Reducing risks associated with ultra-deepwater hydrocarbon systems

Kelly Rose, Ultra-Deepwater Technical Coordinator
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Schematic representation of offshore spill risk profile

- Deviated (30%, 48%) & Exploratory Drilling (29%, 14%)
- Completion &/or Workover (20%, 14%)

Factors Contributing to Blowouts

- Stuck pipe
- Drill into other well
- Casing failure
- Cementing
- Equipment failure
- Formation fracture
- Swabbing

Number of contributing factors to blowouts (some blowouts had multiple contributing causes)

- Recent offshore events, such as Katrina/Rita (2005) & Deepwater Horizon spill (2010)
- 2010 Executive Order 13547, Interagency Ocean Policy Task Force (IOPTF)
  - Executive agencies (including DOE) challenged to enhance national stewardship of the ocean, coasts, & Great Lakes
- 2012 Challenges Identified by DOI’s OESAC Spill Prevention Subcommittee
  - Deep water and offshore frontier areas face production risks that are fundamentally distinct from onshore operations:
    - Drilling phase identified as having highest number of risks and uncertainties
    - Concerns about fracturing the formation can have a big impact on well design, lost circulation, and loss of well control
    - Well design incorporating multiple barriers are essential to safety.

• Cementing Failures
• Equipment & Casing Failures
• Higher risk targets, “exploratory” systems
Complementary Program Portfolio
Ultra-Deepwater (UDW)

Improved Science Base for Materials and Wellbore Integrity

– Characterizing the Behavior of Metal-Based Systems Used for Control Devices in Extreme Environments [Lead: Jeff Hawk] 2010 to present

– Improving Science-Base for Wellbore Integrity, Foam Cements [Lead: Barbara Kutchko] 2010 to present
  • FY13 merit review, Excellent rating

– Evaluation of Lithology:Cement:Casing Barrier Integrity under UDW Subsurface Conditions [Leads: Margaret Ziomek-Moroz and Barbara Kutchko] NEW

Reducing Risks & Mitigating Impacts Associated with Extreme Offshore Conditions

– Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature (HPHT) [Lead: Isaac Gamwo] 2010 to present

– Assessing Risks and the Potential for Environmental Impacts for Deepwater and Ultra-Deepwater GOM Resources [Lead: Kelly Rose] 2010 to present
  • FY13 merit review, Very Good rating

Improving Safety through Rapid Detection and In Situ Characterization

  • FY13 merit review, Very Good rating

UDW Tech Transfer to Date:

47 Conference Presentations

20 Published Articles & Reports
  • Additional manuscripts undergoing internal and external peer review

12 Datasets released via EDX

2 Data-driven tool/app via EDX

NOW UPDATED WITH FY13 Q3 PUBS, PRESENTATIONS, TOOLS, ETC

www.edx.netl.doe.gov/udw
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Improving Safety through Rapid Detection and In Situ Characterization

- Improving Deepwater Drilling Safety through Enhanced Understanding of Multiphase Flow Dynamics of Hydrocarbon Mixtures [Leads: Bob Warzinski and Frank Shaffer]
- Risk Reduction at the Drill Bit - Adaptation of Existing Technology to Reduce Risks Associated with Deep and Ultra-Deep Drilling [Lead: Kelly Rose]
Characterizing the Behavior of Metal-Based Systems Used for Control Devices in Extreme Environments (Lead: Hawk)

- Reducing Risk of Material Failures During Offshore Operations
- Studying corrosion & fatigue performance of high-strength tubulars in seawater & sour brine environments
- Improving understanding of how conventional alloys & advanced alloys and surface treatments may allow for safe and reliable use of metallic components in extreme wellbore conditions
Anticipated FY13 Products:
• Report characterizing the behavior of “welded” metal-based systems used for piping and control devices in extreme conditions
• Report summarizing evaluation of surface treatments on corrosion & fatigue behavior at HPHT
  • Hammer peening vs. Low Plasticity Burnishing (LPB)

Driver: Lack of data on key safety-performance metrics for metallic components at extreme conditions

Project Goal: Expand the science base on the performance of new HPHT alloys and surface treatments designed for use in extreme conditions

pre-FY13 Status: ORD strength/corrosion experiments of common UDW alloys to date found:
• No evidence one alloy is superior to another
• Best materials for conventional drilling do not translate to extreme conditions
• Prior seawater and air tests not relevant for HPHT or sour systems
• Identified preferential locations for pit and fatigue crack development = point of weakness in HPHT/UDW

FY13 R&D Focus: On corrosion & fatigue performance at HPHT conditions of advanced metallic surface treatments & metallic welds

Anticipated FY13 Products:
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• Report summarizing evaluation of surface treatments on corrosion & fatigue behavior at HPHT
  • Hammer peening vs. Low Plasticity Burnishing (LPB)

UDW Reports & products summarized at: www.edx.netl.doe.gov/udw
Improving Science-base for Wellbore Integrity of Foamed Cements

(Lead: Kutchko)

- API RP10-B at room P,T
- Lab-based Pressure Vessel (on loan from Schlumberger)
- Slip Stream at Wellhead (with BP & Schlumberger)
- In situ Conditions

Reducing Risk of Cement-Related Failures During Offshore Operations

- Development of imaging and analysis protocols
- Evaluation over range of mix-design parameters
- Evaluation of mix designs under field conditions
- CFD to simulate mesostructure
Improving Science-base for Wellbore Integrity of Foamed Cements

(Lead: Kutchko)

**Driver:** Unknown properties of foamed cements under downhole conditions (high P, T). Need to know strength & permeability.

**Project Goals:**
- Database of foamed cement properties—mesostructure (e.g., gas distribution), strength, permeability for various mix designs.
- Predictive relationship for properties as function of mesostructure.
- Predictive relationship for mesostructure based on mix design, placement conditions, etc.

**pre-FY13 Status:**
- Completed gap assessment (NETL-TRS-003-2012)
- Developed imaging & analysis techniques (NETL-TRS-2-2013)
- Analyzed first field sample (slip-stream) using CT (TRS under develop.)

**FY13 Focus:**
- Characterize multiple slip-stream samples from 3 major service companies
- Characterize lab-based samples for different foaming agents, stabilizers, and foam qualities at two pressures (500 psi, 1000 psi)

**Anticipated FY13 Products:**
- TRS describing imaging & analysis data on slip-stream samples
- TRS describing data on variation in physical properties as function of mix design
Driver: Changes in pressure and temperature cycles or corrosion can cause the development of microannuli (potential flow paths) in offshore cement barriers. This is especially significant in ultra-deepwater wells, which are large heat exchangers and are drilled in extreme HP/HT environments.

Project Goal: Study the interactions between wellbore materials that may lead to catastrophic failure of the well over time

pre-FY13 Status: This is a new project

FY13 Focus:
• Complete a knowledge/gap analysis study to constrain key research concerns.
• Use the results of the gap analysis to drive initial FY13 experiments.

Anticipated FY13 Products:
• Report summarizing findings of scoping and gap study
• Results from initial experiments to determine potential flow paths in HP/HT environments
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Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature

[Project Lead: Gamwo]

Expand data on density & viscosity to 40 kpsi, 500 °F (pure compounds, mixtures, crude)

1. Borescope/Camera
2. View Cell
3. LVDT

Develop higher accuracy equations of state
Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature

[Project Lead: Gamwo]

Driver: Limited availability of hydrocarbon fluid properties at high PT associated with deepwater wells

Project Goals:
1) Expand database on hydrocarbons to 40kpsi & 500 °F
2) Develop higher accuracy equations of state for high PT
3) Develop standards for high PT property measurement

pre-FY13 Status:
• Built apparatuses for density & viscosity measurement
• Characterized pure compounds: densities (19), viscosities (4)
• Characterized density of binary mixture (C3+C10)
• Developed higher accuracy EOS for pure compounds
• Identified/characterized viscosity standard

FY13 Focus:
• Characterize binary mixtures: densities & viscosities
• Characterize crude oil: density
• Extend EOS to real oil mixtures; develop EOS tool

Anticipated FY13 Products:
• TRS detailing density datasets on binary mixtures
• Web-based, user-friendly program for density EOS
Assessing Risks and the Potential for Environmental Impacts for Deep & Ultra-Deepwater GOM

[Project Lead: Rose]

Developing tools and information to evaluate and predict what happens in extreme offshore hydrocarbon systems

NETL Gulf of Mexico IAM
1st coordinated platform to allow for:
- independent,
- rapid-response,
- science based prediction of UDW hydrocarbon production risks and environmental impacts

Coordinated data:simulation system for oil spill impact & risk evaluation
Assessing Risks and the Potential for Environmental Impacts for Deep & Ultra-Deepwater GOM

[Project Lead: Rose]

Driver: Need for a cohesive suite of tools and data to support independent, rapid science-based prediction of UDW hydrocarbon risks and assessment of spills

Project Goal: Reducing risks and environmental impacts from extreme offshore hydrocarbon production

pre-FY13 Status:
- Released GOM Geocube, online map based tool containing key spatial data for the GOM
- TRS summarizing key GOM impact receptor analysis
- Completed beta water column component model, BLOSOM
- Continued development of GOM subsurface database

FY13 Focus:
- Complete beta GOM subsurface database
- Complete beta development of cumulative risk tool
- Complete integration of 3 IAM component models
- Shakedown BLOSOM, run in API oil spill modeling study

Anticipated FY13 Products: Beta integrated platform to allow for independent, rapid-response, & science based prediction of UDW hydrocarbon production risks and environmental impacts

Coordinated data:simulation system for oil spill impact & risk evaluation
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Improving Deepwater Drilling Safety through Enhanced Understanding of Multiphase Flow Dynamics of Hydrocarbon Mixtures

[Project Lead: Warzinski]

Develop software to quantify flow accurately using high speed video from ROV

4" turbulent dyed water jet studied at UCB

CH₄ bubble w/ hydrate shell

Develop science base to predict hydrate formation & hydrocarbon compositions & volumes in water column plumes
Improving Deepwater Drilling Safety through Enhanced Understanding of Multiphase Flow Dynamics of Hydrocarbon Mixtures

**[Project Lead: Warzinski]**

**Driver:** Quantification of gas/oil flows using high-speed video from ROVs

**Project Goals:** Develop video-analysis tool for accurate quantification of oil/gas plume rates; incorporate hydrate formation in quantification tool

**pre-FY13 Status:**
- Completed scoping for appropriate surrogate multi-phase conditions for validation
- Completed data collection for water-water and air-water plumes (UC-B facility).
- Completed data collection for Type I/II hydrates (methane, ethane, propane) (NETL facility)

**FY13 Focus:**
- [Perform oil-water(-gas) experiments at OHMSETT (funded by BSEE)]
- Validate video-analysis tool using datasets on air-water, water-water, and oil-water
- Complete analysis of experimental data on Type I/II hydrates
- Initiate incorporation of hydrates into video-analysis tool

**Anticipated FY13 Products:**
- Video-analysis tool (prototype) for quantifying plume rates using high speed images from ROV

4” turbulent dyed water jet studied at UCB

CH\textsubscript{4} bubble w/ hydrate shell
**Driver:** Significant concerns have been raised about how to safely develop UDW resources and ensure domestic supply. Detecting in a timely, efficient manner when there is a kick is a significant challenge in deepwater systems.

**Project Goal:**
To develop a low cost means for detecting kicks when they happen at the bit, utilizing largely existing wellbore data

**pre-FY13 Status:**
- Initiated scoping and feasibility study
- Filed “report of invention” in preparation for NETL patent review process

**FY13 Focus:**
- Complete scoping and approach feasibility study
- Initiate numerical and experimental efforts to validate and implement approach for supporting early kick detection

**Anticipated FY13 Products:**
- Preliminary tool/approach for early kick detection

**Early Detection is Critical**
- Maintain control of well
- Reduce environmental, human, and economic impacts
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