

# The Role of Fluoro-Surfactants in AFFF

## DuPont M-TEC Technical Centre

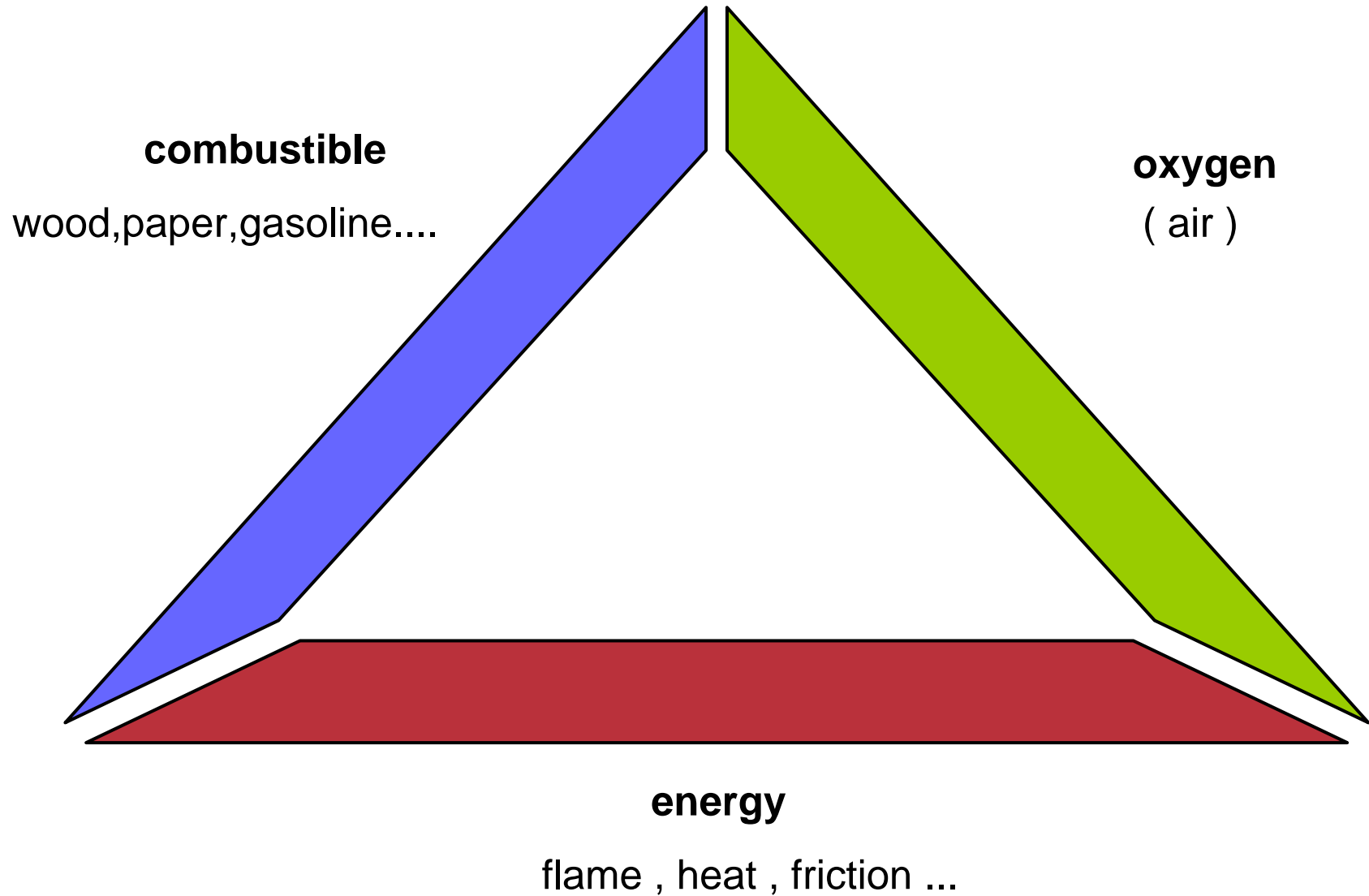
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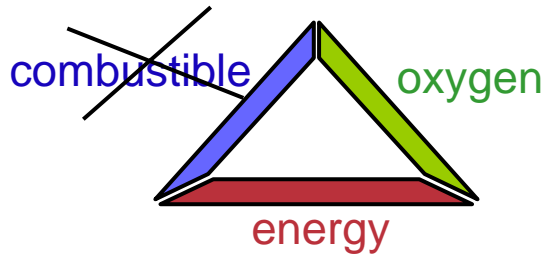
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# The Fire Triangle



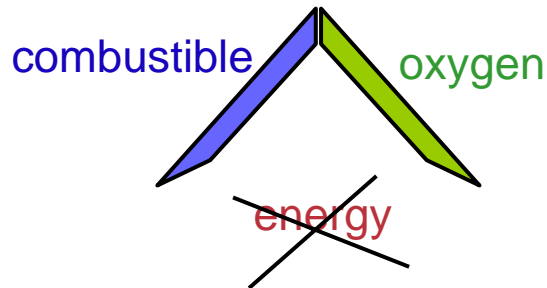
# The Fire Triangle

## How to extinguish the fire ?



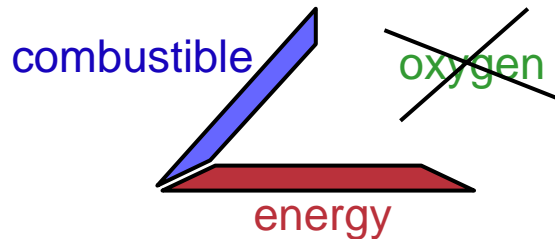
### Suppression of the combustible

- isolation of the combustible from the oxygen with sand, blanket, foam, **aqueous film from AFFF**



### Suppression of the energy

- cooling down with water



### Suppression of the oxygen

- replacement of air by nitrogen or CO<sub>2</sub> or water mist

# The Classes of Fire

## CLASS A FIRE =

- All material that produces embers
  - wood ; paper ; straw ; cotton .....

## CLASS B FIRE =

- combustible liquid
  - hydrocarbon solvent ; gasoline ; alcohol ; keton .....

## CLASS C FIRE =

- gas fire

## CLASS D FIRE =

- metal fire

# AFFF:

## AQUEOUS FILM FORMING FOAM

For non water-miscible solvents fires  
(hydrocarbon solvents, gasoline....)

# AFFF- AR:

**AQUEOUS FILM FORMING FOAM  
ALCOHOL-RESISTANT**

For water-miscible solvents fires ( alcohols,ketons....)

# FFFP:

## PROTEIN FLUORO FILM FORMING

For non water-miscible solvents fires  
(hydrocarbon solvents, gasoline....)

# FFFP-AR:

**PROTEIN FLUORO FILM FORMING  
ALCOHOL-RESISTANT**

For water-miscible solvents fires ( alcohols,ketons....)

# Film Formation-Spreading Coefficient

$$SC = ST(H) - (ST(s) + ST(i))$$

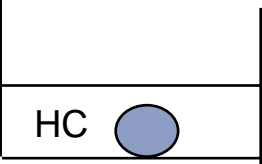
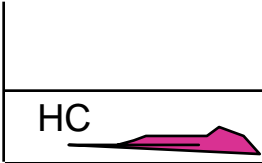
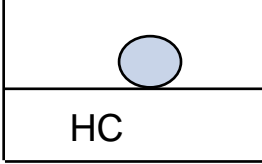
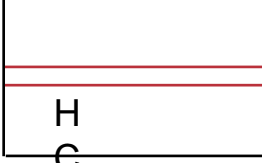
$ST(H)$  = surface tension of hydrocarbon solvent

$ST(s)$  = surface tension of aqueous solution

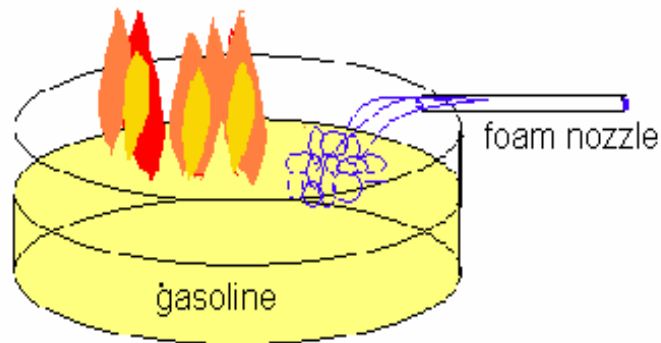
$ST(i)$  = interfacial tension hydrocarbon / solution

**for an AFFF solution SC must be  $> 0$**

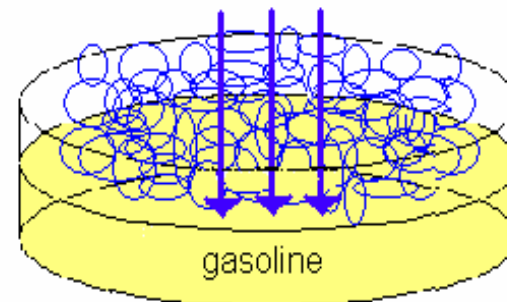
# Film Formation-Spreading Coefficient

	ST hydrocarbon		ST aqueous solution		IT hydrocarbon/solution		SC
<p>water</p> 	22	-	( 72	+	44.5 )	=	<b>- 94.5</b>
<p>hc surfactant</p> 	22	-	( 35	+	0 )	=	<b>- 13</b>
<p>fs surfactant</p> 	22	-	( 16	+	6 )	=	<b>0</b>
<p>AFFF solut.</p> 	22	-	( 16	+	3 )	=	<b>3</b>

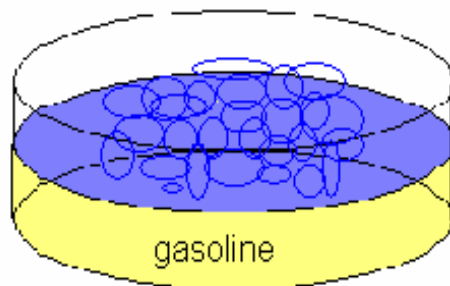
# THE ACTION OF AFFF AND FFFP



1- the foam smothers the flames

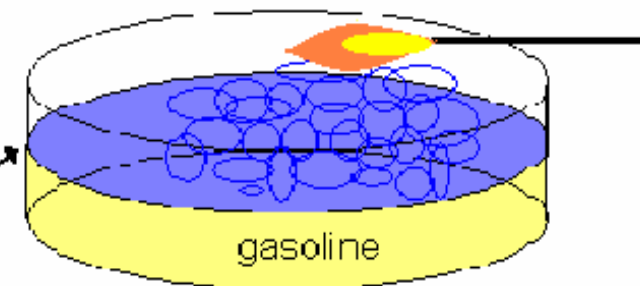


2- Solution drains from the foam



3-leaving a film of AFFF

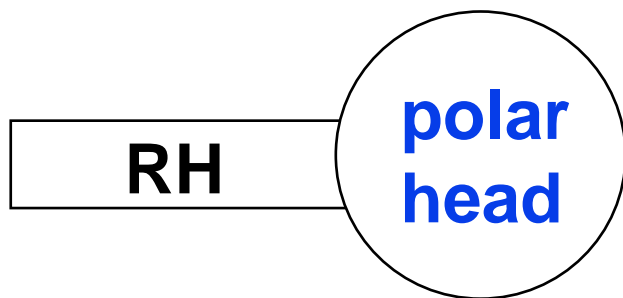
thin film of AFFF



4- no burnback

# SURFACTANTS

## HYDROCARBON SURFACTANT

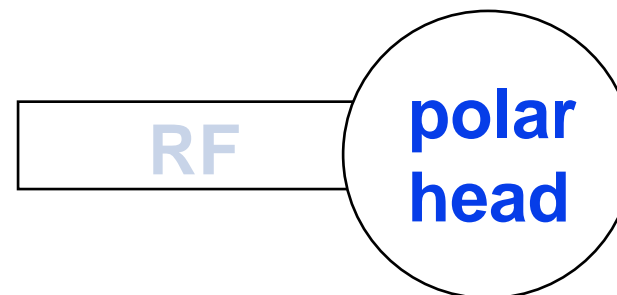


**hydrophilic**  
**oleophilic**

**lowers interfacial tension**

between AFFF solutions and hydrocarbons

## FLUORINATED SURFACTANT



**hydrophilic**  
**oleophobic**

**lowers surface tension**

of AFFF solutions

# Main standards for foam concentrates



**ISO 7203-1 (International)**



**EN 1568-3 (European)**

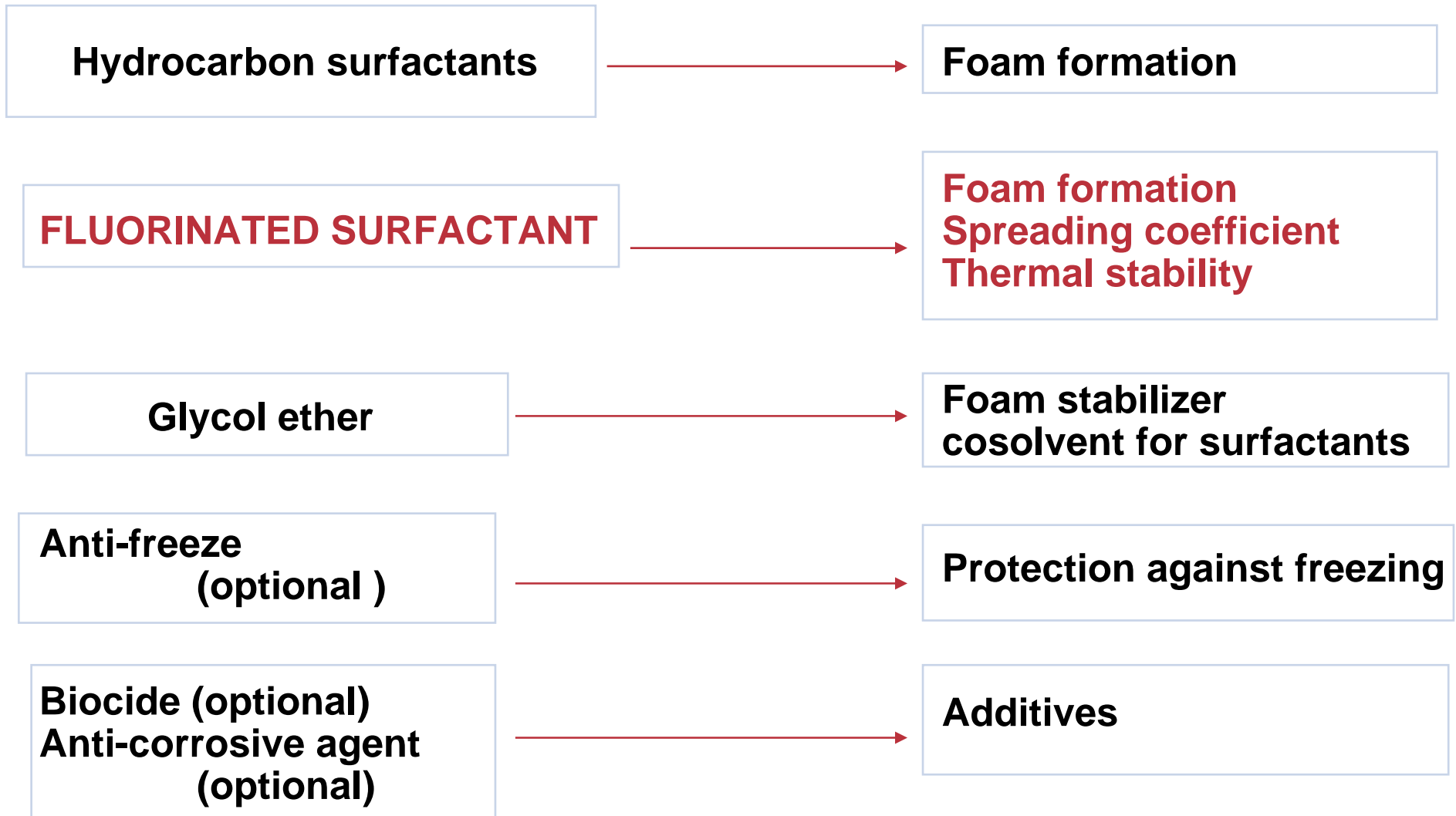


**UL 162 (US)**

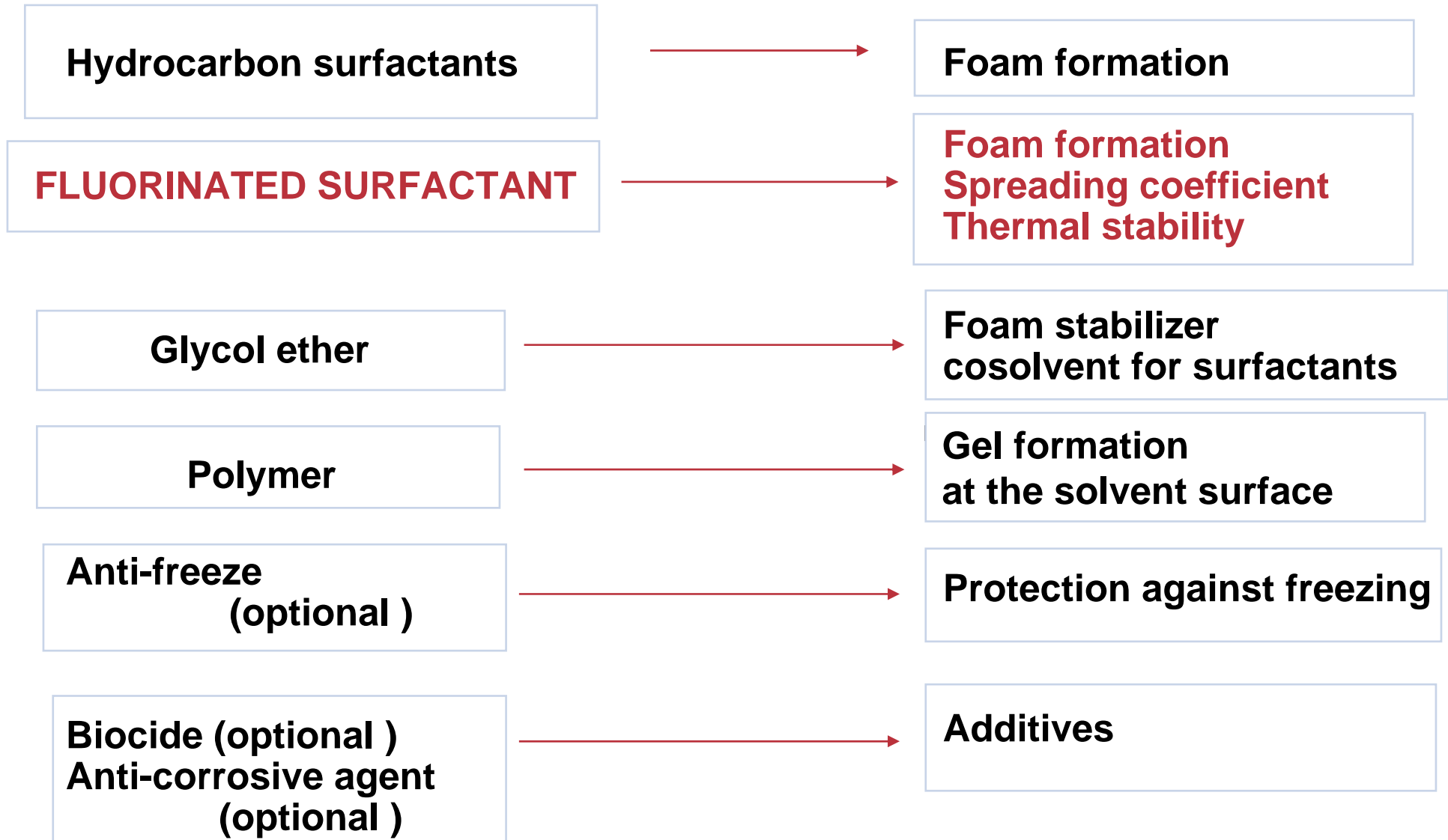


**Mil.Spec. F-24385F (US Military)**

## COMPOSITION OF AFFF FOAM CONCENTRATE FOR hydrocarbon solvents/gasoline



## COMPOSITION OF AFF-AR FOAM CONCENTRATE FOR HYDROCARBON SOLVENTS AND WATER-MISCIBLE SOLVENTS (ALCOHOLS , KETONES...)



## USE OF AQUEOUS FOAM FOR FIRE FIGHTING (SOLVENT FIRE)

**FOAM used to :** - Deposit water at the solvent surface

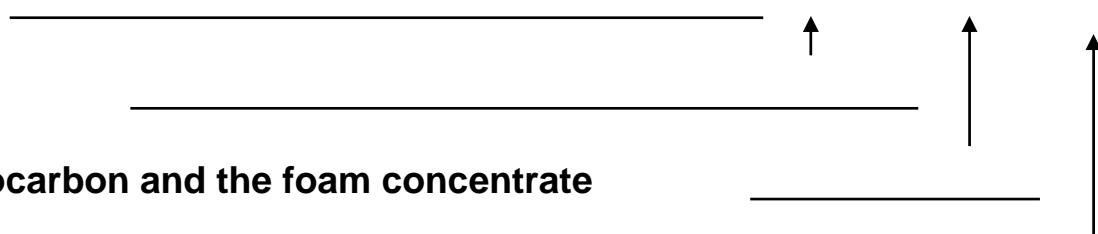
**REQUIRED PROPERTIES :** - Stability at a temperature as high as possible

- spreading on the solvent :  $SC = \gamma_{HC} - (\gamma_s + \gamma_i)$

Hydrocarbon surface tension

Foam concentrate surface tension

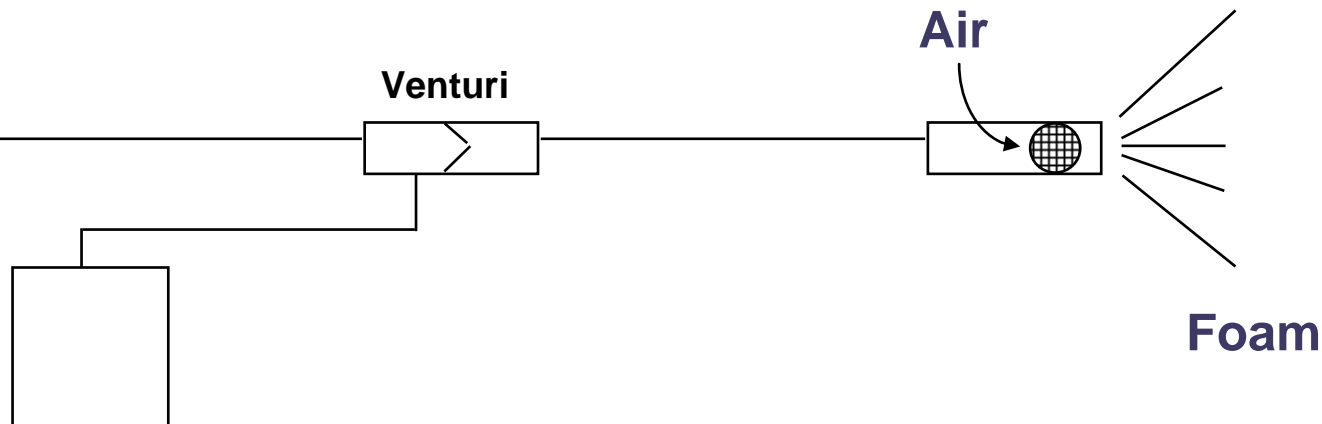
Interfacial tension between the hydrocarbon and the foam concentrate



**FOAM CREATION :**

Water

Foam concentrate



## COMPOSITION OF A FOAM CONCENTRATE FOR POLAR SOLVENTS

Hydrocarbon surfactant  
or protein

Foam formation

**FLUORINATED SURFACTANT**

**Foam formation**  
**Spreading coefficient**  
**Thermal stability**

Butylcarbytol

**Foam stabilizer**  
**cosolvent for surfactants**

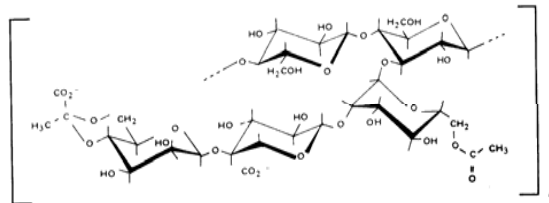
1,2 propane diol

**Protection against freezing**

Polysaccharide

**Gel formation at the solvent  
surface**

$M_w \approx 2,5 \cdot 10^6$





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