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(54) Title: LOW VISCOSITY FUNCTIONAL FLUIDS

(57) Abstract: Low viscosity functional fluids are described which comprise borate ester glycols, glycols, and a set of corrosion inhibitors that include one or more triazoles, amines, inorganic borates, inorganic nitrates, and alkenyl succinic anhydride. The fluids are particularly well-suited for use as DOT 4 brake fluids and provide robust corrosion performance over an extended life, thereby reducing the frequency with which the fluids must be replaced.



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LOW VISCOSITY FUNCTIONAL FLUIDS

TECHNICAL FIELD

CLAIM OF BENEFIT OF FILING DATE

[0001] The present application claims the benefit of the filing date of U.S. Application Serial No. 61/112,460, filed November 7, 2008, which is hereby incorporated by reference for all purposes.

[0002] This disclosure relates to low viscosity functional fluids which are useful in a variety of applications, and in particular, as brake fluids.

BACKGROUND

[0003] Functional fluid compositions based on borate esters are well known in the art. The U.S. Government has developed standards that govern the designation and certification of functional fluids that are used as brake fluids using a system of DOT (Department of Transportation) designations (e.g, DOT 3, DOT 4, DOT 5.1, etc.). The standards are embodied in Federal Motor Vehicle Safety Standard 116 ("FMVSS 116"). In addition, certain standard-setting organizations such as the Society of Automotive Engineers ("SAE") and the International Standards Organization ("ISO") have developed their own standards and certifications for brake fluids. SAE Standard J1704 covers "borate ester based brake fluids" that achieve a level of performance above those of the SAE J1703 standard. Similarly, ISO 4925 provides a number of brake fluid designations that are used outside of the United States, such as "Class 3," "Class 4," "Class 5-1," and "Class 6." FMVSS 116, SAE J1704, and ISO 4925 provide stringent physical property and performance requirements particularly with respect to minimum dry equilibrium reflux boiling point (ERBP), minimum wet equilibrium boiling point (WERBP) and maximum low temperature (-40 °C) viscosity while maintaining adequate resistance to corrosion, stability and meeting other physical property requirements such as pH, reserve alkalinity, rubber swell, etc.

[0004] The standards for DOT 4 fluid certification set forth in FMVSS 116 are comparable to those for J1704 Fluids and ISO 4925 Class 4 fluids, some of which are shown in Table 1:

Table 1

	DOT 4	J1704	ISO 4925
Min. ERBP °C	230	230	230
Min. WERBP °C	155	155	155
Max. -40 °C Kinematic viscosity (cST)	1800	1800	1500

[0005] Brake fluids and other functional fluids may cause corrosion of different materials with which they come into contact over time. As a result, FMVSS 116, J1704, and ISO 4925 each include corrosion specifications based on defined test procedures in which metal strips of various metals are submerged in a mixture of 5 percent water (by volume) and the brake fluid for a specified time (120 hours) at a specified temperature (100 °C).

[0006] It has been found that the FMVSS 116, J1704, and ISO 4925 standards do not reliably reproduce the actual road conditions to which many brake fluids are subjected, especially roads in the northern climates of the U.S. which are frequently salted in the winter to control ice accumulation. As a result, it has been proposed to modify the test procedures used to evaluate corrosion by adding a chloride salt (e.g., NaCl) to the water/brake fluid mixture. However, current brake fluids are not able to provide the level of corrosion resistance required for DOT 4, J1704 and ISO 4925 fluids when subjected to this modified test. For example, Shannon, U.S. Patent No. 6,558,569 and Park U.S. Patent No. 6,339,050 describe DOT 4 brake fluids comprising alkyl glycol borate esters, alkyl glycols, and a corrosion inhibitor package. However, they do not address the issue of brake fluid contamination with salt water mixtures and provide no indication that the disclosed fluids could meet the DOT 4, J1704 or ISO 4925 corrosion

standards when subjected to a salt water environment. Thus, a need has arisen for a functional fluid which addresses the foregoing issues.

SUMMARY

[0007] In accordance with one aspect, a fluid composition is provided which comprises at least one glycol borate ester, at least one glycol, and an additive package that includes at least one corrosion inhibitor. When the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, and the total composition is subjected to the corrosion testing protocol set forth in SAE Standard J1704, the mass change per unit area of tinned iron is no more than 0.2 mg/cm². In preferred embodiments, the total composition meets the maximum permissible weight change specification for tinned iron, steel, aluminum, cast iron, brass and copper set forth in SAE Standard J1704.

[0008] In accordance with another aspect, a fluid composition is provided which comprises at least one glycol borate ester, at least one glycol, and an additive package including at least one corrosion inhibitor. The at least one corrosion inhibitor comprises at least one triazole, at least one amine, at least one inorganic borate, at least one inorganic nitrate, and at least one alkenyl succinic anhydride. In preferred embodiments, when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, the total composition meets the maximum permissible weight change specification for tinned iron, steel, aluminum, cast iron, brass and copper set forth in SAE Standard J1704.

[0009] In accordance with yet another aspect, a fluid composition is provided which comprises at least one glycol borate ester, at least one glycol, and an additive package comprising at least one corrosion inhibitor. The at least one corrosion inhibitor is present in an amount effective to inhibit the corrosion of tinned iron when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition. In preferred embodiments, the at least one corrosion inhibitor comprises at least one triazole, at least one non-triazole amine, at least one inorganic borate, at least one inorganic nitrate, and at least one alkenyl succinic anhydride.

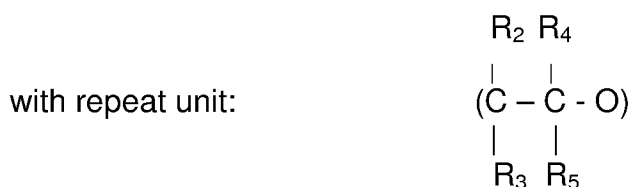
DETAILED DESCRIPTION

[0010] This disclosure relates to functional fluids comprising one or more glycols, one or more glycol borate esters, and an additive package that includes at least one corrosion inhibitor. The corrosion inhibitors are preferably present in an amount that is effective to inhibit the corrosion of metals when the brake fluid is contaminated with salt water. In a more preferred embodiment, the corrosion inhibitors are present in an amount that is effective to inhibit the corrosion of tinned iron, brass, aluminum, copper, cast iron, and steel when the fluid is mixed with 5 percent water (by volume) and 50 ppm (by weight) of chloride ion. In an even more preferred embodiment, the corrosion inhibitors are present in an amount that is effective to inhibit the corrosion of tinned iron, brass, aluminum, copper, cast iron, and/or steel when the fluid is mixed with 5 percent water (by volume) and 50 ppm (by weight) chloride ion and subjected to the SAE J1704 (Rev. April 2004) and FMVSS 116 (49 CFR § 571.116) corrosion test protocols. In an especially preferred embodiment, the functional fluids meet the SAE J1704 and FMVSS 116 specifications for the maximum permissible weight change of tinned iron, steel, aluminum, cast iron, brass, and copper when the fluid is mixed with 5 percent (by volume) water and 50 ppm (by weight) chloride ion and the

mixture is subjected to the SAE J1704 and FMVSS 116 corrosion testing protocols. The entirety of SAE J1704 (Rev. April 2004) and FMVSS 116 are hereby incorporated by reference.

[0011] The total amount of glycols (excluding glycol borate esters) present in the functional fluid formulation is preferably at least about 30 percent, more preferably at least about 35 percent and most preferably at least about 38 percent by weight of the total functional fluid formulation. The total amount of glycols present in the functional fluid formulation is preferably no greater than about 50 percent, more preferably no greater than about 45 percent, and most preferably no greater than about 43 percent by weight of the total functional fluid formulation.

[0012] The glycol component can be formed partially, substantially entirely (at least 90 percent or at least 95 percent by weight) or entirely of one, two, three or more glycols, polyglycols, or both. Preferably, the glycols or polyglycols of the glycol component have the formula of EQUATION I:



[0013] Each of R₁, R₂, R₃, R₄, R₅ is either hydrogen (H) or an alkyl group containing 1 to 8 or more carbon atoms or mixtures thereof such as one disclosed in Provisional Application Ser. No. 60/976,010 (filed September 28, 2007) entitled "Functional Fluid Composition", which is hereby incorporated by reference for all purposes. It is preferable that R₁ be an alkyl group containing 1 to 8 carbon

atoms such that the glycol or polyglycol is an alkoxy glycol ether (e.g., an alkyl end capped glycol ether) as opposed to being simply a glycol where R_1 is H. Typically, R_1 is H for less than about 30 percent, more typically less than about 10 percent and even possibly less than about 5 percent or less than about 2 percent by weight of the glycol component. It will be understood that, as used herein, the term "polyglycol" refers to a glycol such as that of EQUATION I in which n is at least 2 or greater. The term "glycol" is inclusive of all polyglycols. It should also be understood that the glycol component can include both those glycols in which R_1 is an alkyl group and those in which R_1 is H.

[0014] The glycol component can include an amount of glycol where $n=1$. When included, such glycol is less than about 5 percent by weight of the glycol component. Preferably, glycols of the glycol component comprise glycols (e.g., alkoxy glycols) where $n = 2$, glycols (e.g., alkoxy glycols) where $n = 3$, glycols (e.g., alkoxy glycols) where $n = 4$ or more, or any mixture thereof. More preferable glycol components comprise a mixture of glycols (e.g., alkoxy glycols) having $n = 2$ and $n = 3$. It is also preferred for the glycols wherein $n = 2$ or more to be present in the glycol component in an amount that is at least about 50 percent by weight, more preferably at least about 60 percent by weight and more preferably at least about 75 percent by weight of the glycol component. The amount of glycol in which n is 2 or more is even more preferably at least about 90 percent by weight of the glycol component. In certain exemplary formulations, n is essentially 2 to 4.

[0015] It is also preferred for the glycols wherein $n = 2$ or more to be present in the glycol component that is no greater than about 99 percent by weight.

[0016] The glycols in which $n=2$ are preferably present in an amount that is at least about 0.5 percent by weight of the total glycol component, more preferably at least about 1 percent by weight of the total glycol component, and even more preferably at least about 1.5 percent by weight of the total glycol component. The glycols in which $n=2$ are preferably present in an amount that is no greater than

about 5 percent by weight, more preferably no greater than about 2 percent by weight, and even more preferably no greater than about 1.8 percent by weight of the total glycol component.

[0017] The glycols in which $n=3$ are preferably present in an amount that is no greater than about 99 percent by weight of the total glycol component, more preferably no greater than about 98 percent by weight of the total glycol component, and even more preferably no greater than about 97 percent by weight of the total glycol component. The glycols in which $n=3$ are preferably present in an amount that is at least about 85 percent by weight, more preferably at least about 90 percent by weight, and even more preferably at least about 95 percent by weight of the total glycol component.

[0018] The glycols in which $n=4$ or greater are preferably present in an amount that is no greater than about 5 percent by weight, more preferably no greater than about 3 percent by weight, and even more preferably no greater than about 2 percent by weight of the total glycol component. In certain exemplary formulations, no glycols are included in which $n=4$ or greater. Preferable glycol components include an R_1 group comprising a methyl, an ethyl, a propyl, a butyl, or combinations thereof.

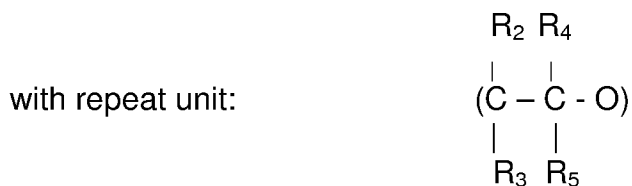
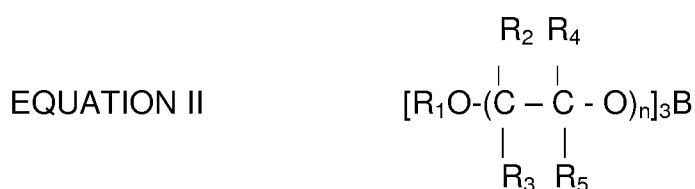
[0019] Without limitation, examples of useful glycols (e.g., alkoxy glycols or otherwise) include methoxy triglycol, methoxy diglycol, methoxy tetraglycol, methoxy polyglycol (e.g., mixtures of methoxy triglycol, methoxy tetraglycol, and other glycols in which R_1 is CH_3 and n is 5 or more), ethoxy triglycol, ethoxy diglycol, ethoxy tetraglycol, propoxy triglycol, butoxy triglycol (e.g., triethylene glycol monobutyl ether), butoxy diglycol (e.g., diethylene glycol monobutyl ether), butoxy tetraglycol, butoxy polyglycol (e.g., mixtures of butoxy triglycol, butoxy tetraglycol, and other glycols in which R_1 is an alkyl having 4 carbon atoms and n is 5 or greater), butoxy pentoxy diglycol, pentoxy triglycol, 2-ethylhexyl diglycol and any mixture thereof.

[0020] Preferable glycols (e.g., alkoxy glycols) of the glycol component include, without limitation, methoxy triglycol, methoxy diglycol, methoxy polyglycol, methoxy tetraglycol, ethoxy polyglycol, ethoxy triglycol, ethoxy diglycol, ethoxy tetraglycol, butoxy polyglycol, butoxy triglycol, butoxy diglycol, butoxy tetraglycol, triethylene glycol monohexyl ether, diethylene glycol monopropyl ether, triethylene glycol monopropyl ether, dipropylene glycol monomethyl ether, dipropylene glycol monopropyl ether, tripropylene glycol monopropyl ether, dipropylene glycol monobutyl ether, tripropylene glycol monobutyl ether, polypropylene glycol monobutyl ether, polypropylene glycol monopropyl ether, or mixtures thereof. More preferable alkoxy glycol components comprise methoxy triglycol, methoxy diglycol, methoxy polyglycol, butoxy triglycol, butoxy diglycol, butoxy polyglycol, triethylene glycol monohexyl ether, diethylene glycol monopropyl ether, triethylene glycol monopropyl ether, dipropylene glycol monomethyl ether, dipropylene glycol monopropyl ether, tripropylene glycol monopropyl ether, dipropylene glycol monobutyl ether, tripropylene glycol monobutyl ether, polypropylene glycol monopropyl ether, polypropylene glycol monobutyl ether or mixtures thereof. Most preferable alkoxy glycol components comprise a mixture of two or more of methoxy polyglycol, butoxy diglycol, butoxy triglycol, butoxy polyglycol, triethylene glycol monopropyl ether, tripropylene glycol monopropyl ether, tripropylene glycol monobutyl ether, polypropylene glycol monopropyl ether, or polypropylene glycol monobutyl ether.

[0021] Further examples of useful glycols (e.g., alkoxy glycols or the like) include, without limitation, diethylene glycol monopropyl ether, triethylene glycol monopropyl ether, dipropylene glycol monomethyl ether, dipropylene glycol monopropyl ether, tripropylene glycol monopropyl ether, dipropylene glycol monobutyl ether, dipropylene glycol monomethyl ether, tripropylene glycol monoethyl ether, tripropylene glycol monopropyl ether, tripropylene glycol monobutyl ether, polypropylene glycol monopropyl ether, polypropylene glycol monobutyl ether, polybutylene glycol monopropyl ether, polybutylene glycol monobutyl ether, combinations thereof or the like.

[0022] Without limitation, methods of preparing useful alkoxy glycols include an alkoxylation reaction that reacts an alkylene oxide with an alcohol to produce an alkoxy glycol. In one exemplary implementation, the glycol component comprises at least about 50 percent, more preferably at least about 60 percent, and most preferably at least about 65 percent methoxy triglycol based on the total weight of the glycols present in the fluid. The glycol component preferably comprises no greater than about 80 percent, more preferably not greater than about 70 percent, and most preferably no greater than about 68 percent methoxy triglycol based on the total weight of the glycols present in the fluid. In a further illustrative example, the glycol component preferably comprises at least about 20 percent, more preferably at least about 25 percent, and most preferably at least about 28 percent butoxy triglycol based on the total weight of the glycols present in the fluid. In accordance with the illustrative example, the glycol component preferably comprises no greater than about 40 percent, more preferably no greater than about 35 percent, and most preferably no greater than about 32 percent butoxy triglycol based on the total weight of the glycols present in the fluid.

[0023] The glycol borate ester(s) of the functional fluid preferably include at least one ingredient having the formula:



wherein R₁, R₂, R₃, R₄, and R₅ can be any of groups as specified with respect to EQUATION I and n can be as specified with respect to EQUATION I. The glycol

borate ester component can have any of the repeat units of glycol component as discussed with respect to EQUATION I herein. In certain exemplary formulations, n is essentially 2 to 4. It is also understood that the glycol borate ester component and any borate containing compound is not considered as part of the glycol component, but rather is separate.

[0024] Examples of glycol borate ester components include alkoxy glycol borate ester components such as methoxy triethylene glycol borate ester, ethoxy triethylene glycol borate ester, butoxy triethylene glycol borate ester and mixtures thereof disclosed in U.S. Patent No. 6,558,569, hereby incorporated by reference. The amount of glycol borate ester in the functional fluid is preferably at least about 30 percent by weight of the total fluid composition, more preferably at least about 40 percent by weight of the total fluid composition and most preferably at least about 50 percent by weight of the total fluid composition. In an especially preferred embodiment, the amount of glycol borate ester is at least about 52 percent by weight of the total fluid composition. The amount of glycol borate ester is preferably no greater than about 70 percent by weight of the total fluid composition, more preferably no greater than about 65 percent by weight of the total fluid composition, and most preferably no greater than about 60 percent by weight of the total fluid composition. In an especially preferred embodiment, the amount of glycol borate ester is no greater than about 56 percent by weight of the total fluid composition. The species of glycol borate ester in which $n=3$ is preferably present in an amount that is greater than about 90 percent by weight of the total weight of glycol borate esters in the fluid composition. Borate esters and their methods of preparation are well known in the art. Borate esters useful in the functional fluid compositions of the present invention may be prepared by reacting boric acid with a suitable glycol component which is typically a selective mixture of glycols containing at least 90 percent by weight, and preferably 95 percent by weight, of the triethylene glycol species.

[0025] Examples of useful borate esters include those containing methoxy triethylene glycol borate ester, ethyl triethylene glycol borate ester, butyl

triethylene glycol borate ester and mixtures thereof. Particularly good results have been obtained with a borate ester component containing greater than 90 percent methoxy triethylene glycol borate ester based on the total weight of all glycol borate ester components.

[0026] As mentioned above, the functional fluids of the present disclosure also include an additive package which contains one or more corrosion inhibitors and one or more of the following: an antifoaming agent, a pH stabilizer, a chelating agent, and an antioxidant. The corrosion inhibitors are preferably present in an amount that is at least about 0.3 percent by weight of the fluid formulation, more preferably at least about 1.0 percent by weight of the fluid formulation, and most preferably at least about 3.0 percent by weight of the fluid formulation. The corrosion inhibitors are preferably present in an amount that is no greater than about 10 percent by weight of the fluid formulation, more preferably no greater than about 6.0 percent by weight of the fluid formulation, and most preferably no greater than about 4.0 percent by weight of the fluid formulation.

[0027] The corrosion inhibitors in the additive package preferably include compounds that inhibit the corrosion of tinned iron, steel, aluminum, cast iron, brass, and copper, each of which has a corrosion specification set forth in SAE J1704 and FMVSS 116. However, in an especially preferred embodiment, the corrosion inhibitors also include one or more compounds that inhibit the corrosion of zinc.

[0028] The corrosion inhibitors preferably include at least one heterocyclic nitrogen-containing compound, for example, triazoles such as benzotriazole, tolyltriazole, 1,2, 4 triazole, and mixtures thereof. The triazole compounds are preferably present in an amount that is at least about 0.01 percent, more preferably at least about 0.05 percent, and most preferably at least about 0.1 percent by weight of the total fluid weight. The triazole compounds are preferably present in an amount that is no greater than about 0.4 percent, more preferably

no greater than about 0.3 percent, and most preferably no greater than about 0.25 percent by weight of the total fluid formulation. Without wishing to be bound by any theory, triazole compounds such as benzotriazole, tolyltriazole, and 1, 2, 4 triazole are believed to be particularly effective for inhibiting copper corrosion.

[0029] The corrosion inhibitors also preferably include amine compounds other than triazoles, including alkyl amines (e.g., di n-butylamine and di n-amylamine), cyclohexylamine, piperazines (e.g., hydroxylethyl piperazine), and salts thereof. Non-triazole amine compounds which are particularly useful as corrosion inhibitors in the functional fluid compositions of the present disclosure include the alkanol amines, preferably those containing one to three alkanol groups with each alkanol group containing from one to six carbon atoms. Examples of useful alkanol amines include mono-, di- and trimethanolamine, mono-, di- and triethanolamine, mono-, di- and tripropanolamine and mono-, di- and triisopropanolamine. Preferred alkanol amines include butyldiethanol amine and diisopropanolamine. Without wishing to be bound by any theory, the alkanolamines are believed to be effective for inhibiting the corrosion of ferrous compounds (e.g, iron, steel) and also act as a buffer.

[0030] The non-triazole amine compounds are preferably present in an amount that is at least about 0.01 percent, more preferably at least about 0.1 percent, and even more preferably, at least about 0.2 percent by weight of the fluid formulation. The non-triazole amine compounds are preferably present in an amount that is no greater than about 4 percent, more preferably no greater than about 3.5 percent, and most preferably no greater than about 3.0 percent by weight of the total fluid formulation.

[0031] In certain preferred embodiments, the corrosion inhibitors also include one or more alkenyl succinic anhydrides. Preferred alkenyl succinic anhydrides include derivatives of maleic anhydride. Dodecenyl succinic anhydride is especially preferred. The alkenyl succinic anhydrides are preferably present in an

amount that is at least about 0.1 percent, more preferably at least about 0.12 percent, and most preferably at least about 0.14 percent by weight of the functional fluid composition. The alkenyl succinic anhydrides are preferably present in an amount that is no greater than about 0.5 percent, more preferably no greater than about 0.3 percent, and most preferably no greater than about 0.2 percent by weight of the functional fluid composition.

[0032] In certain preferred embodiments, the corrosion inhibitors also include one or more inorganic nitrates, preferably sodium nitrate. The inorganic nitrates are preferably present in an amount that is at least about 0.01 percent, more preferably at least about 0.02 percent and most preferably at least about 0.04 percent by weight of the fluid formulation. The inorganic nitrates are preferably present in an amount that is no greater than about 0.1 percent, more preferably no greater than about 0.08 percent, and most preferably no greater than about 0.06 percent by weight of the fluid formulation. Without wishing to be bound by any theory, the inorganic nitrates are believed to be effective at inhibiting the corrosion of aluminum.

[0033] In additional preferred embodiments, the corrosion inhibitors include one or more inorganic borates such as Sodium Tetraborate, commonly known as Borax. The inorganic borates are preferably provided as solid hydrates. An especially preferred inorganic borate is sodium tetraborate pentahydrate $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$, also known as Borax 5 Mol. Another exemplary inorganic borate is sodium tetraborate decahydrate ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$). The inorganic borate is preferably provided in an amount that is at least about 0.03 percent, more preferably at least about 0.05 percent, and most preferably at least about 0.07 percent by weight of the fluid formulation. The inorganic borate is preferably provided in an amount that is no greater than about 0.1 percent, more preferably greater than about 0.09 percent, and most preferably no greater than about 0.08 percent by weight of the fluid formulation. Without wishing to be bound by any theory, the inorganic borates are believed to be effective at inhibiting ferrous corrosion (e.g, iron and steel).

In further preferred embodiments, the corrosion inhibitors may include one or more silicone compounds such as silicate esters. Preferred silicate esters include polymers of dialkoxysiloxanes, including without limitation poly(diethoxysiloxane) (e.g., PSI-21). The silicone corrosion inhibitor is preferably provided in an amount that is at least about 0.001 percent, more preferably at least about 0.003 percent, and most preferably at least about 0.004 percent by weight of the fluid composition. The silicone corrosion inhibitor is preferably provided in an amount that is no greater than about 0.008 percent, more preferably no greater than about 0.007 percent, and most preferably no greater than about 0.006 percent by weight of the fluid composition. Without wishing to be bound by any theory, the silicone corrosion inhibitors are believed to inhibit the corrosion of brass and aluminum.

[0034] In addition to the foregoing corrosion inhibitors, the functional fluid additive package may also include other additive compounds such as antifoaming agents, pH stabilizers, chelating agents, antioxidants, and the like. Preferred antifoaming agents include poly(dimethylsiloxane) and silicone-based compounds such as SAG 100 Antifoam, a product of GE Advanced Materials. The antifoaming agent is preferably provided in an amount that is no greater than about 0.00020 percent and more preferably no greater than about 0.00015 percent by weight of the fluid composition. The antifoaming agent is preferably present in an amount that is at least about 0.00001 percent and more preferably at least about 0.00005 percent by weight of the fluid composition.

[0035] Suitable antioxidants include phenolic compounds and quinoline compounds. Exemplary phenolic antioxidants include BHT (Butylated Hydroxytoluene); 2,6-di-tert-butyl-4-methyl phenol (which is supplied by Great Lakes Chemical Corporation under the name Lowinox[®] 624); 2,6-di-tert-butyl-p-cresol); 2,6-di-tertiary-butyl-4-sec-butylphenol (which is supplied by the SI Group under the name Isonox[®] 132); and bisphenol A. Exemplary quinoline antioxidants include Agerite[®] Resin D, a polymerized trimethyl dihydroquinoline compound

supplied by the R.T. Vanderbilt Company. If antioxidants are included in the additive package, they are preferably provided in an amount that is at least about 0.1 percent, more preferably at least about 0.2 percent, and most preferably at least about 0.3 percent by weight of the fluid composition. The antioxidants are provided in an amount that is preferably no greater than about 1.0 percent, more preferably no greater than about 0.8 percent, and most preferably no greater than about 0.6 percent by weight of the fluid composition.

[0036] Suitable metal chelating agents include triocetylphosphine oxide, tributylphosphate, and dibutyl butyl phosphonate, DEHPA (Di (2-ethylhexyl) phosphoric acid) and propanediamine/xylene compositions such as Dupont Metal Deactivator (N,N' Disalicylidene-1,2-propanediamine and xylene). The chelating agents are preferably present in an amount that is at least about 0.01 percent, more preferably at least about 0.05 percent, and most preferably at least about 0.08 percent by weight. The chelating agents are preferably present in an amount that is no greater than about 0.2 percent, most preferably no greater than about 0.15 percent, and most preferably no greater than about 0.13 percent by weight of the fluid composition.

[0037] As mentioned above, SAE Standard J1704 includes standards for borate ester based brake fluid certification which are similar to those of the DOT 4 standards set forth in FMVSS 116. In accordance with both standards, two sets of six specified metal corrosion test strips are polished, cleaned and weighed. The six metal strips comprising each set are fastened together at one end. Each strip is approximately 8 cm long, 1.3 cm wide, not more than 0.6 mm thick, and has a surface area of $25 \pm 5 \text{ cm}^2$. The specified metals are copper, brass, cast iron, aluminum, steel, and tinned iron. Two styrene-butadiene rubber ("SBR") cups are provided as set forth in Section 7.6 of FMVSS 116 and Appendices C and D of SAE J1704 (Rev. April 2004), and their base diameters are measured. In addition, the cups' International Rubber Hardness Degree ("IRHD") values are determined using the ASTM D1415 test method, the entirety of which is

incorporated herein by reference. The two SBR cups and two metal strip assemblies are placed in a jar containing the brake fluid and 5 percent water (by volume) with the metal strip assemblies each being placed in one of the respective cups. The jar is capped and placed in an oven at 100 °C for 120 hours. The strips are then removed and desiccated at 23 °C $\pm$ 2 °C for 1 hour. Following desiccation, the strips are each weighed to the nearest 0.1 mg and the change in weight is calculated for each strip. The area of the strips is then determined, and the weight change per unit area in mg/cm² of surface area is calculated. The diameter and IRHD values of the cups are then determined. According to FMVSS 116, in order to be certified as a DOT 4 brake fluid, the weight change per unit surface area must not exceed the following specifications, which are identical to those of SAE J1704:

Table 1

Test Strip Material	Maximum weight change in mg/cm ²
Steel, tinned iron, cast iron	0.2
Aluminum	0.1
Brass, Copper	0.4

In addition, the SBR cup specification of FMVSS 116 calls for an inner cup diameter increase of no more than 1.4mm and a hardness decrease of no more than 15 International Rubber Hardness Degrees. The SAE J1704 specifications are identical, except that they call for an SBR Cup volume increase of no more than 16 percent instead of specifying a diameter increase.

[0038] As mentioned above, it has been proposed to modify the brake fluid/water composition used to perform the FMVSS 116 and SAE J1704 test procedures in order to better simulate the environments to which many brake fluids are subjected. In particular, many localities use road salt to keep roads free of ice and snow during the winter months. As a result, the brake fluid frequently

becomes contaminated with water/salt solutions which can degrade the brake fluid's performance. In one preferred embodiment, when the functional fluids of the present disclosure are subjected to the J1704 corrosion test using a mixture of brake fluid with 5 percent water (by volume) and 25 ppm chloride ion, the mixture meets the J1704 and FMVSS 116 corrosion specifications for the maximum allowable weight change per surface area for tinned iron, steel, aluminum, cast iron, brass and copper. In a more preferred embodiment, the mixture meets the same specifications when the mixture of brake fluid and 5 percent (by volume) water includes 50 ppm chloride ion.

[0039] In addition to their corrosion inhibition properties, the fluid compositions of the present disclosure exhibit superior water stability and are able to maintain high boiling points and low viscosities at relatively high water levels. In certain preferred embodiments, the fluid compositions maintain an equilibrium reflux boiling point (ERBP) of no less than about 130 °C, preferably no less than about 140 °C, and more preferably no less than about 145 °C at a water level of 5 percent by weight of the fluid composition. At the same water level, the fluids preferably have a -40 °C kinematic viscosity of no more than about 1800 cSt, more preferably no more than about 1600 cSt, and most preferably no more than about 1400 cSt.

EXAMPLES

Example 1—Corrosion Performance of Current DOT 4 Brake Fluids

[0040] Four (4) commercially available DOT 4 brake fluids are subjected to an SAE J1704/FMVSS 116 corrosion test in which the brake fluid/ 5 percent water mixture includes 50 ppm chloride ion. The tested brake fluids are DBF 460 and DBF 700, which are supplied by The Dow Chemical Company, a BASF DOT 4 brake fluid, and a Shell DOT 4 brake fluid. The results are set forth below in Tables 2 and 3:

Table 2

Brake Fluid	Mass Change mg/cm ²					
	Tinned Iron	Steel	Aluminum	Cast Iron	Brass	Copper
Dow DBF 460	-0.4	0.0	0.0	0.0	-0.1	-0.3
Dow DBF 700	-0.5	0.0	0.0	0.0	-0.2	-0.2
BASF DOT 4	-0.6	0.0	0.0	0.0	-0.3	-0.3
Shell DOT 4	-0.5	0.0	0.0	0.0	-0.2	0.0

Table 3

Brake Fluid	Change in SBR Cup Diameter (mm)	Change in SBR Cup Hardness (IRHD)
Dow DBF 460	0.1	-0.2
Dow DBF 700	0.07	-4.8
BASF DOT 4	0.01	-0.9
Shell DOT 4	0.02	-1.0

[0041] Each of the tested brake fluids is certified to meet the J1704/FMVSS 116 corrosion standards. However, when the test is modified to include 50 ppm chloride ion in the brake fluid/water mixture, none of the brake fluids meet the tinned iron corrosion requirement of not more than 0.2 mg/cm² set forth in SAE J1704 and FMVSS 116.

Example 2—Exemplary Formulation of a DOT 4 Brake Fluid Capable of Meeting the Modified J1704/FMVSS 116 Corrosion Standard

[0042] In this example, a Dow Chemical Company DBF 700 brake fluid is modified to include an additive package in accordance with the present disclosure. The unmodified and modified (“DBF 700a”) formulations are set forth below in Table 4:

Table 4

Component	DBF 700a Wt. %	DBF 700 Wt. %
CARBITOL Solvent LG (Diethylene glycol monoethyl ether)	0.72	
Methoxy triethylene glycol	28.3	28.3
Butoxy triethylene glycol	12.5	14.5
Methoxy triethylene glycol borate ester	54.215	55.17
Monoethylene glycol	0.2	
Propylene glycol	0.5192	
Agerite [®] Resin D	0.1504	
Dodecenyl succinic anhydride	0.15	
Di (2-ethyl hexyl) phosphoric acid	0.1	
Borax 5 Mol	0.0708	
Sodium Nitrate	0.05	
Benzotriazole	0.0104	
Dupont Metal Deactivator	0.01	
SAG 100 Antifoam	0.0001	0.0001
Hydroxyethyl piperazine	0.5	
Butyl diethanol amine	0.4992	
Diisopropanol amine	1.5	1.5
Isonox 132	0.3	0.3
Tolytriazole	0.1	0.1
1,2,4 triazole	0.1	0.1
Silicon Corrosion Inhibitor PSI-21	0.005	
Total	100.0001	100.0001

[0043] Both the DBF 700 and DBF 700a brake fluids are subjected to the SAE J1704 and FMVSS 116 corrosion tests in which the brake fluid/5 percent (vol.) water mixture is modified to include 25 ppm chloride ion and 50 ppm chloride ion. The results are set forth below in Tables 5 and 6:

Table 5

Brake Fluid	Mass Change mg/cm ²					
	Tinned Iron	Steel	Aluminum	Cast Iron	Brass	Copper
DBF 700 50 ppm Cl	-0.4913	0.0041	-0.0082	-0.0035	-0.2141	-0.1973
DBF 700 25 ppm Cl	0.0562	-0.1315	0.1224	-0.1786	0.0646	0.1329
DBF 700a 50 ppm Cl	0.0047	0.0123	0.0082	0.0000	-0.0566	-0.1369
DBF 700a 50 ppm Cl	0.0047	0.0000	-0.0041	0.0000	-0.0687	-0.1691
DBF 700a 25 ppm Cl	0.0562	0.0534	0.0286	0.0210	-0.0323	-0.0886

Table 6

Brake Fluid	Change in SBR Cup Diameter (mm)	Change in SBR Cup Hardness (IRHD)
DBF 700 50 ppm Cl	0.0700	-4.8
DBF 700 25 ppm Cl	0.0762	-1.7
DBF 700a 50 ppm Cl	0.0900	-2.1
DBF 700a 50 ppm Cl	0.2450	-3.3
DBF 700a 25 ppm Cl	0.2150	-3.6

As the data indicates, the DBF 700a fluid meets the tinned iron specification when mixed with 5 percent water (by volume) and 50 ppm chloride ion. However, the DBF 700 fluid--which lacks the corrosion inhibitors of the DBF 700a fluid--does not.

Example 3—Water Stability of Functional Fluids of Present Disclosure

[0044] In this example, the DBF 700a fluid described above is mixed with varying degrees of water, and the boiling points and kinematic viscosities of the mixtures are determined. As indicated in the table below, the base formulation has a small amount of water (0.1416 percent by weight of the formulation) due to the moisture content of the various materials used to prepare it.

Table 7

<u>Sample No.</u>	Water content (wt. %)	Added Water (wt. %)	Total Water (wt. %)	ERBP (°C)	Kinematic Viscosity (cSt) at -40 °C
1	0.0416	0.000	0.1416	257	725.9
2	0.1416	0.8584	0.9611	227	798.7
3	0.1416	1.8584	1.8928	199	888.1
4	0.1416	3.8584	3.8571	163	1056.4
5	0.1416	5.8584	5.7097	143	1245.6

[0045] Interpolating between the data for samples 4 and 5 indicates that at a water level of five (5) percent by weight, the ERPB is approximately 151 °C and the kinematic viscosity is about 1170 cSt. Thus, even at high water levels, the functional fluids described herein maintain high boiling points and low viscosities.

[0046] It will be further appreciated that functions or structures of a plurality of components or steps may be combined into a single component or step, or the functions or structures of one-step or component may be split among plural steps or components. The present disclosure contemplates all of these combinations. Unless stated otherwise, dimensions and geometries of the various structures depicted herein are not intended to be restrictive of the disclosure, and other dimensions or geometries are possible. Plural structural components or steps can be provided by a single integrated structure or step. Alternatively, a single

integrated structure or step might be divided into separate plural components or steps. In addition, while a feature of the present disclosure may have been described in the context of only one of the illustrated embodiments, such feature may be combined with one or more other features of other embodiments, for any given application. It will also be appreciated from the above that the fabrication of the unique structures herein and the operation thereof also constitute methods in accordance with the present disclosure.

[0047] The explanations and illustrations presented herein are intended to acquaint others skilled in the art with the disclosure, its principles, and its practical application. Those skilled in the art may adapt and apply the disclosure in its numerous forms, as may be best suited to the requirements of a particular use. Accordingly, the specific embodiments of the present disclosure as set forth are not intended as being exhaustive or limiting. The scope of the disclosure should, therefore, be determined not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. The disclosures of all articles and references, including patent applications and publications, are incorporated by reference for all purposes.

We claim:

1. A fluid composition, comprising:
at least one glycol borate ester;
at least one glycol; and
an additive package including at least one corrosion inhibitor;
wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, and the total composition is subjected to the corrosion testing protocol set forth in SAE Standard J1704, the mass change per unit area of tinned iron is no more than 0.2 mg/cm².
2. The fluid composition of claim 1, wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, and the total composition is subjected to the corrosion testing protocol set forth in SAE Standard J1704, the mass change per unit area of steel is no more than 0.2 mg/cm².
3. A fluid composition in accordance with either claim 1 or claim 2, wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, and the total composition is subjected to the corrosion testing protocol set forth in SAE Standard J1704, the mass change per unit area of aluminum is no more than 0.1 mg/cm².

4. A fluid composition in accordance with any one of claims 1-3, wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, and the total composition is subjected to the corrosion testing protocol set forth in SAE Standard J1704, the mass change per unit area of cast iron is no more than 0.4 mg/cm^2 .

5. A fluid composition in accordance with any one of claims 1-4, wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, and the total composition is subjected to the corrosion testing protocol set forth in SAE Standard J1704, the mass change per unit area of brass is no more than 0.4 mg/cm^2 .

6. A fluid composition in accordance with any one of claims 1-5, wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, and the total composition is subjected to the corrosion testing protocol set forth in SAE Standard J1704, the mass change per unit area of copper is no more than 0.4 mg/cm^2 .

7. A fluid composition in accordance with any one of claims 1-6, wherein the at least one glycol borate ester is present in an amount that is at least about 30 percent by weight of the fluid composition.

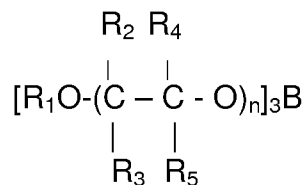
8. A fluid composition in accordance with any one of claims 1-7, wherein the at least one glycol borate ester is present in an amount that is no greater than about 70 percent by weight of the fluid composition.

9. A fluid composition in accordance with any one of claims 1-8, wherein the at least one glycol is present in an amount that is at least about 30 percent by weight of the fluid composition.
10. A fluid composition in accordance with any one of claims 1-9, wherein the at least one glycol is present in an amount that is no greater than about 50 percent by weight of the fluid composition.
11. A fluid composition in accordance with any one of claims 1- 10, wherein the at least one corrosion inhibitor is present in an amount that is at least about 0.3 percent by weight of the fluid composition.
12. A fluid composition in accordance with any one of claims 1-11, wherein the at least one corrosion inhibitor is present in an amount that is no greater than about 10 percent by weight of the fluid composition.
13. A fluid composition in accordance with any one of claims 1-12, wherein the at least one corrosion inhibitor comprises at least one triazole, and the at least one triazole is present in an amount that is at least about 0.01 percent by weight of the fluid composition.
14. A fluid composition in accordance with any one of claims 1-13, wherein the at least one corrosion inhibitor comprises at least one triazole and the at least one triazole is present in an amount that is no greater than about 0.4 percent by weight of the fluid composition.
15. A fluid composition in accordance with any one of claims 1-14, wherein the at least one corrosion inhibitor comprises at least one non-triazole amine, and the at least one non-triazole amine is present in an amount that is at least about 0.01 percent by weight of the fluid composition.

16. A fluid composition in accordance with any one of claims 1-15, wherein the at least one corrosion inhibitor comprises at least one non-triazole amine, and the at least one non-triazole amine is present in an amount that is no greater than about 4.0 percent by weight of the fluid composition.
17. A fluid composition in accordance with any one of claims 1-16, wherein the at least one corrosion inhibitor comprises at least one alkenyl succinic anhydride, and the at least one alkenyl succinic anhydride is present in an amount that is at least about 0.1 percent by weight of the fluid composition.
18. A fluid composition in accordance with any one of claims 1-17, wherein the at least one corrosion inhibitor comprises at least one alkenyl succinic anhydride, and the at least one alkenyl succinic anhydride is present in an amount that is no greater than about 0.5 percent by weight of the fluid composition.
19. A fluid composition in accordance with any one of claims 1-18, wherein the at least one corrosion inhibitor comprises at least one inorganic borate, and the at least one inorganic borate is present in an amount that is at least about 0.03 percent by weight of the fluid composition.
20. A fluid composition in accordance with any one of claims 1-19, wherein the at least one corrosion inhibitor comprises at least one inorganic borate, and the at least one inorganic borate is present in an amount that is no greater than about 0.1 percent by weight of the fluid composition.
21. A fluid composition in accordance with any one of claims 1-20, wherein the at least one corrosion inhibitor comprises at least one inorganic nitrate, and the inorganic nitrate is present in an amount that is at least about .01 percent by weight of the fluid composition.

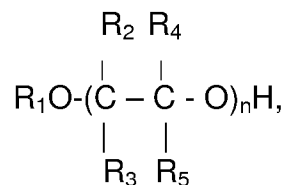
22. A fluid composition in accordance with any one of claims 1-21, wherein the at least one corrosion inhibitor comprises at least one inorganic nitrate, and the inorganic nitrate is present in an amount that is no greater than about 0.1 percent by weight of the fluid composition.

23. A fluid composition in accordance with any one of claims 1-22, wherein the at least one glycol borate ester has the formula:



wherein R₁, R₂, R₃, R₄, R₅ are independently hydrogen (H) or an alkyl group containing 1 to 8 or more carbon atoms or mixtures thereof.

24. A fluid composition in accordance with any one of claims 1-23, wherein the at least one glycol has the formula:



wherein R₁, R₂, R₃, R₄, R₅ are independently hydrogen (H) or an alkyl group containing 1 to 8 or more carbon atoms or mixtures thereof.

25. A fluid composition in accordance with any one of claims 1-24, wherein the fluid composition has an ERBP of at least about 230°C, a WERBP of at least about 155°C, and a kinematic viscosity at -40°C of no greater than about 1800 centistokes.

26. A fluid composition comprising at least one glycol borate ester, at least one glycol, and an additive package including at least one corrosion inhibitor, wherein the at least one corrosion inhibitor comprises at least one triazole, at least one non-triazole amine, at least one inorganic borate, at least one inorganic nitrate, and at least one alkenyl succinic anhydride.

27. The fluid composition of claim 26, wherein the at least one corrosion inhibitor is present in an amount that is at least about 0.3 percent by weight of the fluid composition.

28. A fluid composition in accordance with any one of claims 26-27, wherein the at least one corrosion inhibitor is present in an amount that is no greater than about 10 percent by weight of the fluid composition.

29. A fluid composition in accordance with any one of claims 26-28, wherein the at least one triazole is present in an amount that is at least about 0.01 percent by weight of the fluid composition.

30. A fluid composition in accordance with any one of claims 26-29, wherein the at least one triazole is present in an amount that is no greater than about 0.4 percent by weight of the fluid composition.

31. A fluid composition in accordance with any one of claims 26-30, wherein the at least one non-triazole amine is present in an amount that is at least about 0.01 percent by weight of the fluid composition.

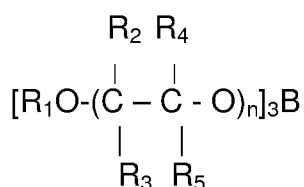
32. A fluid composition in accordance with any one of claims 26-31, wherein the at least one corrosion inhibitor comprises at least one non-triazole amine, and the at least one non-triazole amine is present in an amount that is no greater than about 4.0 percent by weight of the fluid composition.

33. A fluid composition in accordance with any one of claims 26-32, wherein the at least one inorganic borate is present in an amount that is at least about 0.03 percent by weight of the fluid composition.
34. A fluid composition in accordance with any one of claims 26-33, wherein the at least one inorganic borate is present in an amount that is no greater than about 0.1 percent by weight of the fluid composition.
35. A fluid composition in accordance with any one of claims 26-34, wherein the at least one inorganic nitrate is present in an amount that is at least about 0.01 percent by weight of the fluid composition.
36. A fluid composition in accordance with any one of claims 26-35, wherein the at least one inorganic nitrate is present in an amount that is no greater than about 0.1 percent by weight of the fluid composition.
37. A fluid composition in accordance with any one of claims 26-36, wherein the at least one alkenyl succinic anhydride is present in an amount that is at least about 0.1 percent by weight of the fluid composition.
38. A fluid composition in accordance with any one of claims 26-37, wherein the at least one alkenyl succinic anhydride is present in an amount that is no greater than about 0.5 percent by weight of the fluid composition
39. A fluid composition in accordance with any one of claims 26-38, wherein the at least one glycol borate ester is present in an amount that is at least about 30 percent by weight of the fluid composition.
40. A fluid composition in accordance with any one of claims 26-39, wherein the at least one glycol borate ester is present in an amount that is no greater than about 70 percent by weight of the fluid composition.

41. A fluid composition in accordance with any one of claims 26-40, wherein the at least one glycol is present in an amount that is at least about 30 percent by weight of the fluid composition.

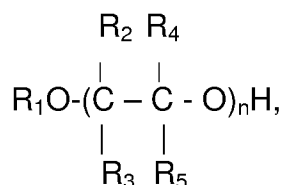
42. A fluid composition in accordance with any one of claims 26-41, wherein the at least one alkoxy glycol is present in an amount that is no greater than about 50 percent by weight of the fluid composition.

43. A fluid composition in accordance with any one of claims 26-42, wherein the at least one glycol borate ester has the formula:



wherein R₁, R₂, R₃, R₄, R₅ are independently hydrogen (H) or an alkyl group containing 1 to 8 or more carbon atoms or mixtures thereof.

44. A fluid composition in accordance with any one of claims 26-43, wherein the at least one glycol has the formula:



wherein R₁, R₂, R₃, R₄, R₅ are independently hydrogen (H) or an alkyl group containing 1 to 8 or more carbon atoms or mixtures thereof.

45. A fluid composition in accordance with any one of claims 26-44, wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is five (5) percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, the total composition meets the maximum permissible weight change specification for tinned iron, steel, aluminum, cast iron, brass and copper set forth in SAE Standard J1704.

46. A fluid composition in accordance with any one of claims 26-45, wherein the fluid composition has an ERBP of at least about 230 °C, a WERBP of at least about 155 °C, and a kinematic viscosity at -40 °C of no greater than about 1800 centistokes.

47. A fluid composition comprising at least one alkyl glycol borate ester, at least one alkyl glycol, and an additive package comprising at least one corrosion inhibitor, wherein the at least one corrosion inhibitor is present in an amount effective to inhibit the corrosion of tinned iron when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition.

48. The fluid composition of claim 47, wherein when the fluid composition is combined with water and a chloride salt to yield a total composition in which water is present in an amount that is 5 percent by volume of the total composition and chloride ion is present in an amount that is 50 parts per million by weight of the total composition, the total composition meets the maximum permissible weight change specification for tinned iron, steel, aluminum, cast iron, brass and copper set forth in SAE Standard J1704.

49. A fluid composition in accordance with either claim 47 or claim 48, wherein the at least one corrosion inhibitor comprises at least one triazole, at least one non-triazole amine, at least one inorganic borate, at least one inorganic nitrate, and at least one alkenyl succinic anhydride.

50. A fluid composition in accordance with any of claims 49-50, wherein the fluid composition has an ERBP of at least about 230°C, a WERBP of at least about 155°C, and a kinematic viscosity at -40°C of no greater than about 1800 centistokes.

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2009/059181

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10M169/04

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)
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)

EPO-Internal, WPI Data, PAJ, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 074 992 A (LEVESQUE PIERRE [US]) 13 June 2000 (2000-06-13) column 3, line 13 - line 37 claims; examples	1-50
X	WO 02/38711 A (UNION CARBIDE CHEM PLASTIC [US]) 16 May 2002 (2002-05-16) cited in the application page 6, line 21 - page 7, line 25 claims; examples	1-12, 15, 16, 23-25, 47, 48, 50
X	EP 0 454 110 A (HOECHST AG [DE]) 30 October 1991 (1991-10-30) page 3, line 8 - page 5, line 21 claims; examples	1-16, 23-25, 47, 48, 50
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

19 November 2009

Date of mailing of the international search report

09/12/2009

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2009/059181

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 617 116 A (BP CHEM INT LTD [GB]; BP CHEMICALS SNC [FR]) 28 September 1994 (1994-09-28) page 3, line 2 - line 30 claims; examples -----	1-8,10, 15,16, 23-25, 47,48,50
X	US 3 635 825 A (SAWYER ARTHUR W ET AL) 18 January 1972 (1972-01-18) column 2, line 41 - column 3, line 6 column 5, line 5 - column 6, line 7 claims; examples -----	1-12,15, 16,19, 20,24, 47,48
P,X	WO 2009/052024 A (DOW GLOBAL TECHNOLOGIES INC [US]; ZHAO JIN [US]; BOUCHARD KENN L [US];) 23 April 2009 (2009-04-23) paragraph [0004] - paragraph [0005] paragraph [0029] - paragraph [0033] claims; examples -----	1-50

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2009/059181

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 6074992	A	13-06-2000	AT 307866 T	15-11-2005
			AU 2748500 A	25-08-2000
			BR 0009311 A	27-11-2001
			CA 2360632 A1	10-08-2000
			CN 1343243 A	03-04-2002
			DE 60023459 D1	01-12-2005
			DE 60023459 T2	13-07-2006
			EP 1159380 A1	05-12-2001
			ES 2249247 T3	01-04-2006
			JP 2002536494 T	29-10-2002
			MX PA01007818 A	10-09-2003
			WO 0046325 A1	10-08-2000
WO 0238711	A	16-05-2002	AT 302832 T	15-09-2005
			AU 3410802 A	21-05-2002
			BR 0115465 A	19-08-2003
			CA 2429048 A1	16-05-2002
			CN 1479779 A	03-03-2004
			DE 60112968 D1	29-09-2005
			DE 60112968 T2	18-05-2006
			EP 1346015 A1	24-09-2003
			ES 2243574 T3	01-12-2005
			JP 2004514024 T	13-05-2004
			MX PA03004122 A	12-02-2004
			US 6558569 B1	06-05-2003
EP 0454110	A	30-10-1991	DE 4013243 A1	31-10-1991
			DE 59100117 D1	24-06-1993
			DK 0454110 T3	22-11-1993
			ES 2058980 T3	01-11-1994
			IE 911388 A1	06-11-1991
			JP 2925038 B2	26-07-1999
			JP 4227690 A	17-08-1992
			PT 97459 A	31-01-1992
EP 0617116	A	28-09-1994	DE 69422075 D1	20-01-2000
			DE 69422075 T2	06-04-2000
			ES 2141196 T3	16-03-2000
			FR 2702772 A1	23-09-1994
US 3635825	A	18-01-1972	NONE	
WO 2009052024	A	23-04-2009	US 2009099048 A1	16-04-2009