4.4
0.63	0.26	0.11	299	6.2	2	8	4.8
0.68	0.26	0.06	243	6.4	2	9	4.5
0.64	0.27	0.09	284	6.3	2	10	4.6

W_HFO-1252ZC	W_R32	W_R134	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.67	0.25	0.08	259	6.3	2	7	4.7
0.68	0.25	0.07	248	6.3	2	7.2	4.6
0.63	0.27	0.1	295	6.2	2	9.8	4.7
0.64	0.24	0.12	297	6	2	4.8	4.9

Example 13a

[0213] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, HFC-32 and CO₂.

[0214] Broadly, for cooling mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 44.0% of R32, and 1.0% to 89.0% of CO₂ will have a GWP less than 298, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -26.7% to 217.4% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from -57.8% to 4.3% than that of the cooling COP of R-454C evaluated with the same conditions set. Table X lists example compositions within the GWP<298 range that have ASHRAE flammability classifications of 2, 3 and 1.

[0215] Similarly, but a little less broadly for cooling mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 22.0% of R32, and 1.0% to 89.0% of CO₂ will have a GWP less than 150, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1 and 3, a cooling capacity range has a deviation of -26.7% to 215.3% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of -57.8% to 4.3% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0216] Preferred blend composition ranges for cooling mode within a composition range of 1.0% to 18.0% of HFO-1252ZC, 2.0% to 22.0% of R32, and 72.0% to 89.0% of CO₂ will have a GWP < 150, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1, the minimum and maximum cooling capacities are 167.0% and 215.3% than that of R-454C evaluated at the

same conditions set, and the minimum and maximum cooling COP efficiencies are -57.8% and -30.0% than that of R-454C evaluated at the same conditions set.

[0217] The composition for the preferred maximum cooling capacity, which is 215.3% than that of R-454C, is 1.0 wt-% HFO-1252ZC, 15.0 wt-% R32 and 84.0 wt-% CO₂, where the COP for cooling is -34.4% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 4.6 K and its ASHRAE flammability classification is 1.

[0218] The composition for the preferred maximum cooling COP efficiency, which is -30.0% than that of R-454C, is 9.0 wt-% HFO-1252ZC, 17.0 wt-% R32 and 74.0 wt-% CO₂, where the CAP for cooling is 203.8% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.9 K and its ASHRAE flammability classification is 1.

TABLE 13A

W_HFO-1252ZC	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.54	0.44	0.02	298	6.8	2	31.6	-1.1
0.98	0.01	0.01	7	2.9	3	-26.7	4.3
0.01	0.21	0.78	190	6.1	1	216.8	-29
0.02	0.09	0.89	136	4.2	1	211.2	-36.1
0.91	0.08	0.01	54	6.5	3	-16	3.4
0.01	0.19	0.8	177	5.6	1	217.4	-30.6
0.09	0.1	0.81	102	5.2	1	199	-57.8
0.13	0.1	0.77	102	7	1	196.2	-33.9
0.13	0.07	0.8	82	6.2	1	192.4	-37.2
0.57	0.42	0.01	284	6.8	2	26.7	-0.5
0.93	0.06	0.01	41	5.6	3	-19	3.6
0.01	0.15	0.84	150	4.6	1	215.3	-34.4
0.01	0.14	0.85	143	4.3	1	213.7	-35.5
0.05	0.22	0.73	150	5.6	1	210.6	-32.1
0.96	0.01	0.03	7	7	3	-20.3	2.1
0.95	0.04	0.01	27	4.7	3	-22.1	3.8
0.15	0.07	0.78	55	6.2	1	183	-40.6
0.93	0.05	0.02	34	6.9	3	-17.4	2.8
0.18	0.02	0.8	14	6.6	1	176.5	-42.8
0.11	0.17	0.72	123	6.8	1	200.4	-32.3
0.15	0.04	0.81	35	5.2	1	167	-46.1
0.09	0.17	0.74	150	6.9	1	203.8	-30
0.09	0.08	0.83	89	4.6	1	193.1	-39.7

W_HFO-1252ZC	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.18	0.04	0.78	28	7	1	174.1	-42.8
0.13	0.02	0.85	48	4.9	1	180.9	-42.8
0.06	0.19	0.75	150	5.9	1	209.1	-31.5

Example 13b

[0219] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, HFC-32 and CO₂.

[0220] Broadly, for heating mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 44.0% of R32, and 1.0% to 66.0% of CO₂ will have a GWP less than 298, a maximum average glide of about 7.0 K, a heating capacity range that has a deviation range of -26.1% to 272.8% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from -20.4% to 6.4% than that of the heating COP of R-454C evaluated with the same conditions set. Table 5b lists example compositions within the GWP<298 range that have ASHRAE flammability classifications of 1, 3 and 2.

[0221] Similarly, but a little less broadly for heating mode, a composition range of 1.0% to 65.0% of HFO-1252ZC, 23.0% to 44.0% of R32, and 1.0% to 66.0% of CO₂ will have a GWP less than 298, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1 and 2, a heating capacity range has a deviation of 26.2% to 272.8% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of -20.4% to 3.3% than that of the heating COP of R-454C evaluated with the same conditions set.

[0222] Preferred blend composition ranges for heating mode within a composition range of 53.0% to 65.0% of HFO-1252ZC, 34.0% to 44.0% of R32, and 1.0% to 4.0% of CO₂ will have a GWP < 298, a maximum average heat exchanger glide of 6.9 K, an ASHRAE flammability classification of 2, the minimum and maximum heating capacities are 26.2% and 49.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 1.9% and 3.3% than that of R-454C evaluated at the same conditions set.

[0223] The composition for the preferred maximum heating capacity, which is 49.0% than that of R-454C, is 54.0 wt-% HFO-1252ZC, 42.0 wt-% R32 and 4.0 wt-% CO₂, where the COP for heating is 1.9% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.9 K and its ASHRAE flammability classification is 2.

[0224] The composition for the preferred maximum heating COP efficiency, which is 3.3% than that of R-454C, is 65.0 wt-% HFO-1252ZC, 34.0 wt-% R32 and 1.0 wt-% CO₂, where the CAP for heating is 26.2% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.9 K and its ASHRAE flammability classification is 2.

TABLE 13B

W_HFO-1252ZC	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.01	0.37	0.62	298	6.2	1	272.6	-13.5
0.98	0.01	0.01	7	2.3	3	-26.1	6.4
0.51	0.44	0.05	298	6.8	2	55.7	1.5
0.95	0.01	0.04	7	6.8	3	-17.9	5.6
0.02	0.32	0.66	292	6.1	1	271.4	-13.7
0.59	0.4	0.01	271	6.3	2	35.9	2.8
0.03	0.39	0.58	278	5.9	1	272.8	-14.6
0.18	0.23	0.59	156	6.8	1	244.5	-20.4
0.15	0.3	0.55	210	7	1	246.1	-15.8
0.12	0.29	0.59	210	6.1	1	258.2	-17.5
0.1	0.35	0.55	285	6.9	2	239.9	-11.6
0.87	0.11	0.02	75	6.8	3	-8.3	5
0.65	0.34	0.01	230	6.9	2	26.2	3.3
0.52	0.44	0.04	298	6.5	2	52.3	1.7
0.63	0.36	0.01	244	6.8	2	29.4	3.1
0.6	0.39	0.01	264	6.4	2	34.3	2.9
0.53	0.44	0.03	298	6.3	2	48.8	2
0.54	0.44	0.02	298	6	2	45.5	2.3
0.54	0.42	0.04	284	6.9	2	49	1.9
0.62	0.37	0.01	251	6.6	2	31	3
0.58	0.41	0.01	278	6.1	2	37.5	2.7
0.56	0.43	0.01	291	5.8	2	40.6	2.6

Example 14a

[0225] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, HFO-1132E, HFC-134 and HFC-32.

[0226] Broadly, for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 26.0% of R134, and 1.0% to 42.0% of R32 will have a GWP less than 300, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -29.2% to 66.4% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from -2.5% to 5.7% than that of the cooling COP of R-454C evaluated with the same conditions set. Table 6a lists example compositions within the GWP<300 range that have ASHRAE flammability classifications of 2, 3 and 2L.

[0227] Similarly, but a little less broadly for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 12.0% of R134, and 1.0% to 20.0% of R32 will have a GWP less than 149, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 3 and 2, a cooling capacity range has a deviation of -28.9% to 60.6% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of -2.5% to 5.7% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0228] Preferred blend composition ranges for cooling mode within a composition range of 1.0% to 84.0% of HFO-1252ZC, 1.0% to 95.0% of HFO-1132EE, 1.0% to 12.0% of R134, and 1.0% to 20.0% of R32 will have a GWP < 149, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 3 and 2, the minimum and maximum cooling capacities are -10.0% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -2.1% and 3.7% than that of R-454C evaluated at the same conditions set.

[0229] Even more preferred blend composition ranges for cooling mode within a composition range of 1.0% to 54.0% of HFO-1252ZC, 25.0% to 95.0% of HFO-1132EE, 1.0% to 12.0% of R134, and 1.0% to 20.0% of R32 will have a GWP < 149, a maximum average heat exchanger glide of 6.5 K, an ASHRAE flammability

classification of 2, the minimum and maximum cooling capacities are 10.5% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -2.1% and 1.3% than that of R-454C evaluated at the same conditions set.

[0230] The composition for the even more preferred maximum cooling capacity, which is 50.0% than that of R-454C, is 8.0 wt-% HFO-1252ZC, 81.0 wt-% HFO-1132EE, 2.0 wt-% R134 and 9.0 wt-% R32, where the COP for cooling is -2.0% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 1.2 K and its ASHRAE flammability classification is 2.

[0231] The composition for the even more preferred maximum cooling COP efficiency, which is 1.3% than that of R-454C, is 42.0 wt-% HFO-1252ZC, 44.0 wt-% HFO-1132EE, 12.0 wt-% R134, and 2.0 wt-% R32, where the CAP for cooling is 10.5% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 5.4 K and its ASHRAE flammability classification is 2.

TABLE 14A

W_HFO-1252ZC	W_HFO-1132EE	W_R134	W_R32	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.33	0.24	0.02	0.41	300	3.5	2	41.9	-1.4
0.97	0.01	0.01	0.01	18	1.2	3	-28.8	5.6
0.01	0.71	0.24	0.04	296	5	2	30.2	-0.3
0.01	0.97	0.01	0.01	18	0.3	2	51.7	-2
0.78	0.01	0.2	0.01	231	1	3	-29	5.7
0.63	0.1	0.26	0.01	298	3.4	3	-20.9	4.6
0.74	0.24	0.01	0.01	18	5.8	3	-7.3	3.2
0.33	0.24	0.01	0.42	296	3.2	2	43.2	-1.5
0.33	0.4	0.26	0.01	298	5.7	2	4.4	2.1
0.01	0.56	0.01	0.42	296	0.3	2L	66.4	-2.3
0.72	0.01	0.26	0.01	298	1	3	-29.2	5.7
0.01	0.73	0.01	0.25	180	0.4	2	62.3	-2.5
0.54	0.13	0.14	0.19	285	7	2	6.4	2.4
0.02	0.56	0.01	0.41	289	0.4	2L	65.6	-2.3
0.42	0.33	0.09	0.16	209	5.9	2	19.8	0.6
0.83	0.02	0.13	0.02	159	2	3	-26.4	5.3
0.58	0.22	0.03	0.17	149	6.9	3	12.5	1.3
0.01	0.81	0.02	0.16	131	0.7	2	57.9	-2.4
0.94	0.01	0.04	0.01	52	1.1	3	-28.8	5.7
0.59	0.27	0.12	0.02	148	5.8	3	-3.7	2.9
0.33	0.46	0.01	0.2	147	3.8	2	36.3	-1.3

W_HFO-1252ZC	W_HFO-1132EE	W_R134	W_R32	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.53	0.26	0.01	0.2	147	6.4	2	19.8	0.3
0.55	0.4	0.04	0.01	52	5.6	3	6.4	1.7
0.01	0.78	0.01	0.2	147	0.4	2	60.6	-2.5
0.86	0.01	0.12	0.01	141	1.1	3	-28.9	5.7
0.63	0.22	0.03	0.12	115	7	3	6.1	1.9
0.66	0.19	0.04	0.11	119	7	3	2.1	2.4
0.19	0.66	0.03	0.12	115	2.5	2	42.2	-1.6
0.76	0.17	0.06	0.01	74	5	3	-13.7	3.8
0.84	0.02	0.01	0.13	99	6.8	3	-9.9	3.6
0.01	0.87	0.1	0.02	126	2.2	2	43.1	-1.5
0.02	0.95	0.02	0.01	29	0.6	2	50	-1.9
0.83	0.01	0.02	0.14	117	6.9	3	-9.5	3.6
0.33	0.54	0.12	0.01	141	4.7	2	17.2	0.6
0.28	0.58	0.01	0.13	99	3.1	2	37.5	-1.4
0.38	0.41	0.01	0.2	147	4.5	2	32.2	-1
0.25	0.67	0.07	0.01	85	3.4	2	28.1	-0.5
0.08	0.81	0.02	0.09	83	1.2	2	50	-2
0.71	0.18	0.08	0.03	110	5.6	3	-10	3.5
0.78	0.04	0.06	0.12	149	6.5	3	-9.8	3.7
0.15	0.66	0.01	0.18	133	1.6	2	49.8	-2.1
0.16	0.68	0.04	0.12	126	2.4	2	43.4	-1.6
0.52	0.28	0.03	0.17	149	6.4	2	17.5	0.7
0.54	0.25	0.01	0.2	147	6.5	2	19	0.4
0.34	0.53	0.12	0.01	141	4.8	2	16.4	0.7
0.36	0.52	0.01	0.11	86	4.1	2	30	-0.8
0.42	0.37	0.01	0.2	147	5	2	28.9	-0.6
0.12	0.77	0.1	0.01	119	2.8	2	35	-1
0.42	0.44	0.12	0.02	148	5.4	2	10.5	1.3
0.44	0.39	0.07	0.1	146	5.7	2	17.4	0.7

Example 14b

[0232] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, HFO-1132E, HFC-134 and HFC-32.

[0233] Broadly, for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 26.0% of R134, and 1.0% to 42.0% of R32 will have a GWP less than 300, a maximum average glide of about 6.7 K, a heating capacity range that has a deviation range of -29.5% to 96.3% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from 0.3% to 6.6% than that of the heating COP of

R-454C evaluated with the same conditions set. Table 6b lists example compositions within the GWP<300 range that have ASHRAE flammability classifications of 2, 3 and 2L.

[0234] Similarly, but a little less broadly for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 12.0% of R134, and 1.0% to 20.0% of R32 will have a GWP less than 149, a maximum average glide of about 6.4 K, an ASHRAE flammability classification of 3 and 2, a heating capacity range has a deviation of -28.5% to 87.2% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of 0.3% to 6.6% than that of the heating COP of R-454C evaluated with the same conditions set.

[0235] Preferred blend composition ranges for heating mode within a composition range of 8.0% to 85.0% of HFO-1252ZC, 1.0% to 79.0% of HFO-1132EE, 1.0% to 12.0% of R134, and 1.0% to 20.0% of R32 will have a GWP < 149, a maximum average heat exchanger glide of 6.4 K, an ASHRAE flammability classification of 3 and 2, the minimum and maximum heating capacities are -10.0% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 1.0% and 5.3% than that of R-454C evaluated at the same conditions set.

[0236] Even more preferred blend composition ranges for heating mode within a composition range of 8.0% to 54.0% of HFO-1252ZC, 25.0% to 79.0% of HFO-1132EE, 1.0% to 12.0% of R134, and 1.0% to 20.0% of R32 will have a GWP < 149, a maximum average heat exchanger glide of 5.6 K, an ASHRAE flammability classification of 2, the minimum and maximum heating capacities are 16.4% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 1.0% and 2.8% than that of R-454C evaluated at the same conditions set.

[0237] The composition for the even more preferred maximum heating capacity, which is 50.0% than that of R-454C, is 26.0 wt-% HFO-1252ZC, 60.0 wt-% HFO-1132EE, 4.0 wt-% R134 and 10.0 wt-% R32, where the COP for heating is 1.3% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 3.0 K and its ASHRAE flammability classification is 2.

[0238] The composition for the even more preferred maximum heating COP efficiency, which is 2.8% than that of R-454C, is 49.0 wt-% HFO-1252ZC, 33.0 wt-% HFO-1132EE, 6.0 wt-% R134, and 12.0 wt-% R32, where the CAP for heating is 22.6% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 5.3 K and its ASHRAE flammability classification is 2.

TABLE 14B

W_HFO-1252ZC	W_HFO-1132EE	W_R134	W_R32	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.33	0.24	0.02	0.41	300	3.1	2	61.3	1.9
0.97	0.01	0.01	0.01	18	0.9	3	-27.9	6.6
0.01	0.68	0.17	0.14	285	3.9	2	55.4	1.6
0.01	0.97	0.01	0.01	18	0.3	2	73.8	0.3
0.71	0.01	0.17	0.11	265	4.3	3	-14.4	5.7
0.6	0.13	0.26	0.01	298	3.2	3	-18.6	5.2
0.09	0.76	0.01	0.14	106	0.9	2	75.8	0.5
0.37	0.2	0.01	0.42	296	3.3	2	58.8	2
0.88	0.08	0.03	0.01	40	2.6	3	-21.3	5.8
0.01	0.56	0.01	0.42	296	0.4	2L	96.3	1.3
0.72	0.01	0.26	0.01	298	0.8	3	-29.5	6.3
0.01	0.93	0.01	0.05	45	0.4	2	77.1	0.3
0.71	0.01	0.01	0.27	194	6.7	3	12.6	4.1
0.01	0.58	0.02	0.39	286	0.7	2L	93.1	1.2
0.31	0.48	0.01	0.2	147	3.1	2	55.2	1.3
0.51	0.29	0.19	0.01	220	4.6	3	-2.1	4
0.79	0.01	0.03	0.17	149	5.9	3	-3.8	5
0.01	0.83	0.07	0.09	139	1.7	2	69.4	0.7
0.88	0.01	0.07	0.04	106	2.3	3	-23.8	6.2
0.75	0.11	0.12	0.02	148	3.4	3	-17.5	5.3
0.66	0.23	0.01	0.1	79	5.8	3	9	3.6
0.65	0.14	0.01	0.2	147	6.3	3	15.7	3.5
0.91	0.05	0.03	0.01	40	2	3	-24.2	6.1
0.01	0.78	0.01	0.2	147	0.4	2	87.2	0.5
0.86	0.01	0.12	0.01	141	0.8	3	-28.5	6.5
0.73	0.06	0.01	0.2	147	6.4	3	6.7	4.2
0.13	0.77	0.02	0.08	77	1.4	2	65.8	0.6
0.5	0.35	0.08	0.07	137	5.1	3	16	3.1
0.85	0.01	0.01	0.13	99	5.3	3	-9.8	5.3
0.08	0.79	0.12	0.01	141	2.7	2	49.5	1.1
0.4	0.46	0.12	0.02	148	4.5	2	18.4	2.7
0.55	0.33	0.01	0.11	86	5.3	3	22	2.7
0.59	0.38	0.02	0.01	29	4.8	3	10.1	3.2
0.26	0.6	0.04	0.1	113	3	2	50	1.3

0.74	0.18	0.06	0.02	81	4.3	3	-10	4.7
0.84	0.01	0.02	0.13	110	5.2	3	-9.9	5.3
0.25	0.73	0.01	0.01	18	2.1	2	49.4	1
0.36	0.52	0.03	0.09	95	3.8	2	39.6	1.7
0.64	0.22	0.09	0.05	135	5	3	-1.4	4.2
0.52	0.28	0.03	0.17	149	5.5	2	26.2	2.8
0.54	0.25	0.01	0.2	147	5.6	2	28.3	2.7
0.27	0.6	0.12	0.01	141	3.7	2	31.3	1.9
0.47	0.32	0.01	0.2	147	4.9	2	36.5	2.2
0.41	0.38	0.01	0.2	147	4.3	2	43.5	1.8
0.26	0.68	0.05	0.01	63	2.8	2	42.3	1.3
0.42	0.44	0.12	0.02	148	4.6	2	16.4	2.8
0.49	0.33	0.06	0.12	148	5.3	2	22.6	2.8
0.2	0.65	0.1	0.05	146	3.2	2	43.9	1.4

Example 15a

[0239] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, HFO-1132E, HFC-134 and CO₂.

[0240] Broadly, for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 80.0% of R134, and 1.0% to 79.0% of CO₂ will have a GWP less than 291, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -27.5% to 203.3% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from -56.8% to 4.6% than that of the cooling COP of R-454C evaluated with the same conditions set. Table 7a lists example compositions within the GWP<291 range that have ASHRAE flammability classifications of 3, 2 and 1.

[0241] Similarly, but a little less broadly for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 80.0% of R134, and 1.0% to 79.0% of CO₂ will have a GWP less than 291, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 3, 2 and 1, a cooling capacity range has a deviation of -27.5% to 203.3% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of -56.8% to 4.6% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0242] Preferred blend composition ranges for cooling mode within a composition range of 29.0% to 78.0% of HFO-1252ZC, 20.0% to 44.0% of HFO-1132EE, 1.0% to 26.0% of R134, and 1.0% to 1.0% of CO₂ will have a GWP < 291, a maximum average heat exchanger glide of 6.8 K, an ASHRAE flammability classification of 2 and 3, the minimum and maximum cooling capacities are -10.0% and 10.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are 1.0% and 3.1% than that of R-454C evaluated at the same conditions set.

[0243] Even more preferred blend composition ranges for cooling mode within a composition range of 29.0% to 53.0% of HFO-1252ZC, 21.0% to 44.0% of HFO-1132EE, 15.0% to 26.0% of R134, and 1.0% to 1.0% of CO₂ will have a GWP < 291, a maximum average heat exchanger glide of 6.5 K, an ASHRAE flammability classification of 2, the minimum and maximum cooling capacities are -9.4% and 10.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are 1.2% and 3.1% than that of R-454C evaluated at the same conditions set.

[0244] The composition for the even more preferred maximum cooling capacity, which is 10.0% than that of R-454C, is 34.0 wt-% HFO-1252ZC, 44.0 wt-% HFO-1132EE, 21.0 wt-% R134 and 1.0 wt-% CO₂, where the COP for cooling is 1.3% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.2 K and its ASHRAE flammability classification is 2.

[0245] The composition for the even more preferred maximum cooling COP efficiency, which is 3.1% than that of R-454C, is 52.0 wt-% HFO-1252ZC, 21.0 wt-% HFO-1132EE, 26.0 wt-% R134, and 1.0 wt-% CO₂, where the CAP for cooling is -9.4% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.1 K and its ASHRAE flammability classification is 2.

TABLE 15A

W_HFO-1252ZC	W_HFO-1132EE	W_R134	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.7	0.01	0.26	0.03	291	6.3	3	-21.1	2.5
0.97	0.01	0.01	0.01	11	2.6	3	-27.3	4.4
0.01	0.89	0.03	0.07	34	3.4	2	65	-4

W_HFO-1252ZC	W_HFO-1132EE	W_R134	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.01	0.97	0.01	0.01	11	0.7	2	53.3	-2.3
0.92	0.01	0.04	0.03	45	6.7	3	-20.9	2.1
0.11	0.08	0.8	0.01	23	6.7	1	192.4	-37.8
0.2	0.74	0.01	0.05	11	4.3	2	48.5	-3
0.15	0.05	0.01	0.79	12	6.9	1	186.9	-39.5
0.13	0.76	0.1	0.01	112	3.3	2	36	-1.2
0.01	0.22	0.03	0.74	34	6.9	1	203.3	-32.5
0.72	0.01	0.26	0.01	291	2.5	3	-27.5	4.6
0.08	0.14	0.76	0.02	12	6.1	1	192.7	-56.8
0.27	0.62	0.04	0.07	45	7	3	44.8	-3.1
0.32	0.5	0.15	0.03	168	7	2	21.5	-0.3
0.24	0.55	0.19	0.02	213	6.2	2	21.7	-0.1
0.42	0.46	0.11	0.01	123	5.9	3	12.6	0.9
0.01	0.89	0.08	0.02	90	2.6	2	48.6	-2.2
0.83	0.01	0.14	0.02	157	4.5	3	-24.2	3.3
0.78	0.2	0.01	0.01	11	6.5	3	-9.3	3
0.08	0.12	0.01	0.79	34	6.9	1	193.3	-37.3
0.51	0.34	0.14	0.01	157	6.5	3	2.4	2
0.07	0.17	0.01	0.75	12	6.2	1	195.1	-35.7
0.33	0.43	0.23	0.01	258	6.3	2	8.9	1.4
0.67	0.26	0.06	0.01	67	6.6	3	-4.1	2.5
0.52	0.21	0.26	0.01	291	6.1	2	-9.4	3.1
0.29	0.44	0.26	0.01	291	6.4	2	9.3	1.4
0.31	0.44	0.24	0.01	269	6.3	2	9.6	1.4
0.73	0.2	0.06	0.01	67	6.3	3	-9.4	3
0.42	0.31	0.26	0.01	291	6.5	2	-1	2.4
0.54	0.24	0.21	0.01	235	6.3	3	-6.5	2.9
0.58	0.21	0.2	0.01	224	6.1	3	-9	3.1
0.34	0.44	0.21	0.01	235	6.2	2	10	1.3
0.58	0.2	0.21	0.01	235	6	3	-10	3.1
0.56	0.42	0.01	0.01	11	6.3	3	9.8	1
0.69	0.29	0.01	0.01	11	6.8	3	-1.3	2.2
0.32	0.42	0.25	0.01	280	6.4	2	7.9	1.5
0.53	0.22	0.24	0.01	269	6.1	2	-8.4	3
0.53	0.21	0.25	0.01	280	6.1	2	-9.3	3.1
0.51	0.22	0.26	0.01	291	6.1	2	-8.6	3.1
0.42	0.42	0.15	0.01	168	6.2	2	9	1.3
0.37	0.37	0.25	0.01	280	6.5	2	3.9	1.9
0.47	0.32	0.2	0.01	224	6.5	2	0.3	2.2
0.41	0.43	0.15	0.01	168	6.1	2	9.8	1.2
0.39	0.34	0.26	0.01	291	6.5	2	1.4	2.2
0.48	0.25	0.26	0.01	291	6.3	2	-6	2.9

Example 15b

[0246] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, HFO-1132E, HFC-134 and CO₂.

[0247] Broadly, for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 26.0% of R134, and 1.0% to 51.0% of CO₂ will have a GWP less than 291, a maximum average glide of about 7.0 K, a heating capacity range that has a deviation range of -28.2% to 224.8% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from -14.9% to 6.4% than that of the heating COP of R-454C evaluated with the same conditions set. Table 7b lists example compositions within the GWP<291 range that have ASHRAE flammability classifications of 3 and 2.

[0248] Similarly, but a little less broadly for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 13.0% of R134, and 1.0% to 51.0% of CO₂ will have a GWP less than 146, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 2 and 3, a heating capacity range has a deviation of -27.3% to 224.8% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of -14.9% to 6.4% than that of the heating COP of R-454C evaluated with the same conditions set.

[0249] Preferred blend composition ranges for heating mode within a composition range of 1.0% to 40.0% of HFO-1252ZC, 45.0% to 97.0% of HFO-1132EE, 1.0% to 13.0% of R134, and 1.0% to 49.0% of CO₂ will have a GWP < 146, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 2, the minimum and maximum heating capacities are 18.0% and 224.1% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are -13.5% and 2.6% than that of R-454C evaluated at the same conditions set.

[0250] Even more preferred blend composition ranges for heating mode within a composition range of 8.0% to 40.0% of HFO-1252ZC, 45.0% to 78.0% of HFO-1132EE, 1.0% to 13.0% of R134, and 1.0% to 7.0% of CO₂ will have a GWP < 146, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability

classification of 2, the minimum and maximum heating capacities are 18.0% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 0.4% and 2.6% than that of R-454C evaluated at the same conditions set.

[0251] The composition for the even more preferred maximum heating capacity, which is 50.0% than that of R-454C, is 12.0 wt-% HFO-1252ZC, 74.0 wt-% HFO-1132EE, 12.0 wt-% R134 and 2.0 wt-% CO₂, where the COP for heating is 0.9% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 3.6 K and its ASHRAE flammability classification is 2.

[0252] The composition for the even more preferred maximum heating COP efficiency, which is 2.6% than that of R-454C, is 40.0 wt-% HFO-1252ZC, 46.0 wt-% HFO-1132EE, 13.0 wt-% R134, and 1.0 wt-% CO₂, where the CAP for heating is 18.0% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 5.0 K and its ASHRAE flammability classification is 2.

TABLE 15B

W_HFO-1252ZC	W_HFO-1132EE	W_R134	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.69	0.01	0.26	0.04	291	6.3	3	-20.1	5.4
0.97	0.01	0.01	0.01	11	2	3	-26.7	6.4
0.01	0.6	0.01	0.38	12	6.4	2	188.4	-9.1
0.01	0.97	0.01	0.01	11	0.5	2	75.6	0.2
0.91	0.01	0.07	0.01	78	2	3	-27	6.4
0.65	0.08	0.26	0.01	291	3.4	3	-21.9	5.5
0.41	0.53	0.01	0.05	11	6.1	3	42	0.9
0.07	0.41	0.01	0.51	12	6.8	3	223.9	-14.9
0.82	0.11	0.06	0.01	67	4	3	-17.3	5.3
0.04	0.45	0.01	0.5	12	6.4	3	224.8	-14.1
0.72	0.01	0.26	0.01	291	1.9	3	-28.2	6.2
0.08	0.4	0.01	0.51	12	7	3	222.5	-14.9
0.31	0.56	0.04	0.09	45	7	3	59.3	-0.3
0.04	0.91	0.02	0.03	22	1.5	2	76.3	-0.1
0.84	0.02	0.12	0.02	134	3.8	3	-23.6	5.9
0.02	0.71	0.13	0.14	146	7	2	88.5	-1.8
0.01	0.96	0.02	0.01	22	0.8	2	73.9	0.2
0.94	0.01	0.02	0.03	23	5.2	3	-21.3	5.8
0.17	0.64	0.13	0.06	146	5.8	2	53.4	0.4
0.05	0.76	0.01	0.18	11	4.9	2	119.6	-3.5
0.64	0.24	0.11	0.01	123	5.2	3	-4.6	4.2

W_HFO-1252ZC	W_HFO-1132EE	W_R134	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.85	0.01	0.13	0.01	146	2	3	-27.3	6.3
0.02	0.76	0.03	0.19	34	5.3	2	121.7	-3.6
0.47	0.48	0.02	0.03	22	5.8	3	29.1	1.8
0.4	0.46	0.13	0.01	146	5	2	18	2.6
0.01	0.73	0.12	0.14	135	6.7	2	91.2	-1.9
0.38	0.45	0.13	0.04	146	6.6	2	26.7	1.9
0.14	0.7	0.13	0.03	146	4.3	2	49	0.8
0.01	0.63	0.01	0.35	12	6.3	2	178.2	-8.2
0.03	0.47	0.01	0.49	12	6.4	2	222.9	-13.5
0.21	0.74	0.04	0.01	45	2.5	2	50.7	0.9
0.02	0.48	0.01	0.49	12	6.3	2	224.1	-13.5
0.2	0.61	0.08	0.11	90	7	2	70.9	-1
0.27	0.67	0.05	0.01	56	3.2	2	42.8	1.2
0.25	0.55	0.13	0.07	146	7	2	47.6	0.5
0.08	0.78	0.13	0.01	146	3.2	2	49.7	1
0.13	0.72	0.13	0.02	146	3.8	2	47.5	1
0.27	0.71	0.01	0.01	11	2.6	2	48.7	0.9
0.29	0.55	0.09	0.07	101	6.8	2	49.1	0.4
0.15	0.72	0.12	0.01	134	3.4	2	44.8	1.2
0.12	0.74	0.12	0.02	134	3.6	2	50	0.9
0.3	0.55	0.08	0.07	90	6.7	2	49.5	0.4
0.31	0.53	0.09	0.07	101	7	2	46.9	0.5
0.31	0.55	0.13	0.01	146	4.5	2	27.4	2

Example 16a

[0253] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, HFO-1132E, HFC-32 and CO₂.

[0254] Broadly, for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 91.0% of R32, and 1.0% to 92.0% of CO₂ will have a GWP less than 298, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -25.7% to 216.9% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from -75.5% to 31.4% than that of the cooling COP of R-454C evaluated with the same conditions set. Table 8a lists example compositions within the GWP<298 range that have ASHRAE flammability classifications of 2, 3, 1 and 2L.

[0255] Similarly, but a little less broadly for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 91.0% of R32, and 1.0% to 92.0% of CO₂ will have a GWP less than 150, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1, 3 and 2, a cooling capacity range has a deviation of -25.7% to 215.7% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of -75.5% to 4.2% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0256] Preferred blend composition ranges for cooling mode within a composition range of 1.0% to 53.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 91.0% of R32, and 1.0% to 92.0% of CO₂ will have a GWP < 150, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1 and 2, the minimum and maximum cooling capacities are 13.9% and 215.7% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -75.5% and -0.2% than that of R-454C evaluated at the same conditions set.

[0257] Even more preferred blend composition ranges for cooling mode within a composition range of 8.0% to 53.0% of HFO-1252ZC, 3.0% to 90.0% of HFO-1132EE, 1.0% to 22.0% of R32, and 1.0% to 81.0% of CO₂ will have a GWP < 150, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 2 and 1, the minimum and maximum cooling capacities are 13.9% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -75.5% and -0.2% than that of R-454C evaluated at the same conditions set.

[0258] The composition for the even more preferred maximum cooling capacity, which is 50.0% than that of R-454C, is 22.0 wt-% HFO-1252ZC, 69.0 wt-% HFO-1132EE, 4.0 wt-% R32 and 5.0 wt-% CO₂, where the COP for cooling is -3.1% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 4.4 K and its ASHRAE flammability classification is 2.

[0259] The composition for the even more preferred maximum cooling COP efficiency, which is -0.2% than that of R-454C, is 53.0 wt-% HFO-1252ZC, 25.0 wt-% HFO-1132EE, 21.0 wt-% R32, and 1.0 wt-% CO₂, where the CAP for cooling is

23.2% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.9 K and its ASHRAE flammability classification is 2.

TABLE 16A

W_HFO-1252ZC	W_HFO-1132EE	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.02	0.26	0.44	0.28	298	7	2	131.4	-10.1
0.97	0.01	0.01	0.01	7	3.3	3	-25.7	4.2
0.01	0.53	0.17	0.29	115	6.9	2	127.7	-11.1
0.01	0.97	0.01	0.01	7	0.5	2	54.9	-2.4
0.06	0.01	0.12	0.81	109	4.6	1	202.9	-36.9
0.04	0.04	0.91	0.01	102	4.7	1	206.4	-35.3
0.09	0.77	0.01	0.13	7	5.6	2	77.3	-5.9
0.03	0.03	0.02	0.92	109	4.1	1	206.1	-37
0.01	0.85	0.13	0.01	88	0.6	2	61	-2.8
0.01	0.01	0.21	0.77	170	5.5	1	216.9	-30.7
0.42	0.14	0.39	0.05	264	6.9	2	98.3	31.4
0.12	0.03	0.04	0.81	48	1.9	1	13.9	-75.5
0.2	0.41	0.25	0.14	169	7	2	81.4	-6.5
0.06	0.13	0.04	0.77	55	5.6	1	200.8	-33.6
0.05	0.57	0.32	0.06	217	2.2	2	76	-4.2
0.01	0.52	0.44	0.03	298	1	2L	74.4	-3.1
0.43	0.53	0.02	0.02	14	5.7	3	24.9	-0.7
0.01	0.01	0.18	0.8	150	4.8	1	215.7	-33.5
0.01	0.24	0.12	0.63	82	6.7	1	198.7	-25.3
0.05	0.01	0.12	0.82	116	4.5	1	205.3	-36.5
0.04	0.89	0.01	0.06	7	2.6	2	64.3	-3.9
0.03	0.04	0.01	0.92	109	4.4	1	207.6	-35.9
0.35	0.63	0.01	0.01	7	4	3	28.8	-0.9
0.01	0.02	0.21	0.76	150	5	1	215.7	-32.6
0.32	0.6	0.01	0.07	7	7	3	45	-3.2
0.02	0.09	0.02	0.87	96	4.7	1	209.1	-33.8
0.06	0.54	0.16	0.24	109	7	2	112.4	-9.6
0.29	0.61	0.03	0.07	20	6.5	3	48.5	-3.5
0.53	0.24	0.22	0.01	149	6.9	2	23.5	-0.2
0.01	0.77	0.12	0.1	81	3.3	2	81	-5.4
0.17	0.01	0.02	0.8	14	6.5	1	183.1	-41.1
0.03	0.05	0.91	0.01	102	4.6	1	207.8	-35
0.08	0.13	0.01	0.78	41	6	1	197.1	-34.2
0.03	0.84	0.12	0.01	81	0.7	2	59.2	-2.7
0.53	0.25	0.21	0.01	142	6.9	2	23.2	-0.2
0.11	0.02	0.14	0.73	116	7	1	199.4	-31.6
0.21	0.44	0.22	0.13	149	7	2	77.3	-6.1
0.08	0.02	0.12	0.78	143	6.7	1	204.3	-29.8

W_HFO-1252ZC	W_HFO-1132EE	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.05	0.77	0.17	0.01	115	0.8	2	60	-2.7
0.36	0.36	0.22	0.06	149	7	2	48.6	-3.3
0.08	0.9	0.01	0.01	7	1	2	49.9	-2.2
0.39	0.34	0.22	0.05	149	7	2	43.8	-2.8
0.26	0.7	0.01	0.03	7	3.9	2	40.6	-2.1
0.22	0.55	0.22	0.01	149	2.5	2	49.1	-2.3
0.22	0.69	0.04	0.05	27	4.4	2	50	-3.1
0.38	0.44	0.13	0.05	88	7	2	41.1	-2.6
0.34	0.5	0.13	0.03	88	5.3	2	40	-2.2

Example 16b

[0260] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, HFO-1132E, HFC-32 and CO₂.

[0261] Broadly, for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 81.0% of R32, and 1.0% to 83.0% of CO₂ will have a GWP less than 298, a maximum average glide of about 7.0 K, a heating capacity range that has a deviation range of -85.3% to 280.6% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from -44.6% to 6.3% than that of the heating COP of R-454C evaluated with the same conditions set. Table 8b lists example compositions within the GWP<298 range that have ASHRAE flammability classifications of 1, 3, 2 and 2L.

[0262] Similarly, but a little less broadly for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 71.0% of R32, and 1.0% to 73.0% of CO₂ will have a GWP less than 150, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1, 3 and 2, a heating capacity range has a deviation of -85.3% to 280.6% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of -44.6% to 6.3% than that of the heating COP of R-454C evaluated with the same conditions set.

[0263] Preferred blend composition ranges for heating mode within a composition range of 28.0% to 87.0% of HFO-1252ZC, 1.0% to 70.0% of HFO-1132EE, 1.0% to 22.0% of R32, and 1.0% to 7.0% of CO₂ will have a GWP < 150, a maximum

average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 2 and 3, the minimum and maximum heating capacities are -10.0% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 0.3% and 5.1% than that of R-454C evaluated at the same conditions set.

[0264] Even more preferred blend composition ranges for heating mode within a composition range of 30.0% to 55.0% of HFO-1252ZC, 21.0% to 66.0% of HFO-1132EE, 3.0% to 22.0% of R32, and 1.0% to 5.0% of CO₂ will have a GWP < 150, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 2, the minimum and maximum heating capacities are 31.7% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 0.9% and 2.5% than that of R-454C evaluated at the same conditions set.

[0265] The composition for the even more preferred maximum heating capacity, which is 50.0% than that of R-454C, is 42.0 wt-% HFO-1252ZC, 36.0 wt-% HFO-1132EE, 19.0 wt-% R32 and 3.0 wt-% CO₂, where the COP for heating is 1.2% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 5.5 K and its ASHRAE flammability classification is 2.

[0266] The composition for the even more preferred maximum heating COP efficiency, which is 2.5% than that of R-454C, is 55.0 wt-% HFO-1252ZC, 22.0 wt-% HFO-1132EE, 22.0 wt-% R32, and 1.0 wt-% CO₂, where the CAP for heating is 31.7% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.1 K and its ASHRAE flammability classification is 2.

TABLE 16B

W_HFO-1252ZC	W_HFO-1132EE	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.01	0.01	0.4	0.58	298	6.2	1	269.4	-13
0.97	0.01	0.01	0.01	7	2.5	3	-25.2	6.3
0.01	0.52	0.39	0.08	264	1.8	2	119.4	-0.5
0.01	0.97	0.01	0.01	7	0.4	2	78.2	0.1
0.95	0.01	0.01	0.03	7	5.5	3	-19.7	5.7
0.01	0.17	0.81	0.01	197	5.3	2	257.8	-13.7
0.06	0.88	0.01	0.05	7	1.8	2	84	-0.6
0.04	0.12	0.01	0.83	210	5.5	1	258.6	-14.3

W_HFO-1252ZC	W_HFO-1132EE	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.54	0.24	0.21	0.01	142	6	2	32.3	2.4
0.13	0.16	0.17	0.54	116	6.5	2	280.6	-24
0.06	0.53	0.05	0.36	34	4.8	2	-85.3	-44.6
0.12	0.5	0.08	0.3	54	7	2	158.2	-7
0.14	0.1	0.42	0.34	285	7	2	187.7	-6.9
0.27	0.36	0.22	0.15	149	7	2	101.9	-2.3
0.06	0.05	0.24	0.65	244	6	1	258.5	-14
0.09	0.21	0.2	0.5	136	6.1	2	236.6	-14.2
0.02	0.5	0.44	0.04	298	1	2L	108.9	0.5
0.43	0.5	0.03	0.04	20	5.8	3	40.9	1.1
0.18	0.01	0.22	0.59	150	6.8	1	243.4	-20.6
0.01	0.65	0.15	0.19	102	3.9	2	140.7	-3.7
0.91	0.01	0.05	0.03	34	6.7	3	-13.7	5.3
0.05	0.19	0.71	0.05	149	5.3	2	252.3	-15.3
0.33	0.63	0.01	0.03	7	4	3	48.9	0.7
0.02	0.24	0.01	0.73	149	5.1	2	253	-14.4
0.53	0.25	0.21	0.01	142	5.9	2	33.5	2.3
0.03	0.55	0.14	0.28	95	5.1	2	166.9	-6.1
0.62	0.33	0.03	0.02	20	6.4	3	14.5	2.9
0.16	0.05	0.2	0.59	143	6.5	1	245	-19.7
0.5	0.24	0.22	0.04	149	7	2	44.2	1.5
0.87	0.01	0.1	0.02	68	6.7	3	-8.8	5
0.28	0.7	0.01	0.01	7	2.6	3	49.9	0.9
0.82	0.01	0.16	0.01	108	6.7	3	-2.2	4.7
0.61	0.16	0.22	0.01	149	6.6	3	24.7	2.9
0.39	0.55	0.01	0.05	7	5.7	3	46.6	0.6
0.41	0.5	0.02	0.07	14	6.9	3	49.7	0.3
0.61	0.36	0.02	0.01	14	5.6	3	13	3
0.3	0.67	0.01	0.02	7	3.2	3	50	0.8
0.85	0.09	0.04	0.02	27	6.1	3	-10	4.8
0.86	0.03	0.1	0.01	68	5.9	3	-9.6	5.1
0.47	0.38	0.1	0.05	68	7	3	43	1.1
0.82	0.11	0.05	0.02	34	6.5	3	-6.3	4.6
0.46	0.34	0.18	0.02	122	5.6	2	42.3	1.6
0.55	0.21	0.22	0.02	149	6.6	2	33.8	2.3
0.3	0.66	0.03	0.01	20	2.9	2	49.1	0.9
0.54	0.21	0.22	0.03	149	7	2	37.2	2
0.4	0.37	0.22	0.01	149	4.4	2	49.6	1.4
0.45	0.33	0.17	0.05	115	6.8	2	49.8	0.9
0.4	0.43	0.16	0.01	108	4.4	2	46.1	1.4
0.42	0.36	0.19	0.03	129	5.5	2	50	1.2
0.55	0.22	0.22	0.01	149	6.1	2	31.7	2.5
0.41	0.42	0.13	0.04	88	5.8	2	49.9	0.9
0.5	0.26	0.2	0.04	135	7	2	43.1	1.5

W_HFO-1252ZC	W_HFO-1132EE	W_R32	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.45	0.32	0.22	0.01	149	5	2	43.6	1.7

Example 17a

[0267] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, HFO-1132E and CO₂.

[0268] Broadly, for cooling mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, and 1.0% to 84.0% of CO₂ will have a GWP less than 1, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -27.3% to 202.9% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from -42.9% to 4.4% than that of the cooling COP of R-454C evaluated with the same conditions set. Table 9a lists example compositions within the GWP<1 range that have ASHRAE flammability classifications of 1, 3 and 2.

[0269] Similarly, but a little less broadly for cooling mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, and 1.0% to 84.0% of CO₂ will have a GWP less than 1, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1, 3 and 2, a cooling capacity range has a deviation of -27.3% to 202.9% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of -42.9% to 4.4% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0270] Preferred blend composition ranges for cooling mode within a composition range of 1.0% to 26.0% of HFO-1252ZC, 2.0% to 97.0% of HFO-1132EE, and 1.0% to 84.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1 and 2, the minimum and maximum cooling capacities are 35.5% and 202.9% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -42.9% and -1.4% than that of R-454C evaluated at the same conditions set.

[0271] Even more preferred blend composition ranges for cooling mode within a composition range of 4.0% to 26.0% of HFO-1252ZC, 71.0% to 93.0% of HFO-

1132EE, and 1.0% to 8.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 5.0 K, an ASHRAE flammability classification of 2, the minimum and maximum cooling capacities are 35.5% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -3.3% and -1.4% than that of R-454C evaluated at the same conditions set.

[0272] The composition for the even more preferred maximum cooling capacity, which is 50.0% than that of R-454C, is 4.0 wt-% HFO-1252ZC, 88.0 wt-% HFO-1132EE and 8.0 wt-% CO₂, where the COP for cooling is -1.9% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 0.3 K and its ASHRAE flammability classification is 2.

[0273] The composition for the even more preferred maximum cooling COP efficiency, which is -1.4% than that of R-454C, is 26.0 wt-% HFO-1252ZC, 73.0 wt-% HFO-1132EE and 1.0 wt-% CO₂, where the CAP for cooling is 35.5% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 2.8 K and its ASHRAE flammability classification is 2.

TABLE 17A

W_HFO-1252ZC	W_HFO-1132EE	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.17	0.03	0.8	1	6.6	1	183.3	-40.8
0.98	0.01	0.01	0	2.6	3	-27.3	4.4
0.01	0.25	0.74	1	6.5	1	199.6	-28.6
0.02	0.97	0.01	0	0.5	2	53.6	-2.3
0.97	0.01	0.02	0	4.7	3	-24.1	3.1
0.13	0.03	0.84	1	5.8	1	178.7	-41.8
0.05	0.94	0.01	0	0.7	2	51.5	-2.2
0.01	0.2	0.79	1	5.6	1	202.9	-32.4
0.17	0.05	0.78	1	6.9	1	172.9	-42.9
0.04	0.66	0.3	0	7	2	101.7	-8.7
0.03	0.2	0.77	1	5.5	1	200.4	-33.9
0.18	0.77	0.05	0	3.8	2	51	-3.1
0.29	0.63	0.08	0	7	3	49.3	-3.7
0.01	0.93	0.06	0	0.1	2	52.1	-2
0.28	0.71	0.01	0	3	3	33.9	-1.3
0.01	0.22	0.77	1	6	1	202.1	-30.8
0.01	0.83	0.16	0	3.6	2	75	-5.1
0.72	0.27	0.01	0	6.8	3	-3	2.4

W_HFO-1252ZC	W_HFO-1132EE	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.26	0.73	0.01	0	2.8	2	35.5	-1.4
0.01	0.91	0.08	0	0.8	2	56.6	-2.7
0.16	0.02	0.82	1	6.6	1	185.5	-39.7
0.17	0.82	0.01	0	1.8	2	42.6	-1.8
0.09	0.15	0.76	1	6.8	1	193.2	-33.6
0.06	0.86	0.08	0	3.2	2	64.6	-4.1
0.23	0.71	0.06	0	5	2	49.4	-3.3
0.04	0.88	0.08	0	0.3	2	50	-1.9
0.06	0.93	0.01	0	0.4	2	48.6	-1.9
0.22	0.77	0.01	0	2.3	2	38.7	-1.6
0.08	0.89	0.03	0	1	2	49.4	-2.1

Example 17b

[0274] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, HFO-1132E and CO₂.

[0275] Broadly, for heating mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, and 1.0% to 58.0% of CO₂ will have a GWP less than 1, a maximum average glide of about 7.0 K, a heating capacity range that has a deviation range of -26.7% to 225.8% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from -15.9% to 6.4% than that of the heating COP of R-454C evaluated with the same conditions set. Table 9b lists example compositions within the GWP<1 range that have ASHRAE flammability classifications of 3 and 2.

[0276] Similarly, but a little less broadly for heating mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, and 1.0% to 58.0% of CO₂ will have a GWP less than 1, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 3 and 2, a heating capacity range has a deviation of -26.7% to 225.8% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of -15.9% to 6.4% than that of the heating COP of R-454C evaluated with the same conditions set.

[0277] Preferred blend composition ranges for heating mode within a composition range of 1.0% to 26.0% of HFO-1252ZC, 42.0% to 97.0% of HFO-1132EE, and

1.0% to 56.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 2, the minimum and maximum heating capacities are 51.4% and 224.3% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are -13.3% and 0.8% than that of R-454C evaluated at the same conditions set.

[0278] Even more preferred blend composition ranges for heating mode within a composition range of 19.0% to 26.0% of HFO-1252ZC, 73.0% to 80.0% of HFO-1132EE, and 1.0% to 3.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 2.9 K, an ASHRAE flammability classification of 2, the minimum and maximum heating capacities are 51.4% and 59.7% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 0.3% and 0.8% than that of R-454C evaluated at the same conditions set.

[0279] The composition for the even more preferred maximum heating capacity, which is 59.7% than that of R-454C, is 23.0 wt-% HFO-1252ZC, 74.0 wt-% HFO-1132EE and 3.0 wt-% CO₂, where the COP for heating is 0.3% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 2.8 K and its ASHRAE flammability classification is 2.

[0280] The composition for the even more preferred maximum heating COP efficiency, which is 0.8% than that of R-454C, is 26.0 wt-% HFO-1252ZC, 73.0 wt-% HFO-1132EE and 1.0 wt-% CO₂, where the CAP for heating is 51.4% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 2.3 K and its ASHRAE flammability classification is 2.

TABLE 17B

W_HFO-1252ZC	W_HFO-1132EE	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.1	0.32	0.58	1	6.8	3	224.4	-15.9
0.98	0.01	0.01	0	2	3	-26.7	6.4
0.01	0.7	0.29	0	4.9	2	141.2	-4.8
0.02	0.97	0.01	0	0.4	2	76.4	0.1
0.96	0.01	0.03	0	5.2	3	-21.2	5.8
0.62	0.37	0.01	0	5.5	3	10.6	3.1

W_HFO-1252ZC	W_HFO-1132EE	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.05	0.45	0.5	1	6.1	3	225.8	-14.4
0.08	0.53	0.39	0	7	3	179.3	-9.2
0.02	0.59	0.39	0	6.1	2	193.1	-9.6
0.66	0.33	0.01	0	5.5	3	6.2	3.4
0.01	0.93	0.06	0	0	2	74.7	0.3
0.16	0.83	0.01	0	1.4	2	62.4	0.4
0.59	0.4	0.01	0	5.3	3	13.9	2.8
0.03	0.46	0.51	1	6	2	222	-13.3
0.26	0.73	0.01	0	2.3	2	51.4	0.8
0.01	0.69	0.3	0	5	2	144.3	-5.1
0.02	0.42	0.56	1	5.9	2	223.2	-13.2
0.01	0.45	0.54	1	5.8	2	224.3	-13.1
0.1	0.54	0.36	0	7	2	153.7	-6.9
0.04	0.55	0.41	0	6.2	2	170.7	-7.7
0.24	0.73	0.03	0	2.9	2	58.5	0.3
0.19	0.8	0.01	0	1.6	2	59.1	0.5
0.23	0.74	0.03	0	2.8	2	59.7	0.3
0.23	0.76	0.01	0	2	2	54.7	0.7
0.2	0.79	0.01	0	1.7	2	58.1	0.6

Example 18a

[0281] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, HFO-1132E, CF3I and CO₂.

[0282] Broadly, for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 95.0% of CF₃I, and 1.0% to 83.0% of CO₂ will have a GWP less than 1, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -44.6% to 205.2% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from -57.7% to 8.7% than that of the cooling COP of R-454C evaluated with the same conditions set. Table 10a lists example compositions within the GWP<1 range that have ASHRAE flammability classifications of 1, 3, 2 and 2L.

[0283] Similarly, but a little less broadly for cooling mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 95.0% of CF₃I, and 1.0% to 83.0% of CO₂ will have a GWP less than 1, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1, 3, 2 and 2L, a

cooling capacity range has a deviation of -44.6% to 205.2% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of -57.7% to 8.7% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0284] Preferred blend composition ranges for cooling mode within a composition range of 1.0% to 54.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 95.0% of CF3I, and 1.0% to 83.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1, 2 and 2L, the minimum and maximum cooling capacities are -44.6% and 205.2% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -57.7% and 8.7% than that of R-454C evaluated at the same conditions set.

[0285] Even more preferred blend composition ranges for cooling mode within a composition range of 1.0% to 33.0% of HFO-1252ZC, 40.0% to 91.0% of HFO-1132EE, 1.0% to 44.0% of CF3I, and 1.0% to 7.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 2L and 2, the minimum and maximum cooling capacities are 11.2% and 50.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -3.4% and 1.4% than that of R-454C evaluated at the same conditions set.

[0286] The composition for the even more preferred maximum cooling capacity, which is 50.0% than that of R-454C, is 18.0 wt-% HFO-1252ZC, 64.0 wt-% HFO-1132EE, 11.0 wt-% CF3I and 7.0 wt-% CO₂, where the COP for cooling is -3.4% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.8 K and its ASHRAE flammability classification is 2.

[0287] The composition for the even more preferred maximum cooling COP efficiency, which is 1.4% than that of R-454C, is 31.0 wt-% HFO-1252ZC, 40.0 wt-% HFO-1132EE, 28.0 wt-% CF3I, and 1.0 wt-% CO₂, where the CAP for cooling is 11.5% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 7.0 K and its ASHRAE flammability classification is 2.

TABLE 18A

W_HFO-1252ZC	W_HFO-1132EE	W_CF3I	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.18	0.01	0.01	0.8	1	6.9	1	178.5	-42.2
0.97	0.01	0.01	0.01	0	2.6	3	-27.3	4.4
0.01	0.02	0.95	0.02	0	2.4	1	-43.2	8.4
0.01	0.97	0.01	0.01	0	0.6	2	53.8	-2.3
0.69	0.01	0.28	0.02	0	5.9	3	-24.2	3
0.2	0.77	0.01	0.02	0	2.8	2	41.9	-2
0.03	0.13	0.01	0.83	1	6.6	1	195.2	-37
0.33	0.41	0.25	0.01	0	6.8	3	12	1.2
0.09	0.1	0.78	0.03	1	6.7	1	205.2	-32.9
0.02	0.01	0.94	0.03	0	1.5	1	-44.6	8.7
0.08	0.11	0.79	0.02	1	6.3	1	189.5	-57.7
0.05	0.7	0.15	0.1	0	7	2	65.9	-4.7
0.43	0.49	0.05	0.03	0	7	3	22.7	-0.6
0.64	0.26	0.09	0.01	0	7	3	-3.2	2.5
0.16	0.02	0.81	0.01	0	2.3	1	-37.1	7.5
0.02	0.54	0.43	0.01	0	6.8	2L	25.4	0.4
0.06	0.79	0.02	0.13	0	5.5	2	78.1	-5.9
0.59	0.17	0.23	0.01	0	6.9	3	-11.1	3.3
0.01	0.73	0.23	0.03	0	4.7	2	46	-2
0.51	0.01	0.47	0.01	0	4	2	-28.8	4.5
0.1	0.73	0.01	0.16	0	6.9	2	82.9	-6.8
0.73	0.01	0.25	0.01	0	3.2	3	-27.9	4.5
0.01	0.24	0.02	0.73	1	5.7	1	202.4	-33.1
0.01	0.55	0.43	0.01	0	6.8	2L	26.2	0.4
0.03	0.75	0.01	0.21	0	6.8	2	99.7	-8.4
0.32	0.6	0.06	0.02	0	5	3	29	-1
0.54	0.01	0.44	0.01	0	3.9	2	-28.7	4.5
0.01	0.81	0.06	0.12	0	5.3	2	77.5	-5.6
0.08	0.85	0.01	0.06	0	3.2	2	60.4	-3.7
0.07	0.58	0.34	0.01	0	5.7	2	28.2	-0.1
0.08	0.04	0.74	0.14	0	4	1	-36.3	7.4
0.03	0.53	0.43	0.01	0	6.9	2L	24.6	0.5
0.12	0.75	0.11	0.02	0	3.3	2	42.3	-1.8
0.01	0.54	0.44	0.01	0	7	2L	25.4	0.5
0.33	0.4	0.26	0.01	0	6.9	2	11.2	1.3
0.01	0.67	0.28	0.04	0	6.2	2	45.6	-2.1
0.06	0.91	0.02	0.01	0	1.1	2	49.7	-2.1
0.32	0.4	0.27	0.01	0	6.9	2	11.3	1.3
0.24	0.73	0.01	0.02	0	3.2	2	38.7	-1.8
0.18	0.64	0.11	0.07	0	6.8	2	50	-3.4
0.19	0.48	0.32	0.01	0	6.4	2	19.2	0.7
0.31	0.4	0.28	0.01	0	7	2	11.5	1.4

W_HFO-1252ZC	W_HFO-1132EE	W_CF3I	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.19	0.64	0.1	0.07	0	6.8	2	49.7	-3.4
0.02	0.57	0.39	0.02	0	7	2	31.5	-0.4
0.17	0.66	0.16	0.01	0	4	2	32.6	-0.8

Example 18b

[0288] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, HFO-1132E, CF3I and CO2.

[0289] Broadly, for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 95.0% of CF3I, and 1.0% to 52.0% of CO2 will have a GWP less than 1, a maximum average glide of about 7.0 K, a heating capacity range that has a deviation range of -42.3% to 226.1% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from -16.0% to 11.1% than that of the heating COP of R-454C evaluated with the same conditions set. Table 10b lists example compositions within the GWP<1 range that have ASHRAE flammability classifications of 3, 2, 1 and 2L.

[0290] Similarly, but a little less broadly for heating mode, a composition range of 1.0% to 97.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 95.0% of CF3I, and 1.0% to 52.0% of CO2 will have a GWP less than 1, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 3, 2, 1 and 2L, a heating capacity range has a deviation of -42.3% to 226.1% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of -16.0% to 11.1% than that of the heating COP of R-454C evaluated with the same conditions set.

[0291] Preferred blend composition ranges for heating mode within a composition range of 1.0% to 54.0% of HFO-1252ZC, 1.0% to 97.0% of HFO-1132EE, 1.0% to 95.0% of CF3I, and 1.0% to 48.0% of CO2 will have a GWP < 1, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 2, 1 and 2L, the minimum and maximum heating capacities are -42.3% and 224.4% than that of R-454C evaluated at the same conditions set, and the minimum and

maximum heating COP efficiencies are -13.2% and 11.1% than that of R-454C evaluated at the same conditions set.

[0292] Even more preferred blend composition ranges for heating mode within a composition range of 8.0% to 45.0% of HFO-1252ZC, 15.0% to 33.0% of HFO-1132EE, 30.0% to 70.0% of CF3I, and 1.0% to 10.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1 and 2, the minimum and maximum heating capacities are -10.0% and 10.0% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 4.2% and 7.3% than that of R-454C evaluated at the same conditions set.

[0293] The composition for the even more preferred maximum heating capacity, which is 10.0% than that of R-454C, is 28.0 wt-% HFO-1252ZC, 31.0 wt-% HFO-1132EE, 40.0 wt-% CF₃I and 1.0 wt-% CO₂, where the COP for heating is 4.6% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.6 K and its ASHRAE flammability classification is 2.

[0294] The composition for the even more preferred maximum heating COP efficiency, which is 7.3% than that of R-454C, is 8.0 wt-% HFO-1252ZC, 20.0 wt-% HFO-1132EE, 62.0 wt-% CF₃I, and 10.0 wt-% CO₂, where the CAP for heating is -8.6% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 7.0 K and its ASHRAE flammability classification is 1.

TABLE 18B

W_HFO-1252ZC	W_HFO-1132EE	W_CF3I	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.1	0.37	0.01	0.52	1	7	3	224.4	-16
0.97	0.01	0.01	0.01	0	2.1	3	-26.7	6.4
0.01	0.6	0.05	0.34	0	6.7	2	176.2	-8
0.01	0.97	0.01	0.01	0	0.4	2	76.6	0.2
0.89	0.01	0.09	0.01	0	2.2	3	-26.6	6.6
0.01	0.02	0.95	0.02	0	1.9	1	-41	11
0.12	0.77	0.01	0.1	0	3.9	2	89.9	-1.6
0.27	0.49	0.23	0.01	0	5.1	2	29.1	2.7
0.05	0.41	0.04	0.5	1	6.8	3	226.1	-14.8
0.02	0.01	0.94	0.03	0	1.2	1	-42.3	11.1
0.28	0.56	0.07	0.09	0	7	3	63.6	-0.4
0.43	0.29	0.26	0.02	0	7	3	9.3	4

W_HFO-1252ZC	W_HFO-1132EE	W_CF3I	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.29	0.06	0.64	0.01	0	5.6	1	-21.4	7.5
0.71	0.23	0.05	0.01	0	5.4	3	-4	4.3
0.02	0.54	0.43	0.01	0	5.9	2L	37.6	3.2
0.09	0.69	0.18	0.04	0	4.3	2	62.9	0.7
0.01	0.51	0.03	0.45	0	6.4	3	214.6	-12
0.7	0.01	0.27	0.02	0	4.6	3	-23.3	6.6
0.19	0.65	0.01	0.15	0	6.3	3	95.9	-2.6
0.65	0.32	0.02	0.01	0	5.6	3	5.4	3.5
0.31	0.06	0.62	0.01	0	5.5	1	-21.2	7.5
0.54	0.35	0.1	0.01	0	5.7	3	10.1	3.4
0.05	0.44	0.5	0.01	0	6.9	2L	26.6	4.1
0.04	0.57	0.35	0.04	0	6.6	2	53.1	1.8
0.01	0.5	0.01	0.48	0	5.9	2	224.4	-13.2
0.54	0.01	0.44	0.01	0	3.1	2	-26.9	7.4
0.01	0.66	0.15	0.18	0	6.9	2	117.4	-3.2
0.37	0.01	0.6	0.02	0	6.6	1	-23.2	7.4
0.11	0.74	0.01	0.14	0	4.8	2	102.5	-2.5
0.24	0.55	0.2	0.01	0	4.5	2	35.6	2.3
0.01	0.61	0.31	0.07	0	7	2	69.6	0.5
0.26	0.08	0.65	0.01	0	6.2	1	-18.8	7.4
0.13	0.37	0.49	0.01	0	7	2L	18.3	4.5
0.02	0.77	0.04	0.17	0	4.8	2	119.4	-3.3
0.08	0.2	0.62	0.1	0	7	1	-8.6	7.3
0.45	0.17	0.37	0.01	0	5.9	2	-7.8	5.6
0.13	0.33	0.53	0.01	0	6.3	1	9.2	5.3
0.39	0.15	0.45	0.01	0	6.1	2	-9.7	6
0.1	0.19	0.7	0.01	0	6.7	1	-9.7	7.3
0.37	0.32	0.3	0.01	0	6.2	2	9.8	4.2
0.11	0.19	0.6	0.1	0	6.6	1	-9.5	7.3
0.29	0.25	0.45	0.01	0	6.8	2	3	5.2
0.28	0.31	0.4	0.01	0	6.6	2	10	4.6
0.43	0.15	0.41	0.01	0	5.9	2	-10	5.9
0.22	0.29	0.48	0.01	0	7	2	8.3	5
0.3	0.15	0.54	0.01	0	6.6	2	-9.4	6.4

Example 19a

[0295] Refrigerant performance in cooling mode is provided below for compositions containing HFO-1252zc, CF3I and CO2.

[0296] Broadly, for cooling mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 94.0% of CF3I, and 1.0% to 80.0% of CO2 will have a GWP less

than 1, a maximum average glide of about 7.0 K, a cooling capacity range that has a deviation range of -47.2% to 175.8% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation range from -43.1% to 9.3% than that of the cooling COP of R-454C evaluated with the same conditions set. Table 11a lists example compositions within the GWP<1 range that have ASHRAE flammability classifications of 1, 3 and 2.

[0297] Similarly, but a little less broadly for cooling mode, a composition range of 1.0% to 54.0% of HFO-1252ZC, 2.0% to 94.0% of CF3I, and 1.0% to 80.0% of CO₂ will have a GWP less than 1, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1 and 2, a cooling capacity range has a deviation of -47.2% to 175.8% from the cooling capacity of R-454C evaluated with the same conditions set, and the cooling COP range has a deviation of -43.1% to 9.3% than that of the cooling COP of R-454C evaluated with the same conditions set.

[0298] Preferred blend composition ranges for cooling mode within a composition range of 18.0% to 18.0% of HFO-1252ZC, 2.0% to 2.0% of CF3I, and 80.0% to 80.0% of CO₂ will have a GWP < 1, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1, the minimum and maximum cooling capacities are 175.8% and 175.8% than that of R-454C evaluated at the same conditions set, and the minimum and maximum cooling COP efficiencies are -43.1% and -43.1% than that of R-454C evaluated at the same conditions set.

[0299] The composition for the preferred maximum cooling capacity, which is 175.8% than that of R-454C, is 18.0 wt-% HFO-1252ZC, 2.0 wt-% CF3I and 80.0 wt-% CO₂, where the COP for cooling is -43.1% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 7.0 K and its ASHRAE flammability classification is 1.

[0300] The composition for the preferred maximum cooling COP efficiency, which is -43.1% than that of R-454C, is 18.0 wt-% HFO-1252ZC, 2.0 wt-% CF3I and 80.0 wt-% CO₂, where the CAP for cooling is 175.8% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 7.0 K and its ASHRAE flammability classification is 1.

TABLE 19A

W_HFO-1252ZC	W_CF3I	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILITY CLASS	CAP DEV	COP DEV
0.18	0.02	0.8	1	7	1	175.8	-43.1
0.98	0.01	0.01	0	2.3	3	-28.3	4.5
0.01	0.94	0.05	0	0.2	1	-47.2	9.3
0.76	0.23	0.01	0	2.8	3	-28.9	4.6
0.88	0.09	0.03	0	7	3	-21.7	2
0.21	0.78	0.01	0	5.8	1	-33.2	4.2
0.47	0.52	0.01	0	3.8	2	-30.3	4.5
0.67	0.32	0.01	0	3	3	-29.3	4.6
0.54	0.45	0.01	0	3.5	2	-29.9	4.6
0.29	0.7	0.01	0	5	1	-32	4.4
0.19	0.8	0.01	0	6.1	1	-33.6	4.2
0.45	0.54	0.01	0	3.9	2	-30.5	4.5

Example 19b

[0301] Refrigerant performance in heating mode is provided below for compositions containing HFO-1252zc, CF3I and CO₂.

[0302] Broadly, for heating mode, a composition range of 1.0% to 98.0% of HFO-1252ZC, 1.0% to 97.0% of CF3I, and 1.0% to 11.0% of CO₂ will have a GWP less than 0, a maximum average glide of about 7.0 K, a heating capacity range that has a deviation range of -44.8% to -18.8% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation range from 5.7% to 11.5% than that of the heating COP of R-454C evaluated with the same conditions set. Table 11b lists example compositions within the GWP<0 range that have ASHRAE flammability classifications of 1, 3 and 2.

[0303] Similarly, but a little less broadly for heating mode, a composition range of 1.0% to 54.0% of HFO-1252ZC, 45.0% to 97.0% of CF3I, and 1.0% to 11.0% of CO₂ will have a GWP less than 0, a maximum average glide of about 7.0 K, an ASHRAE flammability classification of 1 and 2, a heating capacity range has a deviation of -44.8% to -24.3% from the heating capacity of R-454C evaluated with the same conditions set, and the heating COP range has a deviation of 7.1% to 11.5% than that of the heating COP of R-454C evaluated with the same conditions set.

[0304] Preferred blend composition ranges for heating mode within a composition range of 28.0% to 54.0% of HFO-1252ZC, 45.0% to 71.0% of CF3I, and 1.0% to 2.0% of CO₂ will have a GWP < 0, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1 and 2, the minimum and maximum heating capacities are -30.0% and -24.3% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 7.1% and 8.4% than that of R-454C evaluated at the same conditions set.

[0305] Even more preferred blend composition ranges for heating mode within a composition range of 28.0% to 42.0% of HFO-1252ZC, 56.0% to 71.0% of CF₃I, and 1.0% to 2.0% of CO₂ will have a GWP < 0, a maximum average heat exchanger glide of 7.0 K, an ASHRAE flammability classification of 1, the minimum and maximum heating capacities are -30.0% and -24.4% than that of R-454C evaluated at the same conditions set, and the minimum and maximum heating COP efficiencies are 7.4% and 8.4% than that of R-454C evaluated at the same conditions set.

[0306] The composition for the even more preferred maximum heating capacity, which is -24.4% than that of R-454C, is 42.0 wt-% HFO-1252ZC, 56.0 wt-% CF₃I and 2.0 wt-% CO₂, where the COP for heating is 7.4% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 6.0 K and its ASHRAE flammability classification is 1.

[0307] The composition for the even more preferred maximum heating COP efficiency, which is 8.4% than that of R-454C, is 28.0 wt-% HFO-1252ZC, 71.0 wt-% CF₃I and 1.0 wt-% CO₂, where the CAP for heating is -30.0% than that for R-454C under the same cycle conditions, the maximum average heat exchanger glide is 4.1 K and its ASHRAE flammability classification is 1.

TABLE 19B

W_HFO -1252ZC	W_CF3I	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILIT Y CLASS	CAP DEV	COP DEV
0.01	0.93	0.06	0	6.8	1	-38.2	10.1
0.98	0.01	0.01	0	1.8	3	-27.6	6.6
0.01	0.94	0.05	0	0.2	1	-44.8	11.5
0.02	0.97	0.01	0	6.8	1	-37.6	10
0.97	0.01	0.02	0	3.5	3	-24.9	6.3

W_HFO -1252ZC	W_CF3I	W_CO2	GWP	AVG GLIDE (K)	ASHRAE FLAMMABILIT Y CLASS	CAP DEV	COP DEV
0.04	0.85	0.11	0	6.6	1	-36.5	9.8
0.33	0.66	0.01	0	3.8	1	-29.4	8.2
0.87	0.09	0.04	0	7	3	-18.8	5.8
0.95	0.01	0.04	0	6.5	3	-19.3	5.7
0.21	0.78	0.01	0	4.7	1	-31.1	8.8
0.44	0.54	0.02	0	5.8	2	-24.4	7.4
0.61	0.38	0.01	0	2.6	3	-27.9	7.4
0.54	0.45	0.01	0	2.8	2	-28.1	7.5
0.3	0.69	0.01	0	4	1	-29.7	8.3
0.53	0.45	0.02	0	5.2	2	-24.3	7.1
0.31	0.67	0.02	0	7	1	-24.9	7.7
0.31	0.68	0.01	0	3.9	1	-29.6	8.3
0.5	0.48	0.02	0	5.4	2	-24.3	7.2
0.28	0.71	0.01	0	4.1	1	-30	8.4
0.49	0.49	0.02	0	5.5	2	-24.3	7.2
0.34	0.64	0.02	0	6.7	1	-24.7	7.6
0.43	0.56	0.01	0	3.2	2	-28.6	7.9
0.42	0.56	0.02	0	6	1	-24.4	7.4
0.41	0.57	0.02	0	6	1	-24.4	7.4
0.38	0.61	0.01	0	3.5	1	-28.9	8
0.35	0.63	0.02	0	6.6	1	-24.6	7.6

CLAIMS

What is claimed is:

1. A composition comprising HFO-1252zc and at least one compound selected from the group consisting of HFO-1132E, HFO-1132Z, HFC-32, HFC-134, CF₃I, and CO₂.
2. A composition comprising:
 - HFO-1252zc and HFC-32; or
 - HFO-1252zc and HFO-1132E; or
 - HFO-1252zc and HFC-134; or
 - HFO-1252zc, HFO-1132E and HFC-32; or
 - HFO-1252zc, HFO-1132E and HFC-134; or
 - HFO-1252zc, CF₃I, and HFC-32; or
 - HFO-1252zc, HFO-1132E and CF₃I; or
 - HFO-1252zc, CF₃I and HFC-134; or
 - HFO-1252zc, HFO-1132E, CF₃I and HFC-32; or
 - HFO-1252zc, HFO-1132E, CF₃I and HFC-134; or
 - HFO-1252zc, HFC-32 and HFC-134; or
 - HFO-1252zc, HFC-32 and CO₂; or
 - HFO-1252zc, HFC-1132E, HFC-32 and HFC-134; or
 - HFO-1252zc, HFC-1132E, HFC-134 and CO₂; or
 - HFO-1252zc, HFC-1132E, HFC-32 and CO₂; or
 - HFO-1252zc, HFO-1132E and CO₂; or
 - HFO-1252zc, HFC-1132E, CF₃I and CO₂; or
 - HFO-1252zc, CF₃I and CO₂; or
 - HFO-1252zc, HFO-1132E, and HFO-1132Z; or
 - HFO-1252zc and CF₃I; or
 - HFO-1252zc and CO₂; or
 - HFO-1252zc and HFO-1132Z.

3. The composition of claim 1 or claim 2, comprising:
 - about 56 to 99 weight percent HFO-1252zc and about 1 to 44 weight percent HFC-32, or about 56 to 78 weight percent HFO-1252zc and about 22 to 44 weight percent HFC-32, or about 78 to 99 weight percent HFO-1252zc and about 1 to 22 weight percent HFC-32, or about 85 to 92 weight percent HFO-1252zc and about 8 to 15 weight percent HFC-32; or
4. The composition of claim 1 or claim 2, comprising:
 - about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132E; or
 - about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132E; or
 - about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-1132E; or
 - about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132E.
5. The composition of claim 1 or claim 2, comprising:
 - about 73 to 99 weight percent HFO-1252zc and about 1 to 27 weight percent HFC-134, or
 - about 73 to 86 weight percent HFO-1252zc and about 14 to 27 weight percent HFC-134.
6. The composition of claim 1 or claim 2, comprising:
 - about 31 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 44 weight percent HFC-32; or
 - about 31 to 53 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 22 to 44 weight percent HFC-32; or
 - about 31 to 53 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 22 weight percent HFC-32.
7. The composition of claim 1 or claim 2, comprising:
 - about 49 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 26 weight percent HFC-134; or

about 49 to 62 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 13 to 26 weight percent HFC-134; or

about 49 to 62 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 13 weight percent HFC-134.

8. The composition of claim 1 or claim 2, comprising:
 - about 36 to 98 weight percent HFO-1252zc, about 1 to 44 weight percent HFC-32, and about 1 to 30 weight percent CF₃I; or
 - about 46 to 58 weight percent HFO-1252zc, about 22 to 44 weight percent HFC-32, and about 10 to 20 weight percent CF₃I.
9. The composition of claim 1 or claim 2, comprising:
 - about 55 to 98 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 1 to 20 weight percent CF₃I; or
 - about 55 to 65 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, and about 10 to 20 weight percent CF₃I;
10. The composition of claim 1 or claim 2, comprising:
 - about 53 to 98 weight percent HFO-1252zc, about 1 to 27 weight percent HFC-134, and about 1 to 20 weight percent CF₃I; or
 - about 53 to 77 weight percent HFO-1252zc, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF₃I;
11. The composition of claim 1 or claim 2, comprising:
 - about 11 to 99 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 44 weight percent HFC-32, and about 1 to 20 weight percent CF₃I; or
 - about 11 to 43 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 22 to 44 weight percent HFC-32, and about 10 to 20 weight percent CF₃I.

12. The composition of claim 1 or claim 2, comprising:
 - about 29 to 99 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 1 to 27 weight percent HFC-134, and about 1 to 20 weight percent CF3I; or
 - about 29 to 42 weight percent HFO-1252zc, about 1 to 25 weight percent HFO-1132E, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF3I.
13. The composition of claim 1 or claim 2, comprising:
 - 57.0% to 67.0% of HFO-1252zc, 16.0% to 42.0% of HFC-32, and 1.0% to 17.0% of HFC-134; or
 - 66.0% to 67.0% of HFO-1252zc, 16.0% to 20.0% of HFC-32, and 14.0% to 17.0% of HFC-134; or
 - about 67.0 wt-% HFO-1252zc, about 16.0 wt-% HFC-32 and about 17.0 wt-% HFC-134; or
 - 57.0% to 98.0% of HFO-1252zc, 1.0% to 42.0% of HFC-32, and 1.0% to 26.0% of HFC-134; or
 - 57.0% to 68.0% of HFO-1252zc, 16.0% to 42.0% of HFC-32, and 1.0% to 17.0% of HFC-134; or
 - 63.0% to 68.0% of HFO-1252zc, 16.0% to 27.0% of HFC-32, and 6.0% to 17.0% of HFC-134; or
 - about 64.0 wt-% HFO-1252zc, about 27.0 wt-% HFC-32 and about 9.0 wt-% HFC-134; or
 - about 67.0 wt-% HFO-1252zc, about 16.0 wt-% HFC-32 and about 17.0 wt-% HFC-134.
14. The composition of claim 13, wherein the composition has a GWP less than 300 or less than 299.
15. The composition of claim 13 or claim 14, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 6.7 K or no more than 6.6 K or no more than 6.4 K or no more than 6.3 K or no more than 5.1 K.

16. The composition of any one of claims 13-15, wherein the composition exhibits an ASHRAE flammability rating of 2.
17. The composition of any one of claims 13-16, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
 - 91.2-123.8% of the volumetric cooling capacity of R-454C; or
 - 91.2-96.6% of the volumetric cooling capacity of R-454C; or
 - about 96.6% of the volumetric cooling capacity of R-454C; or
 - about 91.2 of the volumetric cooling capacity of R-454C.
18. The composition of any one of claims 13-17, wherein the composition has a cooling COP in a range of:
 - 100.1-103.9% of the cooling COP of R-454C; or
 - 103.5-103.9% of the cooling COP of R-454C; or
 - about 103.5% of the cooling COP of R-454C; or
 - about 103.9% of the cooling COP of R-454C.
19. The composition of any one of claims 13-16, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
 - 50.6-135.5% of the volumetric heating capacity of R-454C; or
 - 91.9-135.5% of the volumetric heating capacity of R-454C; or
 - 91.9-110.0% of the volumetric heating capacity of R-454C; or
 - about 110.0% of the volumetric heating capacity of R-454C; or
 - about 91.9% of the volumetric heating capacity of R-454C.
20. The composition of any one of claims 13-16 or claim 19, wherein the composition has a heating COP in a range of:
 - 103.1-106.7% of the heating COP of R-454C; or
 - 103.1-105.5% of the heating COP of R-454C; or
 - 104.5-105.5% of the heating COP of R-454C; or
 - about 104.6% of the heating COP of R-454C; or
 - about 105.5% of the heating COP of R-454C.

21. The composition of claim 1 or claim 2, comprising:
- 1.0% to 98.0% of HFO-1252zc, 1.0% to 44.0% of HFC-32, and 1.0% to 89.0% of CO₂; or
 - 1.0% to 98.0% of HFO-1252zc, 1.0% to 22.0% of HFC-32, and 1.0% to 89.0% of CO₂; or
 - 1.0% to 18.0% HFO-1252zc, 2.0% to 22.0% of HFC-32, and 72.0% to 89.0% of CO₂; or
 - about 1.0 wt-% HFO-1252zc, about 15.0 wt-% HFC-32 and about 84.0 wt-% CO₂; or
 - about 9.0 wt-% HFO-1252zc, about 17.0 wt-% HFC-32 and about 74.0 wt-% CO₂; or
 - 1.0% to 98.0% of HFO-1252zc, 1.0% to 44.0% of HFC-32, and 1.0% to 66.0% of CO₂; or
 - 1.0% to 65.0% of HFO-1252zc, 23.0% to 44.0% of HFC-32, and 1.0% to 66.0% of CO₂; or
 - 53.0% to 65.0% of HFO-1252zc, 34.0% to 44.0% of HFC-32, and 1.0% to 4.0% of CO₂; or
 - about 54.0 wt-% HFO-1252zc, about 42.0 wt-% HFC-32 and about 4.0 wt-% CO₂.
22. The composition of claim 21, wherein the composition has a GWP less than 298 or less than 150.
23. The composition of claim 21 or claim 22, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 6.9 K or no more than 4.6 K.
24. The composition of any one of claims 21-23, wherein the composition exhibits an ASHRAE flammability rating of 1 or 2.
25. The composition of any one of claims 21-24, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
- 73.3-217.4% of the volumetric cooling capacity of R-454C; or
 - 73.3-215.3% of the volumetric cooling capacity of R-454C; or

- 167.0-215.3% of the volumetric cooling capacity of R-454C; or
about 203.8% of the volumetric cooling capacity of R-454C; or
about 215.3% of the volumetric cooling capacity of R-454C.
26. The composition of any one of claims 21-25, wherein the composition has a cooling COP in a range of:
42.2-104.3% of the cooling COP of R-454C; or
42.2-70.0% of the cooling COP of R-454C; or
about 65.6% of the cooling COP of R-454C; or
about 70.0% of the cooling COP of R-454C.
27. The composition of any one of claims 21-24, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
73.9-272.8% of the volumetric heating capacity of R-454C; or
126.2- 272.8% of the volumetric heating capacity of R-454C; or
126.2-149.0% of the volumetric heating capacity of R-454C; or
about 149.0% of the volumetric heating capacity of R-454C; or
about 126.2% of the volumetric heating capacity of R-454C.
28. The composition of any one of claims 21-24 or claim 27, wherein the composition has a heating COP in a range of:
79.6-106.4% of the heating COP of R-454C; or
79.6-103.3% of the heating COP of R-454C; or
101.9-103.3% of the heating COP of R-54C; or
about 101.9% of the heating COP of R-454C; or
about 103.3% of the heating COP of R-454C.
29. The composition of claim 1 or claim 2, comprising:
1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 26.0% of HFC-134, and 1.0% to 42.0% of HFC-32; or
1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 12.0% of HFC-134, and 1.0% to 20.0% of HFC-32; or

- 1.0% to 84.0% of HFO-1252zc, 1.0% to 95.0% of HFO-1132E, 1.0% to 12.0% of HFC-134, and 1.0% to 20.0% of HFC-32; or
- 1.0% to 54.0% of HFO-1252zc, 25.0% to 95.0% of HFO-1132E, 1.0% to 12.0% of HFC-134, and 1.0% to 20.0% of HFC-32; or
- about 8.0 wt-% HFO-1252zc, about 81.0 wt-% HFO-1132E, about 2.0 wt-% HFC-134 and about 9.0 wt-% HFC-32; or
- about 42.0 wt-% HFO-1252zc, about 44.0 wt-% HFO-1132E, about 12.0 wt-% HFC-134, and about 2.0 wt-% HFC-32; or
- 1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 26.0% of HFC-134, and 1.0% to 42.0% of HFC-32; or
- 1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 12.0% of HFC-134, and 1.0% to 20.0% of HFC-32; or
- 8.0% to 85.0% of HFO-1252zc, 1.0% to 79.0% of HFO-1132E, 1.0% to 12.0% of HFC-134, and 1.0% to 20.0% of HFC-32; or
- 8.0% to 54.0% of HFO-1252zc, 25.0% to 79.0% of HFO-1132E, 1.0% to 12.0% of HFC-134, and 1.0% to 20.0% of HFC-32; or
- about 26.0 wt-% HFO-1252zc, about 60.0 wt-% HFO-1132E, about 4.0 wt-% HFC-134 and about 10.0 wt-% HFC-32; or
- about 49.0 wt-% HFO-1252zc, about 33.0 wt-% HFO-1132E, about 6.0 wt-% HFC-134, and about 12.0 wt-% HFC-32.
30. The composition of claim 29, wherein the composition has a GWP less than 300 or less than 149.
31. The composition of claim 29 or claim 30, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 6.7 K or no more than 6.5 K or no more than 6.4 K or no more than 5.6 K or no more than 5.4 K or no more than 5.3 K or no more than 4.6 K or no more than 1.2 K.
32. The composition of any one of claims 29-31, wherein the composition exhibits an ASHRAE flammability rating of 2 or 2L.

33. The composition of any one of claims 29-32, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
- 70.8-166.4% of the volumetric cooling capacity of R-454C; or
 - 71.1-160.6% of the volumetric cooling capacity of R-454C; or
 - 90.0-150.0% of the volumetric cooling capacity of R-454C; or
 - 89.9-150.0% of the volumetric cooling capacity of R-454C; or
 - about 50.0% of the volumetric cooling capacity of R-454C; or
 - about 10.5% of the volumetric cooling capacity of R-454C.
34. The composition of any one of claims 29-33, wherein the composition has a cooling COP in a range of:
- 97.5-105.7% of the cooling COP of R-454C; or
 - 97.9-103.7% of the cooling COP of R-454C; or
 - 97.9-101.3% of the cooling COP of R-454C; or
 - about 98.0% of the cooling COP of R-454C; or
 - about 98.7% of the cooling COP of R-454C.
35. The composition of any one of claims 29-32, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
- 70.5-196.3% of the volumetric heating capacity of R-454C; or
 - 71.5-187.2% of the volumetric heating capacity of R-454C; or
 - 90.0-150.0% of the volumetric heating capacity of R-454C; or
 - 116.4-150.0% of the volumetric heating capacity of R-454C; or
 - about 150.0% of the volumetric heating capacity of R-454C; or
 - about 122.6% of the volumetric heating capacity of R-454C.
36. The composition of any one of claims 29-32 or claim 35, wherein the composition has a heating COP in a range of:
- 99.7-106.6% of the heating COP of R-454C; or
 - 101.0-105.3% of the heating COP of R-454C; or
 - 101.0-102.8% of the heating COP of R-454C; or

about 101.3% of the heating COP of R-454C; or

about 102.8% of the heating COP of R-454C.

37. The composition of claim 1 or claim 2, comprising:

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 80.0% of HFC-134, and 1.0% to 79.0% of CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 80.0% of HFC-134, and 1.0% to 79.0% of CO₂; or

29.0% to 78.0% of HFO-1252zc, 20.0% to 44.0% of HFO-1132E, 1.0% to 26.0% of HFC-134, and 1.0% to 1.0% of CO₂; or

29.0% to 53.0% of HFO-1252zc, 21.0% to 44.0% of HFO-1132E, 15.0% to 26.0% of HFC-134, and 1.0% to 1.0% of CO₂; or

about 34.0 wt-% HFO-1252zc, about 44.0 wt-% HFO-1132E, about 21.0 wt-% HFC-134 and about 1.0 wt-% CO₂; or

about 52.0 wt-% HFO-1252zc, about 21.0 wt-% HFO-1132E, about 26.0 wt-% HFC-134, and about 1.0 wt-% CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 26.0% of HFC-134, and 1.0% to 51.0% of CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 13.0% of HFC-134, and 1.0% to 51.0% of CO₂; or

1.0% to 40.0% of HFO-1252zc, 45.0% to 97.0% of HFO-1132E, 1.0% to 13.0% of HFC-134, and 1.0% to 49.0% of CO₂; or

8.0% to 40.0% of HFO-1252zc, 45.0% to 78.0% of HFO-32E, 1.0% to 13.0% of HFC-134, and 1.0% to 7.0% of CO₂; or

about 12.0 wt-% HFO-1252zc, about 74.0 wt-% HFO-1132E, about 12.0 wt-% HFC-134 and about 2.0 wt-% CO₂; or

about 40.0 wt-% HFO-1252zc, about 46.0 wt-% HFO-1132E, about 13.0 wt-% HFC-134, and about 1.0 wt-% CO₂.

38. The composition of claim 37, wherein the composition has a GWP less than 291 or less than 146.

39. The composition of claim 37 or claim 38, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 6.8 K or no more than 6.5 K or no more than 6.2 K or no more than 6.1 K or no more than 5.0 K or no more than 3.6 K.
40. The composition of any one of claims 37-39, wherein the composition exhibits an ASHRAE flammability rating of 1 or 2.
41. The composition of any one of claims 37-40, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
- 72.5-203.3% of the volumetric cooling capacity of R-454C; or
 - 90.0-110.0% of the volumetric cooling capacity of R-454C; or
 - 90.6-110.0% of the volumetric cooling capacity of R-454C; or
 - about 90.0% of the volumetric cooling capacity of R-454C; or
 - about 90.6% of the volumetric cooling capacity of R-454C.
42. The composition of any one of claims 37-41, wherein the composition has a cooling COP in a range of:
- 43.2-104.6% of the cooling COP of R-454C; or
 - 101.0-103.1% of the cooling COP of R-454C; or
 - 101.2-103.1% of the cooling COP of R-454C; or
 - about 101.3% of the cooling COP of R-454C; or
 - about 103.1% of the cooling COP of R-454C.
43. The composition of any one of claims 37-40, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
- 71.8-224.8% of the volumetric heating capacity of R-454C; or
 - 72.7-224.8% of the volumetric heating capacity of R-454C; or
 - 118.0-224.1% of the volumetric heating capacity of R-454C; or
 - 118.0-150.0% of the volumetric heating capacity of R-454C; or
 - about 150.0% of the volumetric heating capacity of R-454C; or
 - about 118.0% of the volumetric heating capacity of R-454C.

44. The composition of any one of claims 37-40 or claim 43, wherein the composition has a heating COP in a range of:

85.1-106.4% of the heating COP of R-454C; or
86.5-102.6% of the heating COP of R-454C; or
100.4-102.6% of the heating COP of R-454C; or
about 100.9% of the heating COP of R-454C; or
about 102.6% of the heating COP of R-454C.

45. The composition of claim 1 or claim 2, comprising:

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 91.0% of HFC-32 and 1.0% to 92.0% of CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 91.0% of HFC-32, and 1.0% to 92.0% of CO₂; or

1.0% to 53.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 91.0% of HFC-32, and 1.0% to 92.0% of CO₂; or

8.0% to 53.0% of HFO-1252zc, 3.0% to 90.0% of HFO-1132E, 1.0% to 22.0% of HFC-32, and 1.0% to 81.0% of CO₂; or

about 22.0 wt-% HFO-1252ZC, about 69.0 wt-% HFO-1132E, about 4.0 wt-% HFC-32 and about 5.0 wt-% CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 81.0% of HFC-32, and 1.0% to 83.0% of CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 71.0% of HFC-32, and 1.0% to 73.0% of CO₂; or

28.0% to 87.0% of HFO-1252zc, 1.0% to 70.0% of HFO-1132E, 1.0% to 22.0% of HFC-32, and 1.0% to 7.0% of CO₂; or

30.0% to 55.0% of HFO-1252zc, 21.0% to 66.0% of HFO-1132E, 3.0% to 22.0% of HFC-32, and 1.0% to 5.0% of CO₂; or

about 42.0 wt-% HFO-1252zc, about 36.0 wt-% HFO-1132E, about 19.0 wt-% HFC-32 and about 3.0 wt-% CO₂; or

about 55.0 wt-% HFO-1252zc, about 22.0 wt-% HFO-1132E, about 22.0 wt-% HFC-32, and about 1.0 wt-% CO₂.

46. The composition of claim 45, wherein the composition has a GWP less than 298 or less than 150.
47. The composition of claim 45 or claim 46, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 6.1 K or no more than 5.5 K or no more than 4.4 K.
48. The composition of any one of claims 45-47, wherein the composition exhibits an ASHRAE flammability rating of 1 or 2 or 2L.
49. The composition of any one of claims 45-48, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
 - 74.3-216.9% of the volumetric cooling capacity of R-454C; or
 - 74.3-215.7% of the volumetric cooling capacity of R-454C; or
 - 113.9-215.7% of the volumetric cooling capacity of R-454C; or
 - 113.9-150.0% of the volumetric cooling capacity of R-454C; or
 - about 150.0% of the volumetric cooling capacity of R-454C.
50. The composition of any one of claims 45-49, wherein the composition has a cooling COP in a range of:
 - 24.5-131.4% of the cooling COP of R-454C; or
 - 24.5-104.2% of the cooling COP of R-454C; or
 - 24.5-99.8% of the cooling COP of R-454C; or
 - about 96.9% of the cooling COP of R-454C.
51. The composition of any one of claims 45-48, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
 - 14.7-280.6% of the volumetric heating capacity of R-454C; or
 - 90.0-150.0% of the volumetric heating capacity of R-454C; or
 - 131.7-150.0% of the volumetric heating capacity of R-454C; or
 - about 150.0% of the volumetric heating capacity of R-454C; or
 - about 131.7% of the volumetric heating capacity of R-454C.

52. The composition of any one of claims 45-48 or claim 51, wherein the composition has a heating COP in a range of:
- 55.4-106.3% of the heating COP of R-454C; or
 - 100.3-105.1% of the heating COP of R-454C; or
 - 100.9-102.5% of the heating COP of R-454C; or
 - about 101.2% of the heating COP of R-454C; or
 - about 102.5% of the heating COP of R-454C.
53. The composition of claim 1 or claim 2, comprising:
- 1.0% to 98.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, and 1.0% to 84.0% of CO₂; or
 - 1.0% to 98.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, and 1.0% to 84.0% of CO₂; or
 - 1.0% to 26.0% of HFO-1252zc, 2.0% to 97.0% of HFO-1132E, and 1.0% to 84.0% of CO₂; or
 - 4.0% to 26.0% of HFO-1252zc, 71.0% to 93.0% of HFO-1132E, and 1.0% to 8.0% of CO₂; or
 - about 4.0 wt-% HFO-1252zc, about 88.0 wt-% HFO-1132E and about 8.0 wt-% CO₂; or
 - about 26.0 wt-% HFO-1252zc, about 73.0 wt-% HFO-1132E and about 1.0 wt-% CO₂; or
 - 1.0% to 98.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, and 1.0% to 58.0% of CO₂; or
 - 1.0% to 98.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, and 1.0% to 58.0% of CO₂; or
 - 1.0% to 26.0% of HFO-1252zc, 42.0% to 97.0% of HFO-1132E, and 1.0% to 56.0% of CO₂; or
 - 19.0% to 26.0% of HFO-1252zc, 73.0% to 80.0% of HFO-1132E, and 1.0% to 3.0% of CO₂; or
 - about 23.0 wt-% HFO-1252zc, about 74.0 wt-% HFO-1132E and about 3.0 wt-% CO₂; or

about 26.0 wt-% HFO-1252zc, about 73.0 wt-% HFO-1132E and about 1.0 wt-% CO₂.

54. The composition of claim 53, wherein the composition has a GWP less than 1.
55. The composition of claim 53 or claim 54, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 5.0 K or no more than 5.5 K or no more than 2.9 K or no more than 2.8 K or no more than 2.3 K or no more than 0.3 K.
56. The composition of any one of claims 53-55, wherein the composition exhibits an ASHRAE flammability rating of 1 or 2.
57. The composition of any one of claims 53-56, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
 - 72.7-202.9% of the volumetric cooling capacity of R-454C; or
 - 135.5-202.9% of the volumetric cooling capacity of R-454C; or
 - 135.5-150.0% of the volumetric cooling capacity of R-454C; or
 - about 150.0% of the volumetric cooling capacity of R-454C; or
 - about 135.5% of the volumetric cooling capacity of R-454C.
58. The composition of any one of claims 53-57, wherein the composition has a cooling COP in a range of:
 - 57.1-104.4% of the cooling COP of R-454C; or
 - 57.1-101.4% of the cooling COP of R-454C; or
 - 96.7-98.6% of the cooling COP of R-454C; or
 - about 98.1% of the cooling COP of R-454C; or
 - about 98.6% of the cooling COP of R-454C.
59. The composition of any one of claims 53-57, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
 - 73.3-225.8% of the volumetric heating capacity of R-454C; or
 - 151.4-224.3% of the volumetric heating capacity of R-454C; or
 - 151.4-159.7% of the volumetric heating capacity of R-454C; or
 - about 159.7% of the volumetric heating capacity of R-454C; or

about 151.4% of the volumetric heating capacity of R-454C.

60. The composition of any one of claims 53-57 or claim 59, wherein the composition has a heating COP in a range of:

84.1-106.4% of the heating COP of R-454C; or
84.1-106.4% of the heating COP of R-454C; or
86.7-100.8% of the heating COP of R-454C; or
100.3-100.8% of the heating COP of R-454C; or
about 100.3% of the heating COP of R-454C; or
about 100.8% of the heating COP of R-454C.

61. The composition of claim 1 or claim 2, comprising:

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 95.0% of CF3I, and 1.0% to 83.0% of CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 95.0% of CF3I, and 1.0% to 83.0% of CO₂; or

1.0% to 54.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 95.0% of CF3I, and 1.0% to 83.0% of CO₂; or

1.0% to 33.0% of HFO-1252zc, 40.0% to 91.0% of HFO-1132E, 1.0% to 44.0% of CF3I, and 1.0% to 7.0% of CO₂; or

about 18.0 wt-% HFO-1252zc, about 64.0 wt-% HFO-1132E, about 11.0 wt-% CF3I and about 7.0 wt-% CO₂; or

about 31.0 wt-% HFO-1252zc, about 40.0 wt-% HFO-1132E, about 28.0 wt-% CF3I, and about 1.0 wt-% CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 95.0% of CF3I, and 1.0% to 52.0% of CO₂; or

1.0% to 97.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 95.0% of CF3I, and 1.0% to 52.0% of CO₂; or

1.0% to 54.0% of HFO-1252zc, 1.0% to 97.0% of HFO-1132E, 1.0% to 95.0% of CF3I, and 1.0% to 48.0% of CO₂; or

8.0% to 45.0% of HFO-1252zc, 15.0% to 33.0% of HFO-1132E, 30.0% to 70.0% of CF3I, and 1.0% to 10.0% of CO₂; or

about 28.0 wt-% HFO-1252zc, about 31.0 wt-% HFO-1132E, about 40.0 wt-% CF3I and about 1.0 wt-% CO₂; or

about 8.0 wt-% HFO-1252zc, about 20.0 wt-% HFO-1132E, about 62.0 wt-% CF3I, and about 10.0 wt-% CO₂.

62. The composition of claim 61, wherein the composition has a GWP less than 1.
63. The composition of claim 61 or claim 62, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 6.8 K or no more than 6.6 K.
64. The composition of any one of claims 61-63, wherein the composition exhibits an ASHRAE flammability rating of 1 or 2 or 2L.
65. The composition of any one of claims 61-64, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
 - 55.4-205.2% of the volumetric cooling capacity of R-454C; or
 - 111.2-150.0% of the volumetric cooling capacity of R-454C; or
 - about 150.0% of the volumetric cooling capacity of R-454C; or
 - about 111.5% of the volumetric cooling capacity of R-454C.
66. The composition of any one of claims 61-65, wherein the composition has a cooling COP in a range of:
 - 42.3-108.7% of the cooling COP of R-454C; or
 - 96.6-101.4% of the cooling COP of R-454C; or
 - about 96.6% of the cooling COP of R-454C; or
 - about 1.4% of the cooling COP of R-454C.
67. The composition of any one of claims 61-64, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
 - 57.7-226.1% of the volumetric heating capacity of R-454C; or
 - 57.7-224.4% of the volumetric heating capacity of R-454C; or
 - 90.0-110.0% of the volumetric heating capacity of R-454C; or
 - about 110.0% of the volumetric heating capacity of R-454C; or
 - about 91.4% of the volumetric heating capacity of R-454C.

68. The composition of any one of claims 61-64 or claim 67, wherein the composition has a heating COP in a range of:
- 84.0-111.1% of the heating COP of R-454C; or
 - 86.8-111.1% of the heating COP of R-454C; or
 - 104.2-107.3% of the heating COP of R-454C; or
 - about 104.6% of the heating COP of R-454C; or
 - about 107.3% of the heating COP of R-454C.
69. The composition of claim 1 or claim 2, comprising:
- 1.0% to 98.0% of HFO-1252zc, 1.0% to 94.0% of CF3I, and 1.0% to 80.0% of CO₂; or
 - 1.0% to 54.0% of HFO-1252zc, 2.0% to 94.0% of CF3I, and 1.0% to 80.0% of CO₂; or
 - 18.0 wt-% HFO-1252zc, 2.0 wt-% CF3I and 80.0 wt-% CO₂; or
 - 1.0% to 98.0% of HFO-1252zc, 1.0% to 97.0% of CF3I, and 1.0% to 11.0% of CO₂; or
 - 1.0% to 54.0% of HFO-1252zc, 45.0% to 97.0% of CF3I, and 1.0% to 11.0% of CO₂; or
 - 28.0% to 54.0% of HFO-1252zc, 45.0% to 71.0% of CF3I, and 1.0% to 2.0% of CO₂; or
 - 28.0% to 42.0% of HFO-1252zc, 56.0% to 71.0% of CF3I, and 1.0% to 2.0% of CO₂; or
 - about 42.0 wt-% HFO-1252zc, about 56.0 wt-% CF3I and about 2.0 wt-% CO₂; or
 - about 28.0 wt-% HFO-1252zc, about 71.0 wt-% CF3I and about 1.0 wt-% CO₂.
70. The composition of claim 69, wherein the composition has a GWP less than 1.
71. The composition of claim 69 or claim 70, wherein the composition exhibits an average temperature glide of no more than 7.0 K or no more than 6.0 K or no more than 4.1 K.

72. The composition of any one of claims 69-71, wherein the composition exhibits an ASHRAE flammability rating of 1 or 2.
73. The composition of any one of claims 69-72, wherein the composition has a volumetric cooling capacity, relative to R-454C, in a range of:
52.8-175.8% of the volumetric cooling capacity of R-454C; or
about 175.8% of the volumetric cooling capacity of R-454C.
74. The composition of any one of claims 69-73, wherein the composition has a cooling COP in a range of:
56.9-109.3% of the cooling COP of R-454C; or
about 56.9% of the cooling COP of R-454C.
75. The composition of any one of claims 69-72, wherein the composition has a volumetric heating capacity, relative to R-454C, in a range of:
55.2-81.2% of the volumetric heating capacity of R-454C; or
55.2-75.7% of the volumetric heating capacity of R-454C; or
70.0-75.7% of the volumetric heating capacity of R-454C; or
70.0-75.6% of the volumetric heating capacity of R-454C; or
about 75.6% of the volumetric heating capacity of R-454C; or
about 70.0% of the volumetric heating capacity of R-454C.
76. The composition of any one of claims 69-72 or claim 75, wherein the composition has a heating COP in a range of:
105.7-111.5% of the heating COP of R-454C; or
107.1-111.5% of the heating COP of R-454C; or
107.1-108.4% of the heating COP of R-454C; or
107.4-108.4% of the heating COP of R-454C; or
about 107.4 of the heating COP of R-454C; or
about 108.4% of the heating COP of R-454C.
77. The composition of claim 1 or claim 2, comprising: about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132Z; or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132Z.

78. The composition of claim 1 or claim 2, comprising: about 75 to 99 HFO-1252zc and about 1 to 25 weight percent HFO-1132E and HFO-1132Z, or about 78 to 89 weight percent HFO-1252zc and about 11 to 22 weight percent HFO-1132E and HFO-1132Z.
79. The composition of claim 1 or 2, wherein the HFC-32 is present at about 1 to 22 weight percent, or at about 10 to 22 weight percent, or at about 15 to 22 weight percent.
80. The composition of claim 1 or 2, wherein the HFC-134 is present at about 1 to 13 weight percent, or at about 5 to 13 weight percent, or at about 8 to 13 weight percent.
81. The composition of claim 1 or claim 2, comprising: about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-1132Z; or about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132Z.
82. The composition of claim 1 or claim 2, comprising: about 1 to 50 HFO-1252zc and about 50 to 99 weight percent HFO-1132E and HFO-1132Z; or about 1 to 26 weight percent HFO-1252zc and about 74 to 99 weight percent HFO-1132E and HFO-1132Z.
83. The composition of any of claims 1 to 82, wherein said composition is classified as class 2 for flammability according to ASHRAE Standard 34.
84. The composition of any of claim 1 to 83, further comprising at least one additional compound selected from the group consisting of methane, ethane, HFC-41, HCC-40, HFCF-22, HFC-23, HFO-1141, HFO-1132E, HFO-1132Z, HFC-161, HFC-152, HFC-143, HFC-143a, HFC-134a, PFC-116, HCFO-1122, HCFO-1122aE, HCFO-1122aZ, HCC-150, HCFC-151, CFO-1112E, CFO-1112Z, HCFC-142a, HCFC-132, HCFC-133, HCFC-133b, HCFC-123, HFO-1123, HFO-1132a, HCFO-1131E, HCFO-1131Z, ethylene, and acetylene.
85. The composition of any of claims 1 to 84, wherein said composition further comprises from 0.1 to 200 ppm by weight of water; from about 10 ppm by volume to about 0.35 volume percent oxygen; and/or from about 100 ppm by volume to about 1.5 volume percent air or NAG.

86. The composition of any of claims 1 to 85, wherein said composition comprises a stabilizer.
87. The composition of claim 86, wherein the stabilizer is selected from the group consisting of nitromethane, ascorbic acid, terephthalic acid, azoles, phenolic compounds, cyclic monoterpenes, terpenes, phosphites, phosphates, phosphonates, thiols, and lactones.
88. The composition of any of claims 86 or 87, wherein the stabilizer is selected from tolutriazole, benzotriazole, tocopherol, hydroquinone, t-butyl hydroquinone, 2,6-di-terbutyl-4-methylphenol, fluorinated epoxides, n-butyl glycidyl ether, hexanediol diglycidyl ether, allyl glycidyl ether, butylphenylglycidyl ether, d-limonene, a-terpinene, b-terpinene, a-pinene, b-pinene, or butylated hydroxytoluene.
89. The composition of any of claims 86 to 88, wherein the stabilizer is present in an amount from about 0.001 to 1.0 weight percent based on the weight of the refrigerant.
90. The composition of any of claims 1 to 89, wherein the composition further comprises a lubricant.
91. The composition of claim 90, wherein said lubricant is at least one selected from the group consisting of polyalkylene glycol, polyol ester, poly- α -olefin, and polyvinyl ether.
92. The composition of claim 90 or 91, wherein said lubricant is a polyol ester or a polyvinyl ether.
93. The composition of any of claims 90 to 92, wherein said lubricant has at least one property selected from the group consisting of volume resistivity of greater than 10^{10} Ω -m at 20 °C; surface tension of from about 0.02 N/m to 0.04 N/m at 20 °C; kinematic viscosity of from about 20 cSt to about 500 cSt at 40 °C; a breakdown voltage of at least 25 kV; and a hydroxy value of at most 0.1 mg KOH/g.
94. The composition of any of claims 1 to 93, wherein the composition comprises at least one tracer.

95. The composition of claim 94, wherein said tracer is present in an amount from about 1.0 ppm by weight to about 1000 ppm by weight.
96. The composition of any of claims 94 or 95, wherein said at least one tracer is selected from the group consisting of hydrofluorocarbons, hydrofluoroolefins, hydrochlorocarbons, hydrochloroolefins, hydrochlorofluorocarbons, hydrochlorofluoroolefins, hydrochlorocarbons, hydrochloroolefins, chlorofluorocarbons, chlorofluoroolefins, hydrocarbons, perfluorocarbons, perfluoroolefins, and combinations thereof.
97. The composition of any of claims 94 to 96, wherein said at least one tracer is selected from the group consisting of HFC-23, HCFC-31, HFC-41, HFC-161, HFC-143a, HFC-134a, HFC-125, HFC-236fa, HFC-236ea, HFC-245cb, HFC-245fa, HFC-254eb, HFC-263fb, HFC-272ca, HFC-281ea, HFC-281fa, HFC-329p, HFC-329mmz, HFC338mf, HFC-338pcc, CFC-12, CFC-11, CFC-114, CFC-114a, HCFC-22, HCFC-123, HCFC-124, HCFC-124a, HCFC-141b, HCFC-142b, HCFC-151a, HCFC-244bb, HCC-40, HFO-1141, HCFO-1130, HCFO-1130a, HCFO-1131, HCFO-1122, HFO-1123, HFO-1234yf, HFO-1234ye, HFO-1243zf, HFO-1225ye, HFO-1132Z, PFC-116, PFC-C216, PFC-218, PFC-C318, PFC-1216, PFC-31-10mc, PFC-31-10my, and combinations thereof.
98. The composition of any of claims 1 to 97, wherein the composition is free of or substantially free of Group A Fluorinated Substances, and wherein degradation products of the composition are free of or substantially free of Group A Fluorinated Substances.
99. A method for cooling comprising evaporating a composition of any of claims 1 to 98 in the vicinity of a body to be cooled and thereafter condensing said composition.
100. A method for heating comprising evaporating a composition of any of claims 1 to 99 and thereafter condensing said composition in the vicinity of a body to be heated.
101. A system for cooling or heating comprising a composition of any of claims 1 to 100.

102. The system of claim 101, comprising an evaporator, compressor, condenser, and expansion device, each operably connected to perform a vapor compression cycle.
103. The system of claim 101 or 102, wherein said system is a residential, light commercial, or industrial air-conditioner, heat pump, or chiller.
104. The system of claim 101 to 103, wherein said system is a medium or low temperature refrigeration system, beverage cooler, supermarket display case, ice machine, or transport refrigeration or freezer system.
105. The system of any of claims 101 to 103, wherein the system is an automobile heat pump for cooling and heating the passenger compartment, battery or electronic systems of an electric or hybrid vehicle.
106. The system of any of claims 101 to 105, wherein the system is a secondary loop system.
107. The system of any of claims 101-106, wherein the system does not include a PTC heater.
108. A method of replacing at least one of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, R-452C, or in refrigeration, air-conditioning, heat pump, or chiller systems comprising providing the composition of any of claims 1 to 98 to the system in place of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, R-452C.
109. Use of the composition of any of claims 1 to 98 as refrigerant in refrigeration, air-conditioning, heat pump, or chiller systems.
110. The use of claim 109, wherein the refrigeration, air-conditioning, heat pump, or chiller systems comprise mobile or stationary air conditioning, mobile or stationary heat pumps, residential, light commercial, or industrial air-conditioner, residential, light commercial, or industrial heat pump, centrifugal chiller, screw chiller, scroll chiller, flooded evaporator chiller, direct expansion chiller, medium or low temperature refrigeration system, beverage cooler,

supermarket display case, ice machine, or transport refrigeration or freezer system.

111. The use of claim 109 or 110, wherein the system is an automobile heat pump for cooling and heating the passenger compartment, battery or electronic systems of an electric or hybrid vehicle.
112. The use of any of claims 109 to 111, wherein the system is a secondary loop system.
113. The use of any of claims 109 to 111, wherein the system does not include a PTC heater.
114. The use of any of claims 109 to 113, wherein the composition of claims 1 to 98 is replacing any one of R-22, HFC-134a, propane, HFO-1234yf, R-407C, R-404A, R-410A, R-513A, R-454A, R-454B, R-454C, R-448A, R-449A, R-449B, R-449C, R-452A, or R-452C.
115. The composition of any of claims 1 to 98, wherein said composition provides average temperature glide less than 8 K, or less than 6 K, or less than 5 K, or less than 4 K, or less than 3 K, or less than 2 K, or less than 1 K.
116. A composition comprising from about 1 to 26 weight percent HFO-1252zc and HFO-1132E, HFO-1132Z, or a combination thereof.
117. An azeotropic or azeotrope-like composition comprising HFO-1252zc selected from:
 - about 73 to 86 weight percent HFO-1252zc and about 14 to 27 weight percent HFC-134; or
 - 53 to 77 weight percent HFO-1252zc, about 13 to 27 weight percent HFC-134, and about 10 to 20 weight percent CF3I.