Maritime & Coastguard Agency

Problems of Oil Spill Response

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Composition of crude oils

- Crude oils are mixtures of many thousands of different hydrocarbons
- These range from propane to bitumen
- Different crude oils have different proportions and therefore different properties

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Relevant oil properties

CRUDE OIL ASSAY OR DATA SHEETS

- Density, Specific Gravity, API Gravity
- Volatility - related to boiling point
- Viscosity
- Pour point
- Wax content
- Asphaltene content

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Fate of spilled oil

- Major processes
  - Spreading
  - Evaporation
  - Emulsion formation
  - Natural dispersion
- Other processes
  - Dissolution
  - Oxidation
  - Sedimentation
  - Biodegradation

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Process with time

Source: *ITOPF*

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Spreading of spilled oil

- Spilled oil floats and spreads out to form an 'oil slick'
  - Very variable thickness from very thin to thick
  - Sheen that is less than 0.1 microns thick
  - Approximate average of 0.1 mm
- 1 tonne of spilled oil will rapidly spread out to a slick with an area of about 10,000 m^2

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Typical oil slick

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Spreading

- Rate of spreading depends on viscosity
- Waxy oils break into pieces, rather than spread
- Slicks broken up by wind and currents
- Form 'windrows' parallel to wind direction

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Evaporation of volatile oil components

Maritime & Coastguard Agency

Evaporation

- Volume of oil on the sea surface decreases depending on:
  - Oil composition
  - Temperature
  - Wind speed

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Consequences of evaporation

- As the gasoline evaporates the residue contains more of the high viscosity components
- The viscosity of what is left behind increases
- The oil becomes thicker and more sticky

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Natural dispersion

- Natural dispersion requires breaking waves
  - Not a significant process in calm seas
  - Proceeds more rapidly in rough seas
- If natural dispersion continued to completion all the spilled oil would eventually be naturally dispersed and there would be no need for oil spill response

Safer Lives, Safer Ships, Cleaner Seas

Natural dispersion

Natural dispersion

Natural dispersion

Natural dispersion
Water depth (m)
0
1
2
3
4
5

Natural dispersion
Water depth (m)
0
1
2
3
4
5

Natural dispersion
Water depth (m)
0
1
2
3
4
5

Maritime & Coastguard Agency

Water-in-oil emulsification

- Water droplets can become incorporated in the body of oil
- Asphaltenes help this emulsification process

Safer Lives, Safer Ships, Cleaner Seas

Water-in-oil emulsification

Water-in-oil emulsification

Water depth (m)
0
1
2
3
4
5

0
1
2
3
4
5

Oil layer thickness (mm)
0
0.5

0
Oil layer thickness (mm)
0.5

0
Oil layer thickness (mm)
0.5

0
Oil layer thickness (mm)
0.5

Consequences of emulsification

Maritime & Coastguard Agency

- Up to 75% volume of water
- Volume of the emulsified oil is 4 times that of residue left after evaporation
- Emulsified oil is much thicker (higher viscosity) than that of oil that was spilled

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

An example

- 1,000 tonnes of a light crude oil spilled
  - Spreads out into a slick with an area of approximately 10 km^2 (10,000,000 m^2).
  - 900 tonnes will be in 1 km^2
  - Approximately 30% (300 tonnes) will evaporate in 24 hours leaving 700 tonnes
  - Remaining oil will incorporate water to produce 2,800 tonnes of emulsified oil
- 1,000 tonnes spilled, 2,800 tonnes formed

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Other processes

- Dissolution
  - A few oil components dissolve in water
- Oxidation
  - Sunlight and air cause oil to change
- Biodegradation
  - Micro-organisms 'eat' oil if it is dispersed
- Sedimentation
  - If there is suspended sediment

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Spilled oil movement

- Oils slicks drift
  - With the current at the speed of the current
  - In the direction of the wind at 3% of wind speed

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Effect of current and wind

Safer Lives, Safer Ships, Cleaner Seas

Maritime & Coastguard Agency

Computer models predict:

- Oil spill movement:
  - Tidal databases and wind direction and speed input
  - Slick trajectory output
- Oil 'weathering' properties:
  - Oil specific inputs
  - Increase in emulsified oil viscosity output
  - Increase in emulsified oil volume output

Safer Lives, Safer Ships, Cleaner Seas

Any Questions???