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Eliminating Environmental Risks in Well Construction and Workovers

Phil Rae
BJ Services
Presentation Overview

- Oil Industry
- Public Concerns and Misconceptions
- Oil - Pollution Risk in Perspective
- Well Service Chemicals
- Barriers to Further Progress
- Closing Remarks
The Oil Industry in Perspective

- Engine of Global Growth?
- Power
- Transport
- Raw Materials for Industry
- Source of Dyes, Pharmaceuticals, Plastics, Detergents, Lubricants.....

→ Improved Health, Living Standards
The Oil Industry in Perspective

• Engine of Global Growth?
• Power
• Transport
• Raw Materials for Industry

... Plastics, Detergents, Lubricants...

... Improved Health, Living Standards...
Public Perception

- “Big Oil”
- Unscrupulous Multi-Nationals
- Little Regard Shown for Nature
- “Dirtier” Than Other Industries
- Practical Alternatives to Oil Exist!!!
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World Energy Consumption by Fuel, 1970-2025
(quadrillion Btu)
Pollution-Related Issues Affecting The Oil Industry

- Habitat Disturbance/Disruption
- Paraphenalia of Oil Exploration
- Decommissioning of Facilities
- Speciality (Toxic) Chemicals
- Greenhouse Gas Emissions
- Oil.....!!!
Oil

- Perceived As A Major Pollution Threat
- Vast Quantities Produced and Transported
- Intense Media Coverage of Spills
- Spills Tend To Be Substantial
Infamous Tanker Disasters

EXXON VALDEZ
HAWAIIAN PATRIOT

AMOCO CADIZ
ODYSSEY
AEGEAN SEA
URQUIOLA
PRESTIGE
JAKOB MAERSK

TORREY CANYON
KHARK 5

ATLANTIC EMPRESS
ART SUMMER
CASTILLO DE BELLVER

BRAER
SEA EMPRESS
HAVEN
INDEPENDENTS
IRENES SERENADE
SEA STAR
KATINA P.
Infamous Tanker Disasters

- Images of dead fish on a shore and polluted water with floating debris.
- Close-up of a bird covered in oil, depicting the impact on wildlife.

These photos illustrate the disastrous effects of oil spills on ecosystems and wildlife.
Oil - Facts

- Oil Is A Natural Product
- Routinely Seeps to Surface In Many Places
- Rich Nutrient Source….but Hydrophobic
- Major Spills Overwhelm Ecosystem
- Quickly Degrades, If Properly Dispersed

- Braer Tanker Disaster (1993) - 85,000 tonnes
  ➔ “Vanished” Within 3 Weeks!!!
No Room for Complacency

- Risk of Escape Will Always Be Present
- Technical Frontiers Continue to Advance
- Slimholes - Less Margin For Error
- Extreme Deep Water Drilling
- Terrorism/Sabotage
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Typical Wellsite Chemicals

- > 2500 Oilfield Chemicals In Use
- Wide Spectrum of Toxicity/Biodegradability
- Main Categories Associated With:
  - Drilling (Mud and Cementing Materials)
  - Completion and Well Cleanup
  - Stimulation (Acidising and Fracturing)
Environmental Risks from Chemicals

- Acute Primary Toxicity
- Chemical Oxygen Demand
- Biodegradability
- Bioaccumulation Potential
- “False Messengers”
False Messengers

- Also Called “Endocrine Disrupters”
- Diverse Group of Chemicals
- Mimic Natural Signalling Molecules
- Trigger Biological Changes at Low Concentrations
- Implicated in Cancer and Genetic Mutations
- NPE’s, Polycyclic Aromatics, Phthalates, etc
Example Endocrine Disruptors

- Bisphenol-a
- p-nonylphenol
- Atrazine
- o,p-DDE
- PCBs
Mechanism of Hormone-Receptor Action and Response

- Estrogen receptor binding
- mRNA transcription
- Vitellogenin production
Possible Victims?
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Drilling Mud

• Single Biggest Wellsite Consumable
• Three Main Generic Types
  – Oil-Base Muds
  – Synthetic Base Muds
  – Water Base Muds
Mud Evolution - 1

- Original Mud Was Water-Based
- Problems Drilling Reactive Formations
- Moved Toward OBM’s - Lubricity/Unreactive
- Until 10 Years Ago, OBM’s Used Diesel Oil
- Now Mainly Switched to Cleaner Paraffin Oils

=> Drill Cuttings Need Special Handling
  - Solvent Extraction
  - Incineration
  - Bio-Remediation
  - Cuttings Injection
Mud Evolution - 2

- Some Places Now Use Synthetic OBM
  => Based on Vegetable Oils or Alpha-Olefins
- These Are Biodegradable But Expensive
- Gradual Move Back Towards Water-Base Mud
- More Sophisticated, Less Toxic Systems
- Cheaper

=> Zero-Discharge Rules Being Enforced
Barite

- Primary Mud Weighting Agent
- 6 Million Tonnes Per Annum
- Significant Levels of Heavy Metals
- Lead, Cadmium, Arsenic, Mercury......
- Often Discharged / Dumped

- Is There Any Alternative......?
Ilmenite

- Oxide of Iron and Titanium
- Much Lower Levels of Heavy Metals
- Significantly Denser Than Barite
- Less Needed For Any Given Mud Weight
- Lower Solid Volume Fraction
- Better Mud Rheology

→ Improved Drilling Hydraulics
→ Less Environmental Impact
Many Other Sources of Pollution
Figure 1. Location of hydrothermal systems and polymetallic massive sulphide deposits at the modern seafloor.
Cementing Chemicals

- Cement and Additives Quite Benign
- Mostly Naturally-Derived Products
- Derivatised-Celluloses, Sugars, Lignins
- Spacers/Washes for Mud Removal
  - Aromatic Sulphonates/NPE’s Replaced
  - Alcohol Ethoxylates, Sorbitan Esters
  - Liquid Cement Premix
Technology Developments

- **Slimhole Drilling**
  - Less Mud, Less Cuttings, Less Cement

- **Multilateral Drilling**
  - Fewer Wells, Improved Recovery

- **Underbalanced Drilling**
  - Less Mud (No Mud!), Less Damage

- **Horizontal/Extended Reach Drilling**
  - Less Obtrusive, Better Productivity
How the Wytch Farm team has reached out to develop the field's offshore reserves: The latest record-setting well (M11), started in May last year, was the 14th to be drilled from the M (left) and F sites on Poole's Goathorn Peninsula since the extended reach drilling programme got underway in April 1995. All of these wells have been drilled in the Sherwood reservoir, a Triassic sandstone at a depth of 1585m which has estimated recoverable oil reserves of some 436 million barrels.
Completion/Well Clean-up

• Many Possible Agents to Impair Production
  – Organic Materials (OSR, Asphalt)
  – Inorganic Materials (LCM’s, CaCO$_3$, Particulates)
  – Blends of Polymers and Particulates
  – Pipe Dope
  – In Old Wells - Scales, Rust, Etc.
Old Cleanup Chemicals Used for Removal of:

- Clays/Fines - Quats, Polyacrylamides
- Polymers - Persulphates, Peroxides
- Rust - Mineral Acids
- Organic Deposits - Aromatics (Xylene)
- Emulsions, etc - NPE’s, Aromatic-SO₃
Newer Cleanup Chemicals Used for Removal of:

- Clays/Fines - Poly-Al Chloride, Chitosan
- Polymers - Natural Enzymes
- Rust - Neutral De-Rusters
- Organic Deposits - Terpenes (Plant H/C’s)
- Emulsions, etc - Sugar Lipids, Alcohol EOs
A Cleaner, Greener Oil Industry
- “Articles of Faith” -

- The Most Effective Method for The Oil Industry to Be Environmentally-Friendly Is To Drill Less Wells and Maximise Productive Potential from Each and Every Well

- Adding Production by Stimulation is Cheaper than Drilling a New Well
Stimulation Chemicals

- Some Serious Potential “Bad Guys” -

- Acids
- Corrosion Inhibitors
- Surfactants
- Biocides
- Organo-Metallic Crosslinkers
- Solvents
Acids

- Represent Acute Spill Problem
- Corrosion Inhibitors Are More “Toxic”
- Mixed Acid / Returns Pose Disposal Problem
- Mineral Acids (HCl + HF) Very Aggressive
- Need To Protect Tubulars (Well Integrity)
- Need To Protect Formation (Productivity)
Acidising Developments - 1

- “Greener” Corrosion Inhibitors
  => Elimination of PAH’s, NPE’s, etc.

- Use of Organic Acids in Place of HCl

- Use of Newer “High pH” HF Systems
  => 1000-10000x Less Acidic Than Mud Acid!
  => Much Less Corrosion Inhibitor Needed
Acidising Developments - 2

- In-Situ Acid Generation
  - Mixture of Enzyme and Ester
  - Non-Corrosive, Non-Toxic
  - Blend at Surface - Pump Downhole
  - Inject Into Formation
  - Hydrolysed to Acid and Alcohol, In-Situ
  - No Corrosion Inhibitor Required
Acidising Developments - 3

• Process-Controlled Acidising
  => Prepare Acid On-The-Fly
  => No Waste ...... No Disposal
  => Safer and More Cost Effective

• Complete Elimination of Acid
  => Use of EDTA-based Systems
  => Skin-Bypass Fracturing
New Fracturing Technology

- “Instant” Fracturing Fluids
- Elimination of Toxic Metallic X-Linkers
- Use of Biodegradable Surfactant Gels
- Use of Lightweight, Buoyant Proppants

- No Breakers, No Biocides Required
- At The Limit, No Fracturing Fluid Needed
- Better Cleanup = Better Productivity
“Green” Technology Status
(Construction/Workover/Stimulation)

- About 60-65% of Chemicals In Use Are OK
- Simple To Raise This Figure to 90%
- Technology To Achieve This Already Exists
- Commitment and Vision Required!

➡️ Norway, Denmark, Holland Lead The Field
➡️ UK, Dragging It’s Heels But Semi-Compliant
➡️ US - Still Behind The Curve, Unfortunately!
Barriers To Progress - 1

- Regulatory Authorities
- Non-Harmonised Environmental Legislation
  - Different Test Species
  - Different Acceptance Criteria
  - Test Complex Mixtures/Test Components
  - Ownership/Security of Proprietary Data
- Poor Understanding of End Use
Irrational Bureaucracy

• **Mandatory Testing of Harmless Chemicals**

  – Potassium Iodide
  – Galactomannanase Enzyme
  – Terpenes (D-Limonene)
  – Polysaccharide Gelling Agent
Barriers To Progress - 2

- Cost .......... Who Pays for Development?
- Legislation is a “Moving Target”
- Lack of Genuine E+P Company Support
- Supplier disadvantaged in commercial bids

=> E+P Co’s need to send a strong message
=> Should reconsider bid evaluation criteria
=> Factor-in cost benefits of waste disposal
Closing Remarks

- Tremendous progress in developing “Greener” additives has been made in the past 10 years.

- Environmental authorities need to harmonise rules and encourage incremental progress.

- The oil industry must strive to anticipate and exceed standards that may be set in future legislation.
Closing Remarks

• The Oil Industry Needs Better PR - A Full-Scale “Charm Offensive” and Public Education Initiative Is Needed To Balance Disinformation From Certain Interest Groups.

• E+P Companies Need to Support Environmentally Responsible Technologies, Not Just At Corporate Level But At Field Level, Too.

• The Cost of Waste Disposal and Treatment, In The Long Term, Will Far Exceed The Development Cost of Bio-Friendly Materials That Can Be Safely Discharged.
That’s All, Folks!

Questions?
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