Oil and Grease

Types and Sources
Environmental Problems
Removal of Free Oil
Emulsion Breaking
Sampling and Analysis

Prepared By
Michigan Department of Environmental Quality
Operator Training and Certification Unit

Oil and Grease

<u>Animal / Vegetable</u>

Sources

Meat Packing

Food Processing

Restaurants

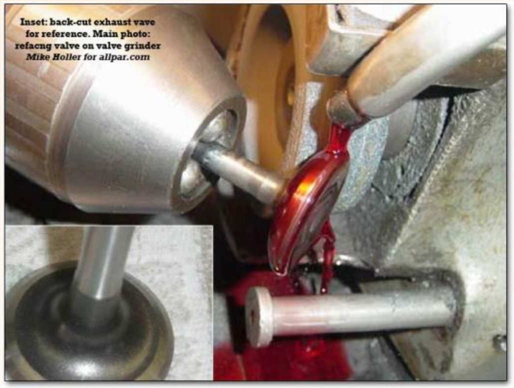
Biodegradable

Usually Free Floating

Oil and Grease

Petrochemical

Sources



- Cutting / Grinding
- Parts Degreasing
- Automotive

Toxic

Often Emulsified

Typical Ranges of Oil and Grease in Wastewater

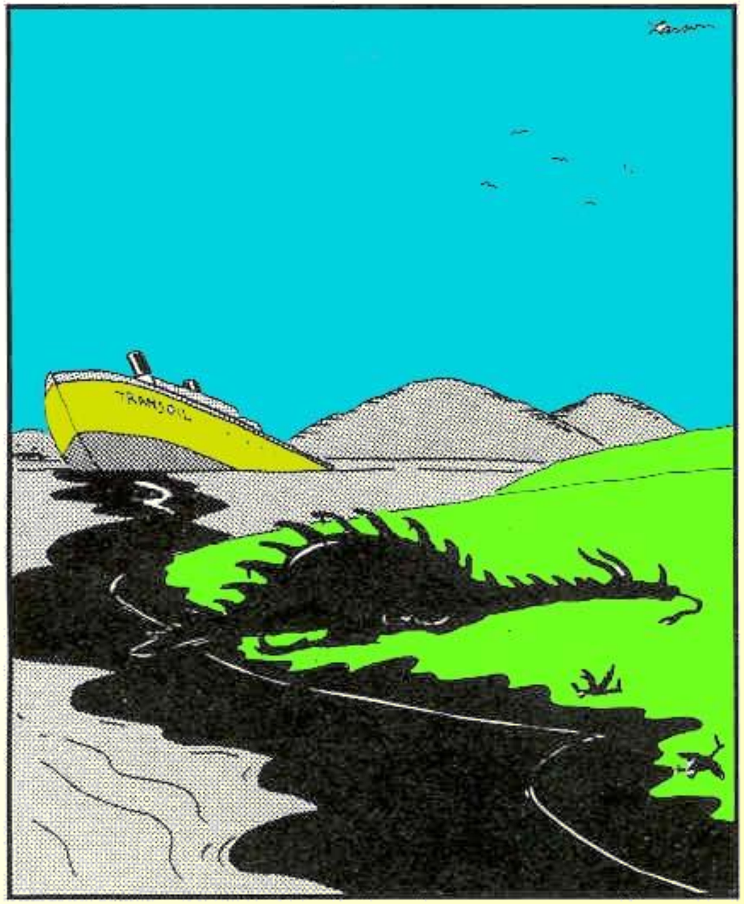
Wastewater	Range, mg/L
Sewage	10 - 100
Food Processing	100 - 1,000
Textile	10 - 500
Refining	100 - 1,000
Primary Metals	
Rinse Waters	10 - 1,000
Concentrates	10,000 - 50,000
Metals Fabrication	10,000 - 100,000
Metal Cleaning	
Rinse Waters	10 - 1,000
Concentrates	100 - 5,000
Commercial Laundries	100 - 2,000

So What's The Problem With Oil and Grease ??

Environmental Problems

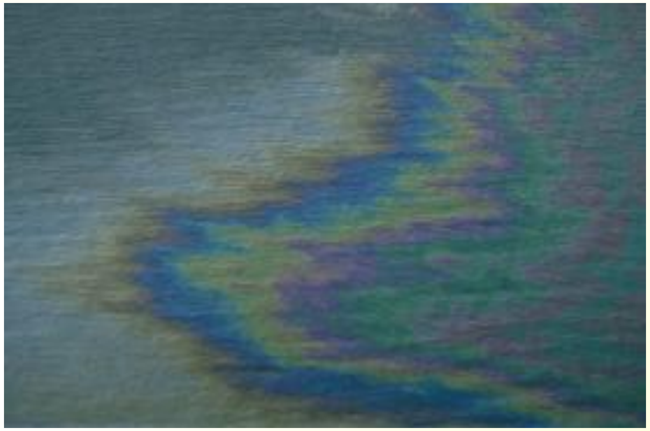
Collection System Probs

WWTP Problems



A tragedy occurs off the coast of a land called Honah-Lee.

Environmental Problems

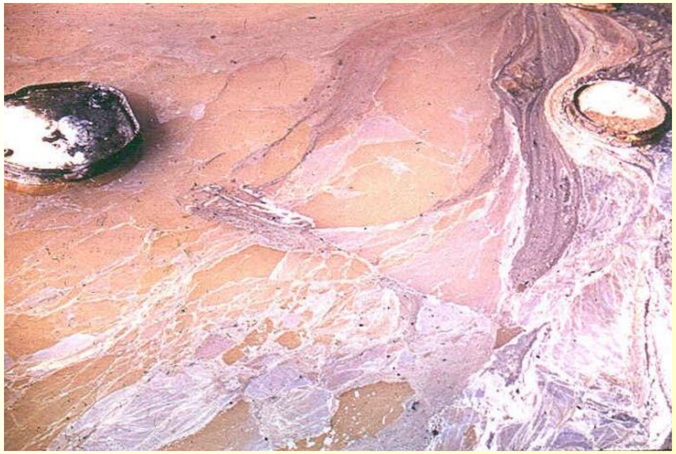


Toxicity

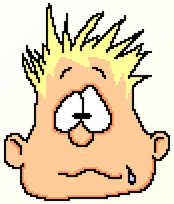
Suffocation

Prevents O_2 Transfer into the Water

Aesthetics



Environmental Problems



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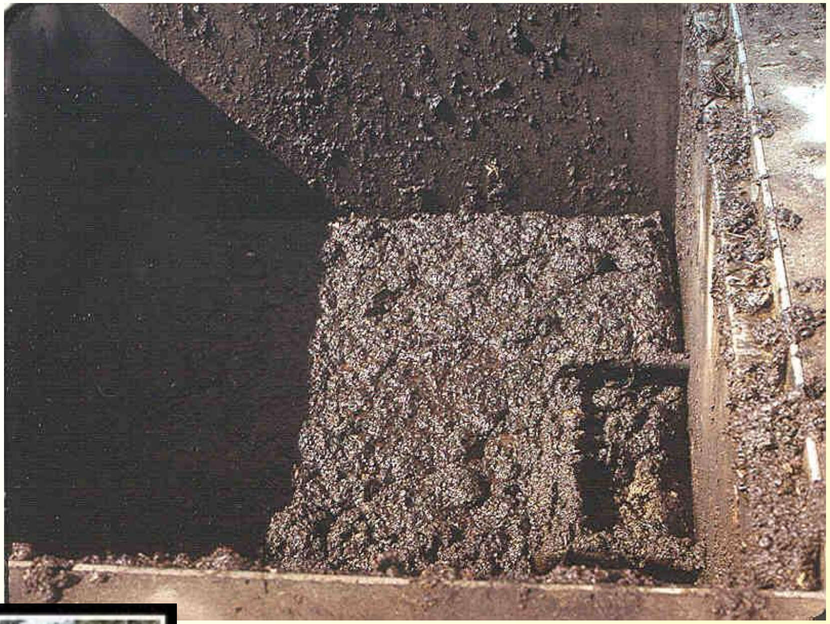
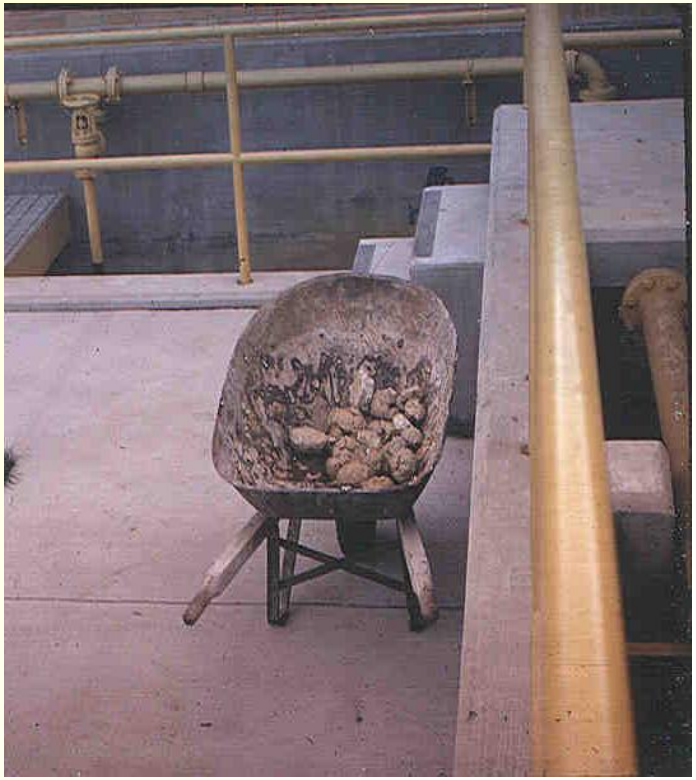
Collection System



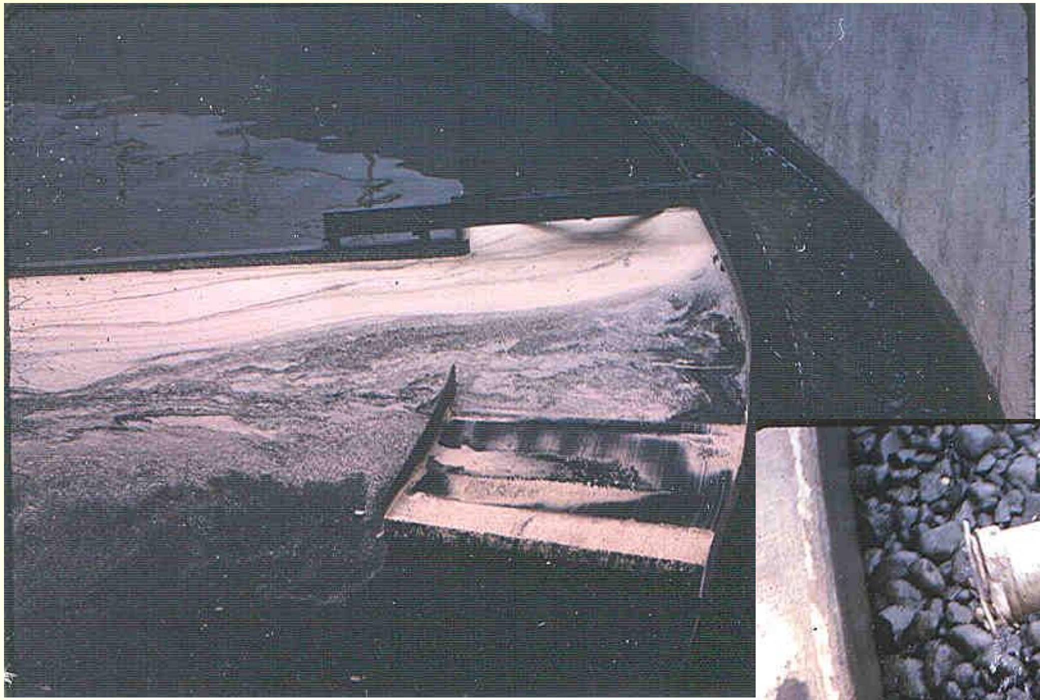
Collection System

Estimated – 40 to 50 %

WWTP Problems - Maintenance



WWTP Problems – Treatment Efficiency



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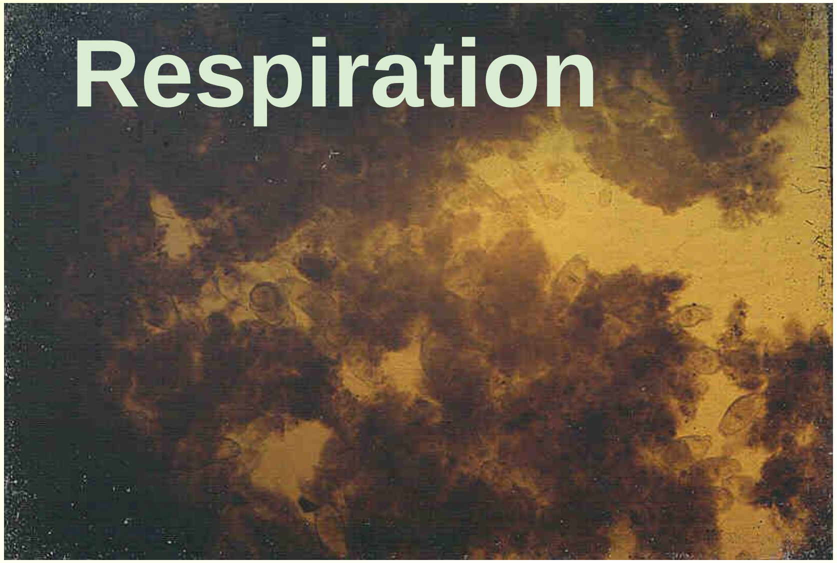
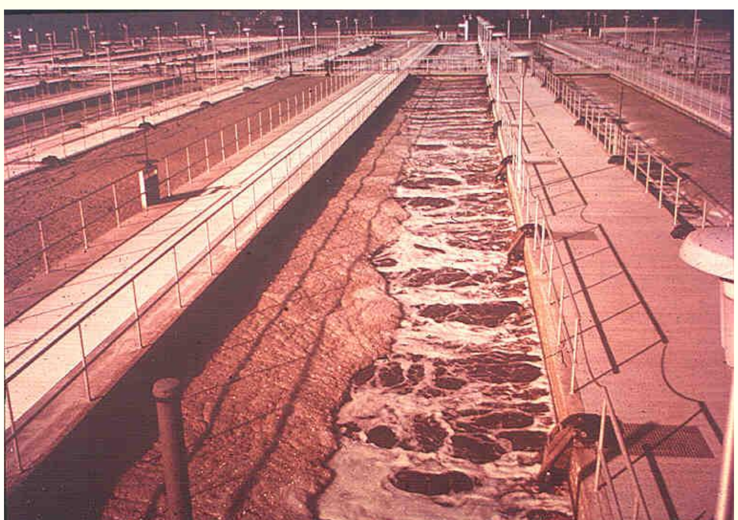
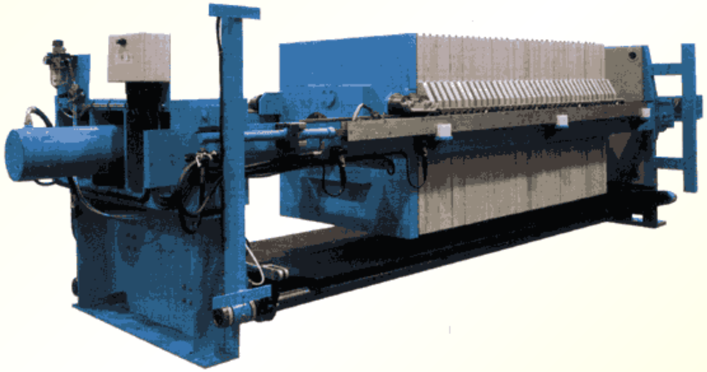


Settleability



Foaming

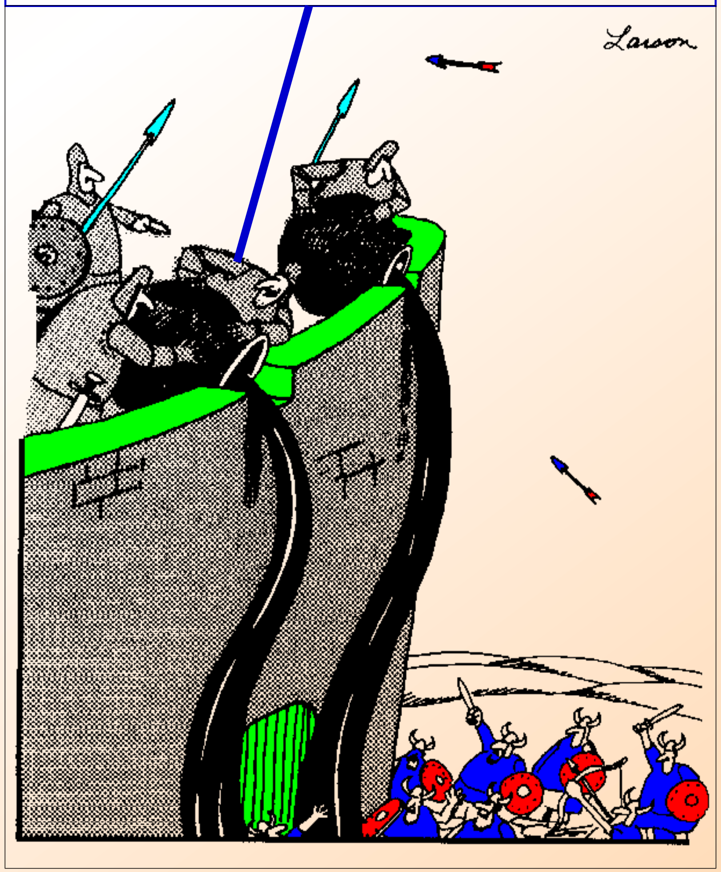
WWTP Problems – Solids Handling



Oil and Grease (FOG)

NEED TO CONTROL

"You know, I have a confession to make, Bernie. Win or lose, I love this job."



Oil and Grease (FOG)

At the Source

NEED TO CONTROL

SEWER USE ORDINANCE

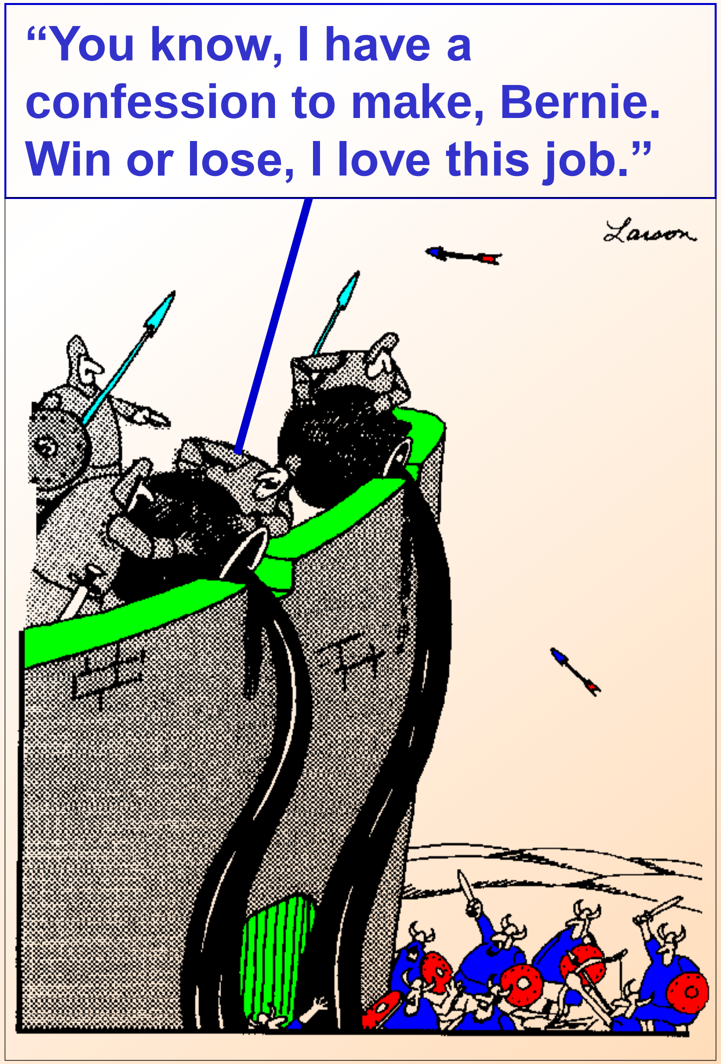
A Means to Regulate Discharges of Pollutants which could Harm the Collection System and Treatment Processes.

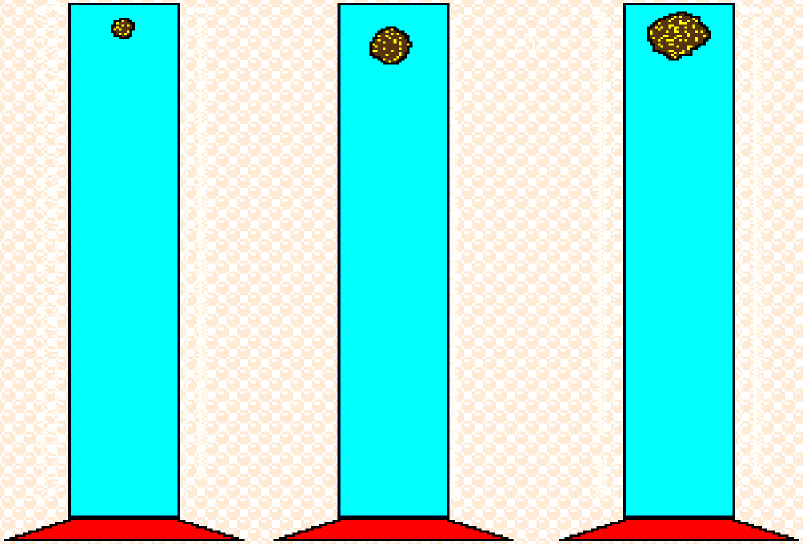
Help to Control

- Hydraulic Loading
- Organic Loading
- Hazardous Materials
  - Corrosive
  - Nuisance
  - Toxic
  - Safety

Oil and Grease (FOG)

NEED TO REMOVE
What Can't
Be Controlled at Source



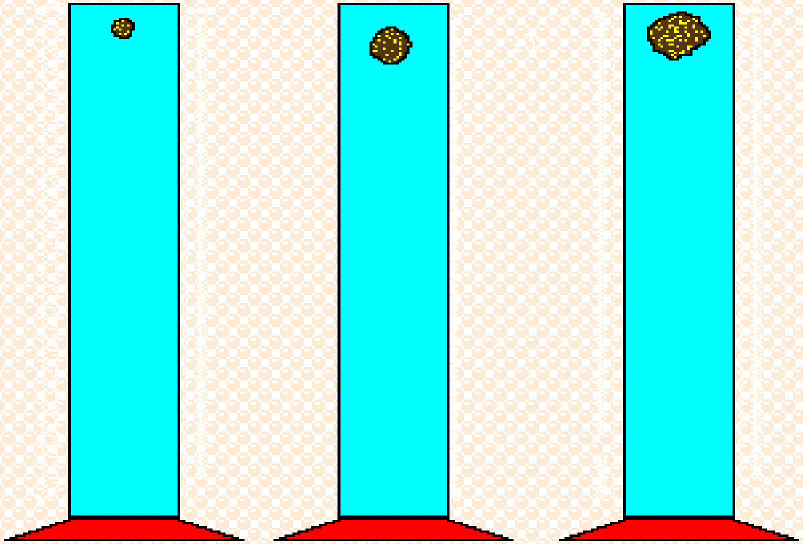


Factors Affecting Separation of Free Oil From Water

Stoke's Law

$$VR = \frac{2(p - p_o)g}{9n}(d/2)^2$$

VR	Rise Velocity
$(p - p_o)$	Density difference between oil droplet and water
n	viscosity of water and oil
g	gravitational acceleration constant
d	diameter of the oil droplet



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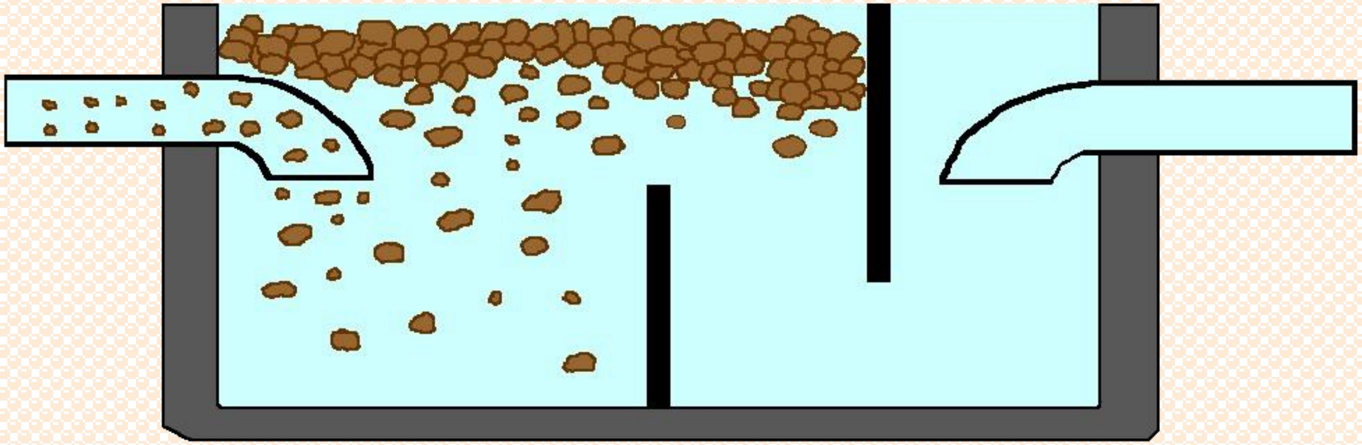
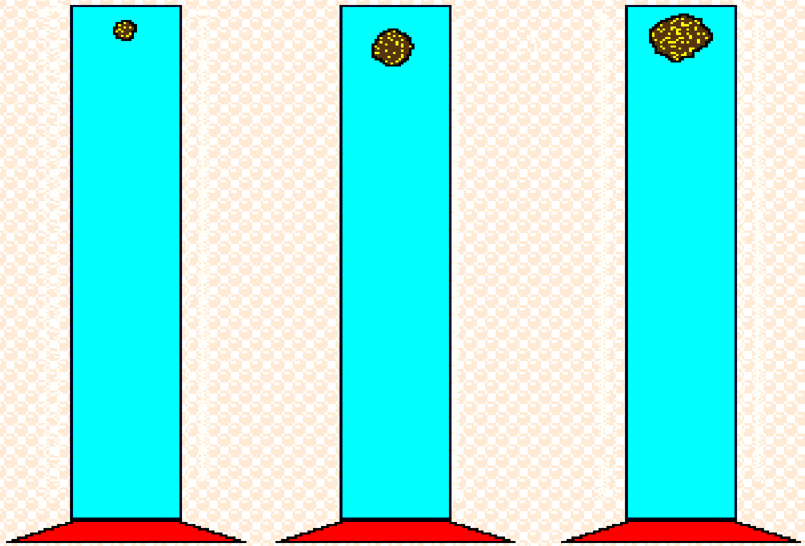
Factors Affecting Separation of Free Oil From Water

Density (Specific Gravity)

Viscosity

Droplet Size





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Factors Affecting Separation of Free Oil From Water

Specific Gravity = the number of times heavier or lighter the solution is than water

Specific Gravity of a Solution = $\dfrac{\text{Weight of the Solution}}{\text{Weight of Water}}$

1 gallon of water weighs 8.34 lbs **Specific Gravity of water = 1.000**

Hydrometer

Sp. Gr. of Oils < 1

Factors Affecting Separation of Free Oil From Water

#6 Fuel Oil SG = 0.95 **#2 Fuel Oil SG = 0.85**

Water SG = 1.00

VR **Rise Velocity Related To**

$(p - p_o)$ **Density difference between oil droplet and water**

Factors Affecting Separation of Free Oil From Water

#6 Fuel Oil SG = 0.95 **#2 Fuel Oil SG = 0.85**

Water SG = 1.00

#6 Fuel Oil	#2 Fuel Oil
1.00	1.00
- .95	- .85
0.05	0.15

Which Will Rise Faster?

How Much Faster?

Factors Affecting Separation of Free Oil From Water

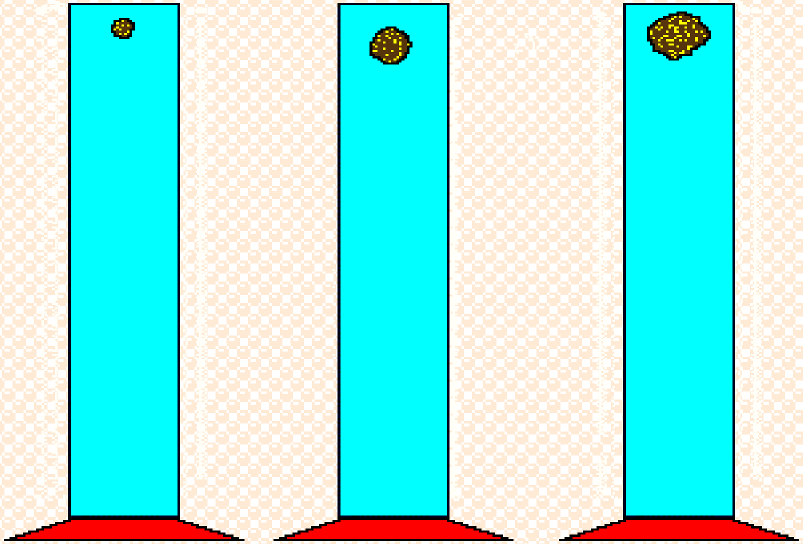
#6 Fuel Oil SG = 0.95 #2 Fuel Oil SG = 0.85

Water SG = 1.00

#6 Fuel Oil	#2 Fuel Oil	
1.00	1.00	
- .95	- .85	
0.05	0.15	

$$\frac{0.15}{0.05} = 3$$

#2 Fuel Oil Will Rise 3 Times Faster in Water Than #6 Fuel Oil



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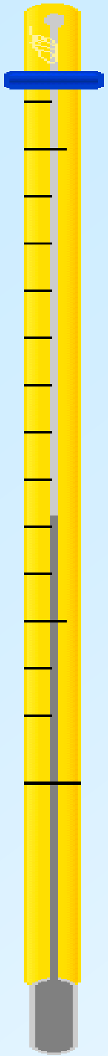
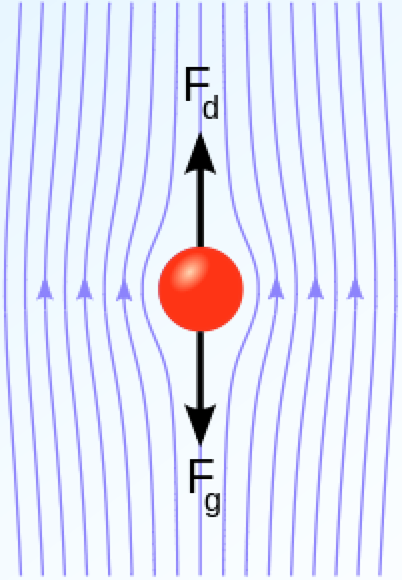
Effect of Temperature on Separation of Oil From Water



Viscosity is Related to Friction - High Viscosity Opposes Flow

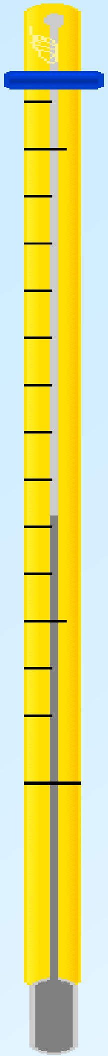


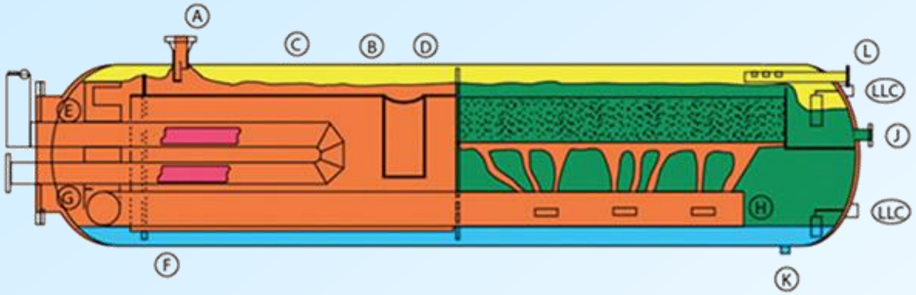
The Lower the Viscosity of the Oil, the Faster it will Rise in Water

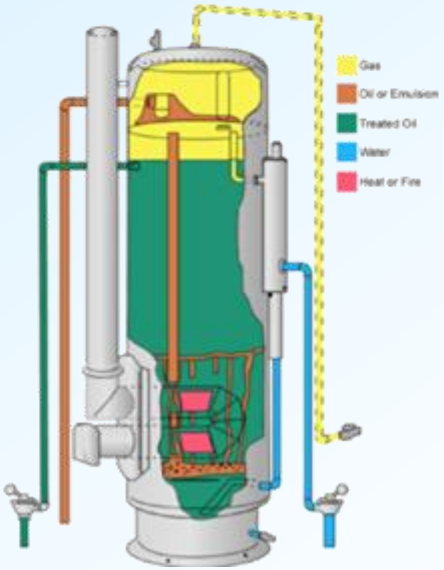
An Increase in Temperature Will Cause the Viscosity to Decrease

Oil Droplets in Water at 40 Degrees F will Rise at Half the Rate of Oil Droplets in Water at 90 Degrees F.

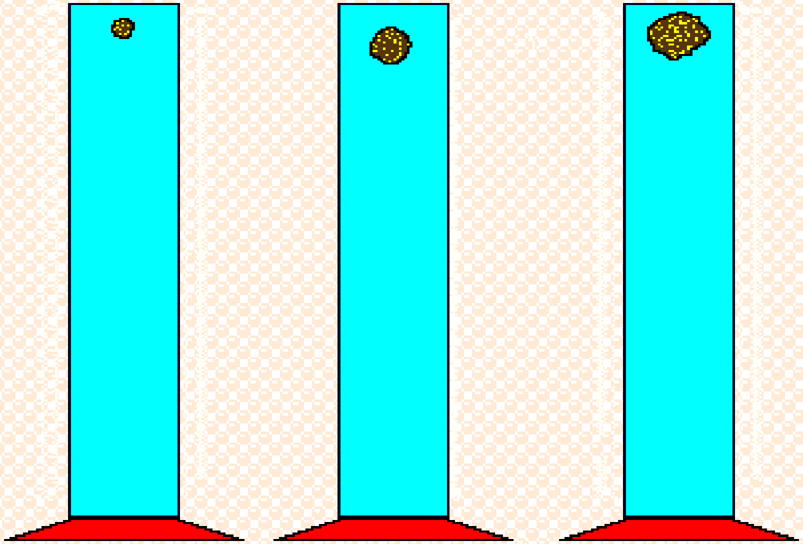
Effect of Temperature on Separation of Oil From Water







An Increase in Temperature Will Cause the Vi



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d	diameter of the oil droplet

Time Required for an Oil Droplet to Rise Three Feet @ 68 Degrees F

SG = 0.85

Droplet Size µm	Droplet Size mm	Rise Time (Hr:Min:Sec)
300	0.300	0:00:12
150	0.150	0:00:42
125	0.125	0:01:00
90	0.090	0:01:54
50	0.050	0:06:18
30	0.030	0:17:24
10	0.010	2:35:02
1	0.001	258:23:53

Types of Oil / Water Separators

Grease Trap

Skimmer

API (American Petroleum Institute)

CPI (Corrugated Plate Interceptor)

Hydro Cyclone

Centrifuge

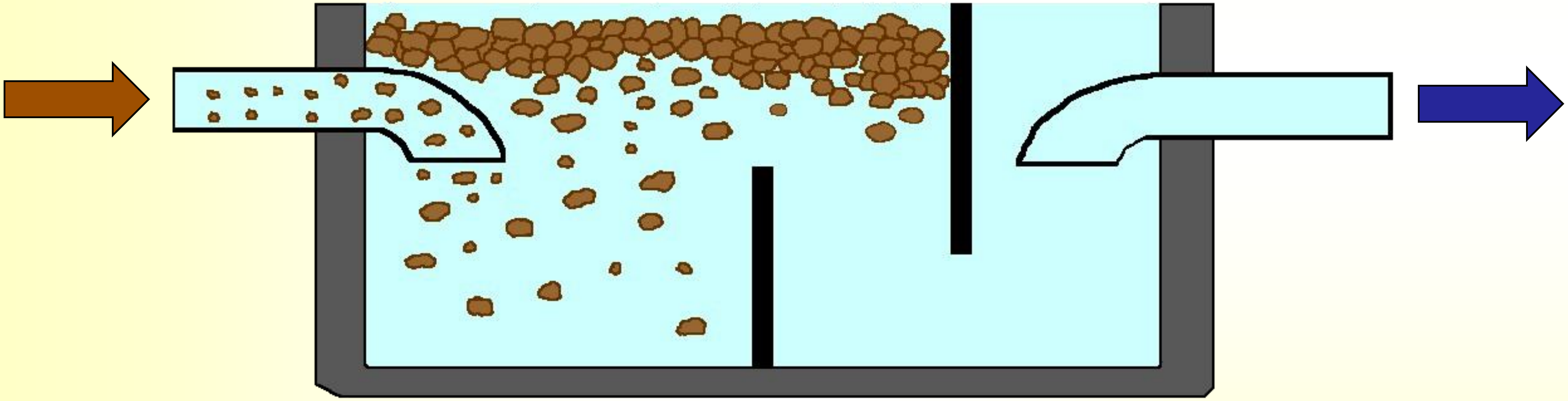
Dissolved Air Floatation

Filtration

Oil and Grease (FOG)

Removal of Free Floating Oil

API Separator (Interceptor)



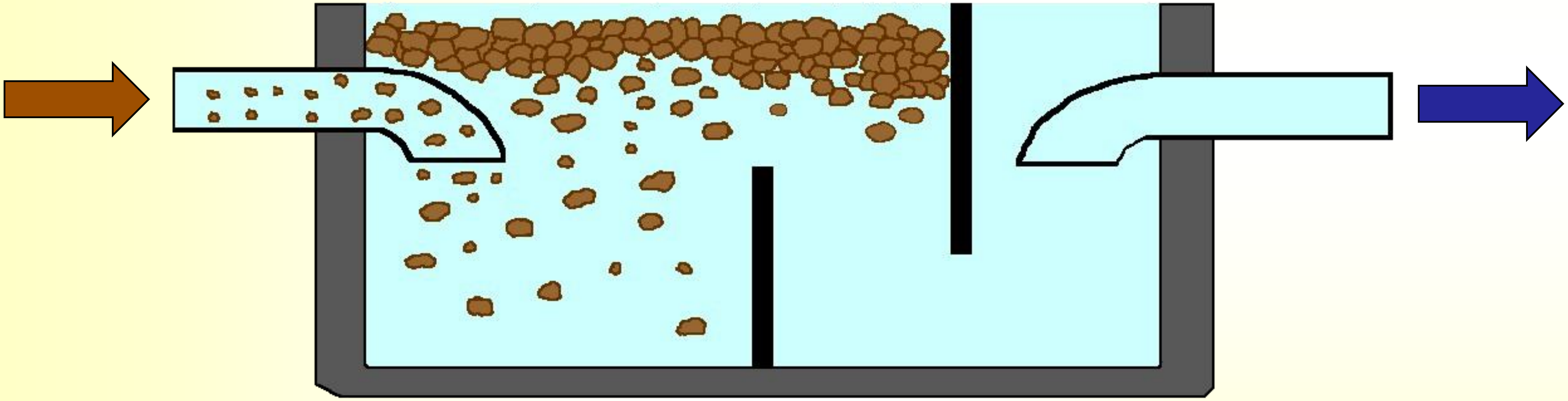
Gravity

>150 micron

Oil and Grease (FOG)

Removal of Free Floating Oil

API Separator



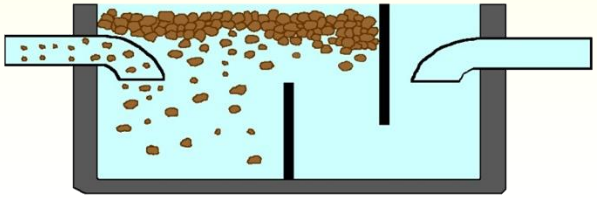
Operate in Design Loading Limits

Minimize Turbulence – Especially at Influent

Oil and Grease (FOG)

Removal of Free Floating Oil

API Separator



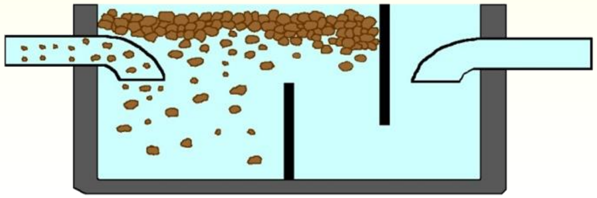
Maintenance Practices

The ability of oil water separators to function properly depends upon the timely performance of required service and maintenance. Oil/water separators must be monitored and maintained by competent personnel who understand how the systems operate. Oil/water separators should be given the same close attention given to any other important piece of equipment. The operators, users, and maintainers of the oil/water separator must clarify who will be responsible for monitoring, inspecting, maintaining, and servicing the system. Frequent inspections should be made of the system and all associated piping, valves, etc. to prevent operational and mechanical failures or inefficiencies. Sludge and oil need to be periodically removed from the oil/water separator to keep it operating properly

Oil and Grease (FOG)

Removal of Free Floating Oil

API Separator



Oil/water separators must be monitored and maintained .

Frequent inspections should be made of the system and all associated piping, valves, etc.

Sludge and oil need to be periodically removed.

Oil and Grease

Removal of Free Floating Oil

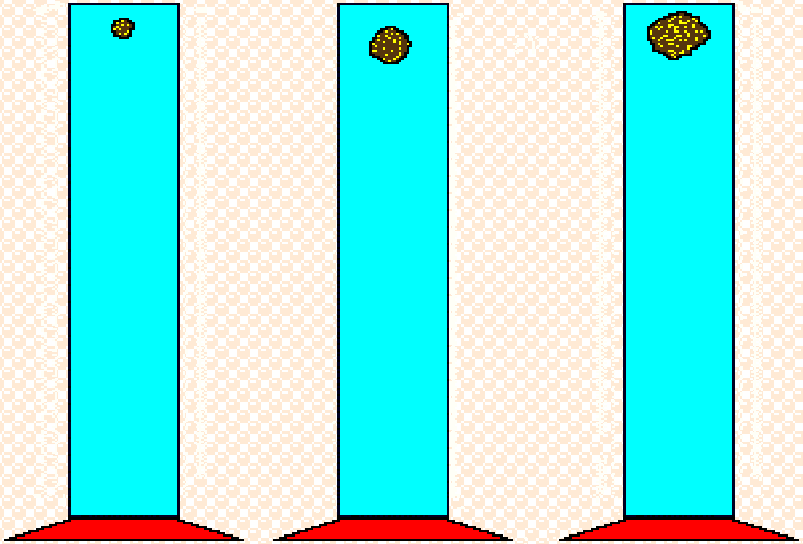
Skimmers

Polypropylene is Oleophillic

Oil and Grease

Removal of Free Floating Oil

Centrifuge



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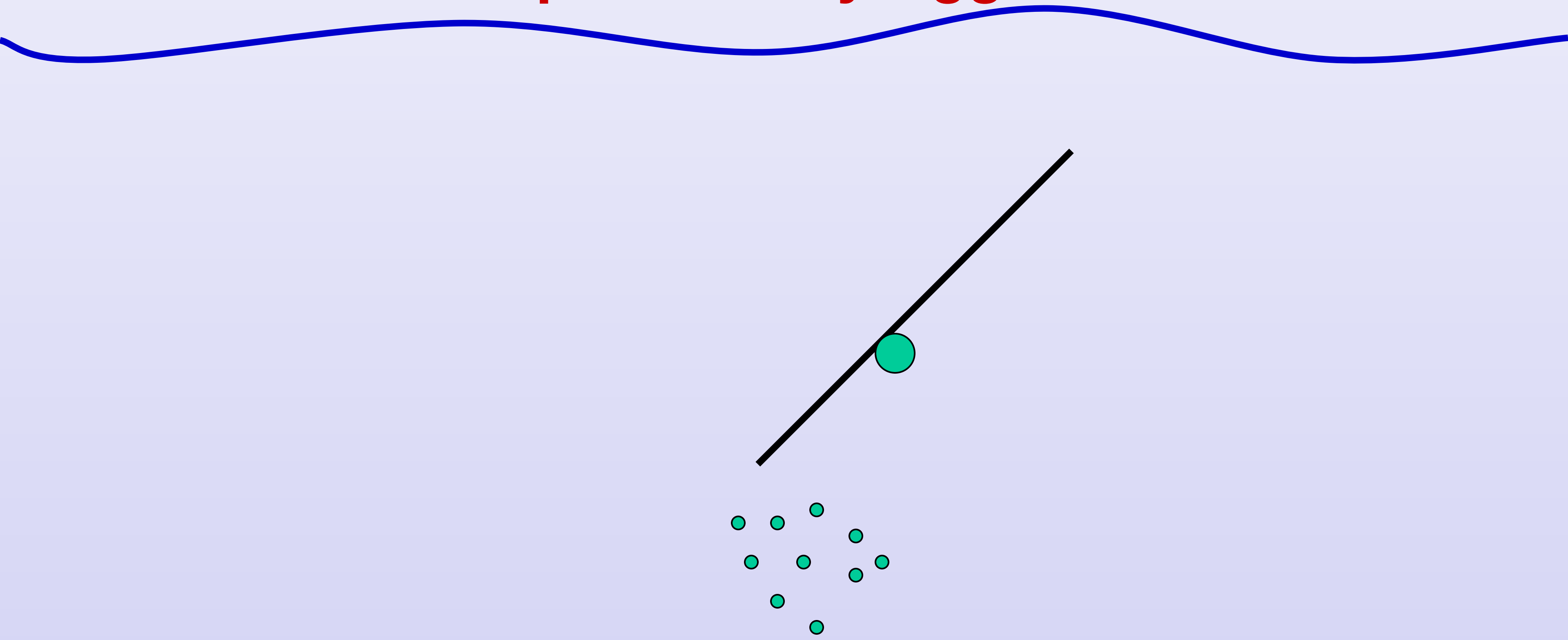
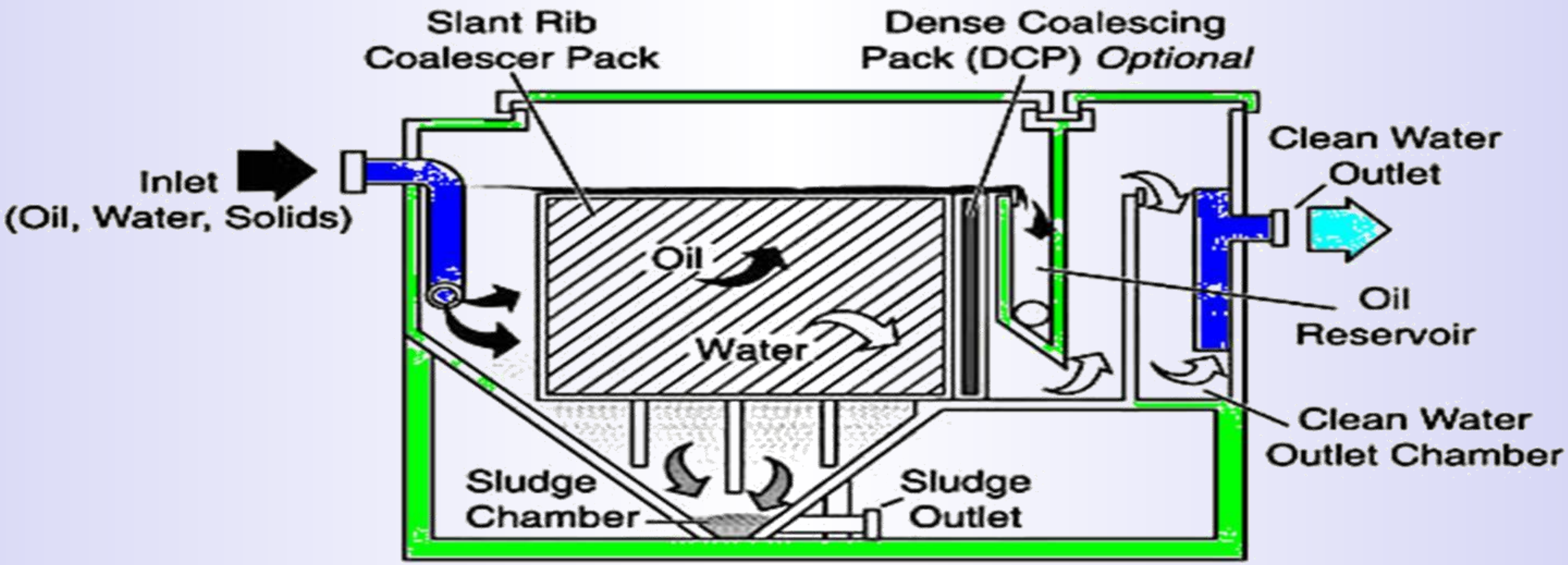
Oil and Grease

Coalescence

Uniting, or Growing Together
Increase Oil Droplet Size by Agglomeration

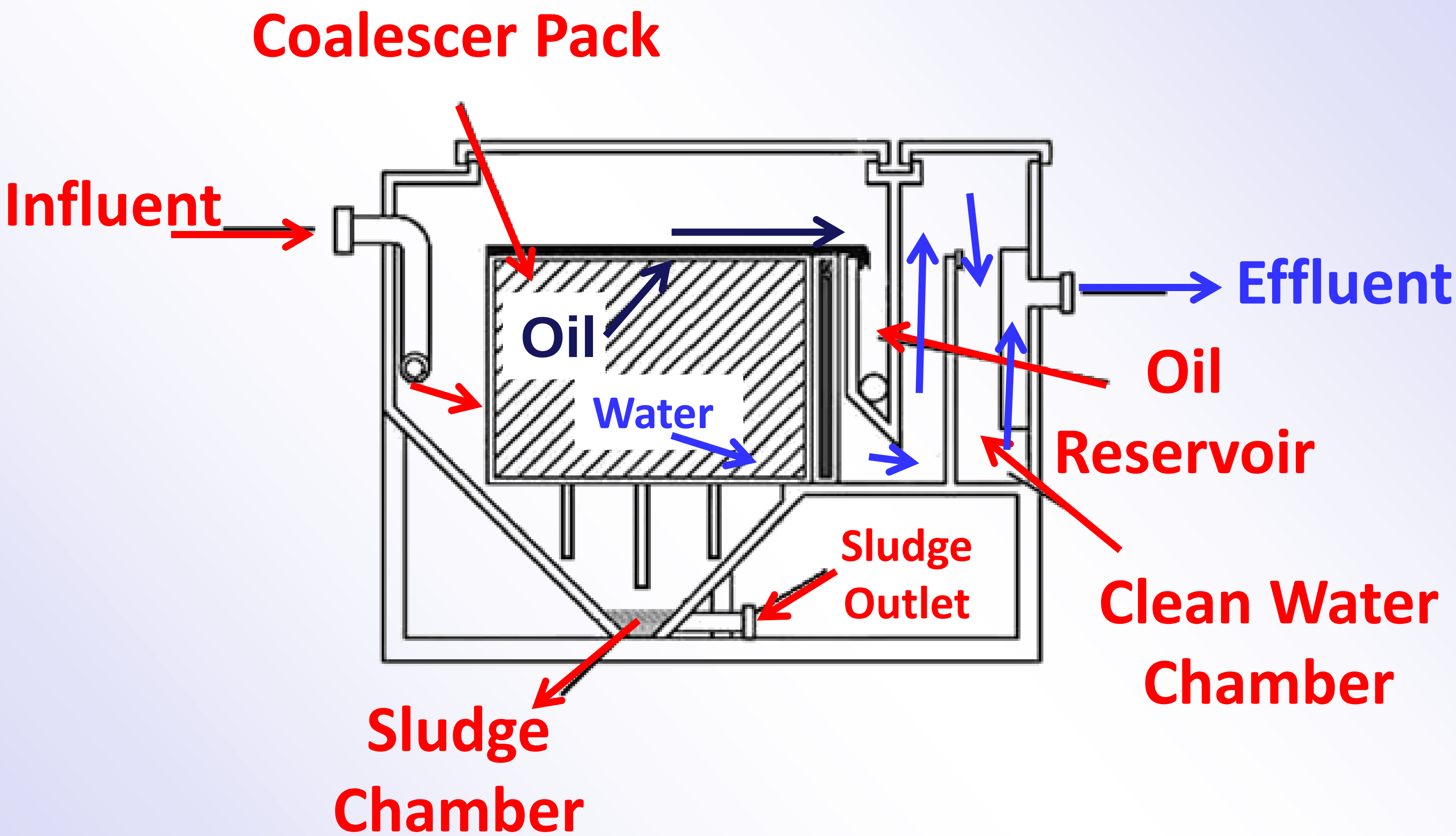


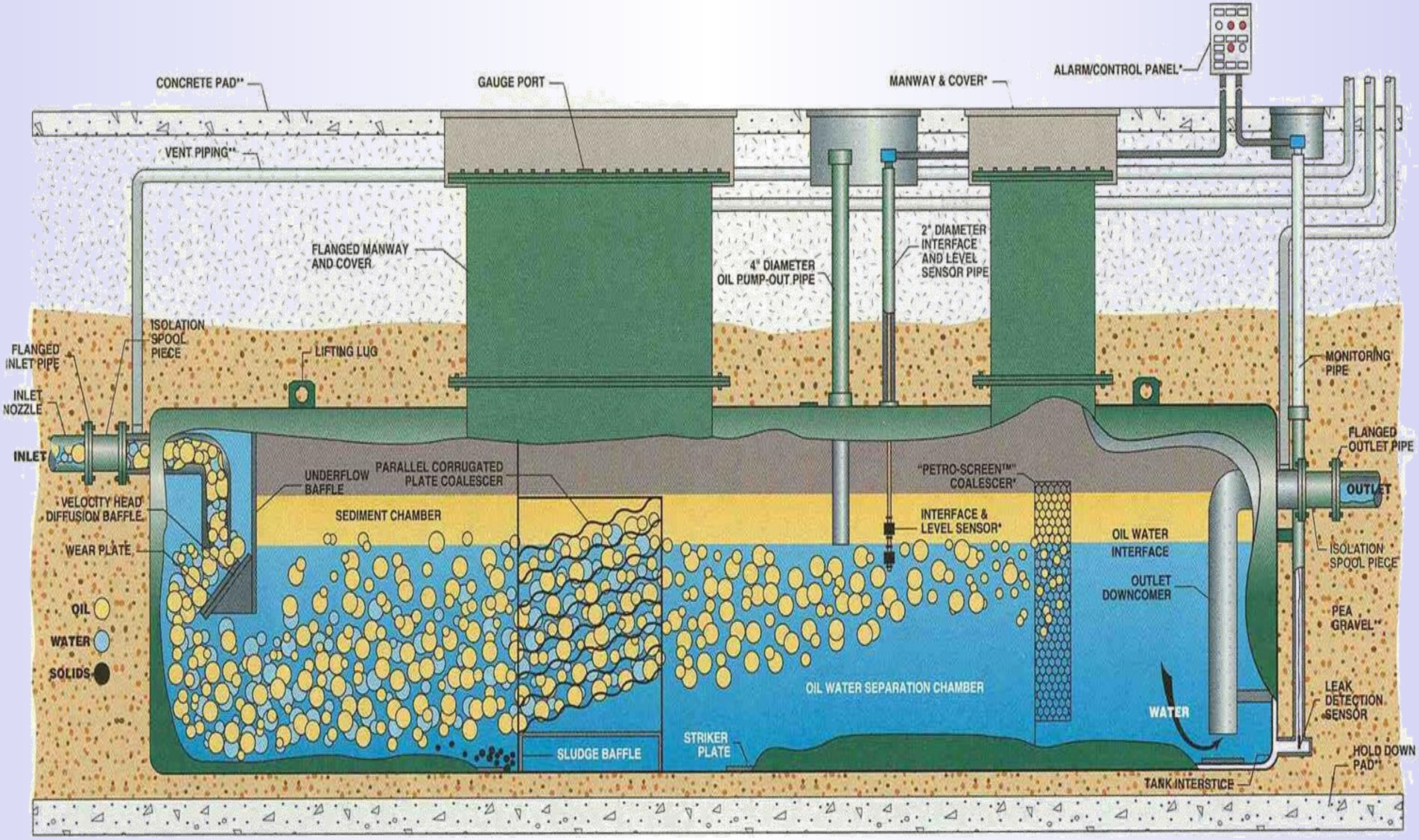
Coalescing Plate Interceptor (CPI)



> 60 micron

Coalescing Plate Interceptor (CPI)





In-Ground Oil Water Separator

Oil Water Separators

Pretreatment Considerations

Isolate From Other WW Flows

Improves Treatability

Increases Chance for Recycle

Eliminate

Rags, Grit, Solids

Solvents

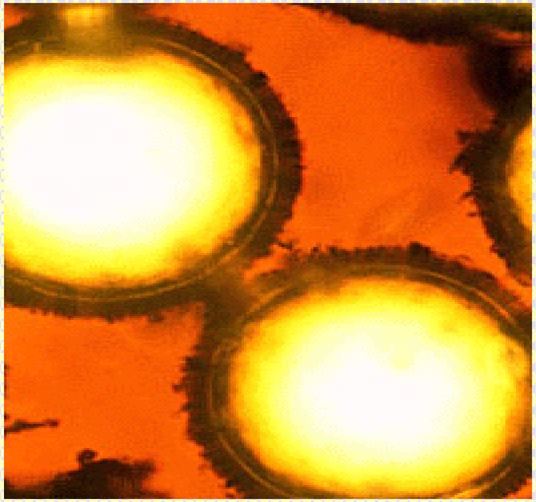
Emulsifiers

Maintenance Considerations

Cleaning

Sludge & Solids Removal

Emulsion



A **disperse system** in which both phases are liquids, one of which is generally water, and the other an oil or other water **immiscible** liquid.

Emulsion

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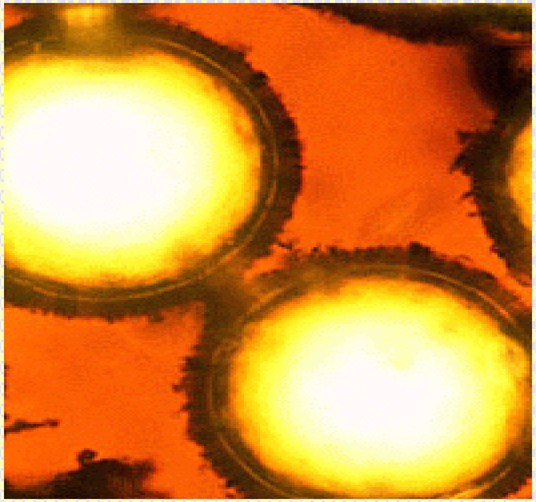


Oil-In-Water Emulsions

Oil is Inner Phase, Water is External Phase

Milk, Egg Yolk

Water-In-Oil Emulsions

Water is Inner Phase, Oil is External Phase

Butter

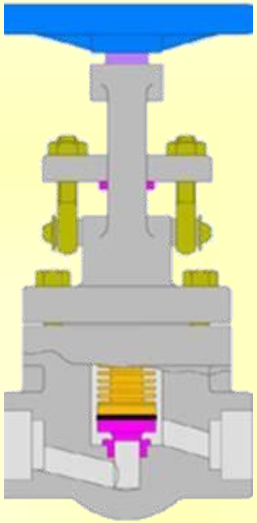
Mechanical Emulsions (Dispersions)

Oil Droplets Broken Into Smaller Droplets Through Shear Forces:

- **Violent Mixing**
- **High Shear**
- **Pumps**

May or May Not Eventually Separate Depending on Electrostatic Charges

Mechanical Emulsions



Avoid:

- **Centrifugal Pumps**
- **Globe Valves**
- **Small Piping**
- **Elbows and Tees in Piping**

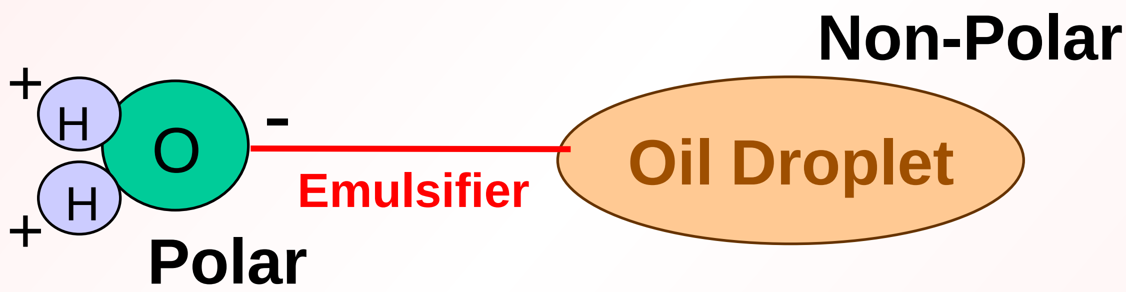
Use:

- **Gravity Flow, Peristaltic, or Progressive Cavity Pumps**
- **Smooth Piping (PVC)**
- **Large Piping, Minimum Pressure Loss**
- **Few Piping Bends and Fittings**

Chemical Emulsions

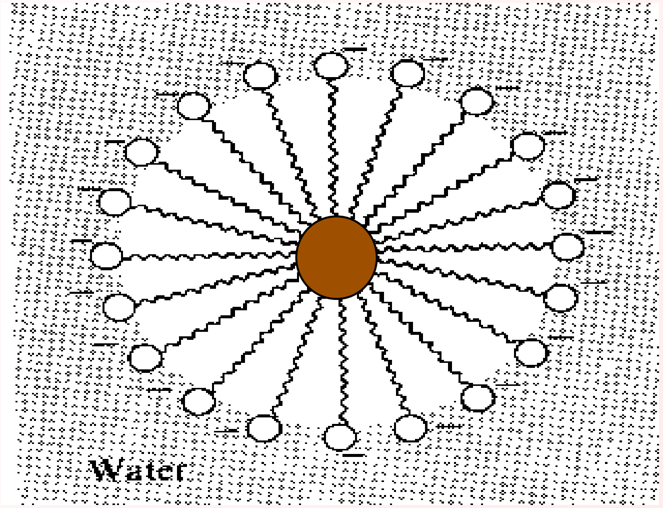
Emulsifying Agent

Causes Emulsion Stability

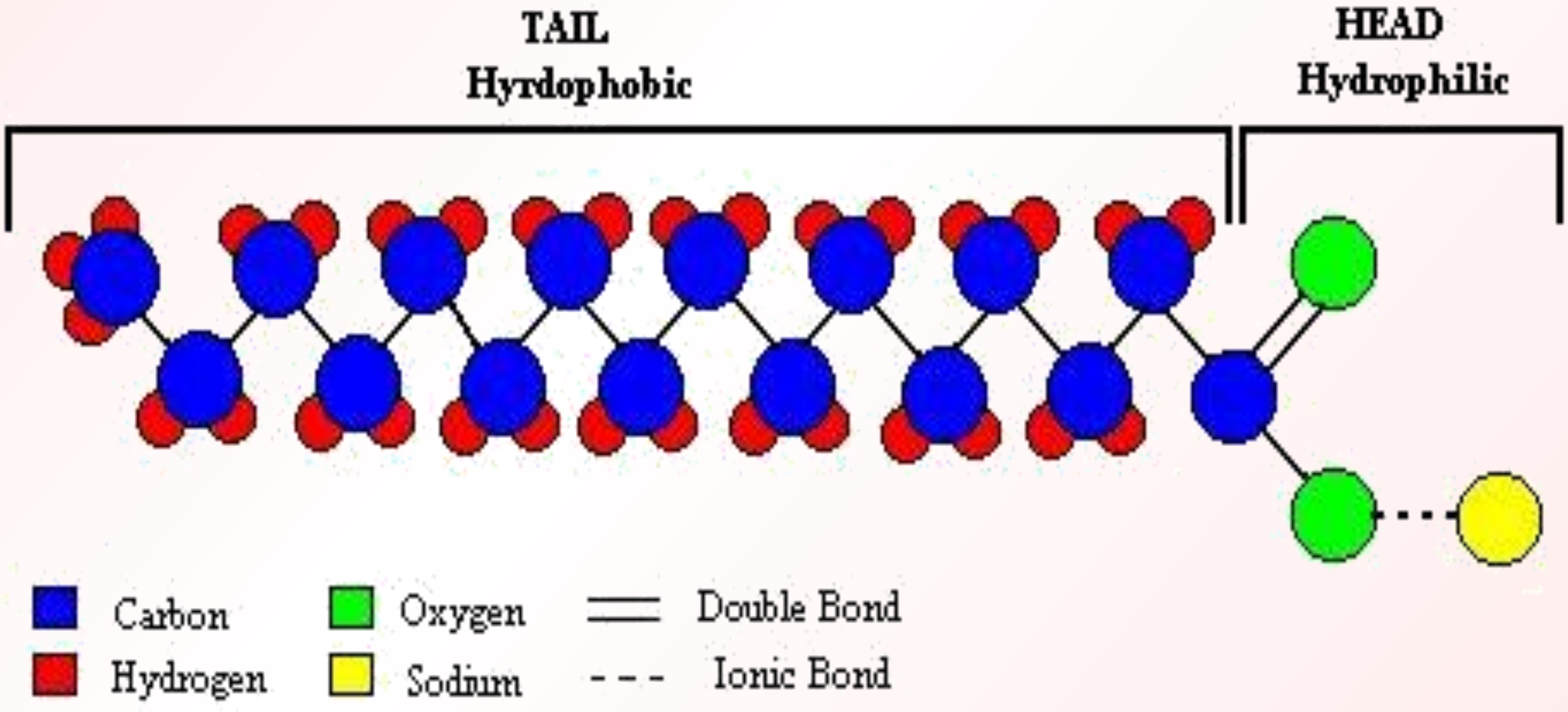


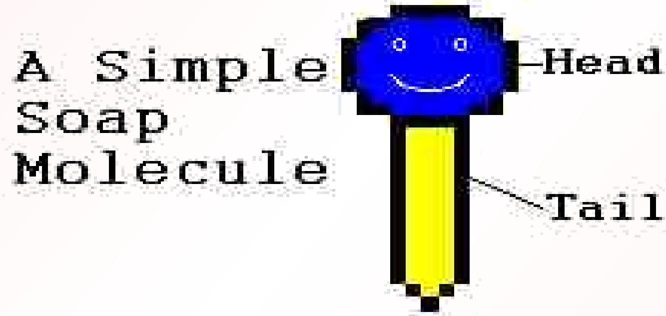
Forms a connection between the non-polar oil droplets and the water which is polar.

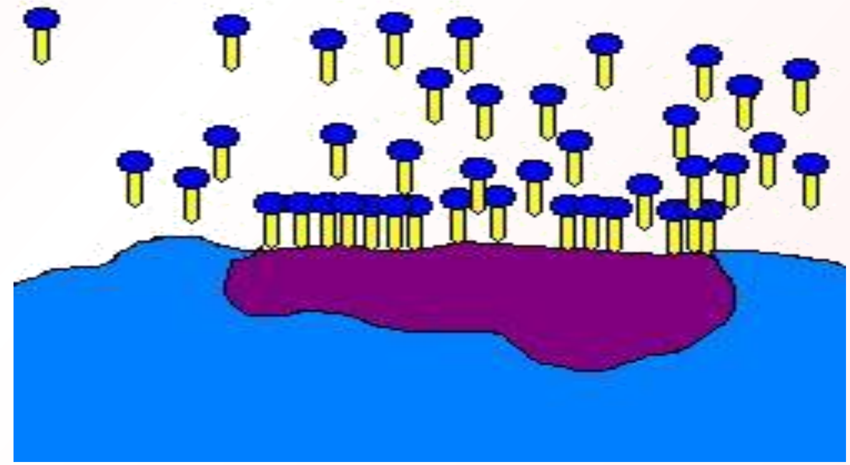
Disperses the oil droplets due to repulsion of like electrical charge.

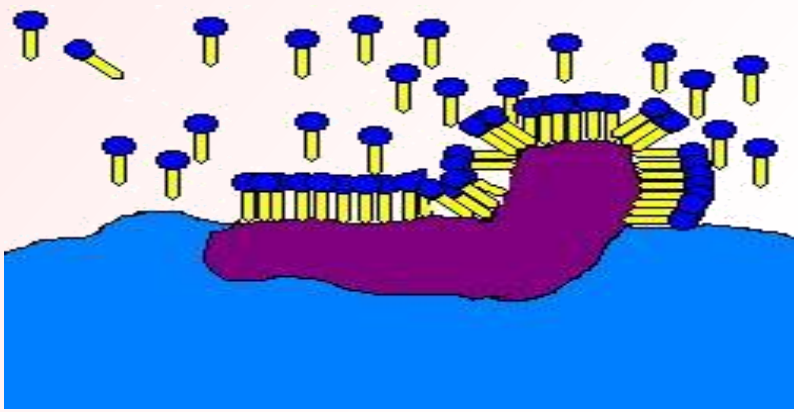


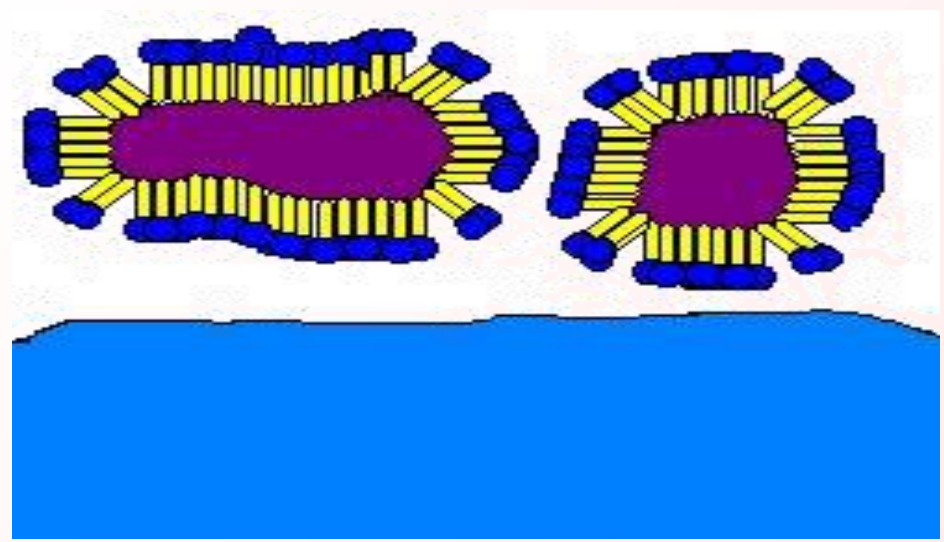
Emulsifiers









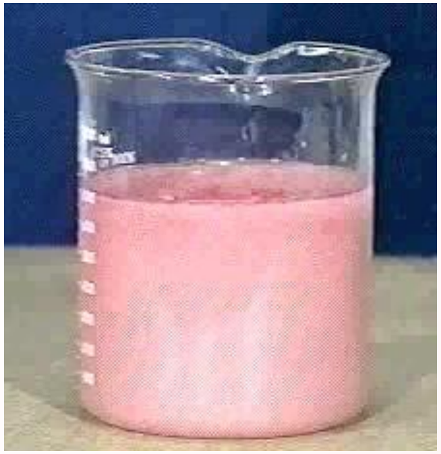


An Emulsion is Formed

Oil

\+

Emulsifier



Wastewater Treatment Problem

Emulsion

Stability of Emulsion Depends On:

Surface Charge

pH

Viscosity

Agitation

Temperature

Emulsifying Agent

Emulsion Breaking

Chemical

or

Physical

Chemical Emulsion Breaking

Either:

- **Destabilize Oil Droplets or**
- **Chemically Bind or Destroy Any Emulsifying Agent Present**

Acidification
Coagulation
Salting Out
Organic Polymers

Chemical Emulsion Breaking

Acidification

Chemical Emulsion Breaking

Acid Cracking

High pH (basic) Solutions Increase the Attraction Between Oil and Water

Addition of Acid to Oil-in Water Emulsion Neutralizes Base Chemicals and Releases the Oil (pH 2 - 4)

Destabilizes by pH Change, Increases Polarity of Water

Chemical Emulsion Breaking

Acid Cracking

Addition of Acid to Oil-in Water Emulsion Neutralizes Base Chemicals and Releases the Oil. (pH 2 - 4)

Effluent Water Must be Neutralized

Effective but Expensive

Chemical Emulsion Breaking

Coagulation

Addition of Aluminum or Iron Salts

Oil Droplets Attach to Floc That Forms From the Treatment Chemicals

Floc Settles to Bottom of Separator, or Rises to Top of DAF Unit Taking the Oil With It

Chemical Emulsion Breaking

Coagulation

Addition of Aluminum or Iron Salts

Floc Settles to Bottom of Separator, or

Rises to Top of DAF Unit

Taking the Oil With It

Sludge Generated is Difficult to Dewater

Reuse of the Oil is Limited

Chemical Emulsion Breaking

Salting Out

Addition of large quantities of an inorganic salt

Increases Dissolved Solids Content and Ionic Character of the Water

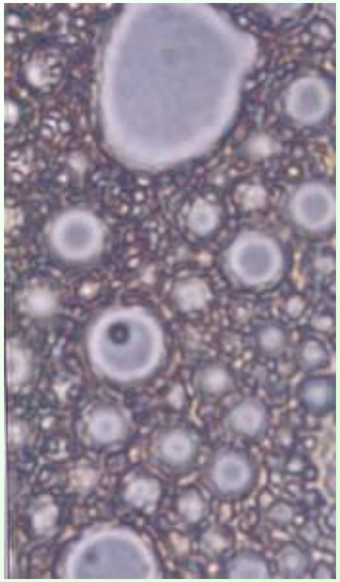
Drives Non-Polar Oil
Into the Oil Layer,
Away From the Water Layer

High TDS in Effluent

Chemical Emulsion Breaking

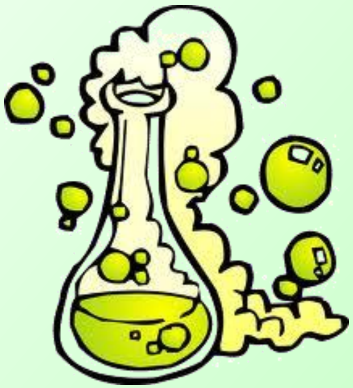
Polymer (Demulsifier) Addition

Destabilizes Charge
Reduces Viscosity
(Surfactant Added)
Specialized
Extremely Effective
Expensive



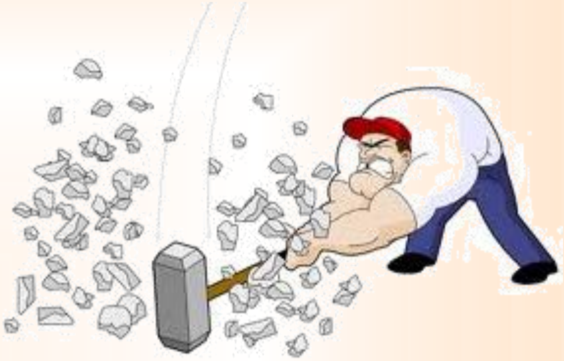
Chemical Emulsion Breaking

Acidification
Coagulation
Salting Out
Organic Polymers



Emulsion Breaking

Physical



Heat

Centrifuge

Membrane Filtration

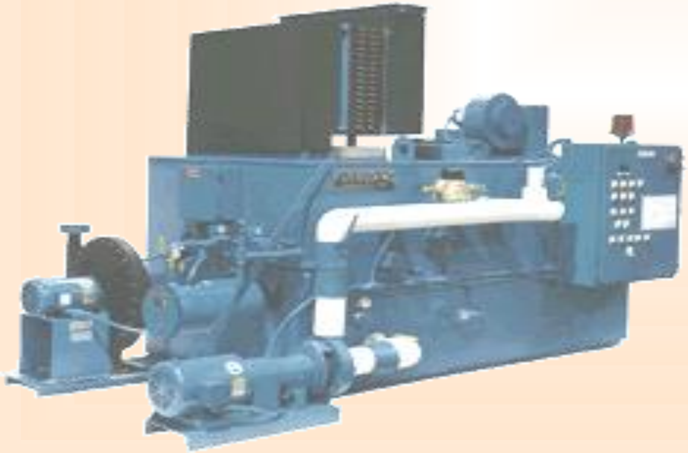
Physical Emulsion Breaking

Heating

Water-in-Oil emulsions can be broken by Decreasing Viscosity of Water and Oil

May Require Up to 200 Degrees F

Don’t Use Heat Unless Flash Point of Oil is High Enough



Don’t Use Heat if Light Fuels or Other Solvents Will Present a Fire Hazard

Physical Emulsion Breaking

Centrifuge

Takes advantage of the difference in specific gravity between oil and water

Lighter Oil material collects near the vortex

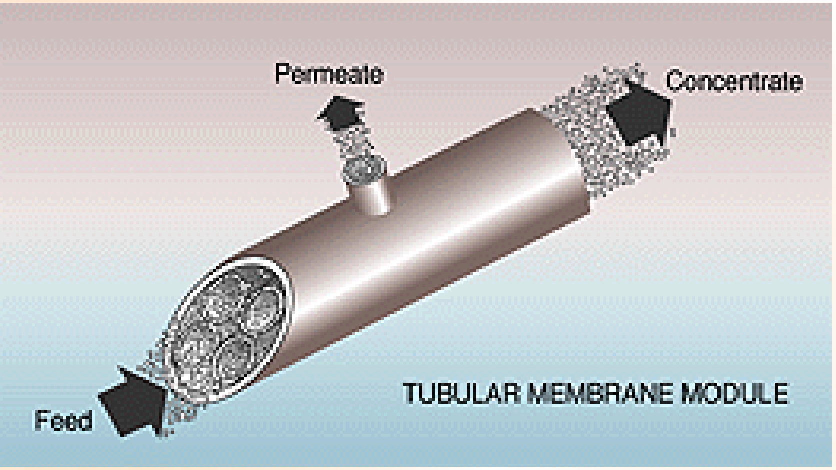
Centrifuge must be designed to remove a column of oil at the centerline

Limited use for
Oil-in-Water emulsions

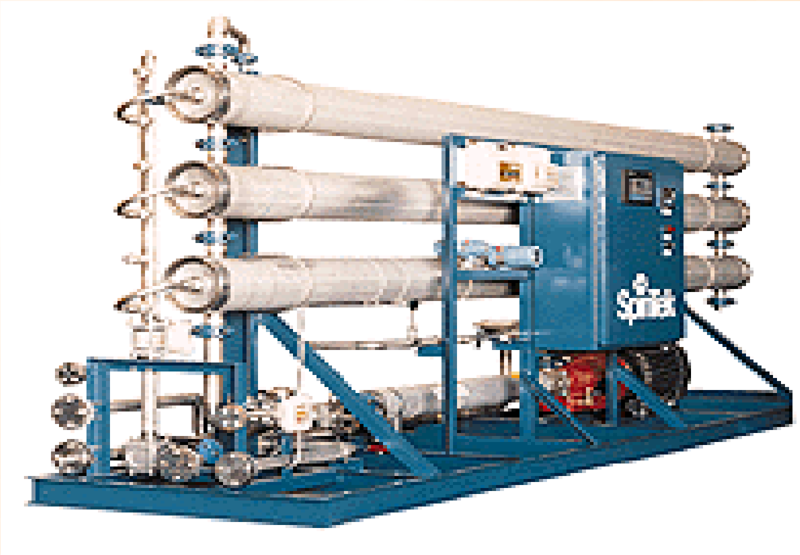
Widespread use for
Water-in-Oil emulsions

Physical Emulsion Breaking

Membrane / Ultra Filtration



- High Quality Effluent
- Small Space Required
- Removes Oil and Particulates Down to 0.01 micron



Concerns

Chemical Resistance

Fouling / Plugging

Cost

Analysis for Oil and Grease

Sampling

Grab Sample

Wide Mouth Glass Bottle

Technique is Critical

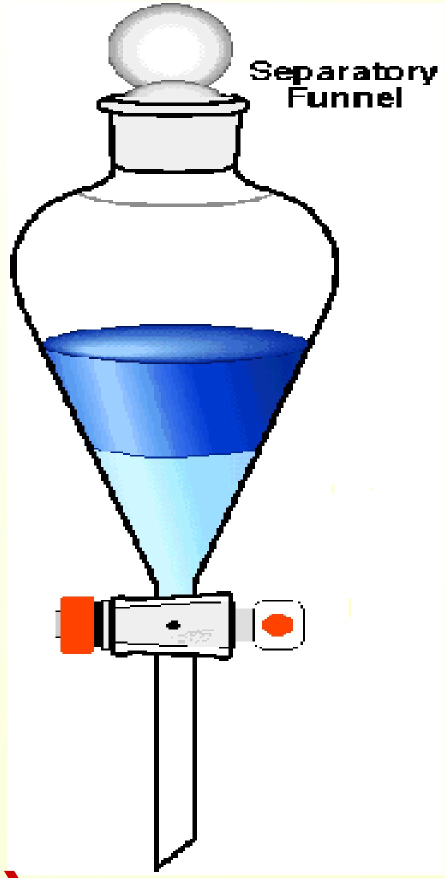
Preservation:

Cool to 4 Degrees C

HCl or H_2SO_4 to pH <2

Max 28 Days Holding

Analysis for Oil and Grease



Extraction of Oil from Sample

Evaporation of extracting solvent

Determination of Oil and Grease by Weighing

Extracting Solvent

Hexane

(EPA Method 1664)
(St. Methods 5310)

Freon (EPA Method 413.1)

Oil / Water Separation
Points to Ponder

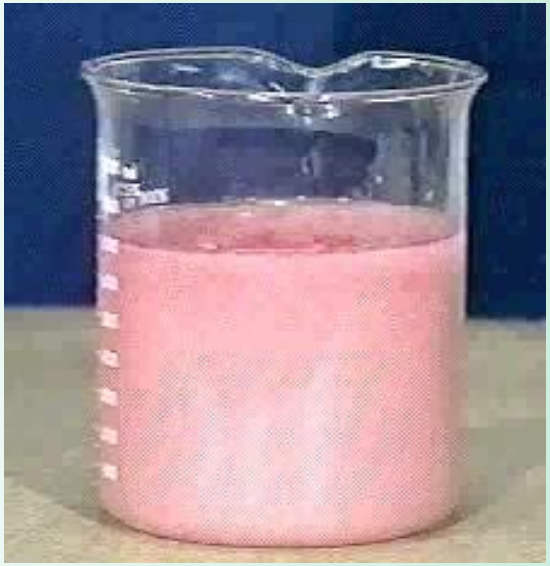
Pollution Prevention – Minimize the amount of oily wastewater that must be treated

- Segregate wastes
- Plug floor drains
- Dry cleanup for spills
- Education

Oil / Water Separation
Points to Ponder

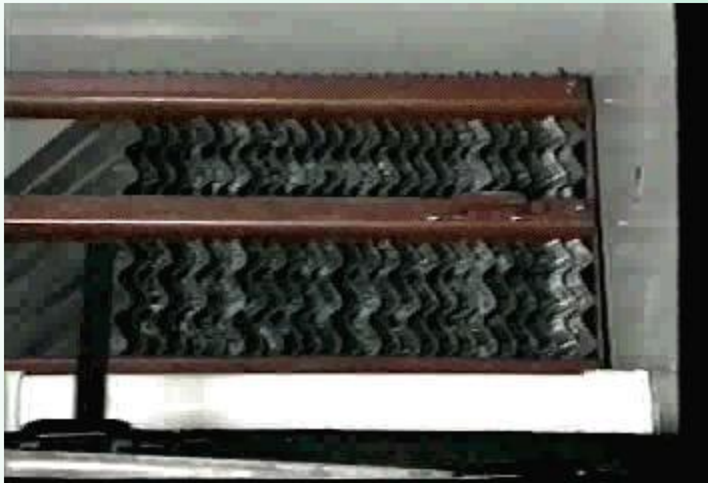
Avoid Emulsions

- Be careful what you buy
- Don't allow emulsifiers in waste stream
  - Soaps and detergents
  - Solvents



Oil / Water Separation
Points to Ponder

- Proper Operation and Maintenance
- Pretreatment
- Cleaning
- Refill with water when putting back into service



Oil and Grease

Types and Sources
Environmental Problems
Removal of Free Oil
Emulsion Breaking
Sampling and Analysis

Prepared By
Michigan Department of Environmental Quality
Operator Training and Certification Unit