AMMONIA REFRIGERATION COMPRESSOR AND TRANSFER PUMP LUBRICATING OIL BASED ON ALKYLATED NAPHTHALENES

Applicant: JAX INC., Menomonee Falls, WI (US)

Inventors: Troy F. Paquette, Merton, WI (US);
Eric J. Peter, Elm Grove, WI (US);
Christopher W. Fotl, Waukesha, WI (US)

Assignee: JAX INC., Menomonee Falls, WI (US)

Appl. No.: 14/153,194

Filed: Jan. 13, 2014

Publication Classification

Int. Cl. C10M 169/04 (2006.01)

U.S. Cl.
CPC .......... C10M 169/045 (2013.01); C10M 101/00 (2013.01)

ABSTRACT

A lubricant composition comprising an alkylated naphthalene component and a mineral oil component and which is essentially free of ammonia reactive components is described. In certain examples, the lubricant composition is food grade. The lubricant compositions are particularly well suited for use in ammonia refrigeration compressors and ammonia refrigerant transfer pumps. The mineral oil has no more than about 60 percent of paraffinic compounds by weight of the mineral oil. When used to lubricate ammonia refrigeration compressors, the lubricant composition has an ISO VG of 46 to 100. When used to lubricate ammonia refrigerant transfer pumps, the lubricant composition has an ISO VG of 22 to 46.
AMMONIA REFRIGERATION COMPRESSOR AND TRANSFER PUMP LUBRICATING OIL BASED ON ALKYLATED NAPHTHALENES

FIELD

[0001] The present disclosure concerns lubricating oils including an alkylated naphthalene component which are suitable for use as compressor lubricants or transfer pump lubricants in ammonia refrigeration systems.

BACKGROUND

[0002] Typical refrigeration systems include a compressor, condenser, an expansion device, and an evaporator. A refrigerant fluid is provided that cools significantly upon expansion in the expansion device to yield a liquid-vapor mixture of the refrigerant. The liquid vapor mixture then passes through an evaporator and absorbs heat from the surroundings, thereby providing the desired refrigeration. The refrigerant typically becomes superheated in the evaporator and is then compressed in a compressor. The compressed refrigerant is typically superheated vapor following compression and then enters a condenser, where it is desuperheated. In order to lubricate the compressor’s various moving parts, a lubricant composition is provided in the refrigerant circuit. The lubricant acts as a heat transfer medium in addition to lubricating the compressor’s moving parts, e.g., pistons and bearings. However, because the lubricant forms a seal around moving parts in the compressor, the lubricant typically will contaminate the refrigerant to some degree. Thus, the physical and chemical interactions of the lubricant and refrigerant are important. For example, if the refrigerant and lubricant react, solid deposits may form and foul heat transfer surfaces or cause undesirable friction effects.

[0003] Refrigerant transfer pumps are used to transport a refrigerant within a refrigeration system. In order to lubricate the pump, a lubricating composition is provided. As with compressor applications, the lubricant forms a seal around moving parts that create an interface with the refrigerant, resulting in a propensity for contamination of the refrigerant with the lubricant. Thus, the refrigerant and lubricant are preferably selected to avoid undesirable chemical reactions or physical interactions.

[0004] Viscosity is an important property of refrigeration compressor or transfer pump lubricating oils. For example, at high viscosities, if the compressor lubricant is carried over into the refrigerant, the lubricant may become trapped in portions of the condenser or evaporator and negatively impact heat transfer. In general, satisfactory lubricating oils should lubricate machine parts, resist viscosity change, resist oxidation, protect against rusting and corrosion, provide wear protection, prevent foaming, and resist the formation of sludge in service. The lubricating oils should also perform effectively at various lubrication regimes ranging from hydrodynamic thick film regimes to boundary thin film regimes.

[0005] Thermal stability is another important property of refrigeration compressor and transfer pump lubricating oils. The thermal stability of the refrigeration lubricant’s base oil helps predict how effectively the oil will maintain its lubricating properties over time and resist deposit formation as well as indicating the length of the lubricant’s useful life (drip interval). Hydrocarbon oils, especially napthenic-based oils used in refrigeration systems, are subject to thermal decomposition at the elevated temperatures that are typically associated with refrigerant compression over prolonged periods of time. Thermal degradation products contribute to the formation of varnish and sludge which can clog valves, plug filters, and result in the over-all breakdown of the viscosity characteristics of the lubricant; requiring more frequent lubricant drain and replacement. Under some circumstances, deposit formation can result in plugging, complete loss of oil system flow, and failure or damage to machinery.

[0006] The thermal stability characteristics of the refrigeration lubricant are also dependent on the additive package. The utilization of an optimized additive system minimizes varnish and sludge formation, viscosity change, acidity change, and the corrosion tendencies of the oil. Superior stability characteristics result in the lubricating oil losing lubricating properties over time and forming varnish or precipitating sludge. It is, therefore, desirable to provide an improved food grade lubricating oil which overcomes most, if not all, of the preceding problems.

[0007] One known refrigerant is ammonia (NH₃). Ammonia is a desirable refrigerant because it does not include ozone depleting halocarbons and does not contribute to climate change. Unlike many halogenated hydrocarbon refrigerants, ammonia is basic, and some known refrigeration lubricating oils have acidic components that can react with ammonia to form deposits. Like thermal degradation products, such precipitates can clog valves, plug filters, and impair heat transfer.

[0008] Refrigeration systems used in food processing plants present additional concerns as compared to systems used in other applications. The equipment used in the food processing industry varies by segment with the three leading segments comprising meat and poultry, beverages, and dairy. While the equipment varies from segment to segment, the majority of manufacturing operations have a significant financial investment in refrigeration compressors and refrigeration transfer pumps. Due to the importance of ensuring and maintaining safeguards and standards of quality for food products, the food industry must comply with the rules and regulations set forth by the United States Department of Agriculture (USDA), originally under The Food Safety and Inspection Service (FSIS), as part of the Federal Food, Drug and Cosmetic Act (FFDCA), which holds responsibility for all programs for the inspection, grading, and standardization of meat, poultry, eggs, dairy products, fruits, and vegetables.

[0009] Under the FFDCA, specifically section 21 CFR 178.3570, lubricants which are susceptible to incidental food contact are considered indirect food additives under USDA regulations. Lubricants classified as H1 are authorized for incidental food contact and may be used on machinery used for producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food. The present disclosure describes certain embodiments of lubricant compositions that are H1 authorized lubricating oils. The phrase “H1 authorized lubricant compositions” and “food grade” will be used interchangeably for purposes of this disclosure. Refrigerant compressors and transfer pumps may be located in areas of a food processing facility where incidental contact between the lubricant and food is possible or likely. “Food grade” lubricant compositions are authorized for use in such areas because their constituents are “food grade” and can be safely ingested as a food contaminant within certain prescribed concentrations.

[0010] Several market factors accentuate the need for a superior food grade refrigeration lubricant. Since the introduction of ISO 22000:2005, many food processors/manufac-
Manufacturers require the use of only H1 authorized lubricants to avoid the possibility of noncompliance. Reducing contamination risks and inventory carrying costs associated with stocking multiple inventories of varying viscosity/FDA approval level oils also provides an economic incentive for exclusive use of H1 authorized lubricants. Furthermore, other firms, reliant upon company image as a marketing resource, may elect to take the conservative approach to health and safety issues and utilize only H1 authorized lubricants. All of the above concerns are addressed by the exclusive use of H1 authorized lubricants. Thus, a lubricant composition and methods of lubricating a refrigeration compressor and refrigerant transfer pump are desired which address the foregoing concerns.

DETAILED DESCRIPTION

[0011] The lubricant compositions of the present disclosure comprise a base oil that includes an alkylated naphthalene component. In addition to a base oil, the lubricant compositions may include one or more additives provided as an additive package. The lubricant compositions are particularly well suited for use with an ammonia refrigerant in ammonia refrigeration compressors and in ammonia refrigerant transfer pumps. In certain preferred examples, the base oil forming the lubricant composition includes both an alkylated naphthalene component and a mineral oil component, and the lubricant composition is essentially free of any ammonia reactive components such as compounds with sufficient acidity to cause acid-base reactions with ammonia, including fatty acids and fatty acid esters. In certain examples, the lubricant compositions are food grade. In illustrative food grade embodiments, the lubricant comprises a base oil that includes an an alkylated naphthalene component that has received a "Food Contact Substance" (FCS) notification from the U.S. Food and Drug administration and a white mineral oil component that meets the requirements of a "technical white oil" under Section 178.3620(c) of Title 21 of the Code of Federal Regulations. The food grade lubricant composition also includes a food grade additive package and is essentially free of any ammonia reactive components.

[0012] Base Oil

[0013] The alkylated naphthalene component of the base oil of the present disclosure consists essentially of one or more alkylated naphthalene compounds. The disclosed alkylated naphthalenes may be produced by any suitable means known in the art, from naphthalene itself or from substituted naphthalenes which may contain one or more short chain alkyl groups having up to about eight carbon atoms, such as methyl, ethyl or propyl, etc. Suitable alkyl-substituted naphthalenes for forming alkylated naphthalenes include alpha-methylnaphthalene, dimethylnaphthalene and ethynylnaphthalene. In certain examples, it is preferred to produce the alkylated naphthalenes from one or more selected from naphthalene, 1-methyl naphthalene, and 2-methylnaphthalene. In certain preferred examples wherein the alkyl naphthalenes are formed from 1-methyl naphthalene and/or 2-methylnaphthalene, the percentage of the substituted long chain alkyl groups attached to the naphthalene and the 2 position is 30 percent or less.

[0014] Alkylated naphthalenes may be characterized using an "alpha/beta ratio" that defines the molar proportion of alpha carbons and beta carbons at which alkyl substitutions are present. The alpha and beta carbons on a naphthalene rings are defined as follows:

[0015] In certain examples, the alkylated naphthalene component described herein has a molar alpha/beta ratio of at least about 0.5 and preferably at least about 0.7. At the same time, the alkylated naphthalene component has a molar alpha/beta ratio of no more than about 1.0 and preferably no more than about 0.7. In certain examples, an alkylated naphthalene component with a molar alpha/beta ratio of 0.8 is used.

[0016] In certain preferred examples, the alkylated naphthalenes in the alkylated naphthalene component of the present disclosure are produced in accordance with U.S. Pat. No. 5,034,563, entitled Naphthalene Alkylation Process, the entirety of which is incorporated by reference. In accordance with the methods described therein, long chain alkyl substituted naphthalenes are produced by the alkylation of naphthalene with an olefin such as an alpha-olefin or other alkylating agent such as an alcohol or alkyl halide possessing at least 6 carbon atoms, preferably 10 to 30 and most preferably 12 to 20 carbon atoms, in the presence of an alkylation catalyst comprising a zeolite which contains cations having a radius of at least 2.5 A. Cations of this size may be provided by hydrated cations such as hydrated ammonium, sodium or potassium cations or by organoammonium cations such as tetraalkylammonium cations. The zeolite is usually a large pore size zeolite USY. The presence of the bulky cations in the zeolite increases the selectivity of the catalyst for the production of long chain mono-alkyl substituted naphthalenes in preference to more highly substituted products.

[0017] In another preferred example, the alkylated naphthalene consists essentially of the reaction products of naphthalene (or a substituted naphthalene) and an olefin in the presence of an alkylation catalyst. Preferred alpha-olefins have at least nine carbon atoms, more preferably at least ten carbon atoms, and still more preferably at least twelve carbon atoms. At the same time, preferred alpha-olefins have no more than twenty-two carbon atoms, more preferably no more than 20 carbon atoms, and still more preferably no more than eighteen carbon atoms. Suitable alkylated naphthalenes include FFPCA authorized alkylated naphthalenes of the type disclosed in U.S. Pat. No. 5,602,086, the entirety of which is hereby incorporated by reference.

[0018] As mentioned previously, in certain examples of lubricating compositions described herein, the lubricating composition is "food grade." In accordance with such examples, the alkylated naphthalene component of the base oil is preferably one for which the U.S. Food and Drug Administration has issued an "Effective Food Contact Substance (FCS) Notification." Such notifications are included on the FDA website at http://www.accessdata.fda.gov." Exemplary alkylated naphthalenes that have received an FCS Notification include the reaction products of naphthalene and 1-dodecene (CAS Reg. No. 939823-19-5) (FCN No. 758), the reaction products of naphthalene and 1-hexadecene (CAS Reg. No. 94247-63-9) (FCN 915), the reaction products of naphthalene and 1-tetradecene (CAS Reg. No. 132983-41-6) (FCN 822 and 899), and a mixture of 50-70 percent by weight.
of hexadecyl naphthalene (CAS Reg. No. 56388-47-7) and 30-50 percent by weight of octadecyl naphthalene (CAS Reg. No. 56388-48-8).

[0019] Commercially available food grade alkylated naphthalenes suitable for forming the lubricant compositions described herein include the SYNNESTIC™ M and SYNNESTIC™ 12 alkylated naphthalenes supplied by ExxonMobil Chemical. SYNNESTIC™ 5, where the “12” and “5” designations refer to the kinematic viscosity in centistokes (cSt) at 100°C. SYNNESTIC™ 5 has a kinematic viscosity of 29 cSt at 40°C. and SYNNESTIC™ 12 has a kinematic viscosity of 109 cSt at 40°C. Other suitable food grade alkylated naphthalenes include the NA-LUBE® KR 006FG and NA-LUBE® KR 015FG alkylated naphthalenes supplied by King Industries. Inc. KR 006FG has a kinematic viscosity of 36 cSt at 40°C, and a kinematic viscosity of 5.6 cSt at 100°C. KR 015 FG has a kinematic viscosity of 114 cSt at 40°C, and a kinematic viscosity of 13.5 cSt at 100°C. In those examples where the lubricant compositions of the present disclosure need not be food grade, suitable commercial alkylated naphthalenes include the NA-LUBE® KR007A and NA-LUBE® KR-015. KR007A has a kinematic viscosity of 22 cSt at 40°C and a kinematic viscosity of 3.8 cSt at 100°C. KR-015 has the same kinematic viscosities at 40°C and 100°C, as KR-015FG.

[0020] The base oil of the lubricant compositions described herein preferably includes a mineral oil component in addition to an alkylated naphthalene component. In preferred examples, the mineral oil is a mixture of liquid hydrocarbons that are essentially paraffinic and naphthenic in nature with trace amounts of aromatic compounds present. As is known in the art, the relative amounts of paraffinic, naphthenic, and aromatic compounds in a mineral oil may be characterized using ASTM D 2140 to yield the parameters C_p, C_n, and C_o, wherein C_p represents the amount of paraffinic compounds by weight of the mineral oil, C_n represents the amount of naphthenic compounds by weight of the mineral oil, and C_o represents the amount of aromatic compounds by weight of the mineral oil. It has been found that mineral oils of the type described herein can beneficially be combined with alkylated naphthalenes to yield a lubricant base oil having good lubricating properties while reducing the required amount of the relatively more expensive alkylated naphthalene component of the base oil. However, excessive amounts of paraffin can cause the formation of solid deposits due to contact with the cold refrigerant. Thus, the use of a mineral oil component with the paraffin content described herein beneficially avoids or reduces the amount of such deposits.

[0021] In general, mineral oils suitable for use in the base oil preferably have a C_o of less than about 60 and a kinematic viscosity at 40°C of 18-68 cSt. A kinematic viscosity range of from about 28 cSt to about 46 cSt at 40°C is more preferred. In certain preferred examples of the mineral oil component of the base oil, C_o is more preferably no more than about 56, and still more preferably no more than about 50. C_p is preferably at least about 40, more preferably at least about 46, and still more preferably at least about 50. In non-food grade lubricating compositions, C_n is preferably no greater than 20, more preferably no greater than about 15, and more preferably no greater than about 12.

[0022] Examples of mineral oils that are suitable for non-food grade lubricating compositions in accordance with the present disclosure include Hyprene 60, Hyprene L150, Hyprene L200 and Hyprene L300, which are supplied by Ergon Refining, Inc. Hyprene 60 has a kinematic viscosity of about 9.4 cSt at 40°C and C_p:C_n:C_o values of 49:45:6. Hyprene L150 has a kinematic viscosity of about 30.1 cSt at 40°C and C_p:C_n:C_o values of 46:44:10. Hyprene L200 has a kinematic viscosity of about 39.9 cSt at 40°C and C_p:C_n:C_o values of 42:46:12. Hyprene L300 has a kinematic viscosity of about 59.1 cSt at 40°C and C_p:C_n:C_o values of 41:47:12.

[0023] Suitable white mineral oils that are not food grade include Calumet Hydrocol 100, Hydrocol 100, HR Turbo, and Cross LP-100 and LP-200. Calumet Hydrocol 100 has a kinematic viscosity at 40°C of about 21 cSt. Calumet Hydrocol 100 has a kinematic viscosity at 40°C of about 21 cSt and C_p:C_n:C_o values of 43:46:11. Calumet HR Turbo has a kinematic viscosity at 40°C of about 21 cSt and C_p:C_n:C_o values of 44:45:11. Cross LP-100 has a kinematic viscosity at 40°C of about 20 cSt and C_p:C_n:C_o values of 41:42:17. Cross LP-200 has a kinematic viscosity at 40°C of about 39 cSt and C_p:C_n:C_o values of 36:47:17.

[0024] In preferred examples of food grade lubricating compositions, the mineral oil component preferably has a C_p value of less than 1.0. In one particular exemplary formulation, the mineral oil component of the base oil of a food grade lubricating composition has a C_p of 48, a C_n of 52 and a C_o of less than 1.0. For food grade lubricating compositions, the mineral oil component of the base oil is preferably a white mineral oil, and more preferably meets the specifications of 21 CFR 178.3620(b) for a “technical white mineral oil.” An example of a suitable commercially available technical white mineral oil under 21 CFR 178.3620(b) is Sonneborn LP-200. Sonneborn LP-200 has a kinematic viscosity at 40°C from about 39 cSt to about 43 cSt and a 1:1 ratio of C_p to C_n with a C_o value of less than 1.0. Another example of a suitable commercially available technical white mineral oil under 21 CFR 178.3620(b) is Sonneborn LP-100. Sonneborn LP-100 has a kinematic viscosity at 40°C of about 18 cSt to about 20 cSt, a C_p of 47, a C_n of 52 and a C_o value of less than 1.0.

[0025] The lubricant compositions described herein have an amount of an alkylated naphthalene component that is preferably at least about 25 percent, more preferably at least about 30 percent, and still more preferably at least about 40 percent by weight of the lubricant composition. At the same time, the amount of the alkylated naphthalene component is preferably no more than about 80 percent by weight, more preferably no more than about 60 percent by weight and even more preferably no more than about 50 percent by weight of the lubricant composition. In one exemplary lubricant composition, the amount of the alkylated naphthalene component in the lubricant composition is about 45 percent by weight of the lubricant composition. The lubricant compositions described herein have an amount of the mineral oil component that is preferably at least about five (5) percent, more preferably at least about ten (10) percent, still more preferably at least about twenty (20) percent by weight, and even more preferably at least about 50 percent by weight of the lubricant composition. At the same time, the amount of the mineral oil component is preferably no more than about 75 percent, more preferably no more than about 70 percent, still more preferably no more than about 65 percent, and even more preferably no more than about 60 percent by weight of the lubricant composition. In one exemplary lubricant composition, the amount of mineral oil is about 55 percent by weight of the lubricant composition.

[0026] The viscosities of the base oil components are preferably selected to achieve an overall lubricating composition...
viscosity that is suitable for the intended application of the lubricating oil. For example, when used to lubricate an ammonia refrigeration compressor, the lubricating oil compositions described herein preferably have an ISO VG (International Standards Organization Viscosity Grade) of at least 46 (41.4 to 50.6 cSt at 40°C) and no more than 100 (90 to 100 cSt at 40°C). An ISO VG of 68 (61.2 to 74.8 cSt) is preferred. When used to lubricate ammonia transfer pumps, the lubricating oil compositions described herein preferably have ISO VGs (International Standards Organization Viscosity Grade) of at least 22 (19.8 to 24.2 cSt at 40°C) and no more than 46 (41.4 to 50.6 cSt at 40°C). An ISO VG of 32 (28.8 cSt to 35.2 cSt) is preferred. Preferred pour points for the lubricating oils described herein are preferably no more than about 0°C C, more preferably no more than about −20°C C, even more preferably no more than about −30°C C, and still more preferably no more than about −40°C C.

Certain of the lubricant compositions described herein include both a base oil and an additive package. The base oil preferably includes an alkylated naphthalene component and a white mineral oil component of the types and in the amounts previously described. The base oil and the additive package are preferably free of ammonia reactive components such as compounds with sufficient acidity to cause an acid base reaction with ammonia.

The lubricant compositions of this invention may contain effective amounts of additives, such as antioxidants, corrosion inhibitors, antifoam agents, or such other additives as may be required. In certain preferred examples, the lubricant compositions consist essentially of a base oil of the type described previously and an additive package that includes an effective amount of one or more antioxidants, an effective amount of one or more corrosion inhibitors, and an effective amount of one or more antifoam agents. In preferred examples, the additive package is essentially free of ammonia reactive components such as compounds with sufficient acidity to cause an acid base reaction with ammonia.

The additives described herein may include an antioxidant package having at least one antioxidant compound. Preferred antioxidant packages are comprised of a combination of at least one food grade phenolic antioxidant and at least one food grade aromatic amine antioxidant. In certain preferred examples, the antioxidant package consists essentially of food grade phenolic antioxidants and/or food grade amine antioxidants. The antioxidants are preferably provided in an amount that is at least about 0.01 percent, more preferably at least about 0.02 percent, and still more preferably at least about 0.025 percent by weight of the lubricant composition. At the same time, the amount of antioxidants is preferably no more than about 3.0 percent, more preferably no more than about 2.5 percent, and still more preferably no more than about 2.0 percent by weight of the lubricant composition. The ratio of phenolic to aromatic amine antioxidants by weight may vary from about 20:1 to about 1:20, although the preferred ratio is from about 1:1 to about 1:3. Oxidation stability performance is superior and fairly consistent over the preferred ratio range.

When included as part of the antioxidant package, the phenolic antioxidants are preferably provided in an amount that is at least about 0.03 percent, more preferably at least about 0.04 percent, and still more preferably at least about 0.05 percent by weight of the lubricant composition. At the same time, the phenolic antioxidants are preferably provided in an amount that is no more than about 0.6 percent, more preferably no more than about 0.55 percent, and still more preferably no more than about 0.5 percent by weight of the lubricant composition.

The class of phenolic antioxidants which can be employed in the practice of the lubricant compositions described herein include food grade, oil-soluble, sterically hindered phenols and thiao-phenols. Included within the definition of phenolic and thio-phenolic antioxidants are sterically hindered phenolics such as hindered phenols and bis-phenols, hindered 4,4'-thiobisphenols, hindered 4-hydroxy- and 4-thiobenzene acid esters and dithio esters, and hindered bis(4-hydroxy- and 4-thiobenzene acid and dithio acid alkylene esters. Examples of sterically hindered phenols include 2,6-di-tert-butyl-p-cresol, 2,6-di-tet-tert-amyl-p-cresol, and 2-tet-tert-butyl-6-tet-amyl-p-cresol.

A second group of hindered phenolic antioxidants are the hindered bisphenols. Examples of these compounds include 4,4'-methylene bis(2,6-di-tet-tertbutylphenol), 4,4'-dimethylene bis(2,6-di-tet-tert-butyl phenol), 4,4' trimethylene bis(2,2-di-tet-tert-amyl phenol), hexamethylenebismes(3,5-di-tet-tert-butyl-4-hydroxyhydrocinnameate), tetrakis(methyleneis(3,5-di-tet-tert-butyl-4-hydroxyhydrocinnameate)methane and 4,4' trimethylene bis(2,6-di-tet-tert-butyl phenol).

Additional hindered phenolic antioxidants that may be utilized include a group of hindered thiobis phenols, i.e., where the sulfur connected to another phenolic group. Examples of these compounds include 4,4'-thio bis(2,6-di-sec-butyl phenol), 4,4'-thio bis(2-tet-tert-butyl-6-isopropyl phenol), thiodyethylenes(3,5-di-tet-tert-butyl-4-hydroxyhydrocinnameate), and 4,4'-thio bis(2-methyl-6-t-butyl phenol). In certain preferred examples, the phenolic antioxidant component of the additive package consists essentially of thiodyethylenes (3,5-di-tet-tert-butyl-4-hydroxyhydrocinnameate) in an amount ranging from about 0.05 percent to about 0.50 percent by weight of the lubricant formulation. In one exemplary formulation, the amount of thiodyethylenes (3,5-di-tet-tert-butyl-4-hydroxyhydrocinnameate) in the lubricant composition ranges from about 0.05 percent to about 0.15 percent by weight of the lubricant composition.

When included as part of the antioxidant package, the aromatic amine antioxidants of the present disclosure are preferably provided in an amount that is at least about 0.05 percent, more preferably at least about 0.04 percent, and still more preferably at least about 0.05 percent by weight of the lubricant composition. At the same time, the aromatic amine antioxidants are preferably provided in an amount that is no more than about 0.6 percent, more preferably no more than about 0.55 percent, and still more preferably no more than about 0.5 percent by weight of the lubricant composition.

Suitable food grade, oil-soluble aromatic amine antioxidants include phenyl-[alpha]- and/or phenyl-[beta]-naphthylamines, naphthyl phenyl amines, alkylated phenyl naphthyl amines, and alkylated diphenyl amines. Examples of aromatic amine antioxidants include, N-phenyl-ar-[1,1,3,3-tetramethylbutyl]-1- alphanaphthaleinamine, N-phenyl-alphaphenyl-naphthylamine, N-phenyl-p-methyl-phenyl-a-phenyl-naphthylamine, and N-phenylbenzamine. Reaction products with 2,4,4'-trimethylpentene and the diphenylamines such as disubstituted diphenylamine, and dioctylphénylamines. In certain preferred examples, the aromatic amine antioxidant component of the additive package consists essentially of N-phenylbenzenaminate reaction products with 2,4,4'-trimethylpentene in an
amount ranging from about 0.05 percent to about 0.50 percent by weight of the lubricant composition. In one exemplary formulation, the amount of N-phenylbenzenamine reaction products with 2,4,4-trimethylpentene in the lubricant composition ranges from about 0.35 percent to about 0.45 percent by weight of the lubricant composition.

[0038] Corrosion Inhibitors

[0039] The additive package described herein may include at least one corrosion inhibitor. Preferred corrosion inhibitors include metal deactivators. Suitable corrosion inhibitors include food grade phosphoric acid, mono and diethylene esters compounds with tetramethyl amines. Examples include phosphoric acid, mono- and diisooctyl esters, reacted with tert-alkyl and (C12-C14) primary amines and phosphoric acid, mono- and diethylene esters compounded with tetramethylammonium amines. The at least one corrosion inhibitor is preferably present in amount that is greater than zero percent, more preferably at least about 0.01 percent, and still more preferably at about 0.05 percent by weight of the lubricant composition. At the same time, the at least one corrosion inhibitor is preferably present in an amount that is no greater than about 0.25 percent, more preferably no greater than about 0.15 percent, and still more preferably at about 0.20 percent by weight of the lubricant composition.

[0040] One suitable metal deactivator for providing corrosion resistance is N,N-Bis(2-ethylhexyl)-aryl-methyl-1H-benzotriazole-1-methanamine. Additional suitable corrosion inhibitors include 2-(8-Heptadecyl)-4,5-dihydro-1H-imidazole-1-ethanol alone or in synergistic combination with N-Methyl-N-(1-oxo-9-octadeceny)glycine. In one preferred example, the corrosion inhibitors used in the additive package consist essentially of from about 0.05 percent to about 0.1 percent by weight of N,N-Bis(2-ethylhexyl)-aryl-methyl-1H-benzotriazole-1-methanamine.

[0041] Anti-Foam Additives

[0042] The additive package described herein may also include at least one anti-foam agent. Suitable anti-foam agents include polymeric anti-foam agents such as Lubrizol 889D or Solutia PC-1244. The at least one anti-foam agent is preferably present in an amount of at least about 10 parts per million (ppm), more preferably at least about 150 ppm, and still more preferably at about 200 ppm by weight of the lubricant composition. At the same time, the at least one anti-foam agent is preferably present in an amount that is no greater than about 500 ppm, more preferably no greater than about 450 ppm, and still more preferably no greater than about 400 ppm by weight of the lubricant composition.

[0043] The foregoing lubricant compositions are particularly well suited for use as refrigeration compressor lubricants and refrigerant transfer pump lubricants. In certain examples, the lubricant composition is charged to the lubricant circuit of an ammonia refrigeration compressor, and ammonia is charged to the refrigerant circuit of the ammonia compressor. In certain examples, the lubricating composition is a food-grade lubricating composition, and the ammonia refrigeration compressor is located in a food processing facility in an area where the lubricant composition is subject to direct contact with food being processed.

[0044] In other examples, the lubricant composition is charged to the lubricant circuit of an ammonia refrigerant transfer pump and ammonia is charged to the refrigerant (process side) circuit of the transfer pump. In certain examples, the lubricating composition is a food grade lubricating composition, and the refrigerant transfer pump is located in a food processing facility in an area where the lubricant composition is subject to direct contact with food being processed.

[0045] Certain preferred lubricant compositions of the present disclosure consist essentially of food grade base oil as described herein and a food grade additive package as described herein. The food grade base oil preferably consists essentially of a food-grade alkylated naphthenalene component and a food-grade white mineral oil component in the weight percentages described above. The food grade additive package preferably consists essentially of an effective amount of at least one antioxidant, an effective amount of at least one corrosion inhibitor, and an effective amount of at least one anti-foam agent. The additive package more preferably consists essentially of about 0.25 percent to about 0.50 percent of at least one aromatic amine antioxidant by weight of the lubricant composition, about 0.25 percent to 0.50 percent of at least one phenolic antioxidant by weight of the lubricant composition, about 0.05 percent to about 0.10 percent of at least one corrosion inhibitor by weight of the lubricant composition; and about 200 parts per million (ppm) of at least one anti-foam additive by weight of the lubricant composition.

[0046] When used to lubricate an ammonia refrigeration compressor located in an area where the lubricant is subject to incidental food contact, the food grade lubricating oil compositions described herein preferably have an ISO VG (International Standards Organization Viscosity Grade) of at least 46 (41.4 to 50.6 cSt at 40°C) and no more than 100 (90 to 100 cSt at 40°C). An ISO VG of 68 (61.2 to 74.8 cSt) is preferred. When used to lubricate ammonia transfer pump located in an area where the lubricant is subject to incidental food contact, the food grade lubricating oil compositions described herein preferably have ISO VG (International Standards Organization Viscosity Grade) of at least 22 (19.8 to 24.2 cSt at 40°C) and no more than 46 (41.4 to 50.6 cSt at 40°C). An ISO VG of 32 (28.8 cSt to 35.2 cSt) is preferred. Preferred pour points for the food grade lubricating oils described herein are preferably no more than about 0°C, more preferably no more than about −20°C, even more preferably no more than about −30°C, and still more preferably no more than about −40°C.

EXAMPLES

[0047] Examples of lubricant compositions in accordance with the present disclosure are provided below. Unless otherwise stated, all weight percentages are based on the total amount of the lubricant composition (i.e., including both the base oil and additivies).

Example 1

[0048] A food grade, refrigeration compressor lubricant composition is prepared in a beaker by:

[0049] a) preparing a base oil by combining 45.0 percent by weight of a Sonneborn IP-200 white mineral oil with a kinematic viscosity at 40°C of from about 39.2 cSt to about 43.5 cSt, and 53.93 percent by weight of a SYNNESTIC™ 12 and/or NA-LUBE® KR-015G alkylated naphthenalene with a viscosity of 100-120 cSt at 40°C; and

[0050] b) adding a food-grade additive package to the base oil, wherein the additive package includes (i) 0.50 percent by weight of an aromatic amine antioxidant, namely N-phenylbenzenamine reaction products with 2,4,4-trimethylpentene, (ii) 0.50 percent by weight of a phenolic antioxidant, namely,
Benzene propanoic acid, 3,5-bis(1,1-dimethyl ethyl)-4-hydroxy-, thiodi-2,1-ethanediyl ester, (ii) 0.05 percent by weight of an N,N-Bis(2-ethylhexyl)-ar-methyl-1H-benzotriazole-1-methanamine corrosion inhibitor, and (iv) 200 parts per million (ppm) of a polymeric anti Foam agent. The resulting food grade lubricant composition is an ISO VG 68 food grade lubricant composition with a kinematic viscosity at 100°C of 8.23 cSt, a kinematic viscosity at 40°C of 67.0 cSt, and a pour point of −40°C.

Example 2

[0051] A refrigerant compressor lubricant composition is prepared in a beaker by:

[0052] a) preparing a base oil by combining 73.43 percent by weight of a Hyprene L-300 mineral oil with a viscosity of 59.1 cSt at 40°C, and 25 percent by weight of a SYNNESTIC™ 12 and/or NA-LUBE® KR-015FG alkylated naphthalene with a viscosity of 100-120 cSt at 40°C; and

[0053] b) adding an additive package to the base oil, wherein the additive package includes (i) 0.50 percent by weight of an aromatic amine antioxidant, namely N-phenylbenzenamine reaction products with 2,4,4-trimethylpentene, (ii) 0.50 percent by weight of a phenolic antioxidant, namely, Benzene propanoic acid, 3,5-bis(1,1-dimethyl ethyl)-4-hydroxy-, thiodi-2,1-ethanediyl ester, (iii) 0.05 percent by weight of an N,N-Bis(2-ethylhexyl)-ar-methyl-1H-benzotriazole-1-methanamine corrosion inhibitor, and (iv) 200 parts per million (ppm) of a polymeric anti Foam agent. The resulting lubricant composition is an ISO VG 68 lubricant composition with a kinematic viscosity at 100°C of 8.3 cSt, a kinematic viscosity at 40°C of 67.2 cSt, and a pour point of −45°C.

Example 3

[0054] A refrigerant transfer pump lubricant composition was prepared in a beaker by:

[0055] a) preparing a base oil by preparing a mineral oil formulation comprising 20.06 percent Sonneborn LP-100 by weight of the mineral oil formulation and 49.45 percent Sonneborn LP-200 by weight of the mineral oil formulation and combining the mineral oil formulation with 33.43 percent NA-LUBE® KR006FG by weight of the base oil; and

[0056] b) adding an additive package to the base oil, wherein the additive package includes (i) 0.50 percent by weight of an aromatic amine antioxidant, namely N-phenylbenzenamine reaction products with 2,4,4-trimethylpentene, (ii) 0.50 percent by weight of a phenolic antioxidant, namely, Benzene propanoic acid, 3,5-bis(1,1-dimethyl ethyl)-4-hydroxy-, thiodi-2,1-ethanediyl ester, (iii) 0.05 percent by weight of an N,N-Bis(2-ethylhexyl)-ar-methyl-1H-benzotriazole-1-methanamine corrosion inhibitor, and (iv) 200 parts per million (ppm) of a polymeric anti Foam agent. The resulting lubricant composition is an ISO VG 68 lubricant composition with a kinematic viscosity at 100°C of 8.3 cSt, a kinematic viscosity at 40°C of 67.2 cSt, and a pour point of −45°C.

Example 4

[0057] A food grade refrigerant transfer pump lubricant composition was prepared in a beaker by:

[0058] a) preparing a base oil by preparing a mineral oil formulation comprising 15.30 percent Sonneborn LP-100 by weight of the mineral oil formulation and 33.68 percent Sonneborn LP-200 by weight of the mineral oil formulation and combining the mineral oil formulation with 49.95 percent NA-LUBE® KR006FG alkylated naphthalene by weight of the base oil; and

[0059] c) adding an additive package to the base oil, wherein the additive package includes (i) 0.50 percent by weight of an aromatic amine antioxidant, namely N-phenylbenzenamine reaction products with 2,4,4-trimethylpentene, (ii) 0.50 percent by weight of a phenolic antioxidant, namely, Benzene propanoic acid, 3,5-bis(1,1-dimethyl ethyl)-4-hydroxy-, thiodi-2,1-ethanediyl ester, (iii) 0.05 percent by weight of an N,N-Bis(2-ethylhexyl)-ar-methyl-1H-benzotriazole-1-methanamine corrosion inhibitor, and (iv) 200 parts per million (ppm) of a polymeric anti Foam agent. The resulting lubricant composition is an ISO VG 32 lubricant composition with a kinematic viscosity at 100°C of 4.80 cSt, a kinematic viscosity at 40°C of 32.62 cSt, and a pour point of −49°C.

[0060] Oxidative stability data are generated for the lubricating compositions of Examples 1-4 as well as for a comparative reference lubricating composition using the ASTM D 2272-02 “Standard Test Method for Oxidation Stability of Steam Turbine Oils By Rotating Pressure Vessel”. Time values in minutes are determined which are indicative of how long the compositions remained stable under oxidizing conditions. The comparative reference lubricating composition is Gargoyle Arctic 300, high performance napthenic, narrow-cut mineral oil, refrigeration compressor lubricant supplied by ExxonMobil Marine Lubricants. Gargoyle Arctic 300 is an ISO VG 68 lubricant with a pour point of −42°C. The results are as follows:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Rotary Pressure Vessel Oxidation Test, Minutes (RPVOT, ASTM D2272)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphthenic-Based Reference - Mobil Arctic Gargoyle 300</td>
<td>43</td>
</tr>
<tr>
<td>Example 1</td>
<td>911</td>
</tr>
<tr>
<td>Example 2</td>
<td>850</td>
</tr>
<tr>
<td>Example 3</td>
<td>921</td>
</tr>
<tr>
<td>Example 4</td>
<td>1377</td>
</tr>
</tbody>
</table>

[0061] The present invention has been described with reference to certain exemplary embodiments thereof. However, it will be readily apparent to those skilled in the art that it is possible to embody the invention in specific forms other than those of the exemplary embodiments described above. This may be done without departing from the spirit of the invention. The exemplary embodiments are merely illustrative and should not be considered restrictive in any way. The scope of the invention is defined by the appended claims and their equivalents, rather than by the preceding description.

What is claimed is:

1. A method of lubricating an ammonia refrigeration compressor or ammonia refrigerant transfer pump having a lubricant circuit and a refrigerant circuit, the method comprising:
   - charging the refrigerant circuit with ammonia;
   - charging the lubricant circuit with a lubricant composition that comprises an alkylated naphthalene component.

2. The method of claim 1, wherein the alkylated naphthalene component is at least about 25 percent by weight of the lubricant composition.
3. The method of claim 1, wherein the lubricant composition further comprises a mineral oil component.

4. The method of claim 3, wherein the mineral oil component comprises no more than about 60 percent of paraffinic compounds by weight of the mineral oil component.

5. The method of claim 3, wherein the mineral oil component comprises no more than about 60 percent of paraffinic compounds by weight of the mineral oil component.

6. The method of claim 1, wherein the lubricant composition is essentially free of ammonia reactive compounds.

7. The method of claim 1, wherein the lubricant composition has an ISO VG of no more than about 100.

8. The method of claim 1, wherein the lubricant composition further comprises:
   an effective amount of at least one antioxidant;
   an effective amount of at least one corrosion inhibitor; and
   an effective amount of at least one anti-foam agent.

9. The method of claim 1, wherein the lubricant composition further comprises:
   about 0.25 percent to 0.50 percent of at least one aromatic amine antioxidant by weight of the lubricant composition;
   about 0.25 percent to 0.50 percent of at least one phenolic antioxidant by weight of the lubricant composition;
   about 0.05 percent to 0.10 percent of at least one corrosion inhibitor by weight of the lubricant composition; and
   about 200 parts per million (ppm) of at least one polymeric antifoam additive by weight of the lubricant composition.

10. The method of claim 1, wherein the lubricant composition is food-grade.

11. The method of claim 1, wherein the lubricant composition further comprises a food-grade, white mineral oil having an aromatic compound content of less than about one percent by weight of the white mineral oil.

12. The method of claim 1, wherein the lubricant composition consists essentially of:
   at least about 25 percent of the alkylated naphthalene component by weight of the lubricant composition;
   at least about 25 percent of the alkylated naphthalene component by weight of the lubricant composition, wherein the mineral oil component has a paraffinic content of no more than about 60 percent by weight of the mineral oil component;
   an additive package consisting essentially of an effective amount of at least one antioxidant, an effective amount of at least one corrosion inhibitor, and an effective amount of at least one anti-foam agent, wherein the lubricant composition has a kinematic viscosity of no more than about 100 centistokes at 40°C.

13. A lubricant composition, comprising:
   at least about 25 percent of an alkylated naphthalene component by weight of the lubricant composition; and
   at least about five percent of a mineral oil component by weight of the lubricant composition, wherein the lubricant composition is essentially free of ammonia reactive components.

14. The lubricant composition of claim 13, wherein the alkylated naphthalene component is about 45 percent by weight of the lubricant composition and the mineral oil component is about 55 percent by weight of the lubricant composition.

15. The lubricant composition of claim 13, wherein the mineral oil component includes no more than about 60 percent of paraffinic compounds by weight of the mineral oil component.

16. The lubricant composition of claim 13, wherein the lubricant composition has an ISO VG of no more than about 100.

17. The lubricant composition of claim 13, consisting essentially of the alkylated naphthalene component, the mineral oil component, and an additive package, wherein the additive package consists essentially of an effective amount of at least one antioxidant, an effective amount of at least one corrosion inhibitor, and an effective amount of at least one anti-foam agent.

18. The lubricant composition of claim 13, further comprising:
   about 0.25 percent to 0.50 percent weight percent of at least one aromatic amine antioxidant by weight of the lubricant composition;
   about 0.25 percent to 0.50 percent weight percent of at least one phenolic antioxidant by weight of the lubricant composition;
   about 0.05 percent to 0.10 percent weight percent of at least one corrosion inhibitor by weight of the lubricant composition; and
   about 200 parts per million (ppm) of a polymeric antifoam additive by weight of the lubricant composition.

19. The lubricant composition of claim 13, wherein the lubricant composition is food-grade, and the mineral oil component is a food-grade, white mineral oil with an aromatic compound content of not more than about one percent by weight of the mineral oil.

20. The lubricant composition of claim 13, wherein the alkylated naphthalene component is about 45 percent by weight of the lubricant composition, the mineral oil component is about 55 percent by weight of the lubricant composition, the mineral oil component includes no more than about 60 percent of paraffinic compounds by weight of the mineral oil component and less than about one percent of aromatic compounds by weight of the mineral oil component, the lubricant composition has an ISO VG of no more than 100 and includes an additive package that consists essentially of an effective amount of at least one antioxidant, an effective amount of at least one corrosion inhibitor, and an effective amount of at least one anti-foam agent.

* * * * *