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SAND2015-4684C

DOE Crude Oil Characterization Research Study – Project Update

Canadian Crude Quality Technical Association
Annual General Meeting
Calgary, Alberta, Canada
June 17, 2015

Presented by:
David Lord, Sandia National Laboratories

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THE UNIVERSITY OF NORTH DAKOTA

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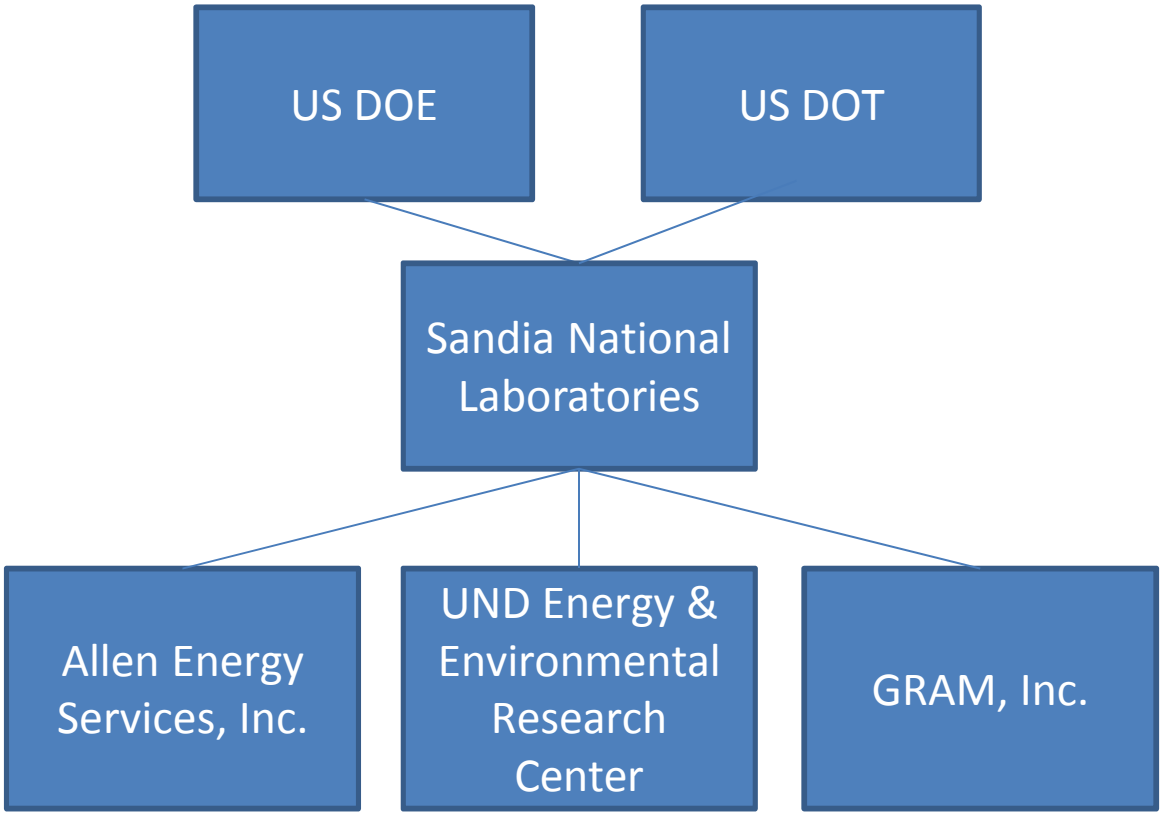
Project Governance



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Crude by Rail – Safety Concerns and Responses

Tight oil physical and chemical properties reports

- NDPC, PHMSA, AFPM crude oil characterization studies
- DOE Tight Oil Flammability & Transportation Spill Safety Project – Sandia and EERC
- NRC Rail Tank Cars Exposed to Fire

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

- ND 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 Budget Availability

- Establish best practices for collecting and analyzing crude samples for physical/chemical properties necessarily retaining light ends
- Evaluate effects of measured physical/chemical properties on combustion characteristics in pool fires and fireballs
- Assess if, how, and to what extent properties impact hazard

Q4 2014	Q1 2015	Q2 2015	Q3 2015	Q4 2015	Q1 2016	Q2 2016

Proposed testing: ~5-meter-diameter pool fire tests at Sandia Labs.

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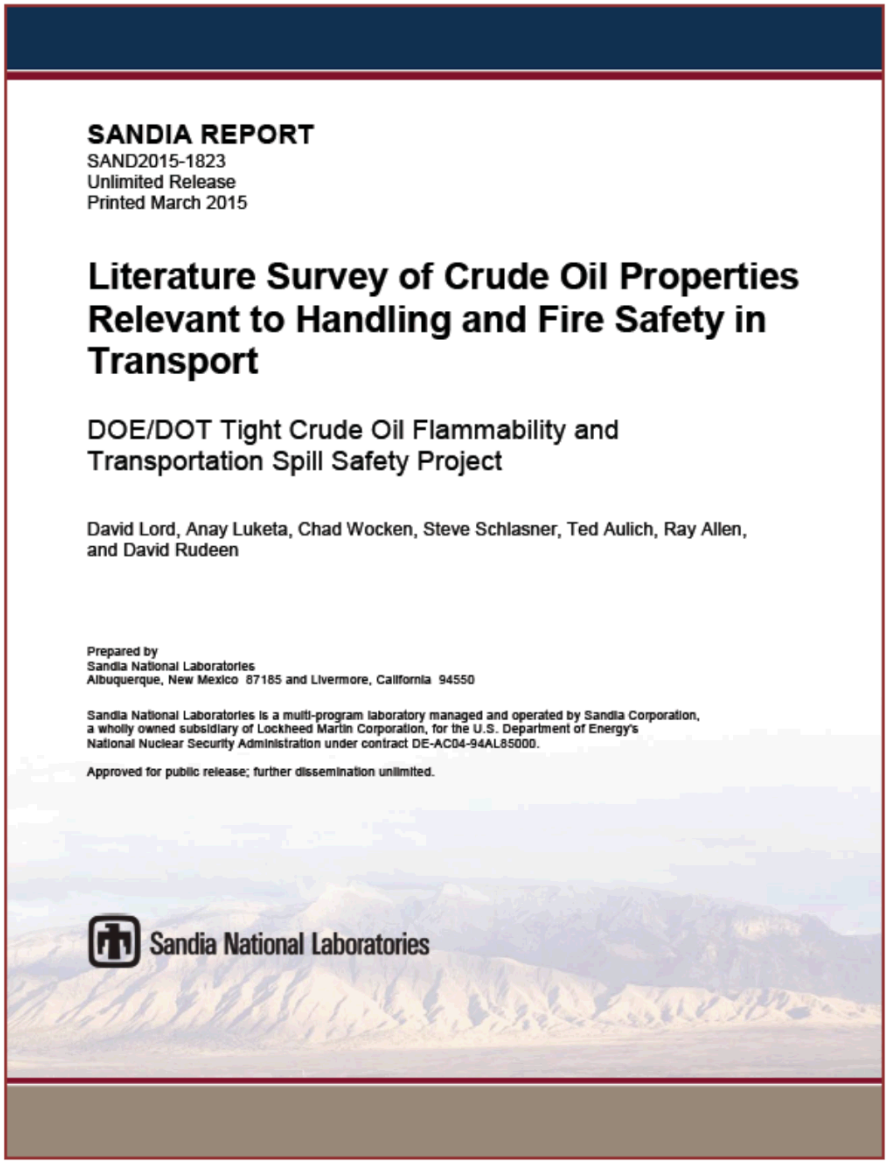
DOE Literature Survey

- Conducted by Sandia National Laboratories, 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 (SPR).
- Published in March 2015 as Sandia Report SAND 2015-1823 – Literature Survey of Crude Oil Properties Relevant to Handling and Fire Safety in Transport.

http://energy.gov/fe/articles/sandia-national-laboratories-releases-literature-survey-crude-oil-properties-relevant



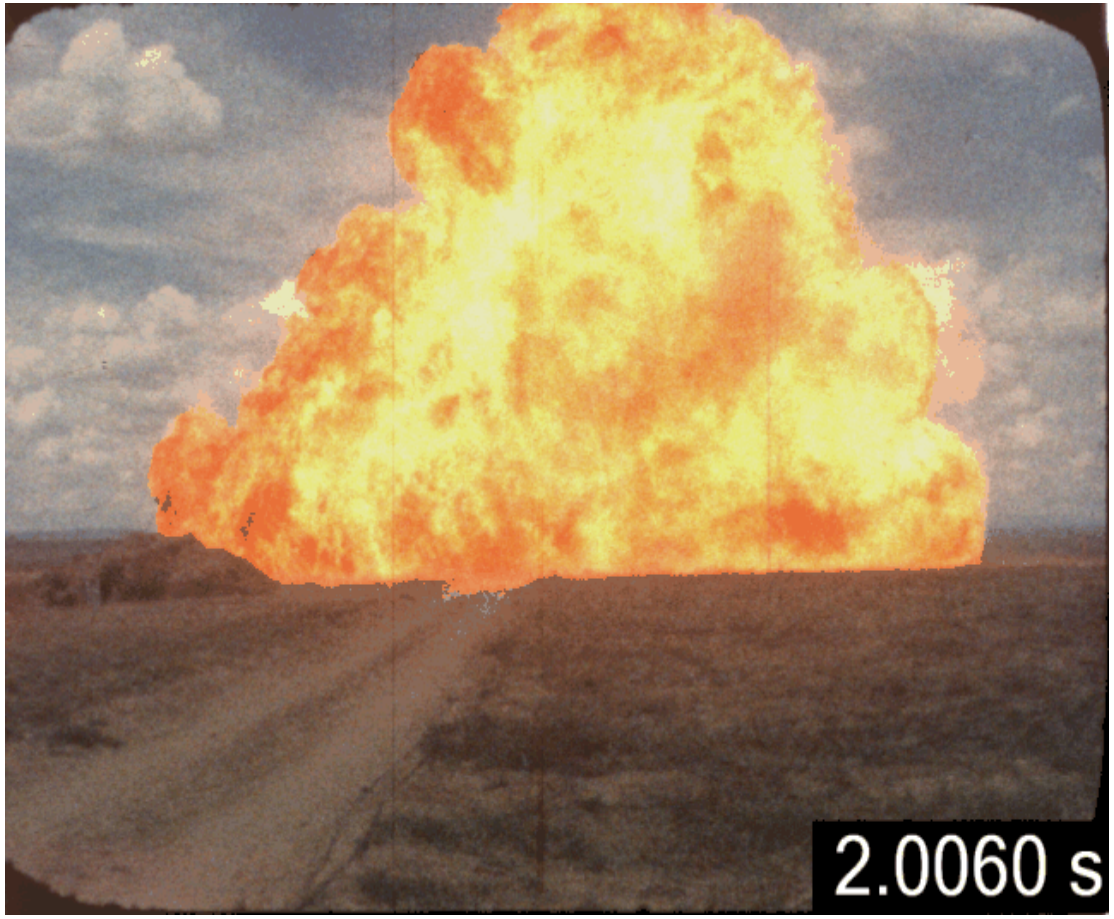
Literature/Data Survey Outcomes

- 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, on-line)
  - Analysis method

Literature/Data Survey Outcomes – 2

- Clear relationships between crude oil properties and probability or severity of rail accident combustion events have not been established.
- Multiple parameters (flashpoint, flammability limits, auto-ignition temp, 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 Sampling, Analysis, and Experimental (SAE) Plan

- Sandia National Laboratories, 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.

SAE Plan – 2

- Objectives, con't:
  - 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 – Conceptual Level

- The subject conceptual SAE plan was proposed by Sandia to U.S. DOE and DOT in a series of internal reports during March-May 2015
- The current information has been approved for public release, and represents Sandia opinion on what areas could/should be investigated with current Sandia capabilities
- As of June 11, 2015, there has been no specific commitment from either DOE/DOT agency as to the scope or budget that may or may not be funded in a potential Phase II of this project

SAE Plan Tasks

- (1) Update Literature Review with New and Emerging Data
- (2) Evaluate Sampling Methods
- (3) Combustion Experiments and Modeling
- (4) Sampling and Analysis of Tight and Conventional Oils
- (5) Large-Scale Combustion Testing and Computational Fluid Dynamics Modeling
- (6) 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
- Attend relevant industry meetings, conferences to facilitate technology transfer and collaboration

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 D5842-14, fuel sampling for volatility measurement
- Flow-Through Method – ASTM D4177-95 (Re 2010)

Analyze 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 used for SPR

Sample collection of tight oil from two rail terminals

- Tight oils comprise majority of rail transported crude

Best method(s) will be employed for subsequent tasks

Task 3: Combustion Experiments and Modeling

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 a comprehensive data set that characterizes multiple crude oil types

- 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.

Acquire samples using previously selected methods 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 gasses, flashpoint)
- Detailed hydrocarbon analysis (assay)
- API, molecular weight, specific heat, conductivity, viscosity, metals, cold flow properties

Task 5: Large-Scale Combustion Testing and Computational Fluid Dynamics Modeling

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

Develop a comprehensive data set that characterizes multiple crude oil types and all the factors influencing their 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

Acquire samples using previously selected methods representing

- Five oil plays
- Multiple sample 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 gasses, flashpoint)
- Detailed hydrocarbon analysis (assay)
- API, molecular weight, specific heat, conductivity, viscosity, metals, cold flow properties

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