REFINERY AUTOMATION INSTITUTE

# CRUDE BLENDING

**COVID-19 pandemic and OPEC oil war are decimating fuel demand and cratering prices. But it will not last forever, so when the time comes, be prepared. Part of that preparation is being flexible to run any type of crude with minimum headaches.**

**Given that crude oil comprises 60% or more of the operating costs of a refinery, how can we improve the economics?**

**This paper examines degradation of crude stored for a long time, e.g. crude bought from the SPR, standard methods of valuing a crude oil using assays, is there a thing such as 'bad' oil that can't be fixed by blending, crude compatibility to avoid asphaltene precipitation, and on-line crude blend optimization.**

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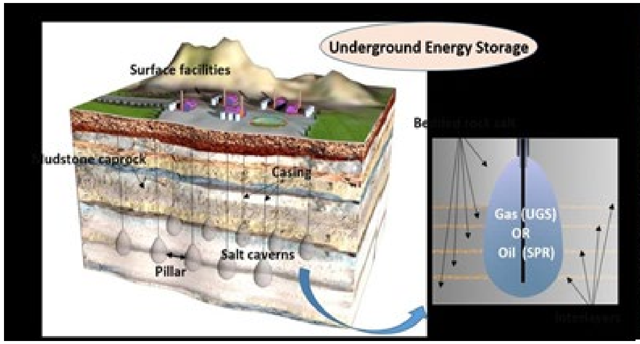
# How you store crude oil

- Crude oils can be stored indefinitely without degradation, particularly when the storage temperature is at or below 30 degree C, and there are no seepages of hydrocarbon contaminants through the storage walls.

- This is in contrast to finished transportation fuels such as gasoline which have a high content of volatile materials such as Butane and Natural Gasoline, which evaporate easily and decrease octane, and contains Olefins (chemical species) which promote the formation of gums and varnishes through oxidation reactions. The loss of octane and gums/varnishes decreases the market value of gasoline.

# How You Store crude oil

The crude oil stored at US SPR is in salt caverns solution-mined in salt formations which provide impermeable walls and a relatively constant storage temperature of approximately 17 degrees C.




Other countries also use underground storage in abandoned mines, salt rock formation, and purpose built concrete underground storage tanks to maintain a constant temperature and minimize contamination.

# Characteristics crude oil

**Crude oil density** (light or heavy) has bearing on the type of hydrocarbons that can yield more (e.g. light) or less (e.g. heavy) of the valuable product, e.g. gasoline. It is measured in Degrees API (lower API for heavier crude), and there is a discount per Degree API for heavier crudes (because of lower yields of the desired product).

**Sulfur content** varies from low Sulfur (max 0.5 %), medium Sulfur (0.5 to 2 %), and high Sulfur (greater than 2%). Sulfur is an environmental pollutant, promoting costly corrosion of refining equipment and poisoning the catalysts used in the refining process. It is very costly to remove Sulfur to meet modern environmental standards, e.g. 10ppm S.

**Acidity** is customarily defined by a crude oil TAN (Total Acid Number) number. The higher the crude TAN number, the more corrosive the crude, “eating” the metal parts of refining equipment.

**The fractional product yields** as defined by a crude assay analysis indicate how much valuable fuel products can be obtained from a barrel of crude oil. Naturally, the higher the yield of gasoline and diesel fuel, the more valuable the crude.

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# Valuation of Crude Oil

The value of a crude oil is defined by value of each crude fraction of a crude assay.

So what is a crude assay? It is a “fingerprint” of the chemistry and properties of a crude oil based on detailed Laboratory analysis

An example is illustrated on the next slide showing the raw crude properties, the yield of each crude “cut: fraction and the properties of each fraction. Each crude fraction is multiplied by its commercial price times the percent yield to estimate the contribution of that cut to the overall crude price. The crude estimated price is the sum of each individual cut. This information completely defines what the yields are for a particular oil refinery configuration, e.g. coker or no coker, and its economic value.

# Valuation of Crude Oil

CRUDE: BASRAH LIGHT ORIGIN: IRAQ DATE: 1983

| CRUDE PROPERTIES | | CRUDE PROPERTIES | | LIGHT HYDROCARBON YIELDS | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | | LV PCT | WT PCT |
| Gravity, degrees API | 33.7 | Conradson Carbon, wt. pct. | 4.18 | ----- | --------- | -------- | -------- |
| Specific Gravity (60 F/60 F) | 0.8565 | Asphaltenes, wt. pct. | 1.10 | Methane | | 0.00 | 0.00 |
| Total Sulfur, wt. pct. | 1.9500 | n-Pentane Insolubles, wt pct | ND | Ethane | | 0.09 | 0.04 |
| Mercaptan Sulfur, ppm wt | ND | Reid Vapor Pressure, psia | ND | Propane | | 0.59 | 0.35 |
| Total Nitrogen, wt. pct. | 0.0950 | Flash Point, degrees F | ND | Isobutane | | 0.30 | 0.20 |
| Pour Point, degrees F | 5.0 | Hydrogen Sulfide, ppm wt | ND | Normal Butane | | 1.30 | 0.89 |
| Viscosity at 70 deg. F, cs | 10.60 | Neutralization Number, mg KOH/g | 0.14 | Isopentane | | 0.90 | 0.66 |
| Viscosity at 100 deg. F, cs | 6.50 | Bottom Water & Sediment, LV pct. | 0.10 | Normal Pentane | | 1.60 | 1.18 |
| Vanadium, ppm wt | 18.00 | Ash Content, wt. pct. | 0.01 | Price for LPG | 1.26 | 4.78 | |
| Nickel, ppm wt | 5.00 | Salt (as NaCl), lbs/1000 bbls | 1.0 | | | | |

| PRODUCT PROPERTIES | | LIGHT GASOLINE | LIGHT NAPHTHA | MEDIUM NAPHTHA | HEAVY NAPHTHA | LIGHT KEROSENE | HEAVY KEROSENE | ATMOS. GAS OIL | VACUUM GAS OIL | VACUUM RESIDUE | ATMOS. RESIDUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TBP Cut Points, degrees F | D | C5/158 | 158/212 | 212/302 | 302/374 | 374/455 | 455/536 | 536/650 | 650/1049 | 1049+ | 650+ |
| Yield, LV pct. | D | 5.18 | 5.06 | 8.58 | 6.98 | 8.05 | 8.07 | 10.62 | 31.07 | 14.11 | 45.18 |
| Yield, wt. pct. | D | 3.95 | 4.21 | 7.44 | 6.32 | 7.56 | 7.80 | 10.58 | 33.62 | 17.04 | 50.66 |
| Gravity, degrees API | C | 86.0 | 67.3 | 59.5 | 51.5 | 44.9 | 39.8 | 34.7 | 21.6 | 5.6 | 16.2 |
| Specific Gravity (60 F/60 F) | D | 0.6507 | 0.7116 | 0.7407 | 0.7733 | 0.8021 | 0.8260 | 0.8512 | 0.9245 | 1.0318 | 0.9580 |
| VABP, degrees F | C | - | 185.0 | 257.1 | 338.0 | 414.7 | 495.2 | 592.3 | 839.2 | - | - |
| Characterization Factor | C | - | 12.14 | 12.08 | 11.99 | 11.92 | 11.92 | 11.95 | 11.80 | - | - |
| Total Sulfur, wt. pct. | D | 0.0015 | 0.0044 | 0.0139 | 0.0444 | 0.2737 | 0.8129 | 1.3869 | 2.3953 | 5.0100 | 3.2748 |
| Mercaptan Sulfur, ppm wt | D | 5.0 | 5.0 | 5.0 | 5.0 | 4.0 | 4.0 | - | - | - | - |
| Total Nitrogen, wt. pct. | D | - | - | - | 0.0001 | 0.0005 | 0.0021 | 0.0088 | 0.1278 | 0.3097 | 0.1890 |
| Aniline Point, degrees F | D | - | - | - | 143.5 | 149.8 | 156.4 | 164.4 | 184.8 | - | - |
| Naphthenes, LV pct. | D | - | 17.6 | 25.5 | 26.4 | - | - | - | - | - | - |
| Aromatics, LV pct. | D | - | 4.4 | 10.1 | 17.6 | 18.0 | 19.7 | - | - | - | - |
| Research Octane No. Clear | D | 66.6 | 52.7 | 39.5 | 24.6 | - | - | - | - | - | - |
| Smoke Point, mm | D | - | - | - | - | 24.7 | 21.9 | - | - | - | - |
| Cetane Index | C | - | - | - | - | 48.9 | 53.3 | 53.7 | 27.6 | - | - |
| Freeze Point, degrees F | D | - | - | - | - | -50.9 | -8.8 | - | - | - | - |
| Pour Point, degrees F | D | - | - | - | - | -47.9 | -14.8 | 22.8 | 101.0 | 112.0 | 56.0 |
| Viscosity at 100 deg. F, cs | C | - | - | - | - | 1.48 | 2.50 | 5.12 | 81.13 | - | - |
| Viscosity at 140 deg. F, cs | N | - | - | - | - | - | - | - | - | ND | ND |
| Viscosity at 210 deg. F, cs | D | - | - | - | - | 0.68 | 0.98 | 1.62 | 9.66 | 2.06E+03 | 3.05E+01 |
| Nickel, ppm wt. | D | - | - | - | - | - | - | - | 0.14 | 28.80 | 9.78 |
| Vanadium, ppm wt. | D | - | - | - | - | - | - | - | 0.05 | 105.00 | 35.35 |
| Conradson Carbon, wt. pct. | D | - | - | - | - | - | - | - | 0.58 | 25.80 | 8.70 |
| Asphaltenes, wt. pct. | D | - | - | - | - | - | - | - | - | 4.90 | 2.20 |
| n-Pentane Insolubles, wt pct | C | - | - | - | - | - | - | - | - | 14.59 | 4.91 |
| $ Price for Fractions | 28.24 | 2.12 | 2.07 | 3.52 | 2.65 | 3.91 | 3.47 | 4.29 | | | 6.19 |

PROPERTY CODES: D = Interpolation/extrapolation of assay data, C = calculated number, N = no data available

| | |
|---|---|
| Crude Value Before Correction for API, S, TAN=LPG+Frac | 29.50 |
| Correction for API, S, TAN | -0.09 |
| Crude Value, $/B after Correction | 29.41 |

# Oil Degradation

Degradation of crude oil occurs when:

- Heating above 30 deg C, the light hydrocarbons such as Butane and Natural Gasoline may evaporate; this lowers the potential yield of gasoline and lowers the price of the crude. With SPR underground tanks, this is not an issue because of the year-round constant temperature of about 17 degrees C in the SPR underground salt caverns.

- Mixing two crudes with differing fuel fraction yields; it may lower the refiner yield of the most profitable products and thus lower the crude blend value to the refiner. This is determined by examining the resulting blend “assay” of the two or more different crudes.

- Mixing “incompatible” crudes or hydrocarbon such as highly paraffinic crude; this may precipitate asphaltenes, which will form a sludge, which coats the tank walls and internals of pipes and pumps. This does not render the crude unusable; it is a headache, and it just increases the cost of pumping and sludge removal, and maintenance costs.

# Oil Degradation

**Mixing two crudes with two significantly different properties impacts the mix quality:**

- Increase Sulfur content, which lowers the value of the resulting mix because of an additional cost of removing Sulfur during refining to meet environmental specs, and increased cost of corrosion of refining equipment

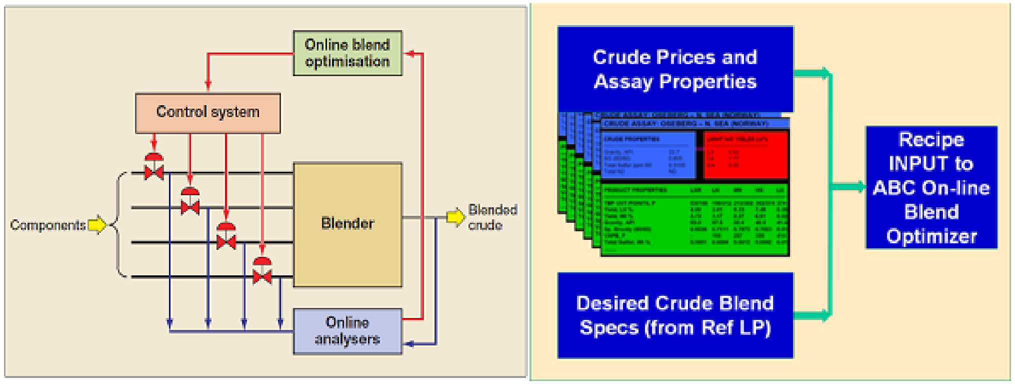
- Increased Asphaltene contents as potential indicator of sludging tendency

- Decrease yield of valuable fuels product fraction which decreases the value of the crude blend for a refiner because of lower profit realization during the refining

# Restoring the Quality of Crude Oil through Blending

It is common worldwide practice for the last 50 years to blend together a multiplicity of crude oils to economically optimize the crude feed "diet" to specific refineries requirements (in terms of yields and qualities).

Typically, a refinery will blend 4 to 11 different crude oils in a "feed" tank or do an in-line blending of different crudes (Fig. 4). For in-line blending, we use an on-line crude mix property analyzer (a Lab in a suitcase) installed on the blender pipe to control precisely and automatically the proportion of each crude oil in the mix based on each crude property assays.




*Typical Crude Assay In-Line Blending Design*

# CRUDE BLEND OPTIMIZER

**Crude blending as the same as gasoline, diesel and bunker blending, has non-linear behavior in blend properties prediction. This is very important to keep in mind since it will influence the final outcome.**

**RAI developed a crude blend optimizer where the user can enter up to 20 different crude oil assays and depending the particular constraints (pushing more towards gasoline? Or residues? Or anything you want) the optimizer decides which crude assays to blend to meet your expectations.**

**All the non-linear properties are calculated non-linearly such as: Viscosity, pour point, flash point and so on.**

**The crude blend optimizer also differentiates from the rest in the market, because takes into account the stability and compatibility. The customer will know a priori if a particular blend is stable or not. We use 3 different methods to calculate the stability and compatibility one of which was developed by RAI and applicable to bunker blends as well.**

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## CRUDE BLEND OPTIMIZER

**The crude blend optimizer is divided  in sections and it is very user friendly.**

**The user needs to enter the crude assays, keeping the traditional format:**

| CRUDE: | MURBAN | ORIGIN: | ABU DHABI, U.A.E. | Date: |
|---|---|---|---|---|

**CRUDE PROPERTIES**

| | | | |
|---|---|---|---|
| Gravity, degrees API | 40.5 | Conradson Carbon, wt. pct. | 1.35 |
| Specific Gravity (60 F/60 F) | 0.8229 | Asphaltenes, wt. pct. | 0.08 |
| Total Sulfur, wt. pct. | 0.7800 | n-Pentane Insolubles, wt pct | |
| Mercaptan Sulfur, ppm wt | 25.0 | Reid Vapor Pressure, psia | 3.46 |
| Total Nitrogen, wt. pct. | 0.0470 | Flash Point, degrees F | |
| Pour Point, degrees F | -11.0 | Hydrogen Sulfide, ppm wt | |
| Viscosity at 70 deg. F, cs | 4.80 | Neutralization Number, mg KOH/g | 0.16 |
| Viscosity at 100 deg. F, cs | 2.70 | Bottom Water & Sediment, LV pct. | 0.05 |
| Vanadium, ppm wt | 1.00 | Ash Content, wt. pct. | |
| Nickel, ppm wt | 0.70 | Salt (as NaCl), lbs/1000 bbls | |

**LIGHT HYDROCARBON YIELDS**

| Component | LV PCT | WT PCT |
|---|---|---|
| Methane | 0.00 | 0.00 |
| Ethane | 0.00 | 0.00 |
| Propane | 0.30 | 0.19 |
| Isobutane | 0.30 | 0.21 |
| Normal Butane | 1.30 | 0.93 |
| Isopentane | 1.10 | 0.84 |
| Normal Pentane | 1.70 | 1.31 |
| | | |

| PRODUCT PROPERTIES | LIGHT GASOLINE | LIGHT NAPHTHA | MEDIUM NAPHTHA | HEAVY NAPHTHA | LIGHT KEROSENE | HEAVY KEROSENE | ATMOS. GAS OIL | VACUUM GAS OIL | VACUUM RESIDUE | ATMOS. RESIDUE |
|---|---|---|---|---|---|---|---|---|---|---|
| TBP Cut Points, degrees F D | C5/158 | 158/212 | 212/302 | 302/374 | 374/455 | 455/536 | 536/650 | 650/1049 | 1049+ | 650+ |
| Yield, LV pct. D | 6.6 | 5.4 | 11.4 | 10.0 | 9.8 | 9.3 | 12.2 | 25.8 | 7.6 | 33.4 |
| Yield, wt. pct. D | 5.3 | 4.7 | 10.4 | 9.5 | 9.6 | 9.4 | 12.6 | 28.1 | 9.1 | 37.2 |
| Gravity, degrees API C | 83.6 | 65.9 | 57.3 | 50.3 | 44.6 | 39.9 | 35.1 | 27.0 | 12.9 | 23.5 |
| Specific Gravity (60 F/60 F) D | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 1.0 | 0.9 |
| VABP, degrees F C | | 185.0 | 258.4 | 338.0 | 416.8 | 495.1 | 592.4 | 818.6 | | |
| Characterization Factor C | | 12.1 | 11.9 | 11.9 | 11.9 | 11.9 | 12.0 | 12.2 | | |
| Total Sulfur, wt. pct. D | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.5 | 0.8 | 1.4 | 2.3 | 1.6 |
| Mercaptan Sulfur, ppm wt N | | | | | | | | | | |
| Total Nitrogen, wt. pct. D | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.3 | 0.1 |
| Aniline Point, degrees F D | | | | 130.0 | 140.1 | 153.3 | 169.1 | 202.0 | | |
| Naphthenes, LV pct. D | | 18.5 | 21.2 | 18.1 | | | | | | |
| Aromatics, LV pct. D | | 6.4 | 14.7 | 21.9 | 21.6 | 21.6 | | | | |
| Research Octane No. Clear D | 64.4 | 52.3 | 39.7 | 26.2 | | | | | | |
| Smoke Point, mm D | | | | | 22.4 | 19.8 | | | | |
| Cetane Index C | | | | | 48.7 | 53.5 | 54.4 | 36.9 | | |
| Freeze Point, degrees F D | | | | | -42.7 | -9.2 | | | | |
| Pour Point, degrees F D | | | | | -58.8 | -16.3 | 30.4 | 90.3 | 124.0 | 93.0 |
| Viscosity at 100 deg. F, cs D | | | | | 1.5 | 2.4 | 4.7 | 37.6 | | |
| Viscosity at 140 deg. F, cs N | | | | | | | | | | |
| Viscosity at 210 deg. F, cs D | | | | | 0.8 | 1.1 | 1.6 | 5.6 | 934.0 | 10.0 |
| Nickel, ppm wt. D | | | | | | | | 0.1 | 7.7 | 1.9 |
| Vanadium, ppm wt. D | | | | | | | | 0.1 | 11.0 | 2.8 |
| Conradson Carbon, wt. pct. D | | | | | | | | 0.5 | 12.4 | 4.0 |
| Asphaltenes, wt. pct. D | | | | | | | | | 0.8 | 0.1 |
| n-Pentane Insolubles, wt pct C | | | | | | | | | 4.7 | 1.1 |

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## CRUDE BLEND OPTIMIZER

**After all the crude assays are inside the optimizer, the user can start the optimization, selecting the constraints that need to be met. For example selecting a particular yield for gasoline.**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | BATCH SIZE [BBL] | | | 0.00 |
| | | RECIPE | | INVENTORY [BBL] | | | | PRICE |
| | Crude | Vol % | BBL | INITIAL | FINAL | REMAINING | | $/BBL |
| 1 | MURBAN | 0% | | | | | | |
| 2 | ZAKUM | 0% | | | | | | |
| 3 | CABINDA | 0% | | | | | | |
| 4 | COLD LAKE | 0% | | | | | | |
| 5 | DAQUING | 0% | | | | | | |
| 6 | ORIENTE | 0% | | | | | | |
| 7 | DURI | 0% | | | | | | |
| 8 | MINAS | 0% | | | | | | |
| 9 | KIRKUK BLEND | 0% | | | | | | |
| 10 | BREGA | 0% | | | | | | |
| 11 | BONNY LIGHT | 0% | | | | | | |
| 12 | ESCRAVOS | 0% | | | | | | |
| 13 | FORCADOS | 0% | | | | | | |
| 14 | BRENT BLEND | 0% | | | | | | |
| 15 | EKOFISK | 0% | | | | | | |
| 16 | ARAB XL | 0% | | | | | | |
| 17 | ALASKAN NS | 0% | | | | | | |
| 18 | LOUISIANA LS | 0% | | | | | | |
| 19 | RUSSIAN EXPT BLD | 0% | | | | | | |
| 20 | WTI | 0% | | | | | | |
| | | | | MIN | MAX | SUM | | |
| | TOTAL % | 0% | 0.00 | | | 0.00 | | |

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## CRUDE BLEND OPTIMIZER

After the constraints are selected, the user clicks on the "optimization' button to get the final blend results, properties and volumetric fractions

**Crude Blend Properties**

| | | | | |
|---|---|---|---|---|
| Gravity, degrees API | 0.00 | | Conradson Carbon, wt. pct. | 0.00 |
| Specific Gravity (60 F/60 F) | 0.00 | | Asphaltenes, wt. pct. | 0.00 |
| Total Sulfur, wt. pct. | 0.00 | | n-Pentane Insolubles, wt pct | 0.00 |
| Mercaptan Sulfur, ppm wt | 0.00 | | Reid Vapor Pressure, psia | 0.00 |
| Total Nitrogen, wt. pct. | 0.00 | | Flash Point, degrees F | 0.00 |
| Pour Point, degrees F | 0.00 | | Hydrogen Sulfide, ppm wt | 0.00 |
| Viscosity at 70 deg. F, cs | 0.00 | #.### | Neutralization Number, mg KOH | 0.00 |
| Viscosity at 100 deg. F, cs | 0.00 | #.### | Bottom Water & Sediment, LV p | 0.00 |
| Vanadium, ppm wt | 0.00 | | Ash Content, wt. pct. | 0.00 |
| Nickel, ppm wt | 0.00 | | Salt (as NaCl), lbs/1000 bbls | 0.00 |

**Product Blend Properties**

| RODUCT PROPERTIE | LIGHT GASOLINE | LIGHT NAPHTHA | MEDIUM NAPHTHA | HEAVY NAPHTHA | LIGHT KEROSENE | HEAVY KEROSENE | ATMOS. GAS OIL | VACUUM GAS OIL | VACUUM RESIDUE | ATMOS. RESIDUE |
|---|---|---|---|---|---|---|---|---|---|---|
| TBP Cut Points, degrees F | C5/158 | 158/212 | 212/302 | 302/374 | 374/455 | 455/536 | 536/650 | 650/1049 | 1049+ | 650+ |
| Yield, LV pct. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Yield, wt. pct. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gravity, degrees API C | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Specific Gravity (60 F/60 F) D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| VABP, degrees F C | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Characterization Factor C | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Sulfur, wt. pct. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mercaptan Sulfur, ppm wt | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Nitrogen, wt. pct. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aniline Point, degrees F D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Naphthenes, LV pct. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aromatics, LV pct. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Research Octane No. Clear | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Smoke Point, mm D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cetane Index C | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Freeze Point, degrees F D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pour Point, degrees F D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Viscosity at 100 deg. F, cs D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Viscosity at 140 deg. F, cs N | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Viscosity at 210 deg. F, cs D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nickel, ppm wt. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Vanadium, ppm wt. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Conradson Carbon, wt. pct. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Asphaltenes, wt. pct. D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| n-Pentane Insolubles, wt pct | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yield Max | Wt% | 6.29 | 7.17 | 12.27 | 9.59 | 10.35 | 12.79 | 19.88 | 40.01 | 46.52 | 81.76 |
| | Crude Type | EKOFISK | EKOFISK | WTI | ESCRAVOS | LOUISIANA LS | BONNY LIGHT | FORCADOS | MINAS | COLD LAKE | COLD LAKE |
| Yield Min | Wt% | 0.00 | 0.84 | 0.73 | 1.03 | 3.33 | 4.23 | 7.15 | 26.59 | 5.75 | 36.40 |
| | Crude Type | DURI | DURI | COLD LAKE | COLD LAKE | COLD LAKE | COLD LAKE | DAQUING | ORIENTE | BONNY LIGHT | ESCRAVOS |

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## CRUDE BLEND OPTIMIZER

**It's not over yet, because the optimizer takes into account other important information such as the economics:**

| ECONOMICS | | |
|---|---|---|
| BLEND COST | [$/bbl] | $49.00 |
| SALES PRICE | [$/bbl] | $56.00 |
| PROFIT | [$/bbl] | $7.00 |
| TOTAL PROFIT | [$] | $2,450,000 |

**and more important the stability and compatibility:**

| STABILITY | | | | | |
|---|---|---|---|---|---|
| TE | | CCAI | | BMCI | |
| | | Insolubility no | | Solubility Blending no | |

| STABILITY-1 | | | |
|---|---|---|---|
| Mixture Blend Solubility Number (SBNmix) | | Compatibility (SBN & IN) | |
| Compatible Blends [Vol Av SBN>1.4 IN Any Oil] | | Compatibility (SBN) | |
| Insolubility Limit (Safe Criteria) | | | |

| STABILITY-2 | | | |
|---|---|---|---|
| Stability K1 ( BMCI-TE) | | STATUS | |
| Stability K2 ( BMCI/TE) | | STATUS | |

| STABILITY-3 | | | |
|---|---|---|---|
| Compatibility (CII) | | STATUS | |

# REFINERY AUTOMATION INSTITUTE

## RAI EXECUTIVES

- **Ara Barsamian – CEO, Director of Project Management/Engineering**

Mr. Barsamian has worked and consulted for the major oil companies, such as Exxon, Mobil, Chevron, Aramco, and PDVSA, in the area of refinery oil terminal automation, and gasoline and diesel blending automation. He has more than 30 years experience with blending, offsites automation, and project management. He has provided blending construction & automation work for HESS, BP, Motiva Port Arthur, Petro-Canada, Suncor, Sasol, etc. He has worked extensively in the development and implementation of a variety of on-line blending analyzers - particularly NIR types - and the associated shelters, sampling systems and sample recovery systems, specifically for gasoline and diesel blending and in-line blend certification. He participates in various standards and recommended practices bodies such as ISA and ASTM. jabarsa@refautom.com

- **Eliseo Lee Curcio – CFO/VP – Blending Management, Sales & Marketing**

Mr. Curcio is a blending expert, with over 10 years of experience working in advanced modeling and optimization for bunker, gasoline diesel and crude blending. He worked closely with traders and brokers in finding cheap components and blend them together to increase profitability. He designed the bunker blending software to predict easily compatibility and profitability. He is the Vice President and CFO at Refinery Automation Institute, where with his marketing and selling skills increased Company cash flow and brought new and fresh light to the business. Mr. Curcio has a M.S. in chemical engineering with high honor from University of Calabria, Italy and M.S. in advanced modeling and optimization from Catholic University of Leuven, Belgium. lee@refautom.com

# REFINERY AUTOMATION INSTITUTE

## THANK YOU

**RAI is involved in many projects Worldwide building new gasoline in-line blender or refurbishing old one to increase profitability. Please reach out to us now, taking advantage of the situation with low costs.**

**We are World Expert and with us you will get the best in blending that you can get.**



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