



Crude Oil Vapor Pressure Monitoring Program at the US Strategic Petroleum Reserve

**Crude Oil Quality Association Meeting
Magnolia Hotel
Houston, TX
March 1, 2012**

**David Lord¹, Ray Allen²
& David Rudeen³**

- (1) Sandia National Laboratories, Albuquerque, NM**
- (2) Allen Energy Services, Inc., Longview, TX**
- (3) GRAM, Inc., Albuquerque, NM**

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.





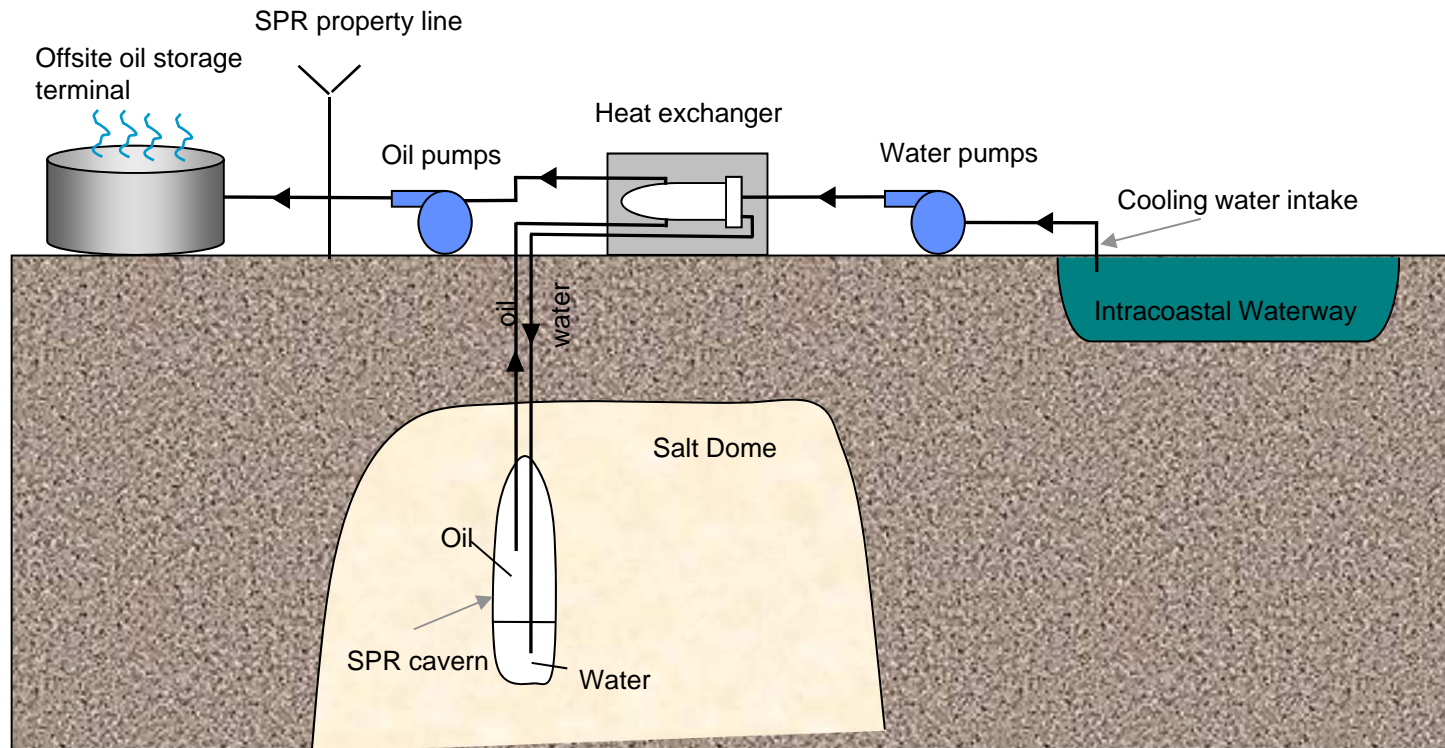
Acknowledgements

- Vapor pressure monitoring program directed by the U.S. Strategic Petroleum Reserve Vapor Pressure Committee
- Funding provided by the U.S. Department of Energy Strategic Petroleum Reserve Project Management Office, New Orleans, LA



Driven by Delivery Requirements

- Project performance criteria limit bubblepoint pressure and gas-oil ratio of outgoing oil at property line, minimizing worker and public exposure to crude oil emissions





Evolving Monitoring Capability, early 1990's

- **Storage site operators observe SPR crude foaming and boiling when drawn to unpressurized sample containers**
- **Project recognized need to somehow quantify volatility of crude oil coming out of storage caverns into atmospheric storage tanks**
- **Pressurized bomb samples sent to lab for bubblepoint pressure analysis showed inconsistent results, BPP = 10-100 psia**



Evolving Monitoring Capability, 1995-

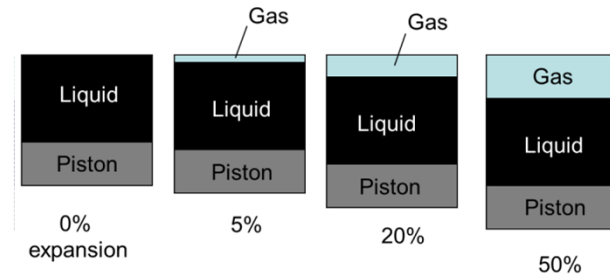
- **Manual mini-skid gas-liquid separator measures bubblepoint pressure of oil at selected temperature (early 1990's)**
- **Partially automated TVP-95 gas-liquid separator measures BPP, GOR, and flash gas compositions (1995-present)**



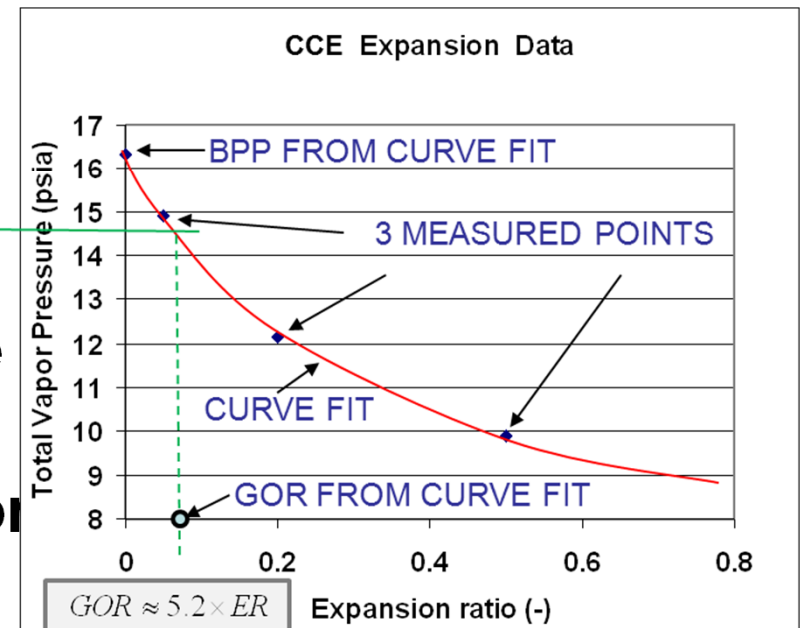


Evolving Monitoring Capability, 2000-

- **Constant composition expansion (CCE)**
 - Obtain 3 measured pressure-expansion points at temperature
 - Fit curve to three points
 - Calculate BPP where curve intersects zero expansion
 - Calculate GOR where curve intersects $P = 14.7$ psia
- Also utilize gas-liq separator and GC for input to EOS model



CCE 3-point expansion sequence



$GOR \approx 5.2 \times ER$
@ $T = 100^\circ F$



RVP vs. TVP for SPR Oils

Table 2. SPR Crude Oil Vapor Pressure Comparisons*

<u>Cavern I.D.</u>	<u>BM-103</u>	<u>BH-106</u>	<u>BM-2</u>	<u>BH-101</u>
Oil Type	Sour	Sour	Sweet	Sweet
Gas Contamination	High	Medium	High	None (Incoming)
<u>True Vapor Pressures</u>				
Gas/Liquid Equilibrium	34.6	24.9	41.9	17.9
Gas Separator Shut-in	34.3	24.5	43.7	17.2
API 2517 Nomograph (From simulated Reid)	9.1–7.5	9.1	11.7	13.0
API 2517 Nomograph (From Reid lab report)	9.3–4.6	7.3	12.0–9.5	12.0
<u>Reid Vapor Pressures</u>				
Simulated	7.4–6.3	7.4	9.0	9.7
Lab Reported	7.5–4.7	6.2	9.1–7.7	9.1

* All Vapor Pressures on nominal 100° F temperature comparison basis.

Reproduced from:
Henderson, J. K. (1994).
"Strategic Petroleum Reserve
Gas and Geothermal Heat
Effects on Crude Oil Vapor
Pressure, Executive
Synopsis." MITRE, New
Orleans, LA.



CCE vs. TVP-95 for SPR Oils

BH Cavern	CCE, psia	TVP-95, psia	Diff, psi	Rel. Diff, -
BH108	18.7	18.0	0.70	0.039
BH113	18.8	18.6	0.20	0.011
BH103	19.0	17.8	1.16	0.065
BH101*	19.9	18.4	1.50	0.082
BH104*	18.7	17.7	1.00	0.056
BH112	16.4	15.1	1.27	0.084
BH102	15.3	14.8	0.49	0.033
BH114	19.0	18.0	1.00	0.056
BH110	16.7	16.6	0.10	0.006
Average			0.82	0.048
2 σ			0.48	0.028

* No parallel test; early CCE BPP; pre degas TVP95



ASTM D6377 vs. SPR CCE

- **ASTM D6377 Method is for the determination of the vapor pressure of crude oil for a single expansion point at a given temperature.**
 - For results related to Test Method D 323 (RVP), V/L would equal 4:1 at 100 F(37.8 C).
- **SPR CCE utilizes an ASTM D6377 compliant analyzer and simply modifies the testing cycle to include 3 expansions at 3 operator settable expansion ratios, typically at 100 F.**
 - The analyzer performs the 3 expansions per the D6377 method and determines the VP for each expansion.
 - The analyzer then performs a curve fit of the 3 vapor pressure data points to determine the VP@0 expansion or BPP.



Synopsis

- **RVP not adequate for characterizing TVP of SPR oils for compliance with emissions requirements**
- **TVP-95 separator currently serves as project experimental baseline**
 - **Measured BPP value is probably slightly lower than true incipient BPP**
- **CCE approach is used for inline degasification process monitoring at SPR**
 - **High reproducibility**
 - **BPP returned from process is likely closer to true incipient BPP**
 - **More compatible with use in EOS models**



Contact Information

- **David Lord, Ph.D.**
 - Principal Member Technical Staff
 - Geotechnology & Engineering Department
 - Sandia National Laboratories
 - Ofc: 505-284-2712
 - dllord@sandia.gov
- **Ray Allen, PE**
 - President, Allen Energy Services, Inc.
 - Ofc: 903-759-6237
 - rallen@allen-energy.com



END OF PREPARED SLIDES