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TECHNICAL UNIVERSITY
N.A. R.E. ALEKSEEV

Sergey N Khrunkov

Fundamentals of Petroleum Engineering

Contacts:

603950, Russia, Nizhny Novgorod, Minin str., 24, of.1358.

phone: +7 902 786 81 18 e-mail: khrunkov@mail.ru

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A Crude Oil Assay

A Crude Oil Assay

There are several hundred grades of crude oil produced today. Crude is not always black, and can be colored or brown. The viscosity of crude can vary from water-like to a near-solid. Crude oil from different reservoirs can contain varying ratios of undesirable elements such as sulfur, nitrogen, water, metals and sediment.

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A Crude Oil Assay

Characteristics of an individual grade of crude oil are defined in an analysis called an assay prepared for sales purposes.

An assay outlines properties of a crude oil important to a refinery, particularly the expected yields of various finished products, density, sulfur content, acidity and viscosity.

LABORATORY REPORT NO. 2017-PTAD-000387

WHOLE CRUDE OIL PROPERTIES

Sample Descriptions / Label : Barrow Crude Oil ex-Eagle Tacoma

TEST	METHOD	UNIT	RESULT
Density @ 15°C	ASTM D 5002	kg/L	0.8447
Specific Gravity @ 60/60° F	Conversion		0.8451
API Gravity @ 60° F	Calculated	° API	35.9

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TRUE BOILING POINT DISTILLATION DATA

(ASTM D 2892)

Barrow Crude Oil ex-Eagle Tacoma

Sl. No.	Vapour Temperature °C	% mass	Cumulative % mass	% Volume	Cumulative % Volume
1	LPG	1.1	1.1	1.7	1.7
2	15 - 70	2.6	3.7	3.4	5.1
3	70 - 100	3.9	7.6	4.4	9.5
4	100 - 120	5.8	13.4	6.5	16.0
5	120 - 140	4.7	18.1	5.1	21.1
6	140 - 160	5.3	23.4	5.8	26.9
7	160 - 190	8.6	32.0	9.0	35.9
8	190 - 230	13.8	45.8	13.8	49.7
9	230 - 250	7.1	52.9	6.9	56.6
10	250 - 280	11.4	64.3	10.9	67.5
11	280 - 310	8.2	72.5	7.7	75.2
12	310 - 330	4.9	77.4	4.5	79.7
14	330 - 360	5.8	83.2	5.3	85.0
15	360 + Residue	16.8	100.0	15.0	100.0

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A crude oil reservoir does not resemble an underground lake. Instead, an accumulation of crude oil is contained between grains of sand or within tiny pores inside a solid rock matrix, like a rigid perforated sponge.

An oilfield is an area containing a single reservoir or group of reservoirs related to the same geological structural feature.

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Crude oil can come from a single well which taps into a field or more typically from a group of wells drilled into the field.

Crude oil from an individual well tends to have relatively stable properties, although these may change very slowly over time.

Production from wells on an individual oilfield is combined for pipeline transportation to form a stream of crude.

Streams from different pipelines are often combined to create a blend.

In addition to blending to save on pipeline transportation costs, crude oil streams are blended to reduce extreme characteristics of individual crude streams such as high sulfur content or acidity.

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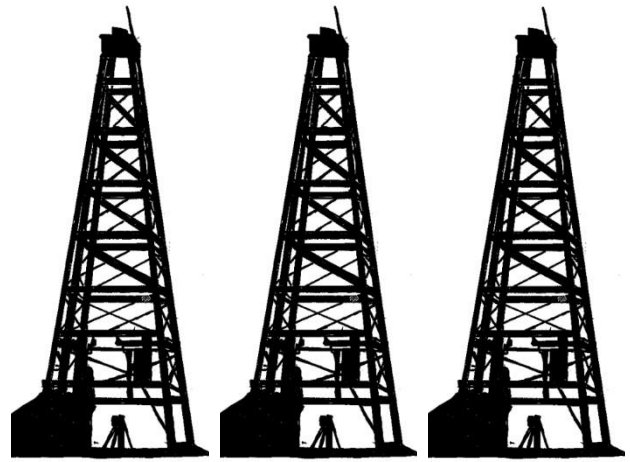
- BLEND
  - Stream #01
    - Field #01
      - Wellhead #01
      - Wellhead #02
      - Wellhead #03
      - Wellhead #04
      - etc.
    - Field #02
    - etc.
  - Stream #02
  - etc.



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A Crude Oil Assay

When marketing a crude oil to refineries, producers frequently give it a name.

For example, Brent Blend is from the Brent stream in the North Sea and Kirkuk Crude is named after the nearby Kirkuk City, Iraq.

The most well known oilfield in the world is the Ghawar super-giant oilfield in Saudi Arabia, discovered in 1948. At its height it produced close to a 6 million barrels per day (bpd).

However, **most oil fields produce less than 100 000 bpd** and of these a large number are marginal field producing just 10 bpd or less. Approximately 60% of daily global production is concentrated in just 317 super giants and giants fields (elephant fields).

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Global oilfield statistics

		Reserves	Number of fields
Elephant Fields	Super Giant	> 5 billion barrels	54
	Giant	0.5-5 billion barrels	263
	Large	50-500 million barrels	481
	Others	< 50 million barrels	70 000 ++

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Density is the most important physical characteristic of a crude oil. Density gives an indication of the hydrocarbon molecules the crude oil contains and thus the products the crude oil will yield when refined.

Heavy crudes are denser because they contain larger hydrocarbon molecules containing more atoms than light crudes. In general, less dense, or lighter, crude is more valuable as it will readily yield more high value lighter products such as gasoline.

Density of crude oil varies with temperature and pressure, which has significant implications for storage and transportation. For example, crude oil loaded on a tanker in a cold climate, although it weighs the same, will occupy a larger volume within the same tanker when it arrives in a warmer climate, as it has become less dense.

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A Crude Oil Assay

Density of water

The three measurements of density used for crude oil are:

- **metric density;**
- **specific gravity;**
- **API gravity.**

API Gravity *°API*	**Metric Density** *kg/m³*	**Specific Gravity (relative density)**	**Barrels per Metric Tonne**
0	1076	1.079	5.93
10	1000	1.000	6.35
20	934	0.934	6.77
30	876	0.876	7.19
40	825	0.825	7.64
…	….	…….	……
150	503	0.503	12.26
160	485	0.485	12.68

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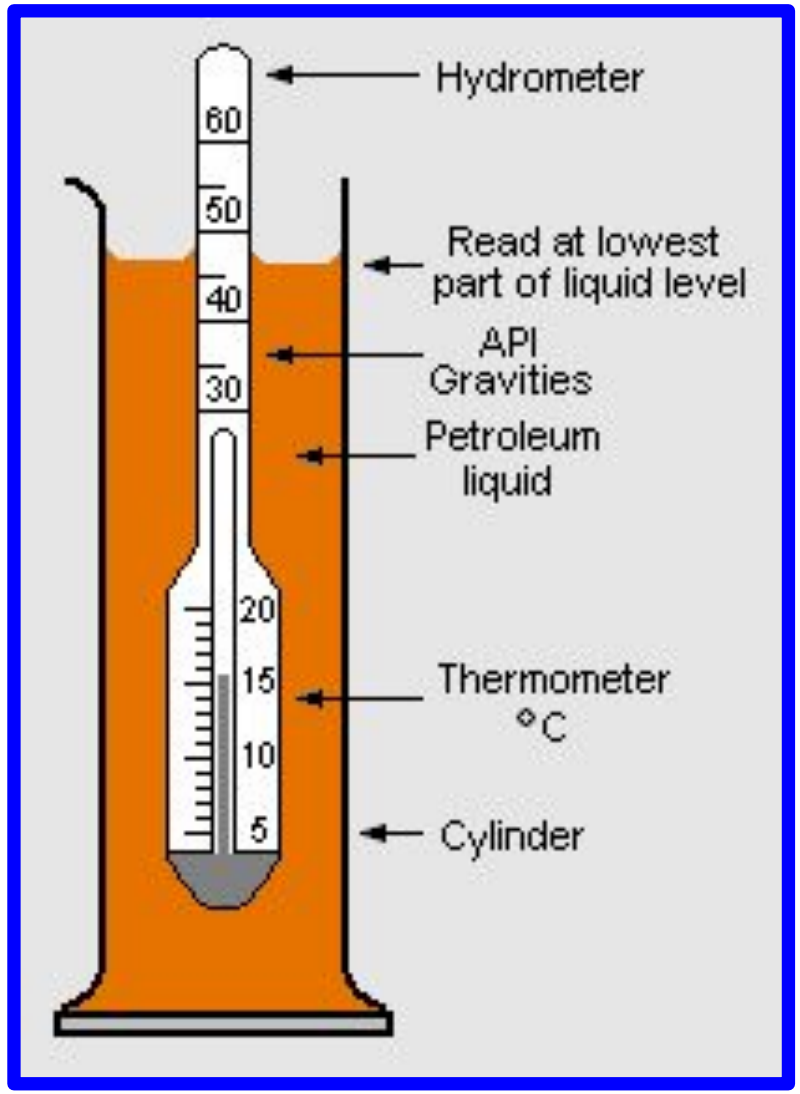
A Crude Oil Assay

Density may be measured by API method.



A hydrometer, in a practical application of the Archimedes principle, is used to measure the density of oil. The hydrometer is made of glass with lead short at the bottom to weigh it down when inserted into the oil sample.

A thermometer is often an integral part of the measurement device, in which case it is called a thermo hydrometer.

The density of the oil can simply be read from lines on the hydrometer.

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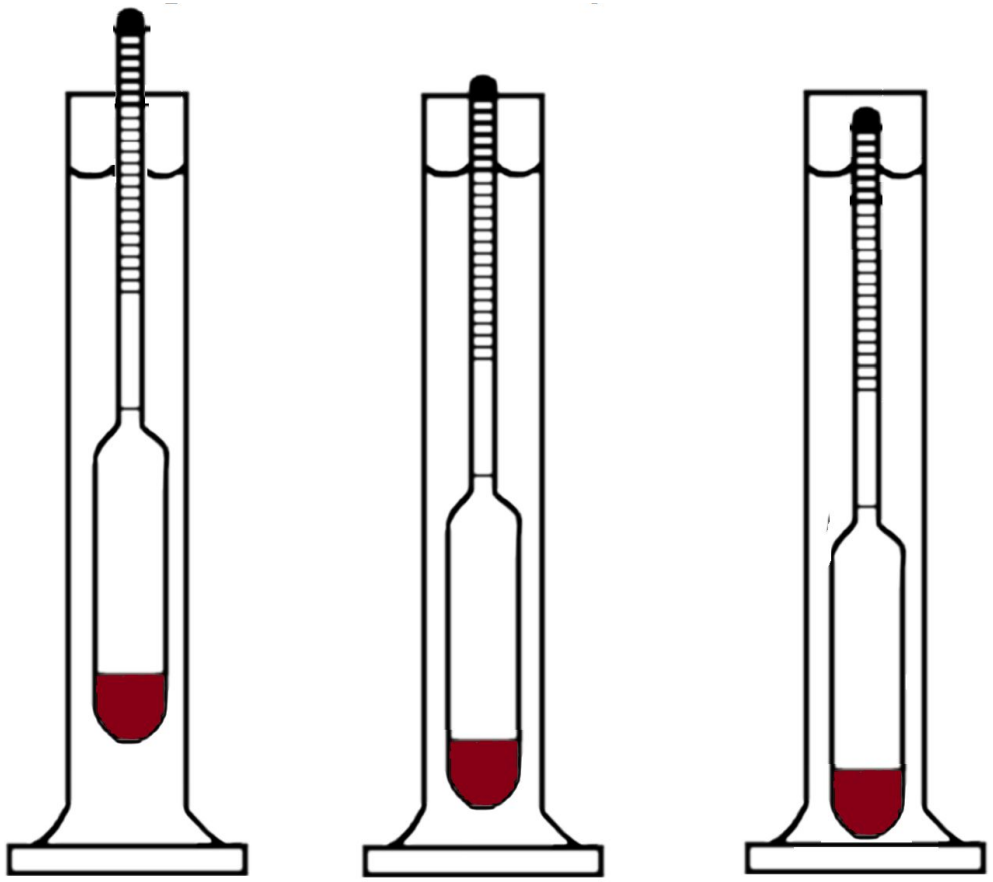
A Crude Oil Assay

Why do we use the thermometer?

It is because crude oil has different densities at different temperatures.

Measurement of oil density is usually carried out at 15°C (60°F) and 1 atmosphere of air pressure.

In case we have other temperature and air pressure, we need to using special tables of pressure and temperature correction.



Temperature affects

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A Crude Oil Assay

The procedure for measuring the density of crude oil is carried out according to the official standards.

Russian standard

ГОСТ 33364-2015

Crude petroleum and liquid petroleum products. Determination of density, relative density and API gravity by hydrometer

API standard

ASTM D 1298-99 (2005)

Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

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Specific gravity, also known as relative density, is the metric density of oil divided by the metric density of water.

Water at 60°F and 1 atmosphere of air pressure has a specific gravity of 1. If oil has a specific gravity less than 1 then it will float in water; otherwise, it will sink.

API Gravity = (141.5 / **Specific Gravity**) - 131.5

example: 39.6° API = (141.5 / 0.827) - 131.5

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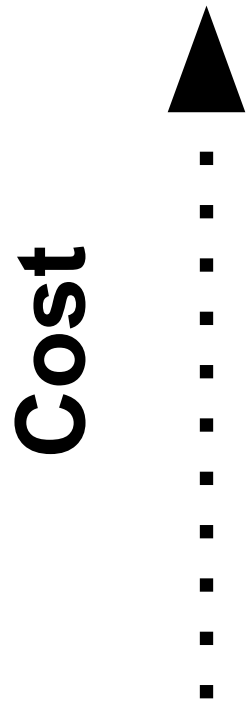
A Crude Oil Assay

API density classification



№	Oil type	API gravity
1	Extra-light	>50°
2	Light	40-50°
3	Medium	30-39°
4	Medium-heavy	25-29°
5	Heavy	10-25°
6	Extra-heavy	<10°

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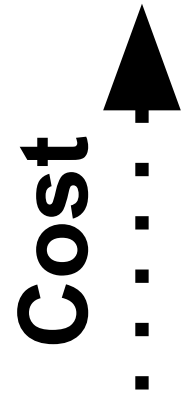
A Crude Oil Assay

Sulfur content.

Sulfur content lowers the cost of crude oil. Sulfur reduces the energy content of crude oil by displacing hydrocarbons molecules. Sulfur also corrodes metal piping and tanks in producer and refining facilities. It becomes a pollutant when oil is burned.

Crude oil can be classified to a sweet (low in sulfur) or sour (high in sulfur).

Crude oil sulfur content (% by weight)	
Sweet	< 0,5
Medium	0,5 – 1,5
Sour	> 1,5



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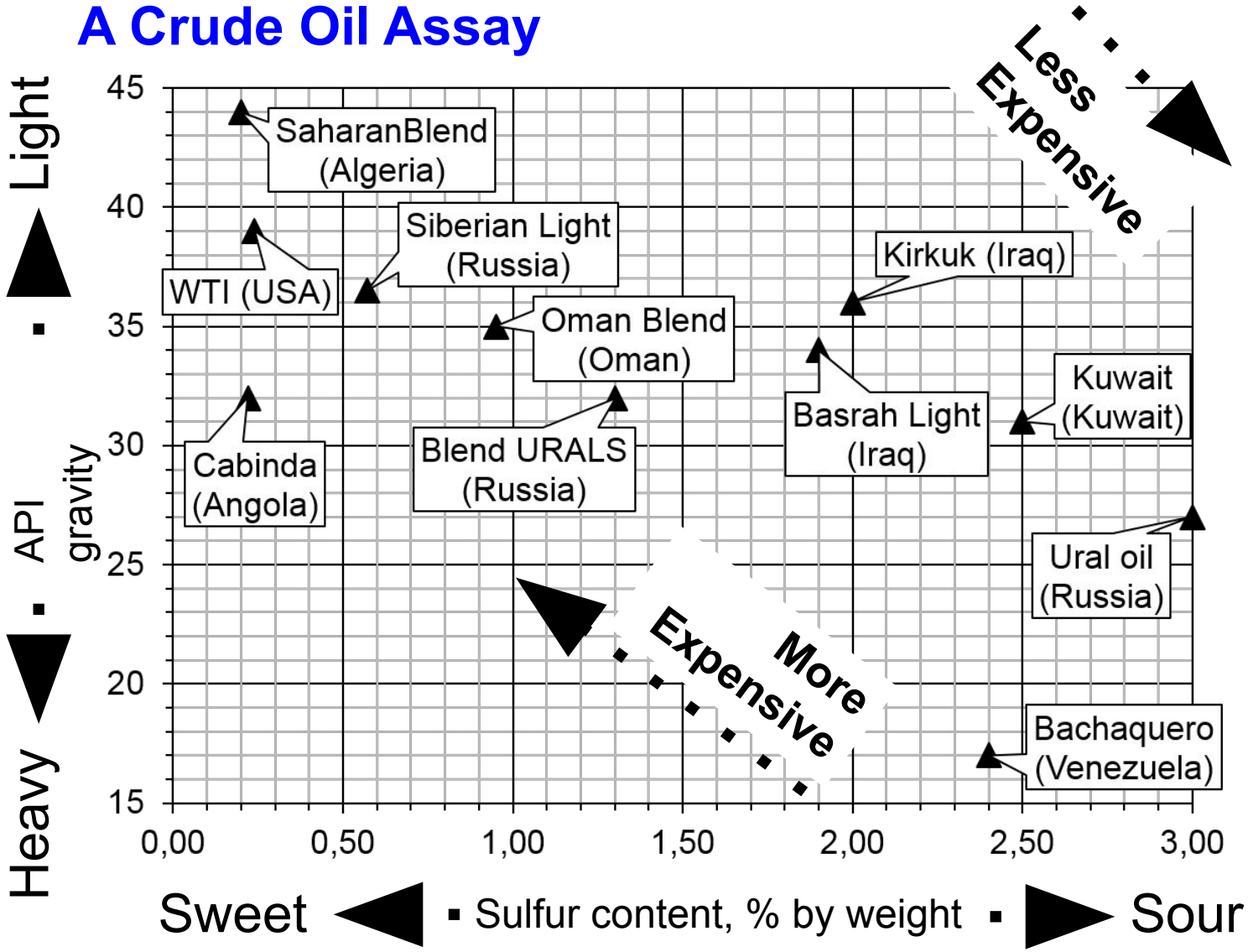
Crude oil density and sulfur content.

The proportion of sour crude production in the world has been increasing over recent years.

Industry needs more complex refineries capable of processing such crude oil.



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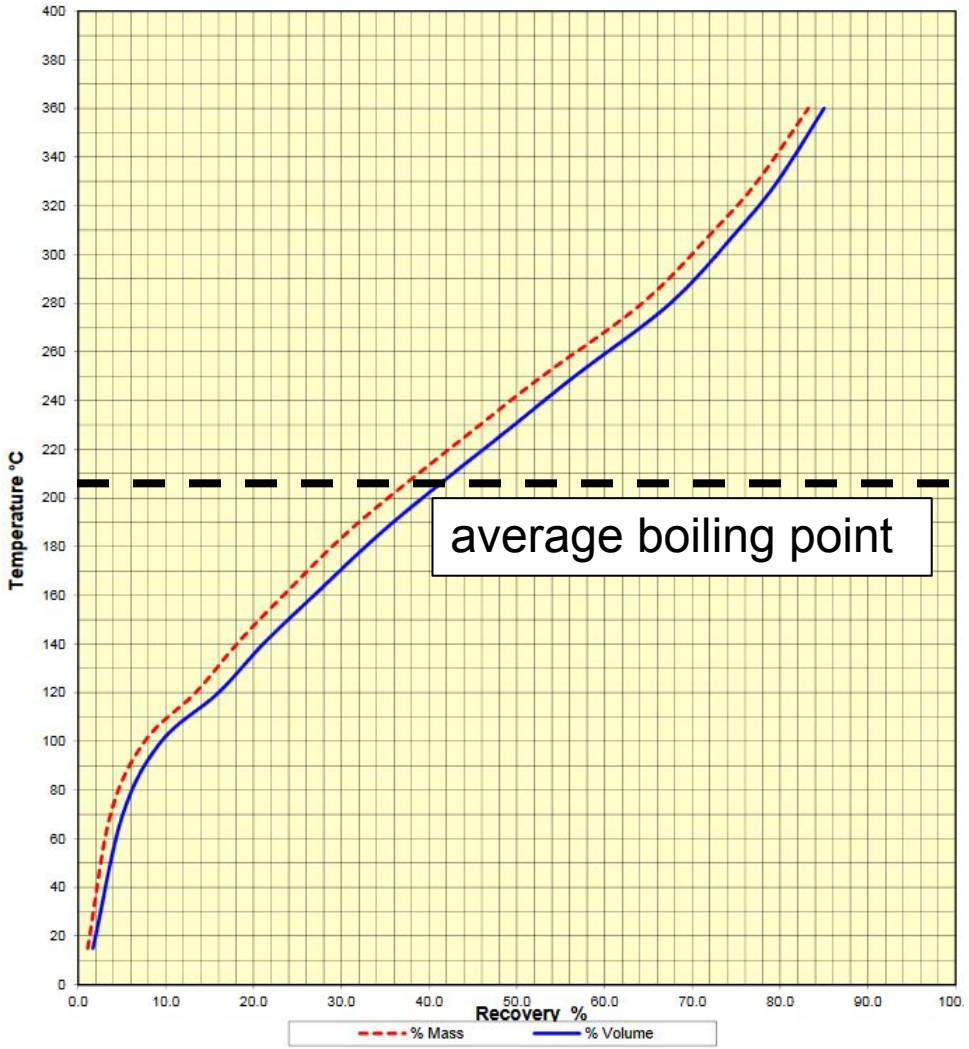
A Crude Oil Assay

Distillation Temperature Profile (DTP)

Distillation profile is closely related to density, and **shows the ratios**, known as fractions, **of products which crude evaporates into a various True Boiling Point (TBP) ranges**.

The assayed volume evaporating in each TBP range give refineries an idea as to the amount of each finished product the crude oil will yield.



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A Crude Oil Assay

Acids

Acids accumulate as a waste product of bio degeneration of crude oil by bacteria in a reservoir. Since bacteria metabolize lighter oil molecules more easily, acidic crudes tend to consist of the remaining heavy hydrocarbon molecules and have more bigger density.

In addition to generally being heavier, highly acidic crude oils are cheaper than less acidic crude oils. The acid must be neutralized before it corrodes steel pipes used in transportation and refineries.

Acid content in crude is measured by a **Total Acid Number (TAN), equal to the milligram weight of potassium hydroxide** (*KOH*) **needed to neutralize a gram of crude oil**. Most refineries are set up to run crude with a TAN under 0.5.

Highly acidic crude oil
TAN > 0.7

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A Crude Oil Assay

Viscosity

Viscosity defines how easily a liquid resists flowing. For example, honey has high viscosity; water has low viscosity.

Because viscosity changes with temperature, it is frequently measured at both 40°C and 100°C.

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A Crude Oil Assay: viscosity

Highly viscous crude oil is commonly heated or blended with less viscous crude oil, or low viscosity finished products such as kerosene in order to flow through a pipeline.

Viscosity of crude oil in a reservoir is measured in poise (**P**). A poise is a unit of absolute viscosity. Absolute viscosity is also referred to as dynamic viscosity.

Outside of reservoir conditions, most viscosity measuring devices rely on timing oil falling due to the force of gravity - known as kinematic viscosity - through a calibrated hole in a testing device. The most commonly used kinematic viscosity measurement unit for crude oil once it has been removed from a reservoir is the stoke (**St**).

Kinematic viscosity is measured with a viscometer. All types of viscometers are used to measure amount of time oil takes to pass through a calibrated hole.

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A Crude Oil Assay: viscosity

There are generally three types of viscometers used in the oil market: ***Redwood***, ***Engler*** and ***Saybolt***.

Kinematic viscosity is the ratio of absolute viscosity to density. If we know the kinematic viscosity we can calculate the absolute viscosity.

Absolute viscosity (**P**) **=** Kinematic viscosity (**St**) * Density (**kg/m^3**)

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A Crude Oil Assay

Pour point

The pour point of a liquid is the temperature below which the liquid loses its flow characteristics. It is defined as the minimum temperature in which the oil has the ability to pour down.

The pour point is related to viscosity and it is the lowest temperature at which crude oil can be pumped easily.

Pour point is often measured at 5° F (-15°C). It is the temperature at which the oil shows no surface movement when inclined for 5 seconds.

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K-Factors

The K-Factors, or Watson Factors, or Characterization Factors, is the physical properties of crude oil used for classification of crude oil with respect to hydrocarbon types.

$$K = \frac{\sqrt[3]{T_b}}{SG_{15°C}}$$

T_b - average boiling point in Rankin degree

$$°C = \frac{5}{9} \cdot °Ra - 273.15$$

$SG_{15°C}$ - specific gravity at 15°C (60°F)

Crude oils are classified as paraffinic (K = 11-12.9), naphthenic (K =10-11), or aromatic (K <10).

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Vapor pressure indicates how readily the crude oil evaporate. Vapor pressure is the pressure which vapors from the oil exert.

Crude oil with a high vapor pressure indicates that the crude should produce a larger amount of light valuable products, such as gasoline and diesel.

Nitrogen content of crude oil is important for refineries producing products meeting environmental restrictions. Nitrogen Oxides (NOx) are produced when burning oil products, and they are a key pollutant which environmental regulators monitor and limit.

Carbon content is an indicator of a crude oil's suitability for coke production. Coke is a solid coal-like product.

Salt in crude can lead to corrosion of steel piping in a refinery and storage tanks. Crude must usually be de-salted before it is processed by a refinery.

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Metals and other elements commonly found in crude oil are nickel, iron, vanadium, silver, mercury, sodium, and calcium.

These elements, even in very small quantities, can interfere with catalytic reactions at a refinery.

Basic Sediment and Water, referred to as **BS&W**, is a catch all category for any water, dirt or junk brought up with the crude. Less than 1% BS&W by weight is desirable for most refineries.

Crude oil almost always contains water when produced. Crude can comprise well over 10 barrels of water, called the water cut, for every barrel of crude produced before dewatering. Water is removed in a dewatering plant close to the producing well, as it is uneconomical to haul the water along with crude oil in an oil tanker or using valuable pipeline capacity.

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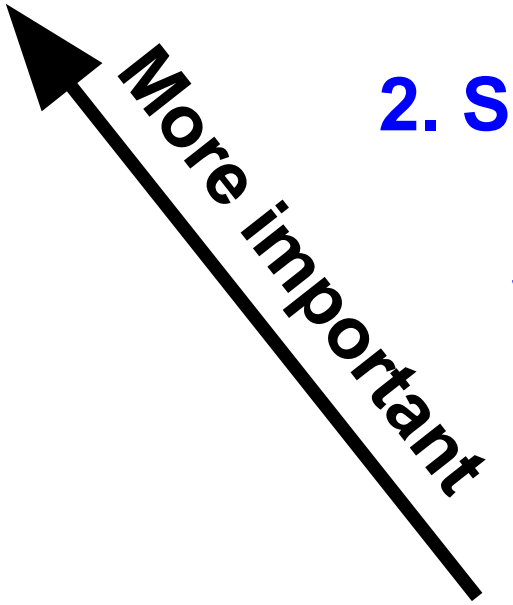
Important Characteristics of Crude Oil

1. API Gravity



2. Sulfur content

3. Total Acid Number (TAN)

4. Distillation Temperature Profile (DTP)

5. Viscosity

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603950, Russia, Nizhny Novgorod, Minin str., 24, of.1358.

phone: +7 902 786 81 18 e-mail: khrunkov@mail.ru