



Industria y Comercio

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División de Nuevas Creaciones

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SOLICITUD

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FASE NACIONAL

06-96953

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54. TÍTULO

COMPOSICION REFRIGERANTE

51. CLASIFICACIÓN INTERNACIONAL

71. SOLICITANTE

RPL HOLDINGS LIMITED

DOMICILIO

ALTRINCHAM, CHESHIRE, REINO UNIDO

74. APODERADO

JAIMÉ EDUARDO DELGADO, VILLEGAS

22. BOGOTÁ, D. C.,

he, Cedula
27-04-2006

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1

☒ Patente de Invención

SOLICITUD DE

☐ Patente de Modelo de Utilidad☒ Capítulo I☐ Capítulo II

2

SOLICITANTE
(71)

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3

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5

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2020-F08 (02-04-01)

10

ANEXOS

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Comprobante de pago de la tasa de presentación de la solicitud

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Documento que acredite la existencia y representación legal cuando el solicitante sea persona jurídica

☐

Podere, si fuere el caso

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Documento de cesión del inventor al solicitante o a su causante

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Declaraciones

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Copia de la solicitud internacional (Resumen, descripción, reivindicaciones, dibujos)

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Traducción de la solicitud internacional al castellano (Resumen, descripción, reivindicaciones, dibujos)

☐

Copia del examen preliminar internacional efectuado por la Autoridad Internacional de Examen Preliminar (IPEA)

☐

Traducción del examen preliminar internacional efectuado por la IPEA

☐

De ser el caso, copia del contrato de acceso

☐

De ser el caso, documento que acredite la licencia o autorización de uso de conocimientos tradicionales de las comunidades indígenas

☐

De ser el caso, certificado de depósito del material biológico

☐

Arte final 12X12 cm

☐

De ser el caso, información de otras solicitudes de patente o títulos obtenidos en el extranjero por el mismo titular o su causante, relacionadas total o parcialmente con la invención de esta solicitud

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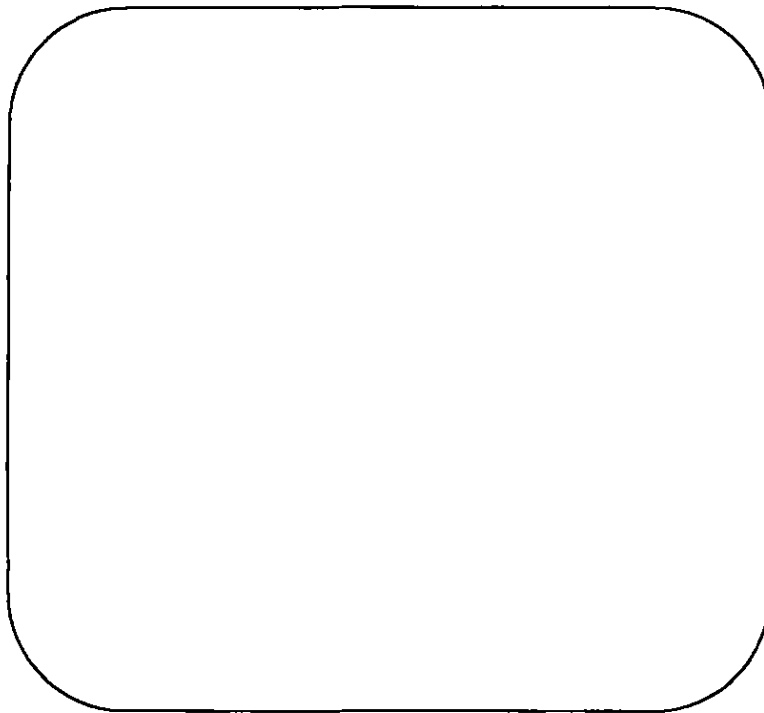
De ser el caso, modificaciones efectuadas a la solicitud internacional, Nuevas Reivindicaciones

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Otros Informe de Búsqueda de Antecedentes Internacional junto con la traducción

11

FIGURA CARACTERISTICA



12

Solicito la concesión de la patente,

NOMBRE: JAIME EDUARDO DELGADO VILLEGAS

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Únicamente para tramites de
Mario Delgado Echeverry Hija Echa
Patente RPL Holdings
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***** CONSIGNACION *****

DEPOSITANTE	TIPO PAGO	BANCO	CUENTA	No. PAGO	FECHA PGO	Vr. PAGO
MARIO DELGADO ECHEVERRY	CONSIGNACION	BANCO POPULAR	050-00110-6	55612947	14/06/2006	16,127,500.00

***** C O N C E P T O *****

CANT.	RENTISTICO	CONCEPTO	TOTAL CONCEPTO
1	50005-01-01	SOLICITUDES	
		1 TRAMITES DE SOL. DE PATENTE DE IN	463,000.00
		TOTAL :	\$ 463,000.00

SON: CUATROCIENTOS SESENTA Y TRES MIL PESOS



RESPONSABLE : _____

RECIBO DE CAJA APLICADO AL EXPEDIENTE No. _____

COMPOSICIÓN REFRIGERANTE

Esta invención se refiere a composiciones refrigerantes que no tienen ningún efecto adverso sobre el ozono estratosférico y a composiciones que son para su uso en sistemas de refrigeración y aire acondicionado diseñados para usar Sustancias Agotadoras de la Capa de Ozono (ODS), CFC12 (diclorodifluorometano), CFC502 (azeótropo de cloropentafluorometano y clorodifluorometano) y HCFC22 (clorodifluorometano) y adicionalmente en nuevos equipos. Estas nuevas composiciones refrigerantes son compatibles con lubricantes que se encuentran comúnmente en sistemas de refrigeración y aire acondicionado.

10 Las composiciones también pueden usarse en equipos para sustancias no agotadoras de la capa de ozono.

Se sabe bien que los clorofluorocarburos (CFC) tales como CFC12 y CFC502 e hidroclorofluorocarburos tales como HCFC22, aunque son eficaces con respecto a la energía, no inflamables y de baja toxicidad, migran a la estratosfera, donde se descomponen por la luz ultravioleta para atacar a la capa de ozono. Estas Sustancias Agotadoras de la Capa de Ozono están en proceso de reemplazo por sustancias alternativas no agotadoras de la capa de ozono tales como hidrofluorocarburos (HFC) que también son no inflamables, eficaces y de baja toxicidad. Existen seis HFC principales, llamados HFC134a, HFC32, HFC125, HFC143a, HFC227ea y HFC152a, que individualmente o mezclados pueden reemplazar a los CFC y HCFC. Aunque pueden usarse HFC134a, HFC227ea y HFC152a para reemplazar directamente a las ODS, HFC32, HFC143a y HFC125 se encuentran generalmente en mezclas como reemplazamientos de ODS. Sin embargo, los HFC no tienen una solubilidad adecuada en lubricantes tradicionales tales como aceites minerales y de alquilbenceno, así que se han introducido lubricantes sintéticos que contienen oxígeno específicamente para los equipos nuevos. Estos nuevos lubricantes son costosos e higroscópicos.

Las mezclas refrigerantes tales como R404A, R507, R410A, R407C y otras se han comercializado como reemplazamientos de los CFC y HCFC pero, debido a que estas composiciones sólo contienen componentes HFC, no pueden usarse con los lubricantes tradicionales que se encuentran comúnmente en uso con los CFC y HCFC. Si estas mezclas van a usarse para reemplazar a los CFC y HCFC en los equipos existentes, los principales fabricantes químicos recomiendan que no se mantenga más de un 5% del

lubricante tradicional en el sistema de manera que se requiera un cambio completo virtual del lubricante a un lubricante sintético que contenga oxígeno que provoque una actualización total del diseño, que normalmente es costosa y técnicamente no satisfactoria.

- 5 Aunque los fabricantes de equipos han adaptado sus unidades para que funcionen con mezclas de HFC, no siempre encuentran tan satisfactorios los productos disponibles en el mercado como los CFC y HCFC a los que reemplazan estos nuevos refrigerantes. En particular, para garantizar una recirculación adecuada del aceite, los lubricantes de hidrocarburo, tales como
- 10 aceite mineral, se han reemplazado por lubricantes que contienen oxígeno, particularmente poliolésteres y polialquilenglicoles. Desafortunadamente, estos materiales son propensos a absorber la humedad atmosférica, especialmente durante el mantenimiento, que pueden contribuir a una corrosión excesiva y desgaste en los equipos reduciendo de esta manera su fiabilidad. Un objetivo
- 15 clave de esta patente es proporcionar mezclas de HFC/hidrocarburos que permitan el uso continuado de aceites de hidrocarburo en equipos existentes y en equipos nuevos.

- Además, algunos refrigerantes, tales como R07C, tienen amplias variaciones de temperatura ($>4^{\circ}\text{C}$) en el evaporador y el condensador, mientras
- 20 que los fabricantes de equipos, basándose en su experiencia con fluidos simples de CFC/HCFC o azeótropos, prefieren refrigerantes con bajas variaciones. Un objetivo clave adicional de esta invención, por lo tanto, es proporcionar mezclas de HFC/hidrocarburos que puedan sustituir a CFC 12, HCFC 22 y azeótropo 502 (CFC 115/HCFC 22), permitiendo tanto el uso
- 25 continuado de lubricantes de hidrocarburo en los equipos y minimizando las variaciones de temperatura en los intercambiadores de calor.

- La presente invención se refiere a composiciones refrigerantes, que son no inflamables en todas las condiciones de fraccionamiento como se define en la Norma ASHRAE 34, y que pueden usarse para reemplazar a las ODS en
- 30 una unidad existente sin necesidad de cambiar el lubricante o realizar ningún cambio significativo en el hardware del sistema. En los equipos nuevos, las composiciones refrigerantes permiten el uso continuado de aceites de hidrocarburo, aunque los fabricantes pueden tener la oportunidad de modificar sus unidades para optimizar las funciones de los nuevos refrigerantes, por
- 35 ejemplo seleccionando las longitudes más apropiadas de los tubos de

capilaridad. Cuando se experimenta acceso de humedad u otros problemas con aceites que contienen oxígeno, las nuevas composiciones permiten que dichos aceites se reemplacen por aceites de hidrocarburo

Se conoce en la técnica que la adición de una pequeña cantidad de hidrocarburo a una composición refrigerante que contiene HFC o mezclas de HFC puede provocar que el hidrocarburo suficiente que se disuelve en el lubricante se transporte por el sistema para que se mantenga en todo momento la lubricación del compresor. Es evidente que cuanto mayor es el contenido de hidrocarburo de la composición, mayor es la capacidad del refrigerante para transportar de nuevo el lubricante al compresor Sin embargo, un contenido demasiado elevado de hidrocarburo puede conducir a mezclas inflamables. Aunque los refrigerantes inflamables son aceptables en algunas aplicaciones, esta invención se refiere a composiciones no inflamables para su uso en equipos en los que se prohíben refrigerantes inflamables Sin embargo, no se entiende bien cómo alcanzar composiciones no inflamables en todas las condiciones, incluyendo fraccionamiento de las composiciones refrigerantes que puede producirse durante una filtración del refrigerante del sistema o durante el almacenamiento

No todos los HFC son no inflamables como se define por la Norma ASHRAE 34 HFC143a y HFC32 no han recibido la calificación de no inflamables por ASHRAE. Esta invención se refiere a composiciones de refrigerantes que no sólo cubren mezclas de HFC no inflamables con hidrocarburos, sino también mezclas de HFC inflamables, HFC no inflamables e hidrocarburos en proporciones seleccionadas de tal forma que dichas composiciones son no inflamables durante el fraccionamiento a la vez que proporcionan efectos refrigerantes similares y un rendimiento termodinámico como el de las ODS a las que reemplazan, denominadas CFC12, CFC502 y HCFC22.

Aunque esta invención se refiere a composiciones refrigerantes que pueden usarse con lubricantes tradicionales tales como aceites minerales y de alquilbenceno, también son adecuadas para su uso con lubricantes sintéticos que contienen oxígeno

En la formulación de mezclas de HFC/hidrocarburo para reemplazar a CFC 12, CFC 502 y HCFC 22 en aplicaciones específicas, generalmente es necesario usar uno o más HFC con un punto de ebullición inferior, con uno o

más HFC con un punto de ebullición mayor. En este contexto, los HFC con un punto de ebullición inferior son HFC 32, HFC 143a y HFC 125, y los HFC con un punto de ebullición mayor son HFC 134a, HFC 134, HFC 227ea y HFC 152a.

- 5 Pare evitar la inflamabilidad en la mezcla, o en una fracción generada por una filtración, por ejemplo como se define por la Norma ASHRAE 34, la cantidad total de hidrocarburo debe minimizarse. Al mismo tiempo, la cantidad de la mezcla de hidrocarburo disuelta en el aceite necesita maximizarse para una buena recirculación del aceite, especialmente en los lugares del circuito en
- 10 los que el aceite tiene su máxima viscosidad, por ejemplo en el evaporador. Un hidrocarburo con punto de ebullición mayor, tal como pentano o *iso*-pentano, sin duda alguna mostraría una solubilidad superior en el aceite que un hidrocarburo con punto de ebullición inferior. Sin embargo, como resultado de una filtración, por ejemplo desde un cilindro, un hidrocarburo con punto de
- 15 ebullición mayor se concentrará en la fase líquida. La cantidad de hidrocarburo, por tanto, necesitará limitarse para evitar que se genere una mezcla inflamable hacia el final de la filtración.

- Este problema podría evitarse usando únicamente un hidrocarburo con punto de ebullición bajo tal como propano o *iso*-butano. Sin embargo, esto tiene
- 20 2 desventajas. En primer lugar, los hidrocarburos con punto de ebullición inferior son menos solubles que los hidrocarburos con punto de ebullición mayor en lubricantes de hidrocarburos en el evaporador cuando están presentes en % en peso similares formulados en la mezcla. Por consiguiente, son menos eficaces a la hora de garantizar una buena recirculación del aceite.
- 25 En segundo lugar, debido a su superior volatilidad, tienden a concentrarse en la fase de vapor de una mezcla. Por lo tanto, su concentración necesita restringirse para evitar que se generen mezclas inflamables al principio de la filtración. Este problema empeora si uno o más de los HFC con punto de ebullición inferior también es inflamable.

- 30 Sorprendentemente, se ha descubierto que la mejor manera de formular mezclas refrigerantes de HFC/HC es usar combinaciones de dos y preferiblemente tres hidrocarburos con puntos de ebullición diferentes. Esto permite que el número total de hidrocarburos de la mezcla se reduzca mientras que se aumenta simultáneamente la cantidad disuelta en el aceite del
- 35 evaporador.

Esta invención tiene la siguiente ventaja. Los componentes de hidrocarburo facilitan la recirculación del aceite, pero, debido a su inflamabilidad, restringen los pesos de los HFC inflamables, particularmente HFC 143a que puede incluirse. La inclusión de estos fluidos puede ser valiosa para alcanzar el equilibrio necesario de propiedades termodinámicas, así que minimizando las cantidades de hidrocarburo presentes se permite un mayor alcance en la formulación de mezclas preferidas

Se conoce bien el mezclado de HFC para alcanzar el equilibrio deseado de propiedades físicas apropiadas para diversas aplicaciones de refrigeración y está disponible en el mercado una diversidad de productos, por ejemplo R407C, R410A y R410B. Aunque éstos se han seleccionado para aplicaciones específicas junto con lubricantes sintéticos que contienen oxígeno, simplemente añadiendo 2 ó 3 componentes de hidrocarburo a estos productos, no se obtienen los productos preferidos para su uso con lubricantes de hidrocarburo. En primer lugar, los componentes de hidrocarburo contribuyen a las propiedades termodinámicas globales de la mezcla, así que afectarán a las relaciones preferidas de los HFC. En segundo lugar, es necesario seleccionar la relación de HFC inflamables a no inflamables para garantizar la no inflamabilidad, por ejemplo, requerida por la Norma ASHRAE 34.

Las mezclas de HFC125, HFC134a, HFC143a, HFC227ea se prefieren particularmente como reemplazamientos de los CFC y HCFC. HFC125 (pentafluoroetano) y R227ea son no inflamables en todas las condiciones de funcionamiento y además son supresores de llama, una aplicación para la que se han desarrollado por la industria contra incendios. La presencia de HFC227ea proporciona una ventaja doble de reducción de la inflamabilidad de la composición y además mejora la recirculación del aceite al compresor debido al emulsionado del lubricante en presencia de un hidrocarburo.

Se ha descubierto que las mezclas de HFC134a, HFC227ea, HFC125 y mezclas de aditivos de hidrocarburo seleccionados son los reemplazamientos preferidos para CFC12 en refrigeradores centrífugos. Se ha descubierto que la interacción de aditivos de hidrocarburo en dichas mezclas facilita las mezclas no inflamables en todas las condiciones de filtración durante el fraccionamiento de modo que puede alcanzarse la no inflamabilidad de acuerdo con la Norma ASHRAE 34. La presencia de hidrocarburos produce que el lubricante vuelva al compresor. La presencia de R227ea permite que el peso molecular requerido

de la mezcla coincida con el de CFC12 y adicionalmente facilita la no inflamabilidad debido a sus propiedades ignífugas. La presencia de R125 aumenta la capacidad de la mezcla. Las mezclas resultantes son una coincidencia cercana a CFC12 en cuanto al rendimiento termodinámico y del sistema.

Sorprendentemente, se ha descubierto que dado el mismo contenido en porcentaje de aditivo de hidrocarburo en la composición refrigerante, aumentando el contenido de HFC125 de la composición se producen mezclas inflamables que se crean durante el fraccionamiento. Esto es muy sorprendente porque parece evidente que cuanto mayor sea la cantidad de HFC125 en la composición, menor será la probabilidad de generar una mezcla inflamable durante el fraccionamiento. Las razones de esta anomalía aparente están relacionadas con la relación de presión/temperatura entre las cantidades de HFC125 y HFC134a de la mezcla y la cantidad y tipo de hidrocarburo y/o mezcla de hidrocarburos. Las siguientes composiciones refrigerantes se prepararon y se filtraron hasta que el cilindro estuvo casi sin líquido de acuerdo con la Norma ASHRAE 34

	%	
	Mezcla 1	Mezcla 2
R134a	48,0	21,0
R125	49,0	76,0
butano	2,7	2,5
isopentano	0,3	0,5

Se descubrió que la Mezcla 2 con el contenido considerablemente mayor de HFC125 creaba una composición inflamable durante el fraccionamiento, mientras que la Mezcla 1 con un contenido menor de HFC125 seguía siendo no inflamable a lo largo del fraccionamiento.

En el documento GC2727427 N A Roberts muestra que, si se usa un hidrocarburo con al menos cuatro átomos de carbono distinto de metilpropano (isobutano), sorprendentemente la inflamabilidad de la composición fraccionada se reduce enormemente. Sorprendentemente, ahora se ha descubierto que la inclusión de isobutano con hidrocarburos elegidos apropiadamente no produce composiciones inflamables durante el fraccionamiento. Se ha descubierto que la selección del aditivo de hidrocarburo o mezclas de los mismos con los componentes de HFC es crítica para alcanzar la no inflamabilidad en todas las

condiciones de funcionamiento y como se define por la Norma ASHRAE 34.

En el documento US 5.800 730 se indica que es necesario añadir HFC 134a a las mezclas de HFC125 y HFC143a como un reemplazamiento de CFC502 para evitar una mezcla inflamable (ejemplo 3). Sorprendentemente, se ha descubierto que excluyendo HFC134a, cambiando la proporción de HFC125 a HFC143a y añadiendo una variedad seleccionada de hidrocarburos se produce una composición que es no inflamable durante el fraccionamiento y una coincidencia exacta para R502 con respecto al rendimiento termodinámico.

En el documento US 5 211 867, se reivindican composiciones azeotrópicas de R125 y R143a. Es una característica clave de esta invención que esté presente un hidrocarburo seleccionado especialmente o mezclas de hidrocarburos para facilitar la recirculación del aceite al compresor. Sorprendentemente, se ha descubierto que, a pesar de la inflamabilidad de HFC143a, la selección de un hidrocarburo o mezclas de hidrocarburos permite que las composiciones sean no inflamables durante el fraccionamiento. La combinación de un hidrocarburo con punto de ebullición elevado tal como isopentano (P.E. 27°C) con butano (P.E. -0,5°C) e isobutano (P.E. -11,5°C) evita el aumento del contenido de hidrocarburos en la fase líquida durante una filtración mientras que el isobutano más volátil se contrarresta en la fase de vapor por el supresor de llama HFC125 debido a la mayor presión de vapor del último y al menor punto de ebullición (P.E. -45°C). Para que la composición sea no inflamable, el contenido de HFC125 de la composición es superior al de la composición azeotrópica, de manera que se reduce el contenido de HFC143a pero sin afectar al rendimiento refrigerante de la composición como reemplazamiento para CFC502.

Aunque la adición de hidrocarburos a HFC se ha descrito previamente, no se ha apreciado anteriormente que es necesario que las volatilidades de los hidrocarburos coincidan con la aplicación para la que se desea el refrigerante. Por ejemplo, se emplea R12 como refrigerante en congeladores domésticos con temperaturas de evaporación de ~-22°C, en frigoríficos domésticos con temperaturas de evaporación de ~-5°C, y en aire acondicionado portátil con temperaturas de evaporación de ~5°C. Un aspecto importante de esta invención es formular mezclas de HFC/HC que garanticen una buena recirculación del aceite en estas aplicaciones dispares garantizando al mismo tiempo que la mezcla refrigerante siga siendo no inflamable de acuerdo con el

criterio elegido Para aplicaciones con evaporadores que funcionan a temperaturas superiores a -5°C , se prefieren hidrocarburos con punto de ebullición mayor Se prefiere especialmente isopentano, solo o mezclado con butano Para aplicaciones con evaporadores que funcionan en el intervalo de -20°C a -5°C , se prefieren mezclas de hidrocarburos que contienen un componente con punto de ebullición mayor, intermedio e inferior. Se prefieren especialmente mezclas que contienen isopentano, butano e isobutano. Para evaporadores que funcionan por debajo de -20°C , se prefieren mezclas de HC que contienen isobutano y butano, opcionalmente con una pequeña cantidad de isopentano.

De acuerdo con la presente invención, una composición refrigerante está constituida esencialmente por una combinación de un componente hidrofluorocarburo constituido por una combinación seleccionada entre las siguientes mezclas.

- (1) R134a y R125;
- (2) R134a, R125 y R143a
- (3) R125 y R143a
- (4) R134a, R227ea y R125

y un componente hidrocarburo que está constituido esencialmente por una combinación seleccionada entre las siguientes mezclas.

- (5) isopentano y butano
- (6) isopentano, butano e isobutano
- (7) butano e isobutano.

En realizaciones preferidas, la composición está constituida por una mezcla de un componente hidrofluorocarburo y un componente hidrocarburo de manera que no está presente una cantidad sustancial de ningún otro componente u otro gas.

En una primera realización preferida, el hidrocarburo está presente en una cantidad del 0,6 al 4% y donde la composición es no inflamable cuando está completamente en fase de vapor.

En una segunda realización preferida, el hidrocarburo está presente en una cantidad del 0,6 al 4% y cuando la composición está en un recipiente donde está presente tanto vapor como líquido, ni la fase de vapor ni la fase líquida son inflamables.

En una tercera realización preferida, el hidrocarburo está presente en

una cantidad del 0,6 al 4% y donde, en cualquier momento durante una filtración del espacio de vapor del recipiente, ni la fase líquida ni la fase de vapor es inflamable.

En una cuarta realización preferida, el hidrocarburo está presente en una cantidad del 0,6 al 4% y donde, en cualquier momento durante una filtración del espacio de líquido del recipiente, ni la fase líquida ni la fase de vapor es inflamable

De acuerdo con una quinta realización preferida, el hidrocarburo está presente en una cantidad del 0,6 al 4% y donde la proporción de hidrocarburo a hidrofluorcarburo en la fase de vapor no difiere de la proporción equivalente en la fase líquida en más de un 40%, más preferiblemente en no más del 30%, aún más preferiblemente en no más del 20% en equilibrio a 25°C.

En una sexta realización preferida, el hidrocarburo está presente en una cantidad del 0,6 al 4% y donde la proporción de hidrocarburo a hidrofluorcarburo en la fase de vapor no difiere de la composición formulada en más del 40%, preferiblemente en no más del 30%, más preferiblemente en no más del 20% en equilibrio a 25°C

En composiciones particularmente preferidas de acuerdo con la quinta o sexta composiciones preferidas anteriores, durante una filtración del espacio de vapor o del espacio de líquido de un recipiente, la proporción de hidrocarburo a hidrofluorcarburo en la fase de vapor o en la fase líquida no difiere de la composición formulada en más del 40%, más preferiblemente en no más del 30%, aún más preferiblemente en no más del 20% en equilibrio a 25°C.

Las composiciones preferidas de acuerdo con esta invención satisfacen dos o más criterios de la realización preferida.

En un primer aspecto de esta invención, el componente hidrocarburo está constituido por una mezcla de isopentano, butano e isobutano.

La cantidad de isopentano es preferiblemente de aproximadamente el 0,6 al 2% o más preferiblemente de aproximadamente el 0,6 al 1%

La cantidad de butano es preferiblemente de aproximadamente el 0,6 al 5%, más preferiblemente de aproximadamente el 0,6 al 3%, aún más preferiblemente de aproximadamente el 0,6 al 2%.

La cantidad de isobutano es preferiblemente de aproximadamente el 0,6 al 5%, más preferiblemente de aproximadamente el 0,6 al 2%, aún más preferiblemente de aproximadamente el 0,6 al 1%.

En un segundo aspecto preferido, el componente hidrocarburo está constituido por una mezcla de isopentano y butano

El isopentano puede estar presente en una cantidad del 0,6 al 1%, preferiblemente de aproximadamente el 0,6%. La cantidad de butano es
5 preferiblemente de aproximadamente el 1,3 al 2,5%, más preferiblemente de aproximadamente el 1,4%

En un tercer aspecto preferido de la invención, el componente hidrocarburo está constituido por una mezcla de butano e isobutano. La cantidad de butano es preferiblemente de aproximadamente el 0,6 al 5% y la
10 cantidad de isobutano es preferiblemente de aproximadamente 0,6 al 5%.

Una primera composición refrigerante preferida que puede encontrar aplicación como reemplazamiento o sustituto para R12 está constituida esencialmente por:

R134a	del 93,1 al 81,5%
R125	5-15%
isopentano	del 0,6 al 1%
butano	del 1,3 al 2,5%

Una composición particularmente preferida está constituida
15 esencialmente por.

R134a	93%
R125	5%
isopentano	0,6%
butano	1,4%

Una segunda composición refrigerante que puede encontrar aplicación como reemplazamiento o sustituto para R12 está constituida esencialmente por.

R134a	del 93,2 al 80%
R125	del 5 al 15%
isopentano	del 0,6 al 1%
butano	del 0,6 al 3%
isobutano	del 0,6 al 1%

Una composición particularmente preferida está constituida
20 esencialmente por:

R134a	93%
R125	5%

isopentano	0,6%
butano	0,8%
isobutano	0,6%

Una composición refrigerante preferida que puede encontrar aplicación como reemplazamiento o sustituto para R22 está constituida esencialmente por.

R134a	del 53,2 al 39%
R125	del 45 al 55%
isopentano	del 0,6 al 1%
butano	0,63%
isobutano	0,62%

5 Una composición particularmente preferida está constituida esencialmente por:

R134a	47,5%
R125	50%
isopentano	0,6%
butano	1%
isobutano	0,9%

Una composición refrigerante adicional que puede encontrar aplicación como reemplazamiento o sustituto para R22 está constituida esencialmente por

R134a	del 10 al 30%
R125	del 80 al 40%
R143a	del 10 al 30%
isopentano	del 0,6 al 2%
butano	del 0,6 al 5%
isobutano	del 0,6 al 5%

10 Una composición particularmente preferida está constituida esencialmente por:

R134a	16,5%
R125	60%
R143a	21%
isopentano	0,6%
butano	0,9%
isobutano	1%

Una composición refrigerante preferida que puede encontrar aplicación como reemplazamiento o sustituto para R502 está constituida esencialmente por

R125	del 75 al 55%
R143a	del 25 al 45%
butano	del 0,6 al 5%

Una composición particular preferida está constituida esencialmente por:

R125	60,5%
R143a	37%
butano	1%
isobutano	1,5%

5 Una composición preferida adicional está constituida esencialmente por:

R125	60,5%
R143a	37%
butano	0,9%
isobutano	1%
isopentano	0,6%

Una composición refrigerante alternativa que puede encontrar uso como reemplazamiento o sustituto para R12 en refrigeradores centrífugos y dispositivos similares está constituida esencialmente por.

R134a	del 58,2 al 36%
R227ea	del 35 al 50%
R125	del 5 al 8%
isopentano	del 0,6 al 2%
butano	del 0,6 al 2%
isobutano	del 0,6 al 2%

10 Una composición particularmente preferida está constituida esencialmente por:

R134a	51%
R227ea	41%
R125	6%
isopentano	0,6%
butano	0,8%
isobutano	0,6%

Los porcentajes y otras proporciones indicadas en esta memoria

descriptiva están en peso a menos que se indique otra cosa y se seleccionan al 100% total dentro de los intervalos descritos

La invención se describe adicionalmente por medio de los ejemplos pero no en sentido limitante.

5

Reemplazamientos para R22 en Aire Acondicionado de Interior

EJEMPLO 1

Mezclas que comprenden fluidos seleccionados entre R125, R143a, 134a, 600, 600a y 601a.

10 El rendimiento de diversas mezclas se evaluó en un ciclo de aire acondicionado estático típico usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.

POTENCIA DE REFRIGERACIÓN LIBERADA	10 kW
EVAPORADOR	
Temperatura media para la evaporación del fluido	7,0°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	45°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
INTERCAMBIADOR DE CALOR ENTRE LA TUBERÍA DE LÍQUIDO/TUBERÍA DE SUCCIÓN	
Eficacia	0,3
COMPRESOR	
Eficacia del motor eléctrico	0,85
Eficacia isentrópica del compresor	0,7
Eficacia volumétrica del compresor	0,82
POTENCIA RESIDUAL	
Ventilador interno	0,3 kW
Ventilador externo	0,4 kW
Controles	0,1 kW

Los resultados del análisis de los rendimientos en una unidad de aire acondicionado usando estas condiciones de funcionamiento se muestran en las Tablas 1a y 1b. Por comparación, también se muestran los rendimientos de R22 y R407C

Tabla 1a

R refrigerante	R-22	R407C	1	2	3	4	5	6	7	8	9	10
R125, % en peso			33	33	38	50	60	33	38	50	60	63
R143a, % en peso			35	38	40	23	23	40	40	33	23	23
R134a, % en peso			30	27	20	25	15	25	20	15	15	12
R600			1	1	1	1	1	1,3	1,3	1,3	1,3	1,3
R600a			1	1	1	1	1					
R601a								0,7	0,7	0,7	0,7	0,7
Presión de descarga (bar) (x100 kPa)	17,91	19,30	18,00	18,50	19,01	18,64	19,80	19,21	18,67	19,28	19,42	19,85
Temperatura de descarga (°C)	104,7	92,5	79,6	79,3	78,8	78,1	76,8	79,0	79,5	78,4	77,6	75,4
COP (sistema)	2,49	2,47	2,45	2,44	2,43	2,44	2,41	2,42	2,44	2,42	2,42	2,39
Capacidad (kW/m³)	3067	3172	2870	2933	2995	2938	3072	3005	2944	3008	3015	3019
Variación en el evaporador (°C)	0	4,8	2,4	2,2	2,0	2,4	1,9	3,0	3,2	3,1	3,2	3,8
Variación en el condensador (°C)	0	4,7	2,1	2,0	1,8	2,1	1,7	2,5	2,7	2,6	2,7	3,1

CA

Tabla 1a

Refrigerante	R 22	R407C	1	2	3	4	5	6	7	8	9	10
R125 % en peso			33	33	38	50	60	33	38	50	60	63
R143a % en peso			35	38	40	23	23	40	40	33	23	23
R134a % en peso			30	27	20	25	15	25	20	15	15	12
R600			1	1	1	1	1	1 3	1 3	1 3	1 3	1 3
R600a			1	1	1	1	1					
R601a								0 7	0 7	0 7	0 7	0 7
Presión de descarga (bar) (x100 kPa)	17 91	19 30	18 00	18 50	19 01	18 64	19 80	19 21	18 67	19 28	19 42	19 85
Temperatura de descarga (°C)	104 7	92 5	79 6	79 3	78 8	78 1	76 8	79 0	79 5	78 4	77 6	75 4
COP (sistema)	2 49	2 47	2 45	2 44	2 43	2 44	2 41	2 42	2 44	2 42	2 42	2 39
Capacidad (kW/m³)	3067	3172	2870	2933	2995	2938	3072	3005	2944	3008	3015	3019
Varación en el evaporador (°C)	0	4 8	2 4	2 2	2 0	2 4	1 9	3 0	3 2	3 1	3 2	3 8
Varación en el condensador (°C)	0	4 7	2 1	2 0	1 8	2 1	1 7	2 5	2 7	2 6	2 7	3 1

Tabla 1b

Refrigerante	R 22	R407C	1	2	3	4	5	6	7	8
R125 % en peso			30	33	35	38	39	60	50	40
R143a % en peso			23	25	28	30	34	23	30	35
R134a % en peso			45	40	35	30	25	15	18	23
R600			1 3	1 3	1 3	1 3	1 3			
R600a			0 7	0 7	0 7	0 7	0 7	1 3	1 3	1 3
R601a								0 7	0 7	0 7
Presión de descarga (bar) (x100 kPa)	17 91	19 30	16 54	17 01	17 49	17 99	18 48	19 66	19 21	18 61
Temperatura de descarga (°C)	104 7	92 5	80 2	79 9	79 6	79 2	79 0	77 3	78 2	79 2
COP (sistema)	2 49	2 47	2 48	2 47	2 46	2 45	2 44	2 41	2 42	2 44
Capacidad (kW/m³)	3067	3172	2678	2740	2802	2865	2928	3043	2998	2933
Varacion en el evaporador (°C)	0	4 8	2 7	2 7	2 6	2 5	2 3	2 8	2 8	2 9
Varacion en el condensador (°C)	0	4 7	2 5	2 5	2 4	2 3	2 1	2 3	2 3	2 5

Tabla 3

Refrigerante	R12	R134a	1	2	3	4	5	6	7	
R125 % en peso			1	3	5	5	7	9	12	
R134a % en peso			97	94 5	93	92 5	91	89	86	
R600 % en peso			1 4	1 6	1 4	1 6	1 4	1 4	1 4	
R601a % en peso			0 6	0 9	0 6	0 9	0 6	0 6	0 6	
Presion de descarga (bar) (x100 kPa)	15 72	17 42	17 29	17 38	17 68	17 58	17 88	18 08	18 39	
Temperatura de descarga (°C)	88 4	84 4	83 9	83 9	83 9	83 8	83 8	83 8	83 7	
COP (sistema)	2 45	2 38	2 37	2 37	2 36	2 36	2 36	2 35	2 34	
Capacidad (kW/m3)	1754	1771	1754	1759	1783	1773	1798	1813	1835	
Varacion en el evaporador (°C)	0	0	0 3	0 6	0 6	0 8	0 8	0 9	1 1	
Varacion en el condensador (°C)	0	0	0 4	0 8	0 8	1 0	1 0	1 2	1 4	

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Reemplazamientos para R12

EJEMPLO 2

Mezclas que comprenden fluidos seleccionados entre R125, R134a, R600, R600a y R601a

- 5

Los rendimientos de las mezclas se evaluaron en un ciclo de aire acondicionado abierto típico tal como aire acondicionado portátil (MAC) usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación

POTENCIA DE REFRIGERACIÓN LIBERADA	10 kW
EVAPORADOR	
Temperatura media para la evaporación del fluido	7,0°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	60,0°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
COMPRESOR	
Eficacia isentrópica del compresor	0,7
Eficacia volumétrica del compresor	0,82
POTENCIA RESIDUAL	
Ventilador externo	0,4 kW
- 10

Los resultados del análisis de los rendimientos en una unidad de aire acondicionado usando estas condiciones de funcionamiento se muestran en la Tabla 2. Por comparación, también se muestran los rendimientos de R12 y R134a

Tabla 2

Refrigerante	R12	R134a	1	2	3	4	5
R125, % en peso			5	7	10	12	15
R134a, % en peso			92,9	90,9	87,9	85,9	82,9
R600, % en peso			0,7	0,7	0,7	0,7	0,7
R600a, % en peso			0,7	0,7	0,7	0,7	0,7
R601a, % en peso			0,7	0,7	0,7	0,7	0,7
Presión de descarga (bar) (x100 kPa)	15,72	17,42	17,77	17,97	18,27	18,48	18,80
Temperatura de descarga (°C)	88,4	84,4	83,9	83,9	83,8	83,8	83,7
COP (sistema)	2,45	2,38	2,36	2,35	2,35	2,34	2,33
Capacidad (kW/m ³)	1754	1771	1789	1804	1826	1841	1863
Variación en el evaporador (°C)	0	0	0,7	0,9	1,1	1,2	1,4
Variación en el condensador (°C)	0	0	0,9	1,1	1,3	1,5	1,7

EJEMPLO 3
Mezclas que comprenden fluidos seleccionados entre R125, R134a, R600 y R601a

Los rendimientos de diversas mezclas se evaluaron en un ciclo de aire acondicionado abierto típico usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.

POTENCIA DE REFRIGERACIÓN LIBERADA	10 kW
EVAPORADOR	
Temperatura media para la evaporación del fluido	7,0°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	60,0°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
COMPRESOR	
Eficacia isentrópica del compresor	0,7
Eficacia volumétrica del compresor	0,82
POTENCIA RESIDUAL	
Ventilador externo	0,4 kW

Los resultados del análisis de los rendimientos en una unidad de aire acondicionado usando estas condiciones de funcionamiento se muestran en la

10 Tabla 3 Por comparación, también se muestran los rendimientos de R12 y R134a.

Tabla 3

Refrigerante	R12	R134a	1	2	3	4	5	6	7	
R125 % en peso			1	3	5	5	7	9	12	
R134a % en peso			97	94 5	93	92 5	91	89	86	
R600 % en peso			1 4	1 6	1 4	1 6	1 4	1 4	1 4	
R601a % en peso			0 6	0 9	0 6	0 9	0 6	0 6	0 6	
Presion de descarga (bar) (x100 kPa)	15 72	17 42	17 29	17 38	17 68	17 58	17 88	18 08	18 39	
Temperatura de descarga (°C)	88 4	84 4	83 9	83 9	83 9	83 8	83 8	83 8	83 7	
COP (sistema)	2 45	2 38	2 37	2 37	2 36	2 36	2 36	2 35	2 34	
Capacidad (kW/m3)	1754	1771	1754	1759	1783	1773	1798	1813	1835	
Varacion en el evaporador (°C)	0	0	0 3	0 6	0 6	0 8	0 8	0 9	1 1	
Varacion en el condensador (°C)	0	0	0 4	0 8	0 8	1 0	1 0	1 2	1 4	

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EJEMPLO 4

Mezclas que comprenden fluidos seleccionados entre R125, R134a, R227ea, R600, R600a y R601a

5 Los rendimientos de diversas mezclas se evaluaron en un ciclo de refrigeración hermético típico del usado en un frigorífico-congelador doméstico usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.

POTENCIA DE REFRIGERACIÓN LIBERADA	1 kW
EVAPORADOR	
Temperatura media para la evaporación del fluido	-25°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	50,0°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
COMPRESOR	
Eficacia isentrópica del compresor	0,7
Eficacia volumétrica del compresor	0,82
Eficacia del motor eléctrico	0,85
POTENCIA RESIDUAL	
Controles	0,01 kW

10 Los resultados del análisis de los rendimientos en un frigorífico-congelador usando estas condiciones de funcionamiento se muestran en la Tabla 4. Por comparación, también se muestran los rendimientos de R12 y R134a

Tabla 4

Refrigerante	R12	R134a	1	2	3	4	5
R125, % en peso			5	6	8	6	6
R134a, % en peso			93	92	90	92	92
R227ea						5,7	5,7
R600, % en peso			0,6	0,7	0,7		0,6
R601a, % en peso			0,7	0,6	0,6	0,6	
R600a, % en peso			0,7	0,7	0,7	0,7	0,7
Presión de descarga (bar) (x100 kPa)	12,59	13,68	13,97	14,09	14,22	14,25	14,37
Temperatura de descarga (°C)	96,7	90,5	89,4	89,3	89,2	87,4	87,2
COP (sistema)	1,56	1,50	1,49	1,48	1,48	1,47	1,47
Capacidad (kW/m³)	568	508	515	518	522	517	523
Variación en el evaporador (°C)	0	0	0,6	0,7	0,8	0,8	0,6
Variación en el condensador (°C)	0	0	0,9	1,0	1,3	1,2	0,9

EJEMPLO 5

Mezclas que comprenden fluidos seleccionados entre R125, R134a, R227ea, R600, R600a y R601a

Los rendimientos de diversas mezclas se evaluaron en un ciclo abierto típico del usado en un congelador centrífugo usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación

POTENCIA DE REFRIGERACIÓN LIBERADA	1 mW
EVAPORADOR	
Temperatura media para la evaporación del fluido	0°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	45,0°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
COMPRESOR	
Eficacia isentrópica del compresor	0,7
POTENCIA RESIDUAL	0,07 mW

Los resultados del análisis de los rendimientos en la unidad frigorífico-congelador usando estas condiciones de funcionamiento se muestran en la Tabla 5 Por comparación, también se muestran los rendimientos de R12 y R134a

Tabla 5

Refrigerante	R12	R134a	1	2	3	4
R134a, % en peso		60	55	59	55	55
R227ea, % en peso		38	43	34	38,6	38
R125, % en peso				5	5	5
R601a, % en peso		0,6	0,6	0,7		
R600, % en peso		0,7	0,7		0,7	0,7
R600a, % en peso		0,7	0,7	1,3	0,7	1,3
Presión de descarga (bar) (x100 kPa)	11,21	11,42	11,29	11,96	11,97	12,01
Temperatura de descarga (°C)	84,8	72,5	71,5	73,1	72,1	72,1
COP (sistema)	1950	1820	1792	1902	1896	1903
Capacidad (kW/m3)	2,56	2,51	2,51	2,51	2,50	2,50

Reemplazamientos para R 502 en Refrigeración a Baja Temperatura
EJEMPLO 6

5 Mezclas que comprenden fluidos seleccionados entre R125, R143a, R134a, R227ea, R600a, R600 y R600a

Los rendimientos de diversas mezclas se evaluaron en un ciclo de refrigeración hermético típico del usado en cámaras congeladoras usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.

POTENCIA DE REFRIGERACIÓN LIBERADA	10 kW
EVAPORADOR	
Temperatura media para la evaporación del fluido	-35°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	35,0°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
INTERCAMBIADOR DE CALOR ENTRE TUBERÍA DE LÍQUIDO/TUBERÍA DE SUCCIÓN	
Eficacia	0,3

COMPRESOR

Eficacia del motor eléctrico	0,85
Eficacia isentrópica del compresor	0,7
Eficacia volumétrica del compresor	0,82

POTENCIA RESIDUAL

Interna y descongelación	0,3 kW
Ventilador externo	0,4 kW
Controles	0,1 kW

Los resultados del análisis de los rendimientos en la unidad frigorífico-congelador usando estas condiciones de funcionamiento se muestran en la Tabla 6. Por comparación, también se muestran los rendimientos de R12 y R134a.

Tabla 6

Refrigerante	R502	R22					
R125, % en peso			65	55		60	50
R143a, % en peso			33	43		33,4	43,4
R134a, % en peso						5	5
R601a, % en peso			0,6	0,6		0,9	0,9
R600, % en peso			0,7	0,7			
R600a, % en peso			0,7	0,7		0,7	0,7
Presión de descarga (bar) (x100 kPa)	15,46	14,07	16,71	16,71		16,25	16,13
Temperatura de descarga (°C)	78,8	120,3	69,3	69,3		71,2	72,8
COP (sistema)	1,56	1,67	1,44	1,44		1,44	1,46
Capacidad (kW/m3)	839	839	774	774		746	752
Variación en el evaporador (°C)	0,1	0	1,4	1,4		1,9	1,9
Variación en el condensador (°C)	0,0	0	1,7	1,7		2,1	2,0

Reemplazamientos para R12 en Aire Acondicionado Portátil

EJEMPLO 7

Mezclas que comprenden fluidos seleccionados entre R134a, R125, 600, 600a y 601a.

- 5 Los rendimientos de diversas mezclas se evaluaron en un ciclo de aire acondicionado estático típico usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.

POTENCIA DE REFRIGERACIÓN LIBERADA	10 kW
EVAPORADOR	
Temperatura media para la evaporación del fluido	7,0°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	60,0°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
COMPRESOR	
Eficacia isentrópica del compresor	0,7
Eficacia volumétrica del compresor	0,82

- 10 Los resultados del análisis de los rendimientos en la unidad de aire acondicionado usando estas condiciones de funcionamiento se muestran en la Tabla 7 Por comparación, también se muestran los rendimientos de R12 y R134a

Tabla 7 Reemplazamientos de CFC12 en Aire Acondicionado Portatil

Refrigerante	R12	R134a	1	2	3	4	5	6	7
R134 % en peso			85	87	91	92 2	93	90	92
R125 % en peso			12	10 8	6 9	5 5	5	7 8	6
R601a % en peso			0 6	0 9	0 7	0 6	0 7	0 9	0 6
R600 % en peso			1 8	0 7	0 7	0 7	0 6	1 3	1 4
R600a % en peso			0 6	0 6	0 7	1	0 7		
Presión de descarga (bar) (x100 kPa)	15 7	17 4	18 4	18 3	18 0	17 9	17 8	17 9	17 8
Temperatura de descarga (°C)	88 4	84 4	83 5	83 8	83 9	83 8	83 9	83 9	83 9
COP (sistema)	2 45	2 38	2 34	2 34	2 35	2 36	2 36	2 36	2 36
Capacidad (kW/m³)	1754	1771	1834	1825	1803	1798	1790	1796	1791
Variación en el evaporador (°C)	0	0	1 2	1 2	0 9	0 7	0 7	1 0	0 7
Varacion en el condensador (°C)	0	0	1 5	1 5	1 0	0 9	0 9	1 2	0 9

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Reemplazamientos para R12 en Equipos de Refrigeración Herméticos
EJEMPLO 8

Mezclas que comprenden fluidos seleccionados entre R134a, R125, 600, 600a y 601a.

5	Los rendimientos de diversas mezclas se evaluaron en un ciclo de aire acondicionado estático típico usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.	
	POTENCIA DE REFRIGERACIÓN LIBERADA	10 kW
	EVAPORADOR	
	Temperatura media para la evaporación del fluido	-20,0°C
	Supercalentamiento	5,0°C
	Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
	CONDENSADOR	
	Temperatura media de condensación del fluido	45,0°C
	Sub-refrigeración	5,0°C
	Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
	INTERCAMBIADOR DE CALOR ENTRE LA TUBERÍA DE LÍQUIDO/TUBERÍA DE SUCCIÓN	
	Eficacia	0,3
	COMPRESOR	
	Eficacia del motor eléctrico	0,85
	Eficacia isentrópica del compresor	0,7
	Eficacia volumétrica del compresor	0,82
	POTENCIA RESIDUAL	
	Ventilador interno	0,3 kW
	Ventilador externo	0,4 kW
	Controles	0,1 kW

Los resultados del análisis de los rendimientos en la unidad de aire acondicionado usando estas condiciones de funcionamiento se muestran en la Tabla 8. Por comparación, también se muestran los rendimientos de R12 y R134a.

10

Tabla 8 Reemplazamientos de CFC12 en Aire Acondicionado Portátil

Refrigerante	R12	R134a	1	2	3	4	5	6	7
R134 % en peso			86	90 9	82 5	84 6	86 4	90	92 5
R125 % en peso			11	7	14	12	11	7	5
R601a % en peso			0 9	0 7	0 9	0 6	0 6	0 8	1
R600 % en peso			2 1	1 4	2	2 1	1 4	1 4	0 7
R600a % en peso					0 6	0 7	0 6	0 8	0 8
Presion de descarga (bar)	11 21	12 06	12 61	12 39	12 88	12 80	12 76	12 43	12 28
Temperatura de descarga (°C)	127 6	118 2	115 0	116 0	114 2	114 5	115 1	115 6	116 2
COP (sistema)	1 36	1 34	1 33	1 34	1 33	1 33	1 33	1 34	1 34
Capacidad (kW/m³)	698	653	682	670	696	693	690	673	664
Variación en el evaporador (°C)	0	0	1 3	0 9	1 6	1 3	1 2	1 0	1 0
Variación en el condensador (°C)	0	0	1 8	1 2	2 1	1 7	1 6	1 3	1 2

Reemplazamientos para R22 en Aire Acondicionado Interior

EJEMPLO 9

Mezclas que comprenden fluidos seleccionados entre R134a, R125, 600, 600a y 601a

- 5 Los rendimientos de diversas mezclas se evaluaron en un ciclo de aire acondicionado estático típico usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.

POTENCIA DE REFRIGERACIÓN LIBERADA 10 kW

EVAPORADOR

Temperatura media para la evaporación del fluido 7,0°C

Supercalentamiento 5,0°C

Pérdida de presión en la tubería de succión (en temperatura saturada) 1,5°C

CONDENSADOR

Temperatura media de condensación del fluido 45,0°C

Sub-refrigeración 5,0°C

Pérdida de presión en la tubería de descarga (en temperatura saturada) 1,5°C

INTERCAMBIADOR DE CALOR ENTRE LA TUBERÍA DE LÍQUIDO/TUBERÍA DE SUCCIÓN

Eficacia 0,3

COMPRESOR

Eficacia del motor eléctrico 0,85

Eficacia isentrópica del compresor 0,7

Eficacia volumétrica del compresor 0,82

POTENCIA RESIDUAL

Ventilador interno 0,3 kW

Ventilador externo 0,4 kW

Controles 0,1 kW

- 10 Los resultados del análisis de los rendimientos en la unidad de aire acondicionado usando estas condiciones de funcionamiento se muestran en la Tabla 9. Por comparación, también se muestran los rendimientos de R22 y R407C.

Tabla 9 - Reemplazamientos para R22 especialmente en unidades de expansión de orificio fijo

Refrigerante	R-22	R407C	1	2	3	4	5
R134a, % en peso			42,2	44,3	46,3	47,8	49,3
R125, % en peso			55	53	51	49	48
R601a			0,8	0,9	0,6	0,8	1
R600			0,8	1	1,4	1,5	1
R600a			1,2	0,8	0,7	0,9	0,7
Presión de descarga (bar) (x100 kPa)	17,91	19,30	16,05	15,78	15,64	15,37	15,27
Temperatura de descarga (°C)	104,7	92,5	78,3	78,6	78,7	78,9	79,1
COP (sistema)	2,49	2,47	2,48	2,48	2,49	2,49	2,49
Capacidad (kW/m³)	3067	3172	2671	2635	2619	2580	2566
Variación en el evaporador (°C)	0	4,8	4,0	4,1	3,7	3,9	4,1
Variación en el condensador (°C)	0	4,7	3,8	3,9	3,7	3,9	4,0

Reemplazamientos para R 502 en Refrigeración a Baja Temperatura
EJEMPLO 10

Mezclas que comprenden fluidos seleccionados entre R125, R143a, R134a, R600a, R600 y R600a

- 5 Los rendimientos de diversas mezclas se evaluaron en un ciclo de refrigeración hermético típico del usado en algunas cámaras congeladoras usando el programa NIST CYCLE D. Las condiciones de modelado se dan a continuación.

POTENCIA DE REFRIGERACIÓN LIBERADA	10 kW
EVAPORADOR	
Temperatura media para la evaporación del fluido	-35°C
Supercalentamiento	5,0°C
Pérdida de presión en la tubería de succión (en temperatura saturada)	1,5°C
CONDENSADOR	
Temperatura media de condensación del fluido	35,0°C
Sub-refrigeración	5,0°C
Pérdida de presión en la tubería de descarga (en temperatura saturada)	1,5°C
INTERCAMBIADOR DE CALOR ENTRE LA TUBERÍA DE LÍQUIDO/TUBERÍA DE SUCCIÓN	
Eficacia	0,3
COMPRESOR	
Eficacia del motor eléctrico	0,85
Eficacia isentrópica del compresor	0,7
Eficacia volumétrica del compresor	0,82
POTENCIA RESIDUAL	
Ventilador interno y descongelación	0,3 kW
Ventilador externo	0,4 kW
Controles	0,1 kW

- 10 Los resultados del análisis de los rendimientos en la unidad frigorífico-congelador usando estas condiciones de funcionamiento se muestran en la Tabla 10 Por comparación, también se muestran los rendimientos de R12 y R134a

Tabla 10

Refrigerante	R502	R22	1	2	3	4	5	6	7	8
R125 % en peso			65	55	60 5	63 9	60 5	62 4	60	50
R143a % en peso			33	43	37	34	37	35	33 4	43 4
R134a % en peso									5	5
R601a % en peso			0 6	0 6			0 6	0 6	0 9	0 9
R600 % en peso			0 7	0 7	1	1 2	1	1 3		
R600a % en peso			0 7	0 7	1 5	0 9	0 9	0 7	0 7	0 7
Presion de descarga (bar) (x100 kPa)	15 46	14 07	16 71	16 71	16 76	16 90	16 50	16 46	16 25	16 13
Temperatura de descarga (°C)	78 8	120 3	69 3	69 3	105 4	104 7	107 3	107 1	71 2	72 8
COP (sistema)	1 56	1 67	1 44	1 44	1 09	1 09	1 08	1 08	1 44	1 46
Capacidad (kW/m³)	839	839	774	774	675	679	651	647	746	752
Variación en el evaporador (°C)	0 1	0	1 4	1 4	0 9	0 8	2 7	2 9	1 9	1 9
Variación en el condensador (°C)	0 0	0	1 7	1 7	0 9	0 8	1 9	2 0	2 1	2 0

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REIVINDICACIONES

1. Una composición refrigerante que está constituida esencialmente por una combinación de un componente hidrofluorocarburo constituido por una
5 combinación seleccionada entre las siguientes mezclas.
- (1) R134a y R125;
 - (2) R134a, R125 y R143a
 - (3) R125 y R143a
 - (4) R134a, R227ea y R125
- 10 y un componente hidrocarburo que está constituido esencialmente por una combinación seleccionada entre las siguientes mezclas.
- (5) isopentano y butano
 - (6) isopentano, butano e isobutano
 - (7) butano e isobutano.
- 15
2. Una composición de acuerdo con la reivindicación 1, que está constituida por una mezcla de uno de los componentes hidrofluorocarburo (1) a (4) y uno de los componentes hidrocarburo (5) a (7).
- 20 3. Una composición de acuerdo con la reivindicación 1 ó 2, en la que el hidrocarburo está presente en una cantidad del 0,6 al 4% y en la que dicha composición es no inflamable cuando está completamente en fase de vapor.
4. Una composición de acuerdo con cualquier reivindicación anterior, en la
25 que el hidrocarburo está presente en una cantidad del 0,6 al 4% y en la que cuando la composición está en un recipiente en el que están presentes vapor y líquido, ni la fase de vapor ni la líquida son inflamables.
5. Una composición de acuerdo con cualquier reivindicación anterior, en la
30 que el hidrocarburo está presente en una cantidad del 0,6 al 4% y en la que en cualquier momento durante una filtración del espacio de vapor en un recipiente, ni la fase líquida ni la fase de vapor son inflamables
6. Una composición de acuerdo con cualquier reivindicación anterior, en la
35 que el hidrocarburo está presente en una cantidad del 0,6 al 4% y en la que en

cualquier momento durante una filtración del espacio de líquido de un recipiente, ni la fase líquida ni la fase de vapor son inflamables

- 5 7. Una composición de acuerdo con cualquier reivindicación anterior, en la que el hidrocarburo está presente en una cantidad del 0,6 al 4% y en la que la proporción de hidrocarburo a hidrofluorocarburo en la fase de vapor no difiere de la proporción equivalente en la fase líquida en más de un 40% en equilibrio a 25°C.
- 10 8. Una composición de acuerdo con la reivindicación 7, en la que la proporción no difiere en más del 30%.
9. Una composición de acuerdo con la reivindicación 8, en la que dicha composición no difiere en más del 20%.
- 15 10. Una composición de acuerdo con cualquier reivindicación anterior, en la que el hidrocarburo está presente en una cantidad del 0,6 al 4% y en la que la proporción de hidrocarburo a hidrofluorocarburo en la fase de vapor no difiere de la composición formulada en más del 40% en equilibrio a 25°C
- 20 11. Una composición de acuerdo con la reivindicación 10, en la que la proporción no difiere en más del 30%.
12. Una composición de acuerdo con la reivindicación 11, en la que la proporción no difiere en más del 20%.
- 25 13. Una composición de acuerdo con cualquier reivindicación anterior, en la que durante una filtración del espacio de vapor o del espacio de líquido de un recipiente, la proporción de hidrocarburo a hidrofluorocarburo en la fase de vapor o en la fase líquida no difiere de la composición formulada en más del 40% en equilibrio a 25°C
- 30 14. Una composición de acuerdo con la reivindicación 13, en la que la proporción no difiere en más del 40%.
- 35

- 15 Una composición de acuerdo con la reivindicación 14, en la que la proporción no difiere en más del 20%.
- 5 16. Una composición de acuerdo con cualquier reivindicación anterior, en la que el componente hidrocarburo está constituido por una mezcla de isopentano, butano e isobuteno
- 10 17 Una composición de acuerdo con la reivindicación 16, en la que la cantidad de isopentano es del 0,6 al 2%
- 15 18 Una composición de acuerdo con la reivindicación 17, en la que la cantidad de isopentano es del 0,6 al 1%.
- 15 19. Una composición de acuerdo con cualquiera de las reivindicaciones 16 a 18, en la que la cantidad de butano es del 0,6 al 5%.
- 20 20. Una composición de acuerdo con la reivindicación 19, en la que la cantidad de butano es del 0,6 al 3%
- 20 21. Una composición de acuerdo con la reivindicación 20, en la que la cantidad de butano es del 0,6 al 2%.
- 25 22 Una composición de acuerdo con cualquiera de las reivindicaciones 16 a 21, en la que la cantidad de butano es del 0,6 al 5%.
- 25 23. Una composición de acuerdo con la reivindicación 22, en la que la cantidad de butano es del 0,6 al 2%.
- 30 24. Una composición de acuerdo con la reivindicación 23, en la que la cantidad de butano es del 0,6 al 1%.
- 35 25. Una composición de acuerdo con cualquiera de las reivindicaciones 1 a 15, en la que el componente hidrocarburo está constituido por una mezcla de isopentano y butano

- 26 Una composición de acuerdo con la reivindicación 25, en la que la cantidad de isopentano es del 0,6 al 1%
27. Una composición de acuerdo con la reivindicación 25 ó 26, en la que la
5 cantidad de butano es del 1,3 al 2,5%.
- 28 Una composición de acuerdo con la reivindicación 27, en la que la cantidad de butano es de aproximadamente el 1,4%.
- 10 29 Una composición de acuerdo con cualquiera de las reivindicaciones 1 a 15, en la que el componente hidrocarburo está constituido por butano e isobutano
30. Una composición de acuerdo con la reivindicación 29, en la que la
15 cantidad de butano es del 0,6 al 5%.
- 31 Una composición de acuerdo con la reivindicación 29 ó 30, en la que la cantidad de isobutano es del 0,6 al 5%
- 20 32 Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por
- | | |
|------------|-------------------|
| R134a | del 93,1 al 81,5% |
| R125 | 5-15% |
| isopentano | del 0,6 al 1% |
| butano | del 1,3 al 2,5% |
33. Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por
- | | |
|------------|------|
| R134a | 83% |
| R125 | 5% |
| isopentano | 0,6% |
| butano | 1,4% |
- 25 34. Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por:

R134a	del 93,2 al 80%
R125	del 5 al 15%
isopentano	del 0,6 al 1%
butano	del 0,6 al 3%
isobutano	del 0,6 al 1%

35 Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por

R134a	93%
R125	5%
isopentano	0,6%
butano	0,8%
isobutano	0,6%

5 36 Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por

R134a	del 53,2 al 39%
R125	del 45 al 55%
isopentano	del 0,6 al 1%
butano	0,63%
isobutano	0,62%

37 Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por:

R134a	47,5%
R125	50%
isopentano	0,6%
butano	1%
isobutano	0,9%

10

38. Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por

R134a	del 10 al 30%
R125	del 80 al 40%
R143a	del 10 al 30%

isopentano	del 0,6 al 2%
butano	del 0,6 al 5%
isobutano	del 0,6 al 5%

39 Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por:

R134a	16,5%
R125	60%
R143a	21%
isopentano	0,6%
butano	0,9%
isobutano	1%

5 40. Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por:

R125	del 75 al 55%
R143a	del 25 al 45%
butano	del 0,6 al 5%

41. Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por:

R125	60,5%
R143a	37%
butano	1%
isobutano	1,5%

10

42. Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por:

R125	60,5%
R143a	37%
butano	0,9%
isobutano	1%
isopentano	0,6%

43. Una composición refrigerante de acuerdo con cualquiera de las

reivindicaciones 1-13 que está constituida esencialmente por:

R134a	del 58,2 al 36%
R227ea	del 35 al 50%
R125	del 5 al 8%
isopentano	del 0,6 al 2%
butano	del 0,6 al 2%
isobutano	del 0,6 al 2%

44 Una composición refrigerante de acuerdo con cualquiera de las reivindicaciones 1-13 que está constituida esencialmente por.

R134a	51%
R227ea	41%
R125	6%
isopentano	0,6%
butano	0,8%
isobutano	0,6%

Resumen:

Una composición refrigerante está constituida esencialmente por una combinación de un componente hidrofluorocarburo que está constituido por una combinación seleccionada entre las siguientes mezclas. (a) R134a y R125; (b) 5 R134a, R125 y R143a; (c) R125 y R143a; (d) R134a, R227ea y R125 y un componente hidrocarburo que está constituido esencialmente por una combinación seleccionada entre las siguientes mezclas. (e) isopentano y butano; (f) isopentano, butano e isobutano; (g) butano e isobutano.

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World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse



INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
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NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

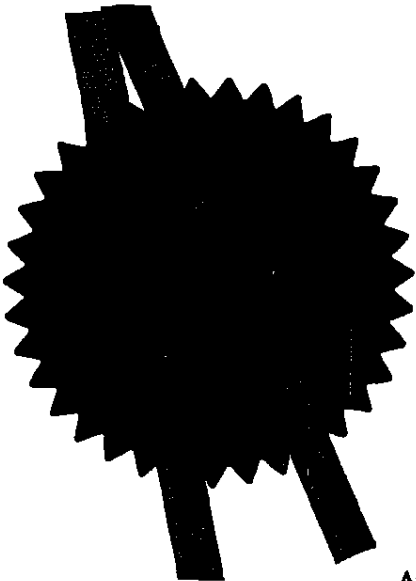
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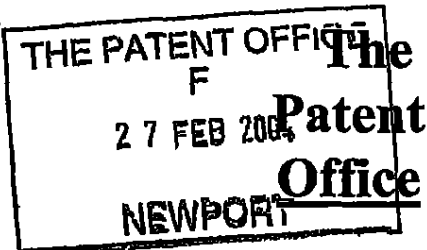
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Cardiff Road
Newport
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27 FEB 2004

1. Your reference

RFB/P202809

2. Patent application number
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0404343.6

3. Full name, address and postcode of the applicant (underline all surnames)

RPL Holdings Limited
N9 Central Park Estate
Westinghouse Road
Trafford Park
Manchester M17 1PG

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

08818387001

Title of the invention

REFRIGERANT COMPOSITION

5. Name of your agent (if you have one)

URQUHART-DYKES & LORD

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Tower North Central
Merrion Way
Leeds LS2 8PA
United Kingdom

Patents ADP number (if you know it)

1644004 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country	Priority application number (if you know it)	Date of filing (day/month/year)
---------	--	---------------------------------

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing (day/month/year)
-------------------------------	---------------------------------

8. Is a statement of Inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
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REFRIGERANT COMPOSITION

This invention relates to refrigerant compositions which have no adverse effect on stratospheric ozone and to compositions which are for use both in refrigeration and air conditioning systems designed to use Ozone Depleting Substances (ODS) CFC12 (dichlorodifluoromethane), CFC502 (azeotrope of chloropentafluoromethane and chlorodifluoromethane) and HCFC22 (chlorodifluoromethane) and additionally in new equipment. These new refrigerant compositions are compatible with lubricants commonly found in refrigeration and air conditioning systems.

It is well known that chlorofluorocarbons (CFCs) such as CFC12 and CFC502 and hydrochlorofluorocarbons such as HCFC22 while being energy efficient, non flammable and of low toxicity migrate to the stratosphere where they are broken down by ultra violet light to attack the ozone layer. These Ozone Depleting Substances are in the process of being replaced by non ozone depleting alternatives such as hydrofluorocarbons (HFCs) which are also non flammable, efficient and of low toxicity. There are six main HFCs, namely HFC134a, HFC32, HFC125, HFC143a, HFC227ea and HFC152a, which either individually or blended into mixtures can replace CFCs and HCFCs. While HFC134a, HFC227ea and HFC152a can be used to replace ODS directly, HFC32, HFC143a, and HFC125 are generally found in blends as replacements for ODS. However, HFCs do not have adequate solubility in traditional lubricants such as mineral and alkylbenzene oils so that synthetic oxygen containing lubricants have been introduced specifically for new equipment. These new lubricants are expensive and hygroscopic.

Refrigerant blends such as R404A, R507, R410A, R407C and others have been commercialised as replacements for CFCs and HCFCs but, because these compositions contain only HFC components, they cannot be used with the traditional lubricants commonly found in use with CFCs and HCFCs. If these blends are to be used to replace CFCs and HCFCs in existing equipment, the major chemical manufacturers recommend that no more than 5% of the traditional lubricant in the system be retained so that a virtual complete change of lubricant to a synthetic oxygen containing lubricant resulting in a full retrofit is required, which is often costly and technically unsatisfactory.

Although equipment manufacturers have adapted their units to operate with HFC blends, they do not always find the commercially available products as satisfactory as the CFCs and HCFCs that these new refrigerants are replacing. In particular to ensure adequate oil return, hydrocarbon lubricants, such as mineral oil, have been replaced by oxygen containing lubricants, notably polyol esters and polyalkylene glycols. Unfortunately these materials are liable to absorb atmospheric moisture, especially during maintenance, which can contribute to excessive corrosion and wear in equipment thus reducing its reliability. A key objective of this patent is to provide HFC/hydrocarbon blends that enable the continued use of hydrocarbon oils in both existing and new equipment.

Additionally some refrigerants, such as R07C, have wide temperature glides ($> 4^{\circ}\text{C}$) in the evaporator and condenser, whereas equipment manufacturers, based on their experience with CFC/HCFC single fluids or azeotropes, prefer refrigerants with low glides. A further key objective of this invention, therefore, is to provide

HFC/hydrocarbon blends that can substitute for CFC 12, HCFC 22 and azotrope 502 (CFC 115/HCFC 22) both allowing the continued use of hydrocarbon lubricants in equipment and minimising the temperature glides in the heat exchangers.

The present invention relates to refrigerant compositions, which are non flammable under all conditions of fractionation as defined under ASHRAE Standard 34, and which can be used to replace ODS in an existing unit without the need to change the lubricant or make any significant change to the system hardware. In new equipment the refrigerant compositions allow the continued use of hydrocarbon oils, although the manufacturers may take the opportunity to modify their units to optimise the performances of the new refrigerants, for example by selecting the most appropriate lengths of capillary tubes. Where the ingress of moisture or other problems are being experienced with oxygen containing oils the new compositions allow such oils to be replaced by hydrocarbon oils

It is known in the art that the addition of a small amount of hydrocarbon to a refrigerant composition containing an HFC or HFC mixtures can result in sufficient hydrocarbon being dissolved in the lubricant to be transported around the system so that lubrication of the compressor is maintained at all times. It is obvious that the greater the hydrocarbon content of the composition the greater the ability of the refrigerant to transport the lubricant back to the compressor. However, too high a hydrocarbon content can lead to flammable mixtures. Although flammable refrigerants are acceptable in some applications, this invention relates to non flammable compositions for use in equipment where flammable refrigerants are prohibited. However, it is not well understood how to achieve non flammable compositions under all conditions including fractionation of the refrigerant compositions which can take place during a leak of the refrigerant from the system or during storage.

Not all HFCs are non flammable as defined under ASHRAE Standard 34. HFC143a and HFC32 have not received a non flammable rating by ASHRAE. This invention relates to compositions of refrigerants which not only covers blends of non flammable HFCs with hydrocarbons but also blends of flammable HFCs, non flammable HFCs and hydrocarbons in selected proportions such that all such compositions are non flammable during fractionation while providing similar refrigerating effects and thermodynamic performances as the ODS they replace, namely CFC12, CFC502 and HCFC22.

While this invention relates to refrigerant compositions which can be used with traditional lubricants such as mineral and alkylbenzene oils, they are also suitable for use with synthetic oxygen containing lubricants.

In formulating HFC/hydrocarbon blends to replace CFC 12, CFC 502 and HCFC 22 in specific applications it is generally necessary to use one or more lower boiling HFCs, with one or more higher boiling HFCs. In this context preferred lower boiling HFCs are HFC 32, HFC 143a and HFC 125, and higher boiling HFCs are HFC 134a, HFC 134, HFC 227ea and HFC 152a.

To avoid flammability in the blend, or in a fraction generated by a leak, for example as defined by ASHRAE Standard 34, the total amount of hydrocarbon should be

minimised. At the same time the quantity of the hydrocarbon mixture dissolved in the oil needs to be maximised for good oil return, especially at those locations in the circuit where the oil is at its most viscous, for example the evaporator. A single higher boiling hydrocarbon, such as pentane or *iso*-pentane, would certainly show higher solubility in the oil than a lower boiling hydrocarbon. However, as the result of a leak, for example from a cylinder, a higher boiling hydrocarbon will concentrate in the liquid phase. The amount of hydrocarbon will, therefore, need to be limited in order to avoid generating a flammable mixture towards the end of the leak.

This problem could be avoided by using only a low boiling hydrocarbon such as propane or *iso*-butane. However, this has 2 disadvantages. Firstly, lower boiling hydrocarbons are less soluble than higher boiling hydrocarbons in hydrocarbon lubricants in the evaporator when present at similar weights % as formulated in the blend. Consequently they are less effective at ensuring good oil return. Secondly, because of their higher volatility they tend to concentrate in the vapour phase of a blend. Their concentration therefore needs to be restricted to avoid generating flammable mixtures at the beginning of a leak. This problem is exacerbated if the one or more of the lower boiling HFCs is also flammable.

Surprisingly we have found that the best approach to formulating HFC/HC refrigerant blends is to use combinations of 2 and preferably 3 hydrocarbons with different boiling points. This allows the total amount of hydrocarbon of the blend to be reduced while simultaneously the amount dissolved in the oil in the evaporator is increased.

This approach has the following advantage. Hydrocarbon components facilitate oil return, but, because of their flammability, restrict the weights of flammable HFCs, notably HFC 32 and HFC 143a that can be included. Inclusion of these fluids can be valuable in achieving the required balance of thermodynamic properties, so minimising the amounts of hydrocarbon present allows more scope in formulating preferred blends.

The blending of HFCs to achieve the desired balance of physical properties appropriate to various cooling applications is well known and a variety of products are available commercially, for example R407C, R410A and R410B. Although these have been selected for specific applications in combination with oxygen containing synthetic lubricants, simply adding 2 or 3 hydrocarbon components to these products does not achieve the preferred products for use with hydrocarbon lubricants. Firstly, the hydrocarbon components contribute to the overall thermodynamic properties of the blend so will affect the preferred ratios of the HFCs. Secondly, the ratio of flammable to non-flammable HFCs will need to be selected to ensure non-flammability, for example, as required by the ASHRAE 34 Standard.

Blends of HFC125, HFC134a, HFC143a, HFC32, HFC227ea and optionally carbon dioxide, are particularly preferred as replacements for CFCs and HCFCs. Both HFC125 (pentafluoroethane) and R227ea are non flammable under all operating conditions and in addition are fire suppressants, an application for which they have been developed by the fire fighting industry. The presence of HFC227ea provides a twofold advantage of reducing the flammability of the composition and also enhances oil return to the compressor due to emulsification of the lubricant in the presence of a hydrocarbon.

Blends of HFC134a, HFC227ea, HFC125 and mixtures of selected hydrocarbon additives have been found to be preferred replacements for CFC12 in centrifugal chillers. It has been found that the interaction of hydrocarbon additives in such mixtures facilitates non flammable mixtures during all conditions of leakage during fractionation so that non flammability can be achieved according to ASHRAE Standard 34. The presence of hydrocarbons results in the lubricant being returned to the compressor. The presence of R227ea enables the requisite molecular weight of the blend to match that of CFC12 and additionally facilitates non flammability due to its fire retardant properties. The presence of R125 increases the capacity of the blend. The resulting mixtures are a close match for CFC12 in thermodynamic and system performance.

Surprisingly it has been found that given the same percentage content of hydrocarbon additive in the refrigerant composition, increasing the HFC125 content of the composition results in flammable mixtures being created during fractionation. This is very surprising since it would seem obvious that the greater the amount of HFC125 in the composition the less would be the likelihood to generate a flammable mixture during fractionation. The reasons for this apparent anomaly relate to the pressure/temperature relationship between the quantities of HFC125 and HFC134a in the mixture and the amount and type of hydrocarbon and/or hydrocarbon mixture. The following refrigerant compositions were made up and leaked away until the cylinder was almost liquid empty according to ASHRAE Standard 34:

	%	
	Blend 1	Blend 2
R134a	48.0	21.0
R125	49.0	76.0
Butane	2.7	2.5
Isopentane	0.3	0.5

Blend 2 with the considerably higher HFC125 content was found to create a flammable composition during fractionation, while Blend 1 with a lower HFC125 content remained non flammable throughout fractionation.

In GC 2727427 N A Roberts teaches that, if a hydrocarbon with at least four carbon atoms other than methyl propane (isobutane) is used, surprisingly the flammability of the fractionated composition is greatly reduced. Surprisingly, we have now found that the inclusion of isobutane with appropriately chosen hydrocarbons does not result in flammable compositions during fractionation. It has been found that the selection of the hydrocarbon additive or mixtures thereof with the HFC components is critical to achieving non flammability under all operating conditions and as defined under ASHRAE Standard 34.

In US5,800,730 it is stated that HFC 134a needs to be added to blends of HFC125 and HFC143a as a replacement for CFC502 in order to avoid a flammable mixture (example 3). Surprisingly we have found that by excluding HFC134a, changing the proportion of HFC125 to HFC143a and adding a selected range of hydrocarbons results in a composition which is non flammable during fractionation and a close match for R502 with regard to thermodynamic performance. Compositions of HFC125, HFC143a, HFC134a and a hydrocarbon or mixtures of hydrocarbons can be formulated to achieve non flammable mixtures during fractionation.

In US5,211.867, azeotropic compositions are claimed of R125 and R143a. It is a key feature of this invention that a specially selected hydrocarbon or mixtures of hydrocarbons are present in order to facilitate oil return to the compressor. Surprisingly it has been found that, despite the flammability of HFC143a, the selection of a hydrocarbon or mixtures of hydrocarbons enables the compositions to be non flammable during fractionation. The combination of a high boiling hydrocarbon such as isopentane (BP 27°C) with butane (BP -0.5°C) and isobutane (BP -11.5°C) avoids build up of hydrocarbon content in the liquid phase during a leakage while the more volatile isobutane is countered in the vapour phase by the fire suppressant HFC125 due to the latter's higher vapour pressure and lower boiling point (BP -45°C). In order for the composition to be non flammable, the HFC125 content of the composition is above the azeotropic composition so that the content of HFC143a is reduced but without affecting the refrigerating performance of the composition as a replacement for CFC502.

It has also been found that a refrigerant composition comprising HFC134a, carbon dioxide and a hydrocarbon additive boiling between -15°C and +35°C matches the thermodynamic performance of HCFC22 and is also compatible with the traditional lubricants commonly found in use with HCFC22. Further, this composition has a lower direct Greenhouse Warming Potential (GWP) than all other non flammable HFC refrigerant blends intended to replace HCFC22..

Although the addition of hydrocarbons to HFCs has been previously described, it has not been previously appreciated that the volatilities of the hydrocarbons need to be matched to the application for which the refrigerant is intended. For example R12 is employed as the refrigerant in domestic freezers with evaporating temperatures of ~22 degC, in domestic fridges with evaporating temperatures of ~5 degC, and in mobile air conditioning with evaporating temperatures of ~5 degC. An important aspect of this invention is to formulate HFC/HC blends that ensure good oil return in these disparate applications while also ensuring that the refrigerant blend remains non-flammable according to the chosen criterion. For applications with evaporators operating at temperatures above -5 degC the higher boiling hydrocarbons are preferred. Specially preferred are isopentane, alone or mixed with butane. For applications with the evaporators operating in the range -20 degC to -5 degC mixtures of hydrocarbons containing a higher, an intermediate and a lower boiling point component are preferred. Especially preferred are blends containing isopentane, butane and isobutane. For evaporators operating below -20 degC HC mixtures containing isobutane and butane are preferred with optionally some isopentane.

According to the present invention, a refrigerant composition consists of one or more of:

- | | | |
|-----|----------------|--------|
| (a) | Carbon dioxide | 1-15% |
| | R134a | 95-85% |
| | R125 | 5-15% |

or a mixture thereof, wherein the aforesaid percentages are of the total composition of (a), (b) and (c),

(b) one or more of:

R134a	1-55%
R125	90-5%
R143a	10-49%
R32	15-30
R227ea	1-55

or a mixture thereof, wherein the aforesaid percentages are of the total composition of (a), (b) and (c),

(c) a hydrocarbon component selected from butane, n-pentane, 2-methylpropane, 2-methylbutane, propane and mixtures thereof in an amount from 0.1 to 4%.

Where R134a is present as component (1) and component (2) the amount of R134a will be from 45% to 99% by weight.

Where R125 is present as component (1) and component (2) the amount of R125 will be from 5% to 90% by weight.

Component (3) will be present in an amount from a trace to 4% by weight.

Component (1) will be present from an amount 1% to 95% by weight.

Component (2) will be present from an amount 1% to 90%.

Where R134a alone or R134a and R125 are present as replacements for R12, component (3) will be a mixture of pentane and n-butane or isopentane and n-butane or isopentane, butane and isobutane.

As a replacement for CFC12, the preferred weights of R125 and R134a are in the ranges:

R125	5-15%
R134a	95-85%

A more preferred range is:

R125	5-12%
R134a	95-88%

A most preferred range is:

R125	5-10%
R134a	95-90%

As a replacement for CFC12 in centrifugal chillers, the preferred weights of R134a, R227ea and R125 are in the ranges:

R134a	67-35%
R227ea	30-55%
R125	3-10%

A more preferred range is:

R134a	62-42%
R227ea	35-50%
R125	3-8%

A most preferred range is:

R134a	61-48%
R227ea	37-45%
R125	2-7%

As a replacement for HCFC22, the preferred weights for carbon dioxide and R134a are:

Carbon dioxide	5-15%
R134a	95-85%

A more preferred range is:

Carbon dioxide	5-12%
R134a	95-88%

A most preferred range is:

Carbon dioxide	5-10%
R134a	95-90%

As a replacement for HCFC22, the preferred weights of R125 and R134a are:

R125	45-90%
R134a	55-10%

A more preferred range is:

R125	45-85%
R134a	55-15%

A most preferred range is:

R125	45-80%
R134a	55-20%

As a replacement for HCFC22, the preferred weights of R125, R134a and R143a are:

R125	80-40%
R134a	10-30%
R143a	10-30%

A more preferred range is:

R125	76-40%
R134a	12-30%
R143a	12-30%

A most preferred range is:

R125	70-50%
R134a	15-25%
R143a	15-25%

As a replacement for HCFC22, the preferred weights of R125, R134a and R32 are

R125	20-35%
R134a	65-45%
R32	15-30%

A more preferred range is:

R125	20-35%
R134a	65-40%
R132	15-25%

A most preferred range is:

R125	20-35%
R134a	65-44%
R32	15-21%

As a replacement for CFC502, the preferred weights of R125 and R134a are:

R125	80-95%
R134a	20-5%

A more preferred range is:

R125	83-95%
R134a	17-5%

A most preferred range is:

R125	85-93%
R134a	15-7%

As a replacement for CFC502, the preferred weights of R125 and R143a are:

R125	75-55%
R143a	25-45%

A more preferred range is:

R125	70-55%
R143a	30-45%

A most preferred range is:

R125	70-60%
R143a	30-40%

As a replacement for CFC502, the preferred weights of R125, R143a and R134a are:

R125	75-50%
R143a	15-49%
R134a	10-1%

A more preferred range is:

R125	70-50%
R143a	27-43%
R134a	3-7%

A most preferred range is:

R125	65-50%
R143a	32-43%
R134a	3-7%

As a replacement for CFC502, the preferred weights of R125, R143a and R227ea are:

R125	75-50%
R143a	15-49%
R227ea	10-1%

A more preferred range is:

R125	70-50%
R143a	27-43%
R227ea	3-7%

A most preferred range is:

R125	65-50%
R143a	32-43%

R227ea

3-7%

Preferred hydrocarbon additives are selected from the group consisting of: 2-methylbutane (isopentane), propane, n-pentane, 2-methylpropane (isobutane) and butane or mixtures thereof. The hydrocarbon additive preferably has a boiling point in the range -15°C to $+35^{\circ}\text{C}$. Use of isopentane, butane, isobutane or mixtures thereof is especially preferred.

Relative proportions of isopentane and butane components, and isopentane, butane and isobutane components may be selected to give a total hydrocarbon content from a trace to 4% of the composition, preferably 0.1% to 4% and most preferably 0.3% to 3% by weight.

Percentages and other quantities in the specification are by weight unless indicated otherwise and are selected to total of 100%.

The invention is further described by means of examples but not in any limitative sense.

Replacements for R22 In Room Air Conditioning

EXAMPLE 1

Blends comprising fluids selected from R125, R143a, 134a, 600, 600a and 601a.

The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Tables 1a and 1b. For comparison the performances of R22 and R407C are also shown.

Table 1a

Refrigerant	R 22	R407 C	1	2	3	4	5	6	7	8	9	10
R125 wt%			33	33	38	50	60	33	38	50	60	63
R143a wt %			35	38	40	23	23	40	40	33	23	23
R134a wt%			30	27	20	25	15	25	20	15	15	12
R600			1	1	1	1	1	13	13	13	13	13
R600a			1	1	1	1	1					
R601a								0 7	0 7	0 7	0 7	0 7
Discharge pressure (bar)	17 9 1	19 30	18 00	18 50	19 01	18 64	19 80	19 21	18 67	19 28	19 42	19 85
Discharge temperature (C)	104 7	92 5	79 6	79 3	78 8	78 1	76 8	79 0	79 5	78 4	77 6	75 4
COP (system)	2 49	2 47	2 45	2 44	2 43	2 44	2 41	2 42	2 4 4	2 42	2 42	2 39
Capacity (kW/m3)	3067	3172	2870	2933	2995	2938	3072	3005	29 44	3008	3015	3019
Glide in evaporator (°C)	0	4 8	2 4	2 2	2 0	2 4	1 9	3 0	3 2	3 1	3 2	3 8
Glide in condenser (°C)	0	4 7	2 1	2 0	1 8	2 1	1 7	2 5	2 7	2 6	2 7	3 1

Table 1b

Refrigerant	R 22	R407C	1	2	3	4	5	6	7	8
R125 wt /			30	33	35	38	39	60	50	40
R143a wt%			23	25	28	30	34	23	30	35
R134a wt%			45	40	35	30	25	15	18	23
R600			1 3	1 3	1 3	1 3	1 3			
R600a			0 7	0 7	0 7	0 7	0 7	1 3	1 3	1 3
R601a								0 7	0 7	0 7
Discharge pressure (bar)	17 91	19 30	16 54	17 01	17 49	17 99	18 48	19 66	19 21	18 61
Discharge temperature (°C)	104 7	92 5	80 2	79 9	79 6	79 2	79 0	77 3	78 2	79 2
COP (system)	2 49	2 47	2 48	2 47	2 46	2 45	2 44	2 41	2 42	2 44
Capacity (kW/m3)	3067	3172	2678	2740	2802	2865	2928	3043	2998	2933
Glide in evaporator (°C)	0	4 8	2 7	2 7	2 6	2 5	2 3	2 8	2 8	2 9
Glide in condenser (°C)	0	4 7	2 5	2 5	2 4	2 3	2 1	2 3	2 3	2 5

EXAMPLE 2

Blends comprising fluids selected from R32, R125, 134a, 600, and 600a.
 The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 2. For comparison the performances of R22 and R407C are also shown.

Tabl 2

Refrigerant	R-22	R407C	1	2
R32 wt%		23	20	20
R125 wt%		25	21	23
R134a wt%		52	57	55
R600 wt%			1	1
R600a wt%			1	1
Discharge pressure (bar)	17.91	19.30	18 13	18.50
Discharge temperature (°C)	104.7	92.5	90 9	90.6
COP (system)	2.49	2.47	2.49	2.48
Capacity (kW/m3)	3067	3172	2995	3045
Glide in evaporator (°C)	0	4.8	4.9	4.8
Glide in condenser (°C)	0	4.7	5.0	4.9

EXAMPLE 3

Blends comprising fluids selected from R125, R143a, R227ea, 600, 600a and 601a
The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 3. For comparison the performances of R22 and R407C are also shown.

Table 3

Refrigerant	R-22	R407C	1	2	3	4	5	6	7
R125 wt%			55	45	40	39	38	55	55
R143a wt%			33	38	38	34	40	23	33
R227ea wt%			10	15	20	25	20	20	10
R600 wt%						1.3	1	1.3	1.3
R600a wt%			0.7	0.7	0.7	0.7	1	0.7	0.7
R601a wt%			1.3	1.3	1.3				
Discharge pressure (bar)	17.91	19.30	19.87	19.23	18.65	18.45	19.03	19.20	20.25
Discharge temperature (°C)	104.7	92.5	76.7	76.9	76.7	75.0	75.7	75.0	75.5
COP (system)	2.49	2.47	2.38	2.40	2.41	2.42	2.41	2.41	2.39
Capacity (kW/m3)	3067	3172	3024	2945	2867	2854	2941	2941	3097
Glide in evaporator (°C)	0	4.8	4.1	4.6	5.1	3.7	3.0	3.3	2.1
Glide in condenser (°C)	0	4.7	3.2	3.6	4.1	3.3	2.6	2.9	1.8

EXAMPLE 4

Blends comprising fluids selected from R134a, R744, 600, 600a and 601a.

The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (In saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (In saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 4. For comparison the performances of R22 and R407C are also shown.

Table 4

Refrigerant	R-22	R407C	1	2	3	4	5	6
R134a wt%			93	90	87	90	90	90
R744 wt%			5	8	11	8	8	8
R600			2	2	2	1	0.6	1
R600a							0.7	1
R601a						1	0.7	
Discharge pressure (bar)	17.91	19.30	15.32	17.44	19.52	17.92	17.78	17.63
Discharge temperature (°C)	104.7	92.5	90.1	93.4	96.3	92.7	92.9	93.1
COP (system)	2.49	2.47	2.51	2.49	2.48	2.49	2.49	2.49
Capacity (kW/m ³)	3067	3172	2505	2831	3155	2911	2887	2863
Glide in evaporator (°C)	0	4.8	8.2	12.0	15.3	10.6	11.0	11.3
Glide in condenser (°C)	0	4.7	13.3	18.2	21.8	16.3	16.9	17.4

Replacements for R12

EXAMPLE 5

Blends comprising fluids selected from R125, R134a, R600, R 600a and R601a

The performances of blends were evaluated in a typical open, air conditioning cycle such as mobile air conditioning (MAC) using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (In saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	60.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (In saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Outside fan	0.4 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 5. For comparison the performances of R12 and 134a are also shown.

Table 5

Refrigerant	R12	R134a	1	2	3	4	5
R125 wt%			5	7	10	12	15
R134a wt%			92.9	90.9	87.9	85.9	82.9
R600 wt%			0.7	0.7	0.7	0.7	0.7
R600a wt%			0.7	0.7	0.7	0.7	0.7
R601a wt%			0.7	0.7	0.7	0.7	0.7
Discharge pressure (bar)	15.72	17.42	17.77	17.97	18.27	18.48	18.80
Discharge temperature (°C)	88.4	84.4	83.9	83.9	83.8	83.8	83.7
COP (system)	2.45	2.38	2.36	2.35	2.35	2.34	2.33
Capacity (kW/m ³)	1754	1771	1789	1804	1826	1841	1863
Glide in evaporator (°C)	0	0	0.7	0.9	1.1	1.2	1.4
Glide in condenser (°C)	0	0	0.9	1.1	1.3	1.5	1.7

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EXAMPLE 6

Blends comprising fluids selected from R125, R134a, R600 and R601a

The performances of various blends were evaluated in a typical open air-conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	60.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Outside fan	0.4 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 6. For comparison the performances of R12 and 134a are also shown.

Table 6

Refrigerant	R12	R134a	1	2	3	4	5	6	7	8
R125 wt%			1	3	5	5	7	9	12	12
R134a wt%			97	94.5	93	92.5	91	89	86	86
R600 wt. /			1.4	1.6	1.4	1.6	1.4	1.4	1.4	1.1
R601a wt%			0.6	0.9	0.6	0.9	0.6	0.6	0.6	0.9
Discharge pressure (bar)	15.72	17.42	17.29	17.38	17.68	17.58	17.88	18.08	18.39	18.32
Discharge temperature (°C)	88.4	84.4	83.9	83.9	83.9	83.8	83.8	83.8	83.7	83.8
COP (system)	2.45	2.38	2.37	2.37	2.36	2.36	2.36	2.35	2.34	2.34
Capacity (kW/m3)	1754	1771	1754	1759	1783	1773	1798	1813	1835	1828
Glide in evaporator (°C)	0	0	0.3	0.6	0.6	0.8	0.8	0.9	1.1	1.3
Glide in condenser (°C)	0	0	0.4	0.8	0.8	1.0	1.0	1.2	1.4	1.6

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EXAMPLE 7

Blends comprising fluids selected from R125, R134a, R227ea, R600, R 600a and R601a
The performances of various blends were evaluated in an hermetic refrigeration cycle typical of that used in a domestic fridge-freezer using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	1 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	-25 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	50.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
Electric motor efficiency	0.85
PARASITIC POWER	
Controls	0.01 kW

The results of analysing the performances in fridge-freezer unit using these operating conditions are shown in Table 7. For comparison the performances of R12 and 134a are also shown.

Table 7

Refrigerant	R12	R134a	1	2	3	4	5
R125 wt%			5	6	8	6	6
R134a wt%			93	92	90	92	92
R227ea						5.7	5.7
R600 wt%			0.6	0.7	0.7		0.6
R601a wt%			0.7	0.6	0.6	0.6	
R600a wt%			0.7	0.7	0.7	0.7	0.7
Discharge pressure (bar)	12.59	13.68	13.97	14.09	14.22	14.25	14.37
Discharge temperature (°C)	96.7	90.5	89.4	89.3	89.2	87.4	87.2
COP (system)	1.56	1.50	1.49	1.48	1.48	1.47	1.47
Capacity (kW/m3)	588	508	515	518	522	517	523
Glide in evaporator (°C)	0	0	0.6	0.7	0.8	0.8	0.6
Glide in condenser (°C)	0	0	0.9	1.0	1.3	1.2	0.9

EXAMPLE 8

Blends comprising fluids selected from R125, R134a, R227ea, R600, R 600a and R601a
The performances of various blends were evaluated in an open cycle typical of that used in a centrifugal chiller using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	1 mW
EVAPORATOR	
Midpoint fluid evaporation temperature	0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
PARASITIC POWER	0.07 mW

The results of analysing the performances in fridge-freezer unit using these operating conditions are shown in Table 8. For comparison the performances of R12 and 134a are also shown.

Table 8

Refrigerant	R12	R134a	1	2	3	4
R134a wt%		60	55	59	55	55
R227ea wt%		38	43	34	38.6	38
R125 wt%				5	5	5
R601a wt%		0.6	0.6	0.7		
R600 wt%		0.7	0.7		0.7	0.7
R600a wt%		0.7	0.7	1.3	0.7	1.3
Discharge pressure (bar)	11.21	11.42	11.29	11.96	11.97	12.01
Discharge temperature (°C)	84.8	72.5	71.5	73.1	72.1	72.1
COP (system)	1950	1820	1792	1902	1896	1903
Capacity (kW/m ³)	2.56	2.51	2.51	2.51	2.50	2.50

Replacements for R 502 in Low Temperature Refrigeration

EXAMPLE 9

Blends comprising fluids selected from R125, R143a, R134a, R227ea, R600a, R600 and R600a

The performances of various blends were evaluated in hermetic refrigeration cycle typical of that used in some frozen cabinets using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	-35 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	35.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Internal and defrost	0.3 kW
External fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in fridge-freezer unit using these operating conditions are shown in Table 9. For comparison the performances of R12 and 134a are also shown.

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Tabl 9

Refrigerant	R502			
R125 wt%		80	85	90
R134a wt%		17	12	7
R600 wt%		1	1	1
R600a wt%		2	2	2
Discharge pressure (bar)	15.46	15.59	16.13	16.70
Discharge temperature (°C)	122.1	109.3	103.0	99.4
COP (system)	1.12	1.09	1.08	1.08
Capacity (kW/m ³)	671	597	620	643
Glide in evaporator (°C)	0.1	2.2	2.2	1.8
Glide in condenser (°C)	0.0	2.5	2.1	1.7

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EXAMPLE 10

Blends comprising fluids selected from R125, R134a, 600a and R600

The performances of various blends were evaluated in an open refrigeration cycle typical of that used in some industrial refrigeration using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	1 mW
EVAPORATOR	
Midpoint fluid evaporation temperature	-35 °C
Superheating	5.0 °C
Suction line pressure drop (In saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	35.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (In saturated temperature)	1.5 °C
COMPRESSOR	
Compressor Isentropic efficiency	0.7

The results of analysing the performances in the industrial refrigeration unit using these operating conditions are shown in Table 10. For comparison the performances of R12 and 134a are also shown.

Table 10

Refrigerant	R502	R22					
R125 wt%			65	55	60	60	50
R143a wt%			33	43	33.4	33.4	43.4
R134a wt%						5	5
R227ea wt%					5		
R601a wt%			0.6	0.6	0.9	0.9	0.9
R600 wt%			0.7	0.7			
R600a wt%			0.7	0.7	0.7	0.7	0.7
Discharge pressure (bar)	15.46	14.07	16.71	16.71	16.30	16.25	16.13
Discharge temperature (°C)	78.8	120.3	69.3	69.3	69.8	71.2	72.8
COP (system)	1.56	1.67	1.44	1.44	1.43	1.44	1.46
Capacity (kW/m ³)	839	839	774	774	734	746	752
Glide in evaporator (°C)	0.1	0	1.4	1.4	2.0	1.9	1.9
Glide in condenser (°C)	0.0	0	1.7	1.7	2.3	2.1	2.0

CLAIMS

(1) A refrigerant composition consisting of components (a), (b) and (c):

(a) one or more of:

Carbon dioxide	1-15%
R134a	95-85%
R125	5-15%

or a mixture thereof, wherein the aforesaid percentages are of the total composition of (a), (b) and (c),

(b) one or more of:

R134a	1-55%
R125	90-5%
R143a	10-49%
R32	15-30
R227ea	1-55

or a mixture thereof, wherein the aforesaid percentages are of the total composition of (a), (b) and (c),

(c) a hydrocarbon component selected from butane, n-pentane, 2-methylpropane, 2-methylbutane, propane and mixtures thereof in an amount from 0.1 to 4%.

(2) A refrigerant composition according to claim (1) which replaces R12 wherein the weights are in the range:

R134a	98.8-97.5%
Isopentane	0.6-0.7%
Butane	0.6-1.8%

(3) A refrigerant composition according to claim (2) wherein the weights are in the range:

R134a	98.8-97.7%
Isopentane	0.6%
Butane	0.6-1.7%

(4) A refrigerant composition according to claim (1) which replaces R12 wherein the weights are in the range:

R134a	98.2-96.5%
Isopentane	0.6-0.7%
Butane	0.6-1.8%
Isobutane	0.6-1%

- (5) A refrigerant composition according to claim (4) R12 wherein the weights are in the range:

R134a	98.2-96.8%
Isopentane	0.6%
Butane	0.6-1.7%
Isobutane	0.6-0.9%

- (6) A refrigerant composition according to claim (1) which replaces R12 wherein the weights are in the range:

R125	5-15%
R134a	95-85%

- (7) A refrigerant composition according to claim (6) wherein the weights are in the range:

R125	5-12%
R134a	95-88%

- (8) A refrigerant composition according to claim (7) wherein the weights are in the range:

R125	5-10%
R134a	95-90%

- (9) A refrigerant composition according to claim (1) which replaces R12 in centrifugal chillers wherein the weights are in the range

R134a	67-35%
R227ea	30-55%
R125	3-10%

- (10) A refrigerant composition according to claim (9) wherein the weights are in the range

R134a	62-42%
R227ea	35-50%
R125	3-8%

- (11) A refrigerant composition according to claim (10) wherein the weights are in the range

R134a	61-48%
R227ea	37-45%
R125	2-7%

- (12) A refrigerant composition according to claim (1) which replaces R22 wherein the weights are in the range:

Carbon dioxide	5-15%
R134a	95-85%

- (13) A refrigerant composition according to claim (12) wherein the weights are in the range:

Carbon dioxide	5-12%
R134a	95-88%

- (14) A refrigerant composition according to claim (13) wherein the weights are in the range:

Carbon dioxide	5-10%
R134a	95-90%

- (15) A refrigerant composition according to claim (1) which replaces R22 wherein the weights are in the range:.

R125	45-90%
R134a	55-10%

- (16) A refrigerant composition according to claim (15) wherein the weights are in the range

R125	45-85%
R134a	55-15%

- (17) A refrigerant composition according to claim (16) wherein the weights are in the range:

R125	45-80%
R134a	55-20%

- (18) A refrigerant composition according to claim (1) which replaces R502 wherein the weights are in the range:.

R125	80-95%
R134a	20-5%

- (19) A refrigerant composition according to claim (18) wherein the weights are in the range:

R125	83-95%
R134a	17-5%

- (20) A refrigerant composition according to claim (19) wherein the weights are in the range:

R125	85-93%
R134a	15-7%

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- (21) A refrigerant composition according to claim (1) which replaces R22 wherein the weights are in the range:

R125	80-40%
R134a	10-30%
R143a	10-30%.

- (22) A refrigerant composition according to claim (21) wherein the weights are in the range:

R125	76-40%
R134a	12-30%
R143a	12-30%

- (23) A refrigerant composition according to claim (22) wherein the weights are in the range:

R125	70-50%
R134a	15-25%
R143a	15-25%

- (24) A refrigerant composition according to claim (1) which replaces R502 wherein the weights are in the range:

R125	75-55%
R143a	25-45%

- (25) A refrigerant composition according to claim (24) wherein the weights are in the range.

R125	70-55%
R143a	30-45%

- (26) A refrigerant composition according to claim (25) wherein the weights are in the range..

R125	70-60%
R143a	30-40%

- (27) A refrigerant composition according to claim (1) which replaces R502 wherein the weights are in the range:

R125	75-50%
R143a	15-49%
R134a	10-1%

- (28) A refrigerant composition according to claim (27) wherein the weights are in the range.

R125	70-50%
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R143a	27-43%
R134a	3-7%

- (29) A refrigerant composition according to claim (28) wherein the weights are in the range..

R125	65-50%
R143a	32-43%
R134a	3-7%

- (30) A refrigerant composition according to claim (1) which replaces R502 wherein the weights are in the range:.

R125	75-50%
R143a	15-49%
R227ea	10-1%

- (31) A refrigerant composition according to claim (30) wherein the weights are in the range.

R125	70-50%
R143a	27-43%
R227ea	3-7%

- (32) A refrigerant composition according to claim (31) wherein the weights are in the range..

R125	65-50%
R143a	32-43%
R227ea	3-7%

- (33) A refrigerant composition as in any one of the preceding claims in which component (c) is n-pentane.

- (34) A refrigerant composition according to claim (1) which replaces R22 wherein the weights are in the range:.

R125	20-35%
R134a	65-45%
R32	15-30%.

- (35) A refrigerant composition according to claim (34) wherein the weights are in the range:

R125	20-35%
R134a	65-40%
R32	15-25%

- (36) A refrigerant composition according to claim (35) wherein the weights are in the range:

R125	20-35%
R134a	65-44%
R32	15-21%

(37) A refrigerant composition according to claims (34), (35) and (36) wherein the component R125 is present at a minimum ratio to R32 of 1.05:1

(38) A refrigerant composition according to claim (6) in which component (c) is n-pentane in the range 1% to 2.5%

(39) A refrigerant composition according to claim (6) in which component (c) is a mixture of butane and isopentane in the range:

Butane	0.3-1.8%
Isopentane	0.3-0.7%

(40) A refrigerant composition according to claim (39) in which component (c) is a mixture of butane and isopentane in the range:

Butane	0.6-1.7%
Isopentane	0.6%

(41) A refrigerant composition according to claim (6) in which isobutane is present optionally in the range 0.3 to 1%.

(42) A refrigerant composition according to claim (41) in which isobutane is present optionally in the range 0.6 to 0.9

(43) A refrigerant composition according to claim (12) in which component (c) is butane in the range 0.6% to 5%.

(44) A refrigerant composition according to claim (43) in which component (c) is butane in the range 1% to 4%.

(45) A refrigerant composition according to claim (44) in which component (c) is butane in the range 1% to 3%..

(46) A refrigerant composition claim according to (12) in which component (c) is isobutane in the range 0.6% to 5%.

(47) A refrigerant composition claim (46) in which component (c) is isobutane in the range 1% to 4%.

(48) A refrigerant composition claim (47) in which component (c) is isobutane in the range 1% to 3%..

(49) A refrigerant composition according to claim (12) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.6-4%
Isobutane	0.6-4%

- (50) A refrigerant composition according to claim (49) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

- (51) A refrigerant composition according to claim (50) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-3%
Isobutane	1-3%

- (52) A refrigerant composition according to claim (12) in which component (c) is a mixture of butane, isopentane and isobutane in the range:

Butane	0.6-4%
Isobutane	0.6-4%
Isopentane	0.6-2

- (53) A refrigerant composition according to claim (52) in which component (c) is a mixture of butane, isopentane and isobutane in the range:

Butane	0.6-3%
Isobutane	0.6-3%
Isopentane	0.6-1.5

- (54) A refrigerant composition according to claim (53) in which component (c) is a mixture of butane, isopentane and isobutane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1.4

- (55) A refrigerant composition according to claim (15) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-4%
Isobutane	0.3-4%

- (56) A refrigerant composition according to claim (55) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

- (57) A refrigerant composition according to claim (56) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-3%
Isobutane	1-3%

- (58) A refrigerant composition according to claim (15) in which component (c) is a mixture of butane, isopentane and isobutane in the range:

Butane	0.3-4%
Isobutane	0.3-4%
Isopentane	0.3-2

- (59) A refrigerant composition according to claim (58) in which component (c) is a mixture of butane, isopentane and isobutane in the range:

Butane	0.6-3%
Isobutane	0.6-3%
Isopentane	0.6-1.5

- (60) A refrigerant composition according to claim (59) in which component (c) is a mixture of butane, isopentane and isobutane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1.4

- (61) A refrigerant composition according to claim (9) in which component (c) is a mixture of butane and isopentane in the range:

Butane	0.3-4%
Isopentane	0.3-2%

- (62) A refrigerant composition according to claim (61) in which component (c) is a mixture of butane and isopentane in the range:

Butane	0.6-3%
Isopentane	0.6-1.5%

- (63) A refrigerant composition according to claim (62) in which component (c) is a mixture of butane and isopentane in the range:

Butane	0.6-2.5%
Isopentane	0.6-1.4%

- (64) A refrigerant composition according to claim (9) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-5%
Isobutane	0.3-5%

- (65) A refrigerant composition according to claim (64) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

- (66) A refrigerant composition according to claim (65) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-3%
Isobutane	1-3%

- (67) A refrigerant composition according to claim (9)n which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.3-4%
Isobutane	0.3-4%
Isopentane	0.3-2%

- (68) A refrigerant composition according to claim (67) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-3%
Isobutane	0.6-3%
Isopentane	0.6-1.5%

- (69) A refrigerant composition according to claim (68) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1.4%

- (70) A refrigerant composition according to claim (18) in which component (c) is butane in the range from 0.3% to 5%.

- (71) A refrigerant composition according to claim (70) in which component (c) is butane in the range from 0.6% to 4%

- (72) A refrigerant composition according to claim (71) in which component (c) is butane in the range from 0.6% to 3%.

- (73) A refrigerant composition according to claim (18) in which component (c) is isobutane in the range from 0.3% to 5%.

- (74) A refrigerant composition according to claim (73) in which component (c) is isobutane in the range from 0.6% to 4%

- (75) A refrigerant composition according to claim (74) in which component (c) is isobutane in the range from 0.6% to 3%.

- (76) A refrigerant composition according to claim (18) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-5%
Isobutane	0.3-5%

- (77) A refrigerant composition according to claim (76) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

- (78) A refrigerant composition according to claim (77) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-3%
Isobutane	1-3%

- (79) A refrigerant composition according to claim (18) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.3-4%
Isopentane	0.3-2%

- (80) A refrigerant composition according to claim (79) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-3%
Isopentane	0.6-1.5%

- (81) A refrigerant composition according to claim (80) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-2.5%
Isopentane	0.6-1.4%

- (82) A refrigerant composition according to claim (18) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.3-4%
Isobutane	0.3-4%
Isopentane	0.3-2%

- (83) . A refrigerant composition according to claim (82) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-3%
Isobutane	0.6-3%
Isopentane	0.6-1,5%

- (84) . A refrigerant composition according to claim (83) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1,4%

- (85) A refrigerant composition according to claim (21) in which component (c) is butane in the range from 0.3% to 5%.
- (86) A refrigerant composition according to claim (85) in which component (c) is butane in the range from 0.6% to 4%
- (87) A refrigerant composition according to claim (86) in which component (c) is butane in the range from 0.6% to 3%.
- (88) A refrigerant composition according to claim (21) in which component (c) is isobutane in the range from 0.3% to 5%.
- (89) A refrigerant composition according to claim (88) in which component (c) is isobutane in the range from 0.6% to 4%
- (90) A refrigerant composition according to claim (89) in which component (c) is isobutane in the range from 0.6% to 3%.
- (91) A refrigerant composition according to claim (21) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-5%
Isobutane	0.3-5%

- (92) A refrigerant composition according to claim (91) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

- (93) A refrigerant composition according to claim (92) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-3%
Isobutane	1-3%

- (94) A refrigerant composition according to claim (21) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.3-4%
Isopentane	0.3-2%

- (95) A refrigerant composition according to claim (94) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-3%
Isopentane	0.6-1.5%

- (96) A refrigerant composition according to claim (95) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-2.5%
Isopentane	0.6-1.4%

- (97) A refrigerant composition according to claim (21) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.3-4%
Isobutane	0.3-4%
Isopentane	0.3-2%

- (98) A refrigerant composition according to claim (97) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-3%
Isobutane	0.6-3%
Isopentane	0.6-1.5%

- (99) A refrigerant composition according to claim (98) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1.4%

- (100) A refrigerant composition according to claim (24) in which component (c) is butane in the range from 0.3% to 5%.

- (101) A refrigerant composition according to claim (100) in which component (c) is butane in the range from 0.6% to 4%

- (102) A refrigerant composition according to claim (101) in which component (c) is butane in the range from 0.6% to 3%.

- (103) A refrigerant composition according to claim (24) in which component (c) is isobutane in the range from 0.3% to 5%.

- (104) A refrigerant composition according to claim (103) in which component (c) is isobutane in the range from 0.6% to 4%

- (105) A refrigerant composition according to claim (104) in which component (c) is isobutane in the range from 0.6% to 3%.

- (106) A refrigerant composition according to claim (24) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-5%
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Isobutane 0.3-5%

- (107) A refrigerant composition according to claim (106) in which component (c) is a mixture of butane and isobutane in the range:

Butane 1-4%
Isobutane 1-4%

- (108) A refrigerant composition according to claim (107) in which component (c) is a mixture of butane and isobutane in the range:

Butane 1-3%
Isobutane 1-3%

- (109) A refrigerant composition according to claim (24) in which component (c) is a mixture of butane and isopentane the range:

Butane 0.3-4%
Isopentane 0.3-2%

- (110) A refrigerant composition according to claim (109) in which component (c) is a mixture of butane and isopentane the range:

Butane 0.6-3%
Isopentane 0.6-1.5%

- (111) A refrigerant composition according to claim (110) in which component (c) is a mixture of butane and isopentane the range:

Butane 0.6-2.5%
Isopentane 0.6-1.4%

- (112) A refrigerant composition according to claim (24) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane 0.3-4%
Isobutane 0.3-4%
Isopentane 0.3-2%

- (113) A refrigerant composition according to claim (112) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane 0.6-3%
Isobutane 0.6-3%
Isopentane 0.6-1.5%

- (114) A refrigerant composition according to claim (113) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1,4%

(115) A refrigerant composition according to claim (27) in which component (c) is butane in the range from 0.3 to 5%.

(116) A refrigerant composition according to claim (115) in which component (c) is butane in the range from 0.6% to 4%

(117) A refrigerant composition according to claim (116) in which component (c) is butane in the range from 0.6% to 3%.

(118) A refrigerant composition according to claim (27) in which component (c) is isobutane in the range from 0.3% to 5%.

(119) A refrigerant composition according to claim (118) in which component (c) is isobutane in the range from 0.6% to 4%

(120) A refrigerant composition according to claim (119) in which component (c) is isobutane in the range from 0.6% to 3%.

(121) A refrigerant composition according to claim (27) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-5%
Isobutane	0.3-5%

(122) A refrigerant composition according to claim (121) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

(123) A refrigerant composition according to claim (122) in which component (c) is a mixture of butane and isobutane in the range.

Butane	1-3%
Isobutane	1-3%

(124) A refrigerant composition according to claim (27) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.3-4%
Isopentane	0.3-2%

(125) A refrigerant composition according to claim (124) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-3%
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Isopentane 0.6-1.5%

- (126) A refrigerant composition according to claim (125) in which component (c) is a mixture of butane and isopentane the range:

Butane 0.6-2.5%
Isopentane 0.6-1.4%

- (127) A refrigerant composition according to claim (27) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane 0.3-4%
Isobutane 0.3-4%
Isopentane 0.3-2%

- (128) A refrigerant composition according to claim (127) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane 0.6-3%
Isobutane 0.6-3%
Isopentane 0.6-1.5%

- (129) A refrigerant composition according to claim (128) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane 0.6-2%
Isobutane 0.6-2%
Isopentane 0.6-1.4%

- (130) A refrigerant composition according to claim (30) in which component (c) is butane in the range from 0.3 to 5%.

- (131) A refrigerant composition according to claim (131) in which component (c) is butane in the range from 0.6% to 4%

- (132) A refrigerant composition according to claim (132) in which component (c) is butane in the range from 0.6% to 3%.

- (133) A refrigerant composition according to claim (30) in which component (c) is isobutane in the range from 0.3% to 5%.

- (134) A refrigerant composition according to claim (133) in which component (c) is isobutane in the range from 0.6% to 4%

- (135) A refrigerant composition according to claim (134) in which component (c) is isobutane in the range from 0.6% to 3%.

- (136) A refrigerant composition according to claim (30) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-5%
Isobutane	0.3-5%

- (137) A refrigerant composition according to claim (136) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

- (138) A refrigerant composition according to claim (137) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-3%
Isobutane	1-3%

- (139) A refrigerant composition according to claim (30) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.3-4%
Isopentane	0.3-2%

- (140) A refrigerant composition according to claim (139) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-3%
Isopentane	0.6-1.5%

- (141) A refrigerant composition according to claim (140) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-2.5%
Isopentane	0.6-1.4%

- (142) A refrigerant composition according to claim (30) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.3-4%
Isobutane	0.3-4%
Isopentane	0.3-2%

- (143) . A refrigerant composition according to claim (142) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-3%
Isobutane	0.6-3%
Isopentane	0.6-1,5%

- (144) A refrigerant composition according to claim (143) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1,4%

- (145) A refrigerant composition according to claim (34) in which component (c) is butane in the range from 0.3 to 5%.
- (146) A refrigerant composition according to claim (145) in which component (c) is butane in the range from 0.6% to 4%
- (147) A refrigerant composition according to claim (146) in which component (c) is butane in the range from 0.6% to 3%.
- (148) A refrigerant composition according to claim (34) in which component (c) is isobutane in the range from 0.3% to 5%.
- (149) A refrigerant composition according to claim (148) in which component (c) is isobutane in the range from 0.6% to 4%
- (150) A refrigerant composition according to claim (149) in which component (c) is isobutane in the range from 0.6% to 3%.
- (151) A refrigerant composition according to claim (34) in which component (c) is a mixture of butane and isobutane in the range:

Butane	0.3-5%
Isobutane	0.3-5%

- (152) A refrigerant composition according to claim (151) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-4%
Isobutane	1-4%

- (153) A refrigerant composition according to claim (152) in which component (c) is a mixture of butane and isobutane in the range:

Butane	1-3%
Isobutane	1-3%

- (154) A refrigerant composition according to claim (34) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.3-4%
Isopentane	0.3-2%

- (155) A refrigerant composition according to claim (154) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-3%
Isopentane	0.6-1.5%

- (156) A refrigerant composition according to claim (155) in which component (c) is a mixture of butane and isopentane the range:

Butane	0.6-2.5%
Isopentane	0.6-1.4%

- (157) A refrigerant composition according to claim (34) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.3-4%
Isobutane	0.3-4%
Isopentane	0.3-2%

- (158) . A refrigerant composition according to claim (157) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-3%
Isobutane	0.6-3%
Isopentane	0.6-1.5%

- (159) A refrigerant composition according to claim (158) in which component (c) is a mixture of butane, isobutane and isopentane in the range:

Butane	0.6-2%
Isobutane	0.6-2%
Isopentane	0.6-1.4%

- (160) A refrigerant composition as in any one of the preceding claims for use in refrigeration and air conditioning equipment.

ABSTRACT

A composition consisting of :

(a) one or more of:

Carbon dioxide	1-15%
R134a	95-85%
R125	5-15%

or a mixture thereof, wherein the aforesaid percentages are of the total composition of (a), (b) and (c).

(b) one or more of:

R134a	1-55%
R125	90-5%
R143a	10-49%
R32	15-30
R227ea	1-55

or a mixture thereof, wherein the aforesaid percentages are of the total composition of (a), (b) and (c).

(c) a hydrocarbon component selected from butane, n-pentane, 2-methylpropane, 2-methylbutane, propane and mixtures thereof in an amount from 0.1 to 4%.

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

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(54) Title: REFRIGERANT COMPOSITION

(57) Abstract: A refrigerant composition consists essentially of a combination of a hydrofluorocarbon component consisting of a combination selected from the following mixtures (a) R134a and R125, (b) R134a, R125 and R143a (c) R125 and R143a (d) R134a, R227ea and R125 and a hydrocarbon component consisting essentially of a combination selected from the following mixtures (e) isopentane and butane (f) isopentane, butane and isobutane (g) butane and isobutane

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REFRIGERANT COMPOSITION

This invention relates to refrigerant compositions which have no adverse effect on stratospheric ozone and to compositions which are for use both in refrigeration and air conditioning systems designed to use Ozone Depleting Substances (ODS) CFC12 (dichlorodifluoromethane), CFC502 (azeotrope of chloropentafluoromethane and chlorodifluoromethane) and HCFC22 (chlorodifluoromethane) and additionally in new equipment. These new refrigerant compositions are compatible with lubricants commonly found in refrigeration and air conditioning systems.

The compositions may also be used in equipment designed for non ozone depleting substances.

It is well known that chlorofluorocarbons (CFCs) such as CFC12 and CFC502 and hydrochlorofluorocarbons such as HCFC22 while being energy efficient, non flammable and of low toxicity migrate to the stratosphere where they are broken down by ultra violet light to attack the ozone layer. These Ozone Depleting Substances are in the process of being replaced by non ozone depleting alternatives such as hydrofluorocarbons (HFCs) which are also non flammable, efficient and of low toxicity. There are six main HFCs, namely HFC134a, HFC32, HFC125, HFC143a, HFC227ea and HFC152a, which either individually or blended into mixtures can replace CFCs and HCFCs. While HFC134a, HFC227ea and HFC152a can be used to replace ODS directly, HFC32, HFC143a, and HFC125 are generally found in blends as replacements for ODS. However, HFCs do not have adequate solubility in traditional lubricants such as mineral and alkylbenzene oils so that synthetic oxygen containing lubricants have been introduced specifically for new equipment. These new lubricants are expensive and hygroscopic.

Refrigerant blends such as R404A, R507, R410A, R407C and others have been commercialised as replacements for CFCs and HCFCs but, because these compositions contain only HFC components, they cannot be used with the traditional lubricants commonly found in use with CFCs and HCFCs. If these blends are to be used to replace CFCs and HCFCs in existing equipment, the major chemical manufacturers recommend that no more than 5% of the traditional lubricant in the system be retained so that a virtual complete change of lubricant to a synthetic oxygen containing lubricant resulting in a full retrofit is required, which is often costly and technically unsatisfactory.

Although equipment manufacturers have adapted their units to operate with HFC blends, they do not always find the commercially available products as satisfactory as the CFCs and HCFCs that these new refrigerants are replacing. In particular to ensure adequate oil return, hydrocarbon lubricants, such as mineral oil, have been replaced by oxygen containing lubricants, notably polyol esters and polyalkylene glycols. Unfortunately these materials are liable to absorb atmospheric moisture, especially during maintenance, which can contribute to excessive corrosion and wear in equipment thus reducing its reliability. A key objective of this patent is to provide HFC/hydrocarbon blends that enable the continued use of hydrocarbon oils in both existing and new equipment.

Additionally some refrigerants, such as R07C, have wide temperature glides ($> 4^{\circ}\text{C}$) in the evaporator and condenser, whereas equipment manufacturers, based on their experience with CFC/HCFC single fluids or azeotropes, prefer refrigerants with low glides. A further key objective of this invention, therefore, is to provide HFC/hydrocarbon blends that can substitute for CFC 12, HCFC 22 and azotrope 502 (CFC 115/HCFC 22) both allowing the continued use of hydrocarbon lubricants in equipment and minimising the temperature glides in the heat exchangers.

The present invention relates to refrigerant compositions, which are non flammable under all conditions of fractionation as defined under ASHRAE Standard 34, and which can be used to replace ODS in an existing unit without the need to change the lubricant or make any significant change to the system hardware. In new equipment the refrigerant compositions allow the continued use of hydrocarbon oils, although the manufacturers may take the opportunity to modify their units to optimise the performances of the new refrigerants, for example by selecting the most appropriate lengths of capillary tubes. Where the ingress of moisture or other problems are being experienced with oxygen containing oils the new compositions allow such oils to be replaced by hydrocarbon oils

It is known in the art that the addition of a small amount of hydrocarbon to a refrigerant composition containing an HFC or HFC mixtures can result in sufficient hydrocarbon being dissolved in the lubricant to be transported around the system so that lubrication of the compressor is maintained at all times. It is obvious that the greater the hydrocarbon content of the composition the greater the ability of the refrigerant to transport the lubricant back to the compressor. However, too high a hydrocarbon content can lead to flammable mixtures. Although flammable refrigerants are acceptable in some applications, this invention relates to non flammable compositions for use in equipment where flammable refrigerants are prohibited. However, it is not well understood how to achieve non flammable compositions under all conditions including fractionation of the refrigerant compositions which can take place during a leak of the refrigerant from the system or during storage.

Not all HFCs are non flammable as defined under ASHRAE Standard 34. HFC143a and HFC32 have not received a non flammable rating by ASHRAE. This invention relates to compositions of refrigerants which not only covers blends of non flammable HFCs with hydrocarbons but also blends of flammable HFCs, non flammable HFCs and hydrocarbons in selected proportions such that all such compositions are non

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flammable during fractionation while providing similar refrigerating effects and thermodynamic performances as the ODS they replace, namely CFC12, CFC502 and HCFC22.

While this invention relates to refrigerant compositions which can be used with traditional lubricants such as mineral and alkylbenzene oils, they are also suitable for use with synthetic oxygen containing lubricants.

In formulating HFC/hydrocarbon blends to replace CFC 12, CFC 502 and HCFC 22 in specific applications it is generally necessary to use one or more lower boiling HFCs, with one or more higher boiling HFCs. In this context preferred lower boiling HFCs are HFC 32, HFC 143a and HFC 125, and higher boiling HFCs are HFC 134a, HFC 134, HFC 227ea and HFC 152a.

To avoid flammability in the blend, or in a fraction generated by a leak, for example as defined by ASHRAE Standard 34, the total amount of hydrocarbon should be minimised. At the same time the quantity of the hydrocarbon mixture dissolved in the oil needs to be maximised for good oil return, especially at those locations in the circuit where the oil is at its most viscous, for example the evaporator. A single higher boiling hydrocarbon, such as pentane or *iso*-pentane, would certainly show higher solubility in the oil than a lower boiling hydrocarbon. However, as the result of a leak, for example from a cylinder, a higher boiling hydrocarbon will concentrate in the liquid phase. The amount of hydrocarbon will, therefore, need to be limited in order to avoid generating a flammable mixture towards the end of the leak.

This problem could be avoided by using only a low boiling hydrocarbon such as propane or *iso*-butane. However, this has 2 disadvantages. Firstly, lower boiling hydrocarbons are less soluble than higher boiling hydrocarbons in hydrocarbon lubricants in the evaporator when present at similar weights % as formulated in the blend. Consequently they are less effective at ensuring good oil return. Secondly,

because of their higher volatility they tend to concentrate in the vapour phase of a blend. Their concentration therefore needs to be restricted to avoid generating flammable mixtures at the beginning of a leak. This problem is exacerbated if the one or more of the lower boiling HFCs is also flammable.

Surprisingly we have found that the best approach to formulating HFC/HC refrigerant blends is to use combinations of two and preferably three hydrocarbons with different boiling points. This allows the total amount of hydrocarbon of the blend to be reduced while simultaneously the amount dissolved in the oil in the evaporator is increased.

This invention has the following advantage. Hydrocarbon components facilitate oil return, but, because of their flammability, restrict the weights of flammable HFCs, notably HFC 143a that can be included. Inclusion of these fluids can be valuable in achieving the required balance of thermodynamic properties, so minimising the amounts of hydrocarbon present allows more scope in formulating preferred blends.

The blending of HFCs to achieve the desired balance of physical properties appropriate to various cooling applications is well known and a variety of products are available commercially, for example R407C, R410A and R410B. Although these have been selected for specific applications in combination with oxygen containing synthetic lubricants, simply adding 2 or 3 hydrocarbon components to these products does not achieve the preferred products for use with hydrocarbon lubricants. Firstly, the hydrocarbon components contribute to the overall thermodynamic properties of the blend so will affect the preferred ratios of the HFCs. Secondly, the ratio of flammable to non-flammable HFCs will need to be selected to ensure non-flammability, for example, as required by the ASHRAE 34 Standard.

Blends of HFC125, HFC134a, HFC143a, HFC227ea are particularly preferred as replacements for CFCs and HCFCs. Both HFC125 (pentafluoroethane) and R227ea are non flammable under all operating conditions and in addition are fire suppressants,

an application for which they have been developed by the fire fighting industry. The presence of HFC227ea provides a twofold advantage of reducing the flammability of the composition and also enhances oil return to the compressor due to emulsification of the lubricant in the presence of a hydrocarbon.

Blends of HFC134a, HFC227ea, HFC125 and mixtures of selected hydrocarbon additives have been found to be preferred replacements for CFC12 in centrifugal chillers. It has been found that the interaction of hydrocarbon additives in such mixtures facilitates non flammable mixtures during all conditions of leakage during fractionation so that non flammability can be achieved according to ASHRAE Standard 34. The presence of hydrocarbons results in the lubricant being returned to the compressor. The presence of R227ea enables the requisite molecular weight of the blend to match that of CFC12 and additionally facilitates non flammability due to its fire retardant properties. The presence of R125 increases the capacity of the blend. The resulting mixtures are a close match for CFC12 in thermodynamic and system performance.

Surprisingly it has been found that given the same percentage content of hydrocarbon additive in the refrigerant composition, increasing the HFC125 content of the composition results in flammable mixtures being created during fractionation. This is very surprising since it would seem obvious that the greater the amount of HFC125 in the composition the less would be the likelihood to generate a flammable mixture during fractionation. The reasons for this apparent anomaly relate to the pressure/temperature relationship between the quantities of HFC125 and HFC134a in the mixture and the amount and type of hydrocarbon and/or hydrocarbon mixture. The following refrigerant compositions were made up and leaked away until the cylinder was almost liquid empty according to ASHRAE Standard 34:

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	%	
	Blend 1	Blend 2
R134a	48.0	21.0
R125	49.0	76.0
butane	2.7	2.5
isopentane	0.3	0.5

Blend 2 with the considerably higher HFC125 content was found to create a flammable composition during fractionation, while Blend 1 with a lower HFC125 content remained non flammable throughout fractionation.

In GC 2727427 N A Roberts teaches that, if a hydrocarbon with at least four carbon atoms other than methyl propane (isobutane) is used, surprisingly the flammability of the fractionated composition is greatly reduced. Surprisingly, we have now found that the inclusion of isobutane with appropriately chosen hydrocarbons does not result in flammable compositions during fractionation. It has been found that the selection of the hydrocarbon additive or mixtures thereof with the HFC components is critical to achieving non flammability under all operating conditions and as defined under ASHRAE Standard 34.

In US5,800,730 it is stated that HFC 134a needs to be added to blends of HFC125 and HFC143a as a replacement for CFC502 in order to avoid a flammable mixture (example 3). Surprisingly we have found that by excluding HFC134a, changing the proportion of HFC125 to HFC143a and adding a selected range of hydrocarbons results in a composition which is non flammable during fractionation and a close match for R502 with regard to thermodynamic performance.

In US5,211,867, azeotropic compositions are claimed of R125 and R143a. It is a key feature of this invention that a specially selected hydrocarbon or mixtures of hydrocarbons are present in order to facilitate oil return to the compressor. Surprisingly it has been found that, despite the flammability of HFC143a, the selection of a hydrocarbon or mixtures of hydrocarbons enables the compositions to be non flammable during fractionation. The combination of a high boiling hydrocarbon such as isopentane (BP 27°C) with butane (BP -0.5°C) and isobutane (BP -11.5°C) avoids build up of hydrocarbon content in the liquid phase during a leakage while the more volatile isobutane is countered in the vapour phase by the fire suppressant HFC125 due to the latter's higher vapour pressure and lower boiling point (BP -45°C). In order for the composition to be non flammable, the HFC125 content of the composition is above the azeotropic composition so that the content of HFC143a is reduced but without affecting the refrigerating performance of the composition as a replacement for CFC502.

Although the addition of hydrocarbons to HFCs has been previously described, it has not been previously appreciated that the volatilities of the hydrocarbons need to be matched to the application for which the refrigerant is intended. For example R12 is employed as the refrigerant in domestic freezers with evaporating temperatures of ~-22°C, in domestic fridges with evaporating temperatures of ~-5°C, and in mobile air conditioning with evaporating temperatures of ~-5°C. An important aspect of this invention is to formulate HFC/HC blends that ensure good oil return in these disparate applications while also ensuring that the refrigerant blend remains non-flammable according to the chosen criterion. For applications with evaporators operating at temperatures above -5°C the higher boiling hydrocarbons are preferred. Specially preferred are isopentane, alone or mixed with butane. For applications with the evaporators operating in the range -20°C to -5°C mixtures of hydrocarbons containing a higher, an intermediate and a lower boiling point component are preferred. Especially preferred are blends containing isopentane, butane and isobutane. For evaporators operating below -20°C HC mixtures containing isobutane and butane are preferred with optionally some isopentane.

According to the present invention a refrigerant composition consists essentially of a combination of a hydrofluorocarbon component consisting of a combination selected from the following mixtures:

- (1) R134a and R125;
- (2) R134a, R125 and R143a
- (3) R125 and R143a
- (4) R134a, R227ea and R125

and a hydrocarbon component consisting essentially of a combination selected from the following mixtures:

- (5) isopentane and butane
- (6) isopentane, butane and isobutane
- (7) butane and isobutane.

In preferred embodiments the composition consists of a mixture of one hydrofluorocarbon component and one hydrocarbon component so that no substantial amount of any other components or other gases are present.

In a first preferred embodiment the hydrocarbon is present in an amount of 0.6 to 4% and wherein the composition is non-flammable when completely in the vapour phase.

In a second preferred embodiment the hydrocarbon is present in an amount of 0.6 to 4% and wherein when the composition is in a container both vapour and liquid present, neither vapour nor liquid phase is flammable.

In a third preferred embodiment the hydrocarbon is present in an amount of 0.6 to 4% and wherein at any time during a leak from a vapour space in a container neither the liquid phase nor the vapour phase is flammable.

In a fourth preferred embodiment the hydrocarbon is present in amount of 0.6 to 4% and wherein at any time during a leak from a liquid space in a container neither the liquid phase nor vapour phase is flammable.

According to a fifth preferred embodiment the hydrocarbon is present in an amount of 0.6 to 4% and wherein the proportion of hydrocarbon to hydrofluorocarbon in the vapour phase does not differ from the equivalent proportion in the liquid phase by more than 40%, more preferably not by more than 30%, most preferably not by more than 20% at equilibrium at 25°C.

In a sixth preferred embodiment hydrocarbon is present in amount of 0.6 to 4% and wherein the proportion of hydrocarbon to hydrofluorocarbon in the vapour phase does not differ from the formulated composition by more than 40%, preferably by not more than 30%, most preferably by not more than 20% at equilibrium at 25°C.

In particularly preferred compositions in accordance with either the fifth or sixth preferred compositions above, during a leak from the vapour space or liquid space in a container, the proportion of hydrocarbon to hydrofluorocarbon in either of the vapour phase or the liquid phase does not differ from the formulated composition by more than 40%, more preferably by not more than 30%, most preferably by not more than 20% at equilibrium at 25°C.

Preferred compositions in accordance with this invention meet two or more of the criteria of the preferred embodiment.

In a first aspect of this invention the hydrocarbon component consists of a mixture of isopentane, butane and isobutane.

The amount of isopentane is preferably about 0.6 to 2% or more preferably about 0.6 to 1%.

The amount of butane is preferably about 0.6 to 5%, more preferably about 0.6 to 3%, most preferably about 0.6 to 2%.

The amount of isobutane is preferably about 0.6 to 5%, more preferably about 0.6 to 2%, most preferably about 0.6 to 1%.

In a second preferred aspect the hydrocarbon component consists of a mixture of isopentane and butane.

The isopentane may be present in an amount of 0.6 to 1%, preferably about 0.6%. The amount of butane is preferably about 1.3 to 2.5%, more preferably about 1.4%.

In a third preferred aspect of the invention the hydrocarbon component consists of a mixture of butane and isobutane. The amount of butane is preferably about 0.6 to 5% and the amount of isobutane is about 0.6 to 5%.

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A first preferred refrigerant composition which may find application as a replacement or substitute for R12 consists essentially of:

R134a	93.1 to 81.5%
R125	5 – 15%
isopentane	0.6 to 1%
butane	1.3 to 2.5%

A particularly preferred composition consists essentially of:

R134a	93%
R125	5%
isopentane	0.6%
butane	1.4%

A second refrigerant composition which may find application as a replacement or substitute for R12 consists essentially of:

R134a	93.2 to 80%
R125	5 to 15%
isopentane	0.6 to 1%
butane	0.6 to 3%
isobutane	0.6 to 1%

A particularly preferred composition consists essentially of:

R134a	93%
R125	5%
isopentane	0.6%
butane	0.8%
isobutane	0.6%

A preferred refrigerant composition which may find application as a replacement or substitute for R22 consists essentially of:

R134a	53.2 to 39%
R125	45 to 55%
isopentane	0.6 to 1%
butane	0.63%
isobutane	0.62%

A particularly preferred composition consists essentially of:

R134a	47.5%
R125	50%
isopentane	0.6%
butane	1%
isobutane	0.9%

A further refrigerant composition which may find application as a replacement or substitute for R22 consists essentially of:

R134a	10 to 30%
R125	80 to 40%
R143a	10 to 30%
isopentane	0.6 to 2%
butane	0.6 to 5%
isobutane	0.6 to 5%

A particularly preferred composition consists essentially of:

R134a	16.5%
R125	60%
R143a	21%
isopentane	0.6%
butane	0.9%
isobutane	1%

A preferred refrigerant composition which may find application as a replacement or substitute for R502 consists essentially of:

R125	75 to 55%
R143a	25 to 45%
butane	0.6 to 5%

In a particular preferred composition consists essentially of:

R125	60.5%
R143a	37%
butane	1%
isobutane	1.5%

A further preferred composition consists essentially of:

R125	60.5%
R143a	37%
butane	0.9%
isobutane	1%
isopentane	0.6%

A alternative refrigerant composition which may find use as a replacement or substitute for R12 in centrifugal chillers and similar devices consists essentially of:

R134a	58.2 to 36%
R227ea	35 to 50%
R125	5 to 8%
isopentane	0.6 to 2%
butane	0.6 to 2%
isobutane	0.6 to 2%

A particularly preferred composition consists essentially of:

R134a	51%
R227ea	41%
R125	6%
isopentane	0.6%
butane	0.8%
isobutane	0.6%

Percentages and other proportions referred to in this specification are by weight unless indicated otherwise and are selected to total 100% from within the ranges disclosed.

The invention is further described by means of example but not in a limitative sense.

Replacements for R22 In Room Air Conditioning

EXAMPLE 1

Blends comprising fluids selected from R125, R143a, 134a, 600, 600a and 601a.

The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Tables 1a and 1b. For comparison the performances of R22 and R407C are also shown.

Table 1a

Refrigerant	R-22	R407C	1	2	3	4	5	6	7	8	9	10
R125 wt%			33	33	38	50	60	33	38	50	60	63
R143a wt%			35	38	40	23	23	40	40	33	23	23
R134a wt%			30	27	20	25	15	25	20	15	15	12
R600			1	1	1	1	1	1.3	1.3	1.3	1.3	1.3
R600a			1	1	1	1	1					
R601a								0.7	0.7	0.7	0.7	0.7
Discharge pressure (bar)	17.91	19.30	18.00	18.50	19.01	18.64	19.80	19.21	18.67	19.28	19.42	19.85
Discharge temperature (°C)	104.7	92.5	79.6	79.3	78.8	78.1	76.8	79.0	79.5	78.4	77.6	75.4
COP (system)	2.49	2.47	2.45	2.44	2.43	2.44	2.41	2.42	2.44	2.42	2.42	2.39
Capacity (kW/m3)	3067	3172	2870	2933	2995	2938	3072	3005	2944	3008	3015	3019
Glide in evaporator (°C)	0	4.8	2.4	2.2	2.0	2.4	1.9	3.0	3.2	3.1	3.2	3.8
Glide in condenser (°C)	0	4.7	2.1	2.0	1.8	2.1	1.7	2.5	2.7	2.6	2.7	3.1

Refrigerant	R 22	R407C	1	2	3	4	5	6	7	8
R125 wt%			30	33	35	38	39	60	50	40
R143a wt /			23	25	28	30	34	23	30	35
R134a wt /			45	40	35	30	25	15	18	23
R600			13	13	13	13	13			
R600a			07	07	07	07	07	13	13	13
R601a								07	07	07
Discharge pressure (bar)	17.91	19.30	16.54	17.01	17.49	17.99	18.48	19.66	19.21	18.61
Discharge temperature (°C)	104.7	92.5	80.2	79.9	79.6	79.2	79.0	77.3	78.2	79.2
COP (system)	2.49	2.47	2.48	2.47	2.46	2.45	2.44	2.41	2.42	2.44
Capacity (kW/m ³)	3067	3172	2678	2740	2802	2865	2928	3043	2998	2933
Glide in evaporator (°C)	0	4.8	2.7	2.7	2.6	2.5	2.3	2.8	2.8	2.9
Glide in condenser (°C)	0	4.7	2.5	2.5	2.4	2.3	2.1	2.3	2.3	2.5

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Replacements for R12

EXAMPLE 2

Blends comprising fluids selected from R125, R134a, R600, R 600a and R601a

The performances of blends were evaluated in a typical open, air conditioning cycle such as mobile air conditioning (MAC) using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	60.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Outside fan	0.4 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 2. For comparison the performances of R12 and 134a are also shown.

Table 2

Refrigerant	R12	R134a	1	2	3	4	5
R125 wt%			5	7	10	12	15
R134a wt%			92.9	90.9	87.9	85.9	82.9
R600 wt%			0.7	0.7	0.7	0.7	0.7
R600a wt%			0.7	0.7	0.7	0.7	0.7
R601a wt%			0.7	0.7	0.7	0.7	0.7
Discharge pressure (bar)	15.72	17.42	17.77	17.97	18.27	18.48	18.80
Discharge temperature (°C)	88.4	84.4	83.9	83.9	83.8	83.8	83.7
COP (system)	2.45	2.38	2.36	2.35	2.35	2.34	2.33
Capacity (kW/m ³)	1754	1771	1789	1804	1826	1841	1863
Glide in evaporator (°C)	0	0	0.7	0.9	1.1	1.2	1.4
Glide in condenser (°C)	0	0	0.9	1.1	1.3	1.5	1.7

EXAMPLE 3**Blends comprising fluids selected from R125, R134a, R600 and R601a**

The performances of various blends were evaluated in a typical open air-conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	60.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Outside fan	0.4 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 3. For comparison the performances of R12 and 134a are also shown.

Table 3

Refrigerant	R12	R134a	1	2	3	4	5	6	7	
R125 wt%			1	3	5	5	7	9	12	
R134a wt%			97	94.5	93	92.5	91	89	86	
R600 wt%			1.4	1.6	1.4	1.6	1.4	1.4	1.4	
R601a wt%			0.6	0.9	0.6	0.9	0.6	0.6	0.6	
Discharge pressure (bar)	15.72	17.42	17.29	17.38	17.68	17.58	17.88	18.08	18.39	
Discharge temperature (°C)	88.4	84.4	83.9	83.9	83.9	83.8	83.8	83.8	83.7	
COP (system)	2.45	2.38	2.37	2.37	2.36	2.36	2.36	2.35	2.34	
Capacity (kW/m3)	1754	1771	1754	1759	1783	1773	1798	1813	1835	
Glide in evaporator (°C)	0	0	0.3	0.6	0.6	0.8	0.8	0.9	1.1	
Glide in condenser (°C)	0	0	0.4	0.8	0.8	1.0	1.0	1.2	1.4	

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EXAMPLE 4

Blends comprising fluids selected from R125, R134a, R227ea, R600, R600a and R601a

The performances of various blends were evaluated in an hermetic refrigeration cycle typical of that used in a domestic fridge-freezer using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	1 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	-25 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	50.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
Electric motor efficiency	0.85
PARASITIC POWER	
Controls	0.01 kW

The results of analysing the performances in fridge-freezer unit using these operating conditions are shown in Table 4. For comparison the performances of R12 and 134a are also shown.

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Table 4

Refrigerant	R12	R134a	1	2	3	4	5
R125 wt%			5	6	8	6	6
R134a wt%			93	92	90	92	92
R227ea						5.7	5.7
R600 wt%			0.6	0.7	0.7		0.6
R601a wt%			0.7	0.6	0.6	0.6	
R600a wt%			0.7	0.7	0.7	0.7	0.7
Discharge pressure (bar)	12.59	13.68	13.97	14.09	14.22	14.25	14.37
Discharge temperature (°C)	96.7	90.5	89.4	89.3	89.2	87.4	87.2
COP (system)	1.56	1.50	1.49	1.48	1.48	1.47	1.47
Capacity (kW/m3)	568	508	515	518	522	517	523
Glide in evaporator (°C)	0	0	0.6	0.7	0.8	0.8	0.6
Glide in condenser (°C)	0	0	0.9	1.0	1.3	1.2	0.9

EXAMPLE 5

Blends comprising fluids selected from R125, R134a, R227ea, R600, R600a and R601a

The performances of various blends were evaluated in an open cycle typical of that used in a centrifugal chiller using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	1 mW
EVAPORATOR	
Midpoint fluid evaporation temperature	0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
PARASITIC POWER	0.07 mW

The results of analysing the performances in fridge-freezer unit using these operating conditions are shown in Table 5. For comparison the performances of R12 and 134a are also shown.

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Table 5

Refrigerant	R12	R134a	1	2	3	4
R134a wt%		60	55	59	55	55
R227ea wt%		38	43	34	38.6	38
R125 wt%				5	5	5
R601a wt%		0.6	0.6	0.7		
R600 wt%		0.7	0.7		0.7	0.7
R600a wt%		0.7	0.7	1.3	0.7	1.3
Discharge pressure (bar)	11.21	11.42	11.29	11.96	11.97	12.01
Discharge temperature (°C)	84.8	72.5	71.5	73.1	72.1	72.1
COP (system)	1950	1820	1792	1902	1896	1903
Capacity (kW/m ³)	2.56	2.51	2.51	2.51	2.50	2.50

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Replacements for R 502 In Low Temperature Refrigeration

EXAMPLE 6

Blends comprising fluids selected from R125, R143a, R134a, R227ea, R600a, R600 and R600a

The performances of various blends were evaluated in hermetic refrigeration cycle typical of that used in some frozen cabinets using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	-35 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	35.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Internal and defrost	0.3 kW
External fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in fridge-freezer unit using these operating conditions are shown in Table 6. For comparison the performances of R12 and 134a are also shown.

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Table 6

Refrigerant	R502	R22					
R125 wt%			65	55		60	50
R143a wt%			33	43		33.4	43.4
R134a wt%						5	5
R601a wt%			0.6	0.6		0.9	0.9
R600 wt%			0.7	0.7			
R600a wt%			0.7	0.7		0.7	0.7
Discharge pressure (bar)	15.46	14.07	16.71	16.71		16.25	16.13
Discharge temperature (°C)	78.8	120.3	69.3	69.3		71.2	72.8
COP (system)	1.56	1.67	1.44	1.44		1.44	1.46
Capacity (kW/m3)	839	839	774	774		746	752
Glide in evaporator (°C)	0.1	0	1.4	1.4		1.9	1.9
Glide in condenser (°C)	0.0	0	1.7	1.7		2.1	2.0

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Replacements for R12 In Mobile Air Conditioning

EXAMPLE 7

Blends comprising fluids selected from R134a, R125, 600, 600a and 601a.

The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	60.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 7. For comparison the performances of R12 and R134a are also shown.

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Table 7 - CFC12 Replacements in Mobile Air Conditioning

Refrigerant	R12	R134a	1	2	3	4	5	6	7
R134wt%			85	87	91	92.2	93	90	92
R125 wt%			12	10.8	6.9	5.5	5	7.8	6
R601a wt%			0.6	0.9	0.7	0.6	0.7	0.9	0.6
R600 wt%			1.8	0.7	0.7	0.7	0.6	1.3	1.4
R600a wt%			0.6	0.6	0.7	1	0.7		
Discharge pressure (bar)	15.7	17.4	18.4	18.3	18.0	17.9	17.8	17.9	17.8
Discharge temperature (°C)	88.4	84.4	83.5	83.8	83.9	83.8	83.9	83.9	83.9
COP (system)	2.45	2.38	2.34	2.34	2.35	2.36	2.36	2.36	2.36
Capacity (kW/m3)	1754	1771	1834	1825	1803	1798	1790	1796	1791
Glide in evaporator (°C)	0	0	1.2	1.2	0.9	0.7	0.7	1.0	0.7
Glide in condenser (°C)	0	0	1.5	1.5	1.0	0.9	0.9	1.2	0.9

Replacements for R12 in Hermetic Refrigeration Equipment

EXAMPLE 8

Blends comprising fluids selected from R134a, R125, 600, 600a and 601a.

The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	-20.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Internal fan	0.3 kW
External fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Tables 8. For comparison the performances of R12 and R134a are also shown.

Table 8 - CFC12 Replacements in Mobile Air Conditioning

Refrigerant	R12	R134a	1	2	3	4	5	6	7
R134wt%			86	90.9	82.5	84.6	86.4	90	92.5
R125 wt%			11	7	14	12	11	7	5
R601a wt%			0.9	0.7	0.9	0.6	0.6	0.8	1
R600 wt%			2.1	1.4	2	2.1	1.4	1.4	0.7
R600a wt%					0.6	0.7	0.6	0.8	0.8
Discharge pressure (bar)	11.21	12.06	12.61	12.39	12.88	12.80	12.76	12.43	12.28
Discharge temperature (°C)	127.6	118.2	115.0	116.0	114.2	114.5	115.1	115.6	116.2
COP (system)	1.36	1.34	1.33	1.34	1.33	1.33	1.33	1.34	1.34
Capacity (kW/m3)	698	653	682	670	696	693	690	673	664
Glide in evaporator (°C)	0	0	1.3	0.9	1.6	1.3	1.2	1.0	1.0
Glide in condenser (°C)	0	0	1.8	1.2	2.1	1.7	1.6	1.3	1.2

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Replacements for R22 in Room Air Conditioning

EXAMPLE 9

Blends comprising fluids selected from R134a, R125, 600, 600a and 601a.

The performances of various blends were evaluated in a typical static air conditioning cycle using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Tables 9. For comparison the performances of R22 and R407C are also shown.

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Table 9 - Replacements for R22 especially in fixed orifice expansion units

Refrigerant	R-22	R407C	1	2	3	4	5
R134a wt%			42.2	44.3	46.3	47.8	49.3
R125 wt%			55	53	51	49	48
R601a			0.8	0.9	0.6	0.8	1
R600			0.8	1	1.4	1.5	1
R600a			1.2	0.8	0.7	0.9	0.7
Discharge pressure (bar)	17.91	19.30	16.05	15.78	15.64	15.37	15.27
Discharge temperature (°C)	104.7	92.5	78.3	78.6	78.7	78.9	79.1
COP (system)	2.49	2.47	2.48	2.48	2.49	2.49	2.49
Capacity (kW/m3)	3067	3172	2671	2635	2619	2580	2566
Glide in evaporator (°C)	0	4.8	4.0	4.1	3.7	3.9	4.1
Glide in condenser (°C)	0	4.7	3.8	3.9	3.7	3.9	4.0

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Replacements for R 502 in Low Temperature Refrigeration

EXAMPLE 10

Blends comprising fluids selected from R125, R143a, R134a, R600a, R600 and R600a

The performances of various blends were evaluated in hermetic refrigeration cycle typical of that used in some frozen cabinets using the NIST CYCLE D program. The modelling conditions are given below.

COOLING DUTY DELIVERED	
10 kW	
EVAPORATOR	
Midpoint fluid evaporation temperature	-35 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	35.0 °C
Subcooling	5.0 °C
Discharge line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Internal fan and defrost	0.3 kW
External fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in fridge-freezer unit using these operating conditions are shown in Table 9. For comparison the performances of R12 and 134a are also shown.

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Refrigerant	R502	R22	1	2	3	4	5	6	7	8
R125 wt%			65	55	60.5	63.9	60.5	62.4	60	50
R143a wt%			33	43	37	34	37	35	33.4	43.4
R134a wt%									5	5
R601a wt%			0.6	0.6			0.6	0.6	0.9	0.9
R600 wt%			0.7	0.7	1	1.2	1	1.3		
R600a wt%			0.7	0.7	1.5	0.9	0.9	0.7	0.7	0.7
Discharge pressure (bar)	15.46	14.07	16.71	16.71	16.76	16.90	16.50	16.46	16.25	16.13
Discharge temperature (°C)	78.8	120.3	69.3	69.3	105.4	104.7	107.3	107.1	71.2	72.8
COP (system)	1.56	1.67	1.44	1.44	1.09	1.09	1.08	1.08	1.44	1.46
Capacity (kW/m3)	839	839	774	774	675	679	651	647	746	752
Glide in evaporator (°C)	0.1	0	1.4	1.4	0.9	0.8	2.7	2.9	1.9	1.9
Glide in condenser (°C)	0.0	0	1.7	1.7	0.9	0.8	1.9	2.0	2.1	2.0

Table 10

CLAIMS

1. A refrigerant composition consisting essentially of a combination of a hydrofluorocarbon component consisting of a combination selected from the following mixtures:

- (1) R134a and R125;
- (2) R134a, R125 and R143a
- (3) R125 and R143a
- (4) R134a, R227ea and R125

and a hydrocarbon component consisting essentially of a combination selected from the following mixtures:

- (5) isopentane and butane
- (6) isopentane, butane and isopentane
- (7) butane and isobutane.

2. A composition as claimed in claim 1 consisting of a mixture of one of hydrofluorocarbon components (1) to (4) and one of hydrocarbon components (5) to (7).
3. A composition as claimed in claim 1 or 2 wherein the hydrocarbon is present in an amount of 0.6 to 4% and wherein the composition is non-flammable when completely in the vapour phase.
4. A composition as claimed in any preceding claim wherein the hydrocarbon is present in an amount of 0.6 to 4% and wherein when the composition is in a

container with both vapour and liquid present, neither vapour nor liquid phase is flammable.

5. A composition as claimed in any preceding claim wherein the hydrocarbon is present in an amount of 0.6 to 4% and wherein at any time during a leak from a vapour space in a container neither the liquid phase nor the vapour phase is flammable.
6. A composition as claimed in any preceding claim wherein the hydrocarbon is present in amount of 0.6 to 4% and wherein at any time during a leak from a liquid space in a container neither the liquid phase nor vapour phase is flammable.
7. A composition as claimed in any preceding claim wherein the hydrocarbon is present in an amount of 0.6 to 4% and wherein the proportion of hydrocarbon to hydrofluorocarbon in the vapour phase does not differ from the equivalent proportion in the liquid phase by more than 40% at equilibrium at 25°C.
8. A composition as claimed in claim 7 wherein the proportion does not differ by more than 30%.
9. A composition was claimed in claim 8 wherein the composition does not differ by more than 20%.
10. A composition as claimed in any preceding claim wherein the hydrocarbon is present in an amount of 0.6 to 4% and wherein the proportion of hydrocarbon to hydrofluorocarbon in the vapour phase does not differ from the formulated composition by more than 40% at equilibrium at 25°C.

11. A composition as claimed in claim 10 wherein the proportion does not differ by more than 30%.
12. A composition as claimed in claim 11 wherein the proportion does not differ by more than 20%.
13. A composition as claimed in any preceding claim wherein during a leak from the vapour space or liquid space a container, the proportion of hydrocarbon to hydrofluorocarbon in either of the vapour phase or liquid phase does not differ from the formulated composition by more than 40% at equilibrium at 25°C.
14. A composition as claimed in claim 13 wherein the proportion does not differ by more than 40%.
15. A composition as claimed in claim 14 wherein the proportion does not differ by more than 20%.
16. A composition as claimed in any preceding claim wherein the hydrocarbon component consists of a mixture of isopentane, butane and isobutene.
17. A composition as claimed in claim 16 wherein the amount of isopentane is 0.6 to 2%.
18. A composition as claimed in claim 17 wherein the amount of isopentane is 0.6 to 1%.

19. A composition as claimed in any of claims 16 to 18 wherein the amount of butane is 0.6 to 5%.
20. A composition as claimed in claim 19 wherein the amount of butane is 0.6 to 3%.
21. A composition as claimed in claim 20 wherein the amount of butane is 0.6 to 2%.
22. A composition was claimed in any of claims 16 to 21 wherein the amount of butane is 0.6 to 5%.
23. A composition as claimed in claim 22 wherein the amount of butane is 0.6 to 2%.
24. A composition as claimed in claim 23 wherein the amount of butane is 0.6 to 1%.
25. A composition was claimed in any of claims 1 to 15 wherein the hydrocarbon component consists of a mixture if isopentane and butane.
26. A composition as claimed in claim 25 wherein the amount of isopentane is 0.6 to 1%.
27. A composition as claimed in claims 25 or 26 wherein the amount of butane is 1.3 to 2.5%.

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28. A composition as claimed in claim 27 wherein the amount of butane is about 1.4%.
29. A composition as claimed in any of claims 1 to 15 wherein the hydrocarbon component consists of butane and isobutane.
30. A composition as claimed in claim 29 wherein the amount of butane is 0.6 to 5%.
31. A composition as claimed in claim 29 or 30 wherein the amount of isobutane is 0.6 to 5%.
32. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:
- | | |
|------------|---------------|
| R134a | 93.1 to 81.5% |
| R125 | 5 – 15% |
| isopentane | 0.6 to 1% |
| butane | 1.3 to 2.5% |
33. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:
- | | |
|------------|------|
| R134a | 83% |
| R125 | 5% |
| isopentane | 0.6% |
| butane | 1.4% |
34. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

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R134a	93.2 to 80%
R125	5 to 15%
isopentane	0.6 to 1%
butane	0.6 to 3%
isobutane	0.6 to 1%

35. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R134a	93%
R125	5%
isopentane	0.6%
butane	0.8%
isobutane	0.6%

36. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R134a	53.2 to 39%
R125	45 to 55%
isopentane	0.6 to 1%
butane	0.63%
isobutane	0.62%

37. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R134a	47.5%
R125	50%
isopentane	0.6%
butane	1%

isobutane 0.9%

38. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R134a 10 to 30%

R125 80 to 40%

R143a 10 to 30%

isopentane 0.6 to 2%

butane 0.6 to 5%

isobutane 0.6 to 5%

39. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R134a 16.5%

R125 60%

R143a 21%

isopentane 0.6%

butane 0.9%

isobutane 1%

40. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R125 75 to 55%

R143a 25 to 45%

butane 0.6 to 5%

41. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R125 60.5%

R143a	37%
butane	1%
isobutane	1.5%

42. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R125	60.5%
R143a	37%
butane	0.9%
isobutane	1%
isopentane	0.6%

43. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R134a	58.2 to 36%
R227ea	35 to 50%
R125	5 to 8%
isopentane	0.6 to 2%
butane	0.6 to 2%
isobutane	0.6 to 2%

44. A refrigerant composition as claimed in any of claims 1-13 consisting essentially of:

R134a	51%
R227ea	41%
R125	6%
isopentane	0.6%
butane	0.8%
isobutane	0.6%

INTERNATIONAL SEARCH REPORT

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IPC 7 C09K5/04

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of box C☒ Patent family members are listed in annex

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INTERNATIONAL SEARCH REPORT

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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
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	Fecha de presentación de la solicitud 28-02-05	N° publicación WO2005/083028 A1	
	No de solicitud PCT/GB2005/000737		
(54) Título COMPOSICION REFRIGERANTE			

Resumen - Reivindicación(es)

Una composición refrigerante está constituida esencialmente por una combinación de un componente hidrofluorocarburo que está constituido por una combinación seleccionada entre las siguientes mezclas: (a) R134a y R125, (b) R134a, R125 y R143a; (c) R125 y R143a; (d) R134a, R227ea y R125 y un componente hidrocarburo que está constituido esencialmente por una combinación seleccionada entre las siguientes mezclas (e) isopentano y butano, (f) isopentano, butano e isobutano; (g) butano e isobutano.



SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO
Rad: 06-096953-00000-0000
Fec: 2006-09-26 17:05:08 Dep. 2020 NUECREACIONES
Tra. 11 PATENTE/II
Evo: 378 FASENACIONALI
Act 411 PRESENTACION Fotos: 150

Industria y Comercio

SUPERINTENDENCIA

Delegatura de Propiedad Industrial
División de Nuevas Creaciones

REQUISITOS NECESARIOS PARA PRESENTACIÓN Y AGILIZACIÓN DEL TRAMITE

	USUARIO	RADICADOR
PATENTE DE INVENCION () ☒ MODELO DE UTILIDAD ()	()	()
-Indicación de que se solicita la concesión de una patente.	()	()
-Datos de identificación del solicitante o de la persona que se presenta la solicitud	()	()
-Descripción de la invención	()	()
-Dibujos de ser estos pertinentes	()	()
-Comprobante de Pago de las tasas establecidas.	()	()
COMPLETA () ☒ INCOMPLETA ()	()	()

DISEÑO INDUSTRIAL ()

-Indicación de que se solicita el registro de Diseño Industrial.	()	()
-Datos de identificación del solicitante o de la persona que se presenta la solicitud.	()	()
-Representación gráfica y fotográfica del Diseño Industrial o muestra del Material que incorpora el diseño	()	()
-Comprobante de Pago de las tasas establecidas.	()	()
COMPLETA () INCOMPLETA ()	()	()

ESQUEMA DE TRAZADO ()

-Indicación de que se solicita el registro de Diseño Industrial	()	()
-Datos de identificación del solicitante o de la persona que se presenta la solicitud.	()	()
-Representación gráfica del Esquema Trazado.	()	()
-Comprobante de Pago de las tasas establecidas.	()	()
COMPLETA () INCOMPLETA ()	()	()

Firma Responsable:

Fecha.

157
150

REPUBLICA DE COLOMBIA
SUPERINTENDENCIA DE INDUSTRIA Y COMERCI

Bogotá,
2020

Doctor(a)
DELGADO VILLEGAS JAIME EDUARDO

REFERENCIA	Radicación No.	6 96953
	Solicitud internacional	PCT/GB205/000737
	Fecha inicio fase nacional	27/09/2006
	Trámite	11
	Evento	378
	Actuación	430
	Oficio No.	12973

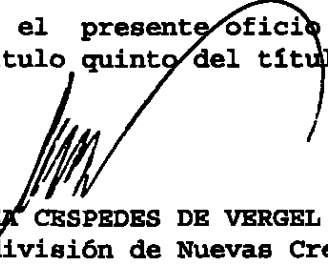
Como resultado del examen de forma, realizado con fundamento en el artículo 38 de la Decisión 486 de la Comisión de la Comunidad Andina, artículo 27 del Tratado de Cooperación en Materia de Patentes (PCT), regla 51 bis del Reglamento y Circular Única de la Superintendencia de Industria y Comercio, se le comunica que:

1. La solicitud no contiene la copia del documento en que consta la cesión del derecho a la patente del inventor al solicitante o a su causante. (Art. 26-k) Decisión 486.

2. La solicitud no contiene el poder debidamente otorgado, con el lleno de los requisitos exigidos por los artículos 63 y subsiguientes del Código de Procedimiento Civil. Adicionalmente, deberá presentar el documento que acredita la existencia y representación legal de la sociedad solicitante, cuando ésta fuere persona jurídica.

En cumplimiento de lo dispuesto por el artículo 39 de la Decisión 486, se le requiere para que dentro del término de dos meses siguientes a la fecha de notificación del presente oficio, complete los requisitos anteriormente enunciados. En caso de no dar cumplimiento al presente requerimiento, la solicitud se considerará abandonada y perderá su prelación.

Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la Circular Unica No.10 de 2001.


ALIX CARMENZA CRESPEDES DE VERGEL
Jefe de la división de Nuevas Creaciones

El anterior requerimiento fue notificado por fijación en lista de fecha _____
adpall 10 NOV. 2006