ECONOMIC CONSIDERATIONS

The PYROCOOL products are used at a 0.4% ratio. In other words, 4 gallons of PYROCOOL are used per 1000 gallons of water to create the use solution. Given the common use ratio of other products, the PYROCOOL advantage is clear. Consider the following example:

TYPICAL USAGE WITH 15,000 GALLONS OF WATER

AFFF at 3%		150 gallons
AFFF AR (or ATC) at 6%	=	300 gallons
PYROCOOL FEF at 0.4%	=	20 gallons

Field tests of the PYROCOOL products, however, demonstrate that, depending on the type of fuel source, the PYROCOOL products extinguish fires between 10% to 40% faster than conventional products. When this additional factor is taken into account, the reduced "flow time" per fire results in even smaller quantities of PYROCOOL products being used. With just a 10% reduction, the above figures change to the following:

AFFF at 3%	=	150 gallons
AFFF AR (or ATC) at 6%	=	300 gallons
PYROCOOL FEF at 0.4%	=	18 gallons

With less product usage, storage, equipment and personnel costs are drastically reduced. Additionally, because PYROCOOL products are so versatile and can be used on so many different fuel fires, there is no need to stock multiple product lines. There are other cost considerations as well.

Because the PYROCOOL products are fully and quickly biodegradable, cleanup costs are minimal. This factor should be considered by potential users in comparison with the "hidden" environmental cleanup costs (and health factors) of conventional products. Further, the use of PYROCOOL products (which mix equally well in fresh, brackish or salt water), because of their faster extinguishment abilities and extraordinary cooling effects, results in less overall consumption of water, a factor of critical importance in areas where water supplies are limited. As a final consideration, the PYROCOOL products do not pose the problems to fuel reclamation created by other commonly used agents.

Each customer will know its own present costs for fire extinguishment products. The distributors of the PYROCOOL products will be glad to provide a quote for your needs which, we believe, will be less in every case than you are paying now when you consider the True Costs of the Finished Foams.

EXTINGUISHMENT

The PYROCOOL products have been extensively tested for their extinguishment capabilities against a broad range of fires. Because of their specific design characteristics, both PYROCOOL and PYROCOOL FEF have achieved remarkable results. The following table sets forth the results of a number of these tests:

TEST TYPE	LOCATION	EXTINGUISHMENT TIME	PRODUCT
150 large computer tapes, packed in **14** boxes	Dutch National Aerospace Laboratory	10"	PYROCOOL FEF
125 liters-Unleaded Gas (NOTE: Backboard splash test pursuant to UL 162)	DuPont de Nemours	2' 57"	PYROCOOL FEF
Magnesium Block	Rotterdam International Safety Center	30"	PYROCOOL
Open tank-150 liters Gasoline & Diesel Fuel	Rotterdam International Safety Center	9"	**PYROCOOL** FEF
80 m2 Propylene Oxide (1072 liters)	ARCO	2' 53"	PYROCOOL FEF
Helicopter deck (38.5 m2) 60 liters Heptane	Royal Navy Fire Training School	51"	PYROCOOL
Pressurized Gasoline Heat Exchanger	British Petroleum	53"	PYROCOOL
Propane tree (NOTE: Extinguishment not recommended by manufacturer of PYROCOOLTM)	British Petroleum	4. 9"	PYROCOOL
80 g. Lithium Block	U.S. Navy Undersea Warfare Engineering Station	3"	PYROCOOL (non-aqueous)

Air Drop from Bell 205 Helicopter onto wooden pallets	Abbotsford, B.C.	2"	PYROCOOL
Open Tank - 8 foot diameter, 5 feet tall, filled w/Gasoline	Kuwait National Fire Training Facility	8"	PYROCOOL
Tires (30)	Kuwait National Fire Training Facility	48"	PYROCOOL
Moat (2000 sq. feet) 10 inches deep filled w/Gasoline	UAE Fire Testing Facility	27"	PYROCOOL
Diesel Fuel & Jet Fuel - approx. 4000 sq. meters	Gajary, Slovakia	2' 30"	PYROCOOL FEF
JP-8 (1500 liters in 40 m2 area)	RDAF Technical School	8"	PYROCOOL FEF
Tanker *Nassia* - Many thousands of gallons of crude oil	Bosphorus Straits	12' 30"	PYROCOOL FEF
JP-4 (300 gallons in 100 foot diameter pool fire)	Tyndall AFB	40"	PYROCOOL FEF
Conventional refinery large oil storage tank - approx. 12 meters high & 65 m2 inch surface area (NOTE: 14 ***minute*** preburn)	Rotterdam International Safety Center	52"	PYROCOOL FEF
Coal (3 x 3 bin)	Rotterdam International Safety Center	50"	PYROCOOL
Pressurized (55 PSI) Diesel Fuel	Gulf Training Safety Center (Dubai)	25"	PYROCOOL FEF

In every PYROCOOL product, significant cooling effects are noted (see ***Cooling*** section of this Report). Because of its cooling effect, firefighters are free to more aggressively attack a fire. This ability, by itself, leads to faster extinguishment. Further, firefighters using PYROCOOL FEF can direct their flow directly

on the base of the fire, an application impossible with most conventional products, especially on three-dimensional fires.

Because PYROCOOL products cool fire site temperatures, correct application of the products in conformity with the manufacturer's suggestions eliminates "burnback". Conventional foam products seal the surface of pool fires with a film, thus depriving the fire of the oxygen component needed for combustion. PYROCOOL products, instead, reduce the heat component of fire. Following extinguishment, both structures and fuel sources are cooled to the point where they pose no risk of reignition. With conventional products, however, there remain., even after extinguishment, hot surrounding surfaces and fuels just waiting for an oxygen supply to recombust. Once the film is broken (as has occurred many times when firefighters walk through it by accident or necessity), the fire can come back, with tragic results.

COOLING EFFECT

A principal attraction of the PYROCOOL fire extinguishment products is their patented ability to dramatically and quickly lower fire site temperature. Firefighters consistently report a "cooling shield" which precedes them when fires are fought with PYROCOOL products. Structures located in or adjacent to fire sites are cool to the touch following extinguishment and the temperature of residual fuel sources (normally a point of reignition concern) is drastically lowered. The beneficial effects of the PYROCOOL cooling phenomenon cannot be underestimated.

The manufacturer of the PYROCOOL products has received many inquiries concerning the scientific basis of the PYROCOOL cooling effect. In response to these inquiries, the following statement by one of PYROCOOL's chemists provides perhaps the most readily understandable scientific explanation:

> "Combustion of common class a and class b materials can be described as a chaotic oxidation of numerous classes of organic compounds. The chemical yield of these reactions is equally chaotic and produces numerous classes of organic compounds in addition to CO 2, H20, and CO. The common denominator of all combustion reactions is that the products yielded are at a much lower total Gibbs free energy state than the fuel reactants. In the process of achieving this lower energy state a great photon yield of radiant energy is delivered. This is evidenced by the various colors and wavelengths present with flame emissions. These emissions, by striking the fuel load directly and

by striking adjacent bodies that reradiate, are responsible for propagating the violent sets of reactions in combustion of organic materials. The PYROCOOL products interfere with these reactions by providing a continuous stream of molecules that will absorb the high energy radiant emissions from the combustion process. PYROCOOL FEF is of such structure that it will absorb a photon, elevate to an excited state, and revert to the ground state within a period of 10 to 10' seconds. Additionally, PYROCOOL FEF will provide a foam blanket or aqueous barrier that will suppress the flood of volatile organic vapors into the air, thus eliminating flashback of the fire into areas that have already been extinguished by the primary mechanism."

In the words of Leon MeeIs, Chief of the RISC Emergency Response Team, and the firefighter who led the successful extinguishment of the huge *Nassia* oil tanker fire in the Bosphorus Straits in March, 1994, *"PYROCOOL eats the heat"*.

TESTING EXAMPLES

In every recorded use of the PYROCOOL products against substantial fires, heat drop has been both immediate and dramatic.

Measuring with a Wahl 'Heat Spy'® thermal measuring instrument, PYROCOOL reduced the temperature of a test tank fire at a large refinery (800 liters gasoline, 2400 liters diesel fuel) from 1060°C to 35°C in less than 16 seconds.*

Using even more sophisticated test equipment, the cooling effects of the PYROCOOL products were independently evaluated over a three day period by SGS Technische Inspecties B.V. (an affiliate of Societe Generale de Surveillance) at the Rotterdam International Safety Center Education & Training facility at the Maasvlakte, Holland, in October, 1993. These tests, using an Inframetrics Model 600 IR Thermal Imaging and Measurement System, were not conducted on behalf of the manufacturer of the PYROCOOL products, but rather on behalf of a potential user of the products. The results were astounding:

PRODUCT	FIRE TYPE	TEMPERATURE AT START	TEMPERATURE WITHIN 30 SECONDS OR LESS
PYROCOOL	SHIP BULKHEAD SIMULATION	600°C	16°C (10 SECONDS)
PYROCOOL FEF	MAGNESIUM	@1700°C	33°C (30 SECONDS)
PYROCOOL	MASSIVE PAPER BALE	900°C	14°C (20 SECONDS)
PYROCOOL FEF	150 LITERS GAS & DIESEL	178°C	5°C (9 SECONDS)
PYROCOOL (INDIRECT APPLICATION)	3 X 3 COAL BIN	900°C	140°C (30 SECONDS) (NOTE TO AMBIENT WITHIN 1 HOUR WITH NO FURTHER APPLICATION OF PRODUCT.)

(Test conducted at British Petroleum, July, 1991. Actual Extinguishment time - 15.25 seconds.)

Videotapes of the above tests are available from the manufacturer of PYROCOOL.

COMMENTS

The importance of a cooling effect in firefighting is immeasurable. With PYROCOOL FEF, firefighters can get in closer to the seat of a fire in much shorter time frames than before. Rescue efforts are greatly enhanced. Structure failure and equipment and property damage are decreased, and the ability to minimize pollution is tremendously expanded. The potential for burnback is virtually eliminated, and in large structure fires (such as ships) the "pre-cooling" time normally required before extinguishment attempts can begin is cut dramatically. Conventional foam products do not cool beyond the normal effect of the water they contain.

LABORATORY
TESTING SUMMARY

PYROCOOL FEF (i.e. Fire Extinguishing Foam) is a revolutionary new firefighting chemical specifically designed for use against difficult fires. Although the product provides extraordinary cooling effects, rapid extinguishment and an impressive layer of foam, of critical import is the fact that it does so without the use of the dangerous fluorocarbons and glycol ethers regularly employed in other foam firefighting products. PYROCOOL FEF contains no fluorocarbons or glycol ethers, which are known to be harmful to the environment and human health and which world governments are beginning to severely monitor and restrict Additionally, the product contains no halocarbons, the allowable use of which in firefighting products has been curtailed in most countries.

PYROCOOL FEF has been extensively tested by independent laboratories to determine its environmental impact through inquiry into its corrosivity, toxicity and biodegradability. The conclusion of that testing (the details of which are set forth in the pages which follow) is this:

BECAUSE OF ITS EXTREMELY HIGH RATE OF BIODEGRADABILITY WHEN IN USE, PYROCOOL F E F POSES NO PRACTICAL RISK WHATSOEVER TO THE ENVIRONMENT.

The manufacturer of PYROCOOL FEF has noted, generally, that explanations of scientific testing are rarely provided to potential product consumers. In an effort to cure this deficiency, the following pages contain not only the results of such testing as performed on PYROCOOL FEF, but also the meaning of the results obtained.

TEST RESULTS

BIODEGRADABILITY

The rapid biodegradability of PYROCOOL FEF when in use is the key to its environmental safety and materials compatibility.

PYROCOOL FEF's biodegradability was evaluated by two different independent laboratories, each using separate and distinct methods of testing approved by the United States Environmental Protection Agency. The first approach was the Biochemical Oxygen Demand (BOD)/Chemical Oxygen Demand (COD) evaluation, taken, respectively, from *17th Edition of Standard Methods,* Method 5210 and *Methods of Chemical Analysis for Waters and Wastes,* 1983 (MCAWW) Method 410.4, and performed by ETS Analytical Services, Inc., a USEPA contract laboratory. These methods are approved by the EPA under the National Pollutant Discharge Elimination System (NPDES), 40 CFR, Part 136. In this approach, BOD and COD are determined and then the ratio of BOD to COD is calculated. The resulting percentage is a statement of total product biodegradation. The second method of evaluation, on the other hand, was the *Modified Zahn-Wellens/EMPA Procedure,* performed on behalf of ENSCI Environmental, Inc. by Earth Tech (formerly Applied Technology and Engineering), also using EPA-approved standards. This method (originally adopted as OECD Guideline 302B for determining inherent biodegradability, and later modified and upgraded to its present form), places the test substance in mixture with mineral nutrients and activated sludge in an aqueous medium, which is then agitated and aerated at 20-25°C over a period of time, during which filtered samples are taken and tested for their chemical oxygen demand (COD), with the rates of eliminated COD being compared to initial values. It is important to note that the *Zahn-Wellens/EMPA* method does not measure total product biodegradation, but rather the biodegradation of those elements within the product

which might pose inhibition hazards to the biological activity necessary for water purification systems. Full explanations of both test methods employed are attached as addendums to this document.

In essence, then, the *Zahn Wellens* procedure identifies, at varying concentrations, the biodegradation rate of potentially harmful substances within the product itself, while the BOD/COD procedure identifies percentages of total product biodegradation, to include not only the potentially harmful elements identified by the *Zahn Weliens* method, but all other components in the product as well.

A.) *BOD/COD*

The BOD/COD approach for PYROCOOL FEF (which did not take into account the additional helpful aeration created for the product when in actual use) produced the following results:

		% of Total Product Biodegradation
COD	2740 mg/L	
BOD (5 day)	1188 mg/L	43.36%
BOD (10 day)	2042 mg/L	74.53%
BOD (20 day)	2628 mg/L	95.91%

The conclusion of ETS Analytical Services was that PYROCOOL FEF was "fully and rapidly biodegradable". As such, the product by all accepted standards poses no realistic immediate or long-term threat to the environment.

B. *Modified Zahn-Wellens*

The *Modified Zahn-Wellens/EMPA Procedure* was employed by ENSCI Environmental, Inc., against PYROCOOL FEF in its concentrate form, which is the most severe and critical testing possible. Results are as follows:

Time	Biodegradability %	Concentrate mg/L	LC50 _nLig&
48 hours	86%	1000	>1000
72 hours	63%	2500	>2500
96 hours	47%	2500	>2500

These results indicate that any potentially harmful elements in PYROCOOL FEF, even in its concentrate form, rapidly disappear. The conclusion of ENSCI Environmental, Inc., was this:

> "Because PYROCOOL FEF, specifically any toxic fraction thereof, biodegrades so easily and rapidly, any effect on biological treatment systems will be quickly minimized. Its rate of inhibition is greater than 1000 ppm and we conclude that its impact on biological water treatment systems (on the recognized scale consisting of "High Impact", "Moderate Impact" and "Low Impact") would be classified as "Low Impact". In all cases tested, the soluble portions of the batch reactor supernatant were not toxic to Ceriodaphnia Dubia (water flea) in 48-hour aquatic toxicity (LC50) tests."

In summary, PYROCOOL FEF, at a minimum, would be over 95% biodegraded within 20 days of atmospheric exposure and any toxic element of the product when evaluated at the standard accepted testing level of 1000 mg/L, would have biodegraded 86% in the first 48 hours.

II
CORROSIVITY

PYROCOOL FEF was tested in its concentrate form for its compatibility with various metals (i.e. corrosivity) in accordance with the United States Environmental Protection Agency's *Test Methods for Evaluating Solid Waste, Physical/Chemical Materials, SW-846,* EPA Method 1110M. The tests were performed by ENSCI Environmental, Inc., an independent laboratory. In the tests, metal coupons were placed in containers of the PYROCOOL FEF concentrate for a period of 90 days. In turn, results were yielded which produced, when extrapolated, measured rates of corrosion in millinches per year (mpy). Because, however, the total PYROCOOL FEF product biodegrades so rapidly in use (over 95% in 20 days), a 90-day test program goes past the time at which the use solution of the product would have totally disappeared through biodegradation. Accordingly, separate test evaluations were provided for the use solution of the product at that interval coinciding with the known biodegradation rates of the product, even though the tests were conducted in a sealed environment non-conducive to biodegradation. In essence, then, the following raw rates give a total mpy loss worst-case scenario for the product in use. The results:

Material	Elapsed Time Immersion in Concentrate Without Biodegradability	Extrapolated Total Yearly Loss in MPY
Aluminum 2024-T3	744 hours (>31 days)	0.54 (0.00762 mmpy)
Steel A1S1-4130	744 hours (>31 days)	1.18 (0.02997 mmpy)
Yellow Brass 65CU-35ZN	744 hours (>31 days)	0.87 (0.02209 mmpy)

In closed storage systems allowing no biodegradation, the yearly loss rates are as follows:

Material	Elapsed Time Immersion	Extrapolated Total Yearly Loss in MPY
Aluminum 2024-T3	90-Day Standard Test	24.8 (0.63 mmpy)
Steel AlS1-4130	90-Day Standard Test	14.2 (0.36 mmpy)
Yellow Brass 65CU-35ZN	90-Day Standard Test	13.8 (0.35 mmpy)

Because of these results, as tested, ENSCI Environmental, Inc. concluded:

> "PYROCOOL FEF is not considered corrosive according to the standards set by USEPA in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* Because PYROCOOL FEF is applied at a 0.4% solution, rather than the 100% concentrate as tested, the use solution of the product is likely to be even more significantly compatible with the metals than the concentrate which was tested. Additionally, because the product on exposure to the atmosphere biodegrades so rapidly, and the yielded test results arose from an environment non-conducive to biodegradation, corrosive effects in areas open to the atmosphere will likely be even less than stated here."

Accordingly, the manufacturer of PYROCOOL FEF recommends no unusual clean-up procedure following use beyond the normal maintenance rinsing or flushing of equipment. In closed storage systems incompatible with biodegradation, however, the manufacturer does recommend the use of standard stainless steel or polyethylene coated

vessels, so as to eliminate or reduce any corrosion risk. Naturally, each user will wish to evaluate the specific needs of its own systems.

III

TOXICITY

A. ***Aquatic***

As previously noted (see "Biodegradability" above), any toxic elements contained in PYROCOOL FEF (even in the concentrate form) are 86% biodegradable within 48 hours of atmospheric exposure. Accordingly, any possible aquatic toxicity of PYROCOOL FEF would be of practical concern only in the first 48-hour period following . direct spillage. Because of the potential use of PYROCOOL **FEF** in water environments, it was decided to subject PYROCOOL FEF, at the manufacturer's specific request, to the most stringent possible laboratory evaluations. In the "real world", natural bodies of water (i.e., streams, rivers, lakes, oceans) are constantly being replenished with new water and new oxygen. PYROCOOL FEF, however, in order to obtain a "worst-case" scenario, was instead tested for aquatic toxicity in closed water systems, having no such replenishment capabilities, even though such systems would be extremely rare, if not absent entirely, in nature. In such closed systems, the "LC50" levels of PYROCOOL FEF (i.e. the levels required to adversely affect more than 50% of aquatic organism) were as follows:

		LC50
PYROCOOLTM FEF Concentrate (100%)	=	50 mg/L
PYROCOOLTM FEF Use Solution (.4%)	=	12500 mg/L*

NOTE: This figure makes no allowance for the volume of water added to make a .4% solution. If this volume were taken into account, the figure would be even higher.

After 48 hours, the LC50 levels are so large as to be virtually meaningless.

These levels far surpass the stringent requirements set forth in the standards adopted by the United States Forest Service (see Sec. 3.8/. "International Specifications", August, 1993, Intermountain Research Station, National Wildfire Coordinating Group & Forestry Canada - copy attached as an addendum to this document).

B. ***Mammalian***

The United States Environmental Protection Agency recognizes a substance as being acutely toxic to mammals only if it induces mortality in animals when administered in doses up to 5.0 g/Kg. The active constituents of PYROCOOL FEF, when tested at the levels used in the product, did not induce any mortality in laboratory animals. The median "lethal dose" required to cause mortality in 50% of the test groups (i.e. the "LC50") was, therefore, determined to be in excess of 5.0 g/Kg. PYROCOOL FEF, accordingly, is not considered acutely toxic to mammals.

CONCLUSION

In its use solution, PYROCOOLTM FEF, because of its rapid biodegradability, is "environmentally friendly", and poses no practical risk whatsoever of either toxicity or corrosion. In its concentrate form, only normal precautions against spillage and corrosion, as would be employed with any chemical, are required.