U.S. Department of Energy Crude Oil Characterization Research Study – Project Update

Crude Oil Quality Association Meeting
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Ted Aulich, Process Chemist, Senior Research Manager
Chad Wocken, Chemical Engineer, Senior Research Manager
Technical Team

• David Lord (Ph.D., Env E.), Principal member of technical staff
  – Geotechnology & Engineering Department, Sandia National Laboratories
• Anay Luketa (Ph.D., Mech E.), Principal member of technical staff
  – Fire Science & Technology Department, Sandia National Laboratories
• Chad Wocken (B.S., Chem E.), Senior Research Manager
  – University of North Dakota Energy & Environmental Research Center
• Steven Schlasner (Ph.D., Chem E., MBA), Research Engineer, PE
  (OH, OK)
  – University of North Dakota Energy & Environmental Research Center
• Ted Aulich (B.S., Chemistry), Senior Research Manager
  – University of North Dakota Energy & Environmental Research Center
• Ray Allen (B.S., Chem E.), PE (TX)
  – President of Allen Energy Services engineering consulting firm
Project Governance

• U.S. Department of Energy (DOE) point-of-contact
  – Richard Elliott, PE, CEM
    ♦ DOE Office of Fossil Energy, Office of Oil & Natural Gas
    ♦ rick.elliott@hq.doe.gov
    ♦ 202-586-0859

• U.S. Department of Transportation (DOT) point-of-contact
  – Joseph Nicklous
    ♦ DOT Office of Hazardous Materials Safety
    ♦ Pipeline and Hazardous Materials Safety Administration
    ♦ joseph.nicklous@dot.gov
    ♦ 202-366-4545
Project Governance

U.S. DOE

U.S. DOT

Sandia National Laboratories

Allen Energy Services, Inc.

UND Energy & Environmental Research Center

GRAM, Inc.
Crude by Rail – Safety Concerns and Responses

Tight oil physical and chemical properties
♦ NDPC, PHMSA, AFPM, COQA, CCQTA crude oil characterization studies
♦ DOE Tight Oil Flammability & Transportation Spill Safety Project – Sandia and the EERC

Adequacy of transport rules/regulations
♦ PHMSA rule released May 1, 2015

Rail integrity (equipment, procedures)
♦ FRA, PHMSA

Packaging (rail tanker construction)
♦ FRA, PHMSA

Tight oil conditioning and stabilization practices
♦ North Dakota Industrial Commission Oil Conditioning Order #25417
**DOE/DOT Crude Oil Characterization Research Study**

### Phase I – Problem Definition
- Review publicly available literature/data on tight oil sampling, properties, combustion – complete.
- Prepare crude oil sampling, analysis, and experimental plan – final review ongoing.

### Phase II – Sampling, Analysis, and Experimental Plan (SAE Plan) Subject to Federal Budget
- Sample and analyze tight and conventional crudes.
- Develop models, refine with small- and rail car-scale combustion testing.
- Assess if, how, and to what extent properties impact hazard.

|---------|---------|---------|---------|---------|---------|---------|

Proposed testing: ~5-meter-diameter pool fire tests at Sandia Labs.
Conducted by Sandia National Laboratories, the EERC, Allen Energy Services, and GRAM Inc.

Primary sources include NDPC, PHMSA, AFPM, COQA, and CCQTA crude characterization studies, and data from U.S. Strategic Petroleum Reserve.


http://energy.sandia.gov/tight-oil-study/
Variability in criteria and procedures used in crude oil sample selection, acquisition, and analysis makes comparison—between crudes and/or against standard—difficult, especially for crudes containing dissolved gases and volatile liquids:

- Supply chain point
- Extent of conditioning employed
- Sampling technique (open, closed, online)
- Analysis method
- Clear relationships between crude oil properties and probability or severity of rail accident combustion events have not been established.

- Multiple parameters (flashpoint, flammability limits, autoignition temperature, ignition energy, burn velocity, others) needed to define flammability.

- Energy generated from an accident has the potential to exceed flammability impact of above and other crude property-based criteria.
Combustion Specialists

Sandia-conducted fireball experiment.
Crude Oil SAE Plan

- Sandia National Laboratories, the EERC, and Allen Energy Services recently submitted an SAE plan to DOE.
- Objectives include:
  - Evaluating sampling methods, identifying best method(s) for crudes with dissolved gases.
  - Developing database of tight and conventional crude properties (determined under standard sampling and analytical protocol).
  - Identifying any significant differences between tight and conventional crudes.
• Objectives, continued:
  – Identifying any properties that could contribute to increased likelihood and/or severity of transport-related combustion events.
  – Identifying and quantifying crude conditioning system operational parameters that impact transport safety-critical properties.
  – Developing preliminary recommendation of properties to include as compliance metrics in “crude oil safe transport specification.”
SAE Plan Tasks

- Update Literature Review with New and Emerging Data
- Evaluate Sampling Methods
- Combustion Experiments and Modeling
- Sampling and Analysis of Tight and Conventional Oils
- Large-Scale Combustion Testing and Computational Fluid Dynamics Modeling
- Comprehensive Crude Oil Characterization
Task 1: Update Literature Review with New and Emerging Data


- Crude oil characterization work is ongoing; new and emerging data will be reviewed and an updated SAND Report will be prepared.

- Provides an opportunity to modify subsequent crude oil characterization tasks based on emerging data.
Task 2: Evaluate Sampling Methods

Evaluate multiple sampling methods for application to crude oils containing volatile hydrocarbons:

- Closed Method – ASTM D3700-14, floating piston cylinder.
- Closed Method – ASTM D1265 and/or GPA 2174, water displacement.
- Closed Method – ASTM D3700, syringe method.
- Open Method – ASTM D5842, fuel sampling for volatility measurement.

Analysis for volatility and composition to assess ability of each method to provide representative sample collection:

- Results compared to data collected with a mobile lab/test separator.

Collect tight oil samples from two rail terminals:

- Tight oils comprise majority of rail transported crude.

Best method will be employed for subsequent tasks.
Assess combustion hazards of both tight and conventional oils:

- Identify crude properties that affect the combustion event hazards.
- Assess the impact of identified properties.
- Develop a prioritized list of properties/parameters that need to be included in subsequent sampling, analysis, and experimental activities.

Acquire large samples of crude oil, using procedures that maintain the integrity and representativeness of the oil and conduct combustion tests at Sandia National Laboratory:

- 2-meter pool fire tests (150 gallons/test).
- 5-meter pool fire tests (1,000 gallons/test).
- 5-gallon fireball tests.
- 500-gallon fireball tests.

Computational Fluid Dynamic (CFD) Simulations of Vapor Dispersion:

- Evaluate dispersion of vapors for tight and conventional crude oils.
- CFD vapor composition inputs based on test measurements of gas composition at different levels of heating.
- Support hazard evaluation regarding flash fires and explosions.
Task 4: Sampling and Analysis of Tight and Conventional Oils

Develop comprehensive data set that characterizes multiple crude oil types, sampled at transport hub (rail or pipeline terminal):

- Illustrate differences in crude oil properties and composition.
- Support combustion property modeling efforts.
- Enable prioritization of future crude characterization based on geography, environmental conditions, well life, and supply chain.

Using selected sampling method(s), collect samples representing:

- Two tight oils (example: Eagle Ford, Bakken).
- Two conventional oils (example: WTI).
- One heavy crude (example: oil sands, rail-bit).

Conduct comprehensive crude oil analysis

- Volatility (VPCRx, light ends including inert gases, flashpoint).
- Detailed hydrocarbon analysis (assay).
- API, molecular weight, specific heat, conductivity, viscosity, metals, cold-flow properties.
Large-scale tests may be conducted based on findings of previous activities (Tasks 1-4):

- Collect empirical data to validate computational models and enable prediction of full-scale combustion events.

Acquire large samples of crude oil, using procedures that maintain the integrity and representativeness of the oil and conduct combustion tests at Sandia National Laboratory:

- Large-scale pool fire tests.
- Large-scale fireball and BLEVE tests.

Computational Fluid Dynamic Simulations:

- Evaluate the impact of crude oil properties on combustion.
- Simulate effect of combustion properties on a rail tanker under different environmental conditions.
**Task 6: Comprehensive Crude Oil Characterization**

Expand Task 4 data set to include effects of supply chain point and other factors on properties:

- Scope of sampling and analysis will be based on findings of previous tasks – determination of properties impacting handling and transport safety will dictate relative value of further crude oil characterization.

Using selected sampling method(s), acquire samples representing:

- Five oil plays.
- Multiple supply chain points between well and refinery.
- Summer and winter months.
- Multiple times across the production life of a well.

Conduct comprehensive crude oil analysis:

- Volatility (VPCRx, light ends including inert gases, flashpoint).
- Detailed hydrocarbon analysis (assay).
- API, molecular weight, specific heat, conductivity, viscosity, metals, cold-flow properties.
Contact Information

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

World Wide Web: www.undeerc.org
Telephone No. (701) 777-5273
Fax No. (701) 777-5181

Ted Aulich, Senior Research Manager
taulich@undeerc.org
Chad Wocken, Senior Research Manager
cwocken@undeerc.org