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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<td></td>
<td>(43) International Publication Date:</td>
<td>11 May 1995 (11.05.95)</td>
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<tr>
<td>(21) International Application Number:</td>
<td>PCT/GB94/02421</td>
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<td>(22) International Filing Date:</td>
<td>4 November 1994 (04.11.94)</td>
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<td>(30) Priority Data:</td>
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<td>6 November 1993 (06.11.93)</td>
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<td>27 July 1994 (27.07.94)</td>
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<td>(72) Inventors; and</td>
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<td>(75) Inventors/Applicants (for US only): GREIG, Barry, Dennis [GB/GB]; 39 Geoffreyson Road, Caversham Heights, Reading, Berkshire RG4 7HS (GB). SMITH, Andrew, Michael [GB/GB]; 6 Offas Close, Benson, Wallingford, Oxfordshire OX10 6NR (GB). SWALLOW, Andrew [GB/GB]; 24 Tredgar Road, Emmer Green, Reading, Berkshire RG4 8QF (GB). O’BRIEN, Margaret, Mary [IE/GB]; 83 Headley Road, Woodley, Reading, Berkshire RG5 4JD (GB).</td>
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<td>(54) Title: LUBRICATION OF REFRIGERATION COMPRESSORS</td>
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<td>(57) Abstract</td>
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A lubricant composition intended for use in a refrigeration system having at least one compressor and employing a halocarbon working fluid such as R134a, comprises a synthetic polyol ester lubricant and a siloxane in an amount sufficient to increase foam density and control vapour evolution.
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LUBRICATION OF REFRIGERATION COMPRESSORS

This invention relates to the lubrication of refrigeration compressors.

In recent years, as a result of environmental pressure, there has been a move away from the traditional use of refrigerant gases such as the chlorofluorocarbons to the use of less damaging fluorocarbons such as 1,1,1,2-tetrafluoroethane. This change has also necessitated a change in the lubricants employed with the working fluid, as the originally used lubricants such as alkyl benzenes and mineral oils are not fully miscible with the new working fluids such as 1,1,1,2-tetrafluoroethane. New lubricants have thus been developed. In particular, synthetic polyl ester lubricants have been shown to be satisfactory for the new working fluids.

However, this change in lubricant has itself caused problems. In particular, it has been found that the fluorocarbon working fluid/synthetic ester lubricant systems can be problematic in certain circumstances of compressor operation which involve excessive and uncontrolled release of refrigerant vapour from the lubricating oil causing vapour flooding which can prevent the lubricant being effectively circulated. This lack of adequate lubrication in the system can lead to high wear rates and/or compressor failure.

Such a situation may occur, for example, at start up of the compressor, but may also occur during operation, for example, in multi
compressor systems where pressure differences affect the lubricant/refrigerant equilibrium in one or more of the compressors.

Of course, such problems can be overcome by redesign of the compressor system so that such flooding cannot occur - however, this is a wasteful and expensive course to take when there are compressors available that have still a long potential working life.

This invention seeks to overcome such problems by enabling the continued use of existing compressors without the need for physical modification of the system.

In accordance with the present invention there is provided a lubricant composition comprising a synthetic polyol ester lubricant and a foam density increasing additive for use in a refrigeration system having at least one compressor and employing a halocarbon working fluid, which additive is present in an amount sufficient to increase foam density and control vapour evolution from the compressor or one or more of the compressors.

Preferably, the foam density increasing additive is a siloxane which has a molecular weight average in the range of from 200 to 13000.

It is recognised that the inclusion of some type of siloxane in a refrigeration fluid system is not, in itself, new. Thus, U.S. patent No. 3792755 describes the use of a foaming agent which is believed to be an organosiloxane dissolved in toluene for noise attenuation during
operation of the compressor. This document, however, is concerned with
the use of traditional working fluids and lubricants. Furthermore, there is
a recognised concern within the document to control the amount of
foaming to prevent foam entering the compression chamber and
damaging the compressor. The use of siloxane polymers as anti-foaming
agents has also been proposed in refrigeration systems, see for example,
U.S. patent No. 5021179. This is hardly surprising as siloxane polymers
have previously been used as anti-foaming agents in a wide variety of
applications.

It was thus surprising to find that the use of siloxane, in
accordance with the invention, was able to overcome the previously
reported problems by increasing foam density and controlling the
evolution of refrigerant vapour during changes in compressor operation,
for example, start up or other situations where the lubricant/refrigerant
equilibrium in the compressor is affected, thus giving the means of
overcoming the potential failure or wear problems and allowing
continued use of existing compressors with the new working
fluid/lubricant systems.

It will be appreciated that other additives capable of increasing foam
density so as to control vapour evolution may be employed, for example,
halogenated aliphatic polymeric esters such as Fluorad FC 430, a
fluorinated aliphatic polymeric ester available from 3M, Bracknell and certain organic polymers such as PC 1244, available from Monsanto.

The synthetic polyol ester lubricant suitably, although not necessarily, comprises an ester having a molecular weight of greater than 250, preferably an ester of an aliphatic mono-carboxylic acid and an alcohol having at least three hydroxy groups such as pentaerythritol and/or dipentaerythritol. Esters of this type are described in European Patent Specification No. 468729.

The polyol ester lubricant may be the sole lubricant of use, or may be present in a mixture with other synthetic and/or mineral based lubricants dependent on the refrigerant working fluid employed and the prior lubricants used in the system.

The halocarbon working fluid is preferably an environmentally acceptable fluorocarbon such as 1,1,1,2-tetrafluoroethane (known as HFC 134a or R 134a), although the invention is also applicable to earlier and now less acceptable working fluids containing chlorine such as R12 (dichlorodifluoromethane). The invention is applicable to "Retrofill" situations where the previously used lubricant was, for example, an alkyl benzene or mineral oil with a working fluid selected from R12, R22, R502 or R511. Such use is described in the above referenced European Patent Specification No. 468729. Alternative newly acceptable refrigerants such as R404a may also be employed.
Siloxanes used as the foam density increasing additive suitably have a molecular weight average of from 200 to 1300 although the actual choice of siloxane will depend on the need for solubility in the lubricant employed. A preferred molecular weight average is from 236 to 5000. The siloxane may also be defined in terms of its viscosity and siloxanes in the viscosity range of from 0.65 to 1000 centistokes at 25 degrees C, preferably 1 to 100 centistokes may be employed dependent on the lubricant and working fluid of use.

A suitable siloxane for use in accordance with the invention has been found to be that known as 200/5CS, molecular weight average 680, available from Dow Corning of Reading, Berkshire.

The amount of foam density increasing additive present must be sufficient to increase foam density and control vapour evolution from the, or one or more of the, compressors in the refrigeration system. While it will be appreciated that the optimum concentration can be determined by the man skilled in the art for a particular application, a preferred concentration lies in excess of 150 ppm additive based on the weight of the lubricant and is preferably greater than 200 ppm. In order to ensure that the additive will remain miscible with the refrigerant, it is preferable to employ not more than 1200 ppm additive. Preferably the lubricant contains less than 0.1% by volume of additive.

The lubricant composition of the invention can be employed with particular advantage to overcome start up flooding problems, for
example for an oil pump lubricated single compressor. Additionally, when operating with a multi-compressor system, the lubricant is advantageously used to obviate unwanted refrigerant flooding effects caused, for example, during supply of lubricant with dissolved refrigerant to the compressor, the refrigerant content being high. This may occur as a result of a high pressure difference during supply of the lubricant, or as a result of a need to supply additional liquid refrigerant for cooling the compressor.

The invention has been found to be particularly useful in respect of semi-hermetic compressors, which are commonly used in multi-compressor installations and in connection with applications involving transportation of equipment where extremes of operating conditions can exacerbate the flooding problems.

The following non-limiting Examples are included to illustrate the invention with respect to A) Compressor Start Up and B) Multiple Compressor Operation.
A) COMPRESSOR START UP

Test Procedure

Lubricant compositions with and without the addition of siloxane were tested in accordance with the following procedure:

A conventional Carrier Thinline "clip-on" container cooling unit was mounted in the open air and operated in the "modulation mode" with the supply air temperature sensor immersed in an ice-water mix (at zero degrees C). The temperature set point was adjusted to about zero degrees C to ensure that the compressor operated continuously. In the modulation mode the suction was restricted to ensure that the supply air temperature was kept constant and to avoid compressor overheating an amount of liquid refrigerant was allowed to enter the compressor. This resulted in the compressor "icing up" due to the cooling effect of the liquid refrigerant evaporating. This procedure was used to artificially generate a "flooded start" situation where the compressor sump contained approximately equal proportions of lubricant and liquid refrigerant.

In the test procedure, once a sufficient ice ball had been built, the compressor was stopped and a bypass valve opened to allow liquid refrigerant from the condenser to enter the sump. After an appropriate "soak" period the compressor was restarted and allowed to run in the modulation mode again. During the first few minutes of operation the actual oil pressure (difference between sump and oil pump discharge) was monitored.
EXAMPLE A I (Comparative)

The above test procedure was carried out using R12 as a working fluid and a standard mineral oil lubricant (available as Napthenic ISO VG 32 from Sun Oil). Two runs were carried out and the results are shown in Figure 1 indicating that the oil pressure was at an acceptable level throughout the start-up period.

EXAMPLE A II (Comparative)

The test procedure was repeated using R 134a as working fluid together with a polyol ester lubricant and available from Castrol as Castrol ICEMATIC SW20.

To the lubricant there had been added 120 ppm of Dow Corning siloxane "200/5CS". The results of Runs 1 and 2 are given in Figure 2. It will be seen that for Run 1 the oil pressure remained unacceptably low throughout start-up while, for Run 2, the pressure fell before attaining a suitable level.

EXAMPLE A III

The test procedure of Example 2 was repeated but employing 240 ppm of siloxane "200/5CS". The results of Runs 1 and 2 are shown in Figure 3. It will be seen that in both cases the initial low oil pressure rapidly reached an acceptable level and thus adequate lubrication during start-up was maintained.
B) MULTIPLE COMPRESSOR OPERATION

A lubricant composition in accordance with the invention was employed with a supermarket refrigeration system shown diagrammatically in Fig. 4.

The system shown in Fig. 1 comprises six Prestcold PL 300/10040 compressors 1, 2, 3, 4, 5 and 6 linked to a single discharge line 7 leading to the configuration system single condenser. Of the six compressors, 1, 2 and 3 are connected to a higher suction pressure line 8. Compressors 4, 5 and 6 are connected to a low suction pressure line 9.

A common lubrication system for the six compressors comprises an oil separator 10 in the discharge line 7 upstream of the condenser, from which oil passes via float level valve to oil holding reservoir 11 maintained at a pressure nominally one bar above the high suction pressure of 3 bar. The lubricant in reservoir 11 is thus saturated with refrigerant (e.g. R22) at 4 bar and ambient temperature, excess refrigerant boiling off via a pressure relief value 12 to the high suction pressure line 8. Each compressor 1, 2, 3, 4, 5 and 6 is provided with a float level valve 14, 15, 16, 17, 18, 19 supplying oil from reservoir 11 when required to that compressor. Thus for compressors 1, 2 and 3 oil is fed from reservoir 11 at 4 bar to the compressor sumps at 3 bar, while for compressors 4, 5 and 6 oil is fed from reservoir 11 at 4 bar to the compressor sumps connected to the low suction pressure line at 1 bar.
In operation using a conventional synthetic polyol ester lubricant (available from Castrol as Castrol ICEMATIC SW 32) at low temperature (below minus 20 degrees C), compressor 4, 5 and 6 suffered from inadequate lubrication.

The conventional napthenic oil lubricant was replaced by a lubricant in accordance with the present invention, a polyol ester, containing 240 ppm of siloxane 200/5cs.

The system operated normally, at low temperatures down to -25 degrees C and showed no sign of inadequate compressor lubrication.
CLAIMS

1. A lubricant composition comprising a synthetic polyol ester lubricant and a foam density increasing additive for use in a refrigeration system having at least one compressor and employing a halocarbon working fluid, which additive is present in an amount sufficient to increase foam density and control vapour evolution from the compressor or one of the compressors.

2. A lubricant composition according to claim 1, wherein the foam density increasing additive is a siloxane.

3. A lubricant composition according to claim 2, wherein the siloxane has a molecular weight average in the range of from 200 to 13000.

4. A lubricant composition according to claim 1 wherein the foam density increasing additive is a halogenated aliphatic polymeric ester.

5. A lubricant composition according to and one of the claims 1 to 4, wherein the foam density increasing additive is present in an amount in excess of 150 ppm based on the weight of the lubricant.

6. A lubricant according to claim 5, wherein the foam density increasing additive is present in an amount in excess of 200 ppm based on the weight of the lubricant.
7. A lubricant composition according to any one of claims 1 to 6, wherein the siloxane is present in an amount of not more than 1200 ppm based on the weight of the lubricant.

8. A lubricant composition according to any one of the preceding claims, wherein the foam density increasing additive is present in an amount of less than 0.1% by volume based on the lubricant.

9. A lubricant composition according to any one of the preceding claims, wherein the polyol ester has a molecular weight greater than 250 and is an ester of an aliphatic mono-carboxylic acid and an alcohol having at least three hydroxy groups.

10. A lubricant composition according to any one of the preceding claims for use in a refrigeration system having at least one semi-hermetic compressor.

11. A lubricant composition according to any one of the preceding claims for use in a refrigeration system employing 1,1,1,2-tetrafluoroethane as working fluid.

12. A lubricant composition according to any one of the preceding claims for use in a refrigeration system employing an oil pump lubricated compressor.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER


According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6  C10M

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>EP,A,0 590 238 (TECUMSEH PRODUCTS COMPANY) 6 April 1994 see claims 1-3,8 see column 6, line 35 - line 45</td>
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<td>DATABASE WPI Week 8322, Derwent Publications Ltd., London, GB; AN 83-53046K[22] &amp; JP,A,58 069 298 (MATSUSHITA REIKI) 25 April 1983 see abstract</td>
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**Further documents are listed in the continuation of box C.**

| Patent family members are listed in annex. |

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search

23 February 1995

Date of mailing of the international search report

15. 03. 95

Name and mailing address of the ISA

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