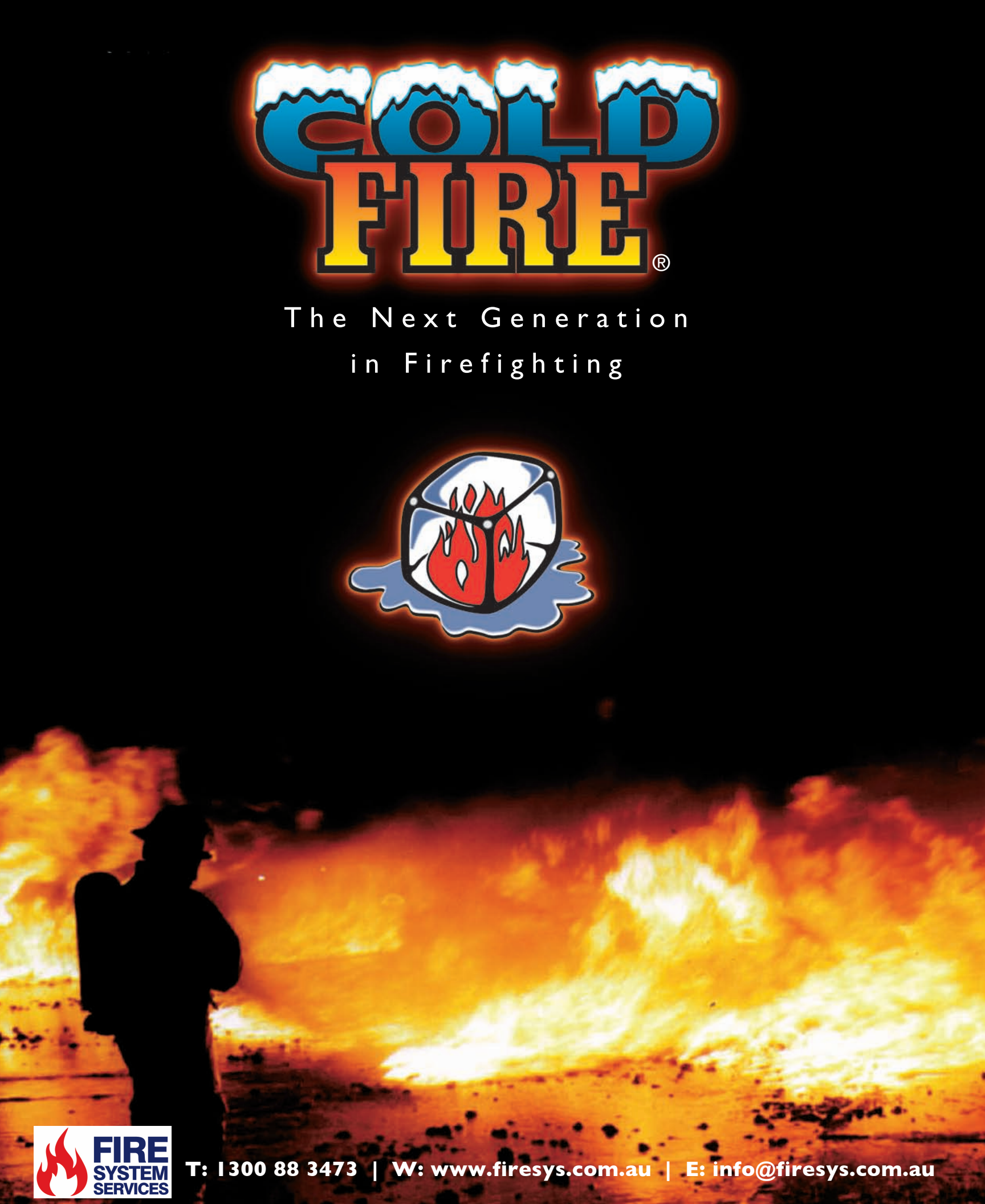
COLD FIRE®

The Next Generation
in Firefighting



FIRE SYSTEM SERVICES

T: 1300 88 3473 | W: www.firesys.com.au | E: info@firesys.com.au

COLD FIRE

COLD FIRE® *is* an environmentally friendly fire extinguishing agent, leading the way in fire fighting technology and revolutionizing the way fire fighters combat fires. **COLD FIRE®** gets *its* name from *its* extraordinary ability to remove extreme heat from any object in which *it* comes in contact. **COLD FIRE®** works to remove heat and the hydrocarbon fuel source from the fire triangle. The suppressants in **COLD FIRE®** use water as a catalyst to remove the heat as well as encapsulate and breakdown the hydrocarbons in the fuel source to extinguish the fire more rapidly.

FIREFREEZE WORLDWIDE, INC., manufacturer of **COLD FIRE®**, developed **COLD FIRE@** based on the need to supply the fire fighting industry with a efficient and effective fire fighting agent that not only extinguishes fire quickly, but does so without harming the environment, fire fighters, and fire victims. **COLD FIRE®** was developed with enhanced safety and future generations in mind.

"Cold Fire® will allow fire fighters to do their job more quickly and safely, saving more lives, property, and the environment for generations to come."

Juergen Giessler,
Inventor of Cold Fire®
and President of
FireFreeze Worldwide, Inc.

WHY USE COLD FIRE@?

- UL Classified Wetting Agent for Class A and B fires.
- EPA-SNAP [Significantly New Alternative Policy Program) Listed.
- Considered an acceptable substitute to toxic foams and Halon.
- Non Toxic
- Non Corrosive-product can be dumped directly into booster tank. No need to flush out lines.
- Biodegradable
- Unique Thermal Insulation Capability. Helps to minimize heat exhaustion.
- Extinguishes on Contact
- Prevents reignition when properly applied
- Encapsulates and breaks down hydrocarbons; thereby reducing hydrocarbon smoke and increasing visibility..
- Enhances the penetration capability of water, extinguishing the fire faster, using less water, thereby reducing water damage and water supply needs.
- No Messy Clean up *is* Required.
- COLD FIRE® is non-slip.
- Indefinite Shelf Life when stored in closed containers-store in your booster tank, water pressurized units or closed loop systems for use anytime.
- Extinguishes Class D fires.

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BULi< APPLICATIONS:

COLD FIRE® is added to pumper apparatus, *reseNoirs* or inducted into fire hose lines in order to attack larger fires. No special equipment is required. **COLD FIRE®** is added at given percentages depending on the nature of the combustible materials *involved.*

PERCENTAGES:

CLASS A: 0.15%-1%
(Use 0.5%-1% for Brush Fires)
CLASS B: I .5%-3%
CLASS D: 6%-10%

APPLICATION PRESSURE:

NOZZLE: Use I 00-1 IOpsi.
PUMP: Use 150-175 psi.

AVAILABILITY:

5 and 55 gals.

PORTABLE EXTINGUISHERS:

COLD FIRE® can also be used in various sized portable extinguishers. Sizes range from I - 4 liter units, as well as 1.5 and 2.5 gallon units. A I 0% solution ratio is recommended. Firefreeze offers 32oz bottles of **COLD FIRE®** to simplify the refilling of these units.

CLOSED LOOP SYSTEMS:

COLD FIRE® can also be used in closed loop systems, sprinkler systems, and on-board extinguishing systems. These systems range in *size* from 5 pound racing systems to 2.5 gallon systems, which can be used in heavy equipment, such as logging skidders. The **COLD FIRE®** systems are available with manual or automatic heads. Other areas of use for these systems include: street rods, kit cars, motor homes, work shops, heavy equipment, aviation, rail and marine industries. These units are re-fillable and rechargeable by the user. Firefreeze offers pre-mixed bottles of **COLD FIRE®** to simplify the refilling of these units.

WINTERIZED COLD FIRE®

COLD FIRE® can now be winterized to -50° below zero in a pre-mixed solution for use in filling your 1.5 and 2.5 water extinguishers and fire suppression systems. This unique mixture allows **COLD FIRE®** to be used in extreme cold weather conditions. The winterized **COLD FIRE®** will be manufactured upon request.

COLD FIRE® 12 OZ. AND 32 OZ. BOTTLE

COLD FIRE® Rapid Surface Cool Down & Heat Barrier Spray was designed as a safety tool for personal safety and trade applications. The product *is* available in three convenient easy to use applications, a *12* oz. high air powered aerosol can (red nozzle), a 12 oz. fine mist air powered aerosol can, (white nozzle), and a 32 oz. pump bottle, depending on your specific application needs.

USAGE:

The product can be used:

- To cool down hot surfaces rapidly for added safety and increased productivity
- *As* a heat barrier spray to help prevent heat damage and the possibility of hidden fires
- To extinguish small start up spot fires

These unique capabilities make **COLD FIRE®** an excellent safety product for plumbers, welders, roofers, and mechanics, all who work with hot surfaces and open flame. For personal safety at home and on the job, keep a can or bottle in your car, boat, workshop, kitchen and garage. These units are light in weight and easy to handle. The aerosol cans spray in any direction, even upside down for use in hard to reach places. The units can easily be carried in tool box or you can attach our convenient ready to use holster to your tool or radio belt for immediate accessibility.

WELDING

Use to cool down hot parts after welding or heating. Use for added protection in paint and body work applications

PLUMBING/HVACR

Use as a heat barrier when soldering to protect valuable parts as well as to prevent hidden fires

MOTORSPORTS

Instantly cools down hot brakes, rear ends and other auto parts

AUTOMOTIVE

Cools down hot engine parts

SPOT FIRES

Extinguishes small spot fires

HOUSEHOLD

Use to cool down lawn and other hot equipment for added safety

TECHNICAL DATA:

Underwriters Laboratories Listing:

@ UL Classified for Class A & B Fires.
UL Classified #: 2N75

Tested in accordance with NFPA 18, Standard for Wetting Agents; UL 162, Applicable portions of the Standard for Foam Equipment and Liquid Concentrate; and UL 71 I for Class B fires.

Underwriters Laboratories of Canada Listing:

c@ ULC Classified under file#: Cex 1225.
ULC Subj. Cl 75.

EPA SNAP (Significantly New Alternative Policy) Program Listing

COLD FIRE® has been listed by the United States Environmental Protection Program on their SNAP Program Vendor List. This list contains products that are considered acceptable alternatives to toxic products on the market today.

COLD FIRE® has been classified by the US EPA under "Surfactant Blend A".

COLD FIRE® is listed by the US EPA under this program as a substitute for Halon I 2I I.

Hazardous Materials Identification System (HMISJ

Health Hazard:	0
Reactivity:	0
Flammability:	0

MSDS & TOXICITY TEST INFORMATION AVAILABLE UPON REQUEST FROM FIREFREEZE WORLDWIDE, INC.

COLD FIRE®'S COOLING EFFECT

COLD FIRE®s cooling effect makes it an advantageous fire fighting product. Not only does this unique characteristic assist in extinguishing the fire faster; but it works to enhance safety and safeguard the lives of fire fighters and victims. When **COLD FIRE®** is applied to a fire, it quickly penetrates the hot surface and extracts the heat from a fire without steam conversion. (Water and foam do not have the same penetration capability of Cold Fire).

COOLING TEST DATA CONDUCTED BY INTERTEK TESTING SERVICES:

Procedure: Materials were heated to 500°F using a hand torch. Using a thermal couple, the surface temperature of each of the following "Hot" materials was recorded as well as how quickly Cold Fire cooled down these surfaces when applied in comparison to water and ambient air.

Copper: Copper was heated and sprayed for 29.89 seconds. It took 27 seconds for the Copper to reach 87.3°F when using Cold Fire. It took 4 min. 30 sec. for the Copper to reach 84.6°F using water: It took 1 I min. 6 sec. for the Copper to reach 95.9°F using ambient air.

Sheet Metal: Sheet Metal was heated and sprayed for 15.69 seconds. It took 14 seconds for the Sheet Metal to reach 84.5°F when using Cold Fire. It took 4 min. 50 sec. for the Sheet Metal to reach 84.5°F using water. It took 9 min. 11 sec. for the Sheet Metal to reach 91°F using ambient air.

Glass: Glass was heated and sprayed for 23.47 seconds. It took 31 seconds for the Glass to reach 84.0°F when using Cold Fire. It took 2 min. 26 sec. for the Glass to reach 85.8°F using water. It took 8 min. 23 sec. for the Glass to reach 85.2°F using ambient air.

Steel: Steel was heated and sprayed for 48.23 seconds. It took 46 seconds for the Steel to reach 88.9°F when using Cold Fire. It took 9 min. 17 sec. for the Steel to reach 89.2°F using water. It took 8 min. 24 sec. for the Steel to reach 91°F using ambient air.

COLD FIRE

TOPIC **SECTION**

Cold Fire® is a new environmentally friendly, fire suppressing agent, leading the way in fire suppressing technology and revolutionizing the way firefighters combat fires.

Cold Fire® gets its name from its extraordinary ability to remove extreme heat from any object (metal, wood, rubber, etc.) with which it comes in contact. The suppressants in **Cold Fire**® are encapsulators that use water as a catalyst to remove heat and fuel from a fire more rapidly. **Cold Fire**® extinguishes on contact, prevents re-ignition when properly applied, and absorbs hydrocarbon smoke. The unique encapsulation characteristic also helps to minimize possible ignition of flammable liquids.

Cold Fire's unique plant based formulation is considered to be 10 times more penetrable than water alone. This extraordinary characteristic enables **Cold Fire**® to penetrate a heated surface and/or fuel source 10 times faster than water. Once the product has penetrated the surface, **Cold Fire**® works to encapsulate the heat and fuel source. By encapsulating the fuel source, **Cold Fire**® simultaneously encapsulates the fuels vapors preventing reignition. As **Cold Fire**® penetrates the surface it safely cools the area under its flashpoint without steam conversion.

Cold Fire® is most commonly used in bulk applications, however, **Cold Fire**® can also be used in its aerosol or pump spray application to pre-spray an area or surface prior to using a torch to help prevent the possibility of a hidden fire. When Cold Fire is sprayed onto a surface, it deeply penetrates and safeguards that surface from fire. When heat is applied, the product works to encapsulate the heat source, thereby helping to prevent heat damage and possible fire.

Cold Fire® FEATURES

- Offers extraordinary firefighting and life-saving capabilities.
- UL listed Wetting Agent for Class A and B fires. UL-2N75 Listing #.
- EPA-SNAP (Significantly New Alternative Policy) Program listed.
- Biodegradable.
- Non-Toxic.
- Non-Corrosive. Can be dumped into a booster tank without threat of corrosion. You do not need to flush out your lines after using **Cold Fire®** as you do with most foams.
- 100% soluble in water. It will not separate in a booster tank. Shelf life is indefinite as long as it is stored in a closed container.
- Reduces the density of hydrocarbon smoke, increasing visibility and enabling easier breathing.
- Rapid Cooling Effect, preventing re-ignition when property applied.
- Unique thermal insulation quality helps protect fire fighters and helps prevent again heat exhaustion. Keeps you cooler!
- Considered an acceptable substitute for toxic foams and halon.
- Will extinguish Class A, B and/or D fires.
- Enhances the penetration capability of water, extinguishing the fire faster using less water, and thereby reducing water damage.
- Possesses cleaning properties; thereby reducing the amount of damage caused by hydrocarbon smoke.
- Non-slip.

When Every Second Counts, Count on Cold Fire®
Your First Line of Defense in Case of a Fire.
Cold Fire has been tested and is used by professional firefighters.

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Cooling Effectiveness of COLD FIRE®
How Does it Work?

Cold Fire® is mixed with water to fight fires. Mixed at given percentages depending on the type of combustibles involved, **Cold Fire**® becomes 6 times thinner than water (see official UL testing results). This unique characteristic enables **Cold Fire**® to fully penetrate the fuel source and attack the heat on contact, cooling down the surface almost immediately. **Cold Fire**® also acts like a magnet to pull the heat out from the fuel source. Water alone cannot penetrate the fuel source as effectively, so as a result when water hits the fuel source it actually bounces back and turns to steam.

Similarly, **Cold Fire**® also acts like a magnet when it comes to reducing hydrocarbons in the smoke. **Cold Fire**® actually attracts and draws in the smoke; thereby encapsulating it and breaking down the hydrocarbon molecules, resulting in better visibility.

COLD FIRE® BULK APPLICATIONS

In professional applications, **Cold Fire®** is added to pumper apparatus, reservoirs or inducted into fire hose lines in order to attack larger conflagrations. **Cold Fire®** is added at given percentages depending on the nature of the combustible materials involved.

Percentages

Class A:	1% to 3%
Class B:	3% to 6%
Class D:	6% to 10%

Cold Fire® is extremely effective on gasoline fires and vehicle fires. When extinguishing a car fire, for example, the vehicle turns cool to the touch moments after it is extinguished. Use **Cold Fire®** to extinguish Class A fires of all types, including brush and grass fires.

Cold Fire® can be used in 2 ½ gallon water extinguishing units for first response, in which you add 1 quart of **Cold Fire®** to 9 quarts water to equal a 10% solution. **Cold Fire®** is added last to the mixture. Pressurize the unit to 100 - 125 pounds of pressure.

Cold Fire® can also be used in enclosed loop systems, sprinkler systems, and on-board systems for aviation, rail, boating and automobile industries.

Cold Fire® concentrate is sold in 5 and 55 gallon drums.

Faster Knock Down, Reduces Heat, Prevents Re-ignition, Reduces the Density of Hydrocarbon Smoke, Use Less Water, Non-Toxic, Non-Corrosive and Environmentally Safe.

All of These Advantages Make Fire Situations Safer for Firefighters and Fire Victims.

On the Job, There is no Time for Questions – Only Answers. When seconds count, make sure you're equipped with the best fire extinguishing agent available, Cold Fire®.

COLD FIRE® AEROSOL SPRAY CAN

Cold Fire® Aerosol Spray is a Safety Tool especially designed to extinguish flames and cool down hot surfaces rapidly. It is an excellent tool for all trade applications, which use open flame (plumbers, welders, roofers, etc.)

The **Cold Fire**® Aerosol Spray is a unique spray can that is solely powered by air and sprays in any direction, even upside down! It is lightweight and easy to handle.

Applications

- Rapidly Cools Down Any Hot Surface in Seconds!
- Extinguishes Flames
- Pre-Spray Areas to Help Prevent the Possibility of Hidden Fires.
- Machine and Mechanic Shops – Cools Down Metals.
- Pre-Spray Sheet Metal Before Brazing – Helps Prevent Distortion.
- Cool Down Hot Cooking Surfaces.
- Keep Handy in Your Car, Workshop, Kitchen and Garage.
- Can Easily Be Carried on a Tool Belt or in a Tool Box.

Easy To Use

- Conveniently Sized Spray Can.
- Easy to Store.
- Quick and Easy to Use.
- Leaves No Messy Residue.
- Perfect for Use in Hard-to Reach Places
- Sprays Upside Down!

Environmentally Safe

- No Fumes or Noxious Odors!
- Safe, Non-Toxic, Non-Corrosive and Biodegradable.
- Non-Flammable.
- Powered by Ordinary Air!
- Harmless to Children and Pets!

Cold Fire® for Safety at Home and on the Job!

THE COLD FIRE® STORY

By

Dr. Addison Bain, Ph.D.

Cold Fire®

A highly effective, environmentally friendly, 21st Century technologically advanced firefighting agent; THE ALTERNATIVE to gels, foams and retardants.

PURPOSE

The purpose of this article is to provide interested parties pertinent information about the product called **Cold Fire®**. The primary focus includes those entities responsible in the management of wildland fires.

BACKGROUND

Cold Fire® (CF) is one of the products produced by FireFreeze Worldwide, Inc. in Rockaway, New Jersey. The author, a former Forest Service employee and 30-year veteran with NASA, was introduced to the product in the fall of 2000. Up to that time **Cold Fire®** had been used as a firefighting agent for local fire departments, the race car industry, as a cool-down agent for plumbers/welders and for wildland firefighting interests in other countries. Seeing **Cold Fire®** as a valuable tool for use in wildland firefighting the challenge was undertaken to work with the US Forestry Service (FS) to obtain their approval, with the objective of getting **Cold Fire®** on the FS Qualified Product List (QPL). The policy of federal agencies is to use only qualified products (NFES 2724 chapter 12). Although a significant amount of testing of **Cold Fire®** had been performed by a number of US and Canadian laboratories, this was not an acceptable substitute by the FS who use a specific test protocol.

Cold Fire® is a very unique product, derivative of German origin, constituting a well-formulated mix of several plant species. Aside from the plant extracts are the mineral and salt makeup naturally absorbed from the respective unique soils. No chemicals are added. The product does not contain any phosphate or bromine derivatives, or polymers common to many retardant and extinguishing agents. It is the discovery that the final product mix when blended with water takes on special characteristics to enhance the overall efficiency of controlling Class A, Class B and Class D fires that make **Cold Fire®** an effective, safe and environmentally friendly agent.

TEST PROGRAM PRIOR TO THE QPL

The following outlines the timing, sources and type of testing done in accordance with regulatory specifications and requirements.

Cold Fire® successfully passed the performance criteria in all cases.

- 1993, USTC/Biological Services, eye and dermal irritation, acute oral toxicity, aquatic toxic on rainbow trout, water flea and alga. Per EPA Health Effects Test Guidelines.
- 1994, UL Inc., Certificate granted 10/1996. Class A & B per NFPA 18, Standard for wetting agents.
- 1995, UL of Canada. Class A & B certifications.
- 1996, SGS US Testing Co. Inc., Aluminum and carbon steel corrosion rate evaluation per 49 CFR 173.120.
- 1996, USGS, acute dermal toxicity study on rabbits, skin sensitization study on Guinea pigs.
- 1997, SGS, acute inhalation toxicity on test animals (rats).
- 1998, EPA Significant New Alternative Policy (SNAP program acceptable substitute for the Halons.)
- 1998, Intertek Testing Service, thermal surface cool down comparisons for metals and glass.
- 1999, UL of Canada, CF testing for Class D performance.

TESTING PROGRAM IN SUPPOR TOF THE QPL

The Forest Service classifies the Fire Chemicals as:

- Long-Term Retardant
- Fire Suppressant Foam
- Water Enhancers

Cold Fire® was evaluated as a water enhancer to FS specification 5100-306a (12/02), the best "fit" at the time.

The evaluation program was initiated in May 2003.

Cold Fire® was approved and initially added to the QPL on April 5, 2005.

It is noted: **Cold Fire®** is not a gel as are the other water enhancers listed.

The following outlines the FS test protocol. Performance requirements and certain parameters had to be met in order to be placed on the QPL.

1. Health and Safety
    a. Mammalian Toxicity and Irritation Tests
    b. Open Cup Flash and Fire Point
2. Environmental Effects
    a. Biodegradability
    b. Fish Toxicity
3. Physical Properties
    a. Density
    b. pH
    c. Viscosity
    d. Pour Point
    e. Miscibility
    f. Marsh Funnel Flow-Through Time
4. Fire Effectiveness
    a. Lateral Ignition and Flame Speed
5. Product Stability
    a. Outdoor Storage Test
    b. Effect of Temperature on Viscosity
    c. Effect of Temperature on Marsh Funnel Flow Through
6. Corrosion Testing
    a. Metals – Uniform Corrosion
    b. Metals – Intergranular Corrosion
    c. Non Metals

Testing was done at the Missoula Technology Development Center (MTDC) in Missoula, Montana as well as back-up testing for correlation at the San Dimas facility in California.

The **Cold Fire®** concentrate, as well as the recommended field mixture, was evaluated. The outdoor storage consisted of one year subject to a freeze–thaw environment. Many of the test parameters were repeated in order to demonstrate no detrimental effect after long-term storage. Special testing was done by outside

labs at Pacific Metallurgical Company, Stillmeadow Inc., U.S. Geological Survey and Underwriters Laboratory, Inc.

CREATION OF COLD FIRE FORESTRY DIVISION (CFD)

In anticipation of the successful program with the FS the corporation of the **Cold Fire Forestry Division, Inc.** (CFD) was formed. In view of the expense and time consuming process of achieving QPL status, on behalf of CFD, an exclusive agreement with FireFreeze was entered into. CFD provides the coordination and consulting effort for **Cold Fire®** applications on federal and state lands in the U.S.

FS TESTING POST INITIAL QPL STATUS

- The QPL listing of 4/5/05 approves **Cold Fire®** for helicopter bucket and ground engine applications. Since then specialized tests of **Cold Fire®** with aluminum coupons has proven successful. Therefore the QPL was updated 2/6/06 to reflect conditional approval for fixed-wing air tanker and single engine air tanker (SEAT) applications. The remaining tests involved the evaluation of **Cold Fire®** for magnesium corrosion (uniform and inter-granular), a requirement for the fixed-tank helicopter application. **Cold Fire®** is the only water enhancer approved for this application. (Documented 08/05/07). **This concluded the 50 month-long test program.*

The Bureau of Land Management sponsors field operational evaluations for QPL listed water enhancers. The evaluations are on-going during the fire seasons. The principal goal is to evaluate, and compare, the effectiveness of water enhancers, using aerial applications (SEAT) to support suppression tactics in grass, brush and timber fuel types.

Some state agencies such as the California Division of Forestry (CalFire) support the field evaluation of products for the helicopter bucket and ground engine applications during respective fire seasons.

The author suggests there are really two aspects of a field evaluation.

a) Experimental, as measured against preconceived *and desired* parameters,
b) Direct visual experience (subjective) to observe and document observations; identifying special attributes, handling characteristics, field set up restrict-

ions, adaptability to the various applications, operational and logistical considerations and lastly a valid *overall comparative economical analysis*.

OTHER RELATED TESTING PROGRAMS

The research laboratory of FM Global, one of the world's largest property insurance and risk management organizations, has evaluated **Cold Fire**®. They have found **Cold Fire**® acts as a surfactant encouraging the formation of fine droplets when sprayed on a fire providing better cooling, good penetration and more rapid extinguishment. A special formulation is affective as an additive for antifreeze fire suppression applications. FM Global found **Cold Fire**® *"has a remarkably high specific heat at temperatures between 32 and 68 degrees F explaining its good cooling properties."* The **Cold Fire**® enhances the water viscosity to a certain degree. Viscosity is significant for aircraft water drops to help hold a tight pattern for the water mix. FM Global also found that **Cold Fire**® spreads very rapidly over surfaces of mineral oil and other liquid fuels. Thus they would anticipate that it would be a very effective extinguishing agent for Class B fires. These types of evaluations continue to enhance the understanding of the properties of **Cold Fire**®, in this case by a renowned certification organization (formally Factory Mutual.)

Rubber tire fires have been notoriously difficult to extinguish. In 2003 under the auspices of Underwriters Laboratory the Michelin Tire Company conducted tests to develop data relative to the fire protection of rubber tires stored on pallets in a warehouse. A typical warehouse overhead sprinkler system was used. Ceiling height was 30 feet. A test with water only was done to establish a reference point. A one-minute average air temperature of 1,600 deg. F and a 1,000 deg. F for overhead steel structural components was the test criteria. With water only, the steel beam temperature above ignition exceeded 1,000 deg. F. Using an aqueous solution consisting of 3% **Cold Fire**® the maximum temperature was 379 deg. F for the one-minute test. Interesting to note that the water-only test had to be put out using a fire hose supplied with a **Cold Fire**® mix to prevent destruction of the test facility.

FireFreeze, the manufacturer of **Cold Fire**®, sponsored the UL testing in 2007 for extinguisher and sprinkler applications. This test program was a result of the updated requirements imposed by the NFPA.

A LITTLE FIRE SCIENCE

Water is the most effective fire-suppressing agent known to man. When water is exposed to the flame combustion temperature it vaporizes. The change in phase

from a liquid to a vapour under goes a “heat of vaporization” process in which the transition requires the absorption of heat. For a gallon of water to vaporize it must “suck-up” over two million calories of heat, thus the cooling process. Applied properly, one volume of water will cool 300 volumes of burning fuel. The trick is to do this effectively and not “waste” a lot of water. One is the firefighter technique; his ability to manipulate the hose nozzle to provide a straight-stream, spray or fog as the situation may dictate is essential. Then comes the science.

For years it has been the challenge of the scientific community to come up with strategies to enhance the capability of water. The use of additives (agents) to reduce surface tension, increase the surface area and regulate droplet size have been investigated. The problem is to have a final product that is not overly toxic or harmful to the environment, easy to use in the field and not cost prohibitive. As such, some products have proven to be satisfactory while others had to be taken off the market.

Water has a surface tension of 73 dynes/cm. **Cold Fire**®, like some foams, can drop that by several factors. This allows the water molecules to penetrate the fuel more effectively and spread the coverage. There is what is known as fuel limited fires. Examples are a burning pile of rubble or a burning pile of tires. Tests by the Michelin Tire Company show that **Cold Fire**® has the deep-seated fire cooling capability needed for fuel-limited situations. Large piles of rubble as a result of post Katrina clean-up operations have also proven **Cold Fire**® unique. The piles caused spontaneous combustion. Water alone was not efficient in putting out the resulting fires. Also very important is its ability to prevent re-ignition of hot spots. The surfactant ingredients in **Cold Fire**® go beyond the surface tension reduction by having a high affinity for carbon, as demonstrated by the Michelin testing, where tires have a high fraction of carbon. Ingredients in **Cold Fire**® provide condensation nuclei to promote droplet formation of the water and increase effect-iveness. It is noted the breakup of the water droplets to a finer configuration exposes more surface area.

Controlled cooling testing, by Intertek, showed timeline factors of CF versus water in surface/mass cooling comparisons ranging from 5:1 for glass up to 21:1 for metals. Thus the cooling aspect is significant (enhanced by the wetting effect).

During the burning process a chemical chain reaction takes place in which new products form, the key to the reaction that produces fire, an important aspect of the fire tetrahedron (fuel, heat and oxygen are the other aspects). The traditional role for the use of water/agents is to interrupt one or more of these aspects to put out or control the fire. **Cold Fire**® goes beyond this relationship as will be discussed.

THE SCIENCE BEHIND COLD FIRE®

The influence of **Cold Fire**® has been explained up to now in the sense of the resulting physical appearance of its effect in certain applications. However, the story goes deeper when we visit what is happening on a chemical/biological basis. The following itemizes these characteristics based on laboratory experimentation.

- In Mother Nature certain plant life has the ability to withstand significantly high degrees of temperature. It has been found that it is the saps in those plants that have the ability to reduce the intensity of the heat and protect the cellulose structure. **Cold Fire**® is made up of a number of selected plant extracts (saps) in a special formulation developed over years of experimentation.

- The organic plant-sap source also endows **Cold Fire**® with additional characteristics associated with the maximization and maintenance of stabilized enzymatic levels and activities. As documented in the published U.S. Army's research in chemical and biological warfare decontamination [dual-use enzyme-based decontaminant (Advanced Catalytic Enzyme System – ACES)], **Cold Fire**® enhanced the enzymatic decontamination by up to 95%. This surfactant/enzyme-enhanced action helps breakup the water tension and increases osmotic open-grain penetration.

- To test the rate (amount) of penetration, a visual experiment was conducted using organic food dyes. Two pieces of wood are used from the same stock. One was placed in a container with colored **Cold Fire**® mix and the other in a container of colored water. The dye penetrated the cellulose structure differently. The piece of wood placed in the container with colored **Cold Fire**® showed a dramatic difference in the level of penetration compared to the colored water. The **Cold Fire**® penetration was up to six times that of the water test coupon.

- It is important to note that in the process of testing the penetration level another characteristic of **Cold Fire**® was confirmed, namely, breaking of molecular bonding of hydrocarbons. It was noted that all oil-based and synthetic colors and dyes were decomposed once they came in contact with **Cold Fire**®. Although in some cases that was instant, in others it took between 24 to 72 hours for the colors to disappear.

- The fore-mentioned characteristic was noted in the effect of **Cold Fire**® on hydrocarbon mass. **Cold Fire**® as a surfactant emulsifies oil-based materials and fuel source and breaks down the molecular bonding, followed by a

leaching process. An experiment to demonstrate this involves the use of used motor oil. The oil is mixed with clean sand and then mixed with the **Cold Fire**®. After applying warm/hot water to the mix, it can be observed that the oil begins to break away from the sand and moves to the surface of water and floats on the surface. After six hours almost all the oil is leached from the sand and floats on the surface. It is noticed that a milky film begins to form at the bottom of the floating oil film. After 72 hours this becomes prominent indicating that the oil is decomposing. Then the mixture is agitated and half of that mixture is poured on a sunny spot on a ground-soil and the other half is left in the container. After 28 to 36 days all the oil film in the container will decomposed into a white film on the water surface. This film will have exceptionally low or no viscosity while the one on the ground disappears in a clear process of bio-degradation.

- Through the fore-mentioned emulsification process, molecules are isolated and encapsulated. Therefore, there is no heat transfer between them. While simultaneously cooling the fuel source below the ignition point (flash-point) and preventing heat transfer between the molecules there will be no ignitable fuel vapour. This explains why there is no re-ignition after the application of **Cold Fire**®.

So, what happens when Cold Fire® is used is actually a simultaneous process involving all its chemical/physical/biological properties.

ADDRESSING QUESTIONS FROM THE FIELD AND GENERAL PUBLIC

There continues to be more interest in the environmental implications of firefighting chemicals.

Fire retardants and suppressants are used extensively for suppression and control of range and forest fires. Each year, fire control agencies utilize millions of gallons of these mixtures on a wide array of ecosystems. These chemicals are often applied in environmentally sensitive areas, which may contain endangered, threatened, or economically significant plant and animal species. The study of the potential impact of these chemicals is on-going. It is a very difficult problem in balancing the benefit of the chemical mixture to accomplish its primary mission to control a fire and to minimize the extent of the environmental impact.

Being of common plant origin, Cold Fire® will meet this challenge.

Please explain the cooling mechanism.

Cold Fire® absorbs heat, retains it, and then releases it through a diffused moisture-air release. This diffusion release is slow and takes place until the surrounding temperature is reduced below the ignition (flash) point. The tremendous thermal absorption capacity of **Cold Fire**® is best demonstrated by the following experiment:

A common white cotton hand towel placed over the experimenter's hand is sprayed with **Cold Fire**®. A handful of magnesium chips is placed on the towel. A propane cylinder soldering-torch is used to ignite the magnesium. After about one minute the magnesium has burnt and during that time reached a peak temperature of 5,600 degrees F., however, leaving the towel still intact, albeit slightly scorched.

Address the specific volume relationship of Cold Fire®/water and burning fuel volumes.

There is no single statistic to equate the volumetric mix of **Cold Fire**® due to all the variable performance parameters that have been observed in the field. The total volume and percentage of **Cold Fire**® in the water varies according to the application. Perhaps the best way to address this topic is to cite two examples:

1) In a house fire a firefighter was able to knock down the flames using a three percent solution. He explained it took only about 25 gallons of the mix, whereas he would estimate it would have normally taken about 100 gallons of plain water.

2) A brush truck was used in an attempt to put out a palmetto-based fire in Florida. The fire chief indicated that after using a "considerable" amount of water he was having no luck in keeping the fire under control as the fire kept rekindling. He mixed in a two percent solution of **Cold Fire**® and was then successful. Normally, a one-half to one percent mix is used in brush fires. Because of the high oil content of the palmetto, FireFreeze recommends a ratio of two to three percent.

There are concerns about the use of existing firefighting apparatus.

Cold Fire® is used in and with the following applications/equipment:

- It is added directly into:
    - fire truck booster tanks
    - fixed units

- CAF (compressed air foam) machines
- Injectors
- Inductors
- sprinkler systems
- automatic fire extinguishing systems
- closed loop systems
- water mist systems
- hand-held extinguishers
- dust collector systems
- forestry equipment & firefighting IFEX systems
- Bambi-bucket applications
- deluge systems

- In UL Certificate of Compliance, UL 2000 Directory for firefighting agents in accordance with NFPA 18 Standard for Wetting Agents, HYPRO and WS Darley (major equipment manufacturers) confirm that and show **Cold Fire**® to be compatable and pumpable through hoses and pumps.

- **Cold Fire**® can be used in standard firefighting equipment without fear of corrosion or clogging of lines and hoses as is very common when using foams, gels and other high viscosity agents. Before introducing **Cold Fire**® it is important to clean the equipment to eliminate residue of these products as **Cold Fire**® performance is severely compromised.

In aerial applications there is the problem of shearing of the mass that to some degree can be reduced by the addition of thickeners/gums. Please comment.

Cold Fire® breaks down water-tension and molecular bonding. Accordingly, water no longer falls as attached molecular mass; but semi-separate molecules. This means less air resistance. Field-testing is necessary to address wind drift.

Thickeners made up of polymers and/or gums could cause other problems. Super-absorbent polymers themselves ignite after a certain point. This might cause re-ignition. The issue should be studied further by subjecting these polymers to high-intensity temperatures. Similarly some gums, which are not 100% soluble in water, also ignite at certain temperatures.

There appears to be some confusion over your product as it relates to the gels.

Perhaps the best way to address this is that the original FS specification was entitled "Gels and Elastomers." The specification was later changed to "Water Enhancers." The products listed on the QPL, in general, use the term gel in their product's name thus the reader is led to assume all of the listed products are gels. **Cold Fire**®, being relatively new to the FS evaluation program, got caught up in this terminology debacle.

Tell us about the use of your product for structure protection.

Normally the process of applying **Cold Fire**® mixed with water to a structure enhances the effectiveness of the water. In theory this mixture is effective until the water has evaporated. Field experience is demonstrating that the residual left on the structure, after the evaporation period, may be extending the protective performance.

Based on field evaluations and feedback from users there is evidence that **Cold Fire**® is providing various degrees of protection depending on a number of factors such as weather and other conditions. Thus the product may provide a protective barrier from oncoming wildfires for a period of time. The longevity of course would be influenced by wind, rain and the natural biodegradability of the product.

It seems the product would be useful in other countries.

Indeed, over the years, countries such as Mexico, Australia and Saudi Arabia have used **Cold Fire**® extensively. It is interesting to note that the U.S. and Australia have a Wildland Firefighting Partnership. The arrangement allows both nations to save lives and property by using personnel and equipment from the other country, thus taking advantage of the countries' differing fire seasons.

Over a recent six month timeframe, Mexico used over 20,000 gallons of **Cold Fire**®. Their government prefers the product as it is not based on the use of chemicals. In one incident **Cold Fire**® proved to be an order of magnitude greater in performance over a commonly used foam.

Please address the apparent reluctance of some agencies to use your product.

Setting the controversy of the Gel nomenclature debacle aside there are probably a number of aspects to address. Fire departments are hesitant to alter established practices, especially during a fire crisis. Feedback from agencies indicate there is a the lack of government field evaluations of products. This is unfortunate as **Cold Fire**® users have established a significant experience base. The cost of product is a convenient excuse, naively ignoring the overall benefit. It has been said, "water is free" and another syndrome is to label **Cold Fire**® as "snake oil."

Federal policy is founded on certain guiding principles. That is, the firefighter and public safety is the first priority in every fire management activity. The fire management plans should be based on the best available science.

FAVORABLE COMMENTS FROM THE FIELD

George Faust, owner of Professional Fire and Safety, Brookhaven, MS:

"After Hurricane Katrina we were called to help extinguish a debris fire in Petal that had been burning for weeks. We could not get there for two days but once we got there, we used 30 gallons of ***Cold Fire***® *and extinguished the fire in 45 minutes."*

Jeff Guite, Success Marketing, Seattle, WA:

"The problem I have with the foams is that they have a shelf life, can congeal, takes the paint off my trucks, damages the pumps and has to be dealt with as a hazardous waste. I have used **Cold Fire**® for years and am now pleased to see it on the QPL."

Greg Smith, Fire Chief, Genola, Utah:

Greg has demonstrated **Cold Fire**® on car fires and said it cools the metal off so the fire doesn't restart. *"There's no stink afterward, usually car fires smell really bad. We use it on brush fires instead of Class A foam. Same with fuel fires. With* ***Cold Fire***®*, you just have to carry the one product. We've been really happy with it."*

John Miner, Cold Fire Distributor in Utah:

John does a demonstration in which he puts a tire in the front seat and another tire in the back seat of a junk car, sprinkles them with petrol and then lights it. After

the car is engulfed in flames, he douses the fire in short order with one or two 2 ½ gallon **Cold Fire**® extinguishers. *"It would take a 150-500 gallon fire truck to do the same thing."*

Gary Mahugh, Mahugh Fire & Safety, LLC:

This **Cold Fire**® distributor in Kalispell, Montana, has used the product for years. *"It is one of the few products suitable for batch mixing and has not caused damage to equipment as other products have done. Local residents are now coming to me to set up their own home protection capabilities."*

Alan Marble, Director of the Office of Emergency Services for Flathead County, Montana:

*"**Cold Fire**® takes no special training, can be batch mixed and no clean-up was required, just figure the percent you need, dump it in, and go."* Alan also stated they used **Cold Fire**® on wood bridges that had creosol ties and did not lose a bridge. One of the fire crew had sprayed a cabin, being used as a camp, and surrounding area with **Cold Fire**®. As a fire approached they decided the safest place was the cabin. The fire simply burnt around them.

COMPARISON DISCUSSION

Water Enhancers

Cold Fire® is the only **non-gel** water enhancer on the QPL. All others are a very viscous gel formulation. Some come in the form of a powder and need to be mixed with water – a tedious task. The development of the gel was primarily intended as a temporary structure protection for advancing wildland fires. Experiences from many state officials indicate that the gel is not living up to its original expectations and causing many problems in the field, such as clogging up equipment. Gels are very slippery. It has been observed that they can cause detrimental effects on painted surfaces, shingles and related structural materials. The gels, like **Cold Fire**®, improves the ability of water to cling to vertical and smooth surfaces.

The FS has issued a precautionary "measure" about the water enhancers as follows:

- When batch mixing is used, all equipment coming into contact with the water enhancers should be thoroughly cleaned at the end of each work day.
- Some of these products contain ingredients that may reduce the effectiveness of other products.
- Ingredients in some products promote rapid bacterial or mold growths in a water solution.

- These products may build up a layer of material that resists removal from mixing and application equipment when cleaning with plain water.

- NOT SO FOR COLD FIRE® -

Class A Foams

Class A foams are now very popular and widely used. Twenty-five years ago, foam was a “hard-sell.” Although they are on the QPL their use is restricted in that special personal protective gear needs to be used. They can be irritating to eyes and skin. Foam concentrates typically consist of three major components: a foaming agent, a stabilizer and surfactant. Foams are thick masses of gas bubbles and water that are used to blanket and smother the fire. Some are corrosive to metals, speed deterioration of sealing materials, and are harmful to the environment in high concentrations. Most post-field operations requires the equipment to be flushed with clean water to remove the foam residuals. Care must be taken to prevent cross mixing of various manufacturer’s products in one system. Foam concentrates exhibit considerable variations in viscosity as a function of temperature. (In the case of the five Class B foams there is the hazard of selecting the wrong one, generating a far greater and more hazardous vapour cloud).

Fire Retardants

A substance that, by chemical or physical action, reduces or slows combustion, thus “retarding” the rate of spread of the flame front. They consist of a mix of water, several chemicals and a coloring agent. The main chemical ingredient is a fertilizer. They are most effective when applied in front of the flame front, not directly on it. So-called long-term retardants contain chemicals, which continue to retard fire even after the water has evaporated.

Forest Service Wildfire Management Policy

The common opinion concerning a forest fire is to allow it to burn and consume the residual fuel on the forest floor and in the underbrush. Experience has shown the forest has a remarkable recovery from such “destruction.” Prescribed burns are common to reduce the fuel on certain terrains. However, when advancing fires pose a threat to structures, preserves or people, then the policy is to “control” the fire in a manageable direction or limitation.

Cold Fire® can be used to accomplish these desires.

THE MYSTERIOUS WILDLAND FIRE FURY

The trained firefighter knows about what is called “flashover.” In say a house fire where furniture and other household items are heated in a closed space with limited oxygen, there is a build-up of pyrolysis products. When these products cannot find enough oxygen to burn, they rise and concentrate near the ceiling. Then, if more oxygen enters the room, say from a door opening or someone smashing a window, the unburned gases ignite in an explosive manner. But in an open forest area sometimes over bare earth and/or in thin air? Here are some interesting stories:

The South Canyon Colorado Fire, 1994, 14 firefighters who tried to escape were killed as the fire raced up the canyon towards them. The evidence hints of a sudden and explosive event.

The McDonald Creek Glacier National Park Fire, 1998, a sudden explosion from the fire front, “shot forward 150 meters at 100 kilometers per hour.”

The Canberra Australia Firestorm, 2003, the unexpected ferocity of the blaze killed four people and destroyed almost 500 homes.

Scientists are in debate as to the foundation of this type of phenomenon. Understanding this issue is under investigation as these strange events could make the difference between life and death. Clearly a technique is needed to pre-determine the possibility of such an event and to immediately select the best way to mitigate the problem.

ECONOMIC ASPECTS

And the bottom line is … ? Cost is a relative thing that can create a lot of debate. Comparing apples to apples is a challenge. Competition among products must be evaluated from many aspects, including the intended application.

1. **Performance**

   The operators can only really judge field performance of **Cold Fire**® versus a popular Class A foam. To date there does not seem to be a good demonstration comparison of products. One important aspect is of course, what does it take in terms of product percentage mix to represent the same success (same fire, same time to put out, etc.)

   If it takes a foam at 1% (at $60/pail) to do that same as **Cold Fire**® at 0.5% (at $120/pail) then it is a toss-up, except for another aspect. The foam selected in this case is made up of fatty alcohol ether sulfates with diethylene glycol monobutyl ether (18%) and ethanol (8%). Of course exposure

controls/personnel protection is necessary and care is needed to prevent the product from being washed into surface waters. The Hazardous Material Identification Systems (HMIS) rating is 1, 2, 0.

That is, a slight hazard to health and moderate hazard in terms of flammability.

The Cold Fire® HMIS rating is 0, 0, 0.

The performance of **Cold Fire**® for a Class D (magnesium) fire (exceeding 5,000 degrees F) demonstrates its penetration and cooling ability for dangerous post fire situations such as bog or muck hot spots.

2. Mixed Agent Value

Assume the fire department has a rig loaded with 1,000 gallons of water on standby. (The 600-gallon brush truck is common for brush fires). It is the "value" of the water that counts. That is, the labor, energy used, other resources used, maintenance of the rig, overhead, and similar costs that gets the water ready for action, not to mention the cost of getting to the fire scene. Add 5 gallons of **Cold Fire**® and the rig is ready to fight a brush fire where the water can then get the best "bang for the buck."

3. Examples of Added Value Overlooked

- For **Cold Fire**® use, specialized personnel protective equipment is not required (barring the need for equipment to protect against the fire, smoke, etc. of the fire itself and standard operating procedures.)
- The logging industry uses **Cold Fire**® to reduce the premiums on their insurance (United Loggers Insurance Agency, Bloomburg, Texas).
- Mullinax Logging was successful in getting equipment insurance underwritten by Lloyd's of London as a result of carrying **Cold Fire**® extinguishers on board their equipment.
- Some products have expirations on storage and after time must be disposed of (and not down the drain). There are those in five gallon containers that must be "turned upside down" periodically to prevent "problems." **Cold Fire**® that was stored over ten years showed no sign of stratification or other detrimental aspects, thus minimizing frequent inventory replacement.
- Post operation clean up is a very important cost consideration.
- Additives, like **Cold Fire**®, make more effective use of limited water resources especially in rural or undeveloped areas. They minimize structural stress (and thus the danger of collapse), since there is far

less weight of water being placed on the structure. They lessen the potential for water damage, and damage from smoke.

- One can place cost on structure loss, people displacement, etc.
- If a fire commander can stop a three-acre fire (using **Cold Fire**®) from spreading to a sixty-acre problem – that has value.

RELATED CONSIDERATIONS AND CONSEQUENCES

- We are all too familiar with the demise of the Halon extinguishing agents due to their effect on the ozone layer.
- One reads more and more about the consequences of using the variety of fire chemical agents. A recent heightened awareness concerns the potential impact on endangered species. To the dismay of the Forest Service a district judge in October 2005 from Missoula, Montana, wrote in a decision, as a result of a lawsuit, "wildfire retardant drops violate environmental law." The saga continues. This further accented by the premise that failure to use the latest "best" technology is in fact grounds for litigation.
- The FS cautions about the use of foams/retardant near aquatic areas. "Retardant drops should not be made within 300 feet of a waterway" per FS policy.
- A recent article indicates that scientists have found that the flame retardant polybrominated diphenyl ether (PBDE) is linked to a number of new diseases attacking the dolphin family.
- Mention has been made of the possible chemical reactions (using certain agents) exposed to extreme fire temperatures forming carcinogenic materials that become airborne. A 2003 study by Labat-Anderson, Inc. quotes, "There are 21 chemical ingredients in products on the Qualified Products List [7/5/02] that meet one or more of the criteria of carcinogenicity, low LD_{50}s [lethal dose], or reportability to EPA and/or OSHA. Many of these chemicals are contained in more than one formulation." It is noted the risk is low but not really quantifiable.
- Wildfires in high-latitude forests are releasing mercury (300 + tons/year).
- Arson is a major cause of fires. Firefighting chemicals may mask the evidence. It has been reported the olfactory factors of animals normally used in the investigation are not affected by the use of **Cold Fire**®.
- Brush fires can have an impact on the local economy. In Florida for instance they can take a toll on the tourism industry. Traffic patterns are altered due to smoke-laden terrain. The mix of smoke with fog aggravates an already dangerous situation. And we all know about the health hazards from the smoke.

The firefighters have a tough job and all the best available technology is made available for their safety and job performance.

Cold Fire® is now another viable tool in the fire technology package.

THE CASE FOR THE AIRSHIP

One of the challenging problems in fighting forest fires is in the method of getting the suppression agent to the fire. For ground engine applications one confronts the difficult, or inaccessible, rugged terrains, such as steep slopes, dense foliage or swamp laden areas. For aerial applications a lot depends on the skill of the pilot for accuracy and timing of the drop. There is the troublesome aspect of the smoke and the very dangerous aspect of the heated air, lowering the air density, affecting aircraft aerodynamics.

Enter the airship. Not a new idea. Their big advantage is the ability to hover near the fire, first as a stationary observation platform. Coordination can be made with the fire commander on the ground to select the best option for an airdrop. On board video fire image coverage, sensors to measure local air density and infrared sensors to locate hot spots are but a few ideas to help with the communication.

The airship would need to employ both the static and dynamic lift features for trim control, as the water/agent drop is a significant ballast release. A snorkel device could be used to load the on-board container (from a body of water). A special holding container would hold the suppression agent to be mixed with the water as is done with the aircraft “water scoopers,” for example. A high pressure water jet could be used to not only deliver the mix several hundred feet, but to break up the water droplet to a finer mist, an aspect that has been demonstrated to enhance the overall effectiveness of water. Clearly the operation would be managed by an on-board computer controlled system.

The large drawback is the upfront expense of the airship. It would make sense to design them for multiple uses. That is, a “fire status” mode and say, a “cargo” mode. The latter, for movement of large equipment, and the many other applications proposed in the literature. A flexible bladder, or detachable container, could be used for the fire status mode so that the static lift volume could be increased, perhaps using the ballonet concept.

The use of water with a modest yet adequate **Cold Fire**® mix would be very effective for knockdown of the flame front. The non-corrosive non-clogging features of **Cold Fire**®, along with all its other attributes in combination with the airship

delivery method would make a fine overall aerial technique for combating the wildland fires.

SOME FINAL NOTES

A serious situation is arising in that the available product list is diminishing as more concern is generated relative to the environmental consequences of some products. In fact, certain formulations have been removed from the QPL and others are to be phased out by 2010.

A recent study by the US National Center for Atmospheric Research in Boulder, Colorado, found that regions downwind of the 2007 California fires were three times as likely as other areas to see ozone levels above official health limits. “The work may discourage adoption of the controversial idea that wildfires should be left to burn-out naturally.”

There is the continuing saga of finding the “Holy Grail” that is, a product that is completely safe (HMIS: 0,0,0.) to people and the environment, easy to use by the firefighter, inexpensive to use, and the ability of the industry to provide such a product. The changing demands of the government continue to challenge the industry, but one wonders – **the fundamental objective is not only to put out the fire, BUT keep it out … key attributes of Cold Fire®**.

ABOUT THE AUTHOR

During his college “summers” Addison Bain worked for the Flathead Country Forest Service in Montana as a surveyor. With NASA he gained his expertise in rocket propellants and hazardous chemicals. He is a member of the NFPA and their Wildland Fire Management Section. He served as first chairman of the DOE Hydrogen Safety Panel, is internationally known for hydrogen related technologies and hydrogen safety and is author of, “The Freedom Element – Living with Hydrogen.” Bain is a lifetime member of Strathmore’s Who’s Who as well as the America’s Registry of Outstanding Professionals.

Awards include the NASA Exceptional Service Metal. He has been a member of the Cape Canaveral Missile Space Range Pioneer club since May 1959. On behalf of NASA he accepted the International Association for Hydrogen Energy Konstantin Tsiolkosvky Award for, “Pioneering the Applications of Hydrogen for Space Exploration.”

Dr. Bain represents FireFreeze Worldwide, Inc. as their technical coordinator on matters relating to the forestry industry.

COLD FIRE® TECHNICAL INFORMATION

Application
Cold Fire® is added to pumper apparatus, reservoirs or inducted into fire hose lines in order to attack large fires. **Cold Fire**® is added at given percentages depending on the nature of the combustible materials involved.

Percentages
Class A: .15% to 3% Class B: 1.5% to 6% Class D: 6% to 10%

Cold Fire® can also be used in water extinguishing units, closed loop systems, sprinkler systems, and on-board systems for aviation, rail, boating, and automobile industries.

Underwriters Laboratories Listing
Cold Fire® is UL listed for Class A & B Fires. Listing #: 2N75
Tested in accordance with NFPA 18, Standard for Wetting Agents, UL 162, applicable portions of the Standard for Foam Equipment and Liquid Concentrates, and UL 711 (for Class B fires). **Cold Fire**® is also C-UL listed. File #: Cex1225. Product was investigated and found to be in compliance with the requirements under ULC Subj. C175.

Environmental Protection Agency
Cold Fire® is registered by United States Environmental Protection Agency on their SNAP (Significantly New Alternative Products) Program Vendor List. **Cold Fire**® has been classified by the US EPA under: "Surfactant Blend A." **Cold Fire**® is approved by the US EPA as a substitute for Halon 1211.

Toxicity
Tested in accordance with US EPA Office of Pollution Prevention and Toxic Criteria for ranking the acute toxicity of chemicals in the aquatic environment. **Cold Fire**® is considered to be of low concern. **Cold Fire**® is not considered to be: a skin sensitizing agent, a dermal, primary skin, or ocular irritant and is not acutely toxic to laboratory animals following oral administration at 5.0 g/kg.

Hazardous Materials Identification Systems (HMIS) Ratings
(Developed by the National Paint & Coatings Association (NCPA)
Health Hazard: 0 Reactivity: 0 Flammability: 0

MSDS, Complete UL Testing and Toxicity Testing Results are available upon request from FIREFREEZE WORLDWIDE, INC.

COLD FIRE® ADVANTAGE

- Unlike Dry Powders, most Chemical Foams & Halons, is Environmentally Friendly and 100% Biodegradable.
- Unlike Halons, Dry Powders, and most Chemical Foams, **Cold Fire**® is Non-Toxic
- Unlike Halons and Carbon Dioxide, **Cold Fire**® is effective on Class A fires.
- Unlike Dry Powders and most Chemical Foams, **Cold Fire**® is Non-Corrosive.
- Unlike Halons, Dry Powders, Carbon Dioxide and most Chemical Foams, **Cold Fire**® helps to Prevent Re-ignition.
- Unlike Halons, Chemicals Foams, Carbon Dioxide and Dry Powders, **Cold Fire**® has a Rapid Cooling Effect.
- **Cold Fire**® will reduce the Quantity of Water required to extinguish a Fire, thus Reducing Water Damage.
- **Cold Fire**® Reduces the Density of Hydrocarbon Smoke.

FIRE SYSTEM SERVICES
T: 1300883473 | E: info@firesys.com.au | W: www.firesys.com.au
COLD FIRE

Recharging A Cold Fire® Extinguisher

You will need a 10-quart measuring bucket, air-compressor, funnel, **Cold Fire®** and water!

Cold Fire Fire Extinguishers should only be serviced and refilled by a qualified fire safety technicians, All Fire Bottles or Fire Extinguishers out of date are required to be retested before being refilled and entering into service.





Step 1	Step 2	Step 3	Step 4	Step 5
Loosen and remove the extinguisher head	Add Funnel Add Water 8.4L / 2.2Gal of water	Add 600mls / 20.2oz Cold Fire Concentrate	Replace and hand tighten extinguisher head. Do not over-tighten.	Charge extinguisher using air-compressor to 125 PSI

Note: Always stand to the side as pictured above while charging fire extinguishers

Cold Fire isn't used on its own — it's a foam concentrate/wetting agent that you dilute with water so that it can enhance the water's ability to cool, penetrate, and extinguish fires more effectively.

The amount of Cold Fire added to water depends on the fire type and application:
Class A fires (ordinary combustibles: wood, brush, paper): ~0.5% – 3% Cold Fire in water
Class B fires (flammable liquids like petrol/oil): ~3% – 6%
Class D fires (metal fires): ~6% – 1

Cold Fire® vs Chemical Foams

Cold Fire®	Foam
Environmentally Safe	Contaminating & Hazardous
Non-Toxic & Non-Corrosive	Toxic & Corrosive
Rapid Cooling Effect	No Cooling Effect
No Re-Ignition	Possible Re-Ignition
Enhances Penetration Capability of Water	No Penetration Capability
10 Times Wetter than Water!	Not Applicable
Reduces Water Damage	Not Applicable
Reduces Smoke Damage	Not Applicable
No Messy Clean Up	Makes a Mess, Needs to be Disposed of as Hazardous Waste
Fights Horizontal & Vertical Fires	Fights Horizontal Fires
Fights Class A, B & D Fires	Fights Class B Fires & Some A Fires
Can be Poured Directly into Fire Tank	Must be inducted
Will not Separate	Not Applicable
Completely Soluble in Water	Not Applicable
Indefinite Shelf Life	Shelf Life is Limited

ADVANTAGES OF THE Cold Fire®
ON-BOARD FIRE SUPPRESSION SYSTEM

1) The system is completely serviceable and easy to inspect for proper operation. It can be tested at any time and put back in service immediately. The system can be serviced as any other part of the car and technical officials can now inspect the system regularly.

2) Easy to refill by using a **Cold Fire®** refill kit and charging the system with nitrogen. The kit comes pre-packaged with the proper amount of product for a particular system along with a complete pressure tested siphon tube assembly.

3) All pin parts and hardware are stainless steel and won't corrode.

4) The system has a bleed pressure pin for testing of the system. The system can be tested without discharging any product.

5) **Cold Fire®** is non-toxic, allowing system nozzles to be placed so that they can be sprayed directly onto the driver/operator.

Cold Fire® is widely used by major racetracks for fire safety. These include: Indianapolis MS, Sebring, Lime Rock Park, Houston Raceway, Firebird Raceway, Englishtown MS, NHIS, Atlanta MS, Watkins Glen, Charlotte, Nazareth, Pocono, Sears Point, Las Vegas, IRP, Pikes Peak, Phoenix MS, Bristol, Disney World, Texas MS, Gateway and by the NHRA, Indy Racing League and DIRT Motorsports.

All racing systems can be ordered without mounting brackets. Please ask when ordering.

STANDARD SYSTEM

Economically priced, the Standard System is designed for applications where easy access to the valve head is available. This system comes complete with all mounting hardware, mounting bracket, 16 feet of tubing, 2 nozzles, valve assembly, 12 tie wraps, fittings and **Cold Fire®** bottle.

Part #	Description
COB5	5 lb. Complete System
COB10	10 lb. Complete System
COBRF5	5 lb. Refill Kit
COBRF10	10 lb. Refill Kit

Recommended for use in any application where access to valve head is available.

SINGLE BOTTLE REMOTE CABLE SYSTEM

Originally designed for the racing world, this system has found a home in many applications. The system is actuated by the use of a push style cable, allowing remote mounting of the bottle for applications where the valve body is not easily accessible. For example, in a Street Rod, the bottle could be hidden in the trunk with only the cable knob being located in an accessible location in the driver's compartment. Even though these systems were designed for racing, they provide enhanced protection in many other applications. This system comes complete with all mounting hardware, 16 feet of tubing, 2 nozzles, valve assembly, 12 tie wraps, a **Cold Fire®** bottle and remote cable actuator, lengths of 3 ft., 5 ft., 8 ft., or 10 ft.

Part #	Description
(To order Mounting Kit with system add the letter "M" after part number)	
COB5-3	5 lb. System w/3 ft. cable
COB5-5	5 lb. System w/5 ft. cable
COB5-8	5 lb. System w/8 ft. cable
COB5-10	5 lb. System w/10 ft. cable
COB10-3	10 lb. System w/3 ft. cable
COB10-5	10 lb. System with 5 ft. cable
COB10-8	10 lb. System with 8 ft. cable
COB10-10	10 lb. System with 10 ft. cable
COBRF5	5 lb. Refill Kit
COBRF10	10 lb. Refill Kit

Recommended for use in race cars, marine engine bays, street rods, motor home engine compartments, kit cars, etc.

SINGLE BOTTLE BELL CRANK SYSTEM

Designed for applications where there is a space consideration for bottle length, the Bell Crank Cable System provides for different mounting options. The system comes complete with all mounting hardware, 16 ft. of tubing, 2 nozzles, valve assembly, 12 tie wraps, a **Cold Fire®** bottle and cable actuator of 3 ft., 5 ft., 8 ft., or 10 ft.

COB5-B3	5 lb. Bell Crank /3 ft. cable
COB5-B5	5 lb. Bell Crank /5 ft. cable
COB5-B8	5 lb. Bell Crank /8 ft. cable
COB5-B10	5 lb. Bell Crank /10 ft. cable
COB10-B3	10 lb. Bell Crank /3 ft. cable
COB10-B5	10 lb. Bell Crank /5 ft. cable
COB10-B8	10 lb. Bell Crank /8 ft. cable
COB10-B10	10 lb. Bell Crank /10 ft. cable
COBRF5	5 lb. Refill Kit
COBRF10	10 lb. Refill Kit

DUAL BOTTLE SYSTEMS

Designed for ultimate protection in racing, this system packs the firefighting capabilities of two bottles in one system. This system allows a designated bottle to be used for driver protection. Isolate one bottle on the driver and the other to extinguish the fire. This system guarantees additional fire safety to the driver in extreme situations. Both bottles are actuated by the same cable simultaneously. This system comes complete with all mounting hardware, 16 feet of tubing, 3 nozzles, 2 valve assemblies, 20 tie wraps, 2 **Cold Fire®** bottles and a remote cable actuator in lengths of 3 ft., 5 ft., 8 ft. or 10 ft.

Part #	Description
COB5-D3	Dual 5 lb. System /3 ft. cable
COB5-D5	Dual 5 lb. System /5 ft. cable
COB5-D8	Dual 5 lb. System /8 ft. cable
COB5-D10	Dual 5 lb. System /10 ft. cable
COB10-D3	Dual 10 lb. System /3 ft. cable
COB10-D5	Dual 10 lb. System /5 ft. cable
COB10-D8	Dual 10 lb. System /8 ft. cable
COB10-D10	Dual 10 lb. System /10 ft. cable

When ordering refills for these systems remember to order 2 for each system.

ACCESSORIES

Re-Fill Kits
Everything you need to refill your system. The kit includes pressure tested syphon tube, assembly and pre-measured **Cold Fire®** for your system.

Part #	Description
COBRF5	5 lb. Refill Kit
COBRF10	10 lb. Refill Kit

Bottle Mount Kit
Includes the mount, 3 clamps and all hardware needed.

COB-5MK	5 lb. Mount Kit
COB-10MK	10 lb. Mount Kit

Tubing
¼" aluminum tubing. Soft annealed, easy to bend tubing, available in 3 lengths.

TK16	16 ft. of tubing
TK25	25 ft. of tubing
TK50	50 ft. of tubing

Cables
Available in 4 lengths with a "T" handle or round handle knob.

C3	3 ft. cable
C5	5 ft. cable
C8	8 ft. cable
C10	10 ft. cable
CR	Round Knob
CT	Tee Knob
CM	Cable Mount Tube

Longer cables available.
Special order, please call.

Replacement Bottles:
5 lb. Bottle - #COB5B
20 lb. Bottle - #COB10B

Replacement Gauge:
#CFG

Replacement Nozzles:
#CFV

Replacement Charge Valve:
#CFN

Fitting Parts: A complete plumbing kit is available, which includes tubing, fittings, nozzles and tie-wrap. #CFPK

COLD FIRE® AND FOREST FIRES

"Protecting our Environment for Future Generations"

- Environmentally friendly
- Non-toxic and biodegradable
- Approved for vertical fires
- Dramatically reduces smoke and heat from fire
- Drastically reduces updraft and turbulence
- Minimizes or eliminates reignition
- Uses at least 30% to 50% less water
- Controls and extinguishes fires faster, saving millions of dollars in:
    - Air time for air support
    - Wages for ground crews
    - Relocation and living costs for victims
    - Valuable timber resources
    - Parkland and wildlife
    - Equipment and product costs
- Reduces or eliminates property damage claims (residential, farm, forestry, business)
- Reduces exposure to loss of life or serious injury
- Does not require special equipment
- Already in use in US, Mexico and Brazil

COLD FIRE® COMPETITIVE EDGE

The advantages of using **Cold Fire®** over the competing products in the market today are extraordinary. Presently, the five most common firefighting products used today are:

- Water
- Halon
- Chemical Foam
- Dry Powder
- Carbon Dioxide

WATER is the most common product, as it is plentiful and available (in most areas) and involves relatively low cost. The problem, however, with water alone is that it is not very effective on oil, chemical, electrical and metal fires and large amounts of water need to be used, increasing the amount of water damage.

HALONS (a contraction of "Halogenated Hydrocarbons") are a group of extinguishing agents, stored under pressure in liquid form and released in such a way as to vaporize rapidly in the fire zone. They extinguish fire by interfering with the chemical reactions involved in the propagation of flame. Halons have limited use in deluge systems for electronics and computer centers and attacks the fire by removing the oxygen. Halons are not especially suitable for Class A fires, which are the most common type, involving materials organic in nature such as wood, paper and furniture. Halons are ozone depleting and have no significant cooling effect, therefore, there is possibility of re-ignition following discharge. The future manufacturer of Halon has been banned by the Environmental Protection Agency as of January 1, 1994 and their future use restricted.

CHEMICAL FOAMS are concentrates which are introduced into water in varying proportions and are derived from a combination of foaming agents and surfactants such a hydrolyzed proteins and fluoro-chemicals. They are utilized both professionally and commercially (through extinguishers and hose lines). The problem with most chemical foams is obvious; they are highly toxic. When foam is used to extinguish a fire there is significant chemical exposure to the firefighter. The area of the fire, once it is extinguished, also becomes difficult and costly to clean-up because the foam needs to be picked up and disposed of as hazardous waste. Foams also tend to decompose in fire, thereby increasing chances of re-ignition.

DRY POWDER extinguishers are the most common. Although not listed as toxic material, significant warnings concerning respiratory exposure exists to all users. Dry powder extinguishers are extremely messy and when discharged, fine particles are dispersed under pressure, resulting in all adjacent surfaces being

covered and penetration into the smallest of cracks and crevices. Using a dry powder extinguisher on a kitchen fire for example, results in exhaustive and diligent cleaning of the entire room, and possibly adjacent rooms. Re-ignition may also occur if the powdered surface is disturbed.

CARBON DIOXIDE is an inert gas which is stored in portable extinguishers (and certain fixed installations) is common in extinguishing fires involving flammable liquids and electrical equipment. Carbon Dioxide is environmentally safe; however, its use is not recommended for Class A fires, fires which are normally encountered in the home, and it has no substantial cooling effect on burning materials, again resulting in the possibility of re-ignition.

The advantages of using Cold Fire® significantly outweigh those of the other products.

Cold Fire® is an effective extinguishing agent which is:

- **ENVIRONMENTALLY SAFE**
- **BIODEGRADABLE**
- **NON-TOXIC**
- **NON-CORROSIVE**
- **HAS NO HAZARDOUS RISK EXPOSURE**
- **PREVENTS RE-IGNITION**
- **DOES NOT STAIN OR LEAVE ANY RESIDUE**
- **USER FRIENDLY AND REQUIRES NO SPECIFIC CLEANUP**

COLD FIRE®

"USED AROUND THE WORLD"

TOP 10 REASONS TO USE COLD FIRE®

- **Puts Down Fires Faster**
- **Prevents Re-ignition**
- **Safer for Firefighters**
- **Safer for the Environment**
- **Easier to Use**
- **Easier on Equipment**
- **No New Equipment Required**
- **Minimizes Damage to Fire Scene**
- **Locally Available**
- **More Cost Effective**

COLD FIRE® APPLICATIONS

Bulk – Available in 5 and 55 Gallon Drums

Application
Product can be dumped directly into booster tanks or can be inducted. Bulk is also purchased to re-fill water extinguishers.

Examples of Industries using this Application
Fire Departments, Heavy Industry, Military, Forestry, Logging, Foundries, Mining, Metal Manufacturing, Racing Industry, etc.

12 oz. Rapid Cool Down Spray Can

Application
Product is used to cool down hot surfaces. Excellent tool for plumbing, heating, welding, mechanical and roofing applications. Product eliminates heat and reduces the probability of heat damage. This application has also been used to extinguish small spot fires, however, is not considered to be an extinguisher.

Examples of Industries using this Application
Plumbing, Welding, Heating, Roofing, Mechanics, Logging and Racing Industries.

32 oz. Bottle of Cold Fire® (pre-mixed)

Application
Product is used to cool down hot surfaces. Excellent tool for plumbing, heating, welding, mechanical and roofing applications. Product eliminates heat and reduces the probability of heat damage.

Examples of Industries using this Application
Plumbing, Welding, Heating, Roofing, Mechanics, Logging and Racing Industries.

32 oz. Concentrate of Cold Fire®

Application
Easy to use bottle to re-fill 1.5 and 2.5 gallon water extinguishers. Will also be used in the near future as an easy way to re-fill soon to be released automatic fire suppression systems for racing, logging and heavy machinery industries.

Examples of Industries using this Application
Fire Departments, Roofing Industry, Logging Industry, Manufacturing Facilities and the Racing Industry.

1.5 and 2.5 Gallon Water Extinguishers filled with Cold Fire®

Application
Used to extinguish fires.

Examples of Industries using this Application
Fire Departments, Police Departments, Roofing Industry, Forestry, Manufacturing Facilities, Foundries, Mining, Commercial, Metal Manufacturing and Motorized Racing Industry.

Automatic Fire Suppression Systems

Application
5 pound systems will soon be available. These systems are closed loop systems and come in two types: automatic or manual. Either system can be installed on-board race cars, logging equipment, heavy equipment, etc. for fire suppression. These systems can be designed to have tubing and nozzles which will spray onto the driver/operator and the engine of the vehicle or equipment for fire safety. Systems can also be designed for facilities. These units will be refillable.

Examples of Industries using this Application
Motorized Racing Industry, Heavy Equipment, Manufacturing Facilities, Forestry, Logging, Aviation, Military, Buses, Locomotive, Gas Stations, Commercial, etc.

COLD FIRE®

ABILITY TO EXTINGUISH TIRE FIRES

Tire fires are very difficult to extinguish due to the fact that once rubber begins to burn it creates its own oxygen and continues to fuel the fire. In extreme situations tire fires are left to burn out or are buried. Both applications are considered a tremendously hazardous environmental concern.

Dry powder and foaming agents are not effective in fighting tire fires as they cannot penetrate the burning rubber and have no cooling effect. Water is also not a very effective agent as it turns to steam due to the tremendous heat of the fire. Water has no penetration power to cool, therefore, the tires continue to burn.

Cold Fire® mixed at a 3% solution is extremely effective on extinguishing tire fires. This is due to Cold Fires ability to:

1) Penetrate the burning rubber's surface 6 to 10 times more rapidly than water.

2) The products extraordinary cooling effect works to cool down the rubber/tire surface, bringing the rubber under its flashpoint immediately. This unique characteristic lends itself to the ability of **Cold Fire®** to extinguish rapidly and prevent re-ignition.

Cold Fire® also works to encapsulate hydrocarbons. When rubber burns, a great deal of hydrocarbon smoke is released into the atmosphere. This smoke is highly toxic. **Cold Fire®** works to encapsulate and rapidly biodegrade the airborne burned hydrocarbons in the smoke. When the agent falls back to Earth the product is biodegraded into plant based carbon within 7 – 21 days.

Cold Fire® is a UL listed Wetting Agent for Class A & B fires. The product is non-toxic, non-corrosive, is listed with the EPA-SNAP Program and has achieved listing with the USDA.

Safety first

Holmatro Indy team struts its stuff at Toronto event

Written by Keith Hamilton

As a firefighter and racing fan, I have had the opportunity to meet with professional racing safety teams from IMSA and Mosport. This summer, I met the only other safety team dedicated to a series in North America: the Indy Racing League Holmatro Safety Team.

For more than 20 years, the hydraulic rescue tools I've used have had the familiar orange colours of Holmatro Rescue tools. Those colours adorn a tractor trailer that travels from Indianapolis across North America, Brazil and Japan. The Indy Racing League is the only open wheel racing series whose dedicated safety team travels to every racing venue providing fire, rescue and medical care for their drivers and team members. This relationship allows the safety team and IndyCar management to practise and train together and to plan for the future. The research and development department at Holmatro can test its rescue tools on the proposed chassis components of future designs to ensure the team is prepared for an emergency.

A Holmatro Safety Team member passes the engine starter so driver Ryan Briscoe can rejoin the race.
Photo by Keith Hamilton

Mike Yates, manager of track safety operations for the IndyCar series' Holmatro Safety Team in July at the Honda Indy in Toronto. He is a veteran of the fire service and the racing safety team. The Holmatro Safety Team was created specifically to look after the IndyCar and Indy Lights racing series. The two cars are similar in terms of safety; the major difference is that the Indy Lights cars have starters, and if they spin but don't crash, they can restart on their own. The rescue truck will still be there in case of other problems or if a restart isn't possible. Indy-type cars do not have starters, and the Holmatro rescue trucks are equipped with the same starters the race teams use to restart a car – if it is safe to do so. Of course, if the four tires are still on a race car, most racers want the safety team to restart them, but if a suspension component has been compromised, the safety team will not restart the car and the race is over for that driver.

The Holmatro safety team consists of 25 members; 15 of them attend each race. The safety team brings three trucks to every race and staffs them with four rescue members each. Two other members work as medics in the pit area, and one member works as a dispatcher and fire controller. Every member is a firefighter/paramedic; the majority are from Indiana, with two members from Florida and one from Phoenix. Most of the 17 IndyCar races are in North America but the team travels internationally with stops in Japan and Brazil during the racing year.

The safety team equipment is taken to each venue on a tractor trailer designed to transport race cars. The three safety trucks are carried above, and all the safety equipment and personal items are carried below, in either the cabinets on the lower level or in storage compartments below floor level. The rescue trucks are kept on a moveable floor that is lowered when the trucks are on board and then raised after the trucks are removed at a venue. The space below is then used by the safety teams as a quiet place to relax or get ready for the day's events. When travelling to Japan or Brazil, all the rescue equipment travels on two 747 jets, loaded on board with the race cars.

Driver Takuma Sato's race is over and the Holmatro safety team rushes to move him out of danger at the end of the Lakeshore Boulevard straight in Toronto.
Photo by Keith Hamilton

Honda supplies Ridgeline trucks for the safety team. Two of the trucks are set up as rescue trucks, with Holmatro tools and two portable power units to operate them.

Holmatro spreaders and cutters are the standard tools with a special pedal cutter added in case of need. **The trucks also carry 60 gallons of water mixed with Cold Fire (foam fire suppressant) routed through a front-bumper mounted, 30-foot forestry-type hose. Pressurized water cans are also carried premixed with Cold Fire foam.**

The rescue trucks also provide emergency medical treatment and carry an assortment of airway and advanced life support equipment for the responding paramedics to use. In most cases, local EMS/paramedics handle advanced life support, but the team is cleared to perform certain procedures depending on the venue.

Driver stabilization equipment is carried and techniques and equipment are practised two or three times a year. If, during the year, any changes are made to the racing cars, the technical people contact the safety team and training is conducted to ensure the changes won't affect the way rescuers approach a car when a driver has to be rescued. Up to eight hours of training is provided to the local fire, safety and EMS personnel when the team arrives at each race location.

Canadian driver Paul Tracy spins in corner three during the race and stalls his car. The Holmatro Safety Team uses its starter to restart his engine so he can complete the race.
Photo by Keith Hamilton

The speed of the cars on the track can be hazardous to the safety crews. The cars do not pit during accidents but are on the track with the safety teams. Drivers are aware of the safety teams and pay attention to directions, but things can be a little violent on race day. Safety team members must stay on edge and never let their guard down or turn their backs to traffic.

Radio communication with the dispatcher is also important to ensure the safety team knows where the race pack is located on the track and whether there is a single car trying to catch the pack, so the rescuers can stand and watch out. It is important that safety team members do not make any movements before they look around to make sure they can move safely.

An actual rescue on the track – and the safety precautions that go with it – is not much different than rescues performed by firefighters every day. The only real difference is the safety team's level of familiarity with the race cars, compared to the myriad makes and models that firefighters deal with daily. Trauma treatment of the drivers is basically the same as on the street – follow the ABCs of airway, breathing and circulation, and immobilize for broken bones or spinal cord injuries. The biggest difference is the environment in which these actions are performed.

The position of safety team members in the truck determines their tasks at the scene. The driver is the incident commander; responsible for size up and calling in resources. The front passenger is the paramedic; he is responsible for the medical needs of the driver. The seat behind the passenger is for firefighter No. 1, whose task is to take the pressurized water can with Cold Fire to the scene and look for fire. Firefighter No. 2 sits behind the driver and is to bring a five-gallon pail of oil dry to contain any spills to the area around the race car.

Hideki Mutoh's car is prepared for removal from the track after crashing in corner two during practice.
Photo by Keith Hamilton

If the driver is uninjured, he can get out on his own and be transported by ambulance or by the IRL doctor car. If the driver is injured, firefighter No. 2 drops his oil dry responsibility, and gets up onto the engine cowl to take over spinal immobilization so the paramedic can work and get a cervical collar on the driver after the helmet is removed. Firefighter No. 2 can fill in for firefighter No. 2 at that point, or join with the team leader at the driver's shoulders to help with driver removal. It's a very methodical approach that is practised during training sessions. It becomes second nature to know what to grab and what to do when arriving at an incident.

Indy cars use alcohol as a fuel so the rescue teams respond with water and Cold Fire to combat fires. Water mixes with the alcohol and the Cold Fire additive can be easily turned into foam by putting a thumb over the nozzle to create a fine spray. Dry chemical extinguishers aren't used because of the proximity to the drivers and their confined space in the cockpit. Dry chemical can cause respiratory irritation and are harmful to the aluminium parts on the race car, including the engine.

Rescue teams are also responsible for the race track. Fluids or debris that get onto the track from an accident can create further danger to other racers. The rescue team helps to clean and remove debris and fluids from the racing surface to prevent putting the other racers in danger. The rescue trucks carry kits to allow the Indy race cars to be picked up by tow trucks. They also have "diapers" to keep fluids from dropping onto the track.

Holmatro has supplied rescue equipment for the Indy Racing League since it began in 1996. This year, Holmatro, after being an important resource for the IZOD IndyCar Series and Firestone Indy Lights, took over as sponsor of the Racing League Safety Team.

Keith Hamilton *is a captain on a rescue squad with Toronto Fire Services. He has 32 years of service with 22 years on the squad. Being a photographer and avid race fan gives him the opportunity to be close to the action and see how various racing series' safety teams function. Contact him at rescues313@bell.net* rescues313@bell.net

The purpose of this paper is to introduce and illustrate the unique firefighting and live-saving characteristics of Cold Fire and to outline why Cold Fire should be evaluated further, as a safe and effective “solution” to Halon and Class A & B foams in both total-flooding and streaming applications.

Cold Fire, a UL Listed Wetting Agent, is considered to be an acceptable alternative to Halon under the Environmental Protection Agency’s Significant New Alternatives Policy Program (SNAP). All possible replacement and/or alternative agents to Halon need to comply with existing requirements such as environmental standards, toxicity, corrosion, storage, penetration capability and system capability to name a few. Cold Fire satisfies these requirements and offers additional advantages.

What is Cold Fire?

Cold Fire is a UL listed Wetting Agent for Class A and B fires in both the US and Canada[1]. Cold Fire was tested in accordance with UL 162, UL 71 [1] and NFPA 18 requirements for Wetting Agents. Cold Fire is unique, however, in comparison to most wetting agents, it has the capability to extinguish Class B [1] and D fires [2]. This environmentally friendly agent is plant and water-based and has been approved by the Environmental Protection Agency under their Significant New Alternatives Policy Program (SNAP) [3] as an acceptable substitute for Halon 1211 and Halon 1301. The agent is non-toxic, non-corrosive and offers an unprecedented cooling effect.

How does Cold Fire work on extinguishing a fire?

Cold Fire works by ceasing the chain propagation of the free radical reaction of fire. It does this by removing the heat from the fire triangle and immediately bringing the fire below its flash point. Simultaneously, Cold Fire works to encapsulate the fuel source. When properly applied this cooling and encapsulation process prevents the possibility of reignition.

Several criteria must be considered when assessing various replacement agents for aircraft fire suppression. The following defines the compliance of Cold Fire with these criteria.

CRITERIA

Environmental Considerations

Cold Fire is considered to be environmentally friendly and non-toxic. The agent has successfully completed extensive toxicity, corrosive and biodegradability testing with the following EPA recognized laboratories:

- SGS US Testing (Fairfield, NJ)
- Consumer Product Testing (Fairfield, NJ)

All tests were conducted in accordance with procedures outlined in the Environmental Protection Agency *Health Effects Test Guidelines,* EPA 560/6-82-001 and *Pesticide Assessment Guidelines*, EPA 540/9-82-025, Office of Pesticides and Toxic Substances.

Toxicity

Cold Fire poses no health risk to workers, crew members and/or passengers. It has received an HMIS rating:

- 0 Reactivity
- 0 Flammability
- 0 Health Hazard

Dermal Toxicity	When tested, Cold Fire was not considered to be a dermal irritant. Cold Fire was not acutely toxic following dermal administration at 5.0 g/kg.
Ocular Toxicity	When tested, Cold Fire was not considered to cause eye irritation.
Oral Toxicity	Cold Fire did not induce any mortality in laboratory animals following oral administration at 5.0 g/kg. Cold Fire was considered to have an acute oral LD_{50} value greater than 5.0 g/kg.
Skin Sensitization	When tested, Cold Fire was not considered to be a skin sensitizing agent.
Acute Inhalation Toxicity	When tested, Cold Fire was not toxic to the test animals following a 4-hour exposure at a nominal concentration of 35.3 mg/L (actual concentration was 16.9 mg/L). The LC50 was estimated to be greater than 35.3 mg/L (actual concentration was 16.9 mg/L.) Asphyxiation and toxicity are therefore not considered to be of concern if using Cold Fire as a total-flooding and/or streaming agent.

Limited Water Damage

When considering a replacement or alternative to Halon for aircraft fire suppression the issue of possible excess water damage and clean-up is of concern. Although Cold Fire is approximately 94% water, it penetrates a surface and/or area 6 times faster than water alone [1]. This penetration factor results in the use of less water to extinguish the fire and in minimal, if any, consequent water damage. Less clean-up is also required.

Indefinite Shelf Life

Cold Fire is 100% soluble in water and the agent will not separate or gel and it is freeze-thaw stable. The shelf life of the agent is indefinite, as long as it is kept in a closed container or system. If left open, normal evaporation of the water over time will occur [1].

Increased Visibility

Aside from fire, heat and smoke can cause serious health hazards that, in some cases can prove fatal to crew members and passengers. When a fire occurs onboard an aircraft, smoke becomes a significant factor and consumes the body of the aircraft in a matter of minutes, if not seconds. Once consumed, visibility to reach an exit is minimized, if not eliminated. Cold Fire works to:

- extinguish the fire and cool the area.
- encapsulate the hydrocarbons in the smoke.
- transform the smoke from black to white almost immediately (increasing visibility and enhancing rescue). After a few minutes, most, if not all the black hydrocarbon smoke, is eliminated.
- cools and absorbs hydrocarbon smoke reducing the likelihood of smoke inhalation and steam burns.

Minimal Clean-up

Cold Fire is a non-hazardous material and requires minimal clean-up. The agent is non-staining, leaves no residue and not a slipping hazard.

Corrosion

Cold Fire is non-corrosive. The results of the DOT corrosion testing completed by SGS US Testing on aluminum and steel are shown in the following table.

Test Results

	Corrosion Rate	
	mm/year	in/year
Aluminum 7075 T-6 Bare	0.07 – 0.08	0.003 – 0.003
Steel	0.23 – 0.27	0.009 – 0.011

Comments

Per 49 CFR 173.130(A) (2) a liquid is considered to have a severe corrosion rate if its corrosion rate exceeds 6.25 mm (0.0246 in) a year on steel (SAE 1020) or aluminum (non-clad 7075 T-6) at a test temperature of 55°C (131°F) [4].

ADVANTAGES IN USING COLD FIRE

When water is applied to a fire and/or heated surface, it converts to heated steam resulting in possible superheated steam inhalation and/or steam bum. Although water is an excellent firefighting median it lacks the enhanced cooling and penetration capability which are inherent characteristics of Cold Fire.

Cooling Effect

Cold Fire works to destroy the molecular structure of heat. Unlike water or air, Cold Fire's extraordinary penetration capability allows the agent to be RAPIDLY absorbed into a heated surface, destroying the molecular structure of heat on contact. This destruction allows the heat to be instantaneously released and dispersed into the atmosphere at ambient temperature.

Cooling tests conducted by Intertek Testing Services on various materials show that [5] Cold Fire has the ability to cool down a surface an average of 10 times faster than water alone. Tests were conducted on copper, sheet metal, steel and glass. Results are as follows:

Cold Fire Cooling on Copper

The copper was heated to 500°F and sprayed for 29.89 seconds.

- It took 27 seconds for Cold Fire to cool the copper to 87.378°F.
- It took water 4 minutes & 30 seconds to cool the copper to 84.624°F.
- It took air 11 minutes & 6 seconds to cool the copper to 95.994°F.

Cold Fire Cooling on Sheet Metal

The sheet metal was heated to 500°F and sprayed for 15.69 seconds.

- It took 14 seconds for Cold Fire to cool the sheet metal to reach 84.522°F.

- It took water 4 minutes & 50 seconds to cool the sheet metal to 84.538°F.
- It took air 9 minutes & 11 seconds to cool the sheet metal to 90.872°F.

Cold Fire Cooling on Glass

The sheet metal was heated to 500°F and sprayed for 23.47 seconds.

- It took 31 seconds for Cold Fire to cool the glass to reach 84.093°F.
- It took water 2 minutes & 26 seconds to cool the glass to 85.821°F.
- It took air 8 minutes & 23 seconds to cool the glass to 85.176°F.

Cold Fire Cooling on Steel

The sheet metal was heated to 500°F and sprayed for 48.23 seconds.

- It took 46 seconds for Cold Fire to cool the steel to 88.894°F.
- It took water 9 minutes & 170 seconds to cool the steel to reach 89.251°F.
- It took air 8 minutes & 24 seconds to cool the steel to 109.25°F.

Penetration

According to our UL test results Cold Fire is considered to be 6 times more penetrable than water [1]. The result is faster knockdown, rapid extinguishment and rapid cooling. This enhanced penetration capability also allows Cold Fire to attack deep-seated and hidden fires successfully. Cold Fire viscosity is low (15 centipoise), allowing it to be absorbed much more quickly than water alone.

Cooling and Penetration Comparison to Water

Example 1

Imagine a fully involved car fire. It would normally take a fire truck with a 1.5 inch hose line and a straight stream nozzle to extinguish such a fire in approximately 5 minutes using anywhere between 150 – 500 gallons of water.

Cold Fire can extinguish such a fire with just two 2.5 gallon water extinguishers (5 gallons of material at a 10% mix) within approximately 1 minute. Within a few minutes after extinguishment the metal of the vehicle is cool enough to touch.

Example 2

Cold Fire was used on brush fires in Mexico. Forest firefighters only needed to conduct one helicopter air drop using a Bambi bucket containing 400 gallons of water mixed with a 1% Cold Fire solution. Cold Fire was used to extinguish an area 100 meters wide by 550 meters long. In comparison it took 5 to 8 drops with Class A foam to extinguish the same size area.

COLD FIRE'S ABILITY TO EXTINGUISH CLASS D FIRES

Many parts of an aircraft are made of titanium and magnesium components. To date, the idea of applying water or a water-based agent on such a fire would be inconceivable. When water is thrown on a metal fire a chain reaction occurs in which the water creates explosions and sparks. This is due to the breaking of the water molecules into radical gaseous components that actually reinforce the metal fire. Cold Fire's unique formulation breaks this chain reaction thereby stopping the explosions from occurring and allowing the water to cool the fire down and act as a blanket between the metal and the oxygen.

Cold Fire recently completed its preliminary UL Class D testing on molten magnesium. Testing was conducted at TIMET (Titanium Metals Corporation, Henderson, NV). The preliminary tests conducted were based in part on the Liquid State Fire Tests contained in the Standard for Rating and Fire Testing for Fire Extinguishers and Class D Extinguishing Media, CAN/ULC-S508-M90. 2.5 gallon water extinguishers were used to conduct the tests, each containing a 30% mixture of Cold Fire. The following is a synopsis of the results [3].

Liquid – State Magnesium Spill Fire Test

A three-sided steel pan approximately 3 feet wide by 5 feet long, and with two widths and one length having sides with a height of 6 inches was used for this test.

Approximately 16 lbs of molten magnesium at a temperature of 718°C was poured into the center of the pan providing a varied depth spill of molten material covering approximately ¾ of the pan. The initial discharge of the extinguisher occurred 1 minute after the magnesium was placed in the pan. Flaming of the material and some spurting of burning magnesium was noted. A second extinguisher was applied and then a third extinguisher was used (3:40 from initial application). At 4:40 from the initial application no flaming of the magnesium was noted, only some smoking. The extinguishant was applied intermittently until exhausted. At 8:50 from initial application, a fourth extinguisher was intermittently used until exhausted at 16:30. The temperature of the magnesium was recorded 20 minutes after the initial application. An average temperature of 80°C was observed. Approximately 25% of the initial mass of magnesium was remaining in solid form in the steel pan [3].

APPLICATIONS USING COLD FIRE

Cold Fire can be delivered through fixed systems, hand lines and portable extinguishers. Cold Fire is presently used by the motorized racing industry in closed-loop systems for automobiles. Halon was once the agent of choice, however,

as a result of environmental concerns and banning of Halon under provisions of the Montreal protocol, as well as possible asphyxiation due to the use of the agent, Halon is no longer used. The racing industry prefers Cold Fire for its:

- ability to cool & rapid extinguishment
- prevention of re-ignition
- minimal clean-up and non-toxic and non-corrosive nature

Water-Mist System

Water-mist systems are designed to allow the use of a fine water spray application to provide fire protection with reduced water requirements and reduced consequent damage. New alternative technologies continue to be considered as options to Halon use in such systems.

Cold Fire's extraordinary penetration, cooling effect and ability to use less water would make it an excellent alternative within water-mist systems. Coupled with Cold Fire, such a system would enhance fire protection and safety, use less water and reduce consequent water damage all without compromise to those involved. (NFPA 13 certified for use in sprinkler applications.)

Cold Fire to Water Use Comparison

Cold Fire is recommended to be evaluated further for use in a water-mist system for on-board aircraft fire suppression. (See following table.) Due to the agent's solubility in water and its low viscosity, it flows freely through any fixed system and there is no fear of the agent clogging the orifices of nozzles.

Water	Cold Fire
• Limited penetration • Minimal cooling • Possible reignition • Consequent damage likely • Not very effective on Class B fires • Does not extinguish Class D fires • Risk of possible steam inhalation and steam burn • Extreme amounts of water needed • Significant dollar loss to aircraft • Lack of visibility	• Enhanced penetration • Rapid cooling • Encapsulates vapors • Prevention of reignition • Consequent damage greatly reduced • Very effective on Class B fires • Extinguishes Class D fires • Immediate cooling, alleviating possible steam inhalation and steam bum • Approximately 6 times less water is needed • Reduced dollar loss to aircraft • Enhanced visibility • Direct cooling of surfaces and fuel source • Enhances safety for a safer egress

Extinguishers

Cold Fire has completed preliminary testing with regard to British Standards for its 1.5 and 2.5 gallon extinguishers. Testing was conducted by Loss Prevention Council (Hertfordshire, England) under protocol BS EN 3-1 1996. The results are shown in the following table.

Unit Size and Rating Test Results

Unit Size	Class Rating
9 liter (2.5 gallon unit)	21A
6 liter (1.5 gallon unit)	55B

Cold Fire is classified for Class A, B, D & K fires. Research and development is in process for a Class C rating.

Prevention Application

Cold Fire works to cool down heated surfaces and encapsulates fuel, rendering it inactive. Due to this unique quality the product can be used to pre-spray areas where fear of fire may occur. Such areas would include engine compartments where a fire may originate due to the combination of heat generation and possible leakage of hydraulic fuel, oil, etc.

Today, this prevention application is used in the trade and automobile industry. Cold Fire is used to pre-spray an area or surface prior to using a torch to help prevent a possible hidden fire. Many plumbers, welders, roofers and mechanics use Cold Fire for added safety prior to brazing and soldering and/or when working with hot surfaces. The penetration capability of Cold Fire allows it to safeguard a surface from heat damage and possible fire.

CONCLUSION

COLD Fire rapidly extinguishes and cools down a fire, uses less water to achieve enhanced fire protection and reduces hydrocarbon smoke thereby reducing increasing visibility and allowing for a safe exit. These are just some of the unique fire suppression and live saving capabilities of Cold Fire.

The quest continues to determine the suitability of various agents for aircraft fire suppression with the obligation of finding alternative and/or replacement options for Halon. Cold Fire, a very safe, effective and compatible agent can fulfill this need.

REFERENCES

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5. Rapella, Albert J., *Performance of Thermal Measures for Cold Fire*, Intertek Testing Services NA, Inc., Totowa, NJ, June 1998.

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CERTIFICATE OF COMPLIANCE

CERTIFICATE NUMBER: 10281996-EX4660
ISSUE DATE: October 28, 1996

Issued to: **FIRE FREEZE WORLDWIDE, INC.**
270 Route 46
Rockaway NJ 07866

Report Reference: EX4660, June 16, 1994

This is to Certify that representative samples of: Model cold fire wetting agent

Have been investigated by Underwriters Laboratories Inc. in accordance with the Standard(s) indicated on this Certificate.

5:andard(s) for Safety: NFPA18 - National Fire Protection Association Standard for Wetting Agents

Additional Information:

Only those products bearing the UL Listing Mark should be considered as being covered by UL's Listing and Follow-Up Service.

The UL Listing Mark generally includes four elements as follows: the name "Underwriters Laboratories Inc." in various forms and type styles, or abbreviations such as "Und. Lab. Inc.", or the symbol "UL in a circle" - (VL): the word " Listed"; a control number (may be alphanumeric) assigned by UL; and the product or category name (product identifier), as indicated :n the appropriate UL Directory.

LOOK FOR THE UL LISTING MARK ON THE PRODUCT

Engineer: Underwriters Laboratories/ Inc

Review Engineer Underwriters Laboratories/ Inc

Underwriters Laboratories Inc.®

333 Plingsten Road
Northbrook, Illinois 60062-2096
(708) 272-8800
Fax No (708) 272-8129
MCI Mail No 254-3343
Telex No 6502543343

File Ex4660
Project 94NK2487

June 16, 1994

REPORT

On

WETTING AGENTS

Fire Freeze Worldwide, Inc.
Rockaway, NJ

D E S C R I P T I O N

PRODUCT COVERED:

Model cold fire wetting agent.

CONSTRUCTION DETAILS:

The devices have been examined and found to comply with the applicable requirements in the Standard for Foam Equipment and Liquid Concentrates, UL 162 and the NFPA Standard for Wetting Agents, NFPA 18, in effect as of the date of this Report.

USE:

The products covered by this Report are for use in accordance with the National Fire Protection Association Standard for Wetting Agents, NFPA 18.

G E N E R A L

INTRODUCTION:

This Report describes the investigation of wetting agents intended to be installed in accordance with the National Fire Protection Association Standard for Wetting Agents, NFPA 18.

OBJECT:

The object of this investigation was to determine compliance of the wetting agent with the NFPA Standard for Wetting Agents, NFPA 18 and the applicable portions of the Stand for Foam Equipment and Liquid Concentrates, UL 162

PLAN:

The investigation of the wetting agent consisted of conducting a product conformance evaluation and performance testing as described in NFPA 18 and applicable portions of UL 162.

TEST RECORD NO. 1

SAMPLES:

Representative samples of the Cold Fire wetting agent at a 0.15 percent concentration mixed with water were used in this investigation.

TEST METHOD REFERENCE:

The following tests were conducted in accordance with the requirements described in NFPA 18, UL 162 and UL 711:

1. Concentrate
    a. Qualitative Infrared Analysis
    b. pH Determination
    c. Solubility
    d. Separation Temperature
    e. Separation on Standing
    f. Action after Freezing
    g. Viscosity
    h. Surface Tension
2. Action on Fire Hose
3. Class A Fires
    a. Fiberboard
    b. Cotton
    c. Crib
4. Class B Fires
5. Accelerated Storage (Container)
6. Tensile Strength (Container)

CONCENTRATE TESTS:

METHODS

A. Qualitative Infrared Analysis – An infrared spectrum was obtained by means of an infrared spectrophotometer.

B. pH Determination – The pH of the maximum use concentration of the solution was determined by means of a pH meter.

C. Solubility – Throughout the storage and use temperature range, the wetting agent was observed to determine that a true solution was formed with water, which was stable up to the maximum concentration recommended for use by the manufacturer.

D. Separation Temperature – Aqueous solutions of the wet6ting agent at the maximum use concentration were observed to determine that there was no separation at any temperature between 32-120°F.

E. Separation on Standing – The wetting agent, in concentrations specified for use by the manufacturer, was tested to determine that there was no tendency to “layer out” or otherwise separate, on standing for 30 days.

F. Action after Freezing – Aqueous solutions of the wetting agent in concentrations specific for the use by the manufacturer, were frozen for 1 hour and then warmed to 60°F.

G. Viscosity – Viscosity was determined at 15.6°C by standard laboratory methods.

H. Surface Tension – Surface tension was determined by a Traube Stalagmometer in accordance with ASTM D-1331. A 3.8 percent solution of the sample was made with distilled water. The surface tension of only distilled water was determined before testing the concentrate solution. Three determinations were made.

RESULTS

Test	Results Date of Spectrum
A. Infrared Analysis	N3-23-94
B. pH Determination	5.6
C. Solubility	Acceptable
D. Separation Temperature	Acceptable
E. Separation on Standing	Acceptable
F. Action after Freezing	Acceptable
G. Viscosity	15 (centipoises)
H. Surface Tension	

Sample ID	Concentrate (dyne/cm @ 25°C)	0.0015 Blend (dyne/cm @ 25°C)
Trial #1	31	33
Trial #2	31	34
Trail #3	31	34
Average	31	33.6
Corrected Surface Tension	30.2	32.7

ACTION ON FIRE HOSE:

METHOD

Samples of fire hose were cut into 1 in squares, weighed and placed into 100 cc of the prepared 0.15 percent concentrate solution of wetting agents. Similar samples were placed in distilled water of 30 days. AT the end of the 30 days, the samples were dried and examined for signs of swelling or disintegration. Fifty additional samples of the fire hose were cut into 1 in lengths. For a period of 24 h, 25 samples were immersed in distilled water at 23°C and 25 samples were immersed in prepared 0.15 percent concentrate solutions of wetting agent at 23°C. After 24 h the samples were removed from the solutions, dried and conditioned for 48h at 100°F. After the conditioning at 100°F, the samples were subjected to tensile strength tests in accordance with ASTM D2256 (Test for Breaking Load Strength and Elongation of Yarn by the Single-Strand Method).

RESULTS

ACTION ON FIRE HOSE

Sample	Hose Type	Weight as received g	Weight after conditioning g	Exposure Conditions Time (Days	Temp (°C)	Exposure	Weight Change Percent	Weight Change Average Percent
1	Lined	0.0986	1.1237	30	23	Distilled Water	23.67	24.87
2	Lined	0.9296	1.1585	30	23	Distilled Water	24.60	
3	Lined	0.8943	1.1249	30	23	Distilled Water	25.79	
4	Lined	0.9150	1.1430	30	23	Distilled Water	24.92	
5	Lined	0.9086	1.1390	30	23	Distilled Water	25.36	
6	Lined	0.9092	1.1205	30	23	Distilled Water	23.24	22.87
7	Lined	0.8978	1.1040	30	23	Distilled Water	22.97	
8	Lined	0.9303	1.1444	30	23	Distilled Water	23.01	
9	Lined	0.8937	1.0895	30	23	Distilled Water	21.91	
10	Lined	0.9339	1.1508	30	23	Distilled Water	23.23	
11	Lined	0.8969	1.1088	30	23	Distilled Water	23.63	24.02
12	Lined	0.9378	1.1612	30	23	Distilled Water	23.82	
13	Lined	0.9061	1.1178	30	23	Distilled Water	23.36	
14	Lined	0.9313	1.1574	30	23	Distilled Water	24.28	
15	Lined	0.9207	1.1509	30	23	Distilled Water	25.00	

Sample	Hose Type	Weight as Received g	Weight after Conditioning g	Exposure Conditions Time (Days	Temp (°C)	Exposure	Weight Change Percent	Weight Change Average Percent
16	Lined	0.8897	1.0906	30	23	Distilled Water	22.58	23.88
17	Lined	0.9189	1.1391	30	23	Distilled Water	23.96	
18	Lined	0.8900	1.1195	30	23	Distilled Water	25.79	
19	Lined	0.8829	1.0885	30	23	Distilled Water	23.29	
20	Lined	0.8903	1.1022	30	23	Distilled Water	23.80	
21	Lined	0.9000	1.1273	30	23	Distilled Water	25.26	25.41
22	Lined	0.9244	1.1593	30	23	Distilled Water	25.41	
23	Lined	0.8999	1.1566	30	23	Distilled Water	28.53	
24	Lined	0.9247	1.1391	30	23	Distilled Water	23.18	
25	Lined	0.8881	1.1010	30	23	Distilled Water	24.65	
1	Lined	0.9168	1.1621	30	23	0.15 percent	26.76	26.10
2	Lined	0.9146	1.1398	30	23	0.15 percent	24.62	
3	Lined	0.9272	1.1801	30	23	0.15 percent	27.28	
4	Lined	0.9153	1.1576	30	23	0.15 percent	26.47	
5	Lined	0.9061	1.1360	30	23	0.15 percent	25.37	
6	Lined	0.9227	1.1577	30	23	0.15 percent	25.47	25.55
7	Lined	0.9107	1.1269	30	23	0.15 percent	23.74	
8	Lined	0.9305	1.1593	30	23	0.15 percent	24.59	
9	Lined	0.9306	1.1844	30	23	0.15 percent	27.27	
10	Lined	0.9452	1.1973	30	23	0.15 percent	26.67	
11	Lined	0.9081	1.1923	30	23	0.15 percent	31.30	26.28
12	Lined	0.9058	1.1219	30	23	0.15 percent	23.86	
13	Lined	0.9130	1.1467	30	23	0.15 percent	25.60	
14	Lined	0.8893	1.1081	30	23	0.15 percent	24.60	
15	Lined	0.9291	1.1710	30	23	0.15 percent	26.04	
16	Lined	0.9070	1.1655	30	23	0.15 percent	28.25	26.35
17	Lined	0.9133	1.1579	30	23	0.15 percent	26.78	
18	Lined	0.9300	1.1630	30	23	0.15 percent	25.05	
19	Lined	0.9535	1.2003	30	23	0.15 percent	25.88	
20	Lined	0.9254	1.1623	30	23	0.15 percent	25.53	
21	Lined	0.9031	1.1645	30	23	0.15 percent	28.94	26.90
22	Lined	0.9086	1.2210	30	23	0.15 percent	34.38	
23	Lined	0.8946	1.0939	30	23	0.15 percent	22.28	
24	Lined	0.8858	1.1001	30	23	0.15 percent	22.97	
25	Lined	0.9042	1.1388	30	23	0.15 percent	25.95	

		Tensile Strength Break Load – 1b after Exposure	
Sample	Hose Type	Distilled Water	3% Wetting Agent Solution
1	Lined	25.7	27.7
2	Lined	30.6	32.4
3	Lined	32.0	28.5
4	Lined	24.6	24.9
5	Lined	25.5	23.0
6	Lined	26.0	21.5
7	Lined	25.5	21.0
8	Lined	27.5	26.5
9	Lined	23.6	37.0
10	Lined	23.5	26.3
11	Lined	19.4	25.7
12	Lined	27.5	23.5
13	Lined	33.4	22.3
14	Lined	30.3	22.8
15	Lined	33.5	26.1
16	Lined	21.4	27.0
17	Lined	23.5	23.8
18	Lined	28.5	22.8
19	Lined	35.2	22.8
20	Lined	26.5	23.2
21	Lined	23.7	26.0
22	Lined	33.0	28.0
23	Lined	28.5	29.8
24	Lined	19.5	25.7
25	Lined	23.5	30.5
	Average	26.9	26.0

Class A Fire – Fiber Board:

METHOD

Fiberboards measuring 12 by 12 by ½ in. were used for this test. Sample boards, one at a time, were placed on a steel grid and exposed to an alcohol flame from a burning pan for a period of 105 s. The burning pan was then removed and a clean dry pan was placed under the board to collect the water or agent runoff. 250 cc of water or wetting agent solution was then poured onto the board using a sprinkler bottle. Each sample board was weighed before and after the test to determine weight loss.

RESULTS

Sample	Agent	Weight Before g.	Weight After g.	Weight Loss g.	Weight Loss Percent
1	+	266	302	0	0
2	+	285	355	0	0
3	+	293	306	0	0
4	++	280	318	0	0
5	++	279	312	0	0
6	++	290	412	0	0

+ - Water
++ - Wetting Agent

CLASS A FIRE TEST – COTTON:

METHOD

A cylindrical perforated steel basket 7 in. long and 4 ½ in. diameter was filled with 50 g of cotton. A stainless steel rod preheated to approximately 1100°F was placed into the centre of the basket of top of the cotton. The remaining 50 g of cotton was placed into the basket on top of the stainless steel rod. 250 cc of water or wetting agent solution was then poured onto the cotton in the basket. The runoff of water or wetting agent solution from the basket with cotton was collected and weighed.

RESULTS

Test	Fire Extinguished	Runoff Collected, cc
	Test 1 - Water	
1	No	20
2	No	16
3	No	24
		Average 20

(table continued)

Test	Fire Extinguished	Runoff Collected, cc
	Test 2 – Wetting Agent	
1	Yes	3
2	Yes	8
3	Yes	4
		Average = 5

CLASS A FIRE TEST – CRIB:

METHOD

The construction and arrangement of the wood crib, and ignition and attack of the wood crib fire with the wetting agent are described in Pars. 5.8-5.19 UL 711.

For the tests a 2 ½ gal extinguisher was charged with 2 ½ gal of the premixed wetting agent and pressurized.

RESULTS

Test	Wetting Agent Concentration Percent	Operating Pressure, PSI	Preburn, Min:s	Discharge Duration, Min:s	Crib Size	Fire Extinguished
1	0.15	100	7:50	59:0	2A	Yes
2	0.15	100	7:48	58:5	2A	Yes

CLASS B FIRE TEST:

METHOD

Class B fire tests were conducted in a 50 ft^2 square steel pan as described in Pars. 6.7-6.13 of UL 711. A 2” layer of heptane was floated on a 4” depth of water. A 10 gpm nozzle was fixed in position to direct the wetting agent solution discharge across the pan onto the backboard for the entire duration of the discharge. The fuel was ignited and allowed to burn for 1 min. prior to application of the wetting agent.

RESULTS

Wetting Agent Concentration, Percent	Application Rate, gpm	Nozzle Inlet Pressure, psi	Control Time Min:s	Extinguishment Time, Min:s
0.15	0.2	122	8:25	8:48
0.15	0.2	122	8:45	9:00
0.15	0.2	122	12:05	12:20

AIR OVEN AGING TEST OF CONTAINER:

METHOD

Sample container filled with cold fire wetting agent were conditioned at 50°C for 60 days. Following this conditioning each sample container was rinsed with tap water. Tensile strength specimens were prepared from the conditioned sample container and the “as received” sample container using the vertical side portions of the containers. Tensile strength was determined on both sets of specimens with a crosshead speed of 0.2 in./min as outlined in ASTM D638.

RESULTS

Results are shown in Table I.

TENSILE STRENGTH:

Specimens were cut from containers as-received and after air oven aging testing as described in this Report. The specimens were then subjected to the tensile strength test in accordance with Standard Test Method for Tensile Properties of Plastics, ANSI/ASTM D63.

RESULTS

Results are shown in Table I.

Table I

Sample	Break Load, lb	Container Wall Thickness, mils	Specimen Width, mils	Tensile Strength, psi
		As-Received		
1	116.0	0.090	0.485	2652
2	110.0	0.086	0.488	2621
3	132.5	0.095	0.504	2767
4	113.5	0.086	0.495	2666
5	118.0	0.086	0.518	2649
			Average	2671
		After 60 Days at 50°C (Air Oven Aging)		
1	117.5	0.085	0.504	
2	105.0	0.080	0.486	
3	117.0	0.085	0.515	
4	126.0	0.086	0.519	
5	120.0	0.083	0.525	
			Average	2752

Break load: 1b
Perfect of original = 103

CONCLUSION

Samples of the products covered by this Report have been found to comply with the requirements covering the Class and the products are judged to be eligible for Listing and Follow-Up Service. The manufacturer is authorized to use the Laboratories' Mark on such products, which comply with the Follow-Up Service Procedure and any other applicable requirements of the Underwriters Laboratories Inc. Only those products which properly bear the Laboratories' mark, are considered as Listed by Underwriters Laboratories Inc.

Report by:

Frank Husak
Engineering Associate

Reviewed by:

Emil W. Misichko
Engineering Group Leader

Fire Freeze Worldwide
Cold Fire

PATENT PENDING

270 Route 46
Rockaway, N.T 07866

COMPOSITION OF LISTING MARK ACCEPTED FOR USE ONLY ON LISTED PRODUCTS DESCRIBED BY FOLLOW-UP SERVICE PROCEDURE
DATE
Underwriters Laboratories Inc.

UL ®

LISTED
WETTING AGENT
2N75

Nf • CONTENTS- [ ] U.S. GALLONS

LOT NO. [ ]

INCORPORATED 1 92O

UNDERWRITERS' LABORATORIES OF CANADA

In Replying Please Refer to

CExl225
18865

October 25, 1995

Mr. Juergen Giessler
President
Firefreeze Worldwide, Inc.
270 Route 46 East
Rockaway, New Jersey
U.S.A. 07866

Subject: Wetting Agent. Cold Fire

Dear Mr. Giessler:

We have completed our investigation of the subject device and are pleased to enclose your copy of the Listing Report.

A copy of the Label Service Procedure CExl225, Vol. I was forwarded to you on September 21, 1995.

We are closing out the account under Application No. 18865 and requesting our Accounting Department to forward the final invoice.

If we may be of further assistance, please do not hesitate to contact us.

Yours very truly,

George Unger, P.Eng. Project Engineer
Appliances and Equipment

GU/klp

General Offices and Testing Station 7CROUSE ROAD. SCARBOROUGH, ONTARIO. CANADA MIR 3A9 Telephone (416) 757.2511
Fax: Accounting 1 Standards (416) 757-3915 Engineering (416) 757-1781 Follow-Up-Services (416) 757-9540

INCORPORATED 1920

UNDERWRITERS' LABORATORIES OF CANADA

File Cex1225
Application No. 18865
October 25, 1995

REPORT

on

WETTING AGENT

Firefreeze Worldwide, Inc.
Rockaway, New Jersey

D E S C R I P T I O N

PRODUCT COVERED:

Wetting Agent, Cold Fire.

GENERAL CHARACTER AND USE:

The wetting agent is a chemical compound which, when added to water at a 0.15 percent concentration, reduces the solution's surface tension, increases its penetrating and spreading abilities and provides emulsification and foam characteristics.

The wetting agent, when added to water at a 0.15 percent concentration, is effective on Class A and Class B fires at a discharge rate of up to 80 litres/min. per sq. metre. It may be used in accordance with the Standard of National Fire Protection Association for Wetting Agents, NFPA No. 18.

The wetting agent is suitable for use at or above 2°C.

MARKING:

Each container of listed wetting agent is eligible to bear a label which reads:

Underwriters' Laboratories of Canada
Listed
Wetting Agent
No. _____C

Together with the Listee's name and address.

PACKAGING:

The wetting agent is packaged in the following:
1 plastic 19 Litre Container – "WINPAK"
2 plastic 208 Litre Drum – "HEDRUM"

Both containers are manufactured by Hedwin Corporation, Baltimore, Maryland

THE INVESTIGATION

The object of this investigation was to determine compliance of this product with the current requirements of Underwriters' Laboratories of Canada for this class of product as included under ULC Subject C175.

This wetting agent has been previously investigated by Underwriters' Laboratories Inc., under Project No. 94NK2487, File EX4660. During that investigation, the following tests were conducted with acceptable results:

1. Concentrate – Physical & Chemical Tests
2. Action on Typical Fire Hose
3. Fire Extinguishment – Class A
4. Fire Extinguishment – Class B
5. Container Aging
6. Container Strength

A review of the data obtained indicated that a further complete test program was not necessary to establish a listing.

The following identification tests were conducted at Underwriters' Laboratories of Canada on samples of the product.

TEST RECORD

CHEMICAL IDENTIFICATION:

METHOD

Qualitative Infrared Analysis - An infrared spectrum was obtained using an infrared spectrophotometer.

pH Determination – The pH of a 0.15 percent concentration of the solution and the concentrate alone was determined using and Accument pH meter, 915, at a temperature of 16°C.

Action after Freezing – Aqueous solutions of the wetting agent in a 0.15 percent concentration were frozen for 1 h and then warmed to 16°C. Observations for separation of the wetting agent after warming up were made.

Viscosity – The viscosity of the wetting agent was determined at 16°C by use of a Brookfield Viscometer, Model RUT.

RESULTS

The following results were obtained:

1. Infrared Spectrum – See Appendix A

2. pH – 6.30 – 100 percent
   6.76 – 0.15 percent

3. Action After Freezing – no Separation or Layering

4. Viscosity – 71 cps

C O N C L U S I O N S

CONFORMITY:

On the basis of the foregoing, the design, construction and performance of the product covered by this Report are judged to be in compliance with the current requirements of Underwriters' Laboratories of Canada as included under ULC-Subj. C175.

The wetting agent may be used in accordance with the requirements of the Standard of the National Fire Protection Association for Wetting Agents, NFPA 18.

L I S T I N G T E X T

On the basis of the foregoing, the following listing text will be promulgated under Guide No. 100 X90.24 and the Follow-Up Service inaugurated.

Guide No. 100 X90.24 October 25, 1995 File: CEx1225

Wetting Agent

FIREFREEZE WORLDWIDE, INC., Rockaway, New Jersey 07866

Cold Fire, Wetting Agent, a liquid concentrate for addition to water to produce a solution having a greater fire extinguishing efficiency than plain water. For use on fires in Class A and Class B materials when mixed with water in proportion of not less than 0.15% by volume and applied at a rate of not less than 80 L/min/m^2.

Use of wetting agent solutions should be limited to equipment where the suitability of the wetting agent for use in that equipment has been determined.

The concentrate is suitable for storage at a minimum temperature of 2°C.

Marking: ULC label on each container together with the month and year of manufacture, the batch number, the minimum and maximum storage temperatures, the Listee's name, and product designation and the liquid concentration, and minimum application rate.

LISTED – Label Service

The ULC label or listed marking on a product is the only evidence provided by Underwriters' Laboratories of Canada to indentify products which have been produced under the Listing and Follow-up Service.

See General Information Section under above Guide No. in the ULC List of Equipment and Materials, Volume I, General (and Supplements thereto).

TESTS BY:	REPORT BY:	REVIEWED BY:
S. Steele	George Unger, P.Eng. Project Engineer Appliances & Equipment	S. J.Pople, P.Eng Managing Engineer Appliances & Equipment

UNDERWRITERS'
LABORATORIES OF CANADA

REPORT 3292

R. J. Wright/P.Eng.
Chief Engineer

/kip

INCORPORATED 1920
UNDERWRITERS' LABORATORIES OF CANADA
General Office and Testing Station 7 CROUSE RD, SCARBOROUGH,ON
MIR3A9 Telephone(416)757-3611 Telex 06-963643 Fax
(416)757-9540

In Replying
PlMwhftrioCExl225

Date JAN 3 1996

Firefreeze Worldwide
Inc., 270 Route 46 East,
Rockaway, NJ 07866
U.S.A.

Attention: Mr. Juergen Giessler,
President.

Subject: Listing of your: Wetting Agents

Gentlemen:

We enclose copy of the listing text, which we shall publish in our List of Equipment and Materials for the above-mentioned item.

We suggest that you carefully review this proposed listing and should there be any inaccuracies or omissions, please write to Mr. S. Pople with COPY TO THE UNDERSIGNED.

Unless we hear from you to the contrary within fifteen business days from the above date, we shall assume that the information is acceptable.

Yours very truly,

Tammy Tkachuk,
Support Services Coordinator,
Standards and Records Department.

TT/hf Attachment
Form 443A

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FIRE SYSTEM SERVICES
T: 1300883473 | E: info@firesys.com.au | W: www.firesys.com.au
COLD FIRE

CHEMICAL OPTIONS TO HALONS FOR AIRCRAFT USE

EXECUTIVE SUMMARY

This report which is an update of two earlier reports published in February 1995 and September 1996, summarizes available fire suppression technologies that could be considered as halon substitutes for the four major aircraft onboard applications:

(1) engine nacelles
(2) hand-held extinguishers
(3) cargo compartments
(4) lavatory protection

The options are divided into two groups: replacements (halocarbon agents) and alternatives (all other options). The technologies are discussed and the applicability of each is assessed for the four primary applications.

During preparation of this report, draft versions were updated and posted on an Internet site to permit review, comment, and recommendations by the International Halon Replacement Working Group members and others. In particular, manufacturers were informed of the Internet posting to allow review and comment on discussions of their products.

1. INTRODUCTION

1.1 OVERVIEW OF FIRE PROTECTION

The most common fuels in fire and explosion incidents are petroleum products, cellulosic materials (wood, paper), and polymers. Fires of cellulosic materials are termed —Class A“ and liquid fuel fires are termed —Class B.“ Polymeric material fires can exhibit characteristics of either Class A or Class B depending on the extent of melting (if any) during combustion. Class C fires involve energized electrical equipment and Class D fires, flammable metals. Rapid gas phase combustion can result in an explosion or, in the limit as the combustion becomes very rapid, detonation.

There are five general types of fire and explosion protection applications for aircraft: (1) total- flood fire extinguishment, (2) total-flood fire suppression (3) streaming fire extinguishment, (4) explosion suppression, and (5) inertion against explosions and fires. The Fire Protection Handbook and the SFPE Handbook of Fire Protection Engineering are excellent sources of information on all aspects of fire and explosion protection.

In total-flood applications, an extinguishing agent is discharged into an enclosed space to achieve a concentration sufficient to extinguish or suppress an existing fire. The agent concentration that a system/agent combination is designed to produce is termed the “design concentration.” Total-flood extinguishment usually uses fixed systems (e.g., non-portable systems attached to a protected structure) with either manual or automatic activation. Automatic systems detect a fire and automatically discharge the extinguishing agent. Total-flood applications include protection of enclosed spaces such as aircraft cargo compartments.

In streaming applications, an agent is applied directly onto a fire or into the region of a fire. This is usually accomplished using manually operated wheeled or portable extinguishers. Hand-held portable extinguishers provide fire protection in aircraft passenger compartments.

Halons are bromine-containing gaseous or volatile liquid chemicals used in fire and explosion protection. Most widely employed are Halon 1301, bromotrifluoromethane (CBrF3), used primarily as a total-flood agent, and Halon 1211, bromochlorodifluoromethane (CBrClF2), used primarily in streaming applications. These clean (residue-free) chemicals are applicable to Class A, B, and C fires. They cannot be used for Class D fires.

1.2 ENVIRONMENTAL OVERVIEW

Although airworthiness regulations do not require the use of a particular fire suppression agent, halons have been the agents of choice of airframe manufacturers. For all practical purposes, production of halons has ceased under the provisions of the Montreal Protocol. The primary environmental characteristics to be considered in assessing a new chemical option to halons are Ozone Depletion Potential (ODP), Global Warming Potential (GWP), and Atmospheric Lifetime. The agent selected should have environmental characteristics in harmony with international laws and agreements, as well as applicable national, state, and local laws. An agent that does not have a zero or near-zero ODP and the lowest practical GWP and Atmospheric Lifetime may have problems of international availability and commercial longevity.

1.3 TOXICOLOGY OVERVIEW

The toxicological acceptability of a chemical option to halons is dependent on its use pattern. As a general rule, the agent must not pose an unacceptable health risk for workers during installation, maintenance, or operation of the extinguishing system. In areas where passengers or workers are present, or where leakage could cause the agent to enter the passenger compartment, at no time should the cumulative toxicological effect of the agent, its pyrolytic breakdown products, and the by-products of combustion pose an unacceptable health risk during probable normal and failure conditions.

1.4 OPTIONS

The following defines some terms used in this report. The term “options” is used for anything that could be used in place of halons “Replacements” denote halocarbon fire extinguishants, i.e., agents that are chemically similar to the present halons. “Alternatives” are everything else.

Chemical alternatives“ are materials such as carbon dioxide (CO2), foam, water, and dry chemicals, whose chemistry differs significantly from that of the halons “Engineering alternatives“ (not covered in this report) involve such approaches as rapid response and fire-resistant structures. Note that many alternative technologies are actually “chemical/system” alternatives since the agent and system cannot be separated (e.g., solid propellant gas generators, SPGGs).

Alternatives and replacements have been discussed in a number of papers. Any option to the use of halons must have U.S. Environmental Protection Agency (EPA) approval under the Significant New Alternatives Policy (SNAP) program, which implements section 612 of the amended Clean Air Act of 1990. Following publication of an advance notice of proposed rule making and a request for data on new chemicals, the EPA published the proposed plan for the SNAP program and an initial proposed list of decisions on acceptable and unacceptable halon substitutes on 12 May 1993. The final plan and the first list were promulgated on 18 March 1994. This initial list was prepared from an EPA background document

for halon replacements and alternatives. A current list of acceptability decisions can be found on the EPA website. Substances prohibited, acceptable only under certain conditions or for certain uses, or removed from a list of prohibited or acceptable substitutes are subject to public comment. Other substances for which there are no limitations are listed as acceptable with no public comment required.

2. HALOCARBON REPLACEMENTS

At present, halon replacements (e.g., halocarbons) fall into four major categories (see table 1). Note that two categories noted in the first report from the Task Group on Chemical Options to Halons CFCs (chlorofluorocarbons) and HBFCs (hydrobromofluorocarbons) are no longer being commercialized.

TABLE 1
CLASSES OF HALON REPLACEMENT

HCFCs	Hydrochloroflurocarbons
FCs (PFCs)	Perfluorocarbons
HFCs	Hydrofluorocarbons
FICs	Fluoroiodocarbons

There are a number of desirable characteristics for replacement agents. They must have acceptable global environmental characteristics (low ODPs, low GWPs, and low atmospheric lifetime) and an acceptable toxicity. A continuing debate on acceptable levels for these characteristics is expected. The primary reason for using halocarbons, rather than such alternatives as foams and dry chemicals, is that halocarbons are clean, volatile, and electrically nonconductive. Finally, the agent must be effective. Note, however, that effectiveness does not necessarily mean as effective as the present halons, though this is desirable.

Physical action agents (PAAs) are those that operate primarily by heat absorption. Chemical action agents (CAAs) are those that operate primarily by chemical means – removal of flame-free radicals. The chemical effect contribution to extinguishment by PAAs is only 10 to 25 percent of the physical contribution. In general, CAAs are much more effective extinguishants than are PAAs. Halons 1211 and 1301 are primarily CAAs. Work at the Naval Research Laboratory (NRL) indicates that Halon 1301 extinguishment of n-heptane in air is approximately 20 percent physical and 80 percent chemical. The analysis also indicates that about 25 percent of the extinguishment is due to the CF3 group and about 55 percent is due to the bromine. Though CAAs are more effective, they often have higher ODPs because they often contain bromine. One exception is trifluoroiodomethane, CF3I, which is the only CAA being commercialized today.

Most halocarbons now proposed as halon replacements require significantly higher concentrations than required for Halons 1301 and 1211 and produce larger amounts of toxic or corrosive by-products (e.g., hydrogen fluoride and, for chlorine-containing agents, hydrogenchloride). One halocarbon, CF3I, produces relatively large amounts of iodine. By-product formation is strongly influenced by

the mass flux of inhibitor into the flame sheet and the extinguishment time. Slow extinguishment due to the use of lower concentrations of agent produces more by-products.

2.1 TOXICOLOGY

2.1.1 Acute Toxicological Indices

Table 2 contains a summary of acute toxicological indices. These are discussed in more detail in the following text.

2.1.1.1 Lethality

The LC50 is defined as the concentration of a chemical that causes death in 50 percent of animals exposed for a specified duration of time. The test animals are observed during exposure and for a period of 14 days following exposure for lethality. The approximate lethal concentration (ALC) value, first established by DuPont but now used by other chemical manufacturers, approximates the lowest concentration that causes death (LCLO). Thus, it is lower than the LC50 value. The ALC value is often used in place of the LC50 in assessing safety.

TABLE 2
ACUTE TOXICOLOGICAL INDICES

Exposure		Definition
ALC	Approximate Lethal Concentration	The approximate concentration considered to cause death, similar to LC_{LO} but often used in place of LC_{50} when making assessments.
LC_{50}	Lethal Concentration – 50%	Concentration causing death in 50% of an animal test population exposed for the specified duration of time.
LC_{L0}	Lethal Concentration – Low	The lowest observed lethal concentration.
AD_{50}	Aesthetic Dose – 50%	Dose causing aesthesia in 50% of an animal test
RD_{50}	Respiratory Dose – 50%	Dose causing a 50% decrease in respiratory rate.
LOAEL	Lowest Observed Adverse Effect Level	The lowest exposure level that has been observed to cause an adverse effect. For inhalation of halocarbons, the effect is usually cardiac sensitization.
NOAEL	No Observed Adverse Effect Level	The highest exposure level that has been observed to cause no adverse effect. For inhalation of halocarbons, the effect looked for is usually cardiac sensitization.

2.1.1.2 Irritation

The RD50, the dose that causes a 50 percent decrease in respiratory rate, has been proposed as a measure of irritation of nasal mucosa. The RD50 response in animals appears to correspond to eye, nose, and throat irritation in humans.

2.1.1.3 Anaesthesia

Anaesthesia is the condition of loss of consciousness, usually coupled with the loss of response to pain and other stimuli. General anaesthesia results from a depression of the central nervous system (CNS) and can be exerted by a wide range of chemicals. Some anesthetic agents elicit CNS depression through specific receptor sites; whereas others have more generalized actions on other cellular sites such as the cell membrane. Anesthetic potency of chemicals is tested in experimental animals by observing decrements in coordination, loss of righting reflex (inability to stand upright after being placed on the back), reduced alerting response to an auditory stimulus, etc. The AD50 is the calculated value corresponding to the concentration at which 50 percent of the test animals experience anesthesia. Anesthetic potency or mild CNS depression can also be observed in humans using performance decrement studies.

2.1.1.4 Cardiac Sensitization

Cardiac sensitization is the term used for the phenomenon of the sudden onset of cardiac arrhythmias caused by a sensitization of the heart to epinephrine (adrenaline) in the presence of some concentration of a chemical. Cardiac sensitization (specifically leading to ventricular fibrillation) was first demonstrated in 1912 in cats exposed to chloroform in the presence of epinephrine, which was non-hazardous without epinephrine. Since then, cardiac sensitization has been demonstrated in humans as well as laboratory animals.

When comparing concentrations necessary to elicit acute toxic responses such as anesthesia, cardiac sensitization, or lethality, cardiac sensitization usually occurs at a lower concentration for halocarbons than other acute toxicity endpoints. Therefore, regulatory and standard-making authorities have used cardiac sensitization thresholds as the criterion for determining acceptability for use in areas where human occupancy may occur. Cardiac sensitization is particularly important in firefighting. Higher levels of epinephrine secreted by the body, under the physiological stress of a fire event, may increase the possibility of sensitization.

The experimental procedure used to investigate the cardiac sensitization potential of a chemical involves outfitting dogs with electrocardiographic (ECG) measurement devices and exposing the animals to a sequence of agent and epinephrine. Healthy male beagle dogs (generally six or more animals per exposure concentration), between 1 and 2 years old, are trained to stand in a cloth sling and to wear a snout mask. The dogs also learn to accept venipuncture and ECG monitoring. Thus, they are minimally stressed during the experiment.

The usual sequence of exposure is that the animal is monitored in a baseline condition without any intervention for 2 minutes (see Table 3). Epinephrine is then intravenously infused to determine the effect of this catecholamine on the cardiac system. The dose and time period for infusion varies slightly between laboratories; however, the levels of epinephrine given are always in the

pharmacological rather than the physiological range. (A pharmacological dose is considered to be greater than any potential innate physiological dose.) After approximately 5 minutes from the initial epinephrine administration, the agent is given as a continuous inhalation exposure either through a mask fitting over the dog's snout or in an exposure chamber. After a 5-minute agent exposure, epinephrine is administered intravenously (epinephrine challenge) along with the continuous agent exposure. The animals are monitored for another 5 minutes to determine the effect of epinephrine and agent. This protocol is performed at increasingly higher doses until a marked adverse response occurs.

TABLE 3
PROTOCOL FOR TESTING CARDIAC SENSITIZATION IN DOGS

Time, Minutes	Procedure
0	Start ECG recording
2	Administer epinephrine dose
7	Start inhalation of test gas or air
12	Administer epinephrine challenge dose
17	Stop test gas inhalation; stop ECG recording

A marked adverse response is one considered, in the judgment of the toxicologist, as the appearance of five or more multifocal ventricular ectopic beats or ventricular fibrillation that may be fatal. A mild response is described as an increase in the number of isolated abnormal beats (less than five consecutive beats) following the epinephrine challenge (second epinephrine administration). The threshold level is the lowest concentration at which cardiac sensitization occurs. No definitive rule exists indicating the number of animals that must experience a marked response to determine the threshold value. In most cases, even one animal experiencing a marked response constitutes establishment of a threshold value. This level is also called the Lowest Observed Adverse Effect Level (LOAEL). The highest concentration at which no marked responses occur is called the No Observed Adverse Effect Level (NOAEL). For halocarbons, these values are used when determining safe exposure levels for humans. While it is not known with certainty whether the LOAEL and NOAEL in dogs accurately represent these values in humans, the dog is the preferred animal model for determining cardiac physiology.

LOAEL and NOAEL concentrations entail measurement of cardio toxic effects in animals made sensitive to these effects by the administration of epinephrine. The administered epinephrine doses are just below the concentration at which epinephrine alone would cause cardiotoxicity in the experimental animal and are approximately ten times greater than the concentration a human would be likely to secrete under stress. Thus, LOAEL and NOAEL values are conservative even in high-stress situations.

Because the cardiac sensitization potential is measured in dogs, a means of providing human relevance to the concentration at which this cardiosensitization

occurs (LOAEL) has been established through the use of physiologically based pharmacokinetic (PBPK) modeling.

The PBPK model, as described in the National Fire Protection Association (NFPA) 2001 standard, provides safe human exposure times for various concentrations of halocarbons. A PBPK model is a computerized tool that describes time-related aspects of a chemical's distribution in a biological system. The PBPK model mathematically describes the halocarbon uptake into the body and the subsequent distribution of the halocarbon to the areas of the body where adverse effects can occur. For example, the model describes the breathing rate and uptake of the halocarbon from the exposure atmosphere into the lungs. From there, the model uses the blood flow bathing the lungs to describe the movement of the halocarbon from the lung space into the arterial blood that directly feeds the heart and vital organs of the body.

It is the ability of the model to describe the halocarbon concentration in human arterial blood that provides its primary utility in relating the dog cardiac sensitization test results to a human who is unintentionally exposed to the halocarbon. The concentration of the halocarbon in the dog-arterial blood at the time the cardiac sensitization occurs (5-minute exposure) is the critical arterial blood concentration, and this blood parameter is the link to the human system. Once this critical arterial blood concentration has been measured in dogs, the EPA-approved PBPK model simulates how long it will take the human arterial blood concentration to reach the critical arterial blood concentration (as determined in the dog test) during human inhalation of any particular concentration of the halocarbon agent.

2.1.2 Subchronic and Chronic Tests

2.1.2.1 Ninety-Day Subchronic Toxicity Test

The 90-day subchronic toxicity test is an assay that determines changes due to repeated and prolonged chemical exposure. Subchronic toxicity testing is one of the studies for developing industrial exposure standards.

2.1.2.2 Chronic Toxicity Testing

Chronic toxicity tests are conducted over the greater part of the animal's lifespan (1.5 to 2 years in mice and 2 or more years in rats), starting at weaning, with daily exposure to the test agent.
The principal endpoint is tumor formation, as determined by histological exam.

2.1.2.3 Carcinogenicity Screening

Chemical carcinogenesis is usually the result of long-term exposure to a chemical. To determine the potential for long-term toxicity and possible carcinogenicity, genotoxicity (mutagenicity) tests are often performed. Positive results, i.e., the chemicals produced a mutagenic effect, alert toxicologists to the possibility of

long-term effects including carcinogenicity. The following genotoxicity tests are most often used.

2.1.2.4 Ames Test

The Ames test, an *in vitro* test for mutagenicity and, by implication, carcinogenicity, uses mutant strains of bacterium *Salmonella typhimurium* as a preliminary screen for carcinogenic potential. A number of strains of S. typhimurium comprise the Ames test, and positives indicate that a mutation in the genetic material has occurred. Mutagenic and presumed carcinogenic materials cause genetic mutations that allow the bacterial strains to grow in a histidine-free medium.

2.1.2.5 Mouse Lymphoma Test

The mouse lymphoma test, also an *in vitro* screening test, uses cell cultures of mouse lymphoma cells. The mutagenic potential of a material is tested by observing the ability to confer resistance within this cell line to normally toxic agents. Mutations in the genetic material allow the cells to grow in the presence of other known toxic materials (purines, pyrimidines, or ouabain). Promutagens (mutagenic agents that require metabolic activation) can also be identified.

2.1.2.6 Mouse Micronucleus Test

The mouse micronucleus test, an *in vivo* test, determines the potential of a chemical to cause chromosome breakage or interference with normal cell division. The test entails exposing live mice to the test material, removing premature red blood cells from the bone marrow, and observing the cells for the presence of chromosome fragments or the lack of signs of normal cell division. This test is not considered the most sensitive test for chromosomal aberrations.

2.1.2.7 Other Screening Tests

Other *in vitro* tests that yield information on the carcinogenic potential of an agent include the unscheduled deoxyribonucleic acid (DNA) synthesis test, the sex-linked recessive mutation test, and the sister chromatid exchange test. The unscheduled DNA synthesis (UDS) test involves the exposure of cultured hepatocytes (liver cells) to the test chemicals and monitors the repair of DNA following DNA damage by a mutagen. The sex-linked recessive mutation test for mutagenicity utilizes *Drosophila melanogaster* (fruit fly) males with a marker (yellow body) on the X chromosome. The sister chromatid exchange test, which can also be an *in vivo* test, detects DNA alkylating agents in Chinese hamster ovary cells.

The *in vivo* dominant lethal (rodent) test assesses the ability of a suspected mutagen, which has shown positive in an *in vitro* screen, to cause dominant lethal mutations in rats, mice, or hamsters. Male rodents are treated with the test substance and are then mated to groups of females over several weeks to test for

effects occurring at all stages of sperm formation. Following sacrifice, the females are evaluated for a number of fertility indices.

2.1.2.8 Interpretation of Carcinogenicity Results

For years the predictive value of short-term *in vitro* mutagenicity tests for potential carcinogenicity has been questioned. The degree to which the results of these short-termassays correlate with carcinogenicity in whole animals resulting in actual tumor formation largely depends on chemical class. For fluorinated hydrocarbons, the correlation has not proved to be exact.

2.1.3 Exposure Limits.

Four major non-commercial organizations (two governmental and two nongovernmental) establish or recommend occupational exposure limits. The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) are governmental organizations. Standards established under OSHA are enforceable, whereas NIOSH only sets recommended occupational exposure limits. The American Conference of Governmental Industrial Hygienists (ACGIH) and the American Industrial Hygiene Association (AIHA) are nongovernmental organizations that establish exposure limits. Table 4 gives the various types of exposure limits that have been established by these organizations. The only exposure limits actually used by industrial hygienists are the Permissible Exposure Limit (PEL), the Workplace Environmental Exposure Limit (WEEL), and the Threshold Limit Value (TLV), which all are the appropriate upper exposure limit for safe handling over a lifetime of occupational exposure (e.g., industrial processing rather than firefighting). The Acceptable Exposure Limit (AEL), which is widely cited, was originally used by DuPont; however, it is now given by a number of other commercial organizations. The Occupational Exposure Limit is similar to the other limits but can be established by any organization.

TABLE 4
EXPOSURE LIMIT DEFINITIONS

Exposure Limit		Establishing Organization	Definition
Long Term Exposures			
AEL	Acceptable Exposure Limit	Commercial	
OEL	Occupational Exposure Limit	Any	Similar to PEL but not enforceably
PEL	Permissible Exposure Link	0 SHA	Enforceable 8-hour Time-Weighted Average (TWA exposure limit for airborne substances intended to reduce a significant risk of health or functional capacity impairment.
REL	Recommended Exposure Limited	N10SH	Similar to TLV Values
TLV	Threshold Limit Value	ACGiH	TWA Exposure limits similar to PEL
WEEL	Workplace Environmental Exposure Limit Guide	AIHA	Similar to TLV Values
WGL	Workplace Guidance Level	EPA	Eight-hour per day TWA value analogous to PEL Value
Short-Term Exposures			
CL	Ceiling Level	0SHA	Enforceable exposure level that cannot be exceeded for any time period.
STEL	Short-Term Exposure Lim8it	0SHA	Enforceable 15-minute TWA exposure that should not be exceeded at any time during a workday.

Exposure Limit		Establishing Organization	Definition
IDLH	Immediately Dangerous to Life and Health	N10SH	Maximum concentration from which one could escape within 30 minutes without experiencing escape-impairing or irreversible health effects.
EGL	Emergency Guidance Level	EPA	Applies to a short-term exposure of 15 or 30 minutes and is similar to the IDLH
ERPG1	Emergency Response Planning Guild line, Level 1	AIHA	Maximum airborne concentrations below which it is believed nearly all individuals could be exposed up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
ERPG2	Emergency Response Planning Guild line, Level 2	AIHA	Maximum airborne concentrations below which it is believed nearly all individuals could be exposed up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protection action.
ERPG3	Emergency Response Planning Guild line, Level 3	AIHA	Maximum airborne concentrations below which it is believed nearly all individuals could be exposed up to 1 hour without experiencing or developing life-threatening health effects.

Of greater importance in fire protection are the limits established for exposure during agent discharge. Two somewhat differing sets of criteria have been established for total flood protection. The 2000 edition of the National Fire Protection Association (NFPA) Standard 2001 requires that the design

concentration for total flooding of a normally occupied area by halocarbons not exceed the cardiac sensitization NOAEL. In addition, halocarbon agent concentrations above 24 percent are not allowed in normally occupied areas. The Standard calls for avoidance of unnecessary exposure to agents covered in the Standard and for suitable safeguards to ensure prompt evacuation. Audible and visual pre-discharge alarms are required. New methods to determine limits on exposures and egress times using a physiologically based pharmacokinetic (PBPK) model are included in the Standard. Halocarbon systems for spaces that are normally occupied and designed for concentrations above the NOAEL and up to the LOAEL shall be permitted, given that means be provided to limit exposure to no longer than the time specified. In spaces that are not normally occupied and protected by a halocarbon system designed for concentrations above the LOAEL and where personnel could possibly be exposed, means shall be provided to limit exposure times using tables in the NFPA 2001 Standard. In the absence of the information needed to fulfill the conditions listed above, the following provisions shall apply.

1. Where egress takes longer than 30 seconds but less than 1 minute, the halocarbon agent shall not be used in a concentration exceeding its LOAEL.

2. Concentrations exceeding the LOAEL are permitted only in areas not normally occupied by personnel provided that any personnel in the area can escape within 30 seconds. No unprotected personnel shall enter the area during agent discharge.

The EPA SNAP program uses the cardiotoxic LOAEL value to assess use of an agent in normally occupied areas. In the past, the EPA has established use conditions for total flooding agents used for fire suppression based on OSHA regulation 1910.162. The EPA is preparing to replace these restrictions on exposure limits and egress times for halocarbon and inert gas total flooding agents and to recommend compliance with the 2000 version of the NFPA 2001 Standard. The 2000 version of the Standard is based on new and more precise risk assessment procedures (PBPK model) that bridge toxicological research on animals to actual concentrations measured in humans. The EPA will revise the SNAP listings for halocarbons and inert gas agents to include the comment: "Use of this agent should be in accordance with the safety guidelines in the latest edition of NFPA 2001 Standard for Clean Agent Fire Extinguishing Systems." The EPA expects to make these changes to the SNAP regulations available for public comment in early 2002.

The New Extinguishants Advisory Group (NEAG), a subgroup of the Halon Alternatives Group (HAG) in the U.K., has attempted to base allowable design concentrations for automatic systems in occupied areas on six endpoints: LC50, CNS effects, cardiac sensitization, respiratory sensitization, genotoxicity, and developmental toxicity. For the three halocarbon agents that they evaluated, NEAG found that cardiac sensitization or, in the case of very low-toxicity agents, hypoxia are the critical endpoints. At a recent HAG meeting, it was agreed to use the PBPK model.

2.2 ENVIRONMENTAL CONSIDERATIONS

2.2.1 Ozone Depletion Potential

Ozone Depletion Potentials (ODPs) are the calculated ozone depletions per unit mass of material released relative to a standard, normally CFC-11. It should be noted that ODPs are calculated; they cannot be measured. Although calculations of ODPs require time horizons (see section2.2.3), steady-state calculations have generally been used. Although ODPs vary somewhat, depending on the calculation method, it is believed that relative values for compounds containing the same ozone-depleting element are relatively reliable. Thus, halocarbons that contain only chlorine and fluorine (in addition to carbon and, possibly, hydrogen) can be compared to CFC-11. It is well-established that bromine is much more damaging to ozone than is chlorine on a per atom basis. Exactly how much more, however, is not precisely known and lends some uncertainty to the ODPs of bromocarbons. The model calculations used by the U.S. EPA incorporate an effect ratio of 55 chlorine atoms to 1 bromine atom. An excellent nontechnical historical overview is contained in reference 30.

2.2.2 Atmospheric Lifetime

Atmospheric lifetimes are generally modeled as e-folding lifetimes. The gas concentration decays exponentially following the equation Ct = C0e-t/L where C0 is the initial concentration, Ct is the concentration at any time t, and L is the atmospheric lifetime. After one lifetime, the gas concentration drops to 1/e (approximately 0.369) of its initial value. Note that this equation predicts that the concentration will never reach zero, although it can approach it very closely. For example, after only five lifetimes, the concentration drops to 0.0067 of its initial value.

2.2.3 Global Warming Potential

The GWP is the change in radiative forcing resulting from the emission of 1 kilogram of a chemical relative to the radiative forcing resulting from the emission of 1 kilogram of a reference gas. In the past, CFC-11 was often used as the reference; however, carbon dioxide (CO2) is now typically used. The global warming potential depends on three variables: (1) the location of the IR absorption bands, (2) the strength of the IR absorption bands, and (3) the lifetime of the gas. It is important to note that the GWP can vary significantly depending on the time period used for the comparison of the radiative forcing of the chemical relative to that of the reference. The time period used to calculate the GWP is termed the time horizon and is primarily a policy decision. Time horizons of 100 and 500 years are often used in calculated GWP values; however, other time horizons may be more appropriate. GWPs with longer time periods are believed to be more inaccurate than those with shorter time periods. All GWPs in this report are 100- and 500-year time horizon values referenced to carbon dioxide.

2.2.4 Atmospheric Impacts of Blends

Some replacement agents are blends of more than one component. The atmospheric impacts of blends should be evaluated by looking at the ODP, GWP, and the atmospheric lifetime of each component separately because each component acts independently when released to the atmosphere even if it has been blended with other components. The atmospheric effects of an individual component in a blend have the same impact as if the individual component were released to the atmosphere as a pure substance.

Some manufacturers calculate and report averages of ODP, GWP, and/or atmospheric lifetime for a blend. Other manufacturers do not identify all components and use the environmental characteristics of a principal component to represent the atmospheric impact of a blend. Neither the parties to the Montreal Protocol nor government agencies such as the U.S. Environmental Protection Agency accept such practices as representing an accurate evaluation of the atmospheric impact. Instead, such groups and organizations use the ODP, GWP, and atmospheric lifetime of each component to evaluate the overall atmospheric impact of a blend.

2.2.5 Regulatory Restrictions

Under the Montreal Protocol, production of the most commonly used halons (Halons 1301, 1211, and 2402) ceased on 1 January 1994 in industrialized (non-Article-5) nations (see Table 5). Non-industrialized (Article 5) nations have until 1 January 2010 (10 years from the date of the London Amendment schedule) to phase out halon production. In the U.S., the Clean Air Act implements the Montreal Protocol (see table 6). Under the Protocol, "consumption" is defined as the amount produced by a country minus exports plus imports. Thus, consumption is essentially the same as production.

TABLE 5
REDUCTIONS IN MAXIMUM ALLOWABLE CONSUMPTION UNDER THE MONTREAL PROTOCOL AS AMENDED IN 1995

Year	CFCs	Halons	Methyl Chloroform	Carbon Tetrachloride	Methyl Bromide	HCFCs	HBFCs
1994	75%	50%					
1995				85%	Cap[b]		
1996	100%		100%	100%		Cap[b]	100%
1999					25%		
2001					50%		
2003					70%		
2004						35%	
2005					100%		
2010						65%	
2015						90%	
2020						99.5%	
2030						100%	

[a] Beginning January 1 of the year cited, the annual consumption amounts (essentially, the amount produced) must meet the prescribed cuts. The base years are CFCs in original Protocol, 1986; CFCs in 1990 amendment, 1989; halons, 1986; methyl chloroform and carbon tetrachloride, 1989; and methyl bromide, 1991. The base for HCFCs is the 1989 ODP-weighted HCFC consumption plus 2.8% of the 1989 ODP-weighted CFC consumption.
[b] Freezing at specific year levels

TABLE 6
CONTROLS UNDER CLEAN AIR ACT AMENDMENTS OF 1990

Ozone-Depleting Chemicals	Baseline Year	Allowed Production	
		January	Percent of Base Year
Class I Substances			
Group I: CFC-11,12,113,114,115	1986	1994 1995 1995	25 25 0
Group II: Halon 1211,1301,2402	1986	1994	0
Group III: CFC-13,111,112,211	1989	1994	25
Group IV Carbon Tetrachloride	1989	1994 1995 1996	50 15 0
Group V Methyl Chloroform	1989	1994 1995 1996	50 30 0
Group VI Methyl Bromide	1991	1994 1995 1996 1997 1998 1999 2001 2003 2005	100 100 100 100 100 75 50 30 0
Group VII HBFCs	1991	1994 1995 1996	100 100 0
Class II Substances			
HCFC-141b		2003	0
HCFC-22, -142b		2010 2020	100 0
HCFC-123, -124, remaining HCFCs		2015 2030	100 0

A 100% denotes a freeze in production to the base year. b HCFC-22 and -142b can be produced between 2010 and 2020 only to service equipment manufactured prior to 1 January 2010. HCFC-123, -124, and remaining HCFCs can be produced between 2015 and 2030 only to service appliances manufactured prior to 1 January 2020. The HCFC controls do not apply to used or recycled HCFCs, HCFCs used as feedstocks, or HCFCs for use in a process that transforms or destroys the chemical. c The base for HCFCs is the 1989 ODP-weighted HCFC consumption plus 2.8% of the 1989 ODP-weighted CFC consumption.

2.3 COMMERCIALIZED HALOCARBON REPLACEMENTS

Here, the term commercialized is used to refer to materials now being marketed or which are planned to be marketed in the near future. Most of the commercialized agents are PAAs–hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), or perfluorocarbons (FCs or PFCs). The only CAA now being commercialized is CF3I.

HCFCs have a nonzero ODP and currently face an eventual regulated production phase out. Some restrictions are already in place in parts of Europe. The European Union in many cases has accelerated phase out dates. The current

regulations can be found on the website of the European Communities. Another useful site is the European Union‘s website on ozone layer protection.

Under the SNAP program, the EPA has applied narrowed use limits to the use of perfluorocarbons. PFCs are fully fluorinated compounds, unlike HCFCs or HFCs, and have several attractive features. They are nonflammable, have low toxicity, are exempt from federal volatile organic hydrocarbons (VOC) regulations, and do not contribute to stratospheric ozone depletion. The environmental characteristics of concern, however, are their high global warming potentials (approximately 5,000 to 10,000 times that of CO2 for commercialized halon replacements) and their long atmospheric lifetimes (approximately 5,000 to 7,000 years for commercialized replacements). As the time horizon increases, the GWP for these compounds also increases, making these compounds particularly undesirable. Although the actual contributions to global warming depend upon the quantities emitted, the long lifetimes make the warming effects of PFCs virtually irreversible. The EPA is allowing the use of PFCs for only selected applications where no other substitutes are technically feasible due to performance or safety requirements. Because of the concerns about their long atmospheric lifetimes and high GWP, 3M has pulled out of this business. At a recent Fire Protection subcommittee meeting of the International Maritime Organization (IMO), it was pointed out that new installation of fire suppressant where good fire engineering can be employed, made the use of PFCs unnecessary.

The Maritime Safety Circular (MSC) prohibits the use of PFCs in new shipboard fire suppression systems, since they determined that there are no essential marine uses for PFCs.

HFCs are attractive as replacements for ozone depleting substances for three reasons: (1) they are usually volatile and many have low toxicities, (2) they are not ozone depleting as are the HCFCs and because they have lower atmospheric lifetimes than PFCs, they are likely to receive less regulatory action than HCFCs or PFCs, and (3) they have properties similar to those of halocarbons that have been used in the past. This does not, however, mean that HFCs are not receiving scrutiny from environmental organizations. A recent study by the National Institute of Public Health and Environmental Protection, The Netherlands, has projected a significant increase in greenhouse gas emissions due to use of HFCs to replace CFCs and HCFCs. Moreover, Denmark has announced they plan to phase out all hydrofluorocarbons (HFCs) within the next 10 years (written in 1996) due to global warming. Other European countries such as Austria and Norway are considering regulation of HFC use.

Of particular interest is that halocarbons other than Halons 1211 and 1301 are banned from all fire protection equipment in Denmark other than that used by the Fire Brigade. Denmark is leading the promotion of natural (nonhalocarbon) fire extinguishants (water sprinklers and mist, carbon dioxide, dry chemical, foam, and inert gases).

A large number of candidate replacement agents have been announced for commercialization, and even more chemicals are under serious consideration. A number of halocarbon replacements have been announced for total-flood applications (see Table 7). All of these agents are contained in the NFPA 2001 Standard.

TABLE 7
COMMERCIALIZED TOTAL-FLOOD AGENTS

Agent	Chemical	Formula	Trade Name
Halon 1301	Bromotriflourom ethane	$CBrF_3$	
HCFC-124	Chlorotetrafluoro ethane	$CHC1FCF_3$	DuPont FE-241
HCFC Blend A HCFC-123 HCFC-22 HCFC-124	Additive plus Dichlorotrifluoro ethane Chlorodifluoram ethane Chlorotetrafluoro ethane	 $CHC1_2F_3$ $CHC1F_2$ $CHC1FCF_3$	North America Fire Guardian NAF S-III
HFC-23	Trifluorom ethane	CHF_3	DuPont FE-13
HFC-125	Pentafluoro ethane	$CHCF_2CF_3$	DuPont FE-25
HFC-227ea	Heptafluoropropane	CF_3CHFCF_3	Great Lakes FM-200 DuPont FE-227
HFC-236fa	1,1,1,3,3,3-Hexafluoropropane	$CF_3CF_3CF_3$	DuPont FE-36
FC-218	Perfluoropropane	$CF_3CF_3CF_3$	3M Company CEA 410
FIC-13I1	Trifluoroiodom ethan	CF_3	West Florida Ordnance Iodoguard; Ajay North America

The design concentrations for total-flood fire extinguishment for *n*-heptane, a standard fuel, are shown in Table 8. These design concentrations are, in general, determined as the cup burner extinguishment concentration increased by a safety factor of 30 percent; though the results of other testing may be taken into account. Both the International Standards Organization (ISO) standards on gaseous fire extinguishing agents and the 2000 edition of the NFPA 2001 standard require a safety factor of 30 percent. The information for this table was compiled from (1) information from manufacturers and (2) the NFPA 2001 Standard and the NFPA 12A Standard.

TABLE 8
DESIGN CONCENTRATIONS OF COMMERCIALIZED TOTAL-FLOOD AGENTS (30 Percent Safety Factor)

Agent	Minimum Design Concentration for *n*-heptane, %[d]	Maximum Fill Density, kg/m^3 (lb/ft^3)[d]	Storage Pressure at 21.1°C (70°F), bar (psi)[a,d]
Halon 1301	5[b]	1121 (70)[c]	24.8 (360)[c]
HCFC-124	8.6	1137 (71.0)	13.4 (195)
HCFC Blend A	12.9	900 (56.2)	24.8 (360)
HFC-23	16.8	865 (54.0)[g]	42.0 (608.9)[e]
HFC-125	11.3	929 (58.0)	11.5 (166.4)[e]
HFC-227ea	8.5	1153 (72.0)	24.8 (360)
HFC-236fa	8.2	1249 (78)[f]	1.27 (18.4)[e,f]
FC-218	8.5	1281 (80)[f]	24.8 (360)[f]
FC-3-1-10	7.2	1281 (80.0)	24.8 (360)
FIC-13I1	4.2	1677 (104.7)	24.8 (360)

[a] Unless otherwise noted, storage pressures are with nitrogen pressurization.

[b] The design concentration for Halon 1301 is that set by NFPA Standard 12A [42] and is higher than the value of approximately 3.9% determined by 130% of the cup burner value.

[c] Reference 42

[d] Except where noted, calculated from data in NFPA 2001 and 12A [21 and 42].

[e] This is the actual equilibrium pressure within the container due to the vapor pressure of the agent alone (i.e., without nitrogen pressurization).

[f] Data does not appear in the current NFPA 2001 Standard. Information provided by manufacturer.

[g] HFC-23 has a critical point near room temperature. Because of this, HFC-23 is not stored based on the "normal DOT regulations for liquified compressed gases (hot liquid falls at 130°F), there is a DOT exception for HFC-23. The fill density reflects this storage uniqueness.

Design concentrations may differ for other fuels and will be higher for inertion of an area. Some users are planning to employ or are employing some agents at considerably higher concentrations than the minimum recommended values based on the specific fuel, scenario, and threat. U.S. Navy researchers feel that realistic design concentrations must be determined by tests at a realistic scale. Such tests have shown that, although design concentrations at 20 percent above cup burner can extinguish large turbulent pool fires, these minimum concentrations increase the time required to effect extinguishment and generate extensive decomposition products. In fact, based on the inclusion of safety and other factors, the U.S. Navy plans to employ design concentrations from 50 to 70 percent above the value shown for one agent in table 8 in at least some shipboard applications. Work at the Federal Aviation Administration William J. Hughes Technical Center indicates that required concentrations of Halon 1301 in aircraft exceed 130 percent of the cup burner concentrations, that even the required concentrations may not be adequate for all fires, and that the same level or greater of protection must be demonstrated to determine the acceptable concentration of a

replacement agent. Extensive testing of Class A cargo fires at the FAA has shown that reignition occurs for suppressed fires for some replacement agents when the compartment is maintained at concentrations lower than the inerting concentration. Similarly, extensive testing of Class A and Class B fires by the UK Loss Prevention Council shows failures to extinguish fires in some tests for some agents and excessive formation of decomposition products for halocarbons and, in some cases, using the design concentrations recommended at the time that the work was done and with systems provided by commercial equipment manufacturers. Some recommended design concentrations have since been increased. All of this indicates that required concentrations of halocarbon replacement agents may, under some circumstances exceed the concentrations shown in Table 8.

Table 9 gives weight and storage volume equivalents relative to Halon 1301 for design concentrations of agent. The weight equivalent is the weight of agent required divided by the weight of Halon 1301 required. The storage volume equivalent is the storage volume of agent required divided by the storage volume of Halon 1301 required. Three things must be noted:

First, the storage volume equivalent is different from the simple ratio of the design concentrations. The storage volume equivalent takes into account the volume occupied by the agent (usually, but not always, a liquid) when contained in a cylinder.

Second, this definition results in different values than one would obtain if extinguishing concentrations rather than design concentrations were used because the design concentration for Halon 1301 is more than 130 percent of its extinguishing concentration. In general, this makes the storage volume and weight equivalents lower than would be predicted from the cup burner value or some other measure of extinguishing efficiency.

Third, these equivalents are based on the minimum manufacturer-recommended design concentrations for an *n*-heptane fire and larger design concentrations may be used in some applications based on fuel, scenario, and threat. Thus, the values for equivalents in table 9 are minimum values.

The weight and storage volume equivalents for design concentrations of total-flood agents for *n*-heptane fires are listed in Table 9. The weight equivalents were calculated from the total-flood specific weights (weight/unit volume) at 70°F given in NFPA Standards 2001 and 12A for the *n*-heptane design concentrations and maximum fill densities given in Table 8. In this case, the weight equivalent = (Wa/W1301), where Wa and W1301 are the total-flood specific weights for the agent of interest and Halon 1301 (0.0206 lb/ft^3 at a design concentration of 5 percent at 70°F), respectively. The specific weights are taken from tables in the NFPA Standards 2001. These specific weights include an allowance for normal leakage from a tight enclosure. The storage volume equivalent is then the product of the weight equivalent and the ratio (D1301/Da), where Da and D1301 are the maximum fill densities for the agent of interest and Halon 1301. Note that the equivalents are based on a Class B *n*-heptane fire and may be different for Class A fires and for Class B fuels other than *n*-heptane.

Another method for determining the weight and storage volume equivalents is to directly calculate the values from the laboratory-determined properties. This method does not use the specified design concentration or the fill densities; however, it does more closely compare the actual agent performance to that of Halon 1301. The results are shown in Table 10. The extinguishment concentrations are cup burner values taken from a single source. Note that the number of significant figures for the equivalents is larger than justified by the extinguishment concentration precision.

TABLE 9. WEIGHT AND STORAGE VOLUME EQUIVALENTS FOR DESIGN CONCENTRATIONS OF TOTAL-FLOOD AGENT FOR *n*-HEPTANE FIRES
(30 percent safety factor)

	Normal Leakage (Calculated From Weight Requirements and Fill Densities)		
Agent	Weight Equivalent[a]	Storage Volume Equivalent[a]	Molecular Weight
Halon 1301	1.00	1.00	148.93
HCFC-124	1.67	1.64	136.48
HCFC Blend A	2.20	2.74	92.90
HFC-23	1.79	2.32	70.01
HFC-125	1.95	2.36	120.02
HFC-227ea	2.03	1.97	170.03
HFC-236fa	1.76	1.58	152.04
FC-218	2.20	1.92	188.03
FC-3-1-10	2.30	2.01	238.03
FIC-13I1	1.06	0.71	195.91

[a]Calculated from data in NFPA Standards 2001 and 12A [21 and 42] and table 8.

TABLE 10. COMPARATIVE PERFORMANCE OF TOTAL-FLOOD REPLACEMENTS FOR *n*-HEPTANE FUEL

Agent	Cup Burner Extinguishment Concentration, vol%	Molecular Weight	Liquid Density,[a] g/mL, 25°C	Weight Equivalent	Storage Volume Equivalent
Halon 1301	3.4	148.93	1.551	1.00	1.00
HCFC-124	6.6	136.48	1.357	1.81	2.06
HCFC Blend A	9.9	92.90	1.20	1.82	2.25
HFC-23	12.9	70.01	0.685[b]	1.80	4.07
HFC-125	8.7	120.02	1.190	2.11	2.75
HFC-227ea	6.5	170.03	1.395	2.22	2.46
HFC-236fa	6.3	152.04	1.356	1.89	2.16
FC-218	6.5	188.02	1.321	2.26	2.66
FC-3-1-10	5.5	238.03	1.497	2.49	2.58
FIC-13I1	3.2	195.91	2.106	1.24	0.91

[a] Reference 48

[b] HFC-23 has a critical point near room temperatures, and it is difficult to define a single density. Use caution in interpreting storage volume equivalents calculated here.

TABLE 11. ENVIRONMENTAL AND TOXICITY PROPERTIES OF COMMERCIALIZED TOTAL-FLOOD AGENTS

Agent	ODP [a]	GWP [b,c] (100 years)	GWP [b,c] (500 years)	Atmospheric Lifetime, [c] (yrs)	NOAEL[e] (%)	LOAEL[e] (%)
Halon 1301	12	6,900	2,700	65	5[d]	7.5[d]
HCFC-124	0.026	620	190	6.1	1.0	2.5
HCFC Blend A	0.044[f]	1,450[f]		12[f]	10.0	>10.0
HCFC-123	0.012[a]	120	36	1.4	1.0[f]	2.0[f]
HCFC-22	0.034[a]	1,900	590	11.8	2.5[f]	5.0[f]
HCFC-124	0.086[a]	620	190	6.1	1.0	2.5
HFC-23	0.0[h]	14,800	11,900	243	50	>50
HFC-125	0.0[h]	3,800	1,200	32.6	7.5	10.0
HFC-227ea	0.0[1]	3,800	1,300	36.5	9.0	10.5
HFC-236fa[i]	0.0[1]	9,400	7,300	226	10.0	15.0
FC-218[j]	0.0[1]	8,600	12,400	2,600	30	>30
FC-3-1-10[j]	0.0[1]	8,600	12,400	2,600	40	>40
FIC-13I1[k]	<0.008	<1	<<1	0.005	0.2	0.4

The environmental and toxicity properties of commercialized total-flood agents are shown in Table 11. All agents other than Halon 1301 listed in Table 11 are acceptable under SNAP; however, there are limitations on its use for certain agents.

TABLE 12. COMMERCIALIZED STREAMING AGENTS

Agent	Chemical	Formula	Trade Name
Halon 1211	Bromochlorodifluoromethane	$CBrClF_2$	
HCFC-123	Dichlorotrifluoroethane	$CHCl_2CF_3$	DuPont FE-232
HCFC-124	Chlorotetrafluoroethane	$CHClFCF_3$	DuPont FE-241
HCFC Blend B[a] PFC-14 HCFC-123	Proprietary blend of Tetrafluoromethane Dichlorotrifluoroethane	 CF_4 $CHCl_2CF_3$	American Pacific Halotron I
HCFC Blend C HCFC-123 HCFC-124 HFC-134a	Proprietary additive plus Dichlorotrifluoroethane Chlorotetrafluoroethane 1,1,1,2-Tetrafluoroethane	 $CHCl_2CF_3$ $CHClFCF_3$ CH_2FCF_3	North American Fire Guardian NAF P-III
HCFC Blend D HCFC-123	Proprietary additive plus Dichlorotrifluoroethane	 $CHCl_2CF_3$	North American Fire Guardian BLITZ
HCFC Blend E	Proprietary formulation of HCFC, HFC, and additive		North American Fire Guardian NAF P-IV
HFC-227ea	Heptafluoropropane	CF_3CHFCF_3	Great Lakes FM-200
HFC-236fa	1,1,1,3,3,3-Hexafluoropropane	$CF_3CH_2CF_3$	DuPont FE-36
FC-5-1-14	Perfluorohexane	$CF_3(CF_2)_4CF_3$	3M Company CEA 614[b]
FIC-13I1	Trifluoroiodomethane	CF_3I	West Florida Ordnance Iodoguard; Ajay North America

TABLE 13. ENVIRONMENTAL AND TOXICITY PROPERTIES OF COMMERCIALIZED STREAMING AGENTS

Agent	ODP [a]	GWP [b,c] (100 years)	GWP [b,c] (500 years)	Atmospheric Lifetime, [c] (yrs)	NOAEL (%)	LOAEL (%)
Halon 1211	5.1	1300	390	11	0.5[d]	1.0[d]
HCFC-123	0.012	120	36	1.4	1.0[e]	2.0[e]
HCFC-124	0.026	620	190	6.1	1.0[f]	2.5[f]
HCFC Blend B [g]						
PFC-14	[l]	5700	8900	50,000	>30[f]	>30[f]
HCFC-123	0.012	120	36	1.4	1.0[e]	2.0[e]
HCFC Blend C						
HCFC-123	0.012	120	36	1.4	1.0[e]	2.0[e]
HCFC-124	0.026	620	190	6.1	1.0[f]	2.5[f]
HFC-134a	0.0[h]	1600	500	13.6	4.0[e]	8.0[e]
HCFC Blend D						
HCFC-123	0.012	120	36	1.4	1.0[e]	2.0[e]
HCFC Blend E	[i]	[i]	[i]	[i]	[i]	[i]
HFC-227ea	0.0[h]	3800	1300	36.5	9.0[f]	10.5[f]
HFC-236fa	0.0[h]	9400	7300	226	10.0[f]	15.0[f]
FC-5-1-14[j]	0.0[h]	9000	13200	3200	40[e]	>40[e]
FIC-13I1	<0.008	<1	<<1	0.005	0.2[f]	0.4[f]

[a] Relative to CFC-11. From reference 49 except where otherwise noted.

[b] Based on a time horizon, relative to CO_2.

[c] Reference 49.

[d] Reference 52.

[e] Reference 10.

[f] Reference 21.

[g] The amount and type of PFC must be considered when assessing the environmental impact (see section 2.2.4). This blend contains a PFC in small proportions.

[h] Actually <1.5 x 10^{-5}, essentially zero. It is likely that all HFCs have a small but nonzero ODP.

[i] Data not available.

[j] PFCs are acceptable under SNAP for nonresidential use only when other alternatives are not technically feasible due to performance or safety requirements.

[k] Reference 48.

[l] Reference 53.

All of the halocarbon agents have tradeoffs for total-flood and/or streaming applications. As noted earlier, halon replacements should have four characteristics: a low global environmental impact, acceptable toxicity, cleanliness/volatility, and effectiveness. Though it is very easy to find candidate replacements that meet any three of these criteria, it has been difficult to find agents that meet all four. For most (but not all) applications, significantly more replacement agent is needed to provide the same degree of protection as provided by the present halons. The exception is FIC-13I1, which has total-flood use limitations owing to toxicity.

One potential problem that occurs with many (but not all) of the new halocarbon agents is that they generate four to ten times more hydrogen fluoride (HF) than

Halon 1301 does during comparable extinguishment [13 and 54]. Although a large amount of information is available on hydrogen fluoride toxicity [55 and 21], it is difficult to determine what risk is acceptable. A good review of the toxicity of HF as it relates to short exposures of high concentration of HF can be found in the NFPA 2001 Appendix [21]. Some data exists to determine what hydrogen fluoride levels are likely in real fire scenarios. In general, agent decomposition products and combustion products increase with fire size and extinguishment time [56 and 21]. To minimize decomposition and combustion products, early detection and rapid discharge are recommended.

The effects of HF will occur at the site of contact and will be observed as inflammation (irritation) that can progress to severe, deep-penetrating irritation. At high concentrations of HF (>200 ppm) for an extended duration of time, e.g., 1 hour, fatalities may occur, particularly in the absence of any medical treatment.

At concentrations of <50 ppm for up to 10 minutes, definite irritation of upper respiratory tract, skin, and eyes would be expected to occur. At these low concentrations, escape-impairing effects would not be expected in the healthy individual. As HF concentrations increase to 50 to 100 ppm, an increase in irritation is expected. At 100 ppm for 5 minutes, moderate irritation of all tissue surfaces would be expected, and as the duration of exposure increases to 10 minutes, escape-impairing effects would begin to occur. As the concentration of HF increases, the severity of irritation, including escape-impairing irritation of the eyes and respiratory tract, increases and the potential for delayed systemic effects also increases. At these higher concentrations, humans would be expected to shift to mouth breathing, and deeper lung irritation is expected. At greater concentrations (>200 ppm), respiratory discomfort, pulmonary (deep lung) irritation, and systemic effects are possible. Continued exposure at these concentrations may be lethal in the absence of medical treatment.

The American Industrial Hygiene Association (AIHA) Emergency Response Planning Guideline (ERPG) represents limits established for emergency release of chemicals [24]. These limits are established to also account for sensitive populations, e.g., those with compromised health. The ERPG limits are designed to assist emergency response personnel in planning for catastrophic releases of chemicals. These limits are not developed to be used as safe limits for routine operations. The ERPG limits consist of three levels for use in emergency planning and are typically 1-hour values; 10-minute values have also been established for HF. For the 1-hour limits, the ERPG 1 (2 ppm) is based on odor perception and is below the concentration at which mild sensory irritation has been reported (3 ppm). ERPG 2 (20 ppm) is the most important guideline value set and is the concentration at which mitigating steps should be taken (such as evacuation, sheltering, donning masks). This level should not impede escape or cause irreversible health effects and is based mainly on the human irritation data in references 57 and 58. ERPG 3 (50 ppm) is based on animal data and is the maximum nonlethal level for nearly all individuals. This level could be lethal to some susceptible people. The 10-minute values established for HF and used in emergency planning in fires where HF vapor is generated are ERPG 3 = 170 ppm, ERPG 2 = 50 ppm, and ERPG 1 = 2 ppm.

3. ALTERNATIVE TECHNOLOGIES

Nonhalocarbon substitutes are increasingly being considered as options to the use of halons. Already, water sprinklers are replacing halon systems in many applications. Dry chemical extinguishants and carbon dioxide (CO2) are also receiving increased use. Alternatives can be divided into two types: classical alternatives and new alternatives (see Table 14). Note that the word "new" does not necessarily imply that a technology was developed recently, but that there is a new or renewed interest in the use of a technology as a replacement for halons. Misting and particulate aerosols require decreased amounts of agent. This may decrease the probability of secondary fire damage. Thus, these technologies may allow protection while minimizing the problems normally associated with water and solids. Recent advances allow the use of inert gases and inert gas blends in new applications, particularly in occupied areas.

TABLE 14. ALTERNATIVES

Classical	New
Foams	Water Misting
Water Sprinklers	Particulate Aerosols
Dry Chemicals	Inert Gases
Carbon Dioxide	Solid Propellant Gas Generators
Loaded Stream	Combination

3.1 FOAMS

Foams are an alternative to halon systems for a number of hazards, particularly those involving flammable liquids. Foams extinguish fires by establishing a barrier between the fuel and air. Drainage of water from the foam also provides a cooling effect, which is particularly important for flammable liquids with relatively low flash points and for Class A fuels where glowing embers are a problem. The disadvantages of foams are similar to those of water. They can cause secondary damage and cannot be used on fires involving electrical equipment without careful design considerations.

There are four basic classifications for foam fire protection systems:

a. Fixed Foam Systems are complete installations with foam piped from a central location and discharged through fixed nozzles. The concept is similar to a fixed halon system; although the applicability is very different.

b. Semifixed Foam Systems are of two types. In one type, the foam agent is connected to a fixed piping system remote from the fire threat at the time the

foam is required. In the second type, foam is delivered from a central station to portable foam makers, which may include hose reels.

c. Mobile systems are vehicle-mounted or vehicle-towed complete foam units.

d. Portable systems are nothing more than hand-carried mobile systems. Portable foam extinguishers are generally intended for use on flammable liquids; although foam extinguishers may also be used for general protection against Class A fires in the same manner as water extinguishers.

3.1.1 Low-Expansion Foam

Low-expansion foams have the following limitations:

a. Low-expansion foams are suitable only for horizontal or 2-dimensional fires, not 3-dimensional.

b. The correct foam must be used depending on the type of liquid fuel. There are two basic types of low-expansion foams: hydrocarbon fuel foams and polar solvent foams. The polar solvent foams are primarily for alcohol fires, but may also be used on hydrocarbon fires. These are sometimes called universal foams. Hydrocarbon fuel foams are usually lower cost, but the foam blanket degrades in the presence of polar chemicals like alcohols.

c. Different kinds and brands of foam concentrates may be incompatible and should not be mixed during storage.

d. Since low-expansion foams consist of at least 90 percent water, their use is limited to applications where unacceptable water damage or electrical conductivity is not a problem.

e. Foams are generally used as concentrates, which are proportioned with water during delivery. The effectiveness of a foam on a fire is highly dependent on the system designed to proportion and deliver the foam.

3.1.2 High- and Medium-Expansion Foam

High-expansion foam systems are uncommon but can be used for total flood of a protected space; particularly where a Class A fire may be difficult to access for manual firefighting. Examples of applications include areas between floors, in which a small number of high-expansion foam systems have recently been used in preference to using halon, and marine machinery spaces. A preliminary evaluation of high-expansion foams for U.S. Naval shipboard applications has been performed. Disadvantages of high-expansion foam systems include greater weight and space requirements, the need for a suitable water supply, relatively long extinguishing time, and possible cleanup problems. Also, due to poor visibility, the use of high-expansion foams can be dangerous in large, cluttered, or

hazardous enclosures where people might be present. Toxicity and asphyxiation are not considered to be problems with high-expansion foam, total-flood systems.

High- and medium-expansion foams have the following limitations:

a. Since high- and medium-expansion foams have a relatively low water content, they are not as effective as low-expansion foams for most fire scenarios. The hazard must be carefully evaluated and the foam system carefully designed.

b. The use of high- and medium-expansion foams for fires involving flammable liquids and gases must be carefully evaluated in view of the actual situations. These foams are not as forgiving of poor engineering design and application. In particular, high- and medium-expansion foams are often useless against fires involving liquefied natural gas.

c. Although high- and medium-expansion foams contain less water than low-expansion foams, they should not be used with fires of water-reactive materials or on Class C fires without careful evaluation and testing.

3.2 WATER SPRINKLERS

Water is a very effective extinguishing agent because of its unusually high specific heat and heat of vaporization. Water can be delivered in three ways from fixed systems, from handlines, and from portable extinguishers. It is primarily a Class A fire extinguishant, cooling the fuel to a temperature below the fire point; however, fine water sprays can be very effective against Class B fires and have the additional benefit of cooling to prevent reignition. The quantity of water required is, in some installations, less than the amount of halon needed for the same degree of protection.

As an extinguishing agent, water has a number of disadvantages compared with halons:

a. Secondary damage (damage to facilities and contents due to the agent) may result from discharge.
b. A cleanup requirement may exist after discharge: runoff water may have to be removed and contents of protected areas may require drying.
c. Water is unsuitable for discharge onto live electrical equipment.
d. Water does not penetrate enclosures as well as halons and other gaseous agents.
e. Discharge normally takes longer than that of a gaseous agent.
f. Most water fire protection applications are unsuitable for Class B fires although this may be overcome by misting systems.
g. Water causes problems with storage, discharge, and cleanup at very low temperatures.
h. Of particular importance in aviation is that water may carry a relatively large weight penalty, though this may not be true for zoned systems.

There are several types of fixed water systems for fire protection. Wet pipe sprinkler systems are widely used. These systems have pipes that are constantly pressurized with water and that are connected to sprinkler heads, which are opened by heat activation. They require no electrically activated fire detectors. Dry pipe systems are filled with air or nitrogen under pressure. When the sprinkler heads are opened by fire, the gas is released allowing water to flow to the heads. These systems are a little more costly than wet pipe systems and have a slower response time. Pre-action sprinkler systems require a detection system to actuate a valve allowing water to fill pipes to sprinkler heads, which are closed until fire activation opens them.

These systems are used primarily where inadvertent discharge must be avoided. A detector is required. Water deluge systems have heads that are normally open unlike the wet pipe, dry pipe, and preaction systems which require fire activation of the sprinkler heads. A detector activates a valve allowing water to discharge from all of the heads. This type of system results in widespread water discharge and, therefore, has a higher possibility of water damage. Deluge systems are unlikely to be used for replacement of Halon 1301 total-flood systems. Other, combination and special, systems have been used, including some that shut off the water when a fire has been extinguished.

Automatic sprinkler systems were first developed in the last century and are well proven, highly reliable form of fire protection. This is particularly true in general industrial and commercial premises in which none of the disadvantages listed above are of major practical significance. Automatic sprinklers may be used for protection of many facilities (e.g., computer rooms) for which halon is traditionally used. To avoid damage to the equipment, however, the electrical power must be deactivated before water is discharged. Although most of the new generation of computer equipment is not permanently damaged by water, if it is first powered down, it must be dried out before use. This means that either redundant equipment is needed or the facility must be able to withstand any losses due to down time.

A fixed water sprinkler system may be very cost-effective for protection of an area that already has halon systems if existing piping, valves, and miscellaneous equipment do not require major modifications. However, if protection of a limited area involves installation of a water supply and if a storage tank, pumps, and increased pipe sizing are required, sprinkler protection could be much more expensive than a halon system. Predesign inspections should be a mandatory consideration for all existing halon-protected areas.

3.3 DRY CHEMICALS

Certain finely ground powders can be used as extinguishing agents. The extinguishing mechanism is complex and not fully understood. However, the mechanism depends mainly on the presence of a chemically active surface within the reaction zone of the fire. Sodium bicarbonate was one of the first dry chemical extinguishants to be used. Potassium bicarbonate and monoammonium phosphate

were developed later in the 1960s. These powders typically have particle sizes of less that 10 µm up to 75 µm with average particle sizes of 20 to 25 µm.

Dry chemicals generally provide very rapid knockdown of flames and are more effective than halons in most applications. The main disadvantages of dry chemical fire extinguishants include:

a. poor penetration behind obstacles,
b. no inhibiting atmosphere after discharge,
c. no direct cooling of surfaces or fuel,b
d. secondary damage to electronic, electromechanical, and mechanical equipment,
e. cleanup problems, and
f. temporary loss of visibility if discharged in a confined space.

Fixed dry chemical systems are very uncommon; uses are normally limited to localized applications, such as with textile machines or deep-fat fryers, for which halons would not normally be used. However, these systems should be considered for fire suppression in some marine engine spaces and land-based transportation engine compartments.

Dry chemical extinguishers are suitable for Class A, B, and in some cases, C fires depending on the type of powder used. Powder extinguishers are often suitable substitutes for halon with fires of flammable liquids. They are also suitable for situations where a range of different fires can be experienced, e.g., electrical fires, flammable liquid fires, and fires in solids. In this respect, powder extinguishers resemble halon extinguishers.

3.3.1 Monoammonium Phosphate

This is an excellent explosion and fire suppressant and is effective on Class A, B, and C fires. It is, however, corrosive on metals. This material is often referred to as “ABC Powder.”

3.3.2 Sodium Bicarbonate

This, along with monoammonium phosphate, is considered to be an excellent explosion suppressant. It has been used in stove-top fire extinguishers. It is the largest selling dry chemical primarily because of its low cost and its use in training.

3.3.3 Potassium Bicarbonate

Potassium bicarbonate is a widely used dry chemical fire extinguishant. There is some indication that the potassium ion has a chemical effect on fires. It is widely recognized that the amount of carbon dioxide released by this agent, and by sodium bicarbonate, in fires is insufficient to explain the fire suppression ability.

3.3.4 Proprietary

Here, the term proprietary is used to denote a special dry chemical rather than one of those described above which have small amounts of an additive to improve flow and other characteristics. Monnex, a urea potassium carbonate developed by ICI, is an exceedingly effective proprietary dry chemical. However, it is more expensive than the generic agents discussed above and has a somewhat less effective delivery.

3.4 CARBON DIOXIDE

Carbon dioxide (CO2) resembles the other inert gases discussed in section 3.8. However, CO2 can be considered a classical alternative and is the most common inert gas used as a fire extinguishant today. The physiological effects of carbon dioxide, however, differ significantly from those of the other inert gases. Like Halons 1301 and 1211, CO2 is a gas at normal ambient temperature and pressure. It is also a clean, electrically nonconductive agent with good penetrating capability. Carbon dioxide is discharged as a gas, though some frozen particulate (dry ice) often forms. The presence of frozen particulate increases the heat absorption capacity. Only through the use of refrigerated systems (see below) can any liquid discharge occur.

At one time, CO2 systems were used for many of the applications that now use halon. Indeed, fixed CO2 systems still remain in popular use for a number of applications, particularly in unmanned areas. Carbon dioxide is also a common agent in portable fire extinguishers and in localized fixed systems. Research is under way for using carbon dioxide as a component in twin-fluid water misting systems (Section 3.6) and mixed with particulate aerosols (Section 3.7). Carbon dioxide is used as a pressurizing agent in some dry chemical extinguishers.

Design concentrations for carbon dioxide total-flood systems for protection against Class B fires involving typical liquid hydrocarbons range from 34 to 43 percent depending on the fuel compared with approximately 5 to 8 percent for Halon 1301 systems. Cup burner data show that a concentration of approximately seven times that of halon is required for *n*-heptane. (Note, however, that this does not imply that seven times as much CO2 is needed in a streaming or localized application.) Carbon dioxide is less efficient than halons–the time to extinguishment is longer and, in general, storage requirements are greater. Carbon dioxide is, however, more efficient than other inert gases, a characteristic that may be due to endothermic decomposition processes. For most total-flood applications, an agent storage volume of approximately eight times that required for halon is required for most CO2 systems (however, see the next paragraph for a discussion on liquid CO2 systems where the ratio can be as low as four times). Weight and space considerations are more relevant in retrofitting than in new installations, but they are unlikely to be major obstacles for retrofit into existing industrial and commercial facilities. On the other hand, weight and space requirements are likely to be a barrier for CO2 retrofit of onboard aircraft

applications. Traditionally, CO2 fixed systems cost two to three times (excluding agent cost) that of halon systems.

Pyrozone Sales Pty. Ltd. in Australia manufactures a range of modular low-pressure CO2 storage units that use liquid CO2. Liquid CO2 requires considerably less volume than the gas phase agent found in most CO2 systems and, moreover, it is claimed that Pyrozone Systems have the potential to use existing Halon 1301 pipework and detection equipment. The Pyrozone units use refrigeration to maintain the CO2 as a liquid and have integral contents measuring capability. Pyrozone units are designed to be refilled in situ negating the need to dismantle any part of the system after a discharge.

Concerns exist about the safety hazard to personnel in areas protected with fixed, total-flood CO2 systems. Unlike the other inert gases, CO2 is toxic in large amounts (it is a respiratory regulator), and the design concentrations are well above dangerous levels (above 9 percent, loss of consciousness occurs within a short time, with death occurring around 25 to 30 percent. With most fixed localized systems, on the other hand, the hazard is much less and with portable extinguishers, any hazard is minimal. It is possible to manage the safety hazard with fixed, total-flood CO2 installations by designing the system to ensure that automatic discharge does not occur while people are present in the protected area or by using manual activation. There are many well developed internationally recognized standards that provide the guidelines for the safe use of CO2 total-flood systems. However, owing to the toxicity and the reduced efficiency, CO2 is generally less attractive to fire insurers.

Concerns have been expressed about erasing of magnetic tape and damage from thermal shock due to CO2. Testing has failed to substantiate the first concern, and thermal shock does not normally occur unless the discharge is directed at objects close to the nozzle. Some specialized installations are designed to pass the CO2 through a vaporizing unit (converting all of the CO2 to a gas) to reduce cooling by vaporization and sublimation. Continued use by telecommunications and modern power supply industries support compatibility of CO2 with risks of this type.

Carbon dioxide portable fire extinguishers have been available for many years and are in common use. They have certain disadvantages compared with Halon 1211: larger size, greater weight, lower efficiency, shorter throw range, and no Class A rating. In many applications, however, these disadvantages do not rule out the use of CO2 fire extinguishers. Note, however, that complete protection of any facility with CO2 may leave the facility devoid of sufficient Class A protection, and other types of agents – water, foam, dry chemical – may be needed.

3.5 LOADED STREAM

The term “loaded stream” is used to indicate any mixture of a salt (usually an acetate, a citrate, and/or a carbonate) with water. Most loaded stream agents are used for protection of cooking and restaurant facilities. Kidde puts out two

different types of loaded water extinguishers with sodium acetate, water, and ethylene glycol one contains a mixture with 50 percent sodium acetate and the other a mixture with 30 percent sodium acetate.

Recent work shows that sprays of aqueous solutions containing 60 percent potassium lactate or 60 percent potassium acetate are far superior to neat water sprays in extinguishing JP-8 fuel fires[c]. The improved performance is attributed to the release of solid salts upon evaporation of the water droplets. The work also shows that iodide salt solutions are superior to bromide salt solutions.

3.6 WATER MISTING SYSTEMS

Water misting systems allow the use of fine water sprays to provide fire protection with reduced water requirements and reduced secondary damage. Calculations indicate that on a weight basis, water could provide fire extinguishment capabilities better than those of halons provided that complete or near-complete evaporation of water is achieved. Since small droplets evaporate significantly faster than large droplets, the small droplets achievable through misting systems could approach this capability. The NFPA 750 Standard on water misting systems establishes 1000 microns (micrometers, µm) or less as being the water droplet size for a system to be designated as a water misting system; however, many misting systems have droplet sizes well below this value. Water misting systems extinguish fires by three mechanisms: (1) heat absorption through evaporation and, to a lesser extent, vapor-phase heat capacity, (2) oxygen dilution by the water vapor formed on evaporation, and (3) radiative heat obstruction by the mist. A detailed review of water misting has been written by the Navy Technology Center for Safety and Survivability and Hughes Associates [68]. More recent reviews are presented in references 69 and 70. Water misting is being evaluated both as a possible replacement for total-flooding Halon 1301 systems and for use in hand-held extinguishers.

At the request of the EPA, manufacturers of water misting systems and other industry partners convened a medical panel to address questions concerning the potential physiological effects of inhaling very small water droplets in fire and nonfire scenarios. Disciplines represented on the medical panel included inhalation toxicology, pulmonary medicine, physiology, aerosol physics, fire toxicity, smoke dynamics, and chemistry with members coming from the commercial, university, and military sectors. The executive summary of the final report states the following:

“The overall conclusion of the Health Panel‘s review is that water mist systems using pure water do not present a toxicological or physiological hazard and are safe for use in occupied areas. The Panel does not believe that additional studies are necessary to reach this conclusion. The Health Panel recommends that

[c] JP-8 is a hydrocarbon fuel with a flashpoint typically about 50°C. The fuel in the study cited here had a flashpoint of 50°C.

additives be evaluated on a case-by-case basis depending on the toxic properties of the additive and the concentration at which it is used."

As a result of this study, the EPA is listing water mist systems composed of potable water and natural seawater as acceptable without restriction under SNAP. Water mist systems comprised of mixtures in solution must, however, be submitted to EPA for review on a case-by-case basis.

There are two basic types of water mist suppression systems–single fluid and twin fluid. Single-fluid systems utilize water stored or pumped under pressure; twin-fluid systems use air, nitrogen, or another gas to atomize water at a nozzle. The systems can also be classified according to the pressure in the distribution system piping as high pressure (above 500 psia (34.5 bar)), intermediate pressure (175 to 500 psia (12.1 to 34.5 bar)), and low pressure (175 psia (12.1 bar) or less). Both single- and twin-fluid systems have been shown to be promising for fire suppression. Single-fluid systems have lower space and weight requirements, reduced piping requirements, and easier system design and installation; twin-fluid systems require lower water supply pressure, larger nozzle orifices (greater tolerance to dirt and contaminants and may allow the use of higher viscosity antifreeze mixtures), and increased control of drop size.

The performance of a water mist system depends on the ability to generate small droplet sizes and the ability to distribute mist throughout a compartment in concentrations that are effective. Suppression effectiveness depends on five factors: (1) droplet size, (2) droplet velocity, (3) spray pattern, (4) momentum and mixing characteristics of the spray, and (5) geometry and other characteristics of the protected area.

Water mist systems are reasonably weight efficient. The use of small-diameter distribution tubing and the possible use of composite, lightweight, high-pressure storage cylinders would increase this efficiency. It may also be possible to integrate a central storage of water for use in several potential fire locations (for example, cargo and passenger cabin locations). This integration may not always be beneficial. It could introduce failure modes, decrease availability, and reduce safety.

The major difficulties with water mist systems are those associated with design and engineering. These problems arise from the need to generate, distribute, and maintain an adequate concentration of the proper size drops throughout a compartment while gravity and agent deposition loss on surfaces deplete the concentration. Water mist systems have problems extinguishing fires located high in a space away from the discharge nozzles. Water mists also have difficulty extinguishing deep-seated Class A fires. Other concerns that need to be addressed are (1) collateral damage due to water deposition, (2) electrical conductivity of the mist, (3) inhalation of products of combustion due to lowering and cooling of the smoke layer and adhesion of the smoke particles to the water drops, (4) egress concerns due to loss of visibility during system activation, (5) lack of third-party approvals for most or all applications, and (6) lack of design

standards [74]. Concern has also been expressed about the possibility of clogging of small nozzle orifices used in some systems.

For aircraft use, misting systems are most appropriately considered for cargo bays and, possibly, engine nacelles. Some concern has been expressed that water mists may be inappropriate for cargo bays due to the possibility of deep-seated and hidden fires. The FAA William J. Hughes Technical Center data show that deep-seated fires are probable and have caused several fatal cargo compartment fires. Tests by the FAA and others on deep-seated cargo fires indicate that water mist systems can be effective in combating such fires. Water mist may hold several advantages and should be considered for cargo bay application.

The use of water mists for protection of nacelles may be difficult. First, the low temperatures, around -57°C (-70°F) at altitudes of 36,000 feet, hinder storage, discharge, and evaporation. Second, there is concern about the possible collateral damage due to thermal shock when water contacts hot titanium components. Third, water systems are likely to be bulky. Finally, water is not expected to be distributed as uniformly as halocarbon and other gaseous agents.

Table 15 gives a list of manufacturers for water misting systems. Only the country for the main headquarters is listed; however, most have locations in several countries.

TABLE 15. COMMERCIAL WATER MISTING SYSTEMS

Manufacturer or Distributor	Trade Name	Pressure
Single Fluid		
Baumac International, USA	MicroMist	High
Chemetron Fire Systems, USA	Chemetron	Low
Fike Corporation, USA	Micromist	Medium
FOGTEC Fire Protection, Germany	FOGTEC	High
Ginge-Kerr, Denmark/Kidde-Deugra, Germany	AquaSafe	Low
Grinnell, USA	AquaMist	Medium
GW Sprinkler, Denmark		Low/Medium
Marioff Oy, Finland	Hi-fog	High
Phirex, Australia	[a] Mistex	Low/Medium
Semco Maritime A/S, Denmark	Sem-Safe	High
[b] Spraying Systems Company, USA	FogJet	High
Total Walther, Germany	MicroDrop	Low
Ultra Fog AB, Sweden	Ultra Fog	High
Twin Fluid		
Securiplex, Canada	Fire Scope 2000	Low
International Aero Inc., USA	IAI Water Mist	Low
Technology Unknown		
DAR CHEM, UK		

[a] Both fixed and self-contained portable systems.
[b] Manufactures nozzles only.

Fine particulate aerosols are air-suspended dry chemicals with micron-size particles that give some total-flood capabilities. Dry chemical agents are at least

as effective as halons in suppressing fires and explosions in many applications; however, such agents can damage electronic and mechanical equipment. Moreover, dry chemical agents, as now used, do not provide explosion inertion or fire suppression for time periods similar to those provided by halon systems due to settling of the particles. The discharge of dry chemicals also obscures vision. In Geneva, Switzerland, at the 2nd Conference on the Fire Protecting Halons and the Environment, 1-3 October 1990, representatives of the Soviet Union provided information on a solid agent that they claimed provided relatively long-term (20 minutes or more) inertion of an enclosed volume and excellent fire extinguishment The first detailed technical information on this technology, however, was provided in the 1993 Halon Alternatives Technical Working Conference in Albuquerque, New Mexico.

Most, but not all, of the commercialized technologies for production of particulate aerosols employ an oxidizing agent and a solid fuel which, when ignited, produces a fine solid particulate aerosol providing extinguishment similar to that provided by dry chemical agents. An alternative process manufactures aerosol-size dry chemical agents by spray drying–spraying aqueous solutions into a heated space. The small particle size appears to increase efficiency, decrease deposits, and increases the space-filling capability (multidimensionality) relative to normal dry chemical agents. Some have termed this type of technology “pyrotechnically generated aerosol (PGA).” Others have suggested that the term “pyrogenic aerosol” is more appropriate. In this report, “pyrotechnically generated aerosol” and “pyrogenic aerosol” are considered synonymous. PGAs are generated from nonpressurized containers.

As particle size decreases, the particulate surface on which heterogeneous recombination of combustion chain propagators can occur increases (e.g., Reactions 1, 2). Moreover, as particulate size decreases, the sublimation rate increases, enhancing homogenous gas phase inhibition mechanisms, examples of which are shown in Reactions 3 through 5 for potassium-containing aerosols (the most common type). Thus, in addition to improving dispersion, the small particle sizes inherent in particulate aerosols give these materials a greater weight effectiveness than standard dry chemical agents, decreasing problems due to residue. Both heterogeneous (particulate surface) and homogenous (gas-phase) inhibition appear to contribute to flame inhibition by particulate aerosols. Heat absorption by decomposition reactions and phase changes may also contribute.

$$\bullet O + \bullet H \rightarrow \bullet OH \quad (1)$$

$$\bullet H + \bullet OH \rightarrow H_2O \quad (2)$$

$$\bullet K + \bullet OH + M \rightarrow KOH + M \quad (3)$$

$$KOH + \bullet H \rightarrow \bullet K + H_2O \quad (4)$$

$$KOH + \bullet OH \rightarrow H_2O + KO\bullet \quad (5)$$

The following presents information on some commercialized materials. The design factor is the mass of unignited material per unit volume of a protected area as

specified by the manufacturer or distributor. At present, the NFPA has no standard on fine aerosol technology.

3.7.1 Spectrex Fire-Extinguishing Agent

The family of Spectrex fire-extinguishing agents (S.F.E.) (also known as EMAA, Encapsulated Micron Aerosol Agent) [77] are contained in generators and in applicators. Ansul is licensed by Spectrex Inc. of New Jersey, USA, to produce the S.F.E. agents under the trade name Micro-K and to market them worldwide. The powdered aerosol agents are produced in an oxidation-reduction combustion process that takes place in a combustion chamber specifically designed to contain various amounts of solid-casted material from 100 grams and up to several kilograms. The combustion chamber is introduced in modular units (generators) that include a means (chemical and physical) as well as discharge outlets that direct the aerosol flow towards the protected volume. The agents provide an air-suspended dry chemical aerosol with micron-size particles that give total-flood capabilities.

U.S. Navy and U.S. Air Force tests and evaluation programs [80] indicate that on a weight basis, the agents are three times more efficient than regular dry powders and five times more efficient than halocarbon extinguishing agents. The agents, designated as “powdered aerosol A,″ have been approved under SNAP for total flooding of unoccupied areas. Approval is pending for occupied areas.

The S.F.E. agents were also evaluated by the FAA in a test program performed at its test facilities at the William J. Hughes Technical Center. S.F.E. Formulation “D″ performance is reported in reference 83 and further in section 4.4.3 of this report.

Before ignition, S.F.E. has a density of 1300 to 1800 kg/m3. The combustion temperature is 1500 to 2400 K, and the combustion velocity is 0.3 to 1.5 mm/sec. The material, which may be a solid pellet or a gelled paste, has a shelf life of 15 years. Prior to combustion, the S.F.E. solid material is not affected by prolonged exposures to extreme temperatures (from -55°C to +250°C) and remains functional in its original state (does not change phases to liquid or gas). Emissions from S.F.E. contain 40 percent particulate aerosols with a median diameter of 1 to 2 micron, comprising salts such as K2O, KCl, and K2CO3. The remaining 60 percent of the emissions are gaseous combustion products such as CO2, N2, H2O, O2, and traces (ppm) of hydrocarbons.

Hazardous gases such as CO and NOx are not observed in improved formulations recently tested. The toxicity of S.F.E. agents has been evaluated by the U.S. Navy Medical Research Institute.

Toxicology Detachment - Two formulations, A1 and A2, were compared. Prolonged exposure of test rats to powdered aerosol S.F.E formulation A1 at concentrations exceeding 80 g/m3 caused toxic effects that resulted in deaths and have led to the development of formulation A2. Multiple exposures to the by-products of pyrolyzed formulation A2 at concentrations ranging from 50 g/m3 to 240 gr/m3 caused no deaths to Fischer 344 rats and only minimal toxic effects. All the animals recuperated after the exposure ceased. Formulation A2 is commercialized as S.F.E.

The S.F.E. agents are casted solids contained in modular units (generators) of various sizes containing from 100 grams to 5 kilograms net weight S.F.E., some of which include cooling. The approximate design factor is 50 g/m3 for direct material activation in enclosed areas and 100 to 120 g/m3 when discharged from cooled generators, where a safety factor of 20 percent is included. Typical system configurations include several modular units connected in a loop to a control box/display panel activated electrically by a signal from a separate detection system or by a self-contained detection element incorporated in the modular unit. The modular units and systems are manufactured and distributed by Spectrex (USA), Grinnell Ansul (USA), Gamesa - I.S.E. (Spain), and other companies. The main applications/installations are Modular Unit Micro-K for electrical board, engine compartments, etc., by Ansul; nuclear power stations and transformer rooms by Gamesa - I.S.E.; and deployable and portable extinguisher by Spectronix Ltd., Israel.

3.7.2 PyroGen and Firepak

A pyrotechnically generated aerosol manufactured by Pyrogen Corporation has been approved under SNAP as Powdered Aerosol C for total flood of normally unoccupied areas. The agent is marketed in the U.S. by International Aero Inc. under the name Firepak and in most other countries, including Australia, New Zealand, Southeast Asia, and Europe by Pyrogen Corporation under the trade name PyroGene.

The self-contained nonpressurized canister contains two solid tablets–an aerosol-producing propellant and a coolant. Upon activation of the canister, either electrical or thermal, the propellant burns to produce a fire-extinguishing aerosol a mixture of micron-sized chemical powders and inert gases. The aerosol propels itself through the coolant and out of the canister into the enclosure.

The aerosol-producing propellant consists mainly of potassium nitrate and plasticized nitrocellulose. Combustion products of the propellant are finely dispersed potassium carbonates, carbon dioxide gas (1.2 percent), nitrogen gas, and water vapor; the mixture being the actual extinguishing medium. The design concentration – the mass of nonignited solid aerosol-producing propellant required to produce an adequate amount of aerosol to extinguish a specified type of fire per unit of volume – has been established as 100 g/m3 for Class B fires and surface Class A fires.

Like other PGAs, the use of Firepak in the United States is now limited to normally unoccupied areas, in part because the finely dispersed solid particles of the aerosol decrease visibility in the protected enclosure. Some by-products of the aerosol generating reaction of the solid propellant (e.g., carbon monoxide and nitrogen oxides) could cause moderate local irritation of the upper respiratory tract and eyes. Elevated temperature of the aerosol at the discharge outlet requires that minimum clearances be observed.

3.7.3 Soyus

Dynamit Nobel GmbH Explosivestoff und Systemtechnik, Troisdorf, Germany, produces a number of different sizes of pyrotechnically generated aerosol fire-extinguishing generators.

The aerosol generating units, which are marketed under the trade name Soyus, contain an ignition device, the fire-extinguishing composition, a reaction compartment, and a cooling unit in a cylindrical metal housing. The generators produce potassium carbonate, K2CO3, of which 99 percent has a particle size of 0.5 to 4 micron. The SO 200 E-E01 unit (height = 118 mm, diameter = 82 mm, weight = 0.88 kg) protects a volume of approximately 2.0 m3. The SO 300 E-E01 unit (height = 208 mm, diameter = 82 mm, weight = 1.49 kg) protects a volume of approximately 3.0 m3. Aerosol generation is reported to last 8 seconds for the first unit and 10 seconds for the second unit with a particulate residence time of approximately 1 hour. Ignition can either be electrical or manual.

3.7.4 Aero-K

FireCombat produces three PGA generators (trade name Aero-K), which protect volumes of 1.0, 2.5, and 20 m3 and contain charges of 0.1, 0.250, and 1.65 kg. The generator weights are 0.34, 0.96, and 5.50 kg. The charges consist of alkaline metal nitrates and a combustible organic binder. The combustion products are primarily potassium salts with some ammonium bicarbonate. The aerosol concentration required to extinguish a fire is 40 to 80 g/m3.

3.7.5 KD-A 96

Kidde-Deugra produces a very fine aerosol powder (KD-A 96) using a dry spray technique. The aerosol powder is stored in cylinders together with inert gases as the propellant. This procedure avoids problems of hot gas emissions found for PGAs.

Until recently, the number of agents announced for streaming applications was small. The number has, however, increased markedly (Table 12). Some environmental and toxicological data for these streaming agents are given in Table 13. All agents other than Halon 1211 listed in this table are acceptable or proposed acceptable under SNAP with use limitations for some.

3.8 INERT GASES

Combustion cannot occur when the oxygen content of air at normal pressures is sufficiently reduced (below approximately 15 percent fires cannot be initiated; at lower concentrations, fires are extinguished). Thus, inert gases, such as nitrogen and argon, etc., can extinguish fires by diluting the air and decreasing oxygen content. Extinguishment is also facilitated by heat absorption.

Health problems can occur at low concentrations of oxygen. Although asphyxiation is not probable at concentrations required to extinguish a fire,

sufficient impairment could occur to prevent safe evacuation or emergency response. OSHA requires that no one enter a space with less than 19.5 percent oxygen without a self-contained breathing apparatus (SCBA). NIOSH gives the following effects at varying oxygen concentrations. Note, however, that health problems that can occur would not happen immediately and would be a problem only for extended stays in an environment with a low oxygen level. Thus, there is some feeling that these predictions are meaningless without specifying a time period.

- 16 percent–impaired judgment and breathing
- 14 percent–faulty judgment and rapid fatigue
- 6 percent–difficult breathing, death in minutes

The minimum oxygen concentration where astronauts can still perform the minimum physical and mental activities required to safely pilot a spacecraft, although with great difficulty, has been established by the National Aeronautics and Space Administration (NASA) as 12.3 volume percent. Between 16 and 12.3 volume percent oxygen, performance is increasingly impaired. An expert panel has reported, however, that a 3-minute exposure to an atmosphere containing 10 volume percent oxygen provides an adequate margin of safety considering the variability of a working population, but that lethality occurs quickly at oxygen concentrations below 8 volume percent.

One method that can be used is to increase the atmospheric pressure so that the partial pressure of oxygen does not decrease below that required for human respiration while reducing the percent oxygen to the point that extinguishment occurs. The higher heat capacity due to increased atmospheric pressure also helps suppress fires. For example, submarines could use nitrogen flooding to dilute the oxygen while keeping its partial pressure constant to maintain life support. This method can only be applied to completely enclosed areas with high structural strengths and is, therefore, limited to very few applications.

Pure and blended inert gases marketed as alternatives to halons are shown in Table 16. All of the agents shown in this table are acceptable or proposed acceptable under SNAP. The concentrations needed for extinguishment are approximately 34 to 52 percent, depending on the fuel and the fire scenario. The extinguishing properties of argon are similar to those of nitrogen for Class A, B, and C fires; however, unlike nitrogen, argon is suitable for Class D fires involving metals that react with nitrogen (e.g., magnesium and lithium). Effective extinguishment of a series of *n*-heptane, wood crib, and polyvinyl chloride (PVC) cable crib fires has been reported by the UK Loss Prevention Council for IG-541, IG-55, and IG-01 using the recommended design concentration and systems provided by commercial equipment manufacturers. In general, extinguishment times were longer with the inert gases than found for halocarbon extinguishing agents.

TABLE 16. INERT GASES

Designation	Composition	Extinguishment Concentration[a] (vol %)	Manufacturer
IG-541	Nitrogen 52 ±4% Argon 40 ±4% CO_2 8 ±1%	33	Ansul Incorporated, USA, and Fire Eater A/S, Denmark (INERGEN)
IG-55	Nitrogen 50 ±5% Argon 50 ±5%	35	Ginge-Kerr Denmark A/S (ARGONITE)
IG-01	100% Argon	42	Minimax GmbH (Argotec)
IG-100	100% Nitrogen	33	Koatsu (NN100), Japan

[a]Cup-Burner Extinguishment Concentration with *n*-heptane fuel [97].

In place of NOAEL and LOAEL values, the 2000 NFPA 2001 Standard [21] uses a no effect level (NEL) and a low effect level (LEL) for inert gases. These values are based on physiological effects in humans in hypoxic atmospheres and are the functional equivalents of the NOAEL and LOAEL values given for halocarbons. All inert gas agents listed in the 2000.

Standard (IG-01, IG-541, and IG-55) have sea level-equivalent NEL and LEL values of 43 percent (12-percent oxygen) and 52 percent (10-percent oxygen), respectively. Similar to that done for halocarbon agents, the Standard allows the use of an inert gas agent up to the LEL value for Class B hazards in normally occupied areas where a predischarge alarm and time delay are provided. In the absence of a time delay, only design concentrations up to the NEL are allowed. One major difference between the NFPA and EPA approaches is that the allowable design concentrations are not based on specific egress times in the NFPA Standard.

NEAG/HAG recommends [28] that oxygen concentrations in occupied areas protected by inert gas systems not be less than 12 percent unless a room can be evacuated in 1 minute (2 minutes in the case of INERGEN). This oxygen level corresponds to an inert gas concentration of 43 percent. NEAG/HAG also recommends that exposures to oxygen levels less than 10 percent not be allowed for any period of time.

3.9 SOLID PROPELLANT GAS GENERATORS

Gas generator technology uses ignition of solid propellants to generate large quantities of gases. This gaseous effluent can either be used as is to create an inert environment or can be enhanced with various active agents to more aggressively attack the fire. The U.S. Navy has conducted numerous feasibility and design verification tests on several aircraft platforms to assess and refine

solid propellant gas generator (SPGG) designs. NAVAIR has qualified, installed, and has several years of flight experience with SPGG technology aboard their F/A-18E/F and V-22 aircraft, with notable success in already having successfully extinguished an in-service 3-D pressurized fuel-fed fire in a V-22 mid-wing area. Currently, there is serious consideration by NAVAIR Program Managers to evaluate chemically active gas generators as a means of enhancing system performance/efficiency even further. The U.S. Air Force has been evaluating the technology for aircraft dry-bay applications and will be testing SPGGs for protection of F-22 aircraft. The U.S. Army TACOM (Tank Automotive Command) has been performing testing in engine compartments of tracked vehicles and may also evaluate SPGG technology in crew compartments. Several overviews of SPGG technology and the progress of testing conducted to date have been presented.

3.9.1 Primex Aerospace Inert Gas/Powdered Aerosol Blend

Primex Aerospace Company, which has been supporting U.S. Department of Defense (DoD) testing, has announced that initial engineering, manufacturing, and development contracts have been received from two airframe manufacturers to protect aircraft dry bays. The Primex Aerospace device uses an electrically activated squib to ignite a solid propellant that generates an inert mixture of nitrogen, carbon dioxide, and water vapor.

If the term “sea level-equivalent” means concentrations that have the same oxygen partial pressures as those given by the NEL and LEL values at sea level (respectively, 91.2 Torr and 76 Torr partial pressures at an ambient total pressure of 760 Torr). For example, at an ambient total pressure of 600 Torr, the oxygen concentrations would have to be 15.2% and 12.7% to achieve the same oxygen partial pressure. This would correspond to allowable agent concentrations of 27.6% and 39.5%.

Primex Aerospace markets FS 0140, which has been approved under SNAP as Inert Gas/Powdered Aerosol Blend for use as a total-flood agent in unoccupied areas.

3.9.2 Walter Kidde Aerospace/Atlantic Research Corporation Consortium

Walter Kidde Aerospace has teamed with Atlantic Research Corporation to develop gasgenerator technology for aviation and defense applications. The Walter Kidde Aerospace/Atlantic Research Corporation Consortium is being funded by the DoD under a Defense Advanced Research Projects Agency (DARPA) “Technology Reinvestment Program.”

This program will develop gas generator/vaporizing liquid agent hybrid extinguishers and gas generators that expel chemically active flame inhibiting species for the F-22 dry bay and other military applications. The chemically active gas generators have been shown to be more efficient on a weight basis than inert gas generators. In addition, the Walter Kidde.

Aerospace/Atlantic Research Corporation Consortium is being funded by Battelle Labs to provide chemically active gas generator hardware for the F-22 engine nacelle fire protection test program.

3.10 COMBINATION AND NEW FOAM AGENTS

Mixtures with water or with halocarbon bases have been marketed for many years. One example is the loaded stream type of agents mentioned earlier. In addition, blends of dry chemicals with halons or other halocarbons, sometimes with a gelling agent, have been marketed. With the phaseout of halons, there is an increased interest in and development of such mixtures.

3.10.1 Envirogel

The SNAP list gives a variety of formulations under the category “gelled halocarbon/dry chemical suspension” designated as “Powdered Aerosol B” in the first SNAP listing) developed for particular markets. The materials, which are marketed under the trade name Envirogel by Powsus Inc., have been tested in a number of applications, including tracked vehicles [103 and 104]. Testing to date indicates that at least some formulations have an effectiveness similar to that of Halon 1301 on either a weight basis or a storage volume basis. Each blend contains one or more halocarbons, a dry chemical, and a gel that keeps the powder and gas uniform.

The gelled agents are acceptable under SNAP for use in a streaming application provided that any halocarbon contained has a cardiac sensitization LOAEL of at least 2.0 percent and that the dry chemical is one that is now widely used (i.e., monoammonium phosphate, potassium bicarbonate, and sodium bicarbonate) or is ammonium polyphosphate [12]. Among the halocarbons included in the SNAP submission were HFC-227ea, HFC-125, HFC-134a, and HFC-125 blended with HFC-134a. Also judged acceptable under SNAP for use as total-flood agents in normally unoccupied areas are formulations containing ammonium polyphosphate and monoammonium phosphate blended with either HFC-125 or HFC-134a.

3.10.2 Cease Fire

Cease Fire manufactures CF-33, a patented blend of monoammonium phosphate and a polymer that absorbs an extinguishing gas. The automatic overhead Cease Fire units are UL listed for Class A, B, and C fires and are available in four sizes with coverage from 800 to 2700 cubic feet.

3.10.3 FlameOut

FlameOut, manufactured by Biogenesis Enterprises solely for Summit Environmental Corporation, Inc., is acceptable as a Halon 1211 substitute under SNAP with the generic name Surfactant Blend A. The material is a mixture of organic surfactants and water, which is diluted to strengths of 1 to 10 percent in water for use. The surfactants, like all wetting agents, may enhance the rate of

heat absorption by water. The blend acts on oil, gasoline, and petroleum-based liquid fires (Class B) by encapsulating the fuel, thus removing the fuel source from the fire. This feature prevents flame propagation and reduces the possibility of reignition.
It can also be used on Class A fires. The agent is UL listed as a wetting agent in addition to water for extinguishing Class A and B fires. The extinguishant is a blend of complex alcohols, lipids, and proteins. FlameOut was originally approved by the U.S. EPA SNAP program as a replacement for Halon 1211, under the trade name ColdFire 302. This product should not be confused with ColdFire as manufactured by FireFreeze Worldwide. It is an entirely different blend. Summit Environmental Corporation owns the patent and intellectual property rights to ColdFire 302/FlameOut.

3.10.4 ColdFire.

FireFreeze Worldwide, Inc. manufactures ColdFire, a proprietary blend of organic surfactants and water, which is diluted to strengths of 1-10 percent in water. The surfactants in ColdFire, like all wetting agents, may increase heat absorption by water. ColdFire is UL listed as a wetting agent for Class A and B fires. The agent is said to extinguish Class B fires by fuel encapsulation to separate fuel from fire, reducing possible reignition and preventing flame propagation. ColdFire has successfully completed preliminary testing on molten magnesium and titanium fires (Class D) with Underwriters Laboratories of Canada. ColdFire should not be confused with ColdFire 302/FlameOut. It is an entirely different blend.

3.10.5 Fire-X-Plus

Fire-X-Plus, a foam produced by Firefox Industries, is acceptable under SNAP as a Halon 1301 replacement with the generic name Foam A (formerly Water Mist/Surfactant Blend A).

4. APPLICABILITY OF TECHNOLOGIES TO AIRCRAFT APPLICATIONS.

As noted in the introduction, a major goal for the Task Group on Halon Options is an assessment of the applicability of halon substitute technologies to each major area of onboard aircraft use:

(1) engine nacelles and APU (auxiliary power unit) compartment
(2) hand-held extinguishers
(3) cargo compartments
(4) lavatory protection

In evaluating agents for recommendations, we considered the essential properties/characteristics, the likely fire threat, the present fire detection and suppression practices, applicable regulations, and the current state of the technology. We did not allow the requirements of existing systems to influence our analysis. To allow this would have forced us to just one recommendation:

Halon 1301 for total-flood applications and Halon 1211 for streaming agent applications.

4.1 REQUIREMENTS

The candidate agents must meet the following requirements. The requirements imposed by the specific threat or application are additional to these requirements. A discussion of requirements or possible requirements by application has been published by the FAA.

a. The agent must be suitable for the likely Class of fire. It should be recognized by a technical, listing, or approval organization–National Fire Protection Association (NFPA), Underwriters Laboratories (UL), Factory Mutual Research Corporation (FMRC), etc. as a suitable agent for the intended purpose or such recognition should be anticipated in the near future.

b. It should be compatible with construction materials in the areas where fires may occur and with materials used in the extinguishing systems. There should be, at most, minimal corrosion problems due to extinguishment, either from the neat agent or from likely decomposition products. This is particularly important for aircraft engines and for areas where contact with electronic components could occur.

c. It should comply with the provisions of the Montreal Protocol. It must have a near-zero ozone depleting potential. Low Global Warming Potential (GWP) and atmospheric lifetime are desirable, but presently there are no generally accepted requirements. Nevertheless, GWP and atmospheric lifetimes were considered in these analyses.

4.2 ENGINE AND APU COMPARTMENT

Title 14 Code of Federal Regulation (CFR) Part 25.1195 [107] identifies the requirements for fire suppression systems in aircraft power plants:

1. A fire suppression system is required if other means are not provided to control typical fires, as identified in the CFR.

2. The suppression system must be shown to be effective in quantity of agent, rate of discharge, and distribution by live test during actual or simulated flight conditions.

3. The suppression system must provide adequate, simultaneous protection throughout the compartment.

These requirements apply to all designated fire zones except for combustor, turbine, and tail sections of the turbine engine installations that contain lines or components carrying flammable fluids or gases. These areas are exempted because a fire originating in these sections can be controlled.

The fire threat addressed for these compartments is a Class B fire (aviation fuel, hydraulic fluid, lubricant). The compartments are normally ventilated, have complicated air flow pathways, possess excessively heated materials, and are approximately at ambient pressure. Considerations which may adversely impact the system design are the continual presence of ventilation air flow during and after an agent discharge, potential residual fuel after a shutdown, and the presence of heated surfaces.

Fires result when an engine failure provides simultaneous conditions permitting combustion. Typically, a flammable fluid release results from a mechanical failure. This fluid then comes in contact with an ignition source–possibly hot surfaces or gases associated with operating conditions at the time of failure, abnormal conditions posed by friction (heat or sparks), or electrical energy. Any fire that is detected by thermal sensors activates aural and visual fire warnings on the flight deck. The accepted practice to combat an engine compartment fire is to eliminate ignition and fuel sources and then discharge the fire suppression system. The process is achieved by shutting the engine down, closing local flammable liquid valves, turning off local electrical power, and then discharging the suppression system.

The fire suppression system is evaluated by an agent discharge test, which confirms the capability of the distribution system to provide the design agent concentration for the necessary time duration. The test requires an engine to be operating at critical conditions when the agent release occurs. Typically, 12 sampling probes from a gas analyzer, customarily a Statham or Halonyzer type unit, are located in the compartment during this test. The device records the discharge event in the form of a gas concentration vs. time relationship. The record is reviewed for compliance with FAA-accepted criteria for certification. Advisory Circular 20-100 provides a good summation for the aspects of a discharge test.

The earlier reports proposed establishment of tests for the following two groups of agents. Note that these two groups cover a range of properties and, therefore, cover the range of testing procedures and apparatuses that should be established for halocarbon agents. Based, in part, on these recommendations and the information presented in the earlier reports, a task group consisting only of airframe manufacturer and airline representatives identified three halocarbon agents (HFC-125, HFC-227ea, and FIC-13I1) as being particularly promising. Since HFC-125 was already being evaluated by the U.S. Department of Defense (DoD), it was proposed that the FAA evaluate HFC-227ea and FIC-13I1. The FAA distributed a survey package to airlines and engine, APU, and airframe manufacturers to determine opinions on these two agents and on SPGGs as an alternative technology. Users preferred halocarbons, with SPGGs being considered only as a second choice. Users also expressed significant concern regarding safety and human exposure to agents. Again, in September 1999, the FAA working group evaluated the status of current fire suppression agents. The group issued a

directive to evaluate CF3I first, followed by HFC-125. Additional commentary describing other potential agents is included in the report.

At the time that this report was prepared, a Minimum Performance Standard (MPS) for aircraft engine nacelles was still being prepared. The MPS is currently in a working draft awaiting proof by testing.

4.2.1 HCFCs, HFCs, PFCs, and Blends

These agents are similar in their performance and in their system characteristics. For this reason, they can be treated together when establishing a test protocol. These materials are typical PAAs.

Heptafluoropropane (HFC-227ea) and pentafluoroethane (HFC-125) are the agents of first choice within this group. Both were on the final list of agents being tested at Wright-Patterson AFB and both are recognized acceptable agents for Class B fires by technical and listing organizations, such as UL or equivalent. Both HFC-227ea and HFC-125 are acceptable under SNAP as a Halon 1301 substitutes; however, under the present NFPA Standard 2001, HFC-125 will be restricted to normally unoccupied areas for most fuels (not a problem in this application). It is also recommended that at least one blend be included in establishing test protocols since there may be differences between blends and pure materials in handling and/or performance.

HFC-125 was the final candidate from the DoD program. The program concluded with a design model for HFC-125 that affords the designer the ability to calculate agent mass requirements for a particular nacelle or APU compartment based on parameters of ventilation air temperature and mass flow rate, anticipated fuel type, and compartment volume. This model is based on many points of fire extinguishment data produced in a test fixture. Guidance for the designer and limitations of the model are incorporated in the report.

A second source for HFC-125 design information can be found within the U.S. Navy. The Navy‘s F/A-18E/F underwent an evaluation with respect to potential fire suppression technologies for its aircraft engine nacelle. Ultimately, a quantity of HFC-125 considerably less than that predicted as necessary by the design equation derived from the earlier DoD program, successfully met the design challenge. This effort is based on fire test results as produced in a complex test fixture representing the aircraft engine nacelle. The result represents a single point, but does offer another perspective on the performance for HFC-125 in the engine nacelle.

4.2.2 Trifluoromethyl Iodide (FIC-13I1) and FIC-13I1 Blends

Testing at Wright-Patterson AFB has demonstrated that the chemically active agent trifluoromethyl iodide (FIC-13I1) is more effective in engine nacelle fire extinguishment than any other replacement halocarbon tested to date. A number of blends of CF3I with other halocarbons have been reported as candidate

extinguishing agents. The material is acceptable under SNAP in both streaming and total-flood applications with some use restrictions. The environmental characteristics are good, and the volume requirements and effectiveness are essentially identical to those of Halon 1301. A paper from NOAA (National Oceanic and Atmospheric Administration) states that "...the extremely short lifetime of CF3I greatly limits its transport to the stratosphere when released at the surface, especially at midlatitudes, and the total anthropogenic surface release of CF3I is likely to be far less than that of natural iodocarbons such as CH3I on a global basis. It is highly probable that the steady-state ozone depletion potential (ODP) of CF3I for surface releases is less than 0.008 and more likely below 0.0001. Measured infrared absorption data are also combined with the lifetime to show that the 20-year global warming potential (GWP) of this gas is likely to be very small, less than 5. Therefore this study suggests that neither the ODP nor the GWP of this gas represent significant obstacles to its use as a replacement for halons."

It should be noted that the likely ODP is actually less than that determined for some of the hydrofluorocarbons (HFCs), which are given a nominal ODP of zero. The cardiotoxicity of CF3I is greater than that of other halocarbon candidates; however, the relatively low cardiac sensitization NOAEL and LOAEL values may be of little concern for engine nacelle and APU applications where potential for contact is extremely limited.

Note: Agent concentrations required for the engine and APU compartment may differ from the design concentrations as determined from heptane flame-extinguishing concentrations (Table 8) because (a) fuel is shut off prior to the initiation of suppression, (b) compartments are ventilated, and (c) the fuel is different. Also, the discharge time influences agent quantity. The heptane flame-extinguishing concentrations (and design concentrations) presented in table 8 are intended to provide a basis of comparison. Required concentrations and their duration must be determined by testing. A concern has been expressed about the distribution of CF3I in the protected compartment during low ambient temperature conditions if it is used as a drop-in agent in present systems. This concern arises due to dispersion differences in CF3I and Halon 1301 properties at low temperature and may require modifications of existing supply/distribution systems.

4.2.3 Gas Generators

Inert solid propellant gas generators (SPGGs) have been tested in the U.S. Navy F-18 engine bay; the results, however, were not promising. No SPGG tested provided adequate fire extinguishment. It has been predicted that an SPGG used in engine bay fire protection will impose a take off gross weight (TOGW) penalty significantly lower than that expected for a typical halocarbon extinguishing system (HFC-125); however, the changes in insulation and distribution lines required to protect against the hot gases from an SPGG and the relatively large, bulky first-generation systems, now appear to make this unlikely. Studies indicate that factors other than oxygen starvation or cooling contribute to flame

suppression by SPGGs in military aircraft engine bays [122]. One success story is the successful extinguishment of a real, hydraulic-fluid-fed mid-wing fire involving the rotor positioning unit (RPU) in a Navy V-22 aircraft.

Although work to date with aircraft engine bay fire protection using an SPGG technology has not been as promising as expected, it is far too early to rule out the use of this technology in engine nacelles.

4.3 HAND-HELD FIRE EXTINGUISHERS

Federal Aviation Regulations mandate hand-held fire extinguishers be conveniently located in passenger compartments. The number of required extinguishers depends on the passenger capacity of the airplane. The total number of extinguishers required are shown in Table 17. It is required that at least one of the extinguishers on an airplane with a passenger capacity greater than 31 and two on an airplane with a passenger capacity greater than 61 must contain Halon 1211 (bromochlorodifluoromethane) or equivalent as the extinguishing agent. The minimum performance standard defines the equivalency.

TABLE 17. HAND-HELD EXTINGUISHERS REQUIRED FOR COMMERCIAL AIRCRAFT

Passenger Capacity	Number of Extinguishers
7 through 30	1
31 through 60	2
61 through 200	3
201 through 300	4
301 through 400	5
401 through 500	6
501 through 600	7
601 through 700	8

In addition, at least one hand-held fire extinguisher must be located in the pilot compartment, and at least one extinguisher must be available for use in each Class Ag or Class B cargo or baggage compartment and in each Class E cargo or baggage compartment that is accessible to crew members during flight.

A hand-held fire extinguisher for aviation use must meet the following requirements. These requirements are specified in detail in the Minimum Performances Standard (MPS).

a. Any hand-held fire extinguisher adopted for final use should be listed by a listing organization such as UL or equivalent, be of a specific rating, and be of a size and weight that a typical flight attendant can use. The smallest recommended

hand-held extinguisher has a UL 5-B:C rating in accordance with the UL 711 Standard or a BS 3A:34B rating in accordance with British standards. This corresponds to 2.5 pounds for a Halon 1211 extinguisher. It is expected that this UL 5-B:C or BS 3A:34B fire-extinguishing ability along with a demonstrated ability to extinguish a hidden fire will be required for agents used in this application.

b. The extinguisher must be able to extinguish fires in indirectly accessible spaces (hidden fires) as effectively as Halon 1211. It is desirable that the agent be sufficiently volatile to allow expansion and penetration into such spaces. Hand-held extinguishers are by nature streaming agents; however, Halon 1211 has the ability to also function as a flooding agent. To insure no loss of safety, replacement agents must maintain this ability. A hidden fire test has been developed to assess the firefighting performance of the hand-held extinguisher/agent combination in a flooding scenario. This test was developed by To avoid confusion with fire types, the classification of cargo compartments is underlined in this report.

Kidde International-UK. The operating procedure has since been refined and standardized at the FAA William J. Hughes Technical Center, USA. The hidden fire test will be administered by Underwriters Laboratory. Extinguishers that are filled with acceptable agents (see "c" below) and pass the hidden fire test will receive FAA approvalto replace Halon 1211 in aircraft cabins.

c. The extinguisher must have an acceptable toxicity for use where people are present and must not cause unacceptable visual obscuration or passenger discomfort. In particular, the combined toxicity of the agent and fire products must not be unacceptable for use in an aircraft fire under in-flight conditions. The FAA has determined that the following agents are acceptable from a toxicity viewpoint for use in occupied aircraft cabins:

Dupont FE-36, Great Lakes Chemical FM-200, POWSUS Envirogel, NAFG PIV, and American Pacific Halotron. The FAA aircraft seat fire toxicity test was conducted with each of these agents and the toxicity criterion applied to assess acceptability.

In the first report, the Task Group recommended establishment of tests for the following groups of agents. Note that these three groups of agents operate by different mechanisms and/or have large differences in physical properties. They cover the range of testing procedures and apparatuses that should be established. Dry chemical extinguishing agents are not listed due to (1) the potential for damage to electronic equipment, (2) the possibility of visual obscuration if the agent were to be discharged in the cockpit area, and (3) the clean up problem that results from their use. Restricting the use of dry chemicals to cabin areas does not prevent an extinguisher from inadvertently being carried to the cockpit and discharged in an emergency.

The Civil Aviation Authority (CAA) in the UK has sponsored research establishing a hidden fire test for onboard hand-held fire extinguishers. A test fixture was developed that was comprised of arrays of four fires in two of five locations to establish those regions in which an extinguishing concentration was attained. A matrix of ten tests ensured that each fire location was adequately represented. Tests were carried out with several commercially available hand-held

extinguishers. Results varied from 45- to 60-percent extinguishment depending on the quantity of halon contained in the extinguisher and the discharge rate (a faster discharge rate creates more turbulence, aiding mixing and dispersion). In addition, tests were carried out using under- and over-filled extinguishers to examine the sensitivity of the test method. With the exception of one hand-held extinguisher, all results could be correlated to the mass of agent and the flow rate used.

The CAA project carried out limited testing with six halon replacements: HFC-227ea, HFC-125, FC-3-1-10, FC-5-1-14, HFC-236fa, and FIC-13I1, using apparatus designed to give a constant discharge time (10 ±1 seconds). The results obtained appeared to be similar to Halon 1211(50 ±5 percent extinguishment), provided the quantity of agent is scaled according to its *n*-heptane cup burner concentration. The two exceptions were agents whose volatility is markedly different from that of Halon 1211 (boiling point: -4°C (24.8°F), HFC-125 (boiling point: -49°C (-56.2°F), 65-percent extinguishment), and FE-5-1-14 (boiling point: 58°C (136.4°F), 35-percent extinguishment). The testing indicated that use of the physically acting candidate agents (all except FIC-13I1) would give a weight penalty of 1.4 to 2.6 and a volume penalty of 1.9 to 2.9 compared to Halon 1211.

4.3.1 Halocarbons and Halocarbon Blends

Of all of the halocarbon agents, FICs and, possibly to a lesser extent, HFCs are likely to have the lowest restrictions imposed owing to environmental impacts. Nevertheless, even HFCs could face additional regulatory restrictions. FIC-13I1 (like some of the other halocarbons) will also face some restrictions based on toxicity. Under SNAP, this agent is not permitted as a total-flood agent in a normally occupied area.

HCFCs have a nonzero ODP and currently face an eventual regulated production phaseout. The phaseout dates in the United States depend on the material (Table 6); however, all HCFCs now considered for streaming have the same phaseout schedule. When used in non-residential applications, portable fire extinguishers containing HCFCs are exempted by the U.S. EPA from bans on HCFC-pressurized dispensers [130]. At least one HCFC-based agent should be considered in this application because of their gaseous consistencies and their demonstrated abilities on Class A, B, and C fires.

PFCs are approved by the U.S. EPA [9] (FC-5-1-14 for streaming, FC-218 and FC-4-1-10 for total flooding) for non-residential use where other alternatives are not technically feasible due to performance or safety requirements: (1) due to physical or chemical properties of the agent, or (2) where human exposure to the extinguishing agent may result in failure to meet applicable use conditions. The principal environmental characteristic of concern for these materials are their extremely high GWPs and long atmospheric lifetimes. Nevertheless, PFCs should be considereding this application because of their extremely low toxicity.

Some concern has been expressed about preliminary mutagenicity assays indicating that CF3I might be a carcinogen. Certainly this question may need to be resolved; however, some other halon replacement candidates or components also exhibit positive results in at least one genetic toxicity screening test. In addition, there is some concern that iodine emissions from CF3I could cause a problem. No data have yet been collected showing that iodine emissions are any worse with CF3I than bromine emissions are with Halon 1211. Nevertheless, the potential for toxic breakdown products must be fully evaluated.

It is difficult to rank the various halocarbon agents against one another since any ranking requires that dissimilar criteria be compared (e.g., toxicity versus effectiveness), nevertheless, table 18 gives ratings for two criteria (Halon 1211 is also listed for comparison). Here "1″denotes the highest rating. Note that this is qualitative and, undoubtedly, different groups could arrive at different ratings. It is impossible to reliably evaluate the effectiveness of a streaming agent from only cup burner extinguishment concentrations, particularly when the cup burner measures only Class B effectiveness. Nevertheless, the cup burner values, where known, have been included. These can be used as deemed appropriate. The ability of an agent to suppress a fire in a streaming application depends as much on the physical properties and delivery hardware as on the inherent flame-suppressing ability. (Note that this is definitely not true for total-flood applications. The cup burner has proven to be highly reliable for predicting the effectiveness of total-flood agents for Class B fires, at least for those containing a single component.)

TABLE 18. RATING MATRIX FOR CANDIDATE HALOCARBONS FOR HAND-HELDS

Agent	Cup Burner Extinguishment Concentration, %	Known or Potential Environmental Regulatory Restrictions [a]	Toxicity Based on Cardiac Sensitization NOAEL
Halon 1211	2.22[b]	5	3
HCFC-123	7.5[c]	3	3
HCFC-124	6.6[f]	3	3
HCFC Blend B HCFC-123	6-7[e]	3	3
HCFC Blend C HCFC-123 HCFC-124 HFC-134a	[f]	3	3
HCFC Blend D HCFC-123	[f]	3	3
HCFC Blend E	[f]	[f]	[f]
HFC-227ea	6.5[f]	2	2
HFC-236fa	6.3[f]	2	2
FC-5-1-14	4.4[d]	4	1
FIC-13I1	3.2[f]	1	5

[a] Only includes regulatory restrictions based on possible environmental impact. Does not include restrictions due to toxicity.

[b] Reference 131

[c] Reference 132.

[d] Reference 9.

[e] Estimated [133]. Testing indicates that HCFC Blend B has an equivalency rating of 1.5 pounds to 1 pound of Halon 1211 in airport fire protection streaming applications [134].

[f] Data have not been published.

The agent CF3I is the agent least likely to face serious regulatory restrictions based on environmental impacts and has been given an environmental rating of 1. HFCs were given an environmental rating of 2 due to global warming concerns. Halon 1211, which is already restricted, has been assigned an environmental rating of 5 due to its high ODP. Toxicity indices were assigned based on the NOAEL values of the primary components. Note, however, that acceptability for total-flood use in normally occupied areas is not a criteria for use of an agent for streaming. For a NOAEL < 0.5, the toxicity rating = 5; NOAEL = 0.5 to <1.0, rating = 4; NOAEL = 1.0 to <5.0, rating = 3; NOAEL = 5.0 to <20.0, rating = 2; and NOAEL = 20.0 or above, rating = 1. It should be noted that, for streaming applications, most and possibly all of these halon replacement agents could be used in a normally occupied area. Extensive full-scale testing of both HCFC Blend B and FC-5-1-14 for flight line fire protection has been conducted by both the FAA and the U.S. Air Force. The U.S. Air Force has also conducted significant field testing on several other agents listed in Table 18.

4.3.2 Carbon Dioxide

There has been a large amount of experience with hand-held carbon dioxide fire extinguishers. They are known to be safe to use in a streaming application where people are present, and the carbon dioxide should be able to reach into indirectly accessible areas. A major problem exists in the lack of a Class A rating for hand helds in sizes from 5 pounds (5-B:C rating) to 100 pounds (20-B:C). If testing shows that carbon dioxide extinguishers cannot extinguish Class A fires of the type likely to be found in cabin fire scenarios, this agent would have to be eliminated from consideration.

4.3.3 Combination Agents and Foams

These agents include Surfactant Blend A, Loaded Stream, and Gelled Halocarbon/Dry Chemical Suspension. Though these are listed together, their properties are sufficiently different, therefore, major differences in test procedures will probably be required. In the absence of test results, it is impossible to rank the fire extinguishment effectiveness in hand helds for aircraft use. They should all prove very effective for Class A fires; however, these agents may very well lack the ability to penetrate in indirectly accessible spaces. A study of hand-held fire extinguishers by FMRC states that "around object capability" for Halon 1301 is good, dry chemical is poor, and water is poor [135]. Most, and possibly all, combination agents may also have problems with penetration and obstacles. Moreover, there could be some compatibility problems with electrical equipment and, possibly, structural materials with some of the combination agents. Both the Surfactant Blend A and the Gelled Halocarbon/Dry Chemical Suspension series of agents are EPA approved.

4.4 CARGO COMPARTMENT

The recent ruling eliminating Class D as an option for fire safety certification for cargo compartments in certain transport category aircraft will increase the number of compartments requiring fire suppression systems. Such compartments must now meet the standards of Class C and/or Class E compartments. Most Class C compartments are larger than 1000 ft3; many are larger than 2000 ft^3.

According to the report of Task Group 4, the likely fire by an aircraft-supplied ignition source is a surface fire and will most likely be fueled by Class A material. In some instances, the Class A material may be contaminated by small quantities of Class B material. Human- and cargo-supplied ignition sources can cause a variety of fires (deep seated, flaming, explosive, metallic, fires with their own oxidizer, chemical, etc.). These fires are not easily characterized, but the task group defined, as specified in the Cargo Compartment Minimum Performance Standard, four different fire test scenarios in order to address the variety of fires.

A cargo compartment fire suppression system must meet the following fire test requirements. (See Table 19 to obtain maximum allowable compartment temperatures.)

a. The system must suppress a Class A deep-seated fire (bulk-loaded cargo) for at least 30 minutes.
b. The system must suppress a Class A fire inside a cargo container for at least 30 minutes.
c. The system must extinguish a Class B fire (Jet-A fuel) within 5 minutes.
d. The system must prevent, either by fire control or inerting the compartment, the explosion of an explosive hydrocarbon mixture.

The cargo compartments are normally pressurized with a minimum normal pressure corresponding to an altitude of 8,000 feet. In flight, the temperatures are maintained above freezing by several means, including ventilation. Fire in the cargo compartments is detected by smoke and ionization aerosol detectors or thermal sensors. The fire detection system is required to detect and provide visual indication of the fire to the flight crew within 1 minute after the start of a fire. Also, the system must be capable of detecting a fire at a temperature significantly below that at which the structural integrity of the airplane is substantially decreased (FAR 25.858 [138]). Fire detection systems are certified using an FAA-approved fire simulator.

Systems that provide a warning within 1 minute from the start of smoke generation are considered to be in compliance with FAR 25.858 [138]. The present practice is to control ventilation and drafts within the compartment prior to the activation of the suppression system. However, there is a small infiltration into the compartment through the compartment walls (typically fiberglass liner) and leakage out of the compartment through door seals. The general practice is to divert to the nearest field on detection of a fire. On long-range (across the ocean) aircraft, suppression is required for up to the maximum diversion time which could be in excess of 200 minutes.

The agent or system for cargo compartments must meet the following requirements in addition to the essential requirements identified earlier.

The agent/system for cargo compartments must also meet the requirements of FAR 25.851, Part B [139] and FAR 25.1309 [140].

a. The agent/system must be suitable for fires likely to occur. These include Class A and B fires and hazardous materials.

b. The agent/system must be able to provide fire suppression over a period of up to the maximum diversion time, which could be in excess of 200 minutes, depending on the aircraft type and route structure.

It is desirable for the agent to have the following attributes.

a. Because cargo compartments can be used for transportation of animals, it is desirable that the agent have a low toxicity and that it not be an asphyxiant at the concentrations required for extinguishment. In addition, no agent can be allowed that could leak into occupied compartments in toxic concentrations. Federal regulations require that —There are means to exclude hazardous quantities of smoke, flames, or extinguishing agent from any compartment

occupied by crew or passenger.“ Airframe manufacturers meet this by design. Typical cargo compartments contain a fiberglass liner, which is tested with a smoke generator for leakage and with burners for flame penetration. Escape of smoke or extinguishing agent in hazardous quantities from cargo compartments of properly maintained aircraft is unlikely.

b. The agent should not impose additional (in addition to system recharge and check-out) departure delay following a false discharge.

The FAA has distributed a survey package to airlines and airframe manufacturers to determine opinions on agents and technologies proposed for cargo compartments in the earlier reports. The response was poor. A majority (60 percent) of those responding preferred halocarbons, with a small, but significant, number believing that water and particulate aerosols are best. Respondents were unanimous that the high-expansion foams are not appropriate for use in cargo compartments. Due to this negative response and technical considerations, high-expansion foams have been removed from the list of agents proposed in the past by the Task Group on Halon Options for cargo compartments. The remaining agents–water and water-based agents, halocarbons and halocarbon blends, and particulate aerosols–are still recommended for the establishment of test protocols.

The Minimum Performance Standard for Aircraft Cargo Compartment Gaseous Fire Suppression Systems was published September 2000 [142]. This document provides the extinguishing/suppressing performance of Halon 1301 (when subjected to the four fire scenarios mentioned earlier) and the standard test protocols. Currently, the aerosol explosion protocol section, in this standard, is being modified by the FAA William J. Hughes Technical Center in order to allow the inclusion of a nongaseous system such as water spray.

FAA test data are now available on Halon 1301, HFC-125, HFC-227ea, PGA, and water mist.

The MPS requirements are shown in table 19 for a 2000-ft^3 cargo compartment.

TABLE 19. ACCEPTANCE CRITERIA FOR A 2000-cubic foot CARGO BAY

Fire Scenario	Maximum Temperature °F (°C)	Maximum Pressure psi (kPa)	Maximum Temperature-Time Area °F-min (°C-min)	Comments
Bulk Load	730 (387.8)	[a]	11,900 (6593)	Temperature limit starting 30 seconds after suppression system activation. Temp.-Time area for 30 minutes starting with suppression system activation.
Containerized Load	670 (354.4)	[a]	15,400 (8538)	Temperature limit starting 30 seconds after suppression system activation. Temp.-Time area for 30 minutes starting with suppression system activation.
Surface Fire	1250 (676.7)	[a]	3,270 (1799)	Temperature limit starting 30 seconds after suppression system activation. Temp.-Time area for 5 minutes starting with suppression system activation.
Aerosol Can	[a]	0	[a]	There shall be no explosion

[a] Not applicable.

4.4.1 Water and Water-Based Agents

Water meets almost all of the above requirements. A water system needs to be challenged against the MPS aerosol explosion test to determine its explosion prevention capabilities. Water is the most common fire-extinguishing agent for ordinary combustibles. The efficiency of the agent depends on the application method (sprinkler, mist, total flood, zoned application, etc.).

Several investigators have determined it to be as effective as Halon 1301 for identical fire threats. It can be used in misting or sprinkler applications. In the present application, it is recommended that testing of misting systems be performed; however, sprinkler systems could be considered. Both sprinklers and misting systems could use a zoned application. It is possible to use surfactant/water or dry chemical/water blends; however, in the absence of test results to the contrary, it is difficult to determine what benefit would ensue from

the use of such mixtures. Moreover, such mixtures could cause an increase in clean-up efforts.

The FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey, has carried out a mist system testing program for the FAA TC-10 cargo test compartment. The objective was to design and install a water mist system that would prevent a fire in a luggage container from spreading to an adjacent luggage container and maintain temperatures within the space below 350°C for 90 minutes. The program has shown that one misting system can pass both the loaded luggage container and bulk-loading fire tests for the TC-10 cargo test compartment using 30 gallons of water. These results are encouraging and suggest that an area-coverage water mist system may impose a lower takeoff gross weight (TOGW) penalty for large cargo compartments. Another advantage may be lower sensitivity (compared to gaseous agents) to compartment leakage.

It has been suggested that water-based fire suppression systems may be recharged from the portable water system if the initial capacity fails to adequately suppress a fire. It has also been proposed that it may be possible to recycle water using runoff from discharge to reduce the amount of water needed to provide protection. These proposals would require significant engineering to incorporate and may not be practical. Water-based systems may provide an acceptable environment for animals in the event of a false discharge. In addition, water-based systems may not depend on the integrity of the compartment liner for effective performance.

Some concerns have been expressed about the possibility of stored water freezing; however, design solutions are available to prevent such occurrences.

4.4.2 Halocarbons and Halocarbon Blends

Table 20 gives a rating for various criteria for halocarbons in cargo compartments. Here "1" denotes the highest rating. Arbitrarily, ratings for design concentrations have been assigned as:

- 5 percent and below: 1
- 5 to 8 percent: 2
- 8 to 11 percent: 3
- above 11 percent: 4

Ratings for storage volume and weight equivalents are given ratings as follows:

- 1.0 or less: 1
- 1.0 to 1.5: 2
- 1.5 to 2.0: 3
- above 2.0: 4

Note that these effectiveness ratings were derived from data for a Class B fire with *n*-heptane fuel. They may not indicate performance for a deep-seated Class A fire, which is the probable fire in cargo compartments. Agents with NOAEL values of 30 percent or above are rated as 1 for toxicity. Agents with NOAEL values less than 30 percent but which are acceptable (or likely to be acceptable)

for total flood in normally occupied areas under NFPA Standard 2001 are given a rating of 2. HFC-125, whose NOAEL value is only slightly less than that which would allow total-flood use in normally occupied areas, is given a rating of 3. HCFC-124 with a NOAEL of 1.0 and FIC-13I1 with a NOAEL of 0.2 are rated as 4 and 5, respectively. Note, however, that cargo compartments are not considered to be normally occupied areas. Due to its high-vapor pressure, the delivery characteristics and system requirements for HFC-23 may differ significantly from those for most other halocarbons.

TABLE 20. RATING MATRIX FOR CANDIDATE HALOCARBONS FOR CARGO COMPARTMENT

Agent	Class B Fire Design Conc., %	Class B Fire Weight Equivalent	Class B Fire Storage Volume Equivalent	Known or Potential Regulatory Restrictions [a]	Cardiac Sensitization NOAEL
HCFC-124	3	3	3	3	4
HCFC Blend A	3	2	2	3	2
HFC-23	4	3	4	2	1
HFC-125	3	3	4	2	3
HFC-227ea	2	3	3	2	2
HFC-236fa	2	2	2	2	2
FC-218	3[b]	4[b]	4	3	1
FC-3-1-10	2	3	3	3	1
FIC-13I1	1	1	1	1	5

There has been some work indicating that misting (and, perhaps, standard discharge) of higher molecular weight (lower-vapor pressure) halocarbons can provide total-flood-like protection of enclosed areas. At present, no manufacturer offers such a system, and the technology must still be considered unproven. However, the possibility that one or more new, lower-vapor pressure compounds will be proposed for total-flood protection must be kept in mind.

Class A fires develop slowly. It is feasible to detect a fire in a cargo compartment within a zone and suppress it by a zoned fire suppression system. In the past, total-flood systems have been used, but the federal regulations do not mandate a total-flood system. The halocarbon agents fall in two categories: liquid agents, which could be applied in a zoned application, and gaseous agents for total-flood applications. It is recommended that test protocols for both types of agents be developed.

4.4.3 Particulate Aerosols

Some preliminary testing has been performed by the FAA on type S.F.E. formulation "D" particulate aerosols using modular units of 4 kilograms each. The scope of the test was to evaluate the S.F.E. aerosol performance on deep-seated

Class A fires, specifically shredded papers. The FAA requirements were to extinguish the fire and inert the protected volume for 30 minutes. The S.F.E. particulate aerosol formulation "D" was tested at an concentration of 60-100 gr/m3. The agent partially suppressed a Class A fire in a 2357-ft^3 compartment and inerted the volume for approximately 17 minutes.

These preliminary results and consideration of the possible weight/volume cost benefits of the particulate aerosols technology, render its application to aircraft fire protection as potentially viable, and the technology should be further evaluated.

4.5 LAVATORY TRASH RECEPTACLE

Lavatories are located in the pressurized aircraft cabin with environmental conditions similar to the conditions in other occupied areas. The likely fire threat in the lavatory trash receptacle would involve Class A materials (paper and paper products), with the typical ignition source being burning material discarded into the container, such as a lit cigarette. The trash containers are designed to contain the likely fire. No fire detection system is provided in the container.

Rulemaking was implemented on April 29, 1987, that required each lavatory trash container be equipped with a built-in automatic fire extinguisher that discharges automatically into the container upon the occurrence of a fire. In order to accomplish this, the extinguisher bottle incorporates a eutectic device at the end of a tube directed into the container. In the event of a fire, the heat generated will melt the eutectic tip, releasing the agent directly into the receptacle.

Currently, all aircraft lavatory disposal receptacle fire extinguishers use Halon 1301 as the fire-extinguishing agent. A relatively small amount of agent (100 grams of 1301) is effective in extinguishing this type of fire. For this reason, suitable gaseous replacement agents such as HFC-227ea and HFC-125 can be used in this application, as the additional amount of agent required to extinguish the fire is negligible.

The agent for trash containers must meet the following requirements in addition to the essential requirements identified earlier in Section 4.1, Requirements.

a. The agent must extinguish a Class A (paper towel) fire as defined in the Minimum Performance Standard (MPS) [145].
b. The agent must have a toxicity such that, if the same quantity of agent used for the trash container is released into the entire lavatory, the NOAEL is not exceeded.

A survey of 24 airlines showed that 66 percent preferred halocarbons or halocarbon blends for use in aircraft lavatory trash receptacles [146]. The reasons given for this preference were reduced weight, minimum impact on current installation, and effectiveness. Sixteen percent preferred water, giving as reasons, low environmental impact and reduced maintenance. Weight and effectiveness concerns were mentioned as potential drawbacks for water. The IHRWG, Task Group 7, and the FAA have established a Minimum Performance Standard for lavatory trash receptacles. The following agent types are most likely to have

utility in lavatory trash receptacle applications: HFC-125, HFC-227ea, HFC-236fa, and Envirogel.

4.5.1 Water-Based and Combination Agents

Water, water/surfactant (e.g., Surfactant Blend A), Dry Chemical/Water Mixtures, and combination agents meet all the above requirements. Water is the most common fire-extinguishing agent for paper products. The efficiency of the agent depends on the application method (sprinkler, mist). Loaded stream or surfactant blends could improve surface wetting of Class A materials. These are all likely to be more effective on Class A materials than halocarbons. Pacific Scientific is commercializing a lavatory fire extinguisher containing Envirogel.

4.5.2 Halocarbons and Halocarbon Blends

Most halocarbons would provide acceptable extinguishing ability in this application. Moreover, recent work with HFC-227ea suggests that some halocarbons might allow retrofit into existing systems. However, to achieve the required low-temperature performance (5°F), some halocarbons will need to be pressurized with nitrogen. Since the system may be as important as the agent, it is difficult or impossible to rank agents for this application. This will be primarily a system test.

4.6 SUMMARY

Fire-extinguishing agent technology is extremely dynamic. A number of new agents and technologies are being evaluated in the laboratories across the nation. The recommendations above are based on the present state of the technology, EPA approvals, and listing by technical organizations. These recommendations are intended to guide the FAA in the development of the test protocols. It must be recognized that a test protocol developed for a class (liquid, gaseous, solid) of agents may, with minor modifications, be used to test all agents belonging to the class.

United States Testing Company, Inc.
Biological Services

1415 Park Avenue
Hoboken, New Jersey 07030
Tel: 201-792-2400
Fax: 201-656-0636

REPORT OF TEST

Safety Testing
on

COLDFIRE 30: Fire Suppressing Agent

Conducted for:
North American Environmental Oil and
Chemical Cleaning Supply Company
270A Route 46
Rockaway, New Jersey 07866

April 13, 1993

TEST REPORT NO. 065318-2

SIGNED FOR THE COMPANY
BY

Prepared by:
Joan Breheny, B.S.
Supervisor, Toxicology

Charles C. Tong, Ph.D., D.A.B.T.
Director of Toxicology

Note: Signature copies of this report available upon request.

United States Testing Company, Inc.

Client: North American Environmental 065318-2
Oil & Chemical Cleaning Supply Co. 4/13/93

Evaluation of Test Results:

The dermal irritation scores should be evaluated in conjunction with the nature and reversibility of the responses observed. Individual scores do not represent an absolute standard for the irritant properties of a material but should be viewed as reference values which are only meaningful when supported by a description of the observations.

Results:

Sample ID: Cold Fire 30: Fire Suppressing Agent

Test Dates: 1/20 – 1/23/93

Post Exposoure Observation Period (hrs)	Non-abraded Skin Irritation Index	Individual Animal Test Values						
		1	2	3	4	5	6	Avg
1	Erythema-Eschar Edema	0	0	0	0	0	0	0
24	Erythema-Eschar Edema	0	0	0	0	0	0	0
48	Erythema-Eschar Edema	0	0	0	0	0	0	0
72	Erythema-Eschar Edema	0	0	0	0	0	0	0

Observations:

No dermal reaction was observed in any test animal throughout the 72 hour observation period.

Conclusion:

When tested as specified, the submitted sample was not considered to be a primary skin irritant.

United States Testing Company, Inc.

Client: North American Environmental 065318-2
Oil & Chemical Cleaning Supply Co. 4/13/93

Sample ID: Cold fire 30: Fire Suppressing Agent

Sample Preparation: None. The test sample was administered neat.

Test Dates: 3/2/93 – 3/9/93

Results:

	Animal Rating After 1 Hour					
	1	2	3	4	5	6
Cornea	0	0	0	0	0	0
Iris	0	0	0	0	0	0
Conjunctivae	1	1	1	1	1	1
Chemosis	2	2	3	2	2	3
Discharge	0	0	0	0	0	0

	Animal Rating After 24 Hours					
	1	2	3	4	5	6
Cornea	1	1	0	1	1	1
Iris	1	0	1	1	0	0
Conjunctivae	2	2	2	2	2	2
Chemosis	2	2	2	2	2	2
Discharge	1	0	0	0	0	0

	Animal Rating After 48 Hours					
	1	2	3	4	5	6
Cornea	1	1	1	1	1	1
Iris	1	0	0	0	0	0
Conjunctivae	2	2	3	1	1	2
Chemosis	1	1	2	0	2	1
Discharge	0	0	0	0	1	0

	Animal Rating After 72 Hours					
	1	2	3	4	5	6
Cornea	1	1	1	1	1	0
Iris	0	0	0	0	0	0
Conjunctivae	2	2	2	0	1	1
Chemosis	1	1	1	0	1	0
Discharge	0	0	0	0	0	0

	Animal Rating After 7 Days					
	1	2	3	4	5	6
Cornea	0	0	0	0	0	0
Iris	0	0	0	0	0	0
Conjunctivae	0	0	0	0	0	0
Chemosis	0	0	0	0	0	0
Discharge	0	0	0	0	0	0

United States Testing Company, Inc.

Client:	North American Environmental	065318-2
	Oil & Chemical Cleaning Supply Co.	4/13/93

Observation:

Twenty-four hours after dosing, five of the six test animals display corneal irritation with scattered or diffuse areas of opacity with details of the iris clearly visible. By 48 hours, all six test animals displayed this irritation. The corneal irritation completely disappeared by day 7.

Twenty-four hours after dosing, three of the six test animals showed iris irritation with markedly deepened folds, congestion, with iris still reacting to light. The iris irritation completely disappeared in all three test animals by 72 hours.

One hour after dosing, all six test animals showed conjunctive irritation with some vessels definitely injected. By 24 hours the irritation became more severe in all six test animals. Complete recovery was observed in all six test animals by day 7.

One hour after dosing, all six test animals displayed chemosis. The swelling ranged from obvious swelling with partial eversion of lids to swelling with lids about half closed. Complete recovery was observed in all six test animals by day 7.

Above normal discharge was observed in one test animal at 24 hours and a second test animal by 48 hours. Complete recovery was observed by 72 hours.

Conclusion:

When tested as specified, the submitted test sample was observed to cause eye irritation in all six test animals with complete recovery observed by day 7.

United States Testing Company, Inc.

Client: North American Environmental 065318-2
Oil & Chemical Cleaning Supply Co. 4/13/93

Procedure: Acute Oral Toxicity Test (continued)

Sample Preparation:

The test article was administered as a neat liquid; density = 1.0 g/ml.

Results: Definitive Testing, Acute Oral Toxicity Upper Limit Test

Ten Sprague-Dawley rats (5 male, 5 female) were administered an oral dose of the test article 5 g/kg.

Test Dates:

Sample	Animals	Dose (g/kg)	14-Day Mortality % Total	Average Body Weight (g) Initial	Final
Cold Fire 302	F	5.0	0	210	261
	M	5.0	0	267	374

Observations:

One female test animal showed slight diarrhea/discharge on day 7 of the study. The remaining test animals appeared normal throughout the 14 day observation period.

Gross Pathology:

No abnormalities were noted at necropsy on day 14 of the study.

Conclusion:

When tested as specified, the test article was not acutely toxic to laboratory animals following oral administration at 5.0 g/kg.

SGS U.S. Testing Company Inc.

75 Passaic Avenue
Fairfield, NJ 07004-3833
Tel: 201-575-5252
Fax: 201-244-1694

Report Number: 202536-01
Date: 08/16/96
Page: 1 of 11

REPORT OF TEST

Acute Dermal Toxicity Study in Rabbits on NuShield™

Conducted for:

NuMar Technologies, Inc.
841 Mountain Avenue
Springfield, NJ 07081

Manufactured by:

Firefreeze Worldwide, Inc.

Prepared by:

Joan Breheny, M.S.
Supervisor of Toxicology

SIGNED FOR THE COMPANY BY

Charles C. Tong,Ph.D., D.A.B.T.
Director of Toxicology

Note: Signature copies of this report available upon request.

REPORT OF TEST

GLP Compliance

The characterization of the test substance was the responsibility of the sponsor. To the best of our knowledge, the remaining part of the study was conducted in compliance with 21 CFR 58, FDA Good Laboratory Practices.

_____
Charles C. Tong, Ph.D., D.A.B.T.
Study Director

REPORT OF TEST

QAU STATEMENT

Test Substance: (Sponsor's Code)	NuShield™ (Cold Fire) Manufactured by Firefreeze Worldwide, Inc.
Nature of Study:	Acute Dermal Toxicity Study in Rabbits
Study Number:	202536-01
Study Initiation Date:	05/13/96
QAU Review of Protocol:	05/13/96
QAU Review of In-Life Phases:	05/14/96, 05/24/96
Reported to Study Director:	05/16/96, 05/24/96
Reported to Management:	05/17/96, 05/24/96
QAU Review of Raw Data:	08/12/96
QAU Review of Draft Report:	08/12/96
QAU Review of Final Report:	08/16/96
Study Termination Date:	08/16/96

The above study was conducted at SGS USTC Laboratories in accordance with GLP regulations applicable to the Quality Assurance Unit. This study was inspected by the QAU on the dates specified above. The findings of the in-life inspections were reported to the Study Director and Management on the dates listed.

_____ 8/16/96

R. Franconeri
Quality Assurance Director

Date

REPORT OF TEST

Table of Contents

REPORT OF TEST

Summary

When tested as specified, NuShield™ (Cold Fire) manufactured by Firefreeze Worldwide, Inc. was not acutely toxic to laboratory rabbits following dermal application at a dose level of 2.0g/kg. Thus, under the conditions of this experiment Cold Fire is practically nontoxic following dermal application.

Client: NuMar Technologies, Inc.

Report Number: 202536-01
Date: 08/16/96

REPORT OF TEST

Subject: Sample submitted and identified by the client as:

NuShield™ (Cold Fire) manufactured by Firefreeze Worldwide, Inc.

Project: Acute Dermal Toxicity Test

Introduction and Purpose

The purpose of this safety test is to determine if acute health hazards are associated with dermal exposure to the test article. The measure acute toxicity can be expressed as the median lethal dose (LD50), a statistically derived value that estimates the dose that would theoretically kill 50% of the test animal group. Such tests require the dosing of a large number of animals to generate a precise LD50 value.

Often such a precise measurement of lethality is either not required to characterize the test article or may not be practical as the test article may be minimally toxic to animals following dermal application. To minimize the number of animals used in acute dermal toxicity tests without compromising the intent of such safety test, the use of screening test and the administration of a single building limit dose to a group of animals is often adequate for assessing the inherent acute toxicity of the test article.

The test was conducted in accordance with the procedures as outlined in:

Environmental Protection Agency (EPA) Health Effects Test Guidelines EPA 560/6-82-001 and Pesticide Assessment Guidelines, EPA 540/9-82-025, of the Office of Pesticides and Toxic Substances.

REPORT OF TEST

Testing Regime:

The Client requested characterization of the acute dermal toxicity of the submitted samples. These data were established through the use of acute dermal toxicity upper limit tests.

Procedure: Acute Dermal Toxicity Test

Ten New Zealand stain albino rabbits each weighing between 2.3 to 3.5 kg were selected for each dosage. The animals were housed individually in stainless steel caging with raised flooring in a conditioned animal room. Animals were maintained on a commercial pelleted rabbit food and water was available ad libitum.

On the day of the test, the animals were identified and body weights recorded. The fur from the backs and flanks of the animals was removed with the use of electric clippers. The animals were carefully shaved to avoid abrading the skin. Approximately 20% of the animals' body surfaces were prepared for administering the test article.

The test articles dosages were administered topically to the prepared skin sites. The samples were held in contact with the skin covering the skin site with a single layer of gauze and occluding the trunks of the animals with plastic film. The impervious covering was secured with an elastic wrapping and taped to contain the dosage without leakage during the 24 hour exposure period. After exposure, the animals were thoroughly cleaned of the test articles with water or as specified in submitted protocol whenever appropriate and returned to their cages for observation.

Animals were closely observed for gross toxicological effects immediately after administration of the sample and then daily for a 14-day observation period. Test animals' body weights, a sensitive indicator of toxic insult, were recorded during the observation period and necropsies of dead, morbid or surviving animals were performed if indicated during the progression of the study.

REPORT OF TEST

Procedure: Acute Dermal Toxicity Test

Test Animals:

Strain: New Zealand strain rabbits (male, female)
Source: S&S Associates, Lake Harvey, PA
Date Received: 05/07/96
Number of Animals: 10 animals

Upon arrival, animals were housed individually and ear-tagged with a 4 digit animal identification number. Animals were observed for at least one week for signs of illness or disease prior to initiating tests. There was no randomization procedure used. Animals were selected from a healthy pool of test animals maintained at the facilities.

Sample Preparation:

None. The sample, NuShield™ (Cold Fire) manufactured by Firefreeze Worldwide, Inc. was administered as a neat solution.

Results:

Definitive Testing; Acute Dermal Toxicity Upper Limit Test

Ten New Zealand strain rabbits (5 male, 5 female) were administered a topically applied dermal dose of the liquid at 2.0g/kg.

Test Dates: 05/14/96 – 05/28/96

Sample	No. Of Animals	Dose (g/Kg)	14-Day Mortality % Total	Average Body Weight (Kg)	
				Initial	Final
Cold Fire	5 M	2.0	0	2.6	3.0
	5 F	2.0	0	2.6	3.0

Individual animal body weight, clinical observation and gross necropsy findings are listed in Appendix 1.

REPORT OF TEST

Observations:

All animals appeared normal throughout the 14-day observation period. Twenty-four hours after dosing, one of the ten test animals (#5 Male) displayed slight blanching and dermal irritation at the test site. By day 14, all ten test animals showed normal skin at the test sites. Individual clinical observations are presented in Appendix 1.

Gross Pathology:

Individual necropsy findings are presented in Appendix 1. At necropsy on day 14, in animal #4 female (#2363), a lobular, red-brown, mottled lesion (4x3x2 cm) on the right lateral lobe of the liver was found. After consulting with Dr. F.R. McConnell, DVM, our consulting veterinarian, it is our opinion that the lesion does not appear to be test related.

Conclusion:

When tested as specified, the liquid test article, NuShield™ (Cold Fire) manufactured by Firefreeze Worldwide, Inc., was not acutely toxic to laboratory animals following dermal application and exposure to the test article at 2.0g/kg. Therefore, under the conditions of this experiment TREO Lotion is practically nontoxic following dermal application.

REPORT OF TEST

ARCHIVAL OF RAW DATA

SGS U.S. Testing Company policy regarding GLP studies is to inventory and archive a copy of the final report and all original test data and records generated in support of the study for a period of five years following the date of the final report of test. Upon completion of the five year period, all inventoried original test data and study records (or where applicable, photocopies of the originals), shall be transferred to the sponsor (client) of the study. The appropriate agency shall be notified in writing of such a transfer, as required under current guidelines.

REPORT OF TEST

Analysts' Signatures

Investigators and analysts for the mammalian toxicology study:

Study Director:	Charles C. Tong, Ph.D. D.A.B.T
Quality Assurance:	R. Franconeri
Analyst:	Joan Breheny, M.S.
Analyst:	Stefania Giobbe, M.S.
Analyst:	Suzanne Poppe

REPORT OF TEST

APPENDIX 1

Individual Animal Body Weight
Clinical Observations and Necropsy Findings

Sample: NuShield™ (Cold Fire) manufactured by Firefreeze Worldwide, Inc.

Dose (g/kg)	Animals/ Sex	Dose Vol (ml)	Body Weight (kg) Day 0	Day 7	Day 14	Clinical Observation Day 0 – Day 14	Necropsy Findings
2.0	2360-F	5.0	2.5	2.8	2.8	N	N
	2361-F	5.2	2.6	2.6	2.7	N	N
	2362-F	5.2	2.6	3.0	3.2	N	N
	2363-F	5.2	2.6	2.8	3.0	N	N,2
	2364-F	5.2	2.6	2.9	3.2	N	N
		Average:	2.6	2.8	3.0		
2.0	2370-M	5.0	2.5	2.8	3.0	N	N
	2372-M	5.2	2.6	2.8	3.0	N	N
	2374-M	5.4	2.7	2.9	3.1	N	N
	2375-M	5.4	2.7	3.0	3.2	N	N
	2376-M	5.0	2.5	2.8	2.9	N,1	N
		Average:	2.6	2.9	3.0		

N = Normal.

1 = Slight blanching and dermal irritation at test site.

2 = A lobular red, brown mottled lesion (4 cm x 3 cm x 2 cm) on the right lateral lobe of the liver.

APPENDIX 2

SUMMARY OF PROCEDURE:	Acute Dermal Toxicity Test (LD50)
REFERENCE:	USTC Procedure TOX DERMLD50 . 008 to conform to current guidelines .
PURPOSE:	To access the potential of a test substance to induce Toxicity following skin contact.
Sponsor:	NuMar Technologies, Inc. 841 Mountain Avenue Springfield, NJ 07081
Sponsor Contact:	Ms. Robyn Williamson
Laboratory:	SGS U.S. Testing Company, Inc., Biological Services 75 Passaic Avenue, Fairfield, NJ 07004
Study Director:	Charles C. Tong, Ph.D., D.A.B.T. (201) 575-5252 Ext. 2521
Test Substance (Sample)	Cold Fire
Storage, Handling Conditions:	Ambient temperature
Procedures Proposed:	Acute dermal toxicity Toxicology Procedure DERMLD50 . 008
Amendments/Specs:	Limit Test
Proposed Experimental Start Date:	May 14, 1996
Proposed Experimental Termination Date:	May 28, 1996

1. DURATION OF STUDY: 14 Days
2. EXPOSURE SCHEDULE: Once, Test Day 0, 24 hrs
3. OBSERVATION PERIOD: Daily, up to 14 Days

4. ROUTE OF ADMINISTRATION:	Dermal. After exposure, if the skin site is intact, it will be rinsed with deionized water and wiped with a soft gauze pad or other appropriate material. If the site is "broken," it will be rinsed with normal saline only. There will be no "wiping."
5. EXPOSURE GROUPS:	One group exposed to the test substance at 2.0 g/Kg body weight.
6. CONTROL GROUP:	None.
7. ANIMALS PER GROUP:	5 males and 5 females, females shall be nulliparous & non-pregnant.
8. SPECIES/STRAIN:	New Zealand strain albino rabbits.
9. SEX/AGE/WEIGHT:	Male and female – not less than 2.3 kg.
10. SOURCE:	Sgarlats, Harvey's Lake, PA 18618.
11. RANDOMIZATION OF ANIMALS:	Randomly selected from large pool of healthy subjects maintained at USTC.
12. MEANS OF IDENTIFICATION:	Ear Tags.
13. FOOD & WATER:	Purina Rabbit Chow Brand Feed Purina Mills, St. Louis MO and municipal filtered water. Analysis at least once a year for specific microorganism, heavy metals (water); for specific heavy metals and pesticides (feed). None of these contaminants are reasonably expected to be present at levels sufficient to interfere with this study.
14. JUSTIFICATION OF TEST SYSTEM:	Rabbits historically have been used in safety evaluation studies and are recommended by appropriate regulatory agencies. No alternatives to animal use are currently available. This protocol will be reviewed by the U.S. Testing IACUC for compliance with regulatory guidelines concerning the care and use of animals. If not in compliance, modifications will be required.

15. TEST MEASUREMENTS:

PRE-TEST	
QUARANTINE	- observations only, 7 days
	- Body weights & physical examinations, on test day 0
POST EXPOSURE	
SURVIVAL CHECKS	- at least once daily
CLINICAL OBSERVATIONS	- once daily, 7 days per week
PHYSICAL EXAMINATION	- pretest only
BODY WEIGHTS	- pretest, day 7 and day 14
FOOD CONSUMPTION	- not required
CLINICAL CHEMISTRY	- not required
HEMATOLOGY	- not required
URINALYSIS	- not required
OPHTHALMOLOGY/ DERMATOLOGY	- dermatology if applicable
NECROPSY	- all test animals
HISTOPATHOLOGY	- not required

16. STATISTICAL METHODS: (IF APPLICABLE)

17. RECORD MAINTENANCE: Equipment maintenance/calibration records, test/control article records, environmental records, specimen, raw data, QA/QC reports, communication and final reports will be archived in secured file at USTC.

18. REGULATORY COMPLIANCE: This study will be conducted in accordance with Good Laboratory Practice Regulations as set forth in 21 CFR Part 58, Dec. 22, 1978 (effective June 20, 1979), and any applicable amendments, 40 CFR Part 160, Subpart F (EPA-FIFRA-GLP) and 40 CFR Part 792, Subpart F (EPA TSCA-GLP) as applicable.

Upon approval of this protocol, the sponsor assumes the responsibility of performing, documenting and maintaining documentation that test, control and reference substances are properly characterized in accordance with the guidelines set forth in the following: 40 CFR 160, Subpart F – Test, Control and Reference Substances (EPA-FIFRA); or 40 CFR 792 – Subpart F – Test, Control and Reference Substances (EPA-TSCA); or 21 CFR 58, Subpart F – Test and Control Articles (FDA-GLP), as applicable to this study.

All data generated in support of this study shall be archived at USTC for a period of five years from the date of the final report of test. Upon completion of this time period, the original data (or where applicable, certified photocopies of the original data) shall be inventoried and transferred to the sponsor who shall then assume responsibility for archiving the data in accordance with appropriate GLP guidelines. Concurrently, the inventory of the study and a notice that the files have been transferred to the custody of the sponsor shall be sent to the FDA or EPA, as applicable.

Submitted by:

Charles C. Tong, Ph.D., D.A.B.T.
Director of Toxicology

Reviewed by:
(reserved)

Tina Nuccitelli
Quality Assurance Auditor

Approved by:
(Sponsor)

Guy T. Falzarano
Executive Vice President
NUMAR TECH, INC.

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SGS U.S. Testing Company Inc.

75 Passaic Avenue, Fairfield, NJ 07004-3833 ◆ Tel: 201-575-5252 Fax: 201-244-1823

REPORT OF TEST

Acute Inhalation Toxicity Limit Test
4 Hours
on
JG302 (at a 1:10 Dilution)

Conducted for:

Firefreeze World Wide, Inc.
270 Route 46
Rockaway, New Jersey 07866

Prepared by:

Joan Breheny, M.S.
Supervisor of Toxicology
10/23/97

SIGNED FOR THE COMPANY BY:

Charles Tong, PhD, D.A.B.T.
Study Director
10/23/97

Note: Signature copies of this report available upon request.

REPORT OF TEST

Statement of No Data Confidentiality Claims

No claim of confidentiality is made for any information contained in this study on the basis of its falling within the scope of FIFRA Section 10 (d) (1) (A), (B) or (C).

Sponsor: Fire-Freeze Worldwide, Inc.

Signature: Stephanie E. Giessler

Date: 10/23/97

REPORT OF TEST

GLP Compliance

This study was conducted in compliance with the United States Environmental Protection Agency's Good Laboratory Practice Standards, as described in 40 CFR Part 160 (revised August 17, 1989) except the characterization of the test substance, which was the responsibility of the study sponsor. This deviation did not affect the outcome of the study.

_____

Charles C. Tong, Ph.D., D.A.B.T. 10/23/97
Study Director

QAU Statement

R E P O R T O F T E S T

Test Substance (Sponsor's Code)	JG302 (at a 1:10 Dilution)
Nature of Study:	Acute Inhalation Toxicity Limit Test (4 Hours)
Study Number:	203697
Study Initiation Date:	8/08/97
QAU Review of Protocol:	
QAU Review of In-Life Phases:	
Reported to Study Director:	
Reported To Management:	
QAU Review of Raw Data:	
QAU Review of Draft Report:	
Reported to Study Director:	
Reported To Management:	
QAU Review of Final Report:	
Study Termination Date:	

The above study was conducted at SGS USTC Laboratories in accordance with GLP regulations applicable to the Quality Assurance Unit. This study was inspected by the QAU on the dates specified above. The findings of the in-life inspections and report inspections were reported to the Study Director and Management on the dates listed.

Andrea R. Demby, B.S.
Quality Assurance Coordinator

_____
Date

REPORT TEST

Table of Contents

REPORT OF TEST

Project Summary

When tested as specified, the submitted test substance, JG302 (at a 1:10 Dilution) was not acutely toxic to the test animals following a 4-hour inhalation exposure at a nominal concentration of 35.3 mg/L (actual concentration was 16.9 mg/L). The LC_{50} was estimated to be greater than 35.3 mg/L.

REPORT OF TEST

Test Substance Description: Test substance was submitted and identified by the Sponsor as:

JG302

Project Description: Acute Inhalation (LC50) Toxicity Testing With rodents

Test Animals: Strain: Sprague-Dawley rats (males & females)
Source: Ace Animals, Boyertown, PA
Dates Received: 07/15/97

Test Substance Preparation:

JG302, a clear solution and submitted as a liquid in a 5 gallon bucket (no lot # was provided), was diluted at 1:10 with deionized water in this test facility prior to use. The liquid was collected into the Collision Nebulizer immediately prior to the inhalation procedure.

Procedure: Acute Inhalation (4-hour) Toxicity Limit Test

Ten Sprague-Dawley rats (5 males and 5 females), each weighing between 200 and 300 grams, were selected for each dosage. The animals were housed in wire mesh cages with raised floors in a conditioned animal room. The animals were maintained on a commercial rat food diet. Water was available ad libitum. The inhalation test was conducted in an inhalation apparatus manufactured by CH Technologies (USA), Westwood, NJ 07675 and shown in Figure 1. The exposure was nose-only.

The inhalation test was performed using a single 4-hour exposure.

Following the 4-hour exposure period, the animals were then returned to their cages for observation at one hour, after four hours, and once daily thereafter for a period of fourteen days.

REPORT OF TEST

Inhalation Apparatus and Sample Delivery:

Compressed air, passed through a silica gel drying tube, was delivered to a flow meter and then to a collision nebulizer (BGI 6-Jet modified MRE-type) prior to entry into the exposure chamber (Figure 1). The airflow rate into the exposure chamber was 8 liters per minute throughout the 4 hours of exposure. Animals were housed individually in cylindrical holders that opened into the middle of the chamber. The contaminated air exited the chamber and passed through two aqueous scrubbers. The system was verified to have a total of 8 liters per minute at any one time coming out of the ten ports.

The BGI 6-Jet modified MRE-type collision nebulizer was calibrated with the test substance for the production of respirable size aerosol. The aerosol generated was evaluated using an 8 stage Anderson 2000 particle fractionating sampler with a stage 3 cut-off value of 3.3-4.7 microns and a stage 7 cut-off value of 0.43-0.65 microns. Particles collected in stage 3 and below were considered respirable. When calibrated with the test substance, 63.0% the aerosol generated was respirable with a mean median aerodynamic diameter of 1.5 microns and a geometric standard deviation of 1.8.

Gravimetric measurement of the test substance in the nebulizer at specific time points of the run was used to monitor the test substance being delivered into the system. This information was presented in Table 1. To monitor the minimum actual concentration of the test substance at the breathing zone, one of the two remaining and unused ports were opened periodically for a period of 5 to 10 minutes and a piece of cotton was used to trap the aerosol coming out of the port. The increase in weight of the cotton was then used to calculate the actual aerosol concentration. This would be the minimum actual concentration of the test substance in mg/L at the breathing zone. The concentration of the test substance at the breathing zone was presented in Tables 1 and 2. A summary of the various test conditions was presented in Table 3.

REPORT OF TEST

Procedure: Acute Inhalation (4-hour) Toxicity Limit Test

Test Substance Identification: JG302, a clear solution and submitted as liquid in a 5 gallon bucket (no lot # was provided). The submitted test substance was diluted 1:10 v/v with deionized water in this test facility just prior to use.

Test Dates: 08/08/97 – 08/22/97

Results:

Summary of Dose: (From Tables 1 & 2)

Time	Delivered (nominal)	Actual
1st Hour	34.4 mg/L	9.4 mg/L
2nd Hour	34.4 mg/L	16.4 mg/L
3rd Hour	36.3 mg/L	24.1 mg/L
4th Hour	36.0 mg/L	17.7 mg/L
Average	35.3 mg/L	16.9 mg/L

Summary of Animal Data: (From Individual Animal Body Weight Data)

No. Of Animals	Initial Weight	Nominal Dosage (mg/L)	Exposure Mortality	14-Day Mortality Ratio	Final Weight (g)
5F	241.7	35.3	0/5	0/5	266.7
5M	290.9	35.3	0/5	0/5	381.7

REPORT OF TEST

Table 1
Nominal Sample Concentration

Gravimetric:

Test Substance Identification: JG302 (at a 1:10 Dilution)

Time	Initial Test Substance Weight (g)	Final Test Substance Weight (g)	Amount Delivered (g)	Nominal Conc. (mg/L) [2a]
0-60 min.	287.7	271.2	16.5	34.4
60-120 min.	271.2	254.2	16.5	34.4
120-180 min.	254.7	237.3	17.4	36.3
180-240 min.	237.3	220.0	17.3	36.0
Average of Run (240 min.):	35.3			

[2a] Based on a flow rate of a total of 8 liters per minute per 10 ports.

REPORT OF TEST

Table 2
Actual Sample Concentration

Time Into Runs	Initial Weight Of Cotton (g)	Final Weight Of Cotton (g)	Weight of Test Substance Collected (g)	Actual Concentration (mg/L)[4]
0 – 10 min. 40 - 50 min.	3.0057 3.3091	3.0806 3.3714	0.0749 0.0623	10.3 8.6
Average (For 1st Hour) 9.4				
60 – 70 min. 100 – 110 min.	3.2133 3.6919	3.2981 3.8457	0.0848 0.1538	11.7 21.2
Average (For 2nd Hour) 16.4				
120 – 130 min. 160 – 170 min.	3.5081 3.0306	3.7205 3.1688	0.2124 0.1382	29.2 19.0
Average (For 3rd Hour) 24.1				
180 – 190 min. 210 – 220 min.	3.2060 3.5001	3.3578 3.6057	0.1518 0.1056	20.9 14.5
Average (For 4th Hour) 17.7				

[4] Based on an average flow rate of 8 liters per 11 ports (0.727 liters per port) per minute and adjusted for collection time of 10 minutes.

REPORT OF TEST

Table 3
Summary of Test Conditions

Test Substance Test Conditions:	Dry Air Carrier; Collision Nebulizer
Chamber Dynamics:	8 LPM flow rate
Flow Rate Control:	>20 LPM from compressor 8 LPM – compressor air (with Nebulizer on line)
Exposure:	Head only Temperature – ambient – 75.0 – 77.0F Relative Humidity – 56 – 82%
Monitoring:	Gravimetric Temperature and Humidity – Psychrometer

Observations:

Animals did not appear to be lethargic during the 4-hour exposure period. Normal breathing was observed in all animals immediately post-exposure. The test animals appeared normal throughout the 14-Day observation period.

Gross Pathology:

No abnormalities were observed in the test animals at 14-Day post-exposure.

Discussion:

In the study, JG302 (at a 1:10 Dilution) was delivered at a nominal concentration of 35.3 mg/L (actual concentration was 16.9 mg/L for four hours (Tables 1 & 2).

Conclusion:

When tested as specified, JG302 (at 1:10 Dilution) was not toxic to the test animals following a 4-hour exposure at a nominal concentration of 35.3 mg/L (actual concentration was 16.9 mg/L with 71.4% of the aerosol being respirable). The LC50 was estimated to be greater than 35.3 mg/L (actual concentration was 16.9 mg/L).

REPORT OF TEST

Analysts' Signatures

Investigators and analysts for the mammalian toxicology study on JG302 (at a 1:10 Dilution):

Study Director:	Charles C. Tong, Ph.D., D.A.B.T.	10/23/97 Date
Quality Assurance Coordinator:	Andrea R. Demby, B.S.	10/23/97 Date
Analyst:	Joan Breheny, M.S.	10/23/97 Date
Analyst:	Stefania Giobbe, M.S.	10/23/97 Date
Analyst:	Suzanne Poppe, B.S.	10/23/97 Date
Analyst:	Gregor Balaburski, B.S.	10/23/97 Date
Analyst:	Edwin Cruz	10/23/97

REPORT OF TEST

APPENDIX 1

Individual Animal Body Weight
Clinical Observations and Necropsy Findings

Test Substance: JG302 (at a 1:10 Dilution)

Dose (g/kg)	Animals/ Sex	Body Weight (kg) Day 0	Day 7	Day 14	Clinical Observation Day 0 – Day 14	Necropsy Findings
35.3	7138-F	234.2	245.8	256.7	N	N
	7159-F	250.2	276.4	285.7	N	N
	7158-F	257.0	273.7	282.8	N	N
	7160-F	244.0	251.8	267.8	N	N
	7161-F	223.2	227.9	240.3	N	N
	Average:	241.7	255.1	266.7		
35.3	7181-M	290.5	346.5	402.0	N	N
	7180-M	287.9	340.5	384.7	N	N
	7185-M	311.6	362.8	381.0	N	N
	7184-M	290.9	342.3	381.6	N	N
	7186-M	273.8	322.6	359.5	N	N
	Average:	290.9	342.9	381.7		

N = Normal

SUMMARY OF PROCEDURE:	Acute Inhalation Toxicity Testing with Rodent (LC_{50})
REFERENCE:	SGS USTC Procedure TOX/INHALC$_{50}$.009 to conform to current guidelines.
PURPOSE:	To access and evaluate the lethal toxicity of a single inhalation dose of an extract/liquid in rodents.
Sponsor:	Fire-Freeze Worldwide, Inc. 270 Route 46, Rockaway, NJ 07866 Tel: 201-627-0722
Sponsor Contact:	Ms. Stephanie E. Giessler
Laboratory:	SGS U.S. Testing Company, Inc., Biological Services 75 Passaic Avenue, Fairfield, NJ 07004
Study Director:	Charles C. Tong, Ph.D., D.A.B.T. (201) 575-5252 Ext. 2521
Test Substance (Sample)	JG302 (at dilution to be specified & appended)
Storage, Handling Conditions:	Ambient temperature
Procedures Proposed:	Acute Inhalation Toxicity Testing with Rodents LC_{50} Toxicology Procedure INHALCO$_{50}$.009
Amendments/Specs:	A Limit Test will be conducted
Proposed Experimental Start Date:	June 27, 1997
Proposed Experimental Termination Date:	July 11, 1997

1. DURATION OF STUDY: 14 Days
2. EXPOSURE SCHEDULE: Once, Test Day 0
3. OBSERVATION PERIOD: 14 Days
4. ROUTE OF ADMINISTRATION: Inhalation

5. EXPOSURE GROUPS:	One test group receiving a fixed concentration/ volume of the test substance.
6. CONTROL GROUP:	None.
7. NUMBER PER GROUP:	5 males and 5 females.
8. SPECIES/STRAIN:	Sprague-Dawley Rats
9. SEX/AGE/WEIGHT:	Male and female – 200-300 grams (young adult)
10. SOURCE:	Ace Animals, Boyertown, PA 19512
11. RANDOMIZATION OF ANIMALS:	There is no randomization method used. Test animals are randomly selected from a large pool of healthy subjects maintained at SGS USTC.
12. MEANS OF IDENTIFICATION:	Ear Tags
13. FOOD, WATER AND ENVIRONMENT:	Laboratory Rodent Diet 5001, PMI Feeds, Inc., St. Louis, MO and municipal filtered water. Analysis at least once a year for specific micro-organisms, heavy metals (water): for specific heavy metals and pesticides (feed). None of these contaminants are reasonably expected to be present at levels sufficient to interfere with this study. Animal rooms will be kept approximately at 64-79°C and 35-75% Relative 35-75% Humidity, to the maximum extent possible.
14. JUSTIFICATION OF TEST SYSTEM:	Rats historically have been used in safety evaluation studies and are recommended by appropriate regulatory agencies. No alternatives to animal use are currently available. This protocol will be reviewed by the SGS U.S. Testing IACUC for compliance with regulatory guidelines concerning the care and use of animals. If not in compliance, modifications will be required.

15. TEST MEASUREMENTS:

PRE-TEST QUARANTINE:	- observations only, 7 days - Body weights and physical examinations on Test Day 0
POST EXPOSURE SURVIVAL CHECKS	- at least once daily
CLINICAL OBSERVATIONS	- once daily, 7 days per week
PHYSICAL EXAM	- pretest and Test Day 7 and Test Day 14
BODY WEIGHTS	- pretest and Test Day 7 and Test Day 14
FOOD CONSUMPTION	- not required
CLINICAL CHEMISTRY	- not required
HEMATOLOGY	- not required
URINALYSIS	- not required
OPTHALMOLOGY/ DERMATOLOGY	- All test animals if applicable
NECROPSY	- all test animals
HISTOPATHOLOGY	- not required

16. STATISTICAL METHODS: (IF APPLICABLE) - temperature, relative humidity, particle size and distribution and concentration of test substance at breathing zone if applicable.

17. RECORD MAINTENANCE: - Equipment maintenance/calibration records, test/control article records, environmental records, specimen, raw data, QA/QC reports, communication and final reports will be archived in secured file at SGS USTC.

18. REGULATORY COMPLIANCE: This study will be conducted in accordance with Good Laboratory Practice Regulations as set forth in 21 CFR Part 58, Dec. 22, 1978 (effective June 20, 1979), and any applicable amendments, 40 CFR Part 160, Subpart F (EPA-FIFRA-GLP) and 40 CFR Part 792, Subpart F (EPA TSCA-GLP) as applicable.

Upon approval of this protocol, the sponsor assumes the responsibility of performing, documenting and maintaining documentation that test, control and reference substances are properly characterized in accordance with the guidelines set forth in the following: 40 CFR 160, Subpart F – Test, Control and Reference Substances (EPA-FIFRA); or 40 CFR 792 – Subpart F – Test, Control and Reference Substances (EPA-TSCA); or 21 CFR 58, Subpart F – Test and Control Articles (FDA-GLP), as applicable to this study.

All data generated in support of this study shall be archived at SGS USTC for a period of five years from the date of the final report of test. Upon completion of this time period, the original data (or where applicable, photocopies of the original data) shall be inventoried and transferred to the sponsor who shall then assume responsibility for archiving the data in accordance with appropriate GLP guidelines. Concurrently, the inventory of the study and a notice that the files have been transferred to the custody of the sponsor shall be sent to the FDA or EPA, as applicable.

Submitted by:	_____ Charles C. Tong, Ph.D., D.A.B.T. Director of Biological Services	6/11/97 Date
Reviewed by: (reserved)	_____ Andrea R. Demby, B.S. Quality Assurance Coordinator	6/11/97 Date
Approved by: (Sponsor)	Stephanie E. Giessler	6/13/97

United States Testing Company, Inc.
Biological Services

1415 Park Avenue
Hoboken, New Jersey 07030
Tel: 201-792-2400
Fax: 201-656-0636

REPORT OF TEST

Aquatic Toxicity Tests versus
Oncorhynchus mykiss,
Daphnia pulex, and
Selenastrum capricornutum

COLDFIRE 302

North American Environmental Oil and Chemical
Cleaning Supply Company
270A Route 46
Rockaway, New Jersey 07866

March 11, 1993

To the best of our knowledge, this study was conducted in compliance with the Good Laboratory Practice Standards of: United States EPA 40 CFR, Part 792. Data have been archived at the above laboratory address.

Daniel Cooke 3/11/93
Project Director

TEST REPORT NO. 065318-1

Prepared by:
Daniel Cooke
Mgr, Ecotoxicology

SIGNED FOR THE COMPANY BY:
Daniel Drozdowski
Vice President

Note: Signature copies of this report available upon request.

TABLE OF CONTENTS

AQUATIC TOXICITY REPORT

Client North American Environmental Oil & Chemical Cleaning Supply Company
270A Route 46, Rockaway, New Jersey 07866

Manufacturer Fire-Freeze Worldwide, Inc.
270A Route 46, Rockaway, New Jersey 07866

Testing Facility United States Testing Company, Biological Services Division
1415 Park Avenue, Hoboken, New Jersey 07030

Sample Description, Handling & Stability Identified by client as ColdFire 302, fire suppressor: Class A/B Fire Suppressing Agent. Straw colored, mobile liquid, with a mild lemon odor, water soluble. Sample considered stable. Sampled received 2/1/93.

Project 96 hour Acute LC50 vs Oncorhynchus mykiss (rainbow trout)
48 hour Acute LC50 vs Daphnia pulex (water flea)
96 hour Acute EC50 versus Selenastrum capricornutum (algae)

Test Dates 2/7/93 to 3/2/93

Summary of Results The acute toxicity of ColdFire 302 to the rainbow trout, Oncorhynchus mykiss, was found to be:
96 hour LC50 = 105.1 ppm
The No Observed Effect Concentration (NOEC was 62.5 ppm)

The acute toxicity of ColdFire 302 to the water flea, Daphnia pulex, was found to be:
48 hour LC50 = 159.3 ppm
The No Observed Effect Concentration (NOEC) was 62.5 ppm.

The acute toxicity of ColdFire 302 to the freshwater algae, Selenastrum capricornutum, was found to be:
96 hour EC50 = 153.9 ppm
The No Observed Effect Concentration (NOEC) was < 93.75 ppm

INTRODUCTION

This is a report of aquatic toxicity testing versus North American Environmental Oil & Chemical Cleaning Supply Company and Fire Freeze International's product ColdFire 302 fire suppressant.

Testing was performed versus rainbow trout (O. mykiss), water fleas (D. pulex) and algae (S. capricornutum). Test solutions were diluted with media suitable for survival and growth of each of the organisms. Observations for possible adverse effects were made initially and daily for the duration of the tests.

Stock solutions of ColdFire 302 were prepared by adding measured amounts of product to test water. The solutions were thoroughly mixed and added directly to the test chambers.

No chemical confirmation of concentration was performed for these tests. All concentrations were prepared volumetrically (from the saturated solution), and were judged by the investigators to be satisfactory.

QA REPORT

Sponsor	North American Environment Oil & Chemical Cleaning Supply Company
Study	Aquatic Toxicity versus trout, daphnia and algae
Report	065318-1
Project Start	February 10, 1993
Project Finish	March 11, 1993

To the best of our knowledge, this study was conducted in compliance with the Good Laboratory Practice Standards of the US EPA 40 CFR, Part 792.

The studies were conducted at the Biological Services Division of USTC in a setting which involved frequent repetition of similar or identical procedures. At or about the time the studies were conducted, inspections were made by the QA auditor of the critical procedures relevant to this study type.

The findings of these inspections were reported promptly to the study director and management.

To the best of our knowledge and belief, the final report accurately reflects the conduct of the study, the date obtained and the conclusions that can be shown, within the limits of the procedures used.

James Siniscalchi, PhD
Quality Assurance Auditor

SUMMARY OF PROCEDURES
Acute Toxicity versus Oncorhynchus mykiss (rainbow trout), 96 hour LC50

Reference	40 CFR part 797.1400 “Fish acute toxicity test” USEPA 1989. USTC Procedure PRO/FT FISH 224-7.
Sample storage	Room temp (21°C) original, sealed container
Test type	Static, renewal
Organism source	Aquatic Research Organisms, Hampton, NH
Organism history	Hatch: 12/23/93 – 1/3/93
Organism age	52 – 64 days
Organism size	≤ 35 mm, uniform size
Temperature (°C)	12 ± 2°C
Illumination	16:8 hour light/dark cycle, fluorescent, 50 to 100 ft-candles (lab ambient)
Test vessels	4L polypropylene vessels
Exposure volume	3L
Replication	Minimum 10 fish per replicate, 2 replicates per treatment
Feeding regime	None during test
Aeration	Aerate by mixing test solutions to saturation prior to test; if dissolved oxygen falls below 80 percent saturation in any replicate during the test, supply oil free air at 100 ± 10 bubbles per minute
Concentrations	Minimum 5
Dilution Factor	Approximately 0.5
Dilution Water	US EPA hard reconstituted water
Solvent	None necessary
Controls	Diluent only

SUMMARY OF PROCEDURES
Acute Toxicity versus Oncorhynchus mykiss (rainbow trout), 96 hour LC50
(continued)

Controls	Diluent only
Test duration	96 hours
Response(s)	Mortality, reflex loss, erratic swim daily
Physical data	Temperature, D.O., pH, conductivity initially and daily thereafter
Chemical data	Alkalinity and hardness of control, initially
	TOC and TSS of dilution water prior to test initiation
Acceptability	≥ 90% survival in controls after 96 hours
Data analysis	Probit Analysis, Spearman-Karber Method, or graphical interpolation for lethality
Special Comments	None
Deviations from Test Method	None

United States Testing Company, Inc. Report #065318-1
ColdFire 302

Acute Toxicity versus Oncorhynchus mykiss

Sample - ColdFire 302

Sreening Tests (2/7 – 8/93)

The following mortality data is from initial range finding screens. The screens were performed on a wide range of test product concentrations; from this data, an approximate range of toxicity was determined. The range of toxicity determined in the screen was then bracketed in the definitive assay in order to determine the LC50.

	24 Hour Mortality vs Concentration						
	10,000	1,000	100	10	1.0	0.1	0
ColdFire 302	5/5	5/5	5/5	0/5	0/5	0/5	0/5

Acute Toxicity versus Oncorhynchus mykiss

Sample **-** ColdFire 302 Test Dates: 2/24 – 28/93

Conc. ppm	No Org.	Cumulative Mortality				
		24 hr	48 hr	72 hr	96 hr	% Mortality
0 (control)	20	0	0	0	0	0
31.25	20	0	0	0	0	0
62.5	20	0	0	0	0	0
125	20	13	13	15	15	75
250	20	20	20	20	20	100
500	20	20	20	20	20	100

Data Summary

24 hr LC50 = 112.7 ppm (95% C.L. 97.2 – 130.6)
48 hr LC50 = 112.7 ppm (95% C.L. 97.2 – 130.6)
72 hr LC50 = 105.1 ppm (95% C.L. 91.9 – 120.2)
96 hr LC50 = 105.1 ppm (95% C.L. 91.9 – 120.2)

Statistical Method - Spearman-Karber Trim
The No Observed Effect Concentration (NOEC) was determined to be 62.5 ppm.

Comments

A stock solution of ColdFire 302 was prepared by diluting 6.0 ml of product to 6 liters with EPA hard reconstituted water. Test solutions were diluted with fresh EPA hard water to the above concentrations.

Though there was no mortality observed in the 62.5 ppm concentration, the exposed fish appeared discoloured (dark) after 24 hours. After 96 hours, the fish in the 62.5 ppm concentration appeared to be in a state of torpor. The fish exposed to the 31.25 ppm ColdFire 302 did not appear to suffer any adverse effects.

Juvenile fish were used for this assay (<8 weeks old). Factors such as age and small size generally maximize toxic effect, numerically expressed as the LC50.

United States Testing Company, Inc.

Report #065318-1
ColdFire 302

Acute Toxicity versus Oncorhynchus mykiss

Sample - ColdFire 302

Test Dates: 2/24 – 28/93

Physical / Chemical Data

Test Conc	Control	31.25 ppm	62.5 ppm	125 ppm	250 ppm	500 ppm
Temp (°C)						
mean (N=5)	11.1	11.1	11.1	11.1	11.1	11.1
range	11.0-11.5	11.0-11.5	11.0-11.5	11.0-11.5	11.0-11.5	11.0-11.5
D.O. (mg/L)						
mean (N=8)	9.6	9.6	9.6	9.6	9.6	9.6
range	9.4 – 9.8	9.4 – 9.8	9.4 – 9.8	9.4 – 9.8	9.4 – 9.8	9.4 – 9.8
pH (std)						
mean (N=8)	7.9	7.9	7.9	7.9	8.0	8.0
range	7.8 – 8.1	7.8 – 8.1	7.8 – 8.1	7.8 – 8.1	7.8 – 8.1	7.8 – 8.1
Cond (µmhos)						
mean (N=5)	366	366	366	366	350	350
range	350 - 380	350 - 380	350 - 380	350 - 380	350	350
Alk (mg/L)						
mean (N=5)	150					
range	140 - 160					
Hard (mg/L)						
mean (N=3)	136					
range	130 - 150					
TOC (mg/L)						
mean (N=1)	<2.0					
range	<2.0					
TSS (mg/L)						
mean (N=1)	0					
range	0					

N = number of determinations used in calculation of mean and range
Conc = concentration
Temp = temperature
D.O. = dissolved oxygen, pH given in standard units
Cond = conductivity
Alk = alkalinity (mg/L $CaCO_3$)
Hard = hardness (mg/L $CaCO_3$)
TOC = total organic carbon
TSS = total suspended solids

SUMMARY OF PROCEDURES
Acute Toxicity versus Daphnia pulex (water flea), 48 hour LC50

Reference	40 CFR part 797.1300, 9/27/85 "Daphnia acute toxicity test" USTC Procedure PRO/ST DAPHNIA 231-1
Sample storage	Room temp (21°C) original, sealed container
Test type	Static, non-renewal
Organism source	USTC stock cultures
Organism history	Hatch: 2/27 – 28/93
Organism age	≤ 24 hours
Temperature (°C)	22 ± 1°C
Illumination	16:8 hour light/dark cycle, fluorescent, 50 to 100 ft-candles (lab ambient)
Test vessels	25 x 150 mm glass test tubes, capped
Exposure volume	40 ml
Replication	Minimum 5 daphnia per replicate 4 replicates per treatment
Feeding regime	None during test
Aeration	Aerate by mixing test solutions to saturation prior to test; no aeration during test
Concentrations	Minimum 5
Dilution Factor	Approximately 0.5
Dilution Water	US EPA hard reconstituted water
Solvent	None
Controls	Diluent only

SUMMARY OF PROCEDURES
Acute Toxicity versus Daphnia pulex (water flea), 48 hour LC50 (continued)

Controls	Diluent only
Test duration	48 hours
Response(s)	Mortality, morbidity and appearance
Physical data	Temperature, D.O., pH, conductivity initially and at test termination
Chemical data	Alkalinity and hardness of control, initially
	TOC and TSS of dilution water prior to test initiation
Data analysis	Probit Analysis, Spearman-Karber Method when possible, otherwise, graphical interpolation
Special Comments	None
Deviations from Test Method	None

Acute Toxicity versus Daphnia pulex

Sample - ColdFire 302

Sreening Tests (2/7 – 8/93)

The following mortality data is from initial range finding screens. The screens were performed on a wide range of test product concentrations; from this data, an approximate range of toxicity was determined. The range of toxicity determined in the screen was then bracketed in the definitive assay in order to determine the LC50.

	24 Hour Mortality vs Concentration						
	10,000	1,000	100	10	1.0	0.1	0
ColdFire 302	0/5	0/5	5/5	0/5	0/5	0/5	0/5

Acute Toxicity versus Daphnia pulex

Sample **-** ColdFire 302 Test Dates: 2/28 – 3/2/93

Conc. ppm	No Org.	Cumulative Mortality				
		24 hr	48 hr	72 hr	96 hr	% Mortality
0 (control)	20	0	0	0	0	0
31.25	20	0	0	0	0	0
62.5	20	0	0	0	0	0
125	20	2	3	15	15	15
250	20	20	20	20	100	100
500	20	20	20	20	100	100

Data Summary

24 hr LC50 = 164.9 ppm (95% C.L. 150.3 – 181.0)
48 hr LC50 = 159.3 ppm (95% C.L. 142.6 – 178.0)

Statistical Method - Spearman-Karber Trim
The No Observed Effect Concentration (NOEC) was determined to be 62.5 ppm.

Comments

A stock solution of ColdFire 302 was prepared by diluting 0.5 ml of product to 500 ml with EPA hard reconstituted water, and mixing thoroughly. The resultant solution was diluted with fresh EPA hard water to the above concentrations.

Neonatal organisms were used for this assay (≤ 24 hours old). Factors such as age and small size generally maximize toxic effect, numerically expressed as the LC50.

Control organisms appeared healthy and were actively swimming.

United States Testing Company, Inc.

Report #065318-1
ColdFire 302

Acute Toxicity versus Daphnia pulex

Sample **-** ColdFire 302

Test Dates: 2/28 – 3/2/93

Physical / Chemical Data

Test Conc	Control	31.25 ppm	62.5 ppm	125 ppm	250 ppm	500 ppm
Temp (°C)						
mean (N=3)	21.0	21.0	21.0	21.0	21.0	21.0
range	21.0	21.0	21.0	21.0	21.0	21.0
D.O. (mg/L)						
mean (N=2)	9.0	9.0	9.0	9.0	9.0	9.0
range	8.4 – 9.6	8.4 – 9.6	8.4 – 9.6	8.4 – 9.6	8.4 – 9.6	8.4 – 9.6
pH (std)						
mean (N=2)	8.2	8.2	8.2	8.2	8.2	8.2
range	8.1 – 8.2	8.1 – 8.2	8.1 – 8.2	8.1 – 8.2	8.1 – 8.2	8.1 – 8.2
Cond (µmhos)						
mean (N=2)	415	415	415	415	415	415
range	370 - 460	370 - 460	370 - 460	370 - 460	370 - 460	370 - 460
Alk (mg/L)						
mean (N=1)	140					
range	140					
Hard (mg/L)						
mean (N=1)	130					
range	130					
TOC (mg/L)						
mean (N=1)	<2.0					
range	<2.0					
TSS (mg/L)						
mean (N=1)	0					
range	0					

N = number of determinations used in calculation of mean and range
Conc = concentration
Temp = temperature
D.O. = dissolved oxygen, pH given in standard units
Cond = conductivity
Alk = alkalinity (mg/L $CaCO_3$)
Hard = hardness (mg/L $CaCO_3$)
TOC = total organic carbon
TSS = total suspended solids

SUMMARY OF PROCEDURES

Acute Toxicity versus Selenastrum capricornutum (freshwater alga), 96 hour EC50

Reference	40 CFR part 797.1050 “Algal acute toxicity test” USEPA 1987. USTC Procedure ALGAE 224-7.
Sample storage	Room temp (21°C) original, sealed container
Test type	Static, non-renewal
Organism source	USTC stock cultures, originally from UTEX
Temperature (°C)	24 ± 2°C
Illumination	16:8 hour light/dark cycle, fluorescent, 400 to 450 ft-candles
Test vessels	125 ml Erlenmeyer flasks, capped
Exposure volume	50 ml
Replication	3 replicates per treatment
Inoculum density	Initially 10,000 cells per ml
Agitation	Shaken by hand four to five times daily
Aeration	Aerate by mixing test solutions to saturation prior to test; no aeration during test
Concentrations	Minimum 5 Dilution factor 0.5
Dilution Water (media)	EPA formulation
Solvent	None
Controls	Diluent only

SUMMARY OF PROCEDURES

Acute Toxicity versus Selenastrum capricornutum (freshwater alga), 96 hour EC50 (continued)

Controls	Diluent only
Test duration	96 hours; inhibited replicates inoculated into fresh control media and subcultured up to 9 days for algicidal/algistatic determination
Response(s)	Cell counts by hemocytometer, irregular cell shapes or decrease in cell size noted, cell mortality characterized
Physical data	Temperature and illumination initially and daily, pH initially and at test termination
Chemical data	Initial alkalinity, hardness and TOC of control
Data analysis	Probit Analysis, Spearman-Karber Method, or graphical interpolation for EC50 (% inhibition); Dunnett's Test or Steel's Many-One Rank Test for NOEC and LOEC
Special Comments	Stock solutions to be pH adjusted to 7.5 prior to use in testing
Deviations from Test Method	None

United States Testing Company, Inc.

Report #065318-1
ColdFire 302

Acute Toxicity versus Selenastrum capricorntum

Sample - ColdFire 302

Test Dates: 2/25 – 28/93

Algal Growth Inhibition

		24 hr			48 hr		
Conc	Rep	Cells/ml	Mean	% I	Cells/ml	Mean	% I
Ctrl	A				26.8		
	B	no counts			19.4	23.1	0
	C				23.2		
93.75 ppm	A				19.6		
	B	no counts			18.9	18.6	19.5
	C				17.3		
187.5 ppm	A				10.0		
	B	no counts			11.4	10.1	56.4
	C				8.8		
375 ppm	A				3.5		
	B	no counts			3.2	2.8	87.9
	C				1.7		
750 ppm	A				2.1		
	B	no counts			2.6	1.8	92.1
	C				0.8		
1500 ppm	A				1.2		
	B	no counts			2.4	1.6	93.1
	C				0.9		

Notes

Cells/ml = cells/ml x 10^4
% I = % inhibition
Mean = pooled means

Data Summary

24 hr EC50 = not obtainable
48 hr EC50 = 168.9 ppm (95% C.L. 149.5 – 190.9)

Statistical Method – Spearman-Karber Trim
The 48 hr No Observed Effect Concentration (NOEC) was determined <93.75
No algicidal effects were observed

United States Testing Company, Inc.

Report #065318-1
ColdFire 302

Acute Toxicity versus Selenastrum capricorntum

Sample - ColdFire 302

Test Dates: 2/25 – 28/93

Algal Growth Inhibition

		72 hr			96 hr		
Conc	Rep	Cells/ml	Mean	% I	Cells/ml	Mean	% I
Ctrl	A	66.8			76.9		
	B	68.7	68.1	0	70.6	76.9	0
	C	68.7			83.3		
93.75 ppm	A	36.1			86.2		
	B	36.8	36.2	46.8	70.9	81.0	0
	C	35.7			85.8		
187.5 ppm	A	13.6			73.8		
	B	12.4	12.4	81.8	80.1	80.3	0
	C	11.1			87.0		
375 ppm	A	0.5			64.2		
	B	0.4	0.4	99.4	49.2	54.8	28.7
	C	0.3			51.0		
750 ppm	A	0.3			52.6		
	B	0.3	0.3	99.6	42.0	47.5	38.2
	C	0.3			48.0		
1500 ppm	A	0.0			42.8		
	B	0.0	0.0	100	44.1	43.5	43.4
	C	0.0			43.5		

Notes

Cells/ml = cells/ml x 10^4
% I = % inhibition
Mean = pooled means

Data Summary

72 hr EC50 = 99.5 ppm (95% C.L. 73.2 – 135.3)
96 hr EC50 = 153.9 ppm (95% C.L. 139.1 – 170.3)

Statistical Method – Spearman-Karber Trim
The 72 hr No Observed Effect Concentration (NOEC) was determined <93.75
The 96 hr NOEC was determined <93.75%
Algicidal effects were noted in the 750 ppm and 1500 ppm concentrations

United States Testing Company, Inc.

Report #065318-1
ColdFire 302

Acute Toxicity versus Selenastrum capricorntum

Sample - ColdFire 302

Test Dates: 2/25 – 28/93

Comments

A stock solution of ColdFire 302 was prepared by diluting 10 ml of product to 1.0 liter with algal media, and mixing thoroughly. The resultant solution was diluted with fresh EPA algal media (no product) to the above concentrations.

The initial inoculum was 10,000 cells/ml. Cell growth was insufficient at 24 hours to establish concentration-effect relationships for all concentrations. 24 hour counts were not recorded.

At test termination, each replicate from each test concentration was subcultured into fresh EPA algal media. After six days, the subcultures were examined for the presence of algal growth. Subcultures taken from concentrations below 750 ppm were observed to have a healthy algal population. Subcultures taken from concentrations of 750 ppm and greater did not have any algal growth.

ColdFire 302 appeared to algicidal (killed algal cells) at concentrations of 750 ppm or greater, and algistatic (slowed or stopped growth, but did not kill algal cells) at concentrations between 93.75 ppm and 750 ppm.

United States Testing Company, Inc.

Report #065318-1
ColdFire 302

Acute Toxicity versus Selenastrum capricorntum

Sample - ColdFire 302

Test Dates: 2/25 – 28/93

Physical / Chemical Data

Test Conc	Ctrl	93.75 ppm	187.5 ppm	375 ppm	750 ppm	1500 ppm
Temp (°C)						
mean (N=4)	24.5	24.5	24.5	24.5	24.5	24.5
range	24.5	24.5	24.5	24.5	24.5	24.5
pH (std)						
initial	7.5	7.5	7.5	7.5	7.5	7.5
foma;	9.8	9.7	9.6	8.0	7.5	7.5
Cond (µmhos)						
mean (N=1)	95					
range	95					
Alk (mg/L)						
mean (N=1)	30					
range	30					
Hard (mg/L)						
mean (N=3)	20					
range	20					
TOC (mg/L)						
mean (N=1)	<2.0					
range	<2.0					

N = number of determinations used in calculation of mean and range
Conc = concentration
Temp = temperature
D.O. = dissolved oxygen, pH given in standard units
Cond = conductivity
Alk = alkalinity (mg/L $CaCO_3$)
Hard = hardness (mg/L $CaCO_3$)
TOC = total organic carbon
TSS = total suspended solids

Investigators and analysts for the aquatic toxicity study of North American Environmental Oil & Chemical Cleaning Supply Company and Fire-Freeze International's product ColdFire 302:

Daniel Cooke	(Study Director)
James Siniscalchi	(Quality Assurance)
Dennis Profaca	(Analyst)
Rey Rolon	(Analyst)
Michael Bernardine	(Analyst)

APPENDIX #1

DATA ANALYSIS

BURLINGTON RESEARCH, INC.
TRIMMED SPEARMAN-KARBER METHOD FOR CALCULATION OF
EC50 AND LC50 VALUES IN BIOASSAYS

FOR REFERENCE, CITE
M.A. HAMILTON, R.C. RUSSO AND R.V. THURSTON, 1977
TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
LETHAL CONCENTRATIONS IN TOXICITY BIOESSAYS.
ENVIRON. SCI. TECHNOL. 11(7) 714-719
CORRECTION 12(4) 417 (1978).

DATE	2/25 – 28/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Selenastrum capricornutum
DURATION	96 hours

RAW DATA

CONCENTRATION (ppm)	93.75	187.50	375.00	750.00	1500.00
NUMBER EXPOSED	100	100	100	100	100
MORTALITIES	18	64	98	100	100
SPEARMAN-KARBER TRIM			18.00		
SPEARMAN-KARBER ESTIMATES		EC50	153.8969116		
95% LOWER CONFIDENCE				139.05	
95% UPPER CONFIDENCE				170.33	

DATE	2/25 – 28/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Selenastrum capricornutum
DURATION	72 hours

RAW DATA

CONCENTRATION (ppm)	93.75	187.50	375.00	750.00	1500.00
NUMBER EXPOSED	100	100	100	100	100
MORTALITIES	47	82	99	100	100
SPEARMAN-KARBER TRIM			47.00		
SPEARMAN-KARBER ESTIMATES		EC50	99.4887009		
95% LOWER CONFIDENCE				73.16	
95% UPPER CONFIDENCE				135.30	

BURLINGTON RESEARCH, INC.
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ENVIRON. SCI. TECHNOL. 11(7) 714-719
CORRECTION 12(4) 417 (1978).

DATE	2/25 – 28/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Selenastrum capricornutum
DURATION	48 hours

RAW DATA

CONCENTRATION (ppm)	93.75	187.50	375.00	750.00	1500.00
NUMBER EXPOSED	100	100	100	100	100
MORTALITIES	20	56	88	92	93
SPEARMAN-KARBER TRIM			20.00		
SPEARMAN-KARBER ESTIMATES		EC50	168.9844666		
95% LOWER CONFIDENCE				149.55	
95% UPPER CONFIDENCE				190.94	

BURLINGTON RESEARCH, INC.
TRIMMED SPEARMAN-KARBER METHOD FOR CALCULATION OF
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LETHAL CONCENTRATIONS IN TOXICITY BIOESSAYS.
ENVIRON. SCI. TECHNOL. 11(7) 714-719
CORRECTION 12(4) 417 (1978).

DATE	2/24 – 28/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Oncorhynchus mykiss
DURATION	96 hours

RAW DATA

CONCENTRATION (ppm)	62.50	125.00	250.00
NUMBER EXPOSED	20	20	20
MORTALITIES	0	15	20

SPEARMAN-KARBER TRIM 0.00

SPEARMAN-KARBER ESTIMATES	LC50	105.1120377
95% LOWER CONFIDENCE		91.91
95% UPPER CONFIDENCE		120.21

DATE	2/24 – 28/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Oncorhynchus mykiss
DURATION	72 hours

RAW DATA

CONCENTRATION (ppm)	62.50	125.00	250.00
NUMBER EXPOSED	20	20	20
MORTALITIES	0	15	20

SPEARMAN-KARBER TRIM 0.00

SPEARMAN-KARBER ESTIMATES	LC50	105.1120377
95% LOWER CONFIDENCE		91.91
95% UPPER CONFIDENCE		120.21

BURLINGTON RESEARCH, INC.
TRIMMED SPEARMAN-KARBER METHOD FOR CALCULATION OF
EC50 AND LC50 VALUES IN BIOASSAYS

FOR REFERENCE, CITE
M.A. HAMILTON, R.C. RUSSO AND R.V. THURSTON, 1977
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LETHAL CONCENTRATIONS IN TOXICITY BIOESSAYS.
ENVIRON. SCI. TECHNOL. 11(7) 714-719
CORRECTION 12(4) 417 (1978).

DATE	2/24 – 28/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Oncorhynchus mykiss
DURATION	48 hours

RAW DATA

CONCENTRATION (ppm)	62.50	125.00	250.00
NUMBER EXPOSED	20	20	20
MORTALITIES	0	13	20

SPEARMAN-KARBER TRIM 0.00

SPEARMAN-KARBER ESTIMATES	LC50	112.6562805
95% LOWER CONFIDENCE		97.17
95% UPPER CONFIDENCE		130.61

DATE	2/24 – 28/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Oncorhynchus mykiss
DURATION	24 hours

RAW DATA

CONCENTRATION (ppm)	62.50	125.00	250.00
NUMBER EXPOSED	20	20	20
MORTALITIES	0	13	20

SPEARMAN-KARBER TRIM 0.00

SPEARMAN-KARBER ESTIMATES	LC50	112.6562805
95% LOWER CONFIDENCE		97.17
95% UPPER CONFIDENCE		130.61

BURLINGTON RESEARCH, INC.
TRIMMED SPEARMAN-KARBER METHOD FOR CALCULATION OF
EC50 AND LC50 VALUES IN BIOASSAYS

FOR REFERENCE, CITE
M.A. HAMILTON, R.C. RUSSO AND R.V. THURSTON, 1977
TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
LETHAL CONCENTRATIONS IN TOXICITY BIOESSAYS.
ENVIRON. SCI. TECHNOL. 11(7) 714-719
CORRECTION 12(4) 417 (1978).

DATE	2/28 – 3/2/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Daphnia pulex
DURATION	48 hours

RAW DATA

CONCENTRATION (ppm)	62.50	125.00	250.00
NUMBER EXPOSED	20	20	20
MORTALITIES	0	3	20

SPEARMAN-KARBER TRIM 0.00

SPEARMAN-KARBER ESTIMATES	LC50	159.3200378
95% LOWER CONFIDENCE		142.63
95% UPPER CONFIDENCE		177.97

DATE	2/28 – 3/2/93
TEST #	065318-1
CHEMICAL	ColdFire 302
SPECIES	Daphnia pulex
DURATION	24 hours

RAW DATA

CONCENTRATION (ppm)	62.50	125.00	250.00
NUMBER EXPOSED	20	20	20
MORTALITIES	0	2	20

SPEARMAN-KARBER TRIM 0.00

SPEARMAN-KARBER ESTIMATES	LC50	164.9384766
95% LOWER CONFIDENCE		150.29
95% UPPER CONFIDENCE		181.01

APPENDIX #2

CHEMICAL CONFIRMATION

Acute Toxicity versus ColdFire 302

Appendix #2 – Chemical Confirmation

Regarding aquatic toxicity tests performed according to United States Environmental Protection Agency's "Good Laboratory Practice Standards" (40 CFR, Parts 797-1300 and 797-1400), guidelines recommend confirmation of nominal test concentrations by chemical analysis.

Analytical methodology is generally supplied by the Client, and should be sensitive enough to detect the test compound at environmental levels (levels at which the compound is likely to enter the environment).

Since test concentrations were prepared volumetrically, no confirmation of concentration was performed. The stated concentrations were judged by investigators to be correct.

APPENDIX #3

TOXICITY TEST PLANS AND PROCEDURES

Client	North American Environmental Oil & Chemical Cleaning Supply Company 270A Route 46, Rockaway, New Jersey 07866
Manufacturer	Fire-Freeze Worldwide, Inc. 270A Route 46, Rockaway, New Jersey 07866
Testing Laboratory	United States Testing Company, Inc. Biological Services Division 1415 Park Avenue, Hoboken, New Jersey 07030
Study Director	Daniel Cooke
Test Material	ColdFire 302, fire suppressor: Class A/B Fire Suppressing Agent. Straw colored, mobile liquid, with a mild lemon smell, water soluble. Sample considered stable, received 2/1/93.
Storage/Handling Conditions	Room temperature, in original, sealed container, as per MSDS dated 7/26/92.
Procedures	96 hour Acute LC50 vs Oncorhynchus mykiss 96 hour Acute EC50 vs Selenastrum capricornutum 48 hour Acute LC50 vs Daphnia pulex
Ammendments /Specifications	See attached protocols
Test Dates	February – March 1993

Submitted by:	Daniel Cooke Manager, Ecotoxicology	2/3/93
Reviewed by:	James Siniscalchi, Ph.D. Quality Assurance Auditor	2/18/93
Approved by: (Client)	Mike Trulby, North American Environmental Oil & Chemical Cleaning Supply Company	2/10/83

SUMMARY OF PROCEDURES

Acute Toxicity versus Oncorhynchus mykiss (rainbow trout), 96 hour LC50

Reference	40 CFR Part 797.1400 “Fish acute toxicity test” USEPA 1989. OECD Guidelines for Testing of Chemicals, Method 203 “Fish Acute Toxicity Test” 1984. FDA Environmental Assessment Technical Assistance Handbook, Method 4.11, “Freshwater Acute Toxicity”. USTC Procedure PRO/FT FISH 224-7.
Sample storage	Room temp (21°C) original, sealed container or as specified by MSDS
Test type	Static, renewal
Organism source	Commercial supplier (to be specified)
Organism history	Hatch date and pertinent information
Organism age	In days
Organism size	≥ 40 mm, uniform size
Temperature (°C)	12 ± 2°C
Illumination	16:8 hour light/dark cycle, fluorescent, 50 to 100 ft-candles (lab ambient)
Test vessels	4L polypropylene vessels
Exposure volume	3L
Replication	Minimum 10 fish per replicate 2 replicates per treatment
Feeding regime	None during test
Aeration	Aerate by mixing test solutions to saturation prior to test; if dissolved oxygen falls below 80 percent saturation in any replicate during the test, supply oil free air at 100 ± 10 bubbles per minute.
Concentrations	Minimum 5
Dilution Factor	Approximately 0.5
Dilution Water	US EPA hard reconstituted water
Solvent	As necessary
Controls	Diluent only and solvent control (if necessary)

SUMMARY OF PROCEDURES

Acute Toxicity versus Oncorhynchus mykiss (rainbow trout), 96 hour LC50 (continued)

Controls	Diluent only and solvent control (if necessary)
Test duration	96 hours
Response(s)	Mortality, reflex loss, erratic swim daily
Physical data	Temperature, D.O., pH, conductivity initially and daily thereafter
Chemical data	Alkalinity, hardness, TSS and TOC of control, water initially and with each new batch
Acceptability	≥ 90% survival in controls after 96 hours
Data analysis	Probit Analysis, Spearman-Karber Method, or graphical interpolation for lethality
Special Comments	Nominal product concentrations prepared volumetrically (no confirmation)
Deviations from Test Method	To be specified

SUMMARY OF PROCEDURES

Acute Toxicity versus Selenastrum capricornutum (freshwater alga), 96 hour EC50

Reference	40 CFR Part 797.1050 "Algal acute toxicity test" USEPA 1987. OECD Guideline for Testing of Chemicals, Method 201, "Alga, Growth Inhibition Test" 1984. USTC Procedure ALGAE 224-7.
Sample storage	Room temp (21°C) original, sealed container, or as specified by MSDS
Test type	Static, non-renewal
Organism source	USTC stock cultures originally from UTEX Collection
Temperature (°C)	24 ± 2°C
Illumination	16:8 hour light/dark cycle, fluorescent, 400 to 450 ft-candles
Test vessels	125 ml Erlenmeyer flasks, capped
Exposure volume	50 ml
Replication	3 replicates per treatment
Inoculum density	Initially 10,000 cells per ml
Agitation	Shaken by hand twice daily, or automatic gyratory
Aeration	Aerate by mixing test solutions to saturation prior to test; no aeration during test
Concentrations	Minimum 5 Dilution factor 0.5 to 1.8
Dilution Water	EPA nutrient media
Solvent	As necessary
Controls	Diluent only, solvent control (if necessary)

SUMMARY OF PROCEDURES

Acute Toxicity versus Selenastrum capricornutum (freshwater alga), 96 hour EC50 (continued)

Controls	Diluent only, solvent control (if necessary)
Test duration	96 hours; inhibited replicates inoculated into fresh control media and subcultured up to 9 days for algicidal/algistatic determination
Response(s)	Cell counts by hemocytometer, irregular cell shapes or decrease in cell size noted, cell mortality characterized
Physical data	Temperature and illumination initially and daily, pH initially and at test termination
Chemical data	Initial alkalinity, hardness, TSS and TOC of control media
Data analysis	Probit Analysis, Spearman-Karber Method, or graphical interpolation for EC50 (% inhibition); Dunnett's Test or Steel's Many-One Rank Test for NOEC and LOEC
Special Comments	Nominal concentrations prepared volumetrically (no confirmation) Stock solution of product to be adjusted to pH 7.5 prior to test initiation
Deviations from Test Method	40 CFR 797.1050 specifies a light/dark cycle of 14 hrs light/10 hrs dark. An illumination cycle of 16/8 will be used to more closely match lab culture conditions. Other deviations to be specified.

SUMMARY OF PROCEDURES

Acute Toxicity versus Daphnia pulex (water flea), 48 hour EC50

Reference	40 CFR Part 797.1300 “Daphnid acute toxicity test” USEPA 1987. OECD Guideline for Testing of Chemicals, Method 202, “Daphnia sp., Acute Immobilisation Test” 1984. FDA Environmental Assessment Technical Assistance Handbook, Method 4.08 “Daphnia Acute Toxicity”. USTC Procedure PRO/ST DAPHNIA 231-1.
Sample storage	Room temp (21°C) original, sealed container or as specified by MSDS
Test type	Static, non-renewal
Organism source	USTC stock cultures
Organism history	Hatch date and pertinent information
Organism age	≤ 24 hours
Temperature (°C)	21 ± 1°C
Illumination	16:8 hour light/dark cycle, fluorescent, 50 to 100 ft-candles (lab ambient)
Test vessels	25 x 150 mm glass test tubes, capped
Exposure volume	40 ml
Replication	Minimum 5 daphnia per replicate 4 replicates per treatment
Feeding regime	None during test
Aeration	Aerate by mixing test solutions to saturation prior to test; no aeration during test
Concentrations	Minimum 5
Dilution Factor	Approximately 0.5
Dilution Water	US EPA hard reconstituted water
Solvent	As necessary
Controls	Diluent only and solvent control (if necessary)

SUMMARY OF PROCEDURES

Acute Toxicity versus Daphnia pulex (water flea), 48 hour EC50 (continued)

Controls	Diluent only and solvent control (if necessary)
Test duration	48 hours
Response(s)	Mortality (immobilization), morbidity and appearance
Physical data	Temperature, D.O., pH, conductivity initially and at test termination
Chemical data	Alkalinity, hardness, TSS and TOC of control initially
Data analysis	Probit Analysis, Spearman-Karber Method or graphical interpolation
Special Comments	Nominal concentrations prepared volumetrically (no confirmation) Stock solution of product to be adjusted to pH of dilution water
Deviations from Test Method	To be specified

SGS U.S. Testing Company Inc.

291 Fairfield Avenue
Fairfield, NJ 07004-3833
Tel: 201-575-5252
Fax: 201-244-1694

Report Number: 409277
Date: 11/19/96
Page: 1 of 2
C/R Number: 203026

REPORT OF TEST

CLIENT: Firefreeze World Wide, Inc.
Attn: Stephanie Giessler
270 Route 46
Rockaway, NJ 07866

SUBJECT: One (1) sample received on 10/29/96 and identified by the client as:
COLD FIRE

AUTHORIZATION: Requisition #104532

PURPOSE: To perform DOT corrosion testing (metal)

Employing the submitted sample.

TEST DATES: 11/05/96 – 11/12/96.

SIGNED FOR THE COMPANY BY:

Bernardita Santos
Laboratory Supervisor
/mo

Joseph Kwiatkowski, Director
Specialty & Applied Chemistry

Note: Signature copies of this report available upon request.

REPORT OF TEST

CLIENT: Firefreeze World Wide, Inc.

PROCEDURE: Testing was performed in accordance with method as Specified in 49 CFR 173.136 (A) (2) (NACE TM-01-69).

Conditions: Temperature:	55°C
Agitation:	none
Volume to Area Ratio:	250 ml/in_2
Time:	168 hours
Cleaning:	Steel 20% NaOH;200 g/L Zn
Aluminum:	HNO_3

RESULTS:

	Corrosion Rate	
	mm/yr	in/yr
Aluminum 7075 T-6 Bare	0.07; 0.08	0.003; 0.003
Steel	0.23; 0.27	0.009; 0.011

COMMENTS: Per 49 CFR 173.130 (A) (2) a liquid is considered to have a server corrosion rate if its corrosion rate exceeds 6.25 mm (0.246 inches) a year on steel (SAE 1020) or aluminum nonclad 7075 T-6) at a test temperature of 55°C (131°F).

ENCLOSURE: Certificate of compliance for steel and aluminum

****

End Of Report

SGS U.S. Testing Company Inc.

75 Passaic Avenue
Fairfield, NJ 07004-3833
Tel: 201-575-5252
Fax: 201-244-1823

REPORT OF TEST

28 Day Shake Flask Ready Biodegradability Test

Versus

JG-302

Conducted for :

Firefreeze World Wide, Inc.
270 Route 46
Rockaway, New Jersey 07866

SIGNED FOR THE COMPANY BY:

Daniel Cooke 4/23/97
Manager, Ecotoxicology

Charles Tong, PhD, DABT 4/23/97
Director, Toxicology

Note: Signature copies of this report available upon request.

REPORT OF TEST

TABLE OF CONTENTS

REPORT OF TEST

28 DAY READY BIODEGRADABILITY

Sponsor:	Firefreeze World Wide, Inc.
Address:	270 Route 46 Rockaway, NJ 07866
Testing Facility:	SGS U.S. Testing Company, Inc. Biological Services Division 75 Passaic Avenue Fairfield, New Jersey 07004
Sample Description:	Sample identified by Sponsor as Firefreeze World Wide product JG-302. Chemical composition: proprietary. Clear, colorless, slightly viscous liquid with a slight odor, soluble in water. Sample considered stable, received 3/11/97.
Project Description:	28 day Shake Flask Ready Biodegradability Test Test dates: 3/21/97 – 4/18/97.
Procedures:	SGS USTC Standard Operating Procedure MIC/28DAYSFT.012 “Biodegradability Shake Flask Test, CO2 Evolution, 28 Days”. This procedure is based on: USEPA 796.3240 “Ready Biodegradability: Modified OECD Screening Test”. OECD 301E “Ready Biodegradabilitiy: Modified OECD Screening Test.”

SUMMARY OF RESULTS

Firefreeze World Wide product JG-302 degraded 95.3%, by TOC reduction, within 28 days. The test substance met the degradability and microbial kinetics criteria (that the 70% “pass” level was met within 10 days after reaching 10% degradation) for ready biodegradability.

Carbon dioxide evolution data was not usable due to carbonate interference.

The control substance, aniline, readily degraded, validating the test system.

REPORT OF TEST

INTRODUCTION

This is a report of ready biodegradability assessment performed versus Firefreeze World Wide product JG-302. The test was conducted in a Gledhill Apparatus (Shake Flask) system to determine the sample's biodegradability in a closed aqueous system.

By supplying the test substance as virtually the sole carbon source, the ability of the substance to be metabolized by microbes became the limiting factor. Materials that degrade under such conditions either substantially or completely (to mineralization), within adequate time constraints can be considered "readily" or "ultimately" biodegradable.

Since the environmental conditions of the test are stringent, failure to measure degradability does not necessarily imply that the test substance is not biodegradable. Factors such as culture conditions, microbial inhibition, solubility, quantity and diversity of the microbial inoculum, and the absence of ca nutrients can affect results. Other test systems may be applied to further evaluate biodegradability.

Initial determination of organic carbon content of the batch of test substance submitted was performed by SGS USTC. JG-302 was determined to contain approximately 3350 ppm (0.335%) organic carbon. The Sponsor stated that JG-302 was approximately 97% water and 3% active ingredient. Using this percentage, the active ingredients of the test substance were approximately 11% organic carbon. The results of the biodegradability test described herein deal with this organic portion of the product.

Testing was performed in accordance with SGS USTC procedures and USEPA methodologies.

REPORT OF TEST

SUMMARY OF PROCEDURES
28 Day Flask Ready Biodegradability Assay

References:	USEPA 40 CFR 796.3240, “Ready Biodegradability: Modified OECD Screening Test”. OECD 301E, “ Ready Biodegradability: Modified OECD Screening Test”. SGS USTC Protocol MIC/28DAYSFT.012, “Biodegradability Shake Flask Test, CO_2 Evolution 28 Days”.
Sample storage:	Ambient temperature, original, sealed sample container.
Inoculum source:	The inoculum was collected from the activated sludge channels of a domestic sewage plant, Florham Park Sewerage Authority (NJ) on 2/27/96. Sludge was maintained in SGS USTC SCAS reactor until test initiation. Surface water was collected form SGS USTC Aquatic Laboratory fish culture systems. A soil elutriate was prepared from active soil maintained under incubation in the SGS USTC Microbiology Laboratory.
Temperature:	20 - 25°C.
Illumination:	Low light conditions (to prevent photochermical breakdown or growth of algae in test flasks.
Test vessels:	2000 mL glass shake flasks (Gledhill Apparatus).
Test volume:	1000 mL.
Replication:	3 replicates per treatment.
Test concentration:	Approximately 20 ppm (as Carbon) of test sample.
Controls:	Blank control = nutrient media only. Positive control = nutrient media + Aniline (approx. 20 ppm as C).
Agitation:	Gyratory shaking at 150 ± 10 revolutions per minute.
Test duration:	28 days.
Chemical data:	Captured CO_2 thration at days 3, 7, 14, 21 and 28. Total Organic Carbon (TOC) analysis Shimadzu TOC-5000 Carbon Analyzer at days 0, 7, 14, 21, and 28.

REPORT OF TEST

SUMMARY OF PROCEDURES (Continued)
28 Day Flask Ready Biodegradability Assay

Nutrient media: A defined aqueous inorganic salt medium was used, consisting of 1.0 mL of each of the following stock solutions added to 1.0 L of deionized water:

Stock Solution	Compound	Concentration (g/L)
I	KH_2PO_4 K_2HPO_4 $Na_2HPO_4 - {}_2H_2O$ NH4Cl	8.5 21.75 33.4 20.0
II	$MgSO_4 - 7H_2O$	22.5
III	$CaCl_2$	27.5
IV	$FeCl_3 - 6H_2O$	0.25
V trace elements	$MnSO_4 - 4H_2O$ H_3BO_3 $ZnSO_4 - 7H_2O$ $(NH_4)_6Mo_7O_{24}$ $FeCl_3$, EDTA	0.0399 0.0572 0.0428 0.0347 0.1000
VI vitamins	yeast extract	0.15

Physical Data: Temperature of the system daily, and pH of the test flasks initially.

Response: Co_2 evolution, TOC degradation.

Test acceptability: Positive control substance (aniline) must degrade ≥ 60% as measured by CO_2 evolution and/or ≥ 70% as measured by TOC reduction.

REPORT OF TEST

RESULTS
Biodegradability – CO2 Evolution

TABLE I: Co_2 Titration Data

BLANK	Titrant Value (mL)					
	Rep	Day 3	Day 7	Day 14	Day 21	Day 28
	A	0.8	0.1	0.2	0.7	0.2
	B	1.2	0.4	0.6	1.2	0.3
	C	0.8	0.5	0.6	0.7	0.5
Mean value (x)		0.9	0.3	0.5	0.9	0.3

ANILINE	Titrant Value (mL)					
	Rep	Day 3	Day 7	Day 14	Day 21	Day 28
	A	19.4	5.7	3.5	3.6	0.7
	B	14.4	8.1	5.4	3.4	2.1
	C	19.2	4.5	3.3	3.2	0.5
Mean value (x)		17.7	6.1	4.1	3.4	1.1
Blank Corrected x		16.8	5.8	3.6	2.5	0.8

JG-302	Titrant Value (mL)					
	Rep	Day 3	Day 7	Day 14	Day 21	Day 28
	A	19.7	19.8	12.6	3.6	2.6
	B	19.7	19.9	10.2	6.6	2.7
	C	19.7	19.9	12.3	6.1	3.0
Mean value (x)		19.7	19.9	11.7	5.4	2.8
Blank Corrected x		18.8	19.6	11.2	4.5	2.5

REPORT OF TEST

RESULTS (Continued)
Biodegradability – CO_2 Evolution

TABLE II: Cumulative CO_2 Evolution and % Degradation

	Test Day	Corrected Mean Titrant Value (mL)	Theoretical 100% Titrant value (mL)	% Degradation
ANILINE (20.2 mg as C)	3	16.8	33.7	49.9
	7	5.8	33.7	17.2
	14	3.6	33.7	10.7
	21	2.5	33.7	7.4
	28	0.8	33.7	2.4
			Total	87.6%

	Test Day	Corrected Mean Titrant Value (mL)	Theoretical 100% Titrant value (mL)	% Degradation
JG-302 (23.9 mg as C)	3	18.8	39.9	47.1
	7	19.6	39.9	49.1
	14	11.2	39.9	28.1
	21	4.5	39.9	11.3
	28	2.5	39.9	6.3
			Total	141.9%*

*Carbon dioxide evolution data may also include significant carbonate interference, yielding a potentially spurious endpoint (see Conclusions, page 10).

% Degradation calculation from CO2 Evolution data:

$$\% \text{ Degradation} = \frac{\text{Total } \Delta \text{ HCl titrated}}{(\text{mg C in sample}) \times 1.67}$$

Where: 1) Δ HCl = The difference in titration volume between the initial $Ba(OH)_2$ stock and the CO_2 capture solution on subsequent sample days.

2) mg C in sample = The measured mg of Carbon in the test sample at test initiation.

REPORT OF TEST

RESULTS (Continued)
Biodegradability – TOC Reduction

TABLE III: Total Organic Carbon Data

BLANK	TOC Value (ppm)					
	Rep	Day 0	Day 7	Day 14	Day 21	Day 28
	A	0.4	0	0.3	0	0
	B	0.6	0.2	0	0	0
	C	0.4	0	0	0	0
Mean value (x)		0.5	0	0.1	0	0

ANILINE	TOC Value (ppm)					
	Rep	Day 0	Day 7	Day 14	Day 21	Day 28
	A	20.7	2.0	0.6	0	0
	B	21.1	2.6	1.9	0	0
	C	20.3	2.5	1.2	0	0
Mean value (x)		20.7	2.3	1.2	0	0
Blank Corrected x		20.2	2.3	1.1	0	0
% Degradation		n/a	88.6%	94.5%	100%	100%

JG-302	TOC Value (ppm)					
	Rep	Day 0	Day 7	Day 14	Day 21	Day 28
	A	24.0	3.6	2.4	0.7	1.6
	B	25.1	5.3	2.1	2.2	1.0
	C	24.0	8.2	2.7	0.5	0.7
Mean value (x)		24.4	5.7	2.4	1.1	1.1
Blank Corrected x		23.9	5.7	2.3	1.1	1.1
% Degradation		n/a	76.1%	90.3%	95.3%	95.3%

% Degradation calculation from TOC reduction data:

$$\% \text{ degradation} = 100 \times \frac{(C_0 - B_0) - (C_t - B_t)}{C_0 - B_0}$$

Where: 1) C_o = Mean initial concentration of TOC in the test or reference sample
2) B_o = Mean initial concentration of TOC in the blank control.
3) C_t = Mean concentration of TOC in the test or reference sample at time "t".
4) B_t = Mean concentration of TOC in the blank control at time "t".

REPORT OF TEST

CONCLUSIONS

Biodegradability – CO_2 Evolution/TOC Reduction

When tested as described herein, the following degradation rates were obtained after 28 days:

Sample	Degradation From Co_2 Evolution	Degradation From TOC Reduction
JG-302	141.9% * (71% estimated)	95.3%
ANILINE	87.6%	100%

Firefreeze World Wide product JG-302 satisfied the criteria for ready biodegradability as outlined in OECD 301E and USEPA 796.3240. The test substance degraded › 70% by TOC reduction within 28 days, and the microbial kinetics met OECD criteria because the test substance reached the “pass” criterion within 10 days after reaching 10% degradation.

The carbon dioxide evolution data showed significant interference from inorganic carbon (carbonates). The date indicated degradation of significantly greater than 100%. TOC analysis of a solution of JG-302 was performed before and after acidification. Acidification of the solution lowered the observed total carbon by approximately 200%. This result confirmed that the test substance contained a significant amount of inorganic carbon. This inorganic carbon was apparently given off as CO_2 during the course of the assay, and was recorded as a “false positive” interference, adding to the CO_2 obtained from organic carbon metabolism.

The 141.9% CO_2 evolution exhibited by JG-302 can be adjusted, using the above correction, to be approximately 71%. However, all of the CO_2 data gathered from the test substance must be considered as suspect, due to the observed interference.

Since the CO_2 evolution data for the test substance was suspect, TOC reduction data was considered to be the more appropriate indicator of test substance degradation.

The reference control substance, aniline, readily degraded, validating the test system.

09/01/03

FIRE BLOCK FIRE RETARDANT

The FIRE BLOCK Fire Retardant is a fire retarding agent specially formulated to effectively and safely retard all Class A materials. Developed from the extraordinary life-saving and fire-fighting Cold Fire, rapid cooling fire extinguishing agent, the FIRE BLOCK Fire Retardant is a unique and revolutionary product, which retards first by stopping dangerous flames from spreading. The FIRE BLOCK Fire Retardant works to actually form its own insulation barrier to prevent dangerous flames from spreading. The FIRE BLOCK Fire Retardant also inhibits the development of hydrocarbon smoke. The FIRE BLOCK Fire Retardant is non-flammable, safe to store, handle and use, leaves no residue and is environmentally friendly.

MATERIAL SAFETY DATA SHEET

Capabilities	
Retarding Power	After treatment of retardant on all Class A type surfaces there is zero flame spread.
Applications	Spray on Class A surfaces of all types (wood, paper, cotton, furnishing, all non-polymer surfaces).
Cleanup	None needed. Leaves no residue.

Characteristics	
pH	pH of concentrate is 7.0.
Flash Point	Negligible.
Boiling Point	212°F.
Odor	Mild smell. Does not contain d-limonenes. Light straw color.
Water Solubility	Complete.
Shelf Life	Indefinite when stored in closed containers between 32°F and 120°F.
Dilution Strength	Do not dilute. Use in concentrated form.
Residue	Product leaves little to no residue.

Environmental and Safety Considerations	
Biodegradability	100% in 21 days under ideal conditions.
Hazardous Components	No components are listed in the NIOSH Recommendations for Occupational Health Standards, 1988, or are defined as hazardous by SARA, CERLA or RCRA. No OSHA PEL's are established for other ingredients.
Handling	Retardant is neutral. It will remove oil from the skin and will irritate the eyes if sprayed directly into them. When handling bulk concentrate, eye protection, gloves and impervious clothing should be worn when there is danger of splashing, prolonged exposure to vapour, or prolonged skin contact, as with all chemicals. Do not ingest, splash into eyes or inhale for prolonged periods.
Disposal	Retardant itself may be disposed through municipal systems.

09/01/03

FIRE BLOCK FIRE RETARDANT

SECTION I – IDENTIFICATION

Manufacturer	FIREFREEZE Worldwide, Incorporated	Formulation # JG302R
Address	272 Route 46, Rockaway, N.J. 07866	
Phone / Fax	973-627-0722 / 973-627-2982	
Date Prepared	September 1, 2003	
Trade Name	FIRE BLOCK	
Product	Class A Fire Retardant	

SECTION II – INGREDIENTS AND HAZARD CLASSIFICATION

No components are believed to be hazardous or listed in the NIOSH Recommendations for Occupational Safety and Health Standards, 1988, or are listed as hazardous by SARA, CERCLA or RCRA. No OSHA PEL's are established for any of the other ingredients.

Boiling Point:	212°F	Vapor Pressure (mm Hg):	Same as water
Solubility in water:	100%	Specific Gravity:	1.09 @ 60°F
pH:	7.0	Appearance and Odor:	Straw colored liquid, mild smell (Note: contains no d-limonenes)

Flash Point:	Not applicable	Flammable Limits:	Non-flammable
LEL:	Not applicable	UEL:	Not applicable
Extinguishing Media:	Not applicable		
Special Fire Fighting Procedures:	None	Unusual Fire and Explosion Hazards	None

Stability:	Stable
Incompatibility:	None
Hazardous Decomposition Products:	Carbon monoxide and carbon dioxide
Hazardous Polymerization:	Will not occur

Exposure Limits OSHA PEL:	Not established	ACGIII TLV:	Not established
Routes of Entry Inhalation: Yes	Skin: Yes	Ingestion: Yes	

Signs and Symptoms of Exposure

Skin:	Negligible hazard, not a primary skin irritant.
Eyes:	Not a primary ocular irritant.
Inhalation:	Negligible.
Ingestion:	Hazard is extremely low. Material is considered non-toxic.

First Aid

Eyes:	Immediately flush eyes with water for at least 15 minutes, as per OSHA standards. Seek medical aid if irritation persists.
Skin:	Flush affected area and wash with water.
Inhalation:	Negligible.
Ingestion:	Drink water. Obtain medical attention if necessary.

Carcinogenicity

NTP?: No IARC? No OSHA Regulated? No

Spill or Leak Procedures

Rinse affected area with water. Will not harm the environment.

Waste Disposal Method

Dispose as non-hazardous waste in accordance with local regulations.

1/7/04

COLD FIRE®
Fire Suppressing Agent

Cold Fire is an environmentally friendly fire suppressing agent, specially designed to extinguish Class A, B and D fires. Cold Fire has a rapid cooling effect, which provides rapid extinguishment, prevention of re-ignition and the encapsulation of hydrocarbons. The product is safe to store, handle and use, leaves virtually no residue, is environmentally friendly, non-toxic, non-corrosive and biodegradable.

MATERIAL SAFETY DATA SHEET

Capabilities	
Fire Suppressing Power	Quickly snuffs out fires. “Cools” burning fuel on contact. Prevents reignition by encapsulating fuel source. Retards smoke generation. Cools rapidly.
Applications	Class A, B & D fires of all types.
Cleanup	None needed. Foam layer dissipates without leaving residue. Product biodegrades rapidly. Oil molecules do not form a tight emulsion with the suppressing solution.
Dispersant Capability	Low. Treated oils are not dispersed in water.

Characteristics	
pH	pH of concentrate is 6.15. Neutral when diluted.
Flash Point	Negligible.
Boiling Point	212°F.
Odor	Mild fresh scent. Does not contain d-limonenes. Clear color.
Water Solubility	Complete.
Shelf Life	Indefinite when stored in closed containers between 32°F and 120°F.
Dilution Strength	Use at strengths of 1% to 10% in any type of water.
Residue	Agent layer dissipates rapidly. Product leaves no residue.

Environmental and Safety Considerations	
Biodegradability	100% in 21 days under ideal conditions.
Hazardous Components	No components are listed in the NIOSH Recommendations for Occupational Health Standards, 1988, or are defined as hazardous by SARA, CERLA or RCRA. No OSHA PEL’s are established for other ingredients.
Handling	Suppressor is neutral. It will remove oil from the skin and may irritate the eyes if sprayed directly into them. When handling bulk concentrate, eye protection, gloves and impervious clothing should be worn when there is danger of splashing, prolonged exposure to vapour, or prolonged skin contact, as with all chemicals.
Disposal	Suppressant itself may be disposed through municipal systems.

1/7/04

COLD FIRE

SECTION I – IDENTIFICATION

Manufacturer:	FIREFREEZE Worldwide, Incorporated	Formulation #:	JG302
Address:	272 Route 46, Rockaway, NJ 07866	Trade Name:	Cold Fire 302
Phone / Fax:	973-627-0722 / 973-627-2982	Date Prepared:	Jan 7, 2004
Product:	Class A:B:D fire suppressing agent		

SECTION II – INGREDIENTS AND HAZARD CLASSIFICATION

Components are classified trade secret. No components are believed to be hazardous, or listed in the NIOSH Recommendations for Occupational Safety and Health Standards, 1988, or are listed as hazardous by SARA, CERCLA, or RCRA. No OSHA PEL's are established for any of the other ingredients.

SECTION III – PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point:	212°F	Vapor Pressure (mm Hg):	Same as water
Solubility in water:	100%	Specific Gravity:	1.02 @ 60°F
pH: 6.15 (concentrate) Neutral when diluted		Appearance and Odor:	Clear liquid, fresh smell

SECTION IV – FIRE AND EXPLOSION DATA

Flash Point:	Not applicable	Flammable Limits:	Non-flammable
LEL:	Not applicable	UEL:	Not applicable
Extinguishing Media:	Not applicable		
Special Fire Fighting Procedures:	None	Unusual Fire and Explosion Hazards	None

SECTION V – REACTIVITY DATA

Stability:	Stable
Incompatibility:	None
Hazardous Decomposition Products:	Carbon monoxide and carbon dioxide
Hazardous Polymerization:	Will not occur

SECTION VI – HEALTH HAZARD DATA

Exposure Limits

OSHA PEL: Not established ACGIII TLV: Not established

Routes of Entry

Inhalation: Yes Skin: Yes Ingestion: Yes

Signs and Symptoms of Exposure

Skin:	Negligible hazard, not a primary skin irritant. Liquid is neutral with pH 7.5. Dermal irritation testing for 72 hours on albino rabbits showed no erythema and no edema.
Eyes:	Not considered to be a primary ocular irritant.
Inhalation:	Negligible.
Ingestion:	Not considered to be orally toxic.

First Aid

Eyes:	Immediately flush eyes with water.	Skin:	Rinse with water.
Inhalation:	Negligible. Remove to fresh air.	Ingestion:	Drink water.

Carcinogenicity

NTP?: No IARC? No OSHA Regulated? No

Table Continued on Next Page

SECTION VII – PRECAUTIONS FOR SAFE HANDLING AND USE

Spill or Leak Procedures: Rinse affected area with water.

Waste Disposal Method: Dispose as non-hazardous waste in accordance with local regulations.

Storage and Handling Precautions: Store in temperatures from 32°F to 120°F in closed containers to prevent evaporation and deterioration. Freezing will not damage material as long as container remains intact.

Other Precautions: Although components have low hazard levels, the product will remove oils from the skin like the common soap. Avoid prolonged skin contact.

SECTION VIII – CONTROL MEASURES

Respirator Protection: Not required.

Ventilation: Under ordinary conditions of use for its intended purpose, no special ventilation is required.

Protective Gloves: Wear if there is prolonged skin contact.

Eye Protection: Wear if needed to prevent reasonable probability of eye contact.

SECTION IX – HAZARD CLASSIFICATION

IMO Hazard Class and Number
Non hazardous.

UN Number
Not applicable.

US DOT Hazard Class
Not regulated by DOT.

US DOT Identification Number
Not applicable.

SECTION X – REGULATORY INFORMATION

EPA SNAP: Significantly New Alternative Policy Program Listed. Cold Fire® is listed by the EPA as a substitute for Halon 1211.

HMIS Rating: Health: 0 Flammability: 0 Reactivity: 0

SECTION XI – ENVIRONMENTAL DATA

Biodegradability: Product is 100% biodegradable in an active environment within 21 days.

Toxicity: In accordance with U.S. EPA Office of Pollution Prevention and Toxics criteria for ranking the acute toxicity of chemicals in the aquatic environment, ColdFire 302 is considered to be of low concern.

- 96 hour acute toxicity versus freshwater alga (Selenastrum capricornutum) IAW 40 CFR 797.1050 showed ColdFire 302 was algicidal at concentrations above 750 ppm.
- 96 hour acute toxicity versus juvenile rainbow trout (Oncorhynchus mykiss) IAW 49 CFR 797.1400 showed an LC_{50} of 105 ppm.

The information presented in this MSDS is believed to be factual, however, nothing contained in this information is to be taken as a warranty of any kind by FIREFREEZE Worldwide, Inc. The user should review any recommendations, in the specific context of the intended use, to determine whether they are appropriate.

09/01/03

MOTOR MAX™
Radiator Cooling Additive

General Description/Use

Motor MAX works to reduce water and oil temperature, the temperature of internal engine components, it minimizes hot spots in engines, and in turn the passenger compartment and engine bay temperatures are reduced.

Motor MAX is non-toxic and biodegradable. It is non-corrosive and compatible with all internal engine parts, seals, hoses and accessory components.

Recommended Mixtures

For use in racing, heavy equipment, towing or high stressed applications where more cooling is needed run 1 quart Motor MAX to 10 quarts of water.

For normal use in street driven cars, motor homes, street rods, etc. use 1 quart Motor MAX to 16 quarts of water.

Motor MAX can be safely mixed with antifreeze. Do not mix Motor MAX with any other type of water wetters or radiator additives.

Characteristics

pH:	pH is neutral 7.0
Flash Point:	Negligible
Boiling Point:	400° F
Odor:	Mild, fresh scent, does not contain d-limonenes
Appearance:	Opaque in color
Water Solubility:	Complete
Shelf Life:	Indefinite when stored in closed containers between 20° F – 120°F
Residue:	Product dissipates rapidly and leaves virtually no residue

Shipping Containers

1 Quart (32 oz)	2.3 lbs/quart
1 Case of 12 Quarts	28 lbs/case

Handling & Storage

Store at room temperature. Avoid prolonged storage below 28° F or above 120° F. If frozen, return product to room temperature and allow to thaw before use. Product is freeze/thaw stable. Product is neutral. Rinse hands with soap and water after handling product. As with all chemicals avoid direct eye contact.

09/01/03

MOTOR MAX™
Material Safety Data Sheet

SECTION I – IDENTIFICATION

Manufacturer:	FIREFREEZE Worldwide, Incorporated	Formulation #:	JG302-DF (Formula 500)
Address:	272 Route 46, Rockaway, N.J. 07866	Trade Name:	Motor MAX
Phone / Fax:	973-627-0722 / 973-627-2982		
Product:	Radiator Cooling Additive		

SECTION II – INGREDIENTS AND HAZARD CLASSIFICATION

Components are classified trade secret. No components are believed to be hazardous or listed in the NIOSH Recommendations for Occupational Safety and Health Standards, 1988, or are listed as hazardous by SARA, CERCLA, or RCRA.

SECTION III – PHYSICAL/CHEMICAL CHARACTERISTICS

Vapor Pressure (mm Hg):	Same as water	Specific Gravity:	1.02 – 1.04
Solubility in Water	100%	Appearance/ Odor:	Opaque, fresh scent
pH:	7.0 (neutral)		

SECTION IV – FIRE AND EXPLOSION DATA

Flash Point:	Not applicable	Flammable Limits:	Non-flammable
LEL:	Not applicable	UEL:	Not applicable
Extinguishing Media:	Not applicable		
Special Fire Fighting Procedures:	None	Unusual Fire and Explosion Hazards	None

SECTION V – HEALTH HAZARD DATA

Route of Entry

Inhalation: Yes Skin: Yes Ingestion: No

Signs and Symptoms of Exposure

Skin:	Negligible hazard, not a primary skin irritant.
Eyes:	Not considered to be a primary ocular irritant.
Inhalation:	Negligible.
Ingestion:	Do not ingest.

First Aid

Eyes:	Flush eyes thoroughly with water.
Skin:	Rinse with soap & water after handling.
Inhalation:	Negligible. Remove to fresh air if there is irritation.
Ingestion:	If accidently swallowed drink water and consult a physician if any irritation occurs.

SECTION VI – SAFE HANDLING & USE

Respiratory Protection: None required.

Ventilation: Under ordinary conditions of use for its intended purpose, no special ventilation is required.

Eye Protection: Wear eye goggles or safety glasses if needed to prevent reasonable probability of eye contact.

Table Continued on Next Page

SECTION VI – SAFE HANDLING & USE (Continued)

Protective Gloves: Wear general work gloves if there is a probability of prolonged skin contact to minimize any possible irritation.

Spill or Leak Procedures: Recoup as much of the product as possible. Rinse affected area with water.

Waste Disposal Method: Dispose of a non-hazardous waste in accordance with local, state and federal regulations.

Storage and Handling: Store at room temperature. Do not store for prolonged period in temperatures below 28° F or above 120° F. Keep product in closed containers to avoid evaporation and/or possible contamination.

Other Precautions: Do not mix with any other type of water wetters or radiator additives.

SECTION VII – HAZARD CLASSIFICATION

IMO Hazard Class
Non-hazardous

UN Number
Not applicable

US DOT Hazard Class
Not regulated

HMIS Rating
H-0, R-0, F-0

SECTION VIII – REGULATORY INFORMATION

NJ TSRN's (New Jersey Trade Secret Registration Numbers): JG200-JG800

California Proposition 65
Components present containing listed substances which the State of California has found to cause cancer, birth defects or other reproductive harm which would require a warning under the statue are: **NONE**.

Canada WHMIS (Workplace Hazardous Materials Identification System)
Components present in this product that are listed on the WHMIS hazardous ingredients disclosure list: **NONE**.

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act of 1980)
Requires notification of the National Response Center of release of quantities of hazardous substances equal to or greater than the reportable quantities in 40 CFR 302.4. Components present in this product at a level which could require reporting under the statue are: **NONE**.

SARA (Superfund Amendments and Reauthorization Act of 1986) Title III
Requires submission of annual reports of release of toxic chemicals that appear in 40 CFR 372 (for SARA 313). This information must be included in all MSDS's that are copied and distributed for this material. Components present in this product at a level which could require reporting under the statute are: **NONE**.

The information presented in this MSDS is believed to be factual, however, nothing contained in this information is to be taken as a warranty of any kind by FIREFREEZE Worldwide, Inc. The user should review any recommendations, in the specific context of the intended use, to determine whether they are appropriate.

06/12/00

CF-540
Radiation Extraction & Detoxification Agent

CF-540 is an environmentally friendly product used to extract and detoxify radiation. The product can be used to extract radiation from any exposed surface, including ground contamination. CF-540 is a blend of Cold Fire, an environmentally-UL Listed fire suppressing agent and Protect all, a unique product used to fight free radicals. Due to the unique chemical composition of this agent, the product has the ability to fight Class A, B and D fires, encapsulate hydocarbons and extract and detoxify radiation. The product is water soluble, non-toxic and rapidly biodegradable.

Material Safety Data Sheet

Capabilities	
Extraction & Detoxification	Extracts and eliminates radiation from any exposed surface. Destroys airborne radiation vapour.
Fire Suppressing Power	Quickly snuffs out fires. “Kills” burning fuel on contact. Prevents reignition by encapsulating fuel source. Retards smoke generation. Cools rapidly.
Applications	Use to extract and remove radiation from metal, concrete, soil and human/animal skin surface. Apply agent. Wait 24-48 hours for product to work. Thereafter, wash down treated surface/area with steam or high power pressure washer.
Cleanup	None needed. Foam layer dissipates without leaving residue. Product biodegrades rapidly. Oil molecules do not form a tight emulsion with the suppressing solution.
Dispersant Capability	Low. Treated oils are not dispersed in water.

Characteristics	
pH	pH of concentrate is 7.0.
Flash Point	Negligible.
Boiling Point	212°F.
Odor	Mild fresh scent. Does not contain d-limonenes. Clear color.
Water Solubility	Complete.
Shelf Life	Indefinite when stored in closed containers between 32°F and 120°F.
Dilution Strength	Product is pre-mixed. DO NOT DILUTE.
Residue	Agent layer dissipates rapidly. Product leaves a small layer of residue (fine haze).

Environmental and Safety Considerations	
Biodegradability	100% in 21 days under ideal conditions.
Hazardous Components	No components are listed in the NIOSH Recommendations for Occupational Health Standards, 1988, or are defined as hazardous by SARA, CERLA or RCRA. No OSHA PEL’s are established for other ingredients.
Handling	Agent is neutral. It will remove oil from the skin and may irritate the

	eyes if sprayed directly into them.
Disposal	Agent may be disposed through municipal systems.

06/12/00

CF-540
Radiation Extraction & Detoxification Agent

SECTION I – IDENTIFICATION

Manufacturer:	FIREFREEZE Worldwide, Incorporated	Formulation #:	Blend of JG302/JG540
Address:	272 Route 46, Rockaway, N.J. 07866	Trade Name:	CF-540
Phone / Fax:	973-627-0722 / 973-627-2982	Date Prepared:	Jan 1, 1999
Product:	Radiation Extraction & Detoxifying Agent		

SECTION II – INGREDIENTS AND HAZARD CLASSIFICATION

Components are classified trade secret. No components are believed to be hazardous, or listed in the NIOSH Recommendations for Occupational Safety and Health Standards, 1988, or are listed as hazardous by SARA, CERCLA, or RCRA. No OSHA PEL's are established for any of the other ingredients.

SECTION III – PHYSICAL/CHEMICAL CHARACTERS

Boiling Point:	212°F	Vapor Pressure (mm Hg):	Same as water
Solubility in water:	100%	Specific Gravity:	1.02 @ 60°F
pH:	7.0 Neutral	Appearance and Odor:	Clear liquid, fresh smell

SECTION IV – FIRE AND EXPLOSION DATA

Flash Point:	Not applicable	Flammable Limits:	Non-flammable
LEL:	Not applicable	UEL:	Not applicable
Extinguishing Media:	Not applicable		
Special Fire Fighting Procedures:	None	Unusual Fire and Explosion Hazards	None

SECTION V – REACTIVITY DATA

Stability:	Stable
Incompatibility:	None
Hazardous Decomposition Products:	Carbon monoxide and carbon dioxide
Hazardous Polymerization:	Will not occur

SECTION VI – HEALTH HAZARD DATA

Exposure Limits

OSHA PEL: Not established ACGIII TLV: Not established

Routes of Entry

Inhalation: Yes Skin: Yes Ingestion: Yes

Signs and Symptoms of Exposure

Skin: Negligible hazard, not a primary skin irritant. Liquid is neutral with pH 7.0. Dermal irritation testing for 72 hours on albino rabbits showed no erythema and no edema.

Eyes: Not considered to be a primary ocular irritant.

Inhalation: Negligible.

Ingestion: Not considered to be orally toxic.

First Aid

Eyes:	Immediately flush eyes with water.	Skin:	Rinse with water.
Inhalation:	Negligible.	Ingestion:	Drink water.

Carcinogenicity

NTP?: No IARC? No OSHA Regulated? No

Table Continued on Next Page

06/12/00

SECTION VII – PRECAUTIONS FOR SAFE HANDLING AND USE

Spill or Leak Procedures: Rinse affected area with water.

Waste Disposal Method: Dispose as non-hazardous waste in accordance with local regulations.

Storage and Handling Precautions: Store in temperatures from 32°F to 120°F in closed containers to prevent evaporation and deterioration. Freezing will not damage material as long as container remains intact.

Other Precautions: Although components have low hazard levels, the product will remove oils from the skin like the common soap. Avoid prolonged skin contact.

SECTION VIII – CONTROL MEASURES

Respirator Protection: Not required.

Ventilation: Under ordinary conditions of use for its intended purpose, not special ventilation is required.

Protective Gloves: Wear if there is prolonged skin contact.

Eye Protections: Wear if needed to prevent reasonable probability of eye contact.

SECTION IX – HAZARD CLASSIFICATION

IMO Hazard Class and Number
Not hazardous.

UN Number
Not applicable.

US DOT Hazard Class
Not regulated by DOT.

US DOT Identification Number
Not applicable.

SECTION X – REGULATORY INFORMATION

EPA SNAP: Cold Fire® is listed by the EPA as a substitute for Halon 1211 under their SNAP Program. (Significantly New Alternative Policy Program)

HMIS Rating: Health: 0 Flammability: 0 Reactivity: 0

SECTION XI – ENVIRONMENTAL DATA

Biodegradability: Product is 100% biodegradable in an active environment within 21 days.

Toxicity: In accordance with U.S. EPA Office of Pollution Prevention and Toxics criteria for ranking the acute toxicity of chemicals in the aquatic environment, ColdFire 302 is considered to be of low concern.

- 96 hour acute toxicity versus freshwater alga (Selenastrum capricornutum) IAW 40 CFR 797.1050 showed ColdFire 302 was algicidal at concentrations above 750 ppm.
- 96 hour acute toxicity versus juvenile rainbow trout (Oncorhynchus mykiss) IAW 49 CFR 797.1400 showed an LC_{50} of 105 ppm.

The information presented in this MSDS is believed to be factual, however, nothing contained in this information is to be taken as a warranty of any kind by FIREFREEZE Worldwide, Inc. The user should review any recommendations, in the specific context of the intended use, to determine whether they are appropriate.

09/01/03

ODOR SEAL®
Biodegradable Industrial Odor Eliminator

ODOR SEAL® is an industrial odor eliminator and cleaner specifically formulated for eliminating odors by encapsulating and destroying the odor producing source and its vapour. ODOR SEAL® has also been recognized as an effective all-purpose cleaner. ODOR SEAL® is water soluble and rapidly biodegradable. The concentrate can be used in power washing equipment, high pressure washers and steam cleaners to wash, clean and eliminate all odor producing sources and areas.

MATERIAL SAFETY DATA SHEET

Capabilities	
Cleaning Power	Eliminates odor. Effectively cleans odor producing area. Particularly good when used with machine scrubbing, pressure washing and steam cleaning equipment. **Hot water enhances odor eliminating and cleaning power.**
Applications	Use in sewage treatment, landfills, restrooms, portable toilets, garbage dumpsters and trucks, on boats, in stables, on farms, in locker rooms, spas or use to eliminate smoke and pet odors. Spray directly onto the odor producing source and/or spray into air to destroy any airborne odors.
Oil Emulsification	Slight. Oil molecules do not form a tight emulsion with the cleaning solution.
Dispersant Capability	Low.
Residue	No residue after rinsing.

Characteristics	
pH	7.5 in concentrate form.
Flash Point	Negligible.
Boiling Point	Greater than 212°F.
Odor	Mild fresh scent. Does not contain d-limonenes.
Water Solubility	Complete.
Shelf Life	Indefinite when stored in closed containers between 32°F and 120°F.

Environmental and Safety Considerations	
Biodegradability	100%.
Hazardous Components	No components are listed in the NIOSH Recommendations for Occupational Health Standards, 1988, or are defined as hazardous by SARA, CERLA or RCRA. No OSHA PEL's are established for other ingredients.
Handling	Prolonged contact with product may cause slight dryness of the skin.
Disposal	Cleaner itself may be disposed through municipal systems. Oil cleaned from surfaces must be disposed following local regulations.

Letters of Reference

The follow pages are just a few letters of reference, testimonials, and articles we have collected over the years:

USPC and Fire Freeze Worldwide Inc. Team Up to Educate the Equestrian Community about Cold Fire Extinguishing Agent

Barn and Stable Fires Can Be Devastating.

- 22 show horses killed in New York barn fire - January 2012
- 27 horses perished in a barn fire in Michigan - February 2012
- 6 race horses killed in a fire in Chicago - March 2012
- 18 horses die in a barn fire in Illinois - April 2012

We hear about these tragedies all too often, and hope it does not happen to us. Everyone can remember the 2011 fire, recently profiled on CBS 60 Minutes, which roared through Boyd Martin's stable claiming the lives of 6 horses and causing hundreds of thousands of dollars in loss which almost ended Boyd's career. Miraculously, one of Boyd's mounts Neville Bardos, while suffering extensive burns and damage to his lunges, was spared and came back to be his current Olympic hopeful mount. This is one of those stories which legends are made from, but one which none of us should ever have to experience.

Barns and stables are filled with highly flammable materials, and present a big fire prevention challenge. Add the presence of panicked animals and you have a recipe for a disaster if a fire breaks out. However, barn and stable fires are preventable and can be extinguished with the deployment of good barn management and the right fire extinguishing agent.

Whether you keep your horses at home, or stable them, a barn fire is an event you must plan to prevent. The **United States Pony Clubs, Inc.** has teamed up with **Fire Freeze Worldwide, Inc.** to bring to your attention "Cold Fire" an environmentally horse safe and cost effective fire extinguishing agent.

Join us on **June 29, 2012** at the Kentucky Horse Park, Lexington Kentucky, for a live demonstration of the effectiveness of Cold Fire and an explanation of its benefits to the equestrian community.

Where: The Kentucky Horse Park, Alltech Arena, Lower Parking Area.
Follow the Directional Signs
When: June 29th, 2012 at 11:00am

Please R.S.V.P by June 27th to marketing@ponyclub.org.

COLD FIRE Canada Ltd.

Here's the Link:

http://bc.ctvnews.ca/taking-the-heat-out-of-deadly-fires-1.835525

ColdFire on CTV JUNE5-2012

Our apologies! **CTV** BC should be credited fully with the story and accompanying video regarding Cold Fire...

By:Darcy Wintonyk and Lynda Steele, ctvbc.ca
Date:Tuesday Jun. 5, 2012 11:09 AM PT

Lynda Steele

From plane crashes to hockey riots, emergency responders in Metro Vancouver are being armed with a new fire fighting tool that can help save lives.

While traditional fire foam smothers a fire, the product Cold Fire actually takes the heat out of flames. The product is non-toxic, uses less water and leaves less damage.

Metro Vancouver firefighters are training with the Cold Fire product. While most fire extinguishers smother the flames, Cold Fire takes the heat out the flames and that could mean the difference between life and death in a vehicle fire.

"Cold Fire will actually take away the BTU -- the heat around the person and the individual

that's doing the rescuing -- to allow them to get into the vehicle and get that person out," said Cold Fire President Grant Pearson.

The plant-based product is also saving lives on professional racetracks and being used by emergency workers on both sides of the border. Cold Fire was used to put out a plane crash fire in Richmond last year and is now present in all of the city's fire trucks.

Vancouver police are using the product too. After the Stanley cup mayhem last year, it was decided firefighters would be embedded in riot squads in the future -- and they may soon be equipped with Cold Fire backpacks.

Vancouver Deputy Fire Chief Joe Foster said he's impressed with what he's seen so far.

"The backpack is extremely effective -- easy to carry -- very comfortable, so we're looking at every option we have," Foster said.

And as more communities in B.C.'s Okanagan and Kootenays face the threat posed by wildfires, homeowners may consider dousing their properties in a spinoff product called Fire Block that repels the flames.

"It gives you that thermal protective barrier. Where you can see it, it won't allow fire to spread. It'll turn black and it'll smoke but it won't light on fire," said Pearson.

Outdoor enthusiasts can also treat their RV and boat curtains and cushions for added protection. And a small container is designed for kitchens so that small fires don't turn into a big problem.

Cold Fire Canada

Cold Fire is a multi-purpose fire suppressing agent that beats other foams hands-down! Completely 'green' and non-toxic, Cold Fire puts out Class A, B, D & K fires, hydrocarbons or polar solvents, metals, tires and asphalt fires. Cold Fire also suppresses vapors and helps to re-mediate spills.

Want to find out more? Just hit the CONTACT button below and we will assist you with what you need. We are sure that you will be impressed with Cold Fire's products; their efficacy and ease of use.

CONTACT COLD FIRE CANADA

McCarthy's
ROOFING LIMITED

850 Main Street, Dartmouth, NS 902-469-2260

February 17, 2012

Firefreeze Worldwide Inc

272 Rt. 46 East

Rockaway, NJ 07866

Attn: Eveline Giessler,

Dear Eveline,

McCarthy's Roofing specializes in all types of flat roofs and shingles mostly for the commercial market. We work in an environment where we have a lot of different combustibles and some such as tars and rubber that can get out of hand very quickly. We have been using your product for over a year now and have had several occasions to actual utilize your ColdFire product in fire situations. In our opinion, there are several very significant advantages to using ColdFire:

- All the fires we have encountered were contained and extinguished much quicker than they would have if we had utilized alternative products.
- The local fire departments were quite pleased with our efforts and the use of ColdFire and that allowed us to conduct the necessary investigation and get back to work much quicker than normal.
- The clean-ups after the fires were significantly less and saved several man-days of work and allowed us to focus on getting back to the paying job much sooner. This resulted in our client being much less concerned with the actual fire and to trust us to be able to contain such incidents without extensive loss of assents, material or time.
- The ability to refill our own tanks and rotate product with our crews saves us considerable time and money.

- You winter grade product suites our needs in this area and allows us tom keep our tanks outdoors even in our winter weather.
- However, most important is the ability of your product Fire Block to retard the onset of fire. We use it when we are torching membranes or cap in an area where we have a significant risk of fire such as old/dry wood or other combustible. We spray the area and allow it to dry and then conduct our torching. To date we have not had a fire instance when work has been performed in this manner. This has saved us countless time, effort, expense and unhappy clients.

In closing I would like to state that all the above would be fine but if we did not have a reliable supplier it would still present challenges. You and Ray and your people have been just great to work with. Our requirements have always been met and we have never had a cross-border problem of any kind. Further, every time we encounter a fire department in a new area where we are working, we supply them with one of your DVD's and all issues disappear.

It is a delight to work with all your folks and we look forward to a lasting relationship with a company that believes in their product but also supply all the support needed for us to perform appropriately in this increasingly complex safety oriented environment.

Michael Pollard, CSS

Safety Supervisor- McCarthy's Roofing Ltd

THE PINNACLE OF A LEGEND. . .

It was a routine demo of Hi-Tech Ventures (HTV) turned into a crucible match, which grew out of talks on the invincibility of the BQR. The NBC community, one of the Philippine Navy's most capable with vast experienced firefighters was tapped by Officers of the Philippine Naval Fleet, which dispatched a mammoth 2,000 gallon fire truck for the match.

The scene of the major event was the Baradero de Manila, Sangley Point (former U.S. Naval Base), Cavite City, where two 32 sq. feet ply board structures set up by HTV was laden with flammable and combustible stuffs.

Each structure had two big truck tires, two wood pallets, two plastic pallets, a mound of urethane foams, scraps of wood, plastics, PVC etc., deeply soaked in combustibles and flammable liquids of diesel fuel, high-octane petrol, kerosene, turpentine and oil-based paints. Though the combustible flammable and combustible liquids were equally shared, the odds were weighted in favor of the NBC fire truck: only 20 gallons of the 105 gallons "used diesel fuel" (more flammable) given away by the Naval Logistics Center went to the structure tackled by the NBC fire truck, the bulk of 80 gallons going to BQR's structure; the NBC fire truck was filled to capacity with 2,000 gallons of water, the BQR had only 120 gallons of water and 5 gallons Cold Fire; the fire pump of the NBC's fire truck was ten times more powerful than the BQR; the hoseline of the NBC fire truck was 2" diameter, that of the BQR was only 1"; the NBC fire truck was run by three veteran firefighters in full protective gears, the BQR had a naïve amateur firefighter with nothing on but T-Shirt drenched with Cold Fire and excessive faith on the infallibility of the BQR and Cold Fire.

At the grand display of the two challengers before the match, the small BQR paled into insignificance beside the monstrous NBC fire truck. The sheer size alone of the NBC fire truck was enough to scare the wits out of the officers of Hi-Tech Ventures. It was a classic match - a clash of David and Goliath. Talks abound the NBC's 2,000 gallon fire truck was far too much for a relatively small, unheard of fire truck. Speculations have reached fever pitch the BQR would get the drubbing.

Yet, at 1600 hours on 17 November 2011, the BQR grabbed the limelight. It stole the glory of the colossus, upstage in a blink of an eye! It had the run of the show - clocked 2 minutes with just 80 gallons of water on a blaze of epic proportion (20 times the size tackled by the huge NBC fire truck) before stunned Naval Officers-Observers, Naval Evaluators, and Naval personnel. The nearest the monstrous fire truck could get to was a 7-long minutes, with all 2,000 gallons water gone on a relatively small blaze.

While ignition was in the offing, Benjie Fernandez was seen splashing Cold Fire all over himself girding up for the match – a spectacle that captured the inquiring minds of the Naval Officers and Evaluators. With but T-Shirt soakeing in Cold Fire, he single-handedly fought the blaze; in contrast with the two NBC firefighters rigged to the teeth.

ROBERT BLANCO of TRI-MEDIA, Calabarzon, created a momentous scene when he rushed to hold the steel frame of the structure right immediately after the blaze – proving the rapid cooling effect of Cold Fire on burned materials - a worthy feature vital to the safety of firefighters, trapped victims, and emergency responders in case of accidental contact during fires. The tires and the wooden and plastic pallets did not burn despite the epic proportion of the blaze, proved Cold Fire's efficiency to absolutly suppress on contact.

As soon as the structure burst into flames, the two NBC firefighters jumped the gun before it becomes a raging inferno. When asked why they stepped into the breach, the NBC Fire Chief, one of two firefighters that fought the blaze affirmed, *"they were plunged into confusion not knowing what to do with a multi-class fire that water was not in the least bit effective."* They stepped into the breach to avert a *"crisis of a long-drawn out fire, that the blaze was not as intense as that engaged by the BQR."* The attempt merely whittled down the blaze, the flammable and combustible liquids spilled over and spread out, as the two firefighters put up a good fight shifting back and forth in backbreaking attempts with hoseline in tow as fast as their legs could carry on waterlogged grounds, lost momentum whenever they were on a wild-goose chase on flames after flames re-igniting all over, eventually subdued after a hard fought battle of 7-long minutes with all 2,000 gallons of water gone.

Benjie Fernandez of Hi-Tech Ventures was the man of the hour. He was not a fireman but an avid amateur out to prove the capability of the BQR on all classes of fire regardless of magnitude. With nothing on but T-Shirt soaked with Cold Fire (to ward off the blazing heat) and absolute faith on the infallibility of Cold Fire, he held his time for the fire to blaze up to fully developed stage. As flames hurled and smoke rolled and billowed, he launched his attack single-handedly with great guns in the face of danger, fighting heat off with Cold Fire's wide fog pattern to cool down the raging inferno, then with giant stride pressed on with solid streams of Cold Fire at the seat of the fire for the coup de grace, flat out in 2 minutes with only 80 gallons of water. His cool and easy handling of a crucial situation earned everybody's admiration.

HI-TECH VENTURES PRESIDENT-CEO, BEN FERNANDEZ, explains Cold Fire is a world of difference: it has the monopoly on all classes of fire, with absolute suppression regardless of magnitude. He likened COLD FIRE to ALADDIN'S cave, with a great wealth of advantages in the Protection of Life, Property and the Environment; expounded on COLD FIRE's ability to inhibit flame and smoke propagation, avert spread of fire and conflagration, and dissipate carbon emissions and heat reduces risks of firefighters and trapped victims from suffocation, heat and burns; and mitigate life and property losses in high risk/high value setting; then doused his left arm with a film of Cold Fire, aimed a 6,000 degree F. propane torch at it to prove its inherent thermal protective quality protects from heat and burns. *HE ASSERTS THE ONLY ALTERNATIVE TO COLD FIRE IS COLD FIRE!*

HI·TECH VENTURES

March 3, 2009

Eveline Giessler, President
Firefreeze Worldwide
272 Rt. 46
Rockaway, NJ 07866

Dear Eveline:

Through the past ten years, Hi-Tech Ventures has been proud to be the distributor of Cold Fire in the Philippines. As you know, Cold Fire's performance here has caused it to become the official fire suppressant of our national Bureau of Fire Protection. In particular, I wanted to share with you this recent account of Cold Fire in action.

"The fifth alarm fire was responded by almost thirty five (35) units of firetrucks, both from government and Filipino-Chinese volunteer fire brigades. Almost thirty (30) containers of AFFF Chemicals borrowed from a local volunteer brigade were used, but to no avail. Fortunately, a newly delivered ten (10) containers of "Cold Fire" coolant chemical were mixed with water tanker of our firetruck and once again proved its suppressive effect as the fire immediately subsided and spared the adjacent industrial as well as populated residential structures and it took less than an hour to control the blaze and finally declared fire out a few minutes after. Amazingly, the water treated chemical inside the water tanker was not totally consumed and gallons of water were saved. Furthermore, our gallant firefighters managed to penetrate inside as the chemical coolant dramatically decreased the heat intensity and that they were able to control the blaze in the shortest possible time".

Eveline, I simply could not have commented better about our customers experience with Cold Fire than the heroic fire fighters themselves. Time and again, Cold Fire has proven the life saving and property preserving product it claims to be. As Juergen always said "Seeing is Believing"!

Mabuhay and more power!

Benjamin H. Fernandez, President

37 Francisco Reyes St., Executive Village (GAHA),
Las Pinas City, Philippines, 1747
Telephone number 632-517-2638

REPRESENTING
ALEX SINK
CHIEF FINANCIAL OFFICER
STATE OF FLORIDA

FILED
MAY 1 1 2009
Docketed by

In The Matter Of:

COLD FIRE LAW ENFORCEMENT
FLORIDA, LLC,

Case No.: 103050-09-FM

Petition for Declaratory Statement to the
Florida Department of Financial Services.
_____/

DECLARATORY STATEMENT

THIS CAUSE came on for consideration upon the Petition for Declaratory Statement (hereinafter "Petition") from Cold Fire Law Enforcement Florida, LLC, (hereinafter "Petitioner"), received by the Department of Financial Services, Division of State Fire Marshal (hereinafter the "Department"), on or about March 3, 2009. Upon consideration thereof, and being duly advised, the Chief Financial Officer, as State Fire Marshal, finds as follows:

1. The Chief Financial Officer, as State Fire Marshal, has jurisdiction over the subject matter and the party to this matter.

2. This Declaratory Statement is premised upon the assertions of fact set forth in the Petition. Any modification to those assertions of fact could alter the conclusions set forth in this Declaratory Statement. None of the assertions of fact are admitted by the Department as being true and Petitioner's questions are being answered as purely hypothetical. If any of the facts asserted by the Petitioner are untrue or materially incomplete, the conclusions of this Declaratory Statement could be significantly different.

3. If the Petition contains various legal assertions, conclusions, and arguments, those assertions, conclusions, and arguments are not adopted by the Department and are not used as legal premises or authority for the conclusions of this Declaratory Statement. Legal assertions, conclusions, and arguments are considered only to illustrate the manner in which Petitioner may be an affected person entitled to have the Department issue this Declaratory Statement.

BACKGROUND AND FACTS ASSERTED

4. The Declaratory Statement was requested pursuant to the provisions of Sections 120.565 and 633.01(6), *Florida Statutes*, and Rules 28.105, and 69A-60.007, *Florida Administrative Code*, which authorize a substantially affected person to seek a declaratory statement regarding an agency's opinion as to the applicability of a statutory or rule provision as it applies to the Petitioner's particular set of circumstances.

5. The Petitioner sells a suppression product called Cold Fire.

6. The subject of the Petition is whether Chapter 633, *Florida Statutes*, requires the Petitioner to be licensed to sell the product.

7. According to Petitioner, the product is UL approved, 2N75 approved, and NFPA 13 and 18 approved. The company distributes the product in bulk form or by request in a UL approved 1.5 gallon or 2.5 gallon water can. The product requires no special training or expertise to use and the solution can be used in the water can and then charged with a compressor.

8. By request from various entities, Petitioner will fill the units at the factory with the product in order to help save them time.

9. According to Petitioner, they do not install, inspect or repair any fire extinguishers; they only sell the product which is designed to augment the systems already in use by the departments and does not replace them.

10. Receipt of the Petition herein was published in Volume 35, Number 12 of the *Florida Administrative Weekly,* on March 27, 2009.

QUESTIONS

11. The Petition poses the following question: Does the Petitioner need a dealer's license to sell the Cold Fire suppression product previously described in bulk form or in a UL approved 1.5 gallon or 2.5 gallon water can?

DISCUSSION

12. The Department has authority pursuant to Section 120.565, *Florida Statutes*, to issue declaratory statements, and is required by the provisions of Section 633.01(6), *Florida Statutes*, to issue Declaratory Statements relating to the Code, when requested by a substantially affected person or a local enforcing agency.

13. Section 633.061(1), *Florida Statutes*, provides as follows:

> It is unlawful for any organization or individual to engage in the business of servicing, repairing, recharging, testing, marking, inspecting, installing, or hydrotesting any fire extinguisher or preengineered system in this state except in conformity with the provisions of this chapter. Each organization or individual that engages in such activity must possess a valid and subsisting license issued by the State Fire Marshal. . .

14. The term "fire extinguisher" is defined at Section 633.021(7), *Florida Statutes*, as:

> a cylinder that:
> (a) Is portable and can be carried or is on wheels.
> (b) Is manually operated.
> (c) May use a variety of extinguishing agents that are expelled under pressure.
> (d) Is rechargeable or nonrechargeable.
> (e) Is installed, serviced, repaired, recharged, inspected, and hydrotested according to applicable procedures of the manufacturer, standards of the National Fire Protection Association, and the Code of Federal Regulations.
> (f) Is listed by a nationally recognized testing laboratory.

15. The term "preengineered system" is defined at Section 633.021(21), *Florida Statutes*, as:

> A fire suppression system which:

(a) Uses any of a variety of extinguishing agents.
(b) Is designed to protect specific hazards.
(c) Must be installed according to pretested limitations and configurations specified by the manufacturer and applicable National Fire Protection Association (NFPA) standards.
(d) Must be installed using components specified by the manufacturer or components that are listed as equal parts by a nationally recognized testing laboratory such as Underwriters Laboratories, Inc., or Factory Mutual Laboratories, Inc.
(e) Must be listed by a nationally recognized testing laboratory.
Preengineered systems may incorporate special nozzles, flow rates, methods of application, pressurization levels, and quantities of agents designed by the manufacturer for specific hazards.

16. The term "fire suppression system" is not defined in Chapter 633.021, *Florida Statutes*, or Rule 69A-21, *Florida Administrative Code*.

17. Pursuant Section 633.065(1)b), *Florida Statutes*, fire extinguishers and preengineered fire suppression systems supplied for new installation must be "listed by a nationally recognized testing laboratory, such as Underwriters Laboratories, Inc., or Factory Mutual Laboratories, Inc." In addition, Section 633.065(1)(c) through (e), *Florida Statutes*, requires that:

> Equipment shall be installed in accordance with the applicable standards of the National Fire Protection Association and the manufacturer's drawings and specifications.
>
> Each piece of equipment supplied shall be guaranteed for a period of 1 year against defects in material or operation.
>
> The fire equipment dealer shall furnish the consumer with: the manufacturer's descriptive literature, including the specifications and maintenance requirements as approved by the nationally recognized testing laboratory; the operating instructions for all equipment installed; the mechanical drawings and specifications for proper installation and use of equipment; and a diagram of the final installation, if applicable.

NOW, THEREFORE, in accordance with the foregoing, and the statutes and rules cited therein, it is hereby declared that:

1. Petitioner is a substantially affected person entitled to the issuance of this Declaratory Statement.

2. Question: Does the Petitioner need a dealer's license to sell the product in bulk form or in a UL approved 1.5 gallon or 2.5 gallon water can?

Answer: No. The product is not a fire extinguisher or a preengineered system. Furthermore, the sale of a fire extinguisher or preengineered fire suppression system does not require a license. However, when the product is sold installed in a fire extinguisher or another preengineered system, it must meet all of the requirements of Section 633.065, *Florida Statutes*, and may be installed, recharged, serviced, repaired, tested, marked, inspected and hydrotested only by dealer licensed by the Department in accordance with Section 633.061, *Florida Statutes*.

NOTICE OF RIGHTS

Any party to these proceedings adversely affected by this Declaratory Statement is entitled to seek review of this Declaratory Statement pursuant to Rule 9.110, *Florida Rules of Appellate Procedure*. Review proceedings must be instituted by filing a petition or notice of appeal with Tracey Beal, Agency Clerk, Florida Department of Financial Services, 200 E. Gaines Street, Tallahassee, Florida, 32399-0390,and a copy of the same with the appropriate district court of appeal, within thirty days of rendition of this Declaratory Statement.

ENTERED in the City of Tallahassee, Leon County, Florida, on 11 day of May 2009.

Brian London
Deputy Chief Financial Officer

Mahugh Fire & Safety

--Accurate Fire Systems--

P.O. Box 5013

Kalispell, Montana 59903-5013

Phone: 406-752-0163

e-mail: mahughfire@centurytel.net

Street Address: 1737 Hwy 35

November 8, 2011

RE: ColdFire Experience

My initial exposure to ColdFire was in the early 2000's. I served (and continue to do so) on an Incident Management Team during the large fires in NW Montana in 2001, 2003 and 2007 as well as other wildfire events since that time. My greatest experience came in 2003 on the Wedge Fire as well as on other fires that same year. During that time we used ColdFire in a number of applications ranging from direct fire suppression to structure and vegetation pre-treatment to wood bridge protection. It was found in our pre-treatment efforts that ColdFire played a key role in both vegetation and structure protection—it was evident that in pretreated fuels that fire "stopped" when it reached that pre-treated vegetation. We also showed non-charring of structures which were subjected to flame encroachment when they were treated with ColdFire.

We have also used two different gel products in our structural protection efforts. While these too have shown their ability to protect structures we found the application to be very onerous and clean-up following a fire's passage to be time consuming—while "re-misting" sounds good it seldom happens when a fire front approaches. We also experienced plugged nozzles and hoses when using these products.

There were several advantages we found in using the ColdFire product. These ranged from simplicity of application to ease of clean-up to longer term protection as compared to the gel products. That coupled with the no negative impacts to the environment led to results of a true win / win situation. With the low foaming aspects of ColdFire and the surfactant properties it shows we have a very high level of confidence in the product. There are no storage concerns as experienced with most of the gel products and mixing ratios are simple and straightforward. Batch mixing is very common with no adverse effects to pumps and equipment.

Since those experiences I have elected to sell the ColdFire product through my business. We only sell those products that are tried and tested and that show proven performance. We have sold to many Fire Departments as well as to the general public who appreciate the ease of use and the performance of the product.

I can be contacted at 406-752-0163 and would be happy to answer questions at to my experience with ColdFire.

Respectively,

Gary Mahugh

Gary Mahugh

Cold Fire Canada Ltd.

November 11, 2011

Eveline Giessler & Ray Giessler
FireFreeze Worldwide, Inc.
272 Route 46
Rockaway, NJ 07866

Dear Eveline & Ray,

The purpose of this letter is to bring you up to date on the deployment of Cold Fire in Canada. We are finding that everyday fire, law enforcement, industrial and retail customers are benefitting from the use of Cold Fire. In the past six months Cold Fire has been credited in saving a police officer in Ottawa from a life threatening injury. In another case, at the Vancouver International Airport, Cold Fire was credited for the immediate extinguishment of a plane crash with nine people on board.

As our education to fire professionals increases it becomes very apparent that fire officials see the benefit of an all-natural, environmentally friendly fire suppressant that is amazingly effective for all classes of fires. Of particular note are the departments that have interface responsibility, and Cold Fire's ability to attack wild land fires.

Our difficulty with Cold Fire's success is that we have more and more agencies wanting to use it, but need specific authorization bodies to sanction it. Specifically, BC Ferries Corporation want to use Cold Fire but need Transport Canada's approval.

The other major area where Cold Fire is seen as a dramatic improvement in fire suppression is forest fires. We have several agencies including the Alberta Government waiting for Cold Fire to be reaffirmed onto the USDA QPL. There has been a decree by Environment Canada ending the use of AFFF by May of 2013, and it is imperative that the industry have an environmentally friendly and effective replacement before then. The fact that we can add colour to Cold Fire for forest fire use is also very attractive to these agencies.

Here are but a few comments from some of our clients:

"After equipping my officers with Cold Fire five years ago, the many benefits of the product became obvious. Cold Fire added an unprecedented level of confidence for first responders when attending emergency situations where fire was involved. I believe strong leadership in deploying Cold Fire will protect officers and the community, and it also has the potential to save lives in an environmentally safe manner. Cold Fire, an alternative to traditional fire suppressants, is a leading age product whose time to shine has come." - Chief of Police & Superintendent RCMP (ret) Ward Clapham

www.coldfirecanada.com | 983 Parker Street, White Rock, BC V4B 4R5
Vancouver/Lower Mainland: 778-294-1000 | Toll Free: 1-855-888-COLD (2653)

"Quick story about tonight's training exercises. A portion of the scenario involved the throwing of Molotov cocktails. One of our officers accidently tripped and fell into gas that simultaneously ignited. My officer became fully engulfed in flames; our FSU along with several officers on the line jumped into action and had him out in seconds with Cold Fire. It saved this officer's bacon ... very impressed." - Sgt Rob Bernier, Ottawa Police Service, Emergency Services Unit Coordinator

"Cold Fire is the future of fire suppression, giving trained personnel offensive options not previously considered. Re-equipping the suppression tool box with a combination of firefighter safety and offensive tactics allows attack teams a new level of confidence, with the adaptability to almost every fire emergency." - Deputy Chief Bob Simpson Nanaimo Fire & Rescue

In a recent event this summer, Richmond Fire & Rescue arrived at a blueberry farm where a large stack of tires had caught fire in an environmentally sensitive bog. Cold Fire extinguished the tires and underground bog fire in minutes with a minimal amount of water and Cold Fire. This resulted in little runoff of toxins from the tires into the bog, and the result was considered substantial compared to the suppressants previously used.

In short we are seeing significant success with agencies using Cold Fire, and know we can make huge health and safety improvements in industries currently needing specific approvals. I encourage you, along with our efforts, to continue seeking approvals vital to getting Cold Fire into these markets that desperately need it.

Yours sincerely,

Grant Pearson

Grant Pearson
President
Cold Fire Canada Ltd.

October 5th, 2011
San Pedro Garza Garcia, N.L., Mexico

Firefreeze Worldwide, Inc.,

Over the 13 years that we have been representing the product Cold Fire in Mexico, we've been very satisfied of the performance and acceptance of the product by various entities in Mexico. Since it has been used in defferent types of fires: surface fires, ground fires, and crown fires, with excellent results.

Some of the many benefits of Colf Fire that we have noted are the following:

1. Rapid cooling effect on the affected area.
2. Avoids reignition where it has been applied.
3. Acts as a retardant in the line of fire.
4. Considerable savings on water consumption.
5. Excellent penetration in ground fires.
6. No allergic reactions among users.
7. Great versatility for use in various fire fighting equipments, such as bambi buckets, backpacks, airtankers, fire engines, etc.
8. No harm done to flora and fauna.
9. Has demonstrated to save the lives of people.

We have received by military and civilian agencies, several testimonials and recognition awards for saving lives.

Conclusion
We are very happy and pleased to have Cold Fire in Mexico, as it gives us the security and protection that we need.

Sincerely,

RUMA GROUP INC. S.A. DE C.V.
Aldama # 45 Col. Emiliano Zapata
Monterrey, N.L. CP 64610
Tels. 83-11-32-47 & 83-73-46-61
RGI-980817-K98

Francisco Antonio Ruiz A.
DIRECTOR
COLD FIRE MEXICO

Miami-Dade Fire Rescue Department
Office of The Fire Marshal
Fire Prevention Division
9300 N.W. 41st Street
Doral, Florida 33178-2414
Tel 786-331-4800 ☆ Fax 786-331-4619

www.miamidade.gov

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Miami Shores
Miami Springs
North Bay Village
North Miami
North Miami Beach
Opa-locka
Palmetto Bay
Pinecrest
South Miami
Sunny Isles
Surfside
Sweetwater
Virginia Gardens
West Miami

February 23, 2010

Mr. Elliot Kahana
Cold Fire

VIA EMAIL: ekahana@tampabay.rr.com

Dear Mr. Kahana:

Thank you for the recent presentation and testing opportunity of your product, Cold Fire.

I, along with staff was dully impressed with the wide range of capability of this agent. As you know, I have recommended that our department's Research and Development Team fully assess the performance of Cold Fire for potential replacement of multiple agents used today.

I trust that a favorable outcome will result and I look forward to a successful partnership.

Sincerely,

Chief Manuel C. Mena, Fire Marshal
MDFR Fire Prevention

MCM:skr

c: Control File

Delivering Excellence Every Day

10 MCM 18 E KAHANA PRESENTATION.doc

ELLEN T. HANSON • CHIEF OF POLICE

LENEXA POLICE
KANSAS

12500 WEST 87TH STREET PARKWAY
LENEXA, KANSAS 66215
OFFICE • 913/477-7300
FAX • 913/477-7249

April 3, 2009

MEMO TO: Mr. Mike Payson

FROM: Chief Ellen T. Hanson

RE: Cold Fire

This memo serves to tell you how pleased we are with your product. From the initial research conducted by Officer Gardner, through actual deployment in the field, Cold Fire proves to be superior to other similar products.

We have had opportunities to use the extinguishers in automobile crashes and they perform exceptionally well, quickly putting out the flames and cooling the burning metal immediately. This is a great safety measure for responding officers as well as those they are attempting to save.

Thank you for great customer service and a product that delivers what you promised.

April 10, 2009

Firefreeze Worldwide
272 Rt. 46 East
Rockaway, NJ 07866
Attn: Eveline Giessler, President

Dear Ms. Giessler:

As you know, our Fire Department has been using Cold Fire for more than 10 years now with remarkable results.

Over the years, I have personally experienced a number of situations where Cold Fire spelled the difference between a minor incident and a major conflagration. Its know down power is unsurpassed, and all of our men comment on how little water is need to quench major blazes, which is always a significant concern here in a somewhat rural area. In addition, the cooling effect of Cold Fire allows us to be more aggressive in our firefighting operations, allowing us to penetrate further in to the seat of a blaze and allowing us to extinguish it more quickly. Finally, Cold Fire's penetrating effect is particularly helpful in deep seated fires in our adjacent pineland wild fires, a major concern in hot dry weather.

I can say without hesitation we have found no equal to Cold Fire, and would highly recommend it to any of our fellow firefighters.

Sincerely,

Captain Gregory DeForge

Tuckerton Fire Co. #1
111 North Green Street, Tuckerton, NJ 08087-2856
609.296.4546
www.tuckertonfire.com

Race Car Club of America

166 ELM STREET, NEW ROCHELLE, NY 10805-2011 (914) 576-RCCA

April 11, 1997

To Whom It May Concern:

This letter is to let you know that the Race Car Club of America, a Formula car race club, uses ***COLDFIRE*** as an onboard fire system in our race cars, and our Safety Crew uses them trackside for fire prevention. We are very pleased with this product.

Yours for the Sport,

A. J. Pugliese
CEO and President

N.E. METRO ZONE RCCA

America's #1 Formula Car Club

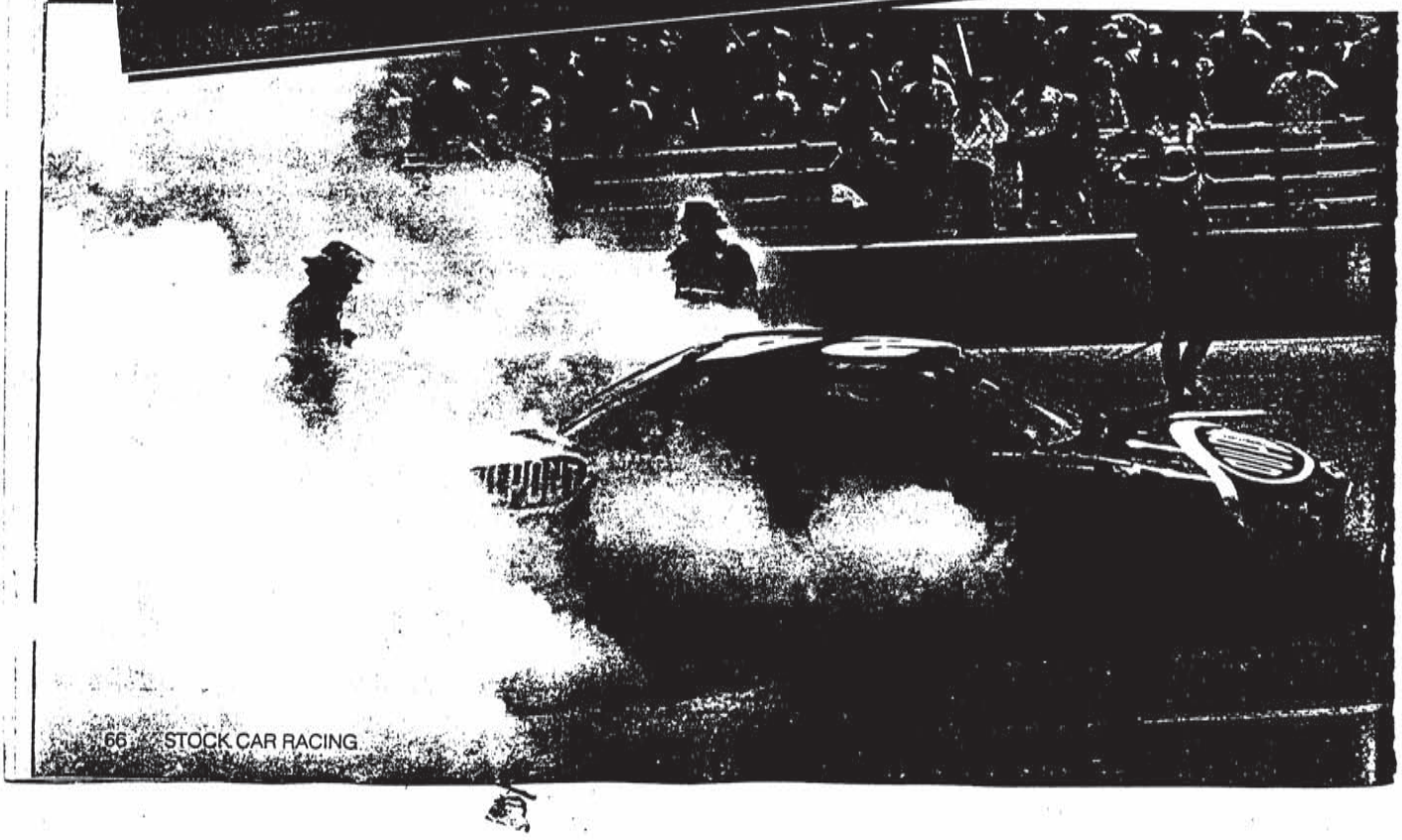
There's
ething
better
your
track.

Doug Gore

new foam fights race car fires

When a gasoline fire breaks out in a stock car it is imperative that it be extinguished as fast as possible. Here the fire crew is using dry chemical extinguishers that quickly knock down the flames but do little to cool off the hot metal and thus reduce the risk of re-ignition. (Vickie Haddock)

Several modern technologies, especially high-quality, fabric-reinforced fuel cells, have reduced the possibility of fires following wrecks. Other advanced fire-resistant materials have dramatically improved driver protection should a fire



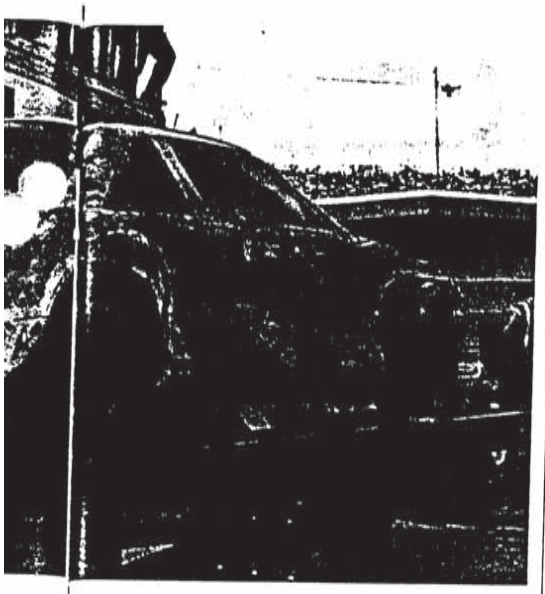
If the fire is not extinguished rapidly, results to the car are devastating, and the injuries to the driver can be worse. Joe Nemechek was lucky in this one that occurred at Daytona—lucky enough to become the Busch Series champion by the end of the season that began with this very fire. (Rob Sneddon)

occur. Now, new fire-fighting agents are helping safety workers do their jobs more effectively.

Because race car fires often present firefighters with several simultaneous problems, no single fire-fighting agent has been completely effective. To understand why, a little background about fires is helpful.

Fire releases a large amount of heat as well as various combustion products, usually carbon dioxide, water, and particulates such as smoke and soot. The combustion can occur slowly and at a moderate temperature (less than 1000°C) in which case the fire is said to be smoldering, or it can occur rapidly

New fire-fighting agents and chemicals are improving the ability of firefighters to do their jobs.



and at a high temperature (greater than 1300°C), in which case it is flaming combustion.

Flaming combustion reactions are very complex, and not completely understood, but it is safe to say that they occur between fuels that have been turned into a gas by heat and oxygen. Most people know liquid gasoline doesn't burn—gasoline vaporized by heat does. The flaming combustion of paper, wood, plastic, and rubber tires also involves the burning of otherwise-solid materials that have been vaporized by heat.

Fires require a fuel, oxygen (air), and sufficient heat to keep the fuel and air at a temperature high enough to sustain the chemical reactions of the fire. Removing any of these elements will extinguish the fire. Adding specific chemicals to the flames can also suppress the fire by reducing flame propagation.

Water is by far the most common fire-fighting agent. It effectively removes huge amounts of heat from a fire by evaporation (boiling), and it can separate fuel from air if enough is available. Carbon dioxide also removes heat from a fire, but its greater effect is to separate fuel from the surrounding air by displacing the air.

Dry chemicals also attack fires in several ways simultaneously. They absorb heat from the fire through chemical reactions, often separate fuel from the air, and they also produce other chemical reactions that inhibit flame propagation.

So which fire-fighting agent works best? Most race car fires are "Class B" fires since they involve flammable liquids, usually gasoline, oil, and/or methyl alcohol. They may also involve solid fuels such as plastics and rubber that

Cold Fire is so effective, it has been adopted by the Indy Racing League as *the* fire-fighting agent. It has been used at the Indianapolis Motor Speedway since 1994.

are involved in "Class A" fires, and occasionally "Class C" fires that are electrically energized.

Gasoline and oil race car fires have traditionally been fought with carbon dioxide and/or dry chemical extinguishers. Water has also been used, although it's far more commonly used on passenger-car fires. Since gasoline floats on water without mixing with it, a *lot* of water is required to extinguish a 22-gallon gasoline fire.

Methanol-fueled race car fires can also be fought with carbon dioxide and/or dry chemical extinguishers, but water works rather well, especially if the fire is not well established. This is partly due to the fact that water and alcohol mix nicely, thus diluting and cooling the alcohol. (For more information, see "How to Fight Alcohol Fires," September 1992 *Open Wheel* magazine.)

The fire-fighting effectiveness of water on both Class A and Class B fires is greatly enhanced by adding small amounts of certain chemicals. Wetting agents such as soaps and surfactants foam the water and allow it to better penetrate burning materials. Many fire departments now use a Class A foam when fighting wood-structure fires and brush fires because it significantly reduces the amount of water required.

For almost 90 years, entirely different types of foaming additives have been used with water for fighting fuel fires. The foams originally required a gentle application over the surface of the burning fuel, where they covered the liquid without mixing with it.

Cold Fire 302 is a new foaming agent that is effective on both gasoline and alcohol fires as well as Class A fires. Notice the special foaming nozzle on this pressurized water extinguisher. The purple K dry chemical extinguisher in this photo is also effective on gas and alcohol fires, but not Class A fires. However, it will not remove very much heat from the materials surrounding the fire, so re-ignition can be more likely to occur than when water or foam are used. (Robin Hartford)

The difficulty of gently applying the foam to a large fire led to the development of foams that could be applied more aggressively with heavy streams of water. These additives, known as Film Forming Fluoroproteins, or triple-F foams, have been an industry standard for fighting large fuel tank fires as well as ship and aircraft fires for around 30 years. More recently, improved film-forming foaming agents have been developed for fighting petroleum fires.

Foams developed for fighting Class B fires function a little differently than those for Class A fires, which are primarily wetting agents that facilitate water's ability to absorb heat. Modern Class B foams are intended to form a thin layer of water bubbles on the surface of the fuel; the floating foam layer then separates fuel from the air. The water contained in additional quantities of foam cool the hot fuel and the surrounding materials.

Most Class B foaming agents work extremely well, but they have serious limitations. For example, they do not work on alcohol fires. For those, a different, alcohol-resistant/polar solvent-type of foaming agent has been required until very recently. That means if a track raced both gasoline-fueled stock cars and alcohol-fueled sprint cars, or perhaps a dirt late model division in which some ran gas and others ran alcohol, they needed different foaming agents. Obviously this was not practical, so many tracks elected to use less effective fire-fighting agents that were more universal.

The fuel-specific limitations of foaming agents was recently overcome by the development of a new agent called Cold Fire 302 by its inventor, Juergen Giessler, the president of FireFreeze Worldwide, Inc. This foaming agent is UL listed for both Class A & B fires including alcohol fires, and is totally environmentally safe.

Like other foaming agents, Cold Fire is mixed with water in a concentration of 1% to 6% depending upon the application, but its application is then universal. The product combines wetting agents with foaming agents to enhance the natural ability of the water mixed with it to remove the heat from a fire. While water absorbs the bulk of the heat from a fire, Cold Fire greatly increases the effectiveness of a given quantity of water. Independent fire department tests show Cold Fire increases the effectiveness of water by as much as a factor of four when fighting a fuel fire.

The product is sold in bulk for fire-department use, and is also available in smaller quantities for adding to the water in common 2½ gallon pressurized water fire extinguishers that are sometimes borrowed from hotels.

Cold Fire is so effective, it has been adopted by the Indy Racing League as *the* fire-fighting agent. It has been used at the Indianapolis Motor Speedway since 1994.

This foaming agent appears to be a hot new product for taking the heat of race car fires. If you are involved with track safety, or if you just want to improve the fire protection in your home or shop, contact the Cold Fire people at:

FireFreeze Worldwide, Inc.
270 Route 46
Rockaway, NJ 07866
201/672-0722

Speedway Fire Crew

2057 Huntington Dr.
Chico, Ca. 95928
(916) 893-4647
http://www.ecst.csuchico.edu/~sfc

Fire Freeze World Wide
ATTN. Mike
270 Route 46E
Rockaway, NJ. 07866

On behalf of auto racers in California, we wish to thank you for your recent donation. As you know, several weeks ago we volunteered to work a monster truck race in Red Bluff, CA. Grave Digger, the star of the show, exploded into a ball of flames after he made a jump. If it had not been for Cold Fire, he might have sustained much worse injuries than he did. The promoter of the event, and several thousand spectators seemed amazed at how rapidly we were able to extinguish such a huge alcohol fire. We received a standing ovation as we drove the fire truck back to the staging area. Once again thank you for helping us save lives.

We have already had to use one of the five gallon buckets of Cold Fire you recently sent us. Two sprint cars got together, and both went flipping off of the track. One of the cars went through the chainlink fencing and landed in an adjacent field. The car instantly caught the tall grass on fire, but we were quickly on the scene to put out both the car and the field.

We also continue to amaze people with the versatility of the spray cans of Cold Fire. The cans put out fires so quickly we rarely empty the whole can. It is amazing though, that those little cans do as much as they do.

In short, thank you for your sponsorship of our crew. It gives us more confidence in our work knowing that we have a product like Cord Fire.

Thanks again Mike, for all of your continued help.

Thank you,

Dan Gerths
Speedway Fire Crew

To: Clay Morse

From: Jim Hinkel

Date: April 17, 1997

Re: Cold Fire

Thank you for the co-operation that you have given me in the use of Cold Fire at Nazareth Speedway. As we discused at the track we will be using Cold Fire in all our P/W exinguishers (20) in the Pits, Grandstands and on the Fire Trucks.

I'm extremely pleased with the product and look forward to working with you and using your product, Cold Fire.

James W. Hinkel, Jr.

James W Hinkel Jr

Fire Director

Nazareth Speedway

P.O. Drawer F • Highway 191 • Nazareth, PA 18064 • (215) 759-8000 • FAX: (215) 759-9055

Watkins Glen International

Inter-Office Memo

TO: **Clay Morse**

FROM: Ernie Thurston

DATE: 3/20/97

RE: ***Cold Fire***

Thank you for the cooperation that you have given me in the use of COLD FIRE at Watkins Glen International.

As we discussed, we will be using COLD FIRE in all of our pressurized water extinguishers (30) on the pit lane and also on our two mini-pumpers by induction.

I am extremely pleased with the product and look forward to working with you and using your COLD FIRE product.

Ernie Thurston
Dir. of Race Operations
Watkins Glen International

Holbrook Volunteer Fire Department

390 Terry Boulevard Holbrook, NY 11741

(516) 588-0099 Emergency Hotline: (516) 588-1118

Michael J. Timo
1st Assistant Chief

Ronald Schnall
Chief

Brian V. Harvey Jr.
2nd Assistant Chief

Stephanie E. Giessler, V.P.
Fire Freeze World Wide
270 Route 46
East Rockaway, NJ 07866

December 16, 1997

Dear Ms. Giessler,

I wanted to take the time to commend you on your product "COLD FIRE". In my 27 years of fire fighting, no fire-fighting product has impressed me as much as yours. Cold Fire lives up to, if not exceeds, all that was advertised.

As Chief of the Holbrook Fire Department, I have used Cold Fire in my portable water extinguisher. My first experience using Cold Fire was at a brush fire approximately 100 ft. in diameter. Using my extinguisher with Cold Fire, I was able to knock the fire and control any further burn until the remainder of our response was on scene. Usually, the fire would have continued to burn out of control. My second experience was at the scene of a car fire; the car, a 1990 Cadillac had major fire in the engine and passenger compartments. With the Cold Fire extinguisher, I was able to put out the fire before our first due engine was on scene. My engine crew was amazed about how quick the fire was put out, and the ease to perform overhaul with practically no heat at all coming from the car. The owner of the car was also very appreciative that the fire was extinguished and had not spread to the trunk compartment with very little water damage.

I feel that Cold Fire will definitely improve our fire fighting and reduce injuries to our members. This is a product that we will be using more and more in the future.

If you have any questions, please feel free to call me at 516-588-0099.

Sincerely,
Ronald Schnall
Ronald Schnall
Chief of the Department
Holbrook Fire Department

Municipality of Monticello
FIRE DEPARTMENT

8-10 Pleasant Street
Monticello, N.Y. 12701

Luke Semmelrock

Dec. 17, 1997

Re: Cold Fire

Vince Price, Chief
Monticello Fire Department

"I have personally used Cold Fire and seen it demonstrated numerous times; and I would highly recommend this product to any Fire Department."

Thank you,

Vince Price
Chief MFD

The City of
HOLYOKE
Massachusetts 01040

MUNICIPAL OFFICE BUILDING
PHONE (413) 534-2250
FAX (413) 534-2247

FIRE DEPARTMENT HEADQUARTERS
206 MAPLE STREET, HOLYOKE, MA 01040

DAVID A. LaFOND
CHIEF OF THE DEPARTMENT

February 14, 1996

Mr. Jargen Geissler
Firefreeze Worldwide Inc.
270 Rt. 46 East
Rockaway, New Jersey 07866

Dear Mr. Geissler,

I am writing to you to express my thoughts on your product, Cold Fire. Our Fire Department which has 141 men and women, has been using Cold Fire for the last month or so.

We, at first, experimented with it on different types of fires. Some small ones and also a very large one. It proved to be extremely effective.

We then placed a 1.25% solution in the water tanks on our five engine companies, so we could see what it would do on active structure fires. The Cold Fire has been working great. It has been eliminating the usual heat that we encounter which in one case, prevented serious injury, to a person who had to be rescued by ground ladder.

Another fire I am told by one of our Officers, felt like it was going to flashover, and when the Cold Fire was applied, all the heat was gone, just like that.

We have been using less water on these fires which has kept additional water damage to a minimum and more importantly, fire extension has greatly been reduced.

There has been other cases of success with Cold Fire that I would be happy to discuss with you if you so desire. Feel free to contact me with any of your questions.

Sincerely,

David A. LaFond
Chief of the Department

DAL\dtg

BIRTHPLACE OF VOLLEYBALL • HOLYOKE, MASSACHUSETTS, U.S.A. 1895

ROCKAWAY

Profiting from Grandfather's Ideas

by Diana G. Lasseter

FireFreeze Worldwide expects 1997 to warm up with extinguishers.

Juergen Giessler is one of the few CEOs in New Jersey who sets fires in the middle of his office floor and lights a torch to his forearm. Most executives try meditation to manage stress, right? Actually, Giessler is not lighting fires to ease his anxiety. He's demonstrating a product that he hopes will help catapult his company's annual sales to more than $10 million in 1997.

Publications like *Business Week* have been buzzing about Giessler's company, FireFreeze Worldwide, and its organically based product known as Cold Fire, which is already used by 90% of the U.S. motor-racing industry. Made from waxes of several plants, Cold Fire not only extinguishes fire, it coats flammable materials so they can't release vapors that would ignite. It also rapidly lowers temperatures to below the flash point of the flammable material.

Cold Fire has been used in bulk by firefighters since 1994. Giessler, however, is expecting a jump in sales when Cold Fire extinguishers go on the consumer market early next year, pending regulatory approval. Much of the firefighting industry is already convinced of the product's value. Emerson Fire Chief Joseph Mara's battalion started buying 5-gal. pails of Cold Fire in June. Shortly after first mixing Cold Fire with the water on its trucks, the Emerson fire department responded to a raging basement blaze. "We put the fire out with 250 gal. of water," recalls Mara. "The inspector said we shouldn't have been able to do that. Cold Fire works very well. It takes the heat and the smoke away from a fire. There's never been anything quite like it." Cold Fire's organic base also satisfies strict environmental requirements.

Seated in his Spartan office, Giessler gushes in a German accent about his company's prospects and how far he has come. He immigrated from Germany in 1956 and started his own construction business, which he ran until the state's construction industry soured in 1990. He then traveled to Kuwait after the Gulf War as an explosives expert, where he saw the damage wrought by oil-well fires. He came home to Rockaway in 1991 to develop Cold Fire and to start a new venture.

But Cold Fire is not FireFreeze Worldwide's only product. As he lights a third cigarette, Giessler announces, "Now I really have something exciting to tell you." FireFreeze Worldwide's biggest-selling product is called Odor Seal. Tested for five years, Odor Seal went on the market a year ago. It has a number of applications including stopping strong odors, treating skin diseases, biodegrading bacteria and eliminating mites on farm animals. The Port Authority of New York and New Jersey uses Odor Seal as a disinfectant. The product was just approved for agricultural, industrial and commercial applications in Brazil, primarily to help stop the spread of salmonella in chicken. Odor Seal has been approved for various uses in 22 countries. Giessler shows photos of people he has visited in South America who suffer from Jungle Rot and the Ebola virus, and cows in Brazil afflicted with painful worms. "Our product helps all of these conditions," he explains. "We do 90% of our business overseas. It took four years and $2.5 million before we made even 10¢. Now it's paying off."

HOT STUFF: Giessler shows a can of Cold Fire

Odor Seal and Cold Fire are derived from the same secret Giessler family recipe. The extracts for FireFreeze Worldwide's plant-based products, which are now made in Hamburg, Germany and exported to New Jersey for reblending and packaging, were first developed in Leipzig, Germany in the 1930s. Giessler's grandfather Adolph sought ways to protect the silos on his farm from fire. He recorded pages of effective plant-based formulations. "My grandfather was extremely smart," says Giessler. "He worked to make everything he owned perfect." Adolph's documents yellowed in the family attic for years, but when Giessler returned to New Jersey from Kuwait in 1991, he took another look. The first product was developed a year later.

Today Giessler and his partner, Michael Trulby, travel to countries like China and Saudi Arabia to explore uses for their environmentally sound compounds. Strict regulations have made it tough for the company to get approvals in the U.S. In fact, Giessler admits that he may never get the okay for certain medical applications. The products, though, show promise in overseas markets.

Giessler's son Eric joined the company in 1992, and his daughter Stephanie came on a year later. Both college business majors, they are working to improve FireFreeze Worldwide's packaging and marketing. The company has 60 employees and offices in Brazil, Germany and China. It is building a factory in Naples, Florida that will open for exporting next September.

To business people like Frank Scarraggi, who is private labeling some of FireFreeze Worldwide's ingredients through his company Numar Technology in East Hanover, the possibilities seem endless. Numar plans to sell an insect repellent and a cleaning agent derived from Firefreeze formulations. Says he: "Juergen's extracts can be used as ingredients in many products to make them better and safer. As we get through the regulatory processes, this company is going to explode." ◆

Developments to Watch

EDITED BY PETER COY

'THIS IS JOE BLOW-DRY, LIVE FROM MARS'

EVANS & SUTHERLAND COMputer Corp. has lowered the cost of sending your local newscaster to, say, the bottom of the ocean. Its system inserts real people into virtual settings on live TV. Unlike simpler systems that create only backdrops, this one immerses the person inside the computer-generated scene, with virtual objects appearing in both the foreground and background. An overhead camera tracks the person's movements, calculating which objects should be in front and which behind.

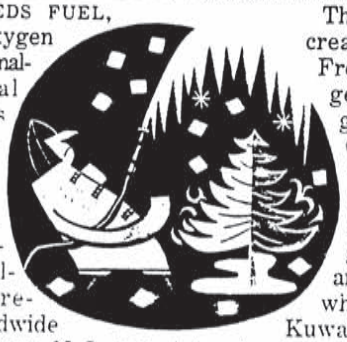
The newscaster, game-show host, or corporate trainer stands in front of a blue-matte screen. The blue is subtracted from the image and replaced with a computer-generated scene. Since it's mainly for live TV, the merging of real and pretend must be nearly instantaneous. Each new frame is composed in under 1/30th of a second, the time between frames in television.

Such high-end systems can cost $500,000 and up. Salt Lake City-based E&S says it cut the price by assembling all the components itself and putting its graphics processor into a Windows NT workstation instead of a costlier Unix-based machine. The MindSet 100 Virtual Set starts at $99,500. □

PHOTOGRAPH COURTESY OF EVANS & SUTHERLAND COMP. REPRODUCED BY CHRISTINE

FIGHTING FIRE WITH... VEGGIES?

FIRE NEEDS FUEL, at, and oxygen o burn. Normaly, chemical extinguishers work by displacing the oxygen. But a vegetable-based compound developed by Fire-Freeze Worldwide Inc. in Rockaway, N. J., neutralizes the fuel source and heat instead.



FireFreeze's product, Cold Fire, is made from waxes of several plants, which it won't identify for competitive reasons. When mixed with water, Cold Fire produces a foam that penetrates flammable materials, coating them so they can't release vapors that would burn. Cold Fire can be sprayed onto fires or used preventively to coat objects or people. The foam also rapidly lowers temperatures elow the flash point of the mable material.

Used by firefighters since 94, Cold Fire extinguishers are scheduled to go on the consumer market early next year, pending regulatory approval. Because it does not use as much water as regular fire extinguishers, Cold Fire causes less water damage. It's nontoxic and biodegradable.

The process was created by Fire-Freeze CEO Juergen Geissler's grandfather in Germany in the 1930s to cope with silo fires. His grandson took an interest in it when he was in Kuwait destroying Iraqi mines and saw the damage wrought by oil-well fires. *Susan Jackson*

INNOVATIONS

■ In pursuit of a male contraceptive, scientists at North Shore University Hospital in Manhasset, N. Y., studied the heart drugs called calcium channel blockers, which are known to block sperm function. They have now discovered how the drugs do that. Their next step is to develop a calcium channel blocker that affects only sperm.

■ The Pentagon is giving U. S. forces in Bosnia five machines for translating Serbo-Croatian documents into English in the field. The U. S. Army Research Laboratory has loaded the Forward Area Language Converter with 49,000 Serbo-Croatian words.

■ Cornell University researchers say they can increase the amount of a cancer-fighting compound in milk by raising the amount of unsaturated fats—such as corn oil—in the cows' feed.

■ County Line Ltd. in Warrensville Heights, Ohio, sells a $100 device that talks trained rescuers through cardiopulmonary resuscitation and choking rescues. For beginners, a $60 home-learning kit consists of adult and infant mannequins, a video, a manual, and six lung bags, which inflate only when the rescuer uses proper technique.

POKING HOLES IN BACTERIA

BACTERIA SHOW A NASTY ability to develop resistance to drugs, leading companies to search for new antibiotics and new targets. One such target is a substance called lipid A, which is found in the outer membranes of many bacteria. Over the past decade, biochemist Christian R. H. Raetz, now at Duke University, has uncovered a complex 10-enzyme pathway that bacteria use to make the substance—and has shown that bugs lacking the proper enzymes quickly die. No one knows exactly why lipid A is necessary for growth, he says, "but without it, the outer surface [of the bacteria] becomes leaky."

Raetz's findings helped prompt a team of scientists at Merck & Co.—where Raetz worked until recently—to search for compounds that inhibit the enzymes needed to make lipid A, thus killing the bacteria. Now, in the Nov. 8 issue of *Science*, they report they've succeeded. They have made several related chemicals that block the second enzyme in the 10-step pathway. Two of the chemicals cured mice of a normally fatal infection. Because the chemicals can't yet get into all types of bacteria and safety tests lie ahead, "it's not something I'd advise buying Merck stock on," cautions Raetz. But the results offer hope for a new weapon in the never-ending battle against microbes. *John Carey*

FOR FURTHER INFORMATION: Go to Business Week Online at America Online or E-mail dtwnov@businessweek.com

Explosion rocks Center Street in Manchester, CT

The Manchester (CT) Fire Department responded to an explosion at 191 Center Street on November 10.

The alarm, which came in at 23:17 hours, was located only one-quarter mile from the station. Three engines, an aerial, and two squads responded. Upon arrival, the firefighters found a partially collapsed 125'x200' commercial structure with heavy fire. It contained a bakery and an auto parts store, with the majority of the fire being in the bakery, which had suffered a partial collapse of the roof, walls, and floor.

The first arriving units heard a male voice in the bakery. Three firefighters made an aggressive rescue attempt, finding that the floor was very unstable. Before they could attempt to proceed, fire swept through the area, forcing the firefighters to retreat and battle the flames using hand lines. The following afternoon, the body of the father of the owner of the bakery was removed from the rubble.

Other units were arriving, and ICS was implemented. One 2 1/2" hand line was run directly to the fire building, while a 1 3/4" hand line was run to deal with a critical exposure on the west side, a rooming house with aluminum siding that was only about eight feet from the fire building.

This engine's 750 gallon tank had been complemented with five gallons of a solution called Cold Fire, a vegetable-based compound that suppresses fire by coating it. Despite having almost direct contact with the flames from the initial fire building, the rooming house, coated with the Cold Fire, showed almost no damage, even to the aluminum siding.

Due to the explosion, a gas pit fire was found, and the line had to be shut down. After the fire was contained, extensive overhaul was required due to the enormous amount of rubble from the collapse. Hose lines had to be snaked through the rubble.

Captain John Rivosa II of the Manchester Fire Department was pleased with the response of the department, and especially with the Cold Fire substance. "We got some good results using it," he said. It is in use in three of their five pumpers.

Cold Fire is a compound made from the waxes of several plants that displace the oxygen a fire needs to burn. The substance can be used directly on fires or preventively to coat objects or people. It drastically reduces the amount of water needed to stop a fire. In one test, 80 gallons of water with a .5% Cold Fire content extinguished a car fire. Over 450 gallons of plain water was required to stop the fire. It is non-toxic and biodegradable.

A total of five engine companies, one ladder, two squads, and 45 firefighters responded to the scene. Firefighters from the Manchester 8th Utilities District and the Bolton Fire Department provided mutual aid for the extensive overhaul and to assist with the fire investigation, which kept firefighters on scene for almost two days. According to Captain Rivosa, the incident was deemed a set fire, with possible tampering of gas appliances and the use of accelerants.

BASEMENT
proved stul

Cheryl White

Weekly For 25 Years

Valley Voice

WEDNESDAY, APRIL 4, 2000

In this issue

Cameron Caught Red Handed

Valley Voice photo by Bob Garrow

Ernie Pomainville, owner of Shoreham Service Center, applies flame from a propane torch to the palm of Mike Cameron's hand during a demonstration of the remarkable cooling effects of COLD FIRE®. Cameron's hand was left unharmed protected only by the COLD FIRE® soaked towel. The product has numerous personal and business applications that could revolutionize the way people protect themselves against fire in the future.

Freezing flames with COLD FIRE®

by Mike Cameron

What would happen if you took a common propane torch and applied it's concentrated flame, full force to the palm of your hand? We would be talking approximately 2500-degrees fahrenheit. How about a little protection? Ok, you can use a common hand towel folded once to protect your hand and let's make it your dominate hand so that after the injury you are about to incur, you will be severely handicapped indefinitely. By the way once the cotton towel ignites it will most likely set the rest of your clothes on fire and in all likelihood turn you into a human torch. We need not go into the sounds you'll make as you begin to cook. Anyone who has suffered a severe burn will know. Even lesser burn victims know that the experience is very painful and frightening.

That's why when one witnesses a demonstration of the firefighting agent COLD FIRE® by Ernie Pomainville at The Shoreham Service Center, the magnitude of the protection provided by this registered trademark product hits home and hits home hard. After watching Ernie demonstrate this amazing substance on his own hand, I asked him to do the same to mine. Like he had just done not a minute before, he placed a small towel on the palm of my extended and open hand. He then applied a liberal soaking of a clear liquid to the towel. The liquid felt just like water. Then he lit a propane torch and adjusted the flame to full force and put the flame to the palm of

Please turn to page 8

Ureka Sunderland

by Mike Cameron

My meeting with Ureka Sunde was like experiencing the warn on a fresh spring day. All of th driving days, snow shoveling anc north winds became less impor We all know those first bright s days of spring hold real promi things to come. Being welcon Mrs. Sunderland's home recently, very much like that.

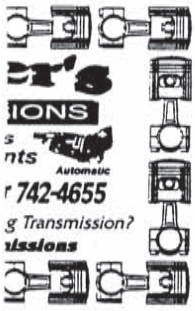
Mrs. Sunderland was bor Elizabethtown New York on A 6th, 1909. "We used to tak transients from the road and them." she said. "My father wo for the Postal Service. They use pick up the mail in Westport by h and buggy and deliver to places Keene, Keene Valley, St. Huberts

Please turn to pa

Middlebury A Now Locally C

Scott Jacobs the new president and ge pictured with their huge selection of ne

Agway Inc.'s retail division has be undergoing a conversion of company owned stores independently owned Agway deale Part of this plan includes Agwa renewed commitment to servicing t



Freezing flames with COLD FIRE®

continued from page 1

my hand point blank. I would soon have a black stump for a hand. be in severe pain and on my way to a burn center followed shortly thereafter by a trip to a psychiatrist. The fact that I am typing this narrative now is proof that COLD FIRE® works.

The clear liquid on that towel protected my skin. The only sense of heat was very mild, not unpleasant at all. "The product cools the heated surface and if it's cool, it can't burn." he says. It doesn't take a person very long after a demonstration like this to warm up to this remarkable product.

The COLD FIRE® formula seems to be a sure fire bet for stopping flames and preventing injuries. Jurgen Giessler, who invented the process says in his promotional material, "COLD FIRE® will allow fire fighters to do their job more quickly and safely, saving more lives, property, and the environment for generations to come."

Environmentally friendly? That's a key company claim. The product is listed by The Environmental Protection Program on their SNAP Program Vendor List. The list contains products that are considered acceptable alternatives for toxic products on the market today. The EPA data is available from FIREFREEZE the products world wide exclusive manufacturer and distributor.

Pomainville has already demonstrated the product to dozens of potential customers including the Shoreham Fire Department, where it is now used on a regular basis.

The product has wide appeal. Pomainville points out a myriad of applications. "COLD FIRE® is available in 12-ounce bottles or it can be purchased as a portable extinguisher in 1.5 and 2.5 gallon sizes. The interesting thing about the product is that a 10-per-cent solution say one quart of COLD FIRE® to 8- quarts of water is a very potent." he said.

The product is UL listed as a wetting agent for class A and class B fires, Pomainville explains that, "It's considered an acceptable substitute for toxic foams and Halon and it extinguishes on contact." he said. The product also is able to enhance the penetration capability of water and thus reduces the amount of hydrocarbon smoke. This gives professional firefighters greater visibility while they are fighting a fire according to the manufacturer. Class D fires containing some of the most intensely hot sources of flame; magnesium for example, can also be extinguished by COLD FIRE® according to promotional literature. The product can be mixed in with ordinary water in a fire department pumper apparatus. It can be added to a water reservoirs or inducted directly into fire hose lines to fight the various classes of fires. Bulk containers of 5 and 55-gallons are available for such purposes. Another aspect of the solutions psychical properties is that it is a non slip substance both before and after it is applied. This creates a a solid safety issue for firefighter and civilian use of the product.

Freeze-Fire Worldwide, Inc. also makes the claim that its COLD FIRE® product is a plant based liquid and naturally biodegradable. According to the company, "the firefighting industry is being supplied with and efficient and effective fire fighting agent that not only extinguishes fire quickly, but does so without harming the environment, fire fighters and fire victims." it says. The product is also touted to have indefinite shelf life when stored in closed containers or in the booster tank of fire apparatus, water pressurized units or closed loop systems.

The closed loop system has gained wide appeal in auto racing. In non-engineering terms, the system can extinguish an on board fire in the vehicle, and as a consequence, save the drivers life. The 5-pound racing system and the 2.5-gallon system used in heavy equipment are impressive when demonstrated.

Pomainville has close ties with auto racing as part of Team New England Mobile Racing. " this product can and has saved lives. People have to see the demonstrations and then the light goes on." he said. Pomainville is heading up distribution for the product in Vermont and the Northeast.

"The people who have seen the demonstrations at our shows and watched video presentations here in the store are impressed to say the least. The product is an excellent safety product for plumbers, welders, farmers, mechanics, and just about anyone who works with hot surfaces. The smaller units can be carried in a tool box or even in a holster on a tool belt." he said

What the future holds for COLD FIRE® remains to be seen but by all appearances, it looks bright indeed, at this point in time. From fighting forest fires to quickly extinguishing a grease fire on the family stove. Freezing fires could be the wave of the future.

(For more information on COLD FIRE® contact Ernie Pomainville at The Shoreham Service Center on Rt 22A in Shoreham, Vermont. 1-802-897-8585

Margaret Sunderland Honored

Bridport Morning Sun Lodge # 5F&AM is celebrating its 200 years of existence this year. It was chartered as # 18 on 13 Oct. 1800.

Sunderland was instrumental in starting, organizing and doing a good share of the pancake breakfasts, yard sales, bake sales, flea markets, auctions whatever it took to make

Racing WITH Jesus
for Excellence in Ministry
BY BROTHER PAT & BETTY EVANS
"Let us run with patience, the race set before us, looking unto JESUS" Hebrews 12:1,2
THE RACER'S CHURCH, 20 Good Win Road #2, Canterbury, CT 06331-1329
PHONE OR FAX (860) 546-9366

Reverend Pat & Betty Evans

...izens and we care about our country.

Lou Rettenmeier is a veteran BNS driver and team owner. Seems he's gotten so busy lately with the business that he may just run the major shows, but hire a full-time driver for the entire series. Things we like about the Sherman, CT driver/owner: hard-working, honest, generous, well-spoken, socially polite and classy. At Pennzoil Motorsports, while right in the middle of his Mobil, Motor Max, Firefreeze display, he offered his car for our use if needed in the ministry display which was right next door to his. His car displayed the Ministry Decals and, of course, had the Driver's Prayer on the dash. The Lou and wife Tracy owned team has Mobil Speedpass, MotorMax, American Environmental Technologies, Mobil 1, and Arbitell Convenience Stores as sponsors. Product Sponsors included New Fairfield auto Body, Cold Fire/ FIREFREEZE Worldwide, Inc., Lime Rock Park, Hocon Industrial Gas and Verdi Custom Cycles. But for right now, we present two of these sponsors who were at the show:

MotorMax by FIREFREEZE is a race proven revolutionary ...oling system additive. It is not simply a water accelerator, but ...uch more. MotorMax is a plant-based organic material that is non-toxic and completely biodegradable. When mixed with what is already in a cooling system, it acts as a heat sink. It allows the fluid to absorb heat more efficiently. During warm-up, the fluid transfers heat more evenly throughout the engine. This results in reduced warm-up time and reduced cold start-up and wear and tear. It also causes the motor to warm more evenly and even during full temp running, it keeps the temp of all cylinder more even thereby reducing uneven temperature misfire. At operating temp, the treated liquid absorbs heat more quickly, causing more rapid shedding of heat through the radiator coils. Tests have shown operating temperatures dropping by as much as 30 degrees in a street car 30 to 35 in a race car.

BNS drivers Kelly Moore and Jamie Aube tested the product. Moore lowered operating temperature by ten degrees while Aube showed a 30 degree drop. I have been running Motor Max in the Ministry Ferree Chevrolet Monte Carlo Pace Car. I am seeing benefits in greater gas mileage. Seems the evenly spread heat helps offset the damage in mileage done by this MTBA additive required by the Socialist State of Connecticut. I am not kidding. Besides poisoning the water supply and smelling awful when pumping gas, this ineffectual additive to gasoline actually causes a decrease in mileage. Of course, the states love it. It produces more tax income when I have to buy more gas. The Monte Carlo 3.4 DOHC powerplant gets about 21 miles per gallon in Connecticut. In North Carolina, it averages about 27. Case Closed. Anyway, since we put in the Motor Max, we are averaging about 22.3 mpg. The heat in the driving compartment is much better. It is as if the heat radiates more. Motor Max along with Slick 50 may be the best way to extend engine life in a passenger, and maybe, race car. If the motor builders ever say they don't' like it, that is a pretty sure sign it ...uces engine wear. We strongly recommend Motor Max for all ...s of vehicles and a natural during time trials when y'all put all ...duct tape over the front of the car. For more information, call ...8-699-4066 or check the web at www.firefreezemotormax.com

COLDFIRE by FireFreeze is now licensed by Simpson. This amazing fire extinguishing system will revolutionize the industry. This rapid cooling fire extinguishing agent does not attempt to smother a fire and remove the oxygen the way Halon does. In fact, halon is only effective if the fire is stationary and then only for a few seconds until the oxygen returns. If there is still enough heat, the fire restarts. Ever see a race car on fire and the it is sprayed with halon? Then the fire comes back to life because the oxygen returns. ColdFire is non-corrosive, non-toxic (ever breathe in halon), extinguishes class A,B and D fires. It surrounds and encapsulates the fuel source preventing re-ignition and quickly cools hot surfaces eliminating the heat source. Already, Cold Fire is used by Indianapolis Motor Speedway, Sebring, Lime rock Park, Houston Raceway, Firebird Raceway, Englishtown, New Hampshire, Atlanta, Watkins Glen, Charlotte, Nazareth, Pocono, Sears Point, Las Vegas, IRP, Pikes Peak, Phoenix, Bristol, Disney World, Texas, Gateway and by the NHRA, IRL and DIRT.

The system is easy to refill in the shop or in the field and is now available for racing, motor homes, trailers, kit cars, street rods, logging equipment, military vehicles, heavy equipment and more. And we now have the low pressure portable unit in the house. Betty said, "This is great. It is easy to use. It's just like a can of hair spray." I am no technician and will not do this product real justice. But I care about anything that can save lives.

RWJM Chaplain and Grandview's winningest Modified driver Rick Schaffer was checking the Cold Fire products with me. I showed him about the onboard bottle. He said, "What is the point if I get knocked out? I can't pull the trigger on the bottle." We showed him the Cold Fire automatic system. Sensors are installed at strategic locations on the car. When the heat reaches over a certain temperature, the Cold Fire System goes off. So, even if a driver has his bell rung in a fiery accident, the system will still operate. That can save lives.

Cold Fire removes the heat from a fire which stops combustion. Ever see a brake rotor catch on fire? That is because it is magnesium which ignites at 1560 degrees. The metal actually burns. Water will not put it out. Halon will not. But Cold Fire will. I watched Lou put a regular towel over his hand and spray Cold Fire on it. Then he put magnesium chips on the towel. Lou torched the chips until they ignited with that white intense flame. He then sprayed Cold Fire on the flaming chips. They went out immediately. And when he dumped them off the towel, they were cold and even the nap on the towel was not burnt or damaged. He took an empty can and heated it until it was red hot. He sprayed it with Cold Fire and immediately handed it to a guy in the audience. The can was cold and easily handled. Cold Fire is an amazing product and a blessing to the entire racing community. Call 973-627-0722 for information or visit www.firefreeze.com and please do it now.

MICHELIN

MICHELIN TIRE MANUFACTURING
US.1 Safety Department
Post Office Box 2846
Greenville, SC 299602
864-458-1283, Office
864-458-0740, Fax

Dear Ken;

Thank you so very much for your willingness to attend our annual fire school on Tuesday Oct. 7,14,21,28 and demonstrate Coldfire™. The participants were extremely impressed with the quick knock down and rapid cooling abilities of this revolutionary product.

As you know, I am sold on Coldfire™. I am certain that since we have purchased the pails to use with inline eductors as well as the 12oz cans we should (hopefully) have the upper hand when fire breaks out.

Once again, thanks for the way that you supported our training.

I am looking forward to working with you in the near future.

Sincerely;

Jeff Cooper

Jeff Cooper
Fire Chief

HYPRO Corporation
A WICOR COMPANY

FACSIMILE TRANSMISSION

TO:
Stephanie E. Giessler
Firefreeze Worldwide, Inc.

FROM:
Robert Hosfield
Hypro Corporation, FoamPro Division
375 Fifth Avenue NW, New Brighton, MN 55112-3288
Engineering Dept Fax:(612) 638-5361

RE: Cold Fire Agent

Total No. of Pages: 1 Including this Page **Date:** 15 October, 1997

Ms. Giessler,

Thank you for sending a sample of your Cold Fire product, the video, and the literature on your product. It certainly appears to be an interesting product that can give some great results.

In my evaluation of your product, I am looking primarily at two items of concern. First is the pumpability, or the ability of our system to pump the product accurately and through the system's full range of operation. The second item of concern is the chemical compatibility of the product with the materials used in manufacturing our systems. We do not endorse or test foams or agents for their fire suppression capabilities. We feel that this is best left to the appropriate agencies and the firefighters themselves.

Cold Fire can be used with our 2001, 2002, 3010, and 3010D systems when evaluated for pumpability and chemical compatibility. The product is very low in viscosity and has no highly corrosive materials as presented in your literature.

We certainly wish you success with your new product in the future. If you should have any questions or concerns regarding the compatibility of your product with our systems, or any future systems, please feel free to contact me.

Best regards,

Robert L. Hosfield
Project Engineer
FoamPro Division
Hypro Corporation

cc: Bill Ballantyne
Terry Burtson
Mark Frieden

Please call (612)628-5196 if there is a problem with this transmission.

W.S. Darley & Co.

2000 ANSON DRIVE MELROSE PARK, IL 60160 USA
PHONE 708-345-8050 FAX 708-345-8993

FROM: PAUL C. DARLEY, VICE PRESIDENT, PUMP DIVISION

TO:	**Allsafe**	**DATE:**	**November 20, 1997**
ATTN:	**Luke Semmelrock**	**SUBJECT:**	
FAX:	**914 665-1536 NY**	**PAGE:**	**1 of 1**

Dear Mr. Semmelrock:

Our Engineering Department has reviewed the MSDS sheets on your cold fire product and find that inasmuch as Class A Foam is proportioned on the discharge vent of the pump, we have no problem with compatibility of our pump.

We also primarily use Hy-Pro 2001 Proportioning Systems, and we are delighted to learn of the compatibility with their systems as well.

If you should have any questions, or if we can provide you with any additional details, please do not hesitate to contact us.

Sincerely,

Paul C Darley

Paul C. Darley
Vice President
Sales/Marketing

PCD:cs

COLD FIRE!

A Tool for the Hot Jobs

By Mark Whitney
Photos Courtesy of Design Engineering Inc.

Whether you are welding, cutting with flame, soldering, or involved in any job where heat is generated, you'll always discover excess heat finds its way to places where it's least wanted. Excess heat can warp and weaken metal in critical areas, as well as creating an extremely "hot to handle" situation. While water has been employed to cool these situations in the past, it has not always proven to be the best choice due to shocking, cracking, and heat transfer in the form of steam. The need to control heat flow in the more highly stressed, precision racing components has paved the way for development in new ways to control heat.

Enter Cold Fire. Created by Firefreeze Worldwide (see separate story) and marketed by companies like Design Engineering, Inc. of Avon, Ohio, Cold Fire was born and bred as a fire suppressing agent and exhibits an unsurpassed cooling effect from any object in which it comes in contact.

Lab tests conducted by Intertek Testing Services of New Jersey have shown that Cold Fire provides a significant reduction in cooling time versus water—upwards of 10 times quicker. Copper was heated to 500 degrees F. When water was applied, it took four minutes, 30 seconds for the surface temperature to return to 84 degrees. When Cold Fire was applied to the 500-degree copper, it took only 27 seconds to accomplish the same end. Tests for sheet metal and steel showed similar results.

Cold Fire is also considered to be thinner than water, allowing penetration into tighter places and providing better cooling for critical areas and objects. Unlike water, Cold Fire works by dissipating heat evenly across the surface and through the cross section of the material. By creating a uniform surface area for heat to spread evenly, heat is encapsulated and diminished at a quicker rate to the ambient air. This method of heat removal also minimizes heat transfer in the form of ambient steam release and helps avoid distortion and warping. What's more, Cold Fire is derived from a 100 percent biodegradable formulation, which is not only non-toxic and non-corrosive, but non-staining and virtually odorless, as well.

While Cold Fire has had a previous history in motorsports as an agent within on-board fire suppression systems as well as track safety equipment, it brings its much-needed effects to fabricators,

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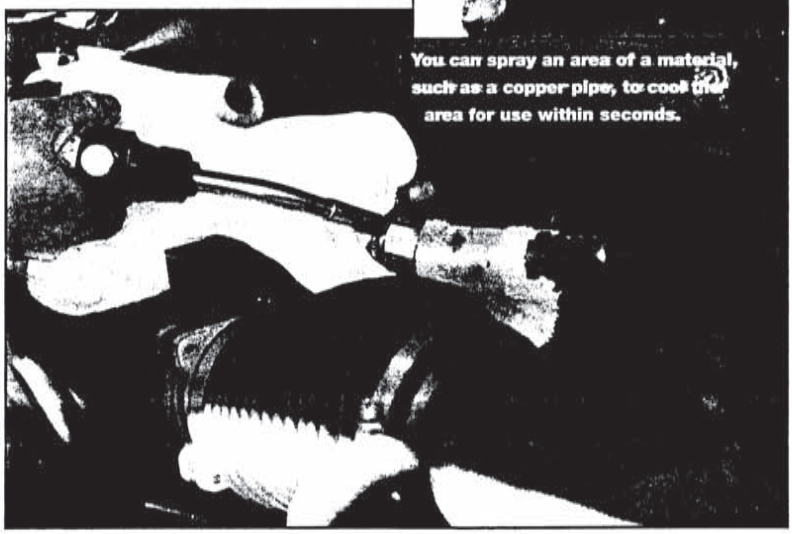
Cold Fire's test of faith. A cloth soaked in Cold Fire is subjected to the heat of a blowtorch. You can hold the cloth without burning your other hand.

crew chiefs, and mechanics in a spray bottle. Cold Fire is now being used to instantly cool such items as intake manifolds, brake rotors, exhaust headers, and spark plugs so work can be performed quicker without a long cool-down.

Cold Fire is also used to create an instant heat shield or barrier by applying the product to a terry cloth towel and wrapping or laying it on an area to be protected from heat spread. An example would be a case where heat is required to stay in an area to protect an in-line Teflon sealed valve close to the weld area. Because of Cold Fire's unique characteristics, heat is stopped at the rag's point of origin.

With the demands from motorsports professionals, companies from all over the world have worked hard to develop products to meet certain needs. Design Engineering, and companies like them, continue to research new products while working closely with mechanics to meet the ever-changing needs of the industry.

You can spray an area of a material, such as a copper pipe, to cool the area for use within seconds.



Cold Fire can serve as a barrier for heat when items like inline sealed valves need to be protected.

With the proper protection, the operator can hold a material to be heated close to the source. It provides a steady hand without fear of being burned.

SIMPSON TO WORK WITH FIREFREEZE

Simpson Performance Products has entered into a licensing agreement with Firefreeze Worldwide, Inc. of Rockaway, New Jersey, to market Firefreeze Worldwide, Inc., products under the Simpson brand name.

Simpson is now expanding its product line into the industrial and consumer marketplace to include Firefreeze Worldwide, Inc. products.

"We've always been in the business of offering the highest performance and quality in our products," says Simpson president Mark Johnson. "That's why we are excited to partner with manufacturers such as Firefreeze that produce technologically advanced, high quality products like Simpson Cold Fire and Simpson Motor Max."

Jurgen Giessler, inventor and president of Firefreeze Worldwide, Inc., says, "This is a great opportunity for Firefreeze Worldwide, Inc. to expand the recognition and credibility of our product line. These products have proven themselves in their respective markets under some of the most extreme conditions, such as racing. Our endorsement from Simpson adds tremendous support to our product line."

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PRESS RELEASE

FOR IMMEDIATE RELEASE

NEW HEAT SUPPRESSANT AEROSOL SPRAY PUTS OUT FLAMES, COOLS HOT SURFACES

Cold Fire by Firefreeze Worldwide, Inc. (Rockaway, NJ), is a remarkable new aerosol spray that instantly cools hot surfaces. This environmentally friendly fire-fighting agent lends itself as an excellent fire and safety tool for welders, plumbers and homeowners alike.

Cold Fire is packaged in CCL Container Aerosol Division's ABS™ bag-in-can barrier package, consisting of a patented bag and valve design housed inside an aluminum aerosol can. The three-layer laminate and foil ABS bag is hermetically sealed to separate the product from the propellant with no air contact. To assure total safety around hot areas, compressed air is used as the pressurization agent.

One of the primary reasons Firefreeze Worldwide chose the ABS system was its ability to spray in any attitude (360° spraying). "This is important," explains Jerry Giessler, president and CEO of Firefreeze Worldwide, "because welders and plumbers, for example, sometimes work in awkward positions and need to be able to spray quickly no matter where they are."

Giessler continues, "This unique application was designed for anyone whose occupation requires using an open flame or working around hot surfaces. Mechanics, for example, use *Cold Fire* to cool down overheated engines, and plumbers use it to pre-spray an area before soldering to help prevent heat damage and to reduce the risk of a hidden fire."

Motorized racing pit crews use the product in bulk to extinguish car fires and to cool down hot brake pads and tires. *Cold Fire* recently became the "official fire fighting agent" for the Pep Boys Indy Racing League. The product is also used by the US Army, Navy and Airforce, and by several auto manufacturing plants.

Originally marketed as an industrial product, *Cold Fire* is now available to consumers who can use the product to cool down overheated cooking surfaces and utensils, as well as craft tools like drill bits and soldering irons. Because its formula is leather-safe, it can also be used to cool sun-baked car seats and steering wheels. The product is sold at Home Depot and other hardware stores in the NJ/NY/CT area, where it is available in a convenient 12-oz. size.

(more)

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The ABS is used for a wide variety of applications. The system is excellent for concentrated products that cannot be diluted and for pharmaceuticals that require clean contact-free dispensing. Also, the laminated pouch can hold the most aggressive active ingredients such as citrus-based formulas. ABS has a quiet and non-chilling discharge and allows all-attitude (360°) dispensing which is especially important for pet sprays. Applications to date include many different personal care products, pharmaceuticals, room deodorizers, insect repellants, and pet sprays, among others.

CCL Container Aerosol Division (formerly Advanced Monobloc) is the largest North American manufacturer of barrier systems for aluminum aerosols. In addition to the ABS, the company also offers a piston-type barrier system. The division is also the leading manufacturer of aluminum aerosol cans, bottles, and other specialty aluminum containers. For more information on the company's services and capabilities, please contact:

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INDUSTRIES IN WHICH COLD FIRE® IS USED:

- Federal, State, City and Local Fire, EMS, and Police Departments
- Military/Governmental Entities
- Port Authorities
- Transportation Agencies
- Marine Industry
- Aviation
- Manufacturing Facilities
- Construction, Plumbing, Welding & Roofing Industries
- Automobile Manufacturing
- Motorized Racing Industry
- Power Plants & Utilities
- Foundries
- Forestry
- Correctional Facilities
- Security Industry
- Paper & Textile Industry
- Mining Industry
- Oil Refineries
- Steel Industry
- Metal Manufacturing
- Logging

Cold Fire can be used to extinguish aircraft fires and to cool down the fuselage for added safety

Cold Fire being used in a Bambi bucket to extinguish forest fires

Extinguishes Class D (metal) fires

Cold Fire's use on extinguishing fuel fires helps to prevent re-ignition

Australian Sales & Service

Testing & Refills of Cold Fire, Fire Extinguishers

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