**Frequently Asked Questions:**

**Can it be used with my existing foam proportioning systems? What about Compressed Air Foam Systems?**

Yes, Novacool carries UL listing as a wetting agent and contains no ingredients that will harm your existing foam equipment. Many departments are currently using Novacool UEF in place of typical "class A" foams as their additive source for compressed air foam systems (CAFS).

**Does Novacool UEF leave sticky residue or any other hazardous bi-products?**

No, Novacool UEF is bio-degradable. Novacool UEF has been tested and generally degrades at a rate of about 4 days in direct UV light. Typically, no trace elements were found after day 4.

**Can I mix Novacool UEF with other foam products?**

Although not recommended we realize this may occur, as rarely do all departments in the same area use the same type or maker of foam. Novacool UEF has been mixed with many other types of foam and no adverse reactions have been noted such as congealing or drying out.

**Can I batch mix Novacool UEF directly into the tank of my truck?**

Yes, several departments in Texas have placed Novacool UEF directly into their tanks without any problems. Novacool UEF is usable with eductors, injectors, CAFS, or batch mixed; it's non-corrosive and has no adverse effects on tanks, pumps, valves, and portioning equipment. Batch mixing is particularly necessary for departments that have older trucks or smaller brush trucks that may not have foam proportioning systems. Novacool UEF in this application is mixed at 0.5%. A 500 gallon tank of water only requires 2.5 gallons of Novacool. A brush truck with a 250 gallon tank only needs to carry (1) five gallon bucket of Novacool UEF. This (1) five gallon bucket will treat 5 tanks of water at 0.4%. (This is the desired application rate for class A materials).

**Will this void my warranty on my new engine or truck?**

No. Novacool UEF is UL listed and certified to N.F.P.A. 18. In general most manufactures design their tanks to accommodate foams certified to these standards.

**Do I need to have a foam eductor to use Novacool?**

In the absence of an around the pump foam proportioning system utilizing a foam eductor is optimal. However, as stated above the solution can be mixed directly into the tank or used through a foam proportioning system. However, if added directly to the tank we recommend some agitation to ensure adequate dilution and even a slightly higher concentration.

**Is Novacool UEF toxic or corrosive? Do I need to worry about it fading my paint, or damaging my equipment?**

No. Novacool UEF contains no harsh detergents, or other ingredients that will damage the environment. Including your truck or the property you are protecting?

**Is Novacool UEF harmful to the environment?**

No. Novacool UEF is non-toxic and biodegradable. Novacool exceeds EPA guidelines and has been extensively tested by water districts throughout the United States. Novacool contains no EPA or DOT reportable ingredients and does not contain any nonylphenolexthoxylates (NPE's) or glycol ethers

**Is there any special training that is required? Do I need to purchase new Nozzles or anything else?**

No. If you already using class A or B foams on a regular basis, then you are ready to go. The only training that is required is for the pump engineer that needs to know what percentage is required. Day-to-day fire service companies will run it at .4%. For polar solvents they will need to run it at .5%. Departments can use existing equipment, including nozzles, etc. There are however, some techniques that will enhance the application of Novacool, but typically these techniques can be accomplished with existing equipment. For instance, foam tubes, high expansion nozzles and CAFS systems enhance the foam characteristics of Novacool UEF.

**Why should I switch?**

Novacool UEF provides firefighting companies with a single source solution for their demanding work environment. Typical residential fires are no longer typical class A fires. Most residential and business fires contain many hazardous substances and in modern times could be classified as Class B fires. Many of these substances are synthetic and very flammable. In answer to the problem of "enhanced" fires many departments have made the switch to routinely using CAFS or some other wetting agent. However, many departments are still using plain water and do not carry any solution for combustible liquid fires on their apparatus. Our research has shown that most engine companies only carry a minimum amount of AFFF or some other foam, but not nearly enough to combat any combustible liquid fire of significance.

Other departments have chosen to add dual agent foam tanks but in reality don't carry enough class B foam to meet the needs of even the smallest class B fire. And finally, there's Ethanol. It is estimated that over 90% of motor fuels will contain at least 10% ethanol by 2010. Ethanol is another problem that departments around the country are only starting to address. Novacool UEF answers all these problems. One 40 gallon foam tank of Novacool UEF will treat 10,000 gallons of water at 0.4%. Departments that have switched to Novacool UEF have seen a dramatic reduction in the consumption of foaming agents.

The bottom line is that Novacool UEF reduces combat time, and provides a safer environment for firefighters to work in. With a reduced water application rate thermal balance is maintained, improving the work environment. Firefighters exhibit less heat stress, and less time in the fight! It's all about safety. Overall, scene times can be reduced, and flow requirements are drastically cut by companies using Novacool UEF. This is accomplished by rapid extinguishment and cooling of the environment. The result of decreased flows is decreased run-off of toxic byproducts.

Novacool UEF is an engineered tool to enhance the overall safety of the fire company, and the public it serves.

## How Does Novacool UEF Work?

Simply Stated:

Novacool UEF is a mixture of anionic, nonionic, and amphoteric surfactants that works in three ways to extinguish a fire. It reduces the surface tension of water to improve the penetrating ability of water; it vastly improves the heat transfer from the fuel into water; and it reduces fuel vapor pressure by emulsifying class B materials at the fuel surface.

Most fire suppressants extinguish a fire by coating it and robbing it of oxygen, which is less than optimal because this allows the fire to potentially re-ignite. Novacool UEF is different; it works by combining with water and reducing water's surface tension, which allows the water to develop a high surface area relevant to the mass it's hitting. This high surface area to mass allows for a very rapid and efficient heat transfer from the object to the water. This transfer results in quick extinguishment and rapid cooling. Cooling helps to prevent fire re-ignition.

One gallon of Novacool UEF will treat 250 gallons of water to create an effective foam substance. It is more concentrated than other commonly used firefighting agents, so less is needed to contain and extinguish a fire. This also results in less water use. Novacool UEF is released through a dispensing agent that automatically combines it with water at 0.1%-0.5%, so it is convenient to use.

Scientifically Stated:

"Combustion of common class A and B materials can be described as a chaotic oxidation of numerous classes of organic compounds. The chemical yield of these reactions is equally chaotic and produces numerous classes of organic compounds in addition to CO2, H2O and CO. The common denominator of all combustion reactions is that the products yielded are at a much lower total Gibbs free energy state than the fuel reactants. In the process of achieving this lower energy state a great photon yield of radiant energy is delivered.

This is evidenced by the various colors and wavelengths present with flame emissions. These emissions, by striking the fuel load directly and by striking adjacent bodies that reradiate, are responsible for propagating the violent sets of reactions in combustions of organic materials. The Novacool UEFproducts interfere with these reactions by providing a

continuous stream of molecules that will absorb the high energy radiant emissions from the combustion process. Novacool UEFproducts are of such structure that each will absorb a photon, elevate to an excited state, and revert to the ground state within a period of 10(-3) to 10(-6) seconds."

## Additional Product Descriptions:

The "Revolutionary" attraction of the Novacool UEF fire extinguishment products is their patented ability to dramatically and quickly lower fire site temperature. Firefighters consistently report a "cooling shield" which precedes them when fires are fought with Novacool UEF products. Conventional foam products do not cool beyond the normal effect of the water they contain. In addition, fire departments using our products, report 70% faster extinguishment as compared to any Class A or B agent and also they are reporting, on average, about 70% to 90% lower water usage as compared to plain water.

Brand name: Novacool UEF (Universal Extinguishing Foam).
Application Ratio: 0.4% standard, 1% and 3% optional.
Fire Class Application: Class A, Class B, Class D, pressurized and 3-D fires.
Approvals: Manufactured under NFPA 18, UL tested and listed.
Shelf life: 10 years +

NFPA 18 - **Document Scope:** 1-1.1 Scope. This standard is limited to qualification tests, methods of evaluation, general rules for application, and limitations for use of wetting agents as related to fire control and extinguishment. 1-1.1.1 The method whereby the wetting agent is added to water is not herein specifically set forth. The solution can be premixed in tanks or can result from bringing the wetting agent into contact with water by any suitable proportioning device, providing, however, said device shall be approved in accordance with applicable standards.

Novacool UEF, a fire extinguishing foam, replaces aqueous film-forming foams and ozone-depleting halon gases, which release both toxic hydrofluoric acid and fluorocarbons into the environment during use. Novacool UEF provides an innovative, highly effective, and environmentally responsible alternative for firefighting. It is effective at approximately one-seventh the concentration of conventional fire fighting chemicals. Novacool UEFselective employment of rapidly biodegradable substances, which dramatically enhances the effectiveness of simple water, while eliminating the environmental and toxic impact of other traditional fire extinguishment agents. Because Novacool UEF is mixed with water at only 0.4 percent, an 87–93 percent reduction in product use is realized compared to conventional extinguishment agents typically used at 3–6 percent.

Why Novacool UEF?

1. Dramatic and immediate COOLING of the fire site!
2. 70% faster extinguishment of the fire!
3. 90% lower water usage !
4. Most cost-effective fire suppressant on the market!
5. Extinguishes A, B, D and K fires and 3D fires; cools, blankets, and emulsifies surfaces; eliminates possibility of re-ignition
6. Usable with eductors, injectors, CAFS, or batch mixed; non-corrosive: no adverse effects on tanks, pumps, valves, and portioning equipment
7. Works effectively when mixed with fresh, brackish, or sea water; eliminates run-off and water damage
8. Non-toxic, biodegradable, UL Listed, EPA “Approved”
9. Manufactured entirely in the U.S.A.

## Kinds of Benefits does Novacool UEF Provide?

Novacool UEF provides benefits for firefighters.

·Extinguishes A, B, D and K fires
·Effectively extinguishes 3D fires, decreasing unsafe firefighting conditions
·"Triple Action" formula cools, blankets, and emulsifies surfaces
·Creates a rapid cooling effect, decreasing unsafe firefighting conditions
·Works effectively when mixed with fresh, brackish, or sea water

Novacool UEF provides benefits for fire departments.

· Most cost effective fire suppressant on the market
· Low portioning rate of 0.4% with water
· No additional training necessary
· No additional equipment purchase necessary
· Non-corrosive: no adverse effects on tanks, pumps, valves, and portioning equipment
· UL Listed

Novacool UEF provides benefits for property owners.

·Quick extinguishing ability and strength of Novacool UEFminimizes water damage
·Coating and cooling effects minimize fire re-ignition
·Proportioning equipment minimizes fire department prep time.
·Quicker extinguishment equals less fire and smoke damage overall

Novacool UEF provides benefits for the environment.

· Non-toxic and biodegradable
· No EPA or DOT reportable ingredients; exceeds EPA guidelines
· Does not contain any nonylphenolexthoxylates (NPE's) or glycol ethers
· Reduced runoff and water damage

## What about Pollution, and the Environment?

How is Novacool UEF Better for the Environment?

Most currently-used fire suppressants (specifically AFFF's) contain fluorochemical surfactants, Perfluorooctyl sulfates (PFOS), and Perfluorooctylbetaines that can oxidize to Perfluorooctanoic acid (PFOA). PFOA and PFOS do not degrade, which often leads to contamination of groundwater supplies and failure of wastewater treatment systems. These fluorosurfactants are persistent in the environment, and testing has shown them to be bioaccumulative. The Environmental Protection Agency (EPA) has been investigating these aqueous, film-forming compounds because of their environmental buildup and damage to our valuable resources.

Novacool UEF does not contain PFOA or PFOS, NPEs, or glycol ethers. Novacool UEF was tested by CH2M Hill in Corvallis, Oregon for aquatic toxicity and biodegradability and was shown not to cause toxic buildup or pollute groundwater. Novacool UEF exceeds EPA guidelines and provides an environmentally responsible alternative to harsh extinguishers that pollute valuable resources in our environment.

Because Novacool UEF is powerful yet environment-friendly, it assists in water preservation and helps prevent water pollution. With Novacool, fewer chemicals are used and less water is used, which also results in less erosive runoff and less water damage to property. Makers of Novacool UEF want to assist firefighters in helping to protect water, land, and other precious resources while extinguishing fires quickly and effectively.

Patent Information – Background of Invention:

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is generally related to a chemical composition designed and formulated for the safe suppression and control of fires involving liquid hydrocarbons and/or polar solvents.

2. Description of the Prior Art

Many fire fighting compositions have employed the mechanism of using a foam blanket to smother the fire and isolate the fuel from an oxygen source that will support combustion of the fuel. Many of them do not produce stable foams in the presence of extremely volatile liquid hydrocarbons and polar solvents. The most successful compositions have used fluorocarbon surfactants as a part of their surfactant group. The presence of the fluorocarbons gives an aqueous solution that will form a tough film to seal the hydrocarbon surface and stabilize the foam formation. Fluorocarbon surfactants are very chemically stable, making them invulnerable to many forms of degradation. Soil bacteria are not able to metabolize fluorocarbon surfactants. At test facilities where repeated use of these materials has occurred, fluorocarbon surfactants

have descended through the soil without being degraded by the normal bacterial compliment, and have contaminated groundwater. Movement of the fluorocarbon surfactants through the groundwater has resulted in contamination of potable water supplies. Their long life has made their indiscriminate use an environmental threat.

Application of most foams, comprised of common surfactants, to volatile hydrocarbon and polar solvent surfaces will result in the rapid breakdown of the foam resulting in failure to extinguish and seal.

## SUMMARY OF THE INVENTION

An object of this invention is to provide a fire fighting and cooling composition that is better suited for extinguishing fires involving liquid hydrocarbons and polar solvents.

Another object of this invention is to provide a fire fighting and cooling composition that is better suited for protectant/retardant applications and which can allow more water to adhere to three dimensional surfaces (homes, buildings, etc.).

According to the invention, a composition containing non-ionic surfactants, anionic surfactants, and amphoteric surfactants, and possibly salts or acids such as sodium chloride and citric acid is used in combination with conventional fire fighting equipment to provide a foam composition with a synergistic and superior fire extinguishing effect. In operation, a mixture layer is formed at the fuel surface which consists of a double concentration gradient with a high concentration of fuel, low concentration water and surfactant at the bottom and a high concentration of water and surfactant, low concentration of fuel at the top. A stable environment is created for the foam by emulsifying the hydrocarbons and mixing them with the hydrocarbon fuels or polar solvents. It is proposed that this gradient layer created by the surfactant blend of this invention will support a long foam life. The addition of various salts and acids to the composition can help facilitate stable foam formation.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

It has been found that a fire fighting and cooling composition especially effective on hydrocarbon and polar solvent fires is formulated using a semi-polar non-ionic surfactant, an anionic surfactant, and an amphoteric surfactant. The fire fighting and cooling composition is sprayable using conventional fire fighting equipment such as that which is available from Akron Brass and other companies.

As used herein, all percentages, parts and ratios are by weight unless otherwise indicated. The surfactants used in the inventive composition include substituted or unsubstituted alkyl and aryl moieties. A typical substituted constituent would be a hydroxy molecule; however, other constituents which may be substituted on the alkyl and aryl moieties will be readily apparent to those skilled in the art.

The non-ionic surfactant used in the fire fighting and cooling composition is typically present at 0.25-10% by weight. The non-ionic surfactant should be semi-polar in character and be selected

from the group consisting of water soluble amine oxides, phosphine oxides, and sulfoxides. Typically the amine oxides, phosphine oxides and sulfoxides will have one alkyl or hydroxyalkyl moiety of 8 to 28 carbon atoms. Additionally, one or two additional alkyl moieties will be joined to the amino, phosphorous, or sulfur group and these moieties will typically include 1-3 carbon atoms and may also be substituted with hydroxy groups. Mixtures of several different non-ionic surfactants can be advantageously employed in the fire fighting and cooling composition. Of the water soluble semi-polar non-ionic surfactants, the group most useful to this invention is the group composed of the water soluble amine oxides. Of this group, those having one alkyl or hydroxyalkyl moiety of 8 to 16 carbon atoms and two alkyl moieties selected from the group consisting of alkyl and hydroxyalkyl groups containing 1 to 3 carbon atoms are most preferred. Examples of this group include dimethyloctylamine oxide, diethyldecylamine oxide, bis-(2-hydroxyethyl) dodecylamine oxide, dimethyldodecylamine oxide, dipropyltetradecylamine oxide, and methylethylhexadecylamine oxide. Of the examples, dimethyldodecylamine oxide is the most preferred water soluble amine oxide.

The anionic surfactant used in the fire fighting and cooling composition is an organic sulfate or organic sulfonate, or mixtures thereof, and is typically present at concentrations of 10-50% by weight. The weight ratio of the semi-polar non-ionic surfactant to the anionic surfactant should range between 1:99 and 1:1. The anionic surfactant is preferably present as an alkaline earth metal salt and is selected from the group consisting of: (a) alkyl, alkyl benzene, alkyl glyceryl ether, and olefin sulfonates wherein the alkyl group contains 8-28 carbon atoms; (b) alkyl sulfates having the formula $(ROSO_3)_nM$ where R is a substituted or unsubstituted alkyl group having 8-28 carbon atoms and M is a divalent alkaline earth metal when n is 1 and M is a sodium, potassium, ammonium or substituted ammonium when n is 2; and (c) alkyl ether sulfates having the formula "$(RO(C_2H_4O)\omega SO_3)_nM$" where R is a substituted or unsubstituted alkyl group having 8-28 carbon atoms, ω ranges from 1-30, and M is a divalent alkaline earth metal when n is 2 and M is a sodium, potassium, ammonium or substituted ammonium when n is 1. The most preferred examples of the anionic surfactants include:

(1) Alkyl benzene sulfonates in which the alkyl group contains from 9 to 15 carbon atoms, preferably 11 to 14 in a straight chain or branched chain configuration. Being more readily metabolized by micro-organisms, the straight chain configuration is preferred, with a 12 carbon alkyl being most preferred.

(2) Alkyl sulfates derived by sulfating an alcohol having 8 to 28 carbon atoms, preferably 12 to 16 carbon atoms. $(ROSO_3)_2M^1$ and $(ROSO_3)M^2$ are the formulas for the alkyl sulfates, where R is the $C_8$-22 alkyl group, $M^1$ is a divalent alkaline earth metal ($Mg^{+}$+ and $Ca^{+}$+), and $M^2$ is $Na^{+}$, $K^{+}$, or $NH_4^{+}$ or substituted ammonium (triethanol ammonium, diethanol ammonium, ethanol ammonium, etc.).

(3) Alkyl sulfonates having 8 to 28 carbon atoms, preferably 12 to 16 carbon atoms in the alkyl moiety.

(4) Olefin sulfonates having 8 to 28 carbon atoms, preferably 12 to 16 carbon atoms.

(5) Alkyl ether sulfates derived from ethoxylating an alcohol having 8 to 28 carbon atoms, preferably 12 to 16 carbon atoms with 1 to 30, preferably 1 to 12 moles of ethylene oxide and then sulfating. The resultant structure is not stable enough to be of a life suitable for commercial use unless it is immediatly reacted with base to form an alkaline earth metal, ammonium, or substituted ammonium salt. The alkyl ether sulfates useful to this invention have the formulas: $[RO(C_2H_4O)\omega SO_3]_2M$ and $[RO(C_2H_4O)\omega SO_3]M^1$

where R is the $C_8$-28 alkyl group, ω is 1 to 30, M is a divalent alkaline earth metal ($Mg^{+}$ + and $Ca^{+}$ +), and $M^1$ is $Na^{+}$, $K^{+}$ or $NH_4^{+}$ or substituted ammonium.

(6) Alkyl glyceryl ether sulfonates having 8 to 28 carbon atoms, preferably 12 to 16 carbon atoms in the alkyl moiety; and

(7) Mixtures of (1)-(6) can provide enhanced results.

(2) and/or (5) are preferred for use as the anionic surfactant.

The above-described anionic surfactants are commercially available in both the acid and neutralized forms. Those available as acids can be converted to the desired salt by direct neutralization with the appropriate base. Those available in a neutralized form can be used to develop a desired alkaline earth metal salt by ion exchange; especially useful for this purpose are the ammonium salts of the anionic surfactants. Magnesium hydroxide is the most preferable ion source for the exchange.

The amphoteric surfactants utilized preferably have an alkyl moiety of 8-28 carbon atoms, a positively charged amino group, and a negatively charged carboxylic acid group. Suitable amphoteric compounds have the following formula: ##STR1## wherein $R_1$-4 are selected from the group consisting of substituted and unsubstituted alkyl constituents, substituted and unsubstituted cycloalyl constituents, substituted and unsubstituted aryl constituents, and ethoxylated hydroxy groups containing 1-10 ethylene oxide units, and may be the same or different. The amphoteric compounds preferably comprise 0.5%-15% of the composition and, most preferably 1-10% by weight of the composition. Particularly preferred amphoteric surfactants would be acylamidoalkylbetaines having the following formula: ##STR2## wherein R is a substituted or unsubstituted alkyl or alkylaryl group having 6-28 carbon atoms, and most preferably 9-12 carbon atoms, $R^1$ is a hydrogen or substituted or unsubstituted alkyl group having 1-6 carbon atoms, and most preferably 1-3 carbon atoms, $R^2$ is a substituted or unsubstituted alkylene group having 1-10 carbon atoms, and most preferably 2-6 carbon atoms, $R^3$ is a substituted or unsubstituted alkyl group containing 1-6 carbon atoms (preferably 1 carbon atom) or an ethoxylated hydroxy group containing 1-10 ethylene oxide units, wherein the ethoxylated hydroxy group has the formula: HC--$(OC_2H_5)_1$-10

and where $R^4$ is a substituted or unsubstituted alkylene group containing 1-6 carbon atoms (preferably 1 carbon atom). Particularly suitable betaines include: coconutacylamidopropyl dimethylbetaine; $C_{12}$-14 acylamidopropylbetaine; "$C_8$ acylamidohexyldiethylbetaine". Preferred betaines are the $C_{10}$-18 acylamidopropyl (or ethyl) dimethyl (or diethyl) betaines. Most prefered is dodecylamidopropyldimethylbetaine.

An alkaline earth metal salt or acid can be added to the fire fighting and cooling composition to control viscosity or pH. They also may be sources for ionic exchange. The salts and acids useful in this invention include magnesium chloride, magnesium sulfate, magnesium citrate, calcium chloride, sodium chloride, sodium sulfate, sodium citrate, citric acids, and mixtures thereof. The salts or acids would be most useful at concentrations from about 0.01% to about 5% by weight.

The fire fighting and cooling composition herein described is to be mixed with water through standard fire fighting equipment and applied to hydrocarbon or polar solvent fires at a concentration of 0.01% to 12% by volume (e.g., 0.01-12% fire fighting and cooling composition and the remainder water); preferably 0.1% to 6% by volume. Lower volatile liquid hydrocarbons will only require application from the low end of the concentration range while higher volatile liquid hydrocarbons and polar solvents will require application from the high end of the concentration range (e.g., diesel fuel 0.2% by volume application; high octane unleaded gasoline 3% by volume application). A fire fighting and cooling composition having the following formula is most preferred:

(a) from about 2% to about 6% of a water soluble amine oxide having one alkyl group of from 8 to about 16 carbon atoms and 2 alkyl groups from 1 to about 3 carbon atoms;

(b) from 10% to about 30% magnesium alkyl sulfate having from about 12 to 16 carbon atoms in the alkyl group;

(c) from 0% to 30% of magnesium alkyl ether sulfate obtained from an alcohol having from about 12 to about 16 carbon atoms, ethoxylated with from about 1 to about 12 mole of ethylene oxide;

(d) from 0% to about 35% of ammonium, mono, di, or triethanolammonium alkyl ether sulfate obtained from an alcohol having from about 12 to about 16 carbon atoms, ethoxylated with from 1 to about 12 moles of ethylene oxide;

(e) from 0.01% to about 8% of a $C_{12}$-14 acylamidopropyldimethylbetaine;

(f) from 0% to about 5% magnesium chloride, magnesium sulfate, magnesium citrate, calcium chloride, sodium chloride, sodium sulfate, sodium citrate, or citric acid or mixtures thereof; and

(g) the balance consists of water or water/$C_1$-$C_5$ alkanol (preferably isopropanol) mixtures.

EXAMPLES

The following fire fighting and cooling compositions are formulated on a weight percent basis.

| A | B | C | D | E | F |
|---|---|---|---|---|---|

Sodium dodecylbenzene sulfonate
34 -- -- -- -- --
Magnesium dodecylbenzene sulfonate
-- 34 -- -- -- --
Sodium lauryl sulfate
-- -- 34 -- -- --
Magnesium lauryl sulfate
-- -- -- 10 -- --
Ammonium lauryl ether sulfate
-- -- -- 24 20 34
Magnesium lauryl ether sulfate
-- -- -- -- 14 --
Dimethyldodecylamine oxide
3 3 3 3 3 3
$C_{12}$-14 acylamidopropyldimethyl-
4 4 4 4 4 4
betaine
citric acid -- -- -- 2 3 2
NaCl -- -- -- 2 2 2
water 59 59 59 52 51 52
Isopropanol -- -- -- 3 3 3

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Formulations were evaluated by comparing their extinguishment and sealing characteristics when applied at 3% in water, through a pressurized water fire extinguisher, to a 1.6 $m^2$ pan containing about 2 to 3 L JP-4 aviation turbine fuel. JP-4 was chosen as it has a low flash point, volatile hydrocarbon content similar to gasoline, and an aromatic hydrocarbon content, of benzene and benzene analogs, of from about 23% to 27%. Volume of fluid applied was constant for each test. Formulas A, B, and C showed acceptable knockdown and extinguishment of the test fire. The foam blankets of A, B, and C were thin and would not inhibit rekindle of the test fire. Formulas D, E, and F showed superior knockdown and extinguishment, and also provided a thick foam blanket that inhibits rekindle. Formula F was tested at a large fire training facility. 200 liters of methanol were placed in a 24 $m^2$ pan after 1.5 min preburn the fire was extinguished in 55 sec., using 2 nozzles flowing 308 l/min each. The foam blanket successfully inhibited rekindle (application of a torch to the surface) with a 0.93% concentration of the F formula; similar application of a 0.67% concentration on 400 liters methanol produced good extinguishment but rekindle was not inhibited. This was a test to determine the low end of the concentration range for application to polar solvent fires, methanol in particular. At the same facility, a test was completed to simulate a vertical gasoline storage tank afire at the top. After a substantial preburn the F formula extinguished the fire in 53 sec. at a concentration of 0.28%. The standard product used to combat this fire, containing fluorocarbon surfactants, required 1 min. 35 sec at a concentration of 3%.

While the above-discussion focusses on the unique ability of the composition to put out a hydrocarbon or solvent fire, it should be understood that the composition also has cooling properties and can also be used as a retardant/protectant. The foam composition is formulated

such that large quantities of water are able to adhere to the surface of three dimensional objects such as houses, buildings, ships, airplanes, trees, etc. This is because the composition allows for the creation of a stable foam that includes large quantities of water. Hence, cooling can be achieved quickly by spraying the foam on a heated object (e.g., coal, metal, etc.), and the composition can be used in protectant/retardant applications by spraying the foam on the object to be protected.

While the invention has been described in terms of its preferred embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.