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HYDRAULIC FLUID EMULSION

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This invention relates to hydraulic fluids with lubricating properties, and more particularly provides novel emulsions with lubricating properties adapted for use as hydraulic fluids.

While mineral oils have satisfactory lubricating qualities for use as hydraulic fluids, occasionally there are failures in hydraulic systems during which the actuating fluid escapes. When this actuating fluid is a mineral oil, the escape of the oil has caused expensive and deadly fires. Accordingly, the use of fire-resistant hydraulic fluids is preferred.

One class of substances coming into consideration as fire-resistant fluids comprises emulsions. It is recognized in the art that emulsions may have some lubricating properties, in that they are employed as coolant lubricants in metal working operations. Thus for example, transparent cutting fluids are flowed over the surface of metal being cut, primarily to provide cooling and secondarily to provide a limited degree of lubrication during the metal working operation.

However, emulsions are in general deficient in the properties required for hydraulic systems. A particular defect of emulsions in this respect is insufficient lubricity. The lubricating qualities required of metal cutting fluids are not very high, since in application for which they are intended, removal of a softer metal in contact with a hard metal is the object being sought. Accordingly, since wear of the softer metal is desired, lubricity requirements are not severe. On the other hand, it is essential to minimize wear in metal-to-metal sliding contact in hydraulic systems, where pumps and other moving parts of the equipment are required to have a long service life. While anti-wear qualities of emulsion fluids have been reported to be improved by the introduction of certain additives such as metal salts, in general satisfactory wear properties have not been attained hitherto with emulsion fluids.

Additionally, for hydraulic purposes, emulsions have the disadvantage, as compared to homogeneous fluids, of instability. Where high lubricity is the object, it is necessary that the emulsion be a water-in-oil rather than oil-in-water type, so that the oil content forms the external phase and is available to effectuate the lubrication of the surfaces contacted. Emulsions are sensitive to changes of environmental conditions such as exposure to extremes of temperature and the like. A result of freezing of the emulsion or other conditions conducive to disturbing the stability thereof is phase inversion. The phase inversion of emulsions may occur in storage of during operation of a hydraulic system. When the ordinary water-in-oil emulsions is inverted in phase to become an oil-in-water emulsion, its lubricating properties are very much adversely affected. The aqueous phase has practically no lubricating value and the contact of the oil with the metal is hampered and prevented. Because of the fact that hydraulic systems are generally closed cycles, if an emulsion were to be used therein as the actuating fluid, a phase inversion would generally not be detected immediately. When emulsions are used as hydraulic fluids, therefore, there is a strong risk of having the equipment suffer expensive injury due to an undetected phase inversion with a consequent drop in the lubricating value of the fluid; and this risk of injury has been a strong deterrent to the adoption of such emulsions as hydraulic fluids heretofore.

Besides these major defects, emulsions which have been

known hitherto also suffer from such disadvantages as unduly high pour points, a tendency to produce foam, and other qualities rendering them unsuitable for adoption in hydraulic systems.

It is an object of this invention to provide an improved hydraulic fluid.

A particular object of this invention is to provide an emulsion having lubricating properties and adapted for use as a hydraulic fluid.

Another object of this invention is to provide a novel fire-resistant hydraulic fluid of the emulsion type.

A further object of this invention is to provide an emulsion characterized by high lubricity.

Another object of this invention is to provide a water-in-oil emulsion resistant to phase inversion.

A further object of this invention is to provide an emulsion which, should it suffer a phase inversion, is still not substantially diminished in lubricating qualities.

Still another object of this invention is to provide a composition susceptible of existence as either a water-in-oil or oil-in-water emulsion, which in either form is characterized by good lubricating qualities.

Still another object of this invention is to provide a method of actuating mechanical devices by means of hydraulic pressure in which the actuating fluid is an emulsion characterized by good lubricating properties when the emulsion is in the form of either an oil-in-water or a water-in-oil emulsion.

Still another object of this invention is to provide a hydraulic system comprising as the hydraulic fluid an emulsion characterized by good lubricating properties, resistance to phase inversion, and acceptable lubricating qualities in either the oil-in-water or water-in-oil phase.

These and other objects will become evident from a consideration of the following specification and claims.

The novel hydraulic fluid provided by this invention is a water-in-oil emulsion comprising 35–45% water, 35–50% mineral oil, 1–10% non-ionic emulsifying agent, 5–15% of a liquid alkyl ester of a long chain fatty acid and 6–9% of a polyhydric alcohol, as further defined hereinafter.

The present emulsion is particularly desirable for use in a method of actuating fluid-driven mechanisms employing a hydraulic fluid. Hydraulic systems comprising the present emulsions as actuating fluids thereof afford numerous and important advantages.

One outstanding feature of the present composition is very great lubricity with comparatively low wear encountered in pumps forming part of the hydraulic system. Another quality whereby this emulsion is distinguished from previously known fluids of a similar nature is a comparatively low pour point. A further and particularly outstanding property of the present emulsions relates to their behaviour under conditions tending to produce emulsion instability. In the first place, the presently provided emulsions are markedly resistant to phase inversion under exposure to temperature extremes or other conditions ordinarily conducive to a diminishment in the stability of emulsions. Secondly, if the present emulsions should invert in phase, they still retain good lubricating properties. By virtue of the particular composition of the present emulsion, even the aqueous phase is characterized by good lubricating properties. Thus in the event of undetected phase inversion in a closd hydraulic system, the possibility of undue wear on the pumps and other moving parts of the equipment is minimized.

So far as we are aware, the provision of an emulsion characterized by satisfactory lubricating qualities whether it is in the oil-in-water or water-in-oil state is an entirely novel development. In emulsions prepared in accordance with the present invention, a substantial proportion of polyhydric alcohol is provided in the aqueous phase. When the emulsion is in the water-in-oil phase, the polyhydric alcohol assists in the development of the excellent lubricating properties exhibited by emulsions of the presently provided novel type. Additionally, should the emulsion invert to the oil-in-water phase, the polyhydric alcohol confers lubricating qualities on the aqueous phase which then becomes external, preventing the excessive wear which would occur if the aqueous phase were not so modified.

The properties of the presently provided emulsions are a function of both the composition and the physical state thereof. To obtain the characteristics required for satisfactory performance in hydraulic systems, the emulsions will be prepared as set forth hereinbelow.

The oil used in preparation of the present emulsions will be a neutral mineral oil. Substantially any known available type of mineral oil may be selected, either from a paraffin base or a naphthene base crude or from mixed base crudes. The viscosity of the oil for the present purposes should be in the Saybolt viscosity (100° F.) range of from about 60 to about 200 Saybolt Universal seconds (SUS). The optimum viscosity in this range depends on the particular service conditions under which the emulsion is to be used. For example, it may vary depending on the type of pump employed in the system and so forth. As pointed out above, the mineral lubricating oil constituent forms from about 35% to about 50% of the composition by weight.

One or more nonionic emulsifying agents are incorporated in the present composition in the amount of about 1–10%, and preferably, about 4–6%, by weight. The preferred system in accordance with the present invention comprises two emulsifying agents, one of which is water-soluble and the other of which is oil-soluble, and each of which is a nonionic emulsifying agent. One especially preferred class of oil-soluble emulsifying agents useful in preparing the present emulsions comprises esters of polyhydric alcohols with fatty acids, especially fatty acids of from 12 to 18 carbon atoms. Illustrative of these are, for example, esters of lower polyols such as glycerol laurate, glycerol oleate, glycerol stearate, ethylene glycol laurate, ethylene glycol oleate, ethylene glycol ricinoleate and propylene glycol oleate; ether esters such as diethylene glycol laurate, diethylene glycol stearate, diethylene glycol tallate, the diethylene glycol ester of coconut fatty acids, hexaethylene glycol laurate, methoxypolyethylene glycol oleate and polymeric polyethylene glycol esters wherein the polyglycol contains up to 300 or more ethylene glycol units, as for example a polyethylene glycol stearate wherein the ethylene glycol chain contains more than 25 and up to about 300 units. Further illustrative esters of the stated class comprise polyglycerol esters such as diglycerol laurate, diglycerol soybean fatty acid ester and diglycerol ricinoleate; esters of hexitols and hexitol anhydrides such as sorbitol laurate, sorbitan laurate, sorbitol oleate, sorbitan oleate, sorbitol stearate, mannitan stearate, sorbitol tallate, sorbitol ricinoleate, sorbitol palmitate, sorbitan palmitate, mannitol palmitate, and so forth. In each case, the ester of the polyhydric alcohol may be one in which either one or a plurality of the hydroxy groups are esterified; thus for example, the presently useful oil-soluble emulsifying agents may comprise esters in which two or more of the alcohol hydroxy groups are esterified such as glycerol dilaurate, ethylene glycol distearate, diethylene glycol dioleate, ethylene glycol dilaurate, sorbitan dilaurate, sorbitol distearate, sorbitan tristearate, and sorbitan triricinoleate, etc. The most preferred of these oil-soluble esters for the present purposes will be the mono- and polyesters of hexitol anhydrides. The stated oil-soluble nonionic emulsifying agent will preferably be employed in a proportion of about 1–3% by weight in the emulsion composition.

The nonionic water-soluble oil-in-water emulsifiers employed in accordance with the present invention will preferably comprise polyalkylene oxide condensates of fatty acids and fatty acid partial esters with polyhydric alcohols. Thus for example, there may be employed condensation products of from 5 up to 60 moles of ethylene oxide with acid esters of the same nature as the oil-soluble nonionics listed above, such as glycerol monooleate, sorbitan monolaurate, sorbitan monooleate, sorbitan trioleate, sorbitan monostearate, sorbitan tristearate, mannitol oleate, mannitan monopalmitate, dulcitol oleate, and so forth. While the foregoing class of polyalkylene oxide condensates is preferred, also useful are condensates of ethylene oxide with fatty acids, such as products of condensation of from about 5 to about 60 ethylene oxide units with fatty acids of from 12 to 18 carbon atoms, illustrative of which are polyethylene glycol esters of stearic acid, lauric acid, palmitic acid, and so forth. Other nonionic emulsifying agents which may be selected for use in accordance with this invention comprise ethers and thioethers of polyalkylene glycols with aliphatic and aromatic alcohols and mercaptans, as for example ethers derived by condensation of ethylene oxide with a fatty alcohol such as tallow alcohol or with an aromatic alcohol such as octylphenol or nonylphenol, and thioethers as illustrated for example by a compound such as t-dodecylmercaptopolyethylene glycol. Additional classes of such nonionics include fatty alkanolamides such as lauroyl ethanolamide, lauroyl diethanolamide and lauroyl isopropanolamide; and mixed ethylene oxide/propylene oxide condensates such as the product of condensation of ethylene oxide with a hydrophobic propylene oxide condensate. The stated water-soluble nonionic emulsifying agent will preferably be employed in a proportion of about 2–4% by weight in the emulsion composition.

As a further component of the presently provided emulsions, there will be present a liquid alkyl ester of a long-chain fatty acid. As will become evident hereinafter, control of the viscosity of the presently provided emulsions, as produced by incorporation of the stated esters in the novel compositions of this invention, is essential to produce fluids of the consistency requisite for hydraulic applications. The esters selected for use in this conjunction will preferably comprise methyl esters of saturated acids containing from 12 to 18 carbon atoms. Illustrative of such esters are, for example, methyl oleate, ethyl oleate, propyl oleate, methyl ricinoleate, methyl tallate, and so forth. As indicated above, this ester will comprise about 5–15% and preferably about 5% to about 9% by weight of the composition.

The novel emulsions provided by this invention will also comprise one or more polyhydric alcohols, present in an amount totalling from about 6% to about 9% by weight. The polyhydric alcohols producing emulsions having properties as set forth hereinabove will be water-soluble polyhydric alcohols wherein the ratio of oxygen to carbon in the molecules is not less than 1:1. In general, lower alcohols containing below about 10 carbon atoms will be preferred. Illustrative of the polyhydric alcohols which may be used in accordance with this invention are alcohols of the class of hydrocarbyl polyols including ethylene glycol, glycerol, pentaerythritol and hexahydric alcohols such as sorbitol, mannitol, dulcitol and the like. Alcohols conforming to the foregoing characteristics also comprise polyhydric alcohols containing additional substituents, insofar as these do not interfere with the utility thereof by reactivity with other components of the emulsion. Exemplary of these are ethers such as diglycerol, anhydride ethers such as sorbitan, and sugars such as glucose and the like, or there may even be used polyhydric alcohol- containing materials such as corn syrup, molasses, and so forth. In some circumstances advantageous results are obtained by the use of blends of the stated alcohols, such as of sorbitol and glycerine, ethylene glycol and glycerine, and so forth.

The balance of the present emulsion will consist of water. Too little water will fail to confer the necessary resistance to flammability upon the emulsion; and with too great a proportion of water in the composition, the required lubricating properties will be lost. For the purposes of the present invention the emulsion should comprise from about 35% to about 45% by weight of water.

While the foregoing comprise the essential components of the present novel emulsions, it is to be understood that if desired, additional substituents may be introduced to modify the properties of the composition. Thus for example, viscosity index improvers such as polymers of alkylene oxides such as ethylene oxide may be introduced to improve the viscosity index characteristics of the emulsions; salts and derivatives of inorganic acids may be added to improve the extreme pressure properties of the products, and so forth. When such additives are to be introduced, care must be taken to adjust the composition appropriately to preserve the balance of desired properties characteristic of the presently provided novel lubricating emulsions. In general, however, the present emulsions are suitably adapted for employment in hydraulic systems without the necessity of resorting to additional components.

To prepare the emulsions provided by this invention, advantageously a water phase and an oil phase will first be prepared, and thereafter the separate phases will be intimately combined with the water-soluble ingredients including the water-soluble polyhydric alcohol and any water-soluble emulsifying agent to be used, while the oil is mixed with oil-soluble materials including the fatty acid liquid alkyl ester and any oil-soluble emulsifying agent to be incorporated in the product. The oil and the water phases will then be combined. Where any advantage is to be gained thereby, however, any one or more of the composition ingredients may be admixed with the others when or after the combination of the oil and the water phase is under way.

To obtain the required properties in the resulting emulsion, it is essential to control not only the composition thereof, but also the physical state. As indicated above, the emulsion will be prepared to exist in the water-in-oil form. Furthermore, however, the particle size of the emulsion must be controlled to maintain it within a limited range if minimum wear is to be produced. With the present emulsion the most satisfactory results are obtained when the median particle size is about 3 microns, and is substantially uniform, i.e., ranging from about 1 to about 8 microns, with a maximum of about 10 microns. Departures from this range, either in the direction of higher or lower particle size, have been found to decrease the lubricating value of the products.

Various means are known to those skilled in the art to produce intimate contact and uniform mixing of emulsion systems; in general, provided that the correct particle size of the dispersed water phase is produced, any variety of such mixing system may be used. Illustrative of systems which may be employed to produce the emulsification are very high speed mixers, colloid mills, gear pumps, sonic mixers and the like. By control of factors such as the time of mixing, the pressure applied to the fluid in the mixer, choice of the wave length employed in sonic mixing, and so forth, the particle size can be controlled.

A further requisite in producing a fluid adapted for use in hydraulic systems, is that the viscosity of the fluid be maintained within a suitable range. If the viscosity is too high, cavitation occurs, with consequent high wear of the metal parts of the system; at too low a viscosity the lubricant film is broken or lost. In general, the viscosity of the emulsion for the present purposes should be in the range of from 150 to 600 Saybolt Universal seconds. Selection of the viscosity to be produced will depend at least in part on the system in which it is to be used. Control of the viscosity can be achieved by the selection of the oil, control of the proportion of oil and water, variation in the amount of the alkyl ester component and so forth.

The product is a milky opaque emulsion having a viscosity in the range of 150–600 SUS and possessing lubricating qualities. As it is produced, the present emulsion will be correctly constituted for immediate use in a hydraulic system. In the course of use, a certain amount of water loss may occur by evaporation from the system. In such case, when the composition of the emulsion is as stated above, it may be replenished simply by addition of water to the circulating system, and the stirring and mixing which the composition undergoes in passage through the pumps of the hydraulic apparatus will incorporate the water in the emulsion to a sufficient degree. This ease of redilution is a characteristic not shared by all emulsions and is a particularly unusual feature in a lubricating emulsion of the water-in-oil type as in the present case.

Following are non-limting examples illustrating the present invention. All parts are by weight.

EXAMPLE I

To form the oil phase of preparations of a sorbitol-containing emulsion of the composition of this invention, to 43 parts of a Solvent Refined Coastal Oil having a viscosity of 100 SUS at 100° F. were added 7.1 parts of methyl oleate and 1.6 parts of an oil-soluble emulsifying agent known to the trade as Span 80 (sold by Atlas Powder Company, Wilmington, Delaware) which is identified by the manufacturer as sorbitan monooleate.

Separately, the aqueous phase of the emulsion was formed by mixing 38.1 parts of water with 7.1 parts of sorbitol and 3.1 parts of a water-soluble emulsifying agent known to the trade as Tween 85 (sold by Atlas Powder Company, Wilmington, Delaware) and identified by the manufacturer as a polyoxyethylene derivative of sorbitan trioleate.

The oil phase and the aqueous phase were then passed through a Sonic homogenizer to form a milky opaque emulsion having a particle size in the range of 1–8 microns (max. 10 microns). Emulsions having viscosities, respectively, of 299 SUS at 100° F. and 310 SUS at 100° F. were prepared following the stated procedure. The pour points of these fluids are about −20° F.

EXAMPLE II

By proceeding as described in Example I, there was prepared an emulsion containing ethylene glycol and having the following composition.

	Material	Percent
Oil Phase	Neutral Oil	43.0
	Span 80	1.6
	Methyl oleate	7.1
Water Phase	Tween 85	3.1
	Ethylene glycol	7.1
	H_2O	38.1
		100.0

The resulting emulsion had a viscosity of 324 SUS at 100° F. and a pour point of about −20° F.

EXAMPLE III

A lubricating emulsion containing a blend of polyhydric alcohols was prepared by mixing the following components according to the procedure of Example I:

	Material	Percent
Oil Phase	Neutral Oil	43.0
	Span 80	1.6
	Methyl oleate	7.1
Water Phase	Tween 85	3.1
	Ethylene glycol	3.6
	Glycerine	3.6
	Water	38.0

The resulting emulsion fluid had a viscosity of 365 SUS at 100° F.

EXAMPLE IV

For comparison purposes, proceeding substantially as described above, emulsions were prepared duplicating the preparations described above, but varying the formulation as indicated below.

Preparation A

To establish the effect of the polyhydric alcohol on the emulsion properties, an emulsion was prepared in the same manner as described in Examples I and II, except that no polyhydric alcohol was incorporated in the formulation. The emulsion comprised 43 parts of the above-described neutral oil, 14.2 parts of methyl oleate, 1.6 parts of Span 80, 3.1 parts of Tween 85, and 38.1 parts of water. It had a pour point of about 25° F.

Preparation B

This emulsion was prepared as described in Example I, to comprise 14.2 parts of sorbitol as a component, but the methyl oleate component of the emulsion of Example I was omitted.

EXAMPLE V

To test the lubricating properties of emulsions prepared as described above, they were cycled in a simulated hydraulic system employing a Vickers' vane pump.

The method used is a modified version of the Vickers' Hydraulic Pump Test described in Lubrication Engineering, JASLE Volume 5, No. 1, February 1949, pp. 16 and 17.

Briefly, the test equipment and the conditions of test are as follows:

The unit consists of a vane-type Vickers V 104–A pump directly connected to an electric motor. The fluid reservoir is mounted on the same table with the motor and pump and the fluid strainer is attached to the fluid intake line in the reservoir. Operating pressure is controlled by a relief valve which is fitted into the pressure line from the pump. The fluid at low pressure returns to the reservoir through a flow meter. Operating temperatures of the hydraulic fluid are controlled by means of an automatic electrothermal regulator and a water-cooling coil.

In beginning the test, the machine is completely disassembled and all parts and lines are thoroughly cleaned. A complete new set of pump parts, i.e., rotor, bronze bushings, seals and weighed ring and vanes, is installed. The sump is charged with the emulsion fluid and the hydraulic circuit is filled by switching the motor on and off until fluid is seen in the flow meter. The pump is then operated at low pressure until all of the air is forced out of the hydraulic system. The test is then started as the pressure is adjusted to operating specification. In the test, the temperature and pump pressure are maintained at 130° F. and 1,000 pounds per square inch respectively, and the flow rate is held constant at 5 gallons per minute. At the completion of the run, the vanes and ring are weighed to determine metal loss due to wear. The pump parts and the rest of the hydraulic system are inspected for evidence of corrosion, deposits or erosion. The fluid is also analyzed for any changes in its properties.

Following the above-described procedure, the emulsions of Examples I and II, having the novel composition of the present invention, were compared with the emulsion of Example IV, Preparation A, which contains no polyhydric alcohol, and with the emulsion of Example IV, Preparation B, containing polyol but omitting the alkyl ester component present in the compositions of Examples I and IV. The data presented in the following table illustrate the substantially enhanced lubricating properties of emulsions prepared in accordance with this invention.

Emulsion	Viscosity SUS at 100° F.	Hours	Ring Wear, mg.	Vane Wear, mg.
Sorbitol-containing [a] emulsion of Ex. I	310	53	47	16
	299	65	41	13
		104	160	18
Ethylene-glycol containing [b] emulsion of Ex. II	324	16	15	8
	318	36	19	14
	300	104	69	----
	289	170	90	29
Emulsion of Ex. IV, [a] Prep. A, containing no polyhydric alcohol	----	18	96	4
		40	349	16
		40	1,148	49
Emulsion of Ex. IV, [a] Prep. B, containing no methyl oleate	546	17	506	8
	528	17	615	7
	523	24	797	10

[a] Separate preparations for each run.
[b] Sequential readings on same preparation.

EXAMPLE VI

The emulsion of Example III, containing a blend of polyhydric alcohols, was tested by the procedure described in Example V, in duplicate 100 hour runs, with the following results:

Ring wear, mg.—	Vane wear, mg.
34	25
58	22

Similarly excellent results were obtained in a more severe test, in which the fluid was run in the test procedure for 1,000 hours at 11 gallons per minute:

Ring wear, mg.:	Vane wear, mg.
161	88

EXAMPLE VII

This example illustrates the effects of emulsions in which water is the external phase.

An oil-in-water emulsion having the composition of Preparation A of Example IV was prepared and subjected to a pump test as described in Example V. After 20 hours at 1000 p.s.i., the viscosity of the fluid had dropped so sharply that it leaked from the pump, and the ring wear was 1284 mg.

For comparison, an emulsion of the composition of Example I containing sorbitol, was prepared to exist in the oil-in-water phase and tested in the pump system described in Example V. During operation, the emulsion spontaneously inverted to the water-in-oil phase, and after 88 hours, the ring wear was only 69 mg. The viscosity of the fluid removed from the pump remained in the required operating range.

While the invention has been illustrated with particular reference to the specified embodiments thereof, it will be understood that modifications and variations can be made within the spirit and scope of the invention.

What is claimed is:

1. A water-in-oil emulsion having a viscosity of from about 150 to about 600 Saybolt Universal seconds at 100° F. and adapted for use as a hydraulic fluid which comprises from about 35% to about 45% by weight of water; from about 35% to about 50% of a neutral mineral oil having a viscosity of the range from about 60 to about 200 Saybolt Universal seconds at 100° F.; from about 1% to about 10% of a non-ionic emulsifying agent comprising an oil-soluble non-ionic emulsifying agent and a water-soluble non-ionic emulsifying agent; from about 5% to about 15% of a liquid alkyl ester of a long-chain fatty acid; and from about 6% to about 9% of a polyhydric alcohol containing up to 10 carbon atoms wherein the ratio of oxygen to carbon atoms is not less than about 1:1.

2. The emulsion of claim 1 wherein said oil-soluble emulsifying agent is an ester of a polyhydric alcohol with a fatty acid.

3. The emulsion of claim 1 wherein said water-soluble emulsifying agent is an polyalkylene oxide condensate.

4. The emulsion of claim 1 in which said long-chain

fatty acid is a fatty acid containing from about 12 to about 18 carbon atoms.

5. The emulsion of claim 1 wherein the particle size of the water phase of said emulsion is within the range of from about 1 to about 8 microns with a maximum particle size of about 10 microns.

6. The emulsion of claim 1 wherein said liquid alkyl ester is the liquid methyl ester of a fatty acid containing 12–18 carbon atoms.

7. The emulsion of claim 1 wherein a blend of at least 2 different polyhydric alcohols is present.

8. A water-in-oil fire-resistant opaque emulsion having a viscosity of from about 150 to about 600 Saybolt Universal seconds at 100° F. and adapted for use as a hydraulic fluid which comprises from about 35% to about 45% by weight of water; from about 35% to about 50% of a neutral mineral oil having a viscosity in the range of from about 60 to about 200 Saybolt Universal seconds at 100° F.; from about 4% to about 6% of nonionic emulsifying agent comprising an oil-soluble nonionic emulsifying agent consisting of an ester of a polyhydric alcohol with a fatty acid and a water-soluble emulsifying agent consisting of a polyalkylene oxide condensate of a partial ester of a polyhydric alcohol with a fatty acid; from about 5% to about 9% of a liquid methyl ester of a long-chain fatty acid containing from about 12 to about 18 carbon atoms; and from about 6% to about 9% of a polyhydric alcohol which is an aliphatic alcohol containing up to 10 carbon atoms wherein the ratio of oxygen to carbon atoms is not less than about 1:1.

9. The emulsion of claim 8 wherein said polyhydric alcohol is sorbitol.

10. The emulsion of claim 8 wherein said polyhydric alcohol is ethylene glycol.

11. The emulsion of claim 8 wherein said polyhydric alcohol is a blend of ethylene glycol and glycerine.

12. The emulsion of claim 8 wherein said ester of a polyhydric alcohol with a fatty acid is a partial ester of a hexitol anhydride with a fatty acid containing from about 12 to about 18 carbon atoms and said polyalkylene oxide condensation product of a partial ester of a polyhydric alcohol with a fatty acid is a polyoxyethylene derivative of a partial fatty acid ester of a hexitol anhydride, said fatty acid containing from about 12 to about 18 carbon atoms.

13. The emulsion of claim 10 wherein said hexitol anhydride is sorbitan.

14. A fire-resistant emulsion having a viscosity of 150–600 Saybolt Universal seconds at 100° F. and wherein the particle size of the water phase of said emulsion is within the range of from about 1 to about 8 microns, with a maximum particle size of about 10 microns, which comprises about 43% of a neutral mineral oil having a viscosity of 100 Saybolt Universal seconds at 100° F., about 7.1% of methyl oleate, about 1.6% of sorbitan monooleate, about 3.1% of a polyoxyethylene derivative of sorbitan trioleate, about 7.1% sorbitol, and the balance, water.

15. A fire-resistant emulsion having a viscosity of 150-600 Saybolt Universal seconds at 100° F. and wherein the particle size of the water phase of said emulsion is within the range of from about 1 to about 8 microns, with a maximum particle size of about 10 microns, which comprises about 43% of a neutral mineral oil having a viscosity of 100 Saybolt Universal seconds at 100° F., about 7.1% methyl oleate, about 1.6% of sorbitan monooleate, about 3.1% of a polyoxyethylene derivative of sorbitan trioleate, about 7.1% ethylene glycol, and the balance, water.

16. A fire-resistant emulsion having a viscosity of 150–600 Saybolt Universal seconds at 100° F. and wherein the particle size of the water phase of said emulsion is within the range of from about 1 to about 8 microns, with a maximum particle size of about 10 microns, which comprises about 43% of a neutral mineral oil having a viscosity of 100 Saybolt Universal seconds at 100° F., about 7.1% methyl oleate, about 1.6% of sorbitan monooleate, about 3.1% of a polyoxyethylene derivative of sorbitan trioleate, about 3.6% ethylene glycol, about 3.6% glycerine, and the balance, water.

17. The method of actuating mechanisms driven by fluid pressure which comprises employing a hydraulic system in which the actuating liquid is the emulsion of claim 1.

18. The method of actuating mechanisms driven by fluid pressure which comprises employing a hydraulic system in which the actuating fluid is the emulsion of claim 16.

19. The method of actuating mechanisms driven by fluid pressure which comprises employing a hydraulic system in which the actuating liquid is the emulsion of claim 8.

20. The method of actuating mechanisms driven by fluid pressure which comprises employing a hydraulic system in which the actuating fluid is the emulsion of claim 14.

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