

**Subject:** Benzene Content - Leviathan Field

**Date:** 10-June-2019

### **Executive Summary:**

Leviathan reservoir fluids have been tested for compositional analysis by multiple laboratories, specifically focusing on benzene content. All testing is in accordance with global best practices and test methods for fluid characterization. The data available is a combination of downhole and separator samples from multiple Leviathan wells, regional analogues from similar reservoirs, and rigorous process modeling of the Leviathan platform.

Summary of key results are:

- Maximum expected benzene content in the sales condensate: 0.09 wt% (914 ppmw)
- Leviathan benzene content expected to be lower than Tamar, based on a higher expected condensate / gas ratio (CGR). While the Leviathan process is ‘thermodynamically similar’ to Tamar, and should yield similar results, the difference in CGR plays a significant role in the final benzene content in the Leviathan sales condensate.
- From a reservoir characterization standpoint, the Leviathan fluids meet the criteria of a “Condensate” or “Wet Gas” system. However, for all other compositionally-based comparisons, these definitions do not apply, as Leviathan liquid properties generally fall outside of any conventional API nomenclature for defining petroleum products. Leviathan liquids are closer to a crude when comparing gravity, sulfur and benzene to typical crudes worldwide.

### **Introduction:**

Leviathan fluids have been obtained through various testing methods, with sample locations ranging from single-phase downhole samples, Drill Stem Test (DST) / Flowback samples, separated gas and liquid samples, and full crude assays. Testing has been carried out at multiple, world-class laboratories and has adhered to known testing standards (i.e. GPA / ISO). Standard BTEX testing method is per ISO-6974 / ISO-6975 or GPA-2286, which generally carry a Limit of Detection (LOD) of 10 ppm. In some instances, a “modified ISO” standard may yield a LOD of 1 ppm, but this limits the number of available laboratories and is challenging for reproducibility. As such, a LOD of 10 ppm on any constituent component (i.e. benzene) should be considered as “best in class”.

Noble has internally vetted multiple laboratories capable of carrying out the sampling programs to the international standards required. Among them include Intertek (US / UK), Maxxam (Canada), SPL (US), BactoChem (Israel) and Chemical Testing Laboratory (Israel). In most cases, the labs have also conducted testing on other Noble assets, required to satisfy the technical and commercial obligations for those assets. Intertek was selected for the Leviathan development to provide a consistent testing basis across all condensate samples collected from the various development wells. Summary results from the Intertek testing is included in Appendix A.

The reported data was also assigned an uncertainty range, as defined through a rigorous Monte Carlo assessment of C6-C10 components analyzed via GPA 2286 (gas) and GPA 2186 (liquids). Uncertainties were assigned, based on round-robin testing from multiple laboratories which provided a statistical distribution of the component uncertainty. This enables each component to be specified with a +/- ppm uncertainty range around any quoted value. This enables a conservative assessment of each component.

The intent of this memo is to summarize the available compositional data related to the Leviathan reservoir and to provide guidance on likely benzene content in the Leviathan sales condensate.

**Testing Programs:**

Several fluid testing campaigns were undertaken, based on Leviathan sample availability. The program was comprehensive, with fluids available and tested from all initial Leviathan wells (L-3, L-4, L-5, and L-7).

**Downhole Sampling Results:**

- Average benzene content, reservoir fluid: 70 ppmw (+/- 38 ppmw uncertainty)

Data was collected from 20+ downhole (“open-hole”) samples, which collected single-phase reservoir fluids, which were then used to estimate the likely reservoir fluid composition.

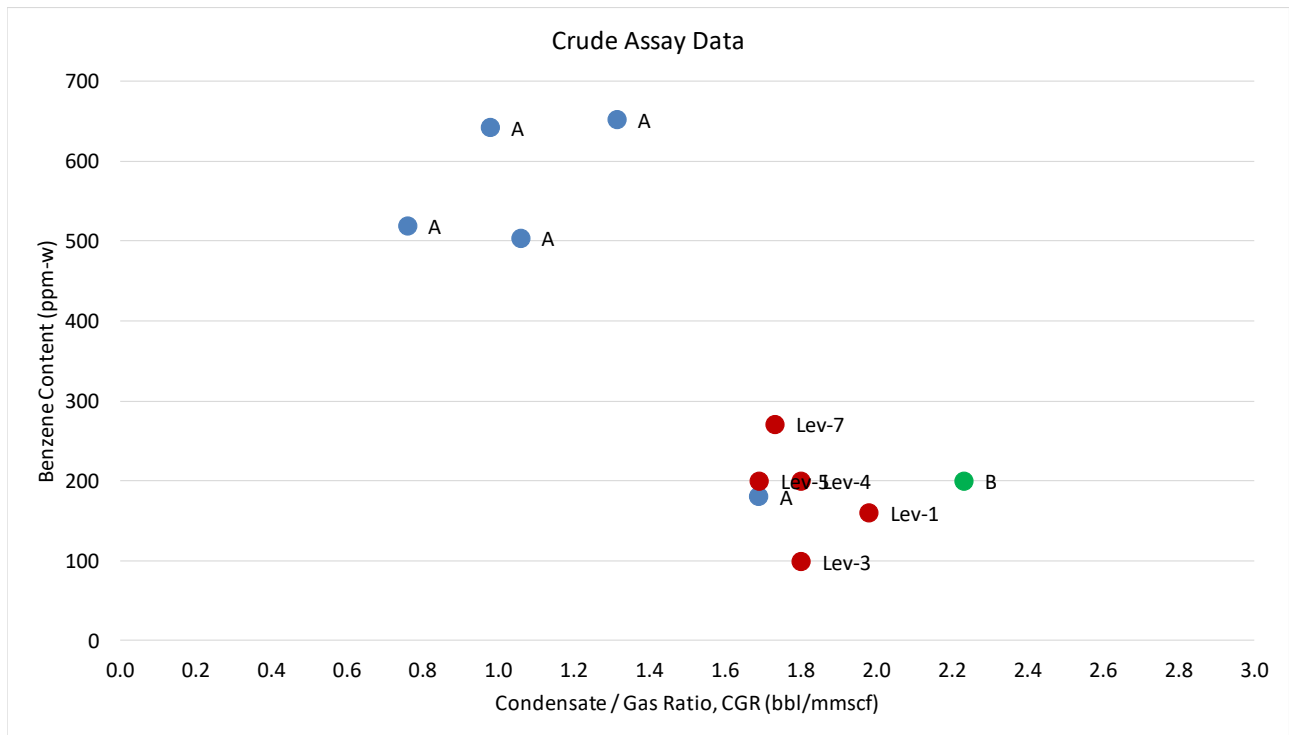
**DST / Flowback Results:**

- Average benzene content, crude assay: 186 ppmw

The DST results highlighted a strong correlation between benzene content and the fluid condensate/gas ratio (CGR), with a decreased benzene content associated with a higher CGR. The results were compared with similar data for analogue fields (“A” and “B” in the graph below), further highlighting the trend.

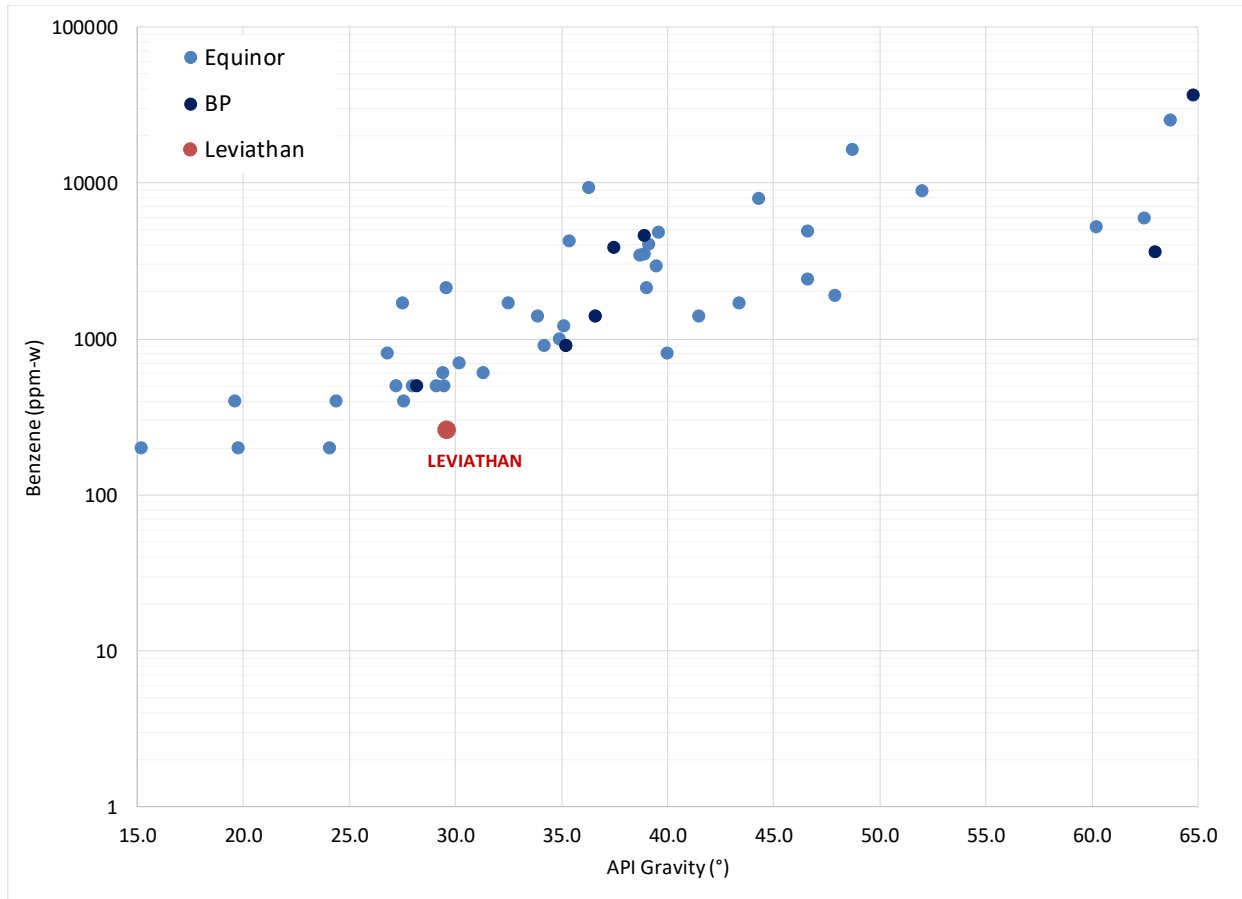
Note that the composition obtained from the DST / Flowback cannot be used as a sales condensate specification. Due to the nature of the test and the process conditions (temperature/pressures) the samples were obtained – which are different than the operating conditions for the Leviathan platform – there are some volatile components which have partitioned to the gas phase and are not reported in the values for the collected liquids.

Fluid composition, including benzene, for the various condensate samples are summarized in Appendix A.



**Analogue Fluids:**

Leviathan fluid properties are compared against several other crude assays across the world, through publicly-available databases. Leviathan liquids were shown to exhibit lower benzene contents than similar API products. Moreover, the benzene content is significantly lower than other traditional “Condensates” (42-45° API), which exhibit benzene fractions 5-10X higher than Leviathan.



**Process Modeling:**

Rigorous modeling (AspenTech’s Hysys) of the Leviathan Production Platform was undertaken to model the topsides separation process and to predict the final sales condensate composition. Several scenarios were considered, all resulting in benzene contents < 0.1wt% (<1000 ppmw).

Case Description	Benzene Content, Inlet (ppmw)	Benzene Content, Condensate (wt%)	Benzene Content, Condensate (ppmw)
Avg Benzene (CGR = 5.0 bbl/mmscf)	70	0.08	781
Max Benzene (CGR = 2.5 bbl/mmscf)	108	0.09	914
Max Benzene (CGR = 5.0 bbl/mmscf)	108	0.09	877

**Appendix A:**

- Lev-1: Condensate Assay Report (17-007821-0-ABDN)
- Lev-3: Condensate Assay Report (2018-DRPK-015612)
- Lev-4: Condensate Assay Report (2018-DRPK-015193)
- Lev-5: Condensate Assay Report (2019-DRPK-000097)
- Lev-7: Condensate Assay Report (2019-DRPK-002326)

Your Ref. : T Golczynski

Date : 11-Oct-12

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## Laboratory Test Report No. 17-007821-0-ABDN

Noble Energy Mediterranean Ltd  
C/O Noble Energy Inc.  
100 Glenborough Dr.  
Houston  
Texas 77067  
United States

**FOR THE ATTENTION OF** : Mr T Golczynski

**SAMPLE DETAILS** : 1 Samples received on 03-Sep-12

**SOURCE** : Noble Energy Mediterranean Ltd

**DESCRIPTION** : **LAB REF**  
Leviathan Condensate Sep 2012 001-00

**CONTAINERS** : IATA Can **SEALS** 0

**RESULTS** : See attached Pages 1

(TOTAL NUMBER OF PAGES 2)

Reported by:   
Jane Brebner - Section Head

Approved by:   
Alistair Park - Technical Manager

Conditions of business are printed on reverse and will apply. Any terms or conditions of the customer shall not apply except as accepted in writing by us.

**DESCRIPTION**

Leviathan Condensate Sep 2012

**LAB REF**

001-00

<b>Component</b>	<b>Vol%</b>
Ethane	0.001
Propane	0.032
Normal Butane	0.093
Iso Butane	0.061
Normal Pentane	0.207
Iso Pentane	0.283
Cyclopentane	0.189
Hexanes	2.212
Benzene	0.016
Toluene	0.274
Ethylbenzene	0.102
P-Xylene	0.052
M-Xylene	0.161
Heptanes	5.041
Octanes	7.030
Nonanes	8.950
Decanes+	75.296

# CRUDE OIL ASSAY REPORT

## Noble Energy Mediterranean Ltd - Leviathan 3 Condensate

**DOCUMENT REFERENCE:**

Leviathan 3 Condensate Crude Assay Report

**CRUDE OIL ASSAY REPORT NUMBER:**

2018-DRPK-015612

**DATE OF ISSUE:**

10-26-18



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## Laboratory Test Report No. 18-015612

**Client Ref:** Leviathan 3 Condensate

**Date:** 10-26-18

**FOR THE ATTENTION OF** : Michael Abendschein

**SAMPLE DETAILS** : 2 x 5 gallon cans received on 10/19/18

**SOURCE** : Noble Energy Mediterranean Ltd

**DESCRIPTION** : Leviathan 3 Condensate

**CONTAINERS** : Gallon Cans

**SEALS** : Yes

**RESULTS** : See attached

**Reported by:** Hally Mathes

**Approved by:** Signature Required Here

Hally Mathes/Crude Assay Manager

Client Name/ Title

Intertek Deer Park Technical Center  
1114 Seaco Avenue  
Deer Park, Texas 77536  
Telephone: (713)844-3200



Laboratory Observations / Test Method Modifications and Exception Details:Description**Leviathan 3 Condensate**LAB REF**18-015612**

<b>COMPONENT</b>	<b>VOL%</b>
ETHANE	0.01
PROPANE	0.06
NORMAL BUTANE	0.13
ISO BUTANE	0.08
NORMAL PENTANE	0.15
CYCLOPENTANE	0.18
HEXANES	0.19
BENZENE	0.01
TOLUENE	0.21
ETHYLBENZENE	0.30
P-XYLENE	0.27
M-XYLENE	0.71
HEPTANES	0.29
OCTANES	0.38
NONANES	0.35
DECANES	0.34
O-Xylene	0.27

## CRUDE OIL ASSAY REPORT

# Noble Energy Mediterranean Ltd - Stock Tank Condensate @ Leviathan 4 Well.

**DOCUMENT REFERENCE:**

Stock Tank Condensate @ Leviathan 4 Well.Crude Assay Report

**CRUDE OIL ASSAY REPORT NUMBER:**

2018-DRPK-015193

**DATE OF ISSUE:**

10-23-18



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Laboratory Test Report No. 18-015193

Client Ref: **Stock Tank Condensate @ Leviathan 4 Well.**

Date: 10-23-18

**FOR THE ATTENTION OF** : Michael Abendschein

**SAMPLE DETAILS** : 1 x 5-gallon cans received on 10/19/18

**SOURCE** : Noble Energy Mediterranean Ltd

**DESCRIPTION** : **Stock Tank Condensate @ Leviathan 4 Well.**

**CONTAINERS** : Gallon Can

**SEALS** : Yes

**RESULTS** : See attached

Reported by: Hally Mathes

Approved by:

Signature Required Here

\_\_\_\_\_  
Hally Mathes/Crude Assay Manager

\_\_\_\_\_  
Client Name/ Title

Intertek Deer Park Technical Center

1114 Seaco Avenue

Deer Park, Texas 77536

Telephone: (713)844-3200

1114 Seaco Avenue

Deer Park, Texas 77536

Telephone: 713-844-3200

Fax: 713-844-3330

Laboratory Observations / Test Method Modifications and Exception Details:Description

Stock Tank Condensate @ Leviathan 4 Well.

LAB REF

18-015193

<b>COMPONENT</b>	<b>VOL%</b>
ETHANE	0.02
PROPANE	0.08
NORMAL BUTANE	0.17
ISO BUTANE	0.11
NORMAL PENTANE	0.18
CYCLOPENTANE	0.23
HEXANES	0.20
BENZENE	0.02
TOLUENE	0.35
ETHYLBENZENE	0.39
P-XYLENE	0.46
M-XYLENE	1.29
HEPTANES	0.32
OCTANES	0.45
NONANES	0.50
DECANES	0.48
O-XYLENE	0.35

# CRUDE OIL ASSAY REPORT

## Noble Energy Mediterranean Ltd – Leviathan-5 Stock Tank Condensate

**DOCUMENT REFERENCE:**

Leviathan-5 Stock Tank Condensate

**CRUDE OIL ASSAY REPORT NUMBER:**

2019-DRPK-000097

**DATE OF ISSUE:**

01-03-19



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Laboratory Test Report No. 19-000097

**Client Ref:** Leviathan-5 Stock Tank Condensate

**Date:** 01-03-19

**FOR THE ATTENTION OF** : Michael Abendschein

**SAMPLE DETAILS** : 1 x 5-gallon cans received on 01/03/19

**SOURCE** : Noble Energy Mediterranean Ltd

**DESCRIPTION** : **Leviathan-5 Stock Tank Condensate**

**CONTAINERS** : Gallon Can

**SEALS** : Yes

**RESULTS** : See attached

**Reported by:** Hally Mathes

**Approved by:**

Signature Required Here

\_\_\_\_\_  
Hally Mathes/Crude Assay Manager

\_\_\_\_\_  
Client Name/ Title

Intertek Deer Park Technical Center

1114 Seaco Avenue

Deer Park, Texas 77536

Telephone: (713)844-3200

1114 Seaco Avenue

Deer Park, Texas 77536

Telephone: 713-844-3200

Fax: 713-844-3330

Laboratory Observations / Test Method Modifications and Exception Details:DescriptionLAB REF

Leviathan-5 Stock Tank Condensate

19-000097

<b>COMPONENT</b>	<b>VOL%</b>
ETHANE	0.01
PROPANE	0.08
NORMAL BUTANE	0.16
ISO BUTANE	0.10
NORMAL PENTANE	0.23
CYCLOPENTANE	0.21
HEXANES	0.30
BENZENE	0.02
TOLUENE	0.27
ETHYLBENZENE	0.33
P-XYLENE	0.32
M-XYLENE	0.79
HEPTANES	0.50
OCTANES	0.75
NONANES	0.43
DECANES	0.35
O-Xylene	0.30

## **CRUDE OIL ASSAY REPORT**

# **Noble Energy Mediterranean Ltd – Leviathan 7**

**DOCUMENT REFERENCE:**

Leviathan 7 Crude Assay Report

**CRUDE OIL ASSAY REPORT NUMBER:**

2019-DRPK-002326

**DATE OF ISSUE:**

5-14-19





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## Laboratory Test Report No. 19-DRPK-002326

**Client Ref:** Leviathan 7

**Date:** 5-14-19

**FOR THE ATTENTION OF** : Michael Abendschein

**SAMPLE DETAILS** : 1 x 5 gallon can received on February 22, 2019

**SOURCE** : Noble Energy Mediterranean Ltd

**DESCRIPTION** : Leviathan 7

**CONTAINERS** : 1 x 5 gallon can

**SEALS** : NA

**RESULTS** : See attached

**Reported by:** Hally Mathes

Hally Mathes/Crude Assay Manager

**Approved by:**

Signature Required Here

Michael Abendschein

Intertek Deer Park Technical Center

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Telephone: (713)844-3200

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Intertek Deer Park Technical Center

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Deer Park, Texas 77536

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Fax: 713-844-3330

Description

Leviathan 7

Lab Reference

2019-DRPK-002326

<b>COMPONENT</b>	<b>VOL %</b>
ETHANE	0.01
PROPANE	0.06
NORMAL BUTANE	0.14
ISO BUTANE	0.12
NORMAL PENTANE	0.17
CYCLOPENTANE	0.18
HEXANES	2.50
BENZENE	0.02
TOLUENE	0.30
ETHYLBENZENE	0.33
P-XYLENE	0.49
M-XYLENE	1.17
O-XYLENE	0.36
HEPTANES	5.58
OCTANES	8.97
NONANES	11.10
DECANES	4.88

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