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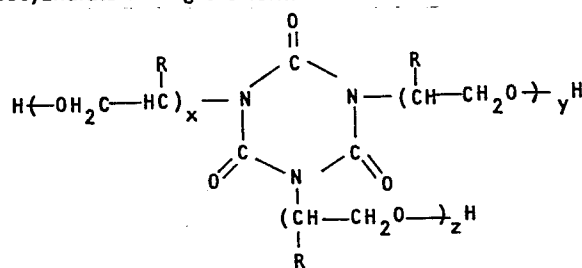
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Hydraulic fluids containing water and hydroxyalkylated isocyanurates.

Disclosed are fire-resistant hydraulic fluids which comprise:

- (a) about 20% to about 60% by weight water;
- (b) a sufficient amount of a hydroxyalkylated isocyanurate to form a hydraulic fluid with a viscosity from about 100 SUS to about 400 SUS at 100°F, aid hydroxyalkylated isocyanurate having the formula:



wherein x, y and z are each from about 3 to about 15, and each R is individually selected from hydrogen and methyl;

- (c) about 0.01% to about 5% by weight of a liquid phase corrosion inhibitor; and
- (d) about 0.01% to about 5% weight of a vapor phase corrosion inhibitor.

isocyanurate fluids are comparable to known water-based glycol fluids in important operating properties such a

lubricity and fire resistance, and have the additional advantage of offering a substantial reduction in the flammability of the residual material resulting from loss of water content.

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HYDRAULIC FLUIDS CONTAINING
WATER AND HYDROXYALKYLATED ISOCYANURATES

Background of the Invention

5 1. Field of the Invention

The present invention relates to fire-resistant hydraulic fluids containing water and hydroxyalkylated isocyanurate base stocks.

2. Description of the Prior Art

10 Water-based hydraulic fluids having fire-resistant properties are well known. See R. E. Hatton, Introduction to Hydraulic Fluids, Chapter 13, "Water-Based Fluids", pages 273-287, Reinhold Publishing Corporation (1962).

15 Such water-based fluids have been used satisfactorily in hydraulic systems containing vane, gear or axial-piston pumps. The fire resistance of these water-based fluids has depended solely upon their water content, and they were generally considered to be

20 satisfactorily fire resistant as long as the water content was maintained. If the water is allowed to boil away or to evaporate by prolonged exposure to elevated temperatures, the residual material will burn when ignited.

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Much of the work on the development of water-based fluids has centered around the use of glycol base stocks such as ethylene glycol. See J. E. Brophy et al, "Aqueous Nonflammable Hydraulic Fluids",
5 Industrial and Engineering Chemistry, Vol. 43, No. 4, pages 884-896 (April 1954). These water-based glycol fluids require a water-soluble thickener to increase the viscosity to an acceptable level, as well as requiring additives to impart corrosion-preventive
10 properties and to enhance anti-wear and lubricity characteristics to the final product.

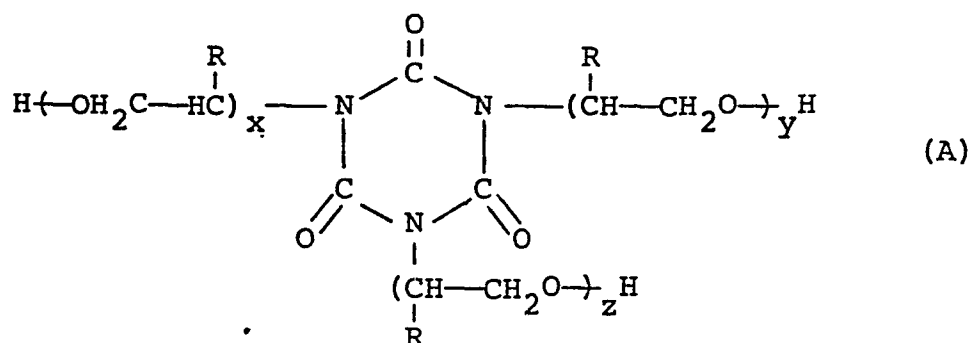
Therefore, there is a need in the art to find a water-based hydraulic fluid which will leave a residue that resists burning when subjected to
15 ignition condition. Furthermore, there is a need for a water-based hydraulic fluid which requires fewer or a lesser amount of additives to simplify manufacturing procedures.

20 Separately, hydroxyalkylated isocyanurates have been known as functional fluids. See U.S. Patent No. 3,859,284, which issued to Formaini et al on January 7, 1975. However, their desirable characteristics of (1) being fire resistant in water-based fluids
25 even after the water is removed and (2) possessing good lubricating properties while in combination with water were not known prior to the present invention.

Brief Summary of the Invention

Accordingly, the present invention is directed to water containing hydraulic fluids which comprise

- (a) about 20% to about 60% by weight water;
- (b) a sufficient amount of a hydroxyalkylated isocyanurate to form a hydraulic fluid with a viscosity from about 100 Saybolt Universal Seconds (SUS) to about 400 Saybolt Universal Seconds (SUS) at 100°F, said hydroxyalkylated isocyanurate having the formula (A):



wherein x, y and z are each from about 3 to about 15 and each R is individually selected from hydrogen and methyl;

- (c) about 0.01% to about 5% by weight of a liquid phase corrosion inhibitor; and
- (d) about 0.01% to about 5% by weight of a vapor phase corrosion inhibitor.

The present invention is also directed to the process of using these fluids in hydraulic operations.

Detailed Description
of Preferred Embodiments

The hydroxyalkylated isocyanurate base stock of the present invention may be prepared either (1) by the catalytic alkoxylation of cyanuric acid or (2) by the catalytic alkoxylation of tris(2-hydroxyethyl) isocyanurate (THEIC). The former method is described in U.S. Patent No. 3,265,694, which issued to Walles et al on August 9, 1966. The latter synthesis is described in U.S. Patent No. 3,741,966, which issued to Weedon et al on June 26, 1973, and in U.S. Patent No. 3,859,284, which issued to Formaini et al on January 7, 1975. Furthermore, a two-step method for making these hydroxyalkylated isocyanurates is described in U.S. Patent No. 3,870,716, which issued to Belsky et al on March 11, 1975, wherein a first step of forming THEIC from cyanuric acid is carried out in the presence of an alkaline catalyst followed by a second step of forming the hydroxyalkylated adduct in the presence of an acid catalyst.

When THEIC is used as the precursor for the present hydroxyalkylated isocyanurates, it is preferred to employ boron trifluoride etherate as an acidic catalyst and reaction temperatures of about 130°C to about 140°C and reaction pressures from atmospheric pressure to about 50 psig. Of course, the present invention is not to be limited to any specific method for making the hydroxyalkylated isocyanurates and any conventional method for making these compounds may be used.

The oxide precursors of these hydroxyalkylated isocyanurates are commercially available chemicals which may be obtained from many sources. Mixtures of different oxides [e.g. ethylene oxide (EO) and propylene oxide (PO)] may also be employed as reactants, either added sequentially or mixed together.

It should be understood that the number of moles of oxide reacted at each of the three reactive sites of the isocyanurate molecule will not always be the same. For example, if 12 moles of EO were reacted to 1 mole of THEIC, it does not necessarily follow that 4 moles of EO were added at each site. Instead, it may be in some instances that only 3 moles, or none, will react at one site and 5, or more, moles may react at another site. Furthermore, it should be understood that the total number of alkylene oxide moles on each resulting adduct molecule will be statistically distributed. Thus, the values for x, y and z in Formula (A) each represent the average amount of alkylene oxide units per reaction site and that the actual number may be less or greater than that amount.

These hydroxyalkylated (i.e. hydroxyethylated and hydroxypropylated and mixtures thereof) isocyanurates are viscous fluids. Unlike ethylene and propylene glycols, they do not require additional thickeners to make water-based hydraulic fluids of acceptable viscosities and lubricity. Generally, the viscosities of these hydroxyalkylated isocyanurates are from about 500 centistokes (cSt) to about 800 centistokes (cSt) at 100°F, which when converted to SUS values by the appropriate tables in ANSI/ASTM 2161-79, equals from about 2300 SUS to about 3700 SUS. For the most common uses of water-based hydraulic fluids, such as with vane-type pumps, the hydraulic fluid may have viscosities in the range from about 100 SUS to about 400 SUS, preferably from about 150 SUS to about 300 SUS. Accordingly, hydraulic fluids having viscosities anywhere in the 100 SUS to 400 SUS range (at 100°F) may be prepared by varying the ratio of isocyanurate base stock to water. Preferably, these viscosities are more easily achieved when the amount of water in the fluid is from about 22% to about 50% by weight and the preferred amount of hydroxylakylated isocyanurate is from about

80% to about 25% by weight, depending upon the specific thickeners and additives present. Furthermore, it is preferred that x, y and z in Formula (A), above, be from about 4 to about 10.

Another advantage of water-based isocyanurate fluids of the present invention over the known water-based glycol fluids is that these hydroxyalkylated isocyanurates per se have better lubricating properties than the glycols. Therefore, lesser amounts of anti-wear and lubricity additives are needed to achieve the same lubricating properties.

Besides water and the hydroxyalkylated isocyanurate base stock, it is necessary to add corrosion inhibitors to the hydraulic fluids of the present invention. At least one liquid phase and at least one vapor phase corrosion inhibitor are needed to prevent corrosion of metal hydraulic system parts. These corrosion inhibitors are necessary because the water would otherwise corrode the metal in which the hydraulic fluid is contained.

Any conventional liquid phase corrosion inhibitor may be employed. Mercaptobenzothiazole or its alkali metal salts such as sodium mercaptobenzothiazole, tolutriazole, secondary and tertiary amines and alkali metal borates, phosphates, nitrites, phosphites and silicates, or other suitable liquid phase corrosion inhibitors may be employed. Preferably, the amount of liquid phase corrosion inhibitors is from about 0.1% to about 1% by weight of the total hydraulic fluid formulation. More preferably, the amount of liquid phase corrosion inhibitors is from about 0.2% to about 0.5% by weight of the total fluid formulation.

Any conventional vapor phase corrosion inhibitor may be used. Vapor phase corrosion inhibitors such as morpholine, organic bases such as cyclohexylamine, dicyclohexylamine, piperidine, and various thiazolines, pyrrolidines and hydrazines are required to protect parts

not completely immersed in the fluid, especially in the fluid reservoirs which would be vulnerable to corrosion above the liquid level. Preferably, the amount of vapor phase corrosion inhibitors is from about 0.5% to about 2% of the total formulation. More preferably, this amount may be from about 0.7% to about 1.25% by weight of the total fluid formulation.

The hydraulic fluids of the present invention may be suitable for industrial hydraulic service throughout the temperature range from about -20°C to about 65°C at atmospheric pressure (higher temperatures may be used under pressurized conditions) and are homogeneous at all temperatures between about -45°C to about 80°C . They require no special packings or seals or filters. These fluids, besides being fire resistant, are non-explosive, will not attack rubber packings, are corrosion-inhibited, nontoxic, oxidation resistant, and have low pour points, good lubricity and stability in service. Furthermore, they are economical to make.

The hydraulic-type fluid systems in which the fluids of the present invention may be used include any system wherein a mechanical effort is converted to pressure at a first location, the pressure is transmitted from this first location to a second location via a hydraulic fluid, and the pressure is converted to a second mechanical effort at the second location. Thus, the hydraulic systems contemplated by the present invention include hydraulic brake systems, hydraulic steering mechanisms, hydraulic transmissions, hydraulic jacks and hydraulic lifts, especially those that require a high degree of fire resistance. Included among these are the hydraulic systems used in heavy equipment and transportation vehicles including highway and construction equipment, railways, and aquatic vehicles.

Various additives, besides the above-mentioned corrosion inhibitors, may be added to the fluids used in the systems of this invention to control or modify performance properties. Included among the various types of additives which can be added to the fluids are thickeners, buffers or pH control agents, antioxidants, viscosity index improvers, pour point depressants, lubricating additives, defoamers, stabilizers, rubber swelling adjusters, demulsifiers, dyes and odor suppressants. Generally, the total amount of additives which may be incorporated into the fluid composition will vary between 0% to about 30%, preferably from about 0.1% to 20% and more preferably from about 0.2% to about 10% by weight, based on the total weight of the fluid formulation.

Thickeners such as polyoxyalkylene glycol-type thickeners such as the water-initiated co-polymers of ethylene oxide and propylene oxide may optionally be added to the fluids of the present invention to effect an increase in the viscosity index of the fluid. Generally, the amount of thickeners added may be from about 0% to about 20%, preferably from about 0% to about 15%, by weight of the total fluid formulation. However, it should be understood that the addition of thickeners reduces both fire-resistance of the residual material and the lubricity of the fluid.

Buffers or pH control agents may optionally be employed in an amount sufficient to maintain alkaline conditions in the fluid compositions, e.g. at an apparent pH value of about 7 to about 11.5, if desired. Acidity might accelerate corrosion and render some corrosion inhibitors ineffective. Desirable buffers include potassium laurate and triethanolamine, ammonium phosphate, borates and the like. These buffers may generally be added to the fluids in amounts from about 0% to about 5% by weight of fluid formulation, preferably from about 0.1% to about 1% by weight of the mixture.

An antioxidant may optionally be used, if desired. Typical antioxidants include 2,2-di(4-hydroxyphenyl) propane, phenothiazine, amines such as phenylalphanaphthylamine and hindered phenols such as dibutyl cresol. Generally, the amount of antioxidant used will vary from 0% to about 3% by weight, preferably from about 0.001% to about 2% by weight, based on the total weight of the fluid formulation.

A defoamer such as a silicone type may be optionally used, if desired. Generally, the amount of defoamer used will vary from 0% to about 0.1% by weight of the fluid formulation; preferably, the amount will be from about 0.01% to about 0.1% by weight of the formulation.

Additionally, other additives, if desired, may be incorporated into the fluid composition. For example, rubber swelling adjusters such as dodecyl benzene may be used.

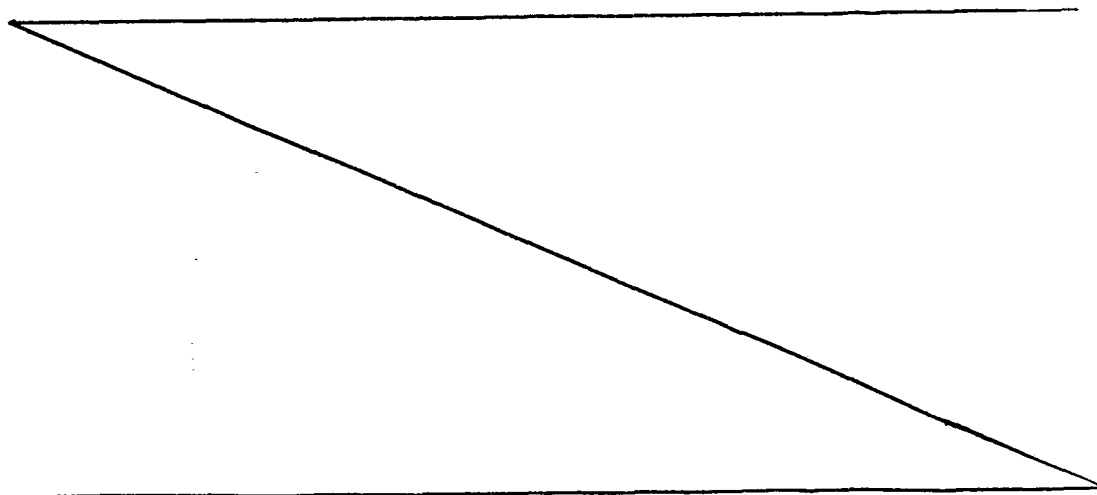
The above-noted inhibitors and additives are merely exemplary and are not intended as an exclusive listing of the many well-known materials which can be added to fluid compositions to obtain various desired properties. Other illustrations of additives which may be used can be found in U.S. Patent No. 3,377,288, and in Introduction to Hydraulic Fluids by Roger E. Hatton, Reinhold Publishing Corporation (1962).

The following examples depict various embodiments of the present invention; they are intended to be illustrative and not limiting in nature. All parts and percentages are by weight unless otherwise specified.

Example 1

To a one-liter steel autoclave, 195.9 grams (0.75 moles) of tris(2-hydroxyethyl) isocyanurate (THEIC) and 2.0 grams of boron trifluoride etherate were added. The latter compound was used as a catalyst in an amount equal to about 1.0% of the weight of the THEIC. The autoclave was sealed and the reaction mixture was heated to about 140°C to melt the THEIC. The reaction pressure was maintained at about 50 psig. Ethylene oxide (EO) was then added to the autoclave over a period of about 3 hours until 436 grams (9.9 moles) EO was charged. The reaction mixture was then post-reacted for 1 hour at 138°-150°C. After this post-reaction time, the reactor was cooled to room temperature, vented to remove any unreacted EO, and the contents were weighed (440.3 grams) and OH number determined (234) which corresponds to a calculated molecular weight of 719. The approximate structural formula of the product, as calculated from the uptake of EO, was $C_3N_3O_3[(CH_2CH_2O)_{4.1}H]_3$ whose formula weight is 680.

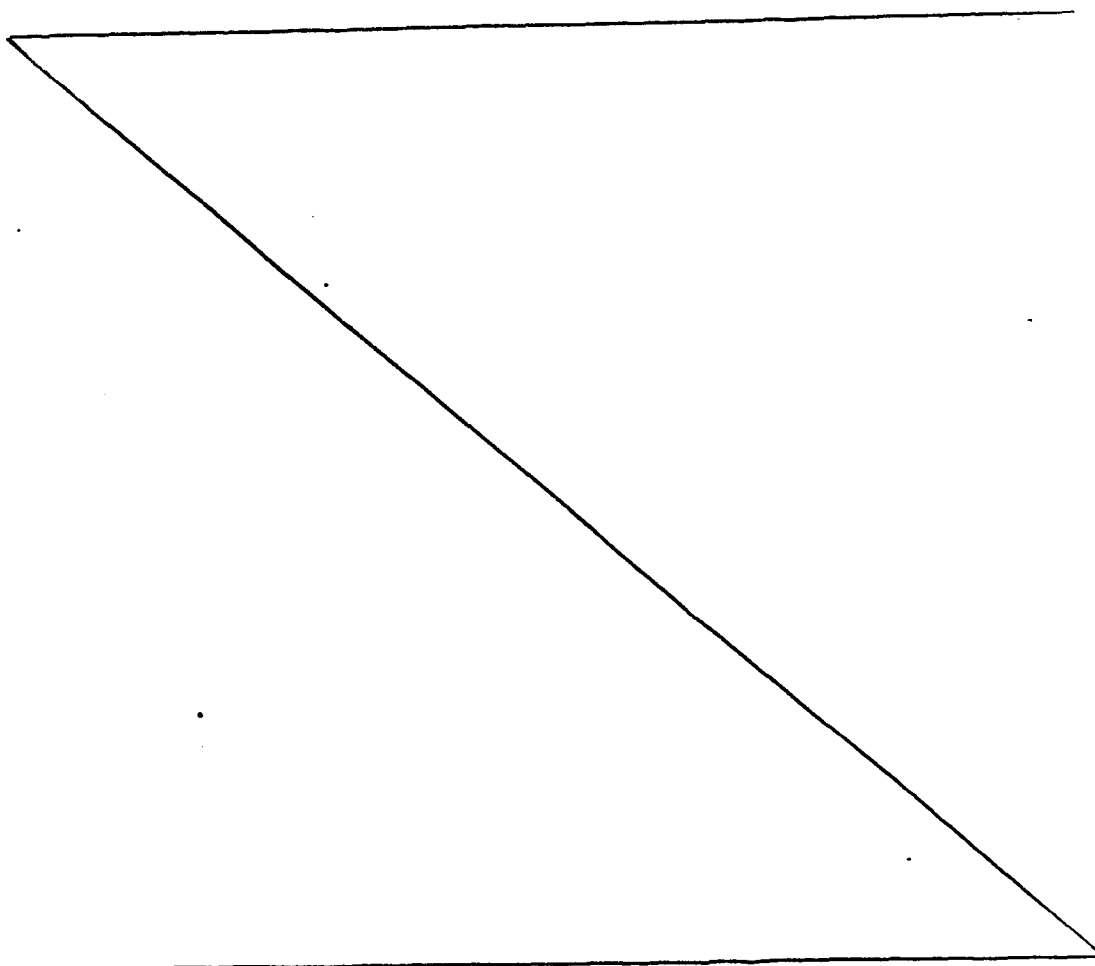
A water-based hydraulic fluid having a 200 SUS viscosity at 100°F, comprising 73.0% by weight of the above hydroxyalkylated isocyanurate and 27.0% distilled water, was prepared and tested for various properties. See Table I for the results of these tests.



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Example 2

5 The hydroxyalkylated isocyanurate product
made in Example 1 was blended with water and a
polyalkylene glycol thickener¹ prepared by
10 base-catalyzed, water-initiated copolymerization of
a mixture of 75% EO and 25% PO by weight (36,000 cSt
at 100°F) to form a hydraulic fluid having a viscosity
of 200 SUS at 100°F. This fluid comprised 39.0%
of the isocyanurate product, 50.0% water and 11.0%
10 thickener. The fluid was also tested for various
properties. See Table I for the results.



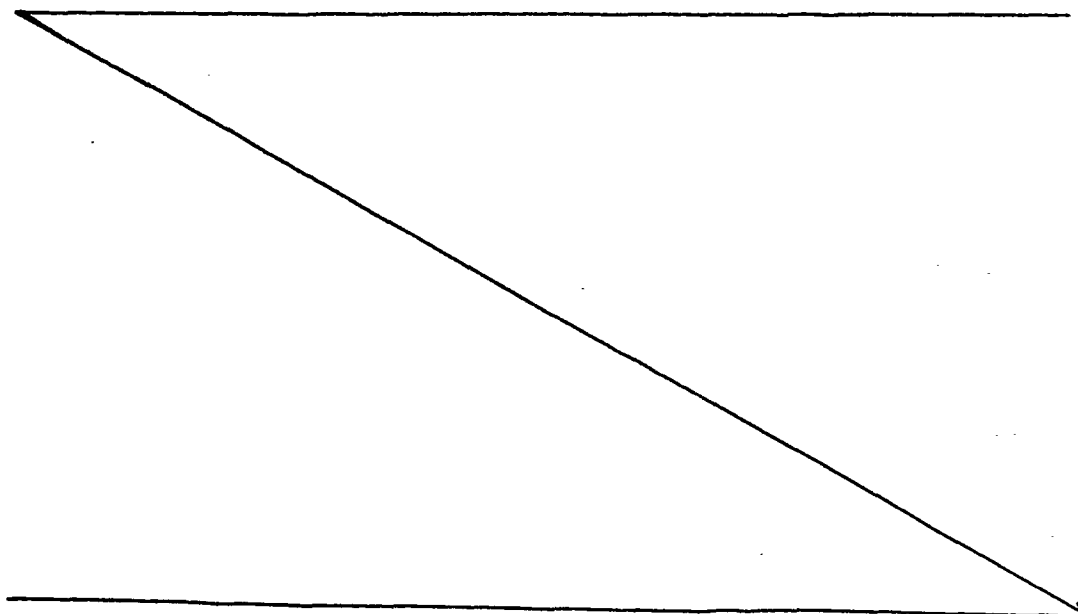
¹Poly-G® polyalkylene glycol thickener
concentrate manufactured by Olin Corporation of
Stamford, Connecticut.

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Example 3

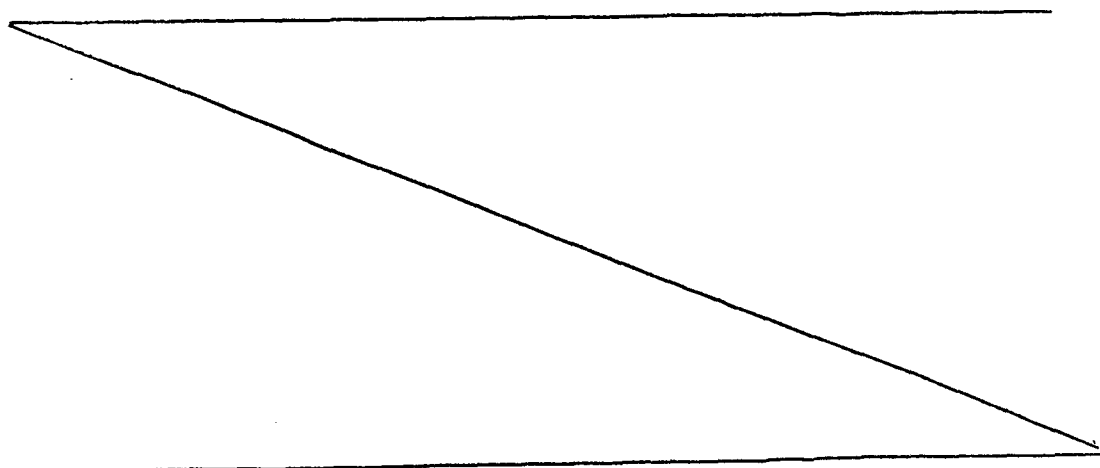
To a 250 ml glass flask equipped with a thermometer, addition funnel, and a cold finger condenser, 52.2 grams (0.2 moles) of THEIC was added. The flask was heated to melt the THEIC (at about 131°C) at atmospheric pressure. Then, 0.52 grams of boron trifluoride etherate was added to the flask, followed by the dropwise addition of 116.3 grams (2.64 moles) of EO at about 133°C to about 140°C over a period of 6.5 hours. Then, the reaction mixture was heated at about 125°C for an additional 16 hours, cooled to room temperature and the contents weighed (159.0 grams) and the OH number was determined (208), which corresponded to a calculated molecular formula of 809. The approximate structural formula of the product, as calculated by the uptake of EO, was $C_3N_3O_3[(CH_2CH_2O)_5H]_3$ whose formula weight is 790.

A water-based hydraulic fluid having about 200 SUS viscosity at 100°F comprising 73.0% by weight of the above hydroxyalkylated isocyanurate and 27.0% distilled water was prepared and tested for various properties. See Table I for the results.



Example 4

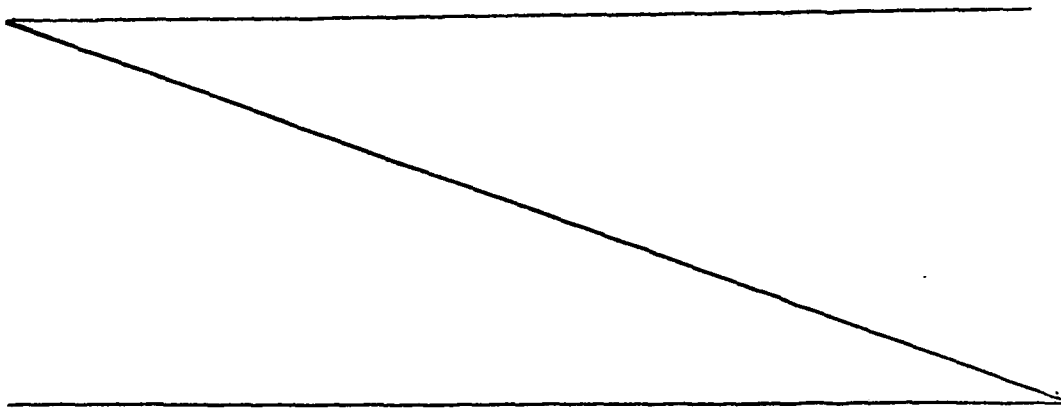
To a 500 ml glass flask equipped with a thermometer, addition funnel and cold finger condenser was charged 31.3 grams (0.12 moles) of THEIC. The flask was heated to melt the THEIC at atmospheric pressure. Boron trifluoride etherate (0.1 gram) was then added to the flask. 156.8 Grams (3.56 moles) of EO was added over a period of 16 hours while maintaining the temperature at about 131°C to about 137°C at atmospheric pressure. Boron trifluoride etherate catalyst was added during the EO addition as required to sustain the reaction. The total amount of catalyst was 2.8% of the THEIC added (0.89 grams). After addition of EO was over, the reaction mixture was heated at about 125°C for about 16 hours, cooled to room temperature and the contents weighed (173.5 grams) and the OH number was determined (152) which corresponded to a molecular weight of 1107. The approximate structural formula of the product, as calculated by the uptake of EO, was $C_3N_3O_3[(CH_2CH_2O)_{9.9}H]_3$ whose formula weight is 1439. A water-based hydraulic fluid having a 200 SUS viscosity of 100°F comprising 75.0% by weight of this isocyanurate product and 25.0% by weight of distilled water was then prepared and tested. The results of those tests are in Table I.



Example 5

5 A hydroxyalkylated isocyanurate compound was prepared by the continuous addition of 41.4 lbs. of EO to 15.4 lbs. of THEIC and 60 grams of BF_3 etherate in a 10-gallon reactor. The reactor was heated to 295°F to melt the THEIC at which point agitation and EO addition were begun. Only half of the EO had been added when the pressure reached its maximum of 65 psig. A second 60 gram catalyst charge was added to the vapor space above the liquid reaction mixture and the run continued until the EO was consumed. The resulting fluid had an OH number of 205. The molecular weight was calculated from the OH number to be 821. The average composition from calculated molecular weight was $\text{C}_3\text{N}_3\text{O}_3[\text{CH}_2\text{CH}_2\text{O}]_{5.2}\text{H}_3$.

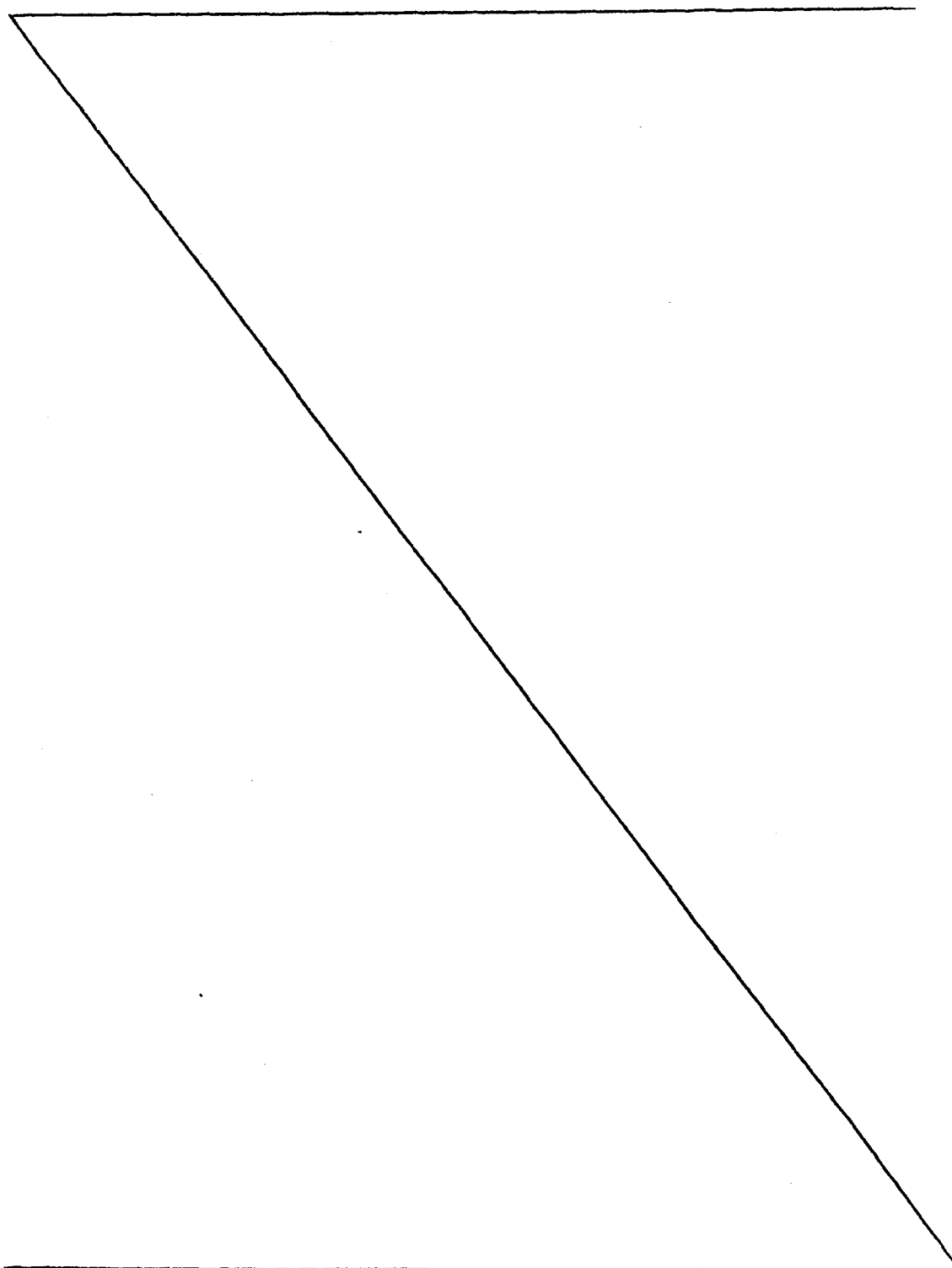
15 A two quart batch of hydraulic fluid having a viscosity of approximately 200 SUS was prepared by mixing 1579.8 grams of the isocyanurate base stock, 630.2 grams of distilled water, 11.0 grams of morpholine and 0.4 grams of SAG-10 silicone defoaming agent² in a beaker. The pH was raised to 9.5 by the addition of 14.6 grams of 1-amino-2-propanol. See Tables I and II for test results. The final composition of the fluid was:



²Manufactured by Union Carbide Co. of New York, New York.

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1569.8g Hydroxyalkylated isocyanurate	70.52%
630.2g Distilled water	28.31%
11.0g Morpholine	0.49%
14.6g 1-Amino-2-propanol	0.66%
0.4g Silicone defoaming agent	0.02%



Example 6

The hydroxyalkylated isocyanurate product for this example was prepared by a reaction similar to that of Example 5 except that only 34.4 lbs. of EO was added and the 60 grams of catalyst was charged into the melted THEIC. No further catalyst addition was necessary. The resulting fluid had an OH number of 199 and as in Example 5, the molecular weight was calculated to be 845 which corresponded to an average composition of: $C_3N_3O_3[CH_2CH_2O]_{5.4}H_3$.

Two quarts of hydraulic fluid having a viscosity of approximately 200 SUS were prepared. The same polyoxyalkylene glycol thickener (36,000 cs at 100°F) as used in Example 2 was used to increase the viscosity index. The viscosity of the thickener allows a lower isocyanurate fluid to water ratio to be used. Corrosion inhibitors, buffers and defoamer were also added. Two hundred grams of thickener were dissolved in 925.6 grams of water with stirring and heating followed by the addition of 788.4 grams of the base stock. An additive package was prepared on adding 4 grams of mercaptobenzothiazole, 18 grams of morpholine and 10 grams of triethanolamine to 50 grams of 20% aqueous potassium laurate buffer solution. This package was blended with the fluid along with four grams of potassium nitrite dissolved in four grams of water. Finally, 6 drops (0.4 grams) of SAG-10 defoamer were added. The composition of the fluid was:

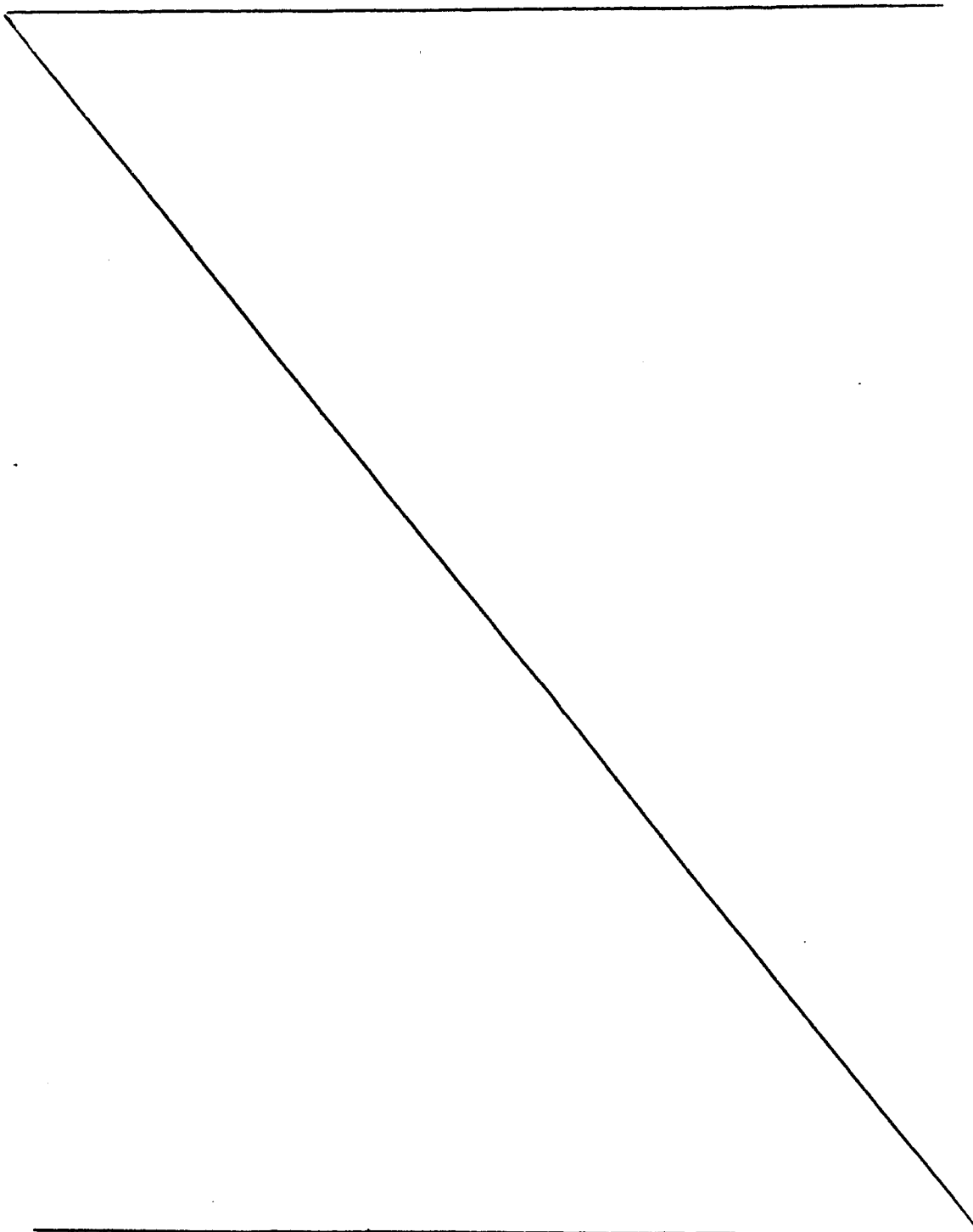
925.6g Distilled water	46.27%
788.4g Hydroxyalkylated isocyanurate	39.41%
200.0g Polyalkylene glycol thickener	10.00%
50.0g 20% Aqueous potassium laurate	2.5 %
4.0g Mercaptobenzothiazole	0.20%

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18.0g Morpholine	0.90%
10.0g Triethanolamine	0.5 %
4.0g Potassium nitrite	0.2 %
0.4g SAG-10 silicone defoaming agent	0.02%

5

This fluid was also tested. See Tables I and II.

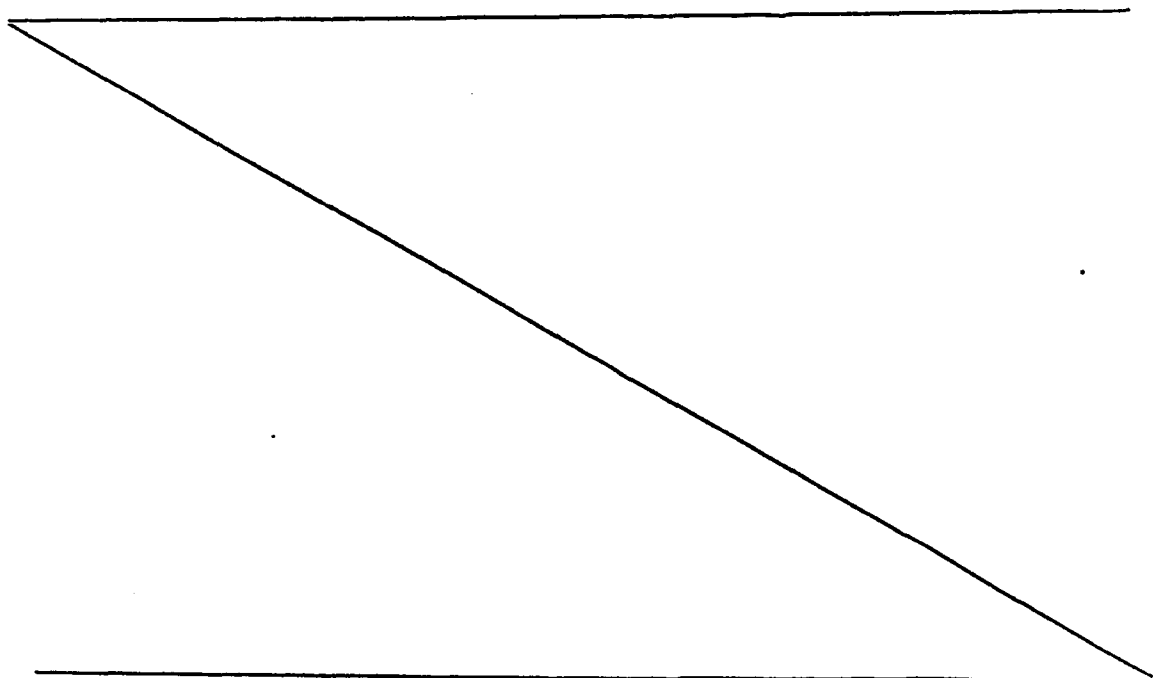


Example 7

The hydroxyalkylated isocyanurate product for this formulation was prepared by a reaction similar to that described in Example 6. The resulting product had an OH number of 209. Its molecular weight was calculated to be 805 which corresponds to an average composition of: $C_3N_3O_3[(CH_2CH_2O)_{5.1}H]_3$.

Two quarts of hydraulic fluid having a viscosity of approximately 275 SUS at 100°F were prepared as in Example 6 and tested (see Tables I and II). The fluid had the following composition:

1603.8g Hydroxyalkylated isocyanurate	72.89%
499.4g Distilled water	22.69%
55.0g 20% Potassium laurate solution	2.50%
8.8g 50% Sodium mercaptobenzothiazole (aqueous solution)	0.40%
2.2g Tolutriazole	0.10%
19.8g Morpholine	0.90%
11.0g Triethanolamine	0.50%
0.4g SAG-10 silicone defoaming agent	0.20%



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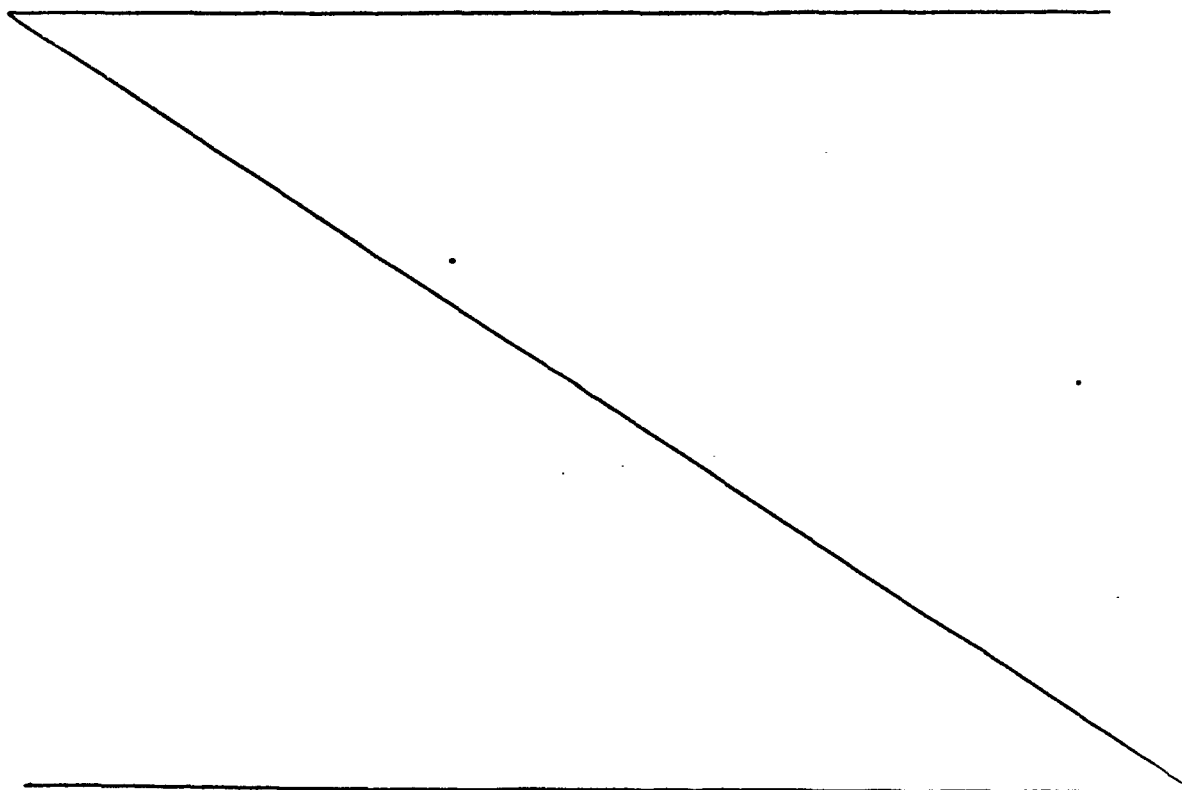
Example 8

The hydroxyalkylated isocyanurate product for this formulation was the same as in Example 7.

About four quarts of hydraulic fluid having 200

SUS viscosity at 100°F were prepared and tested (see Tables I and II). The fluid had the following composition:

	2893.8g Hydroxyalkylated isocyanurate	68.89%
	1121.4g Distilled water	26.69%
10	105.0g 20% Potassium laurate (aqueous solution)	2.50%
	16.8g 50% Sodium mercaptobenzothiazole (aqueous solution)	0.40%
	4.2g Tolutriazole	0.10%
15	37.8g Morpholine	0.90%
	21.0g Triethanolamine	0.50%
	0.8g SAG-10 silicone defoaming agent	0.02%



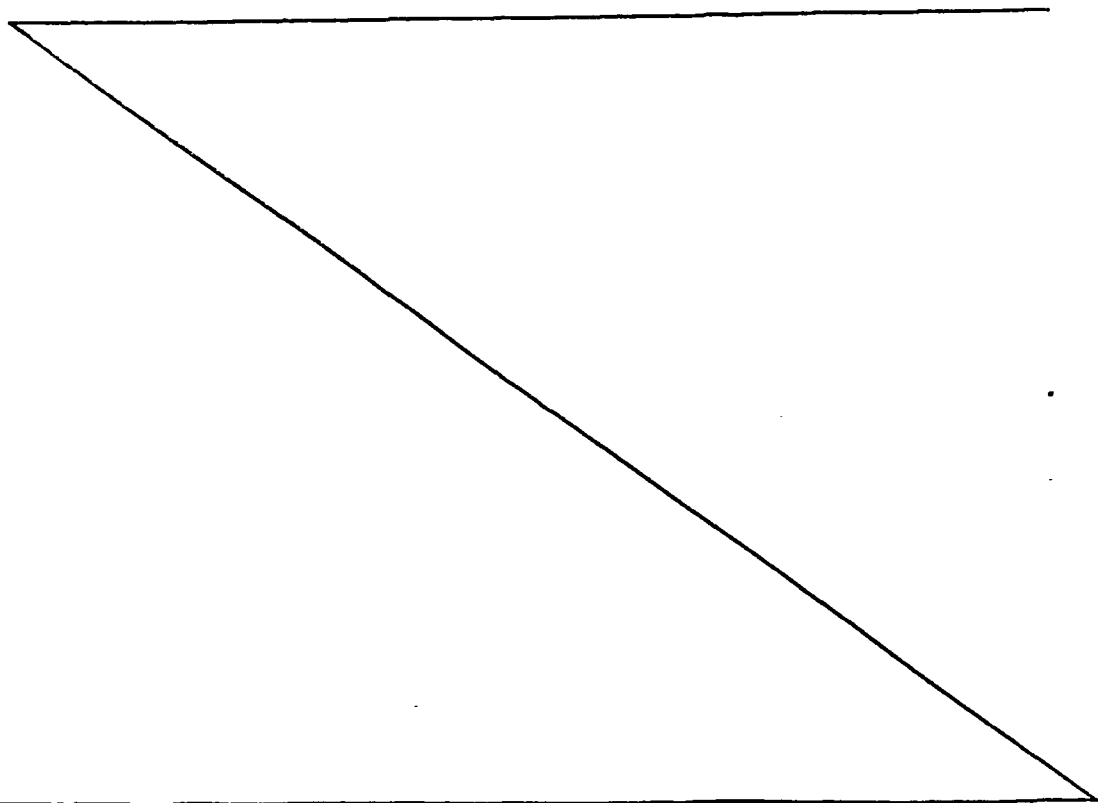
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Example 9

The hydroxyalkylated isocyanurate product for this formulation was the same as in Example 7.

5 About four quarts of hydraulic fluid having 150 SUS viscosity at 100°F were prepared and tested (see Tables I and II). The fluid had the following composition:

	2600.0g Hydroxyalkylated isocyanurate	64.99%
	1224.0g Distilled water	30.59%
10	100.0g 20% Potassium laurate (aqueous solution)	2.50%
	16.0g 50% Sodium mercaptobenzothiazole (aqueous solution)	0.40%
	4.0g Tolutriazole	0.10%
15	36.0g Morpholine	0.90%
	20.0g Triethanolamine	0.50%
	0.8g SAG-10 silicone defoaming agent	0.02%

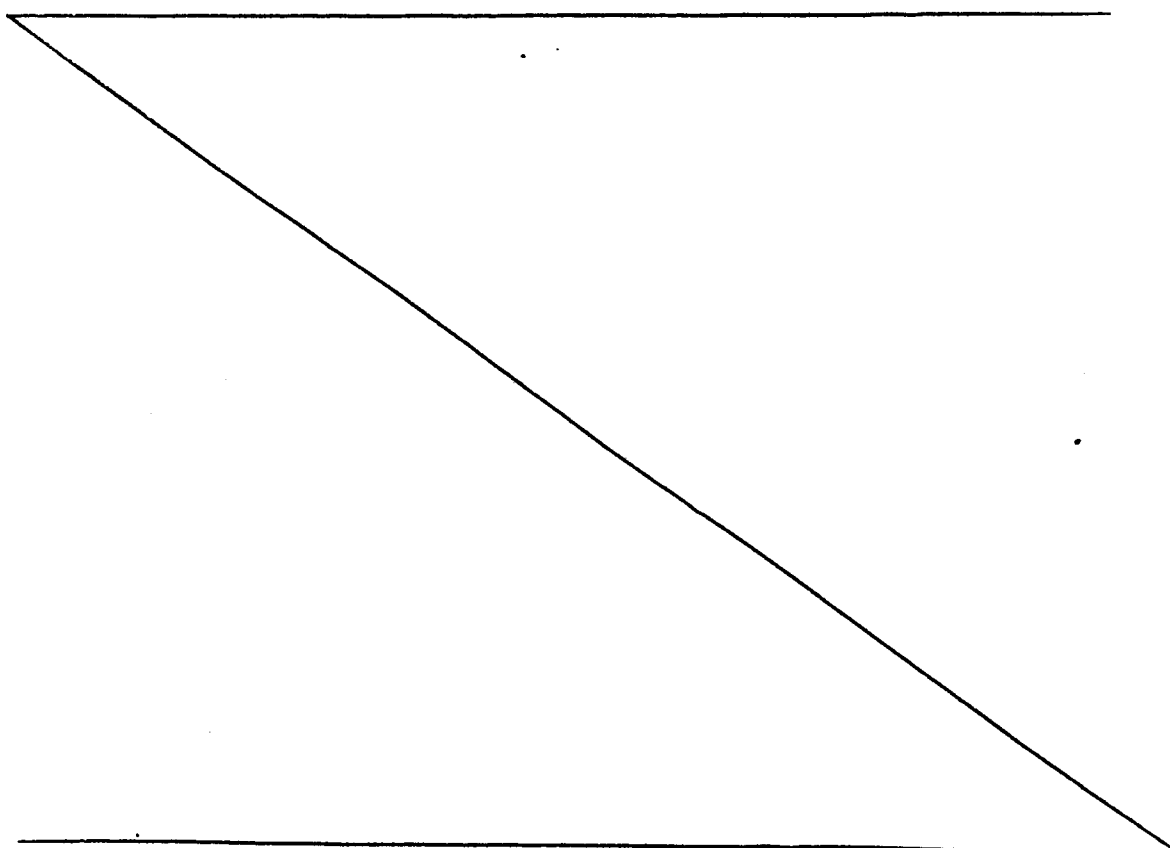


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Example 10

5 The hydroxyalkylated isocyanurate product for this formulation was the same as in Example 7. About four quarts of hydraulic fluid having 100 SUS viscosity at 100°F were prepared and tested (see Tables I and II). The fluid had the following composition:

2268.6g Hydroxyalkylated isocyanurate	59.69%
1364.2g Distilled water	35.89%
10 95.0g 20% Potassium laurate (aqueous solution)	2.50%
15.2g 50% Sodium mercaptobenzothiazole (aqueous solution)	0.40%
3.8g Tolutriazole	0.10%
34.2g Morpholine	0.90%
15 19.0g Triethanolamine	0.50%
0.6g SAG-10 silicone defoaming agent	0.02%



The utility of the fluids prepared in Examples 1-10 as fire-resistant hydraulic fluids and specifically their advantage as replacements for the water glycol types was established by the determination of the following properties of the isocyanurate based fluids and comparison with the properties of Houghtosafe 620, a commercial water glycol hydraulic fluid manufactured by E. F. Houghton. The results are summarized in Tables I and II.

10 A) Viscosity (measured by ANSI/ASTM D-2270-77) - The viscosities at 100°F indicate the ability to formulate a hydroxyalkylated isocyanurate base stock to meet the viscosity specifications of the most commonly used pumps. The kinematic viscosity in centistokes was measured and converted to SUS values
15 by the appropriate tables found in ANSI/ASTM 2161-79.

 B) Viscosity Index (measured by ANSI/ASTM D-2270-79) - The viscosity of the fluids will vary during use due to changes in the fluid temperature.
20 The hydraulic system may not operate properly if the fluid becomes too thin or too thick. The viscosity index (VI) predicts the extent of these changes with a higher value indicating less of a change. A VI of at least 100 would be considered suitable. Only the fluid
25 of Example 3 failed to meet these criteria. Also, the fluids employing thickener are seen to have VI's superior to those fluids without it. The VI's were calculated by utilizing the value for 100°F viscosity and an estimated value for 210°F viscosity obtained by
30 extrapolation on the ASTM Standard Viscosity Temperature chart utilizing the viscosity values at 100°F and either 130°F or 150°F.

C) Pour Point [measured by ANSI/ASTM D-97-66 (1971)] - The pour points of the fluids are important if they are to be shipped, stored or utilized outdoors in cold weather. Except for the fluid of Example 5 which included a thickener, all of the tested fluids had pour point values which would render them suitable for use at temperatures below 0°F.

D) Four Ball Wear Test [measured by ANSI/ASTM D-2266-67 (1977)] - Lubricity testing of the fluids is required since a hydraulic fluid must separate and lubricate the surfaces of system components which are in close contact. Employing conditions of 1 hour, 130°F, 1200 rpm and 40 kg load for the test, the values for most of the isocyanurate based fluids were equal to or better than that of Houghtosafe 620. The fluids with higher values than Houghtosafe 620 still exhibited adequate lubricity performance.

E) Power Steering Pump Test - A test such as the Four Ball Wear Test is useful to screen preliminary formulations. Such a test cannot, however, accurately predict pump performance and thus the fluid must be run through a pump test under end-use conditions to determine whether it has sufficient lubricity. The fluids were tested in a Saginaw power steering pump having a fluid capacity of 1000 cc. The rotor, ring and vanes of the pump are weighed prior to operation. The pump is then assembled and operated for 4 hours at a fluid exit temperature of 150°F and a pump outlet pressure of 500 psig. An external cooling coil in a water bath maintains temperature control and a relief valve maintains the system pressure. At the end of the 4-hour period, the pump is disassembled, the parts weighed and the weight loss

5 recorded. The pump is re-assembled and operated under the same conditions for another 24 hours. The weight loss occurring after the completion of the two cycles is reported as a measure of wear and should be less than about 150 mg for acceptable fluids. Results are given in Table I.

10 F) Wick Flammability Test (measured by U.S. Bureau of Mines Schedule 30, July 1, 1978) - The test simulates fluid soaked in absorbent, flammable material and exposed to open flames. It is performed by soaking a pipe cleaner in the fluid and cycling it into and out of a laboratory burner flame at 25 cycles/min. until a self-sustaining flame is attained. The flammability of the fluids was compared by testing 15 them as is, and after varying amounts of evaporative water loss. Thus, three samples were prepared, one was left in an open petri dish at room temperature, one was placed in an oven at 150°F for 2 hours and one was placed in an oven at 150°F for 4 hours. The Bureau of 20 Mines standard is that the number of cycles before attaining a self-sustaining flame should be 18 or more for the 2-hour sample and 12 or more for the 4-hour sample. As is seen in Table II, the residues of the isocyanurate based fluids retain a significant 25 measure of their ignition resistance while the residue of the glycol-based fluid does not.

30 In summary, the isocyanurate water-based fluids are comparable in physical properties and lubricity characteristics to typical water glycol fire-resistant hydraulic fluids, but offer a substantial reduction in the flammability of the residual material resulting from loss of water content.

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5 Fluids of the present invention such as these may be desirable for improving safety in Naval Ship hydraulic systems, die casting machines, forging and extrusion presses, injection molding machines, continuous casters, rolling mills, furnace controls, automatic welders, hydraulic shears, continuous coal miners and mine shuttle cars, and many other uses where the threat of fires exists.

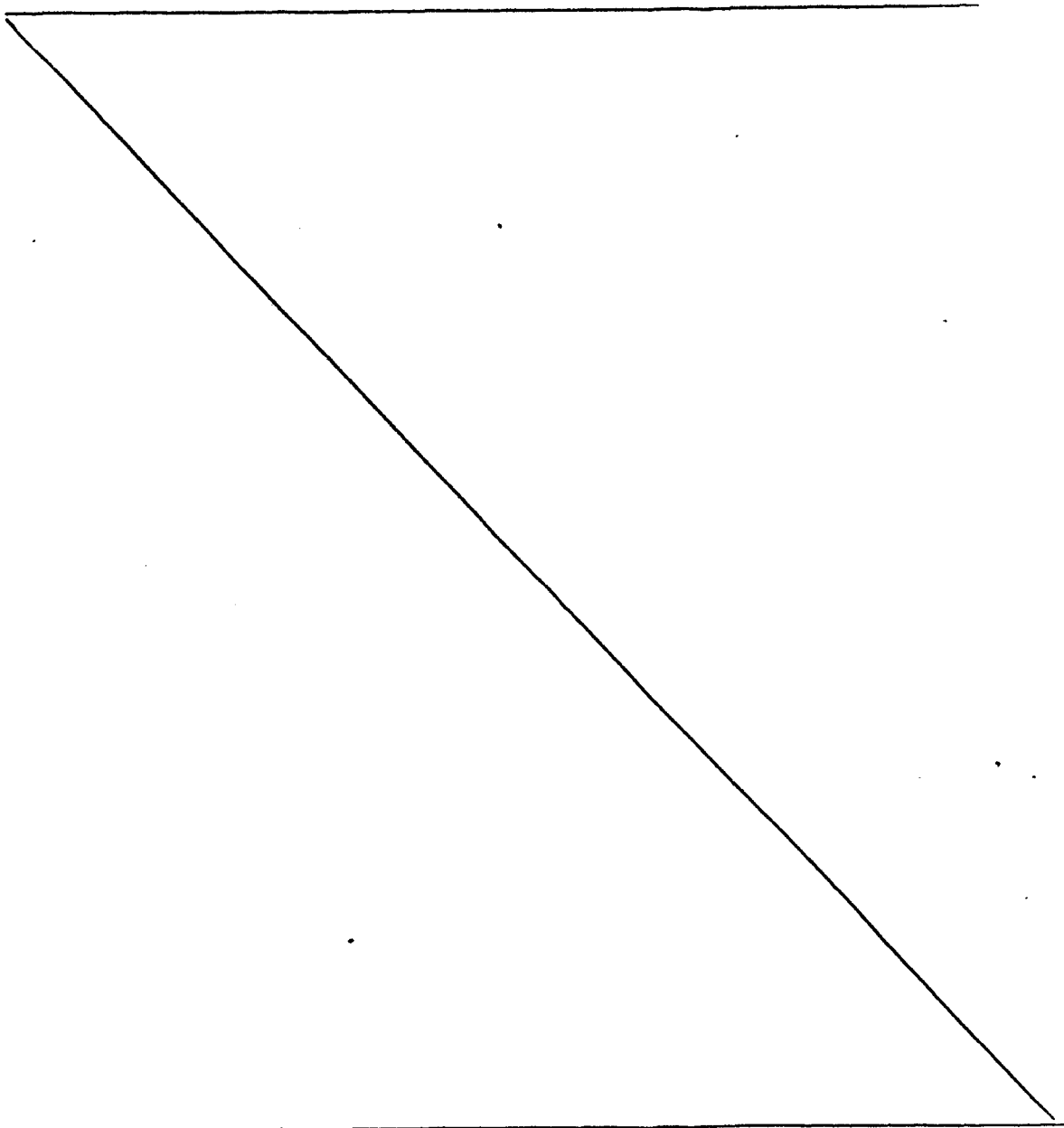


TABLE I
PHYSICAL AND LUBRICITY PROPERTIES OF WATER-BASED FLUIDS

HYDRAULIC FLUID	VISCOSITY 100°F (cs/SUS)	VISCOSITY 130°F (cs)	VISCOSITY 150°F (cs)	VISCOSITY INDEX	POUR POINT	4-BALL WEAR (mm)	POWER STEERING PUMP TEST	
							ROTOR, RING & VANE WEAR (mg)	
HOUGHTOSAPE 620	42.55/198		18.67	215	-65°F	0.88		76.2
EXAMPLE 1	43.79/204	22.40		110		0.84		
EXAMPLE 2	41.46/193	24.70		219		0.98		
EXAMPLE 3	42.12/196	19.85		60	-49°F	0.85		
EXAMPLE 4	49.26/229	24.68		107		0.81		
EXAMPLE 5	45.50/212		16.03	113	-44°F	0.75		70.5
EXAMPLE 6	38.53/180		16.59	199	5°F	0.83		375.0
EXAMPLE 7	62.10/288		20.39	108	-27°F	0.74		111.6
EXAMPLE 8	42.45/198		15.11	110	-44°F	0.80		87.2
EXAMPLE 9	32.91/155		12.25	107	-60°F	0.83		101.1
EXAMPLE 10	22.57/109		9.05	101	-54°F	0.76		124.0

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TABLE II
IGNITION CHARACTERISTICS OF WATER-BASED FLUIDS AND THEIR RESIDUES

	WICK FLAMMABILITY (NO. OF CYCLES)		
	SAMPLE AT ROOM TEMP.	SAMPLE AFTER 2 HRS. EVAPORATION AT 150°F	SAMPLE AFTER 4 HRS. EVAPORATION AT 150°F
HYDRAULIC FLUID			
HOUGHTOSAFA 620	25	20	9
EXAMPLE 5	26	24	20
EXAMPLE 6	24	24	17
EXAMPLE 7	22	18	20
EXAMPLE 8	18	19	18
EXAMPLE 9	22	23	21
EXAMPLE 10	26	23	20

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5. The hydraulic fluid of any preceding claim wherein x, y and z are each from 4 to about 10.
6. The hydraulic fluid of any preceding claim wherein said hydroxyalkylated isocyanurate is present in the amount from about 25% to about 80% by weight.
7. The hydraulic fluid of any preceding claim wherein said liquid phase corrosion inhibitor comprises sodium mercaptobenzothiazole.
8. The hydraulic fluid of any one of claims 1 to 6 wherein said liquid phase corrosion inhibitor comprises tolutriazole.
9. The hydraulic fluid of any one of claims 1 to 6 wherein said liquid phase corrosion inhibitor comprises a combination of sodium mercaptobenzothiazole and tolutriazole.
10. The hydraulic fluid of any preceding claim wherein said vapor phase corrosion inhibitor is morpholine.
11. The hydraulic fluid of any preceding claim which additionally contains from 0% to about 15% by weight of a thickener.
12. The hydraulic fluid of claim 11 wherein said thickener is a co-polymer of ethylene oxide and propylene oxide.
13. The hydraulic fluid of any preceding claim which additionally contains from about 0.1% to about 1% by weight of at least one buffer.
14. The hydraulic fluid of claim 13 wherein said buffer is selected from potassium laurate, triethanolamine, and mixtures thereof.

15. The hydraulic fluid of any preceding claim which additionally contains from about 0.01% to about 0.1% by weight of a defoamer.
16. A method wherein a first mechanical effort is converted to pressure at a first location, the pressure is transmitted from said first location to a second location via a hydraulic fluid, and said pressure is converted to a second mechanical effort at said second location; characterised by employing the fluid of any preceding claim as said hydraulic fluid.