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Technical Proposal for Loading 3,000 Gallon Crude Oil Samples from Field Terminal to Sandia Pressurized Tanker to support US DOE/DOT Crude Oil Characterization Research Study

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1 Purpose

Sandia National Laboratories is seeking access to crude oil samples for a research project evaluating crude oil combustion properties in large-scale tests at Sandia National Laboratories in Albuquerque, NM. Samples must be collected from a source location and transported to Albuquerque in a tanker that complies with all applicable regulations for transportation of crude oil over public roadways. Moreover, the samples must not gain or lose any components, to include dissolved gases, from the point of loading through the time of combustion at the Sandia testing facility. In order to achieve this, Sandia designed and is currently procuring a custom tanker that utilizes water displacement in order to achieve these performance requirements. The water displacement procedure is modeled after the GPA 2174 standard "Obtaining Liquid Hydrocarbons Samples for Analysis by Gas Chromatography" (GPA 2014) that is used routinely by crude oil analytical laboratories for capturing and testing condensates and "live" crude oils, though it is practiced at the liter scale in most applications. The Sandia testing requires 3,000 gallons of crude. As such, the water displacement method will be up-scaled and implemented in a custom tanker.

This report describes the loading process for acquiring a ~3,000 gallon crude oil sample from commercial process piping containing single phase liquid crude oil at nominally 50-100 psig. This document contains a general description of the process (Section 2), detailed loading procedure (Section 3) and associated oil testing protocols (Section 4).

2 General Description of Process

Sandia will coordinate with commercial operators/donors to select a sampling location that allows for safe and effective loading of the Sandia tanker without undue disruption of activity to the donor. Points at or near upstream production facilities or at tank terminals feeding rail loading terminals or pipelines are preferred. Space for the Sandia custom tanker (semi-tractor pulling ~45-foot tank chassis), a 120 BBL vacuum truck (hired by Sandia), and a sampling tap for a qualified crude oil sampling technician (hired by Sandia) to pull several liter-scale pressurized loading samples for analysis back at the lab, will be required. Total time on-site will be less than 8 hours. Sandia understands that 3rd party vendors (vacuum truck operators, crude oil analytical labs) already pre-approved for work on the operator's site can facilitate approvals, so some discussion of this issue is encouraged moving forward.

2.1 Site Access Agreement

Agreement on terms for site access must be reached in advance of the actual sampling event, typically engaging the legal teams from the operator/donor and Sandia. In some cases, an applicable site access agreement was already placed for prior work between Sandia and the donor, which simply requires

confirmation that the existing site access agreement is applicable to the 3,000 gallon sample acquisition activity. In cases where the relationship is new, Sandia has a draft site access agreement that can serve as a starting point for further legal engagement.

2.2 Oil Transfer of Custody

Custody transfer must be arranged so the Sandia tanker can leave the loading site with the 3,000 gal of oil. Sandia is prepared to pay for the sample or can take a donation. These details need to be discussed, and Sandia will engage their purchasing department as necessary.

3 Loading Process Detail

PROCEDURE FOR Filling of Sandia Crude Oil Tanker

- assumed process crude oil pressure 50-100 psig

The following equipment is required to perform the tanker fill:

1. DOT-51 4885 gallon tank ASME code MAWP 250 psig/-20 inHg (vac). Tank to be supplied with OSHA approved work platforms with handrails and access stairs.
2. 120 BBL vacuum truck with fresh water.
3. Process to Tanker connection hose which includes:
    a. 1" high pressure hose (minimum rating 1000 psig)
    b. 1" XXH piping, 3000# valves and threaded fittings.
    c. 0-150 psig pressure gauge
4. Vacuum Truck Manifold (holds backpressure on tanker during fill process) contains the following equipment:
    a. Self-contained back pressure regulator (PCV) (to maintain oil tanker pressure at to 50-75 psig during loading)
    b. 2" XXH piping, 3000# valves and threaded fittings.
    c. 0-100 psig pressure gauge
5. Nitrogen tank (standard high pressure N2 cylinder) for pressurization of internal tank bladder. With standard 2-stage pressure regulator, high pressure hose and additional pressure regulator at bladder inflation point.
6. Grab sample pressurized cylinders to be connected to sampling tap on pressure regulating manifold. Cylinders will be rated for 1200 psig (min) and DOT approved.
7. 55 gal steel drum for flush and line(hose) purge.

The fill methodology assumes the following (see diagram 1 to identify valve tags (ELN)):

1. Connection to process will be on OPERATOR's crude oil system (assumed operating pressure of system is 50-100 psig)
2. The 4885 gallon tank and trailer (Tanker) is on crude oil supply location. Location must be accessible for a tractor-trailer carrying the DOT-51 tank, 120 BBL vacuum truck (Vac Truck).
3. Upon positioning trucks each driver will set parking brake and place chocks to prevent trailer roll-off. Both tankers will be electrically bonded through to process piping and grounded.
4. Vac Truck will connect hose from his main inlet valve directly to tanker 2" Water In/Out valve V-1.
5. Tanker 1" vent valve (V-4) is opened to atmosphere.
6. N2 cylinder connected to bladder inflation valve V-6, and bladder inflated to ~2-5 psig.
7. Vac Truck provides slight positive pressure to his tank and open V-1 to force water flow into Tanker to completely water fill. (V-4 valve will have hose connected to run any water into 55 gal drum, drum will be properly grounded).
8. Once water free flowing from V-4, V-4 is closed. Tanker now is 100% water filled with slight positive pressure from Vac Truck, V-1 still open.

Note: Steps 9-15 are to purge air from 1" Inlet hose.

9. Connect Tanker end of sample inlet hose (V-17) to Tanker oil fill valve V-2.
10. Connect process end of sample inlet hose (V-16) to process valve.
11. Open V-2 and V-17.
12. With slight positive pressure on Vac Truck and Tanker open V-16
13. Connect hose or tubing from V-20 to 55 gallon drum.
14. Slowly open V-20 to purge air from sample inlet hose up to process valve.
15. Once water is free flowing close V-20, V-16, V-17 and V-2.
16. Close tanker V-1 and disconnect Vac Truck hose from V-1.
17. Install Vac Truck Manifold to V-1.
18. Set PCV-26 to minimum setpoint by backing out set screw.
19. Connect Vac Truck hose to outlet fitting of Vac Truck Manifold.
20. Vent Vac Truck to atmosphere
21. Open Vac Truck valve, V-27, leaving V-1 closed.
22. Open V-1 to Vac Truck

Note: At this point all air should be purged from tanker, pressure regulating manifold and process & tanker interconnects.

23. Insure the following valves are CLOSED before proceeding:
    a. Process valve
    b. V-16
    c. V-20
    d. V-17
    e. V-2
24. Insure the following valves are OPEN before proceeding:
    a. V-18 (with PI installed)
    b. V-1
    c. V-27

d. Vac Truck Inlet valve (with Vac Truck vented to atmosphere)
e. V-28 (with PI installed)

25. Open V-2
26. Open V-17
27. Open Process Valve from oil source
28. Slowly crack open V-16 to pressurize system up to PCV-26.
29. Adjust Vac Truck Manifold back pressure regulator PCV-26 to hold minimum of 50 psig back pressure on tanker.
30. Slowly open V-16 while monitoring Process pressure V-18 PI, tanker pressure V-28 PI and Vac Truck pressure.
31. While filling tanker with oil monitor tanker oil/water interface level, Vac Truck water level, tanker pressure, bladder pressure.
32. Once approximately 3500 gallons of oil has been transferred to tanker, close process valve then close V-16.
33. Once V-16 closed close V-2 and V-17.
34. Insure PCV-26 and flow path to Vac Truck still open. Adjust bladder pressure so that bladder pressure is 1-3 psig greater than tanker oil pressure. This is to insure bladder is fully inflated. As bladder inflates additional water will be displaced from tanker to Vac Truck, PCV-26 will hold desired backpressure on tanker during this process.
35. Once bladder pressure is stabilized close V-1 and disconnect Vac Truck hose from Vac Truck Manifold.
36. Bleed pressure and drain through V-18 and V-20 to allow disconnection inlet hose.
37. Place slight positive pressure on Vac Truck and connect V-16 inlet hose inlet to Vac Truck.
38. Flush water through the inlet hose through V-17 and into 55 gallon drum.
39. Connect N2, regulated down to 25 psig, to V-16 to push/blow water from the inlet hose through V-17, into 55 gallon drum.
40. Disconnect Vac Truck Manifold from V-1.
41. Insure all tanker valves are blinded, capped or plugged and all placarding is in place prior to release of tanker.
42. Properly dispose of waste water and oil in 55 gallon drum
43. Release Vac Truck.
44. Task complete.

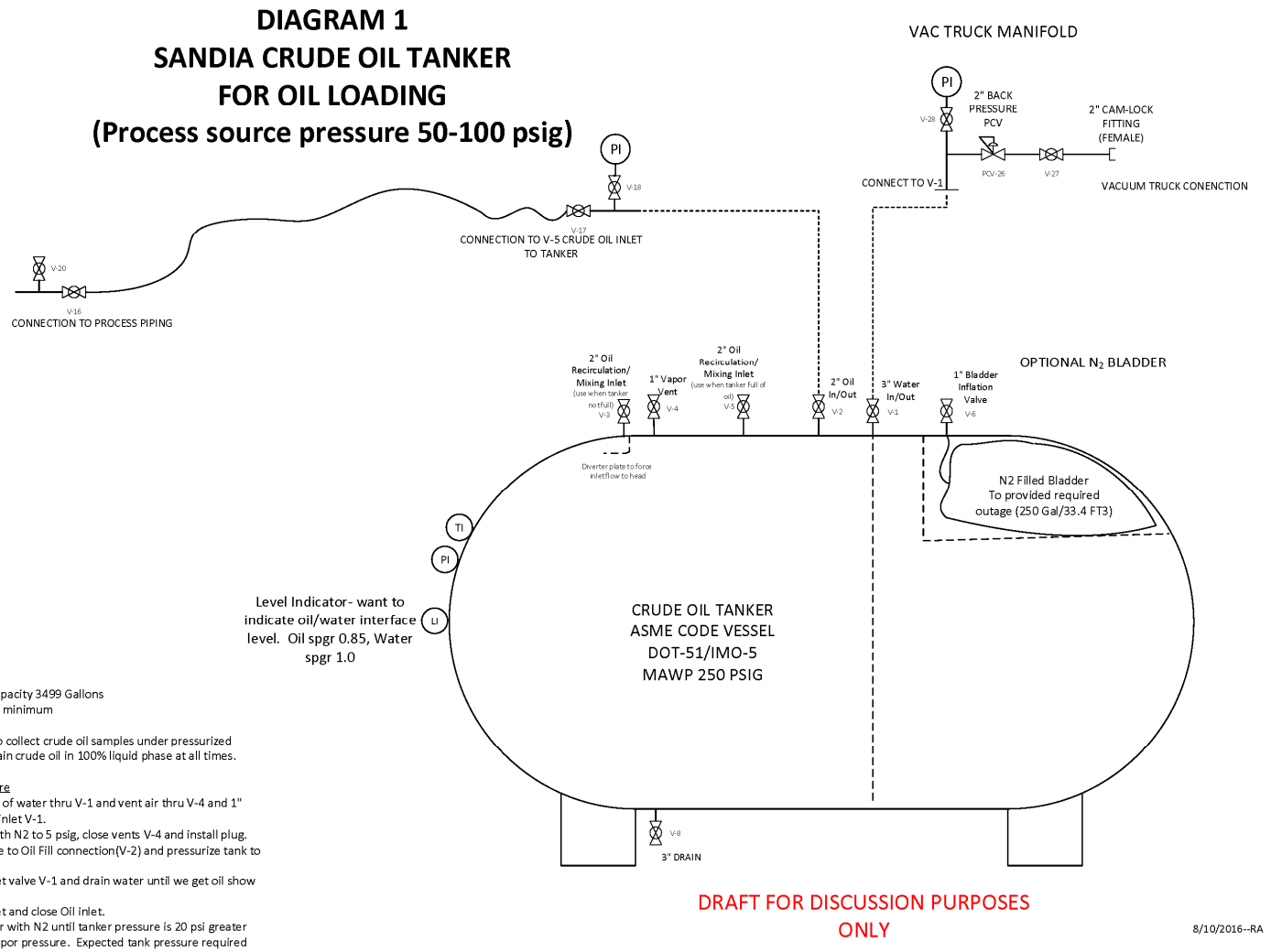

Diagram 1. Sketch of loading manifold for connecting commercial process piping to Sandia crude oil tanker (version 8/10/2016—RA). .

4 Testing Protocols

4.1 On-site sampling

Baseline samples (liter-scale) for crude oil property testing will be taken from the tanker by a qualified sampling technician from a crude oil sampling and analysis laboratory working under contract with Sandia National Laboratories. These will include VPCRx(T) and composition (i.e. GPA 2103) to serve as a QA check on loading procedure that will be compared with crude oil property data to be measured later when the tanker arrives at Sandia

4.2 Transportation and additional testing

Once the tanker is loaded, a qualified commercial driver under contract with Sandia will transport the oil to Albuquerque, NM for a series of tests. Properties to be measured include, but are not limited to the following:

1. VPCRx(T) at selected V/L and Temperature, by ASTM D6377 (ASTM 2016)
2. Light ends composition by GPA 2103 (GPA 2003) or GPA 2177 (GPA 2013)
3. Detailed hydrocarbon analysis by ASTM D7900 (ASTM 2013a)
4. Simulated distillation by ASTM D7169 (ASTM 2011)
5. Physical properties to include density, average molecular weight, and viscosity
6. Flashpoint by ASTM D93 or ASTM D56 (ASTM 2010; ASTM 2013b)
7. Initial boiling point by 0.5 wt% calculation
8. Surface emissive power from pool fire and fireball tests
9. Heat of combustion

4.3 Use and Publication of Data

Oil data acquired from the sampling event will be analyzed and published in unclassified, unlimited release technical research reports and presentations. . Sandia will avoid any specific references to producer name, terminal operator name, or geographic location (lat/long) of the sampling location.

5 Cited References

ASTM 2011 "Standard Test Method for Boiling Point Distribution of Samples with Residues Such as Crude oils and Atmospheric and Vacuum Residues by High Temperature Gas Chromatography." **ASTM D7169-11**. ASTM International, West Conshohocken, PA 19429-2959.

ASTM 2013a "Standard Test Method for Determination of Light Hydrocarbons in Stabilized Crude Oils by Gas Chromatography." **ASTM D7900-13E1**. ASTM International,

ASTM 2016 "Standard Test Method for Determination of Vapor Pressure of Crude Oil: VPCRx(Expansion Method)." **ASTM D6377-16**. ASTM International, West Conshohocken, PA 14928-2959.

ASTM 2010 "Standard Test Method for Flash Point by Tag Closed Cup Tester." **ASTM D56-05 (Re 2010)**. ASTM International, West Conshohocken, PA 19429-2959.

ASTM 2013b "Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester." **ASTM D93-13**. ASTM International, West Conshohocken, PA 19429-2959.

GPA 2013 "Analysis of Natural Gas Liquid Mixtures Containing Nitorgen and Carbon Dioxide by Gas Chromatography." **GPA Standard 2177-13**. Gas Processors Association, Tulsa, OK 74145.

GPA 2014 "Obtaining Liquid Hydrocarbons Samples for Analysis by Gas Chromatography." **GPA 2174-14**. Gas Processors Association, Tulsa, OK 74145.

GPA 2003 "Tentative Method for the Analysis of Natural Gas Condensate Mixtures Containing Nitrogen and Carbon Dioxide by Gas Chromatography." **GPA Standard 2103-03**. Gas Processors Association, Tulsa, OK 74145.