F-500 ENCAPSULATOR TECHNOLOGY

**Insurance Services Office (ISO)**
**FSRS Equivalency List**
**Credit Recognition**

## COMPETITIVE COMPARISON

# The Advantages of Using F-500 Encapsulator Agent

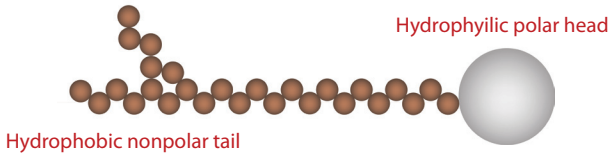
### F-500 Encapsulator Agent

Four elements are required to create a fire. This is known as the fire tetrahedron. Eliminating any of these elements can extinguish a fire. Foam separates the oxygen from the fuel, effectively eliminating one element, the oxygen. F-500 EA works on three elements at once, removing the heat, neutralizing the fuel and interrupting the free radical chain reaction. This results in faster knockdown of the fire, permanent burn back resistance and elimination of most of the steam, soot, smoke and cancer-causing toxins.


Fire Tetrahedron

### How F-500 Encapsulator Agent Works

F-500 EA immediately reduces the surface tension of the water. This makes the water droplets smaller creating more surface area to absorb heat and better penetrate into the pores of solid fuels.

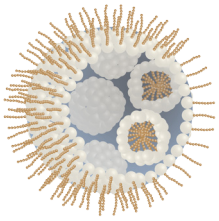



Large, amphipathic F-500 EA molecule

F-500 EA is a large amphipathic molecule, meaning it has a hydrophilic polar head and a hydrophobic nonpolar tail that act independently. When mixed with water, the F-500 EA molecules form spheres, or micelles, as the nonpolar tails try to get away from the water. As these micelles leave the nozzle, the nonpolar tails nearest the surface turn outward, forming a protective skin around the F-500 EA droplet. There will be many micelles within the F-500 EA droplets. F-500 EA tails have an affinity for hydrocarbons and attach themselves to the fuel, whether it is liquid or vapor. The nonpolar tails turn inward toward the hydrocarbon forming micelles or chemical cocoons around the hydrocarbon molecules. The hydrocarbon is now nonflammable.



F-500 EA Micelles

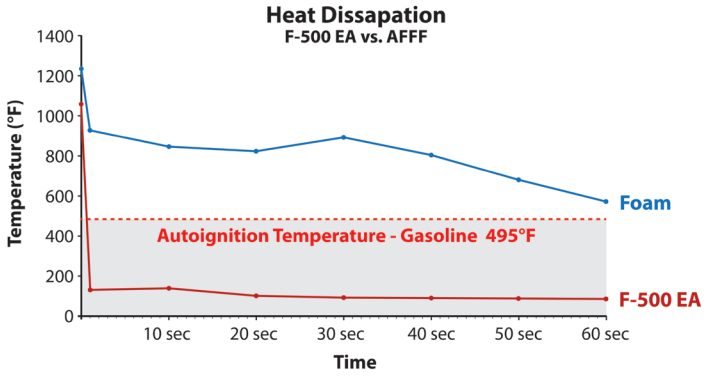


F-500 EA droplet surrounded by F-500 EA molecules with extruding nonpolar tails.

F-500 EA micelles surround hydrocarbons

Plain water droplets convert to steam as they heat up, but F-500 EA droplets are surrounded by F-500 EA molecules and efficiently absorb the heat by Thermal Conveyance. In fact, tests show these droplets remove 6-20 times more heat than plain water droplets.

The cooling of the fuel is rapid. The chart shows the testing of two steel plates heated to 1200°F. Notice within seconds, the F-500 EA reduced the temperature to 127°F. The foam traps in the heat and remains above the autoignition temperature of the fuel throughout the test.




Clemson University heat dissapation test shows F-500 EA rapidly reduces heat

The F-500 EA reduces the surface tension of the water increasing the penetration into the fuel. F-500 EA reduces the temperature, preventing burn back, and encapsulates the fuel rendering it nonflammable. The final step is the interruption of the free radical chain reaction. This reduces smoke and soot, greatly reducing toxins, including cancer-causing toxins and improving visibility for firefighters.

## The Evolution of Firefighting Foams

Firefighting foams became prevalent in the 1960's and have gone through many improvements over the years. Every firefighter is familiar with foam and the techniques necessary to fight fires. Foam creates a blanket, separating the fuel from the oxygen, smothering the fire. Companies designed foams that could withstand high heat and foams that were more viscous so the foam blanket wouldn't fail before the fuel had a chance to cool down below the autoignition temperature. Foams were created that were resistant to alcohols. Then, in 2002, companies realized the foams they were using contained toxic fluorine and had bioaccumulative characterististics. In the United States and Australia, it was legal to use existing stocks of fluorine foams. In Canada, fluorine foams could not be used after May, 2013 and in Europe they had to be incinerated. There was a great shift to replace these foams with fluorine-free foams. On September 11, 2010, 40 delegates from around the world met in Adelaide, Australia to discuss firefighting foams. One conclusion was today's foams last 30% as long as the old PFOS foams and require three times the amount of concentrate and produce three times the amount of run-off. The delegates also noted the "environmentally friendly" fluorine-free foams are generally categorized as R51/53, which is toxic to aquatic life with long-term effects to the aquatic environment.

**F-500 Encapsulator Technology vs. AFFF Foams**
**Advantages and Benefits**

| | F-500 EA | AFFF Foams |
|---|---|---|
| **Encapsulation**<br>• Neutralizes hydrocarbon molecules | F-500 EA molecules are attracted to hydrocarbons forming "micelles" or chemical cocoons. Hydrocarbons become permanently nonflammable and nonignitable. | AFFF foam has no molecular effect on hydrocarbon molecules, or any fuel. |
| **Three-Dimensional Fires**<br>• Vertical surfaces<br>• Transformers<br>• Pressurized piping | F-500 EA is highly effective at extinguishing three-dimensional fires since F-500 EA does not rely on a blanket of foam to smother a fire. | NFPA 11-Annex A.1.1 states "Foam is not suitable for three-dimensional flowing liquid fuel fires or for gas fires" because foam cannot create a smothering foam blanket. |
| **Heat Reduction** | F-500 EA dramatically reduces the temperature of the fuel and surrounding structures by thermal conveyance through the large F-500 EA molecules rather than converting to steam, like plain water. | A blanket of foam literally traps the heat. If the trapped heat exceeds the autoignition temperature of the fuel, reignition can occur. The blanket of foam must be re-established until the temperature drops. |
| **Smoke and Toxic Soot** | F-500 EA interrupts the free radical coalescence, which must be present for a fire to occur. Tests show smoke is reduced 97%, increasing visibility, and soot toxicity is reduced by 98.6%. | Most of the toxic soot remains trapped under the blanket of foam. |
| **Environmental** | F-500 EA is an ecological agent, containing no flourines. F-500 EA is noncorrosive, nontoxic and biodegradable. It is even listed as a surface washing agent by the EPA. | In the United States, existing stocks of AFFF foam containing flourines can be used, however they are being replaced by less effective flourine-free foams. Firefighters from around the world agreed these new foams last 30% as long as flourine foams and therefore require three times the water, increasing run-off significantly. The new foams are categorized as R51/53, which is toxic to aquatic life with long-term effects to aquatic environments. |

F-500 ENCAPSULATOR TECHNOLOGY

## F-500 Encapsulator Technology vs. AFFF Foams
## Fire Classifications

| | F-500 EA | AFFF Foams |
|---|---|---|
| **Class A Fires**<br>• Flammable solids<br>• Wood, cloth, rubber | F-500 EA reduces the surface tension of the water allowing for deep penetration into the pores of the fuel. F-500 EA's rapid cooling results in fast knockdown and excellent burnback resistance. | Not applicable; must use a Class A foam for Class A fires. |
| **Class B Fires - Nonpolar**<br>• Flammable liquids<br>• Gasoline, jet fuel, heating oil | F-500 EA forms micelles around the hydrocarbon liquid and vapor molecules rendering them nonflammable. F-500 EA encapsulates, then cools the fuel so it cannot reignite. | AFFF (foam) must separate the fuel from the oxygen. For Class B fuel spills, NFPA 11-Table 5.8.2.2 states foam must be applied for a minimum of 15 minutes at 0.10 gpm/ft$^2$. The amount of foam and water required far exceeds the F-500 EA and water used for a comparable fire. |
| **Class B Fires - Polar**<br>• Flammable liquids<br>• Ethanol-blended fuels (E10, E85), ethanol, acetone, butanol | F-500 EA can encapsulate both ethanol and ethanol-blended fuels rendering them nonflammable and nonignitable. | Ethanol will break down the AFFF (foam) because it is water-based. An expensive AR-AFFF foam must be used in these circumstances. Even then, it must form a blanket and smother the fire. |
| **Class C Fires**<br>• Class A or B, plus electrically energized objects<br>• High-voltage transformers<br>• High-voltage car batteries | F-500 EA is not recommended for general Class C fires, however, F-500 EA was the only agent tested by ConEdison at 345 kV with negligible electrical feedback to the nozzle. Transformer fires should be attacked after they are de-energized, but there is no need to be concerned about peripheral equipment that could still be energized.<br>Bosch of Germany tested various agents for high-voltage battery fires and only recommends F-500 EA. Dekra, Daimler and Deutsche ACCUmotive also tested agents on lithium-ion battery fires and concluded F-500 EA was the recommended agent to extinguish hybrid and electric vehicle fires. | AFFF (foam) is highly conductive. Transformers are a three-dimensional, hot oil fire with large amounts of hot metal, making AFFF foam ineffective. AFFF (foam) has also been proven to be ineffective on high-voltage, lithium-ion battery fires. |
| **Class D Fires**<br>• Combustible metals<br>• Magnesium, titanium, sodium | Applying foam to combustible metals creates an explosive situation since the foam is applied with water which releases hydrogen and oxygen. F-500 EA molecules are hydrophylic and attach themselves to water droplets. This prevents the droplets from evaporating and reduces the heat rapidly. With F-500 EA there is no violent reaction from the molten metal. | AFFF foam is not to be used on Class D fires and will create an explosive situation. |

# The Economics of Using F-500 EA vs. Foam

F-500 ENCAPSULATOR TECHNOLOGY

The *NFPA 11- Standard for Low, Medium and High Expansion Foam* (Table 5.8.2.2.) states foams must be applied to a nondiked hydrocarbon spill for a minimum of 15 minutes at an application rate of 0.10 gpm/ft$^2$ or 3%. A "nondiked spill" describes a real world spill situation where the fuel spreads freely, not confined by walls or barriers.

As an example, assume 8 gallons of gasoline has spilled on the highway. Eight gallons equates to an 800 sq. ft. spill. To completely encapsulate the spill, 1-gallon of F-500 EA would need to be added to 40-gallons of water. This is a calculated and tested ratio of 1 part F-500 EA, 8 parts fuel and 40 parts of water. The firefighter would set the F-500 EA eductor to 3% and encapsulate the spill in about 30 seconds with an 80 gpm nozzle and hand line. In contrast, the foam will need to be applied for 15 minutes, per the NFPA foam standard. At 3%, using an 80 gpm nozzle, 1,200 gallons of water will be applied and 36 gallons of AFFF foam. If the foam blanket breaks down while the gasoline temperature is still high, additional foam will need to be applied.

The cost of F-500 Encapsulator Agent is comparable to the AFFF foam, but only one gallon of F-500 EA was required compared to 36 gallons of foam. The spill would more than likely be a ethanol-blended fuel, such as E10, in which case, a more expensive AR-AFFF foam would have been required. In a remote highway setting, the pumper truck would need to be carrying 1,200 gallons or more of water.

**Comparison of Agents Required to Mitigate 800 sq. ft. Spill**

| | Proportion in Water | Spill (ft$^2$) | Gpm | Time to Mitigate Spill | Gallons of Water | Agent Required @ 3% (gals) |
|---|---|---|---|---|---|---|
| **F-500 Encapsulator Agent** | 3% | 800 | 80 | 30 secs | 40 | 1 |
| **AFFF Foam** | 3% | 800 | 80 | 15 mins * | 1,200 | 36 |

*Per *NFPA 11- Standard for Low, Medium and High Expansion Foam* (Table 5.8.2.2.)

Finally, F-500 EA is listed by the EPA as a "surface washing agent." Once the spill has been encapsulated it can be easily cleaned up as a nonflammable material, or allowed to evaporate, if permitted by local regulations. On the other hand, the application of foam has left 1,200 gallons of water and 36 gallons of foam. The fuel is still hazardous and flammable and must be removed and hauled away at great expense. Applying absorbent soaks up the fuel, but now the absorbent is flammable. The 1,200 gallons of water are going to run-off somewhere, which could harm the environment or result in fines.

In this chart, you can see the various fire-fighting agents required to fight different fires. Pumper trucks carry various foams and agents to handle these hazards when all they really need to carry and inventory is F-500 Encapsulator Agent.

| Type of Fire | Fire Suppression Agent Required | |
|---|---|---|
| **Class A** | **F-500 Encapsulator Agent** | Class A foam |
| **Class B-Gasoline** | | AFFF foam |
| **Class B-Ethanol** | | AR-AFFF foam |
| **Class C *** | | Powder; $CO_2$; not foam |
| **Class D** | | Powder; not foam |

* Class C Fires - F-500 EA has been tested and recommended by ConEdison/FDNY for de-energized transformer fires and by multiple companies for lithium-ion battery fires.

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