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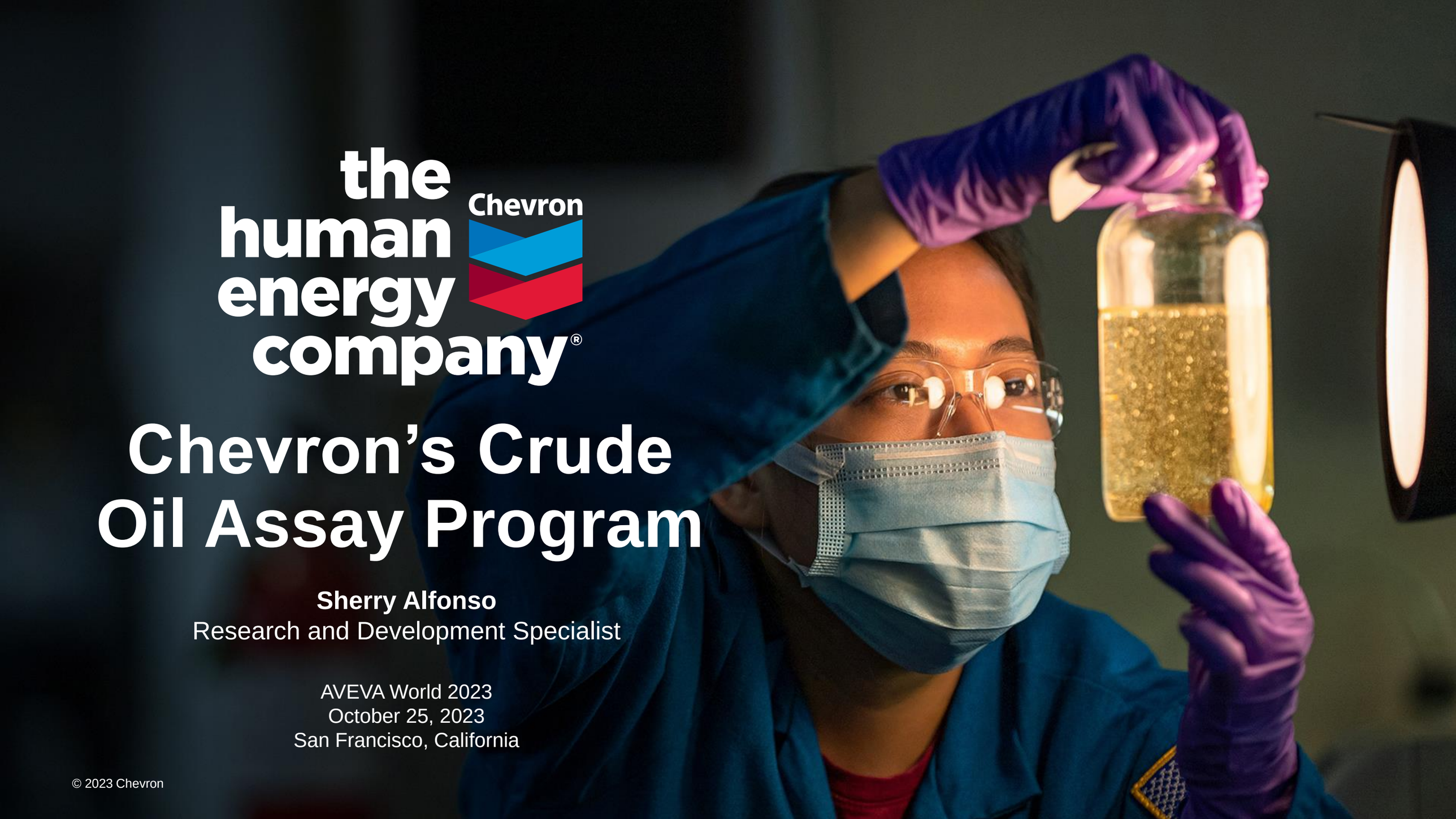
# Chevron’s Crude Oil Assay Program

Sherry Alfonso, Research and Development Specialist



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Chevron

# Chevron's Crude Oil Assay Program

**Sherry Alfonso**
Research and Development Specialist

AVEVA World 2023
October 25, 2023
San Francisco, California

# Agenda

1 Chevron’s Global Operations

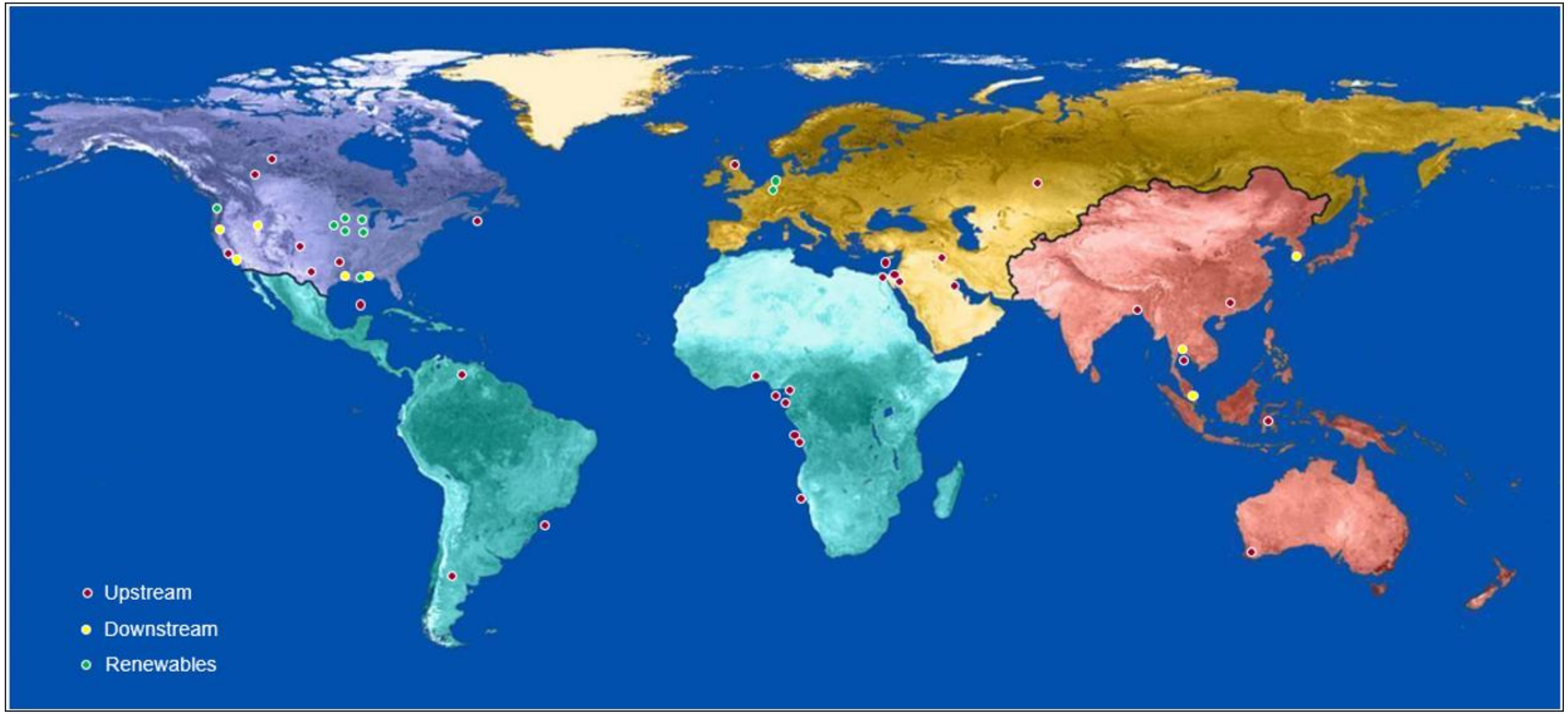
2 Chevron’s Crude Oil assay Program

3 Chevron’s Crude Oil Assay Library

4 Carbon Intensity

5 Real-Time Crude

# Chevron’s Global Operations



# Chevron Technical Center

**Distillation & Processing Specialties Team**

Performs full range TBP distillations for Chevron's crude assay program

**Global Laboratory Services**

Provides analytical testing including the application of advanced chemistry and materials characterization tools, environmental chemistry, new analytical methodologies and targeted research**.**

**Process Planning & Energy Technology**

Maintain and expand the crude oil database and tools for use in economic and plant optimization and marketing of equity crudes.

# Chevron’s Crude Oil Assay Process

**Crude Tracking & Assay Validation**

**Testing**

**Analysis**

# Crude Tracking & Assay Validation

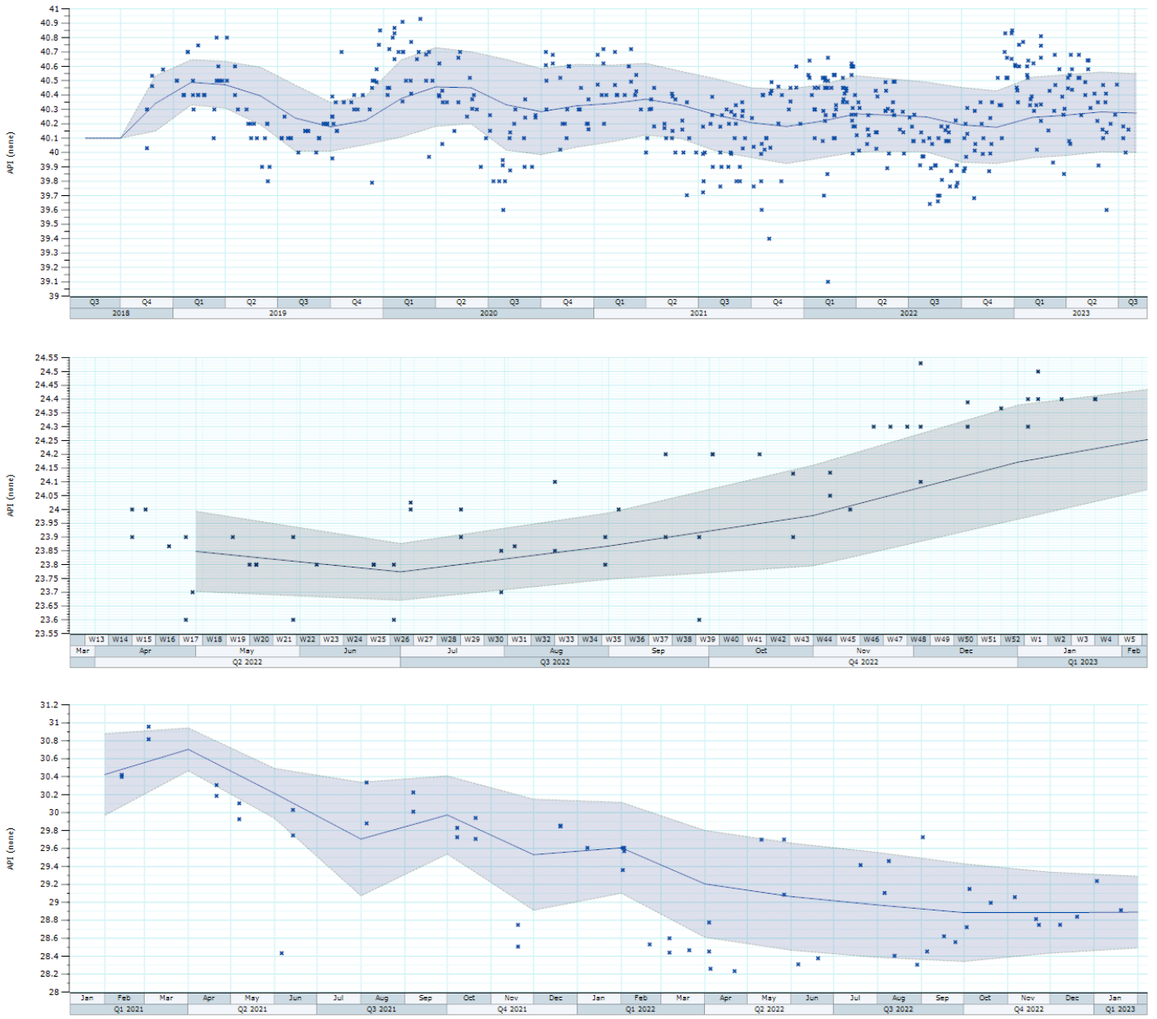
**Chevron's assay validation and updating process relies on tracking Crude Cargo Data**

- Crude quality is tracked via custody transfer information and monitored in AVEVA USC Assay Web
- Crude simulated yields are tracked for known blended crudes or pipeline delivered crudes
- Assays are updated when the current assay is determined to be "invalid."
  – AVEVA USC Validation feature flags "invalid" assays

**Assays are also updated when:**

- Newer 3rd party assays are available
- Commercial intelligence indicates significant production changes
- Older assays need to be updated with current crude quality data or data from new or improved test methods

## Crude Quality Changes over Time

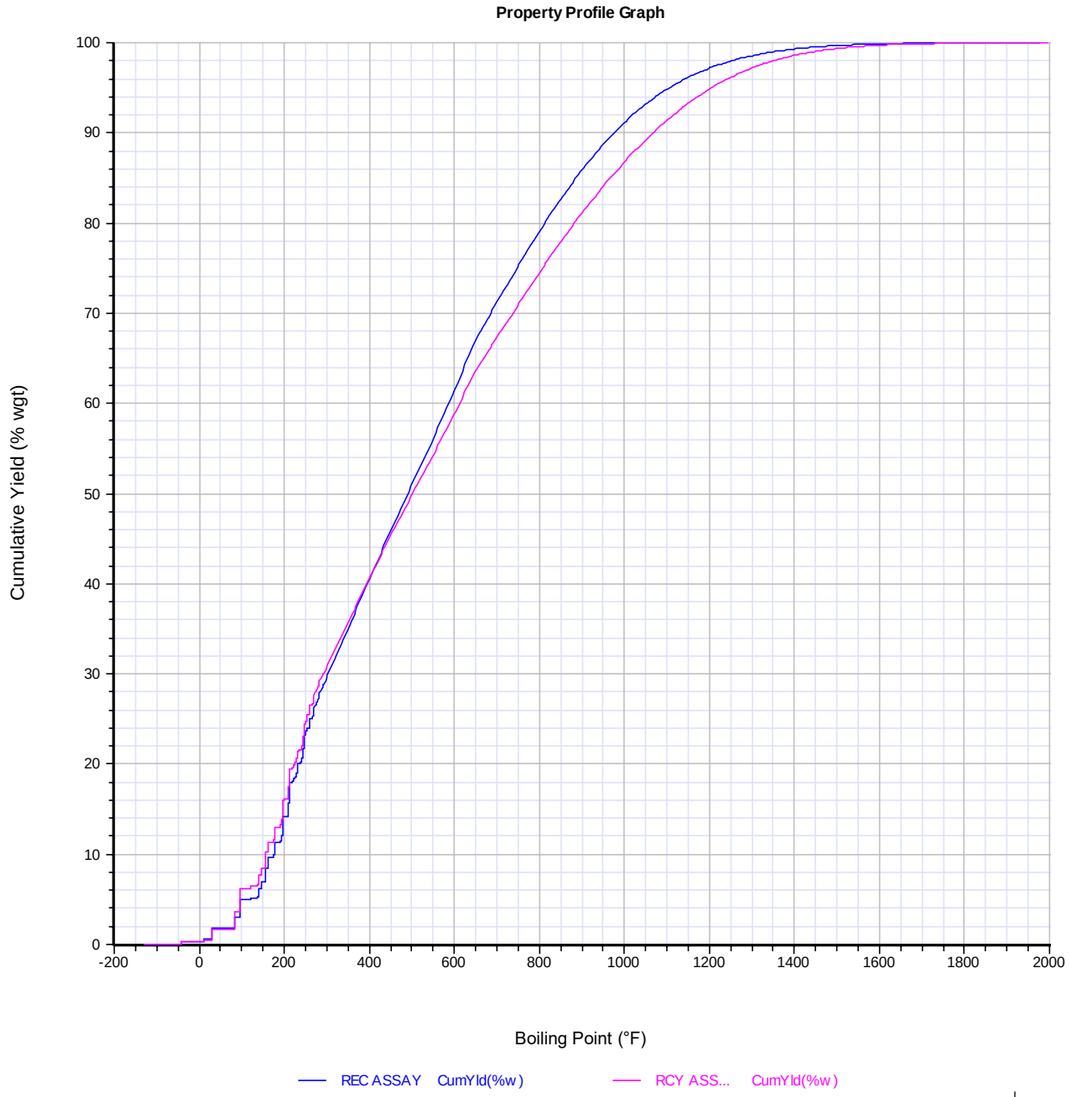


# Crude Tracking & Assay Validation

**Crude simulated yields show Recommended Assay Yield Profile no longer matches delivered Crude Yield Profiles**

- Rapid Crude Yield Tracking for Blended Crudes or Pipeline Delivered Crudes
  - Same Crude, Similar API but Different Yields
    - REC ASSAY: Recommended Assay
    - RCY ASSAY: RCY Monitored Sample
      - Higher VRES Yield
      - Lower DSL Yield

| SAMPLE TYPE | YLD,W,% SampleDate | API | Sulfur WT% | IBP 100F | 100F 350F | 350F 450F | 450F 650F | 650F 850F | 850F 1025F | 1025F FBP |
|---|---|---|---|---|---|---|---|---|---|---|
| REC ASSAY | 3/23/2022 | 43.13 | 0.11 | 4.91 | 30.12 | 10.78 | 21.15 | 15.68 | 10.54 | 7.79 |
| RCY ASSAY | 7/7/2022 | 42.81 | 0.14 | 6.20 | 29.50 | 9.62 | 18.27 | 14.30 | 11.31 | 11.98 |
| | ABS DIFF | -0.32 | 0.03 | 1.29 | -0.62 | -1.15 | -2.88 | -1.38 | 0.77 | 4.20 |



# Testing

**Distillation & Processing Specialties Team**

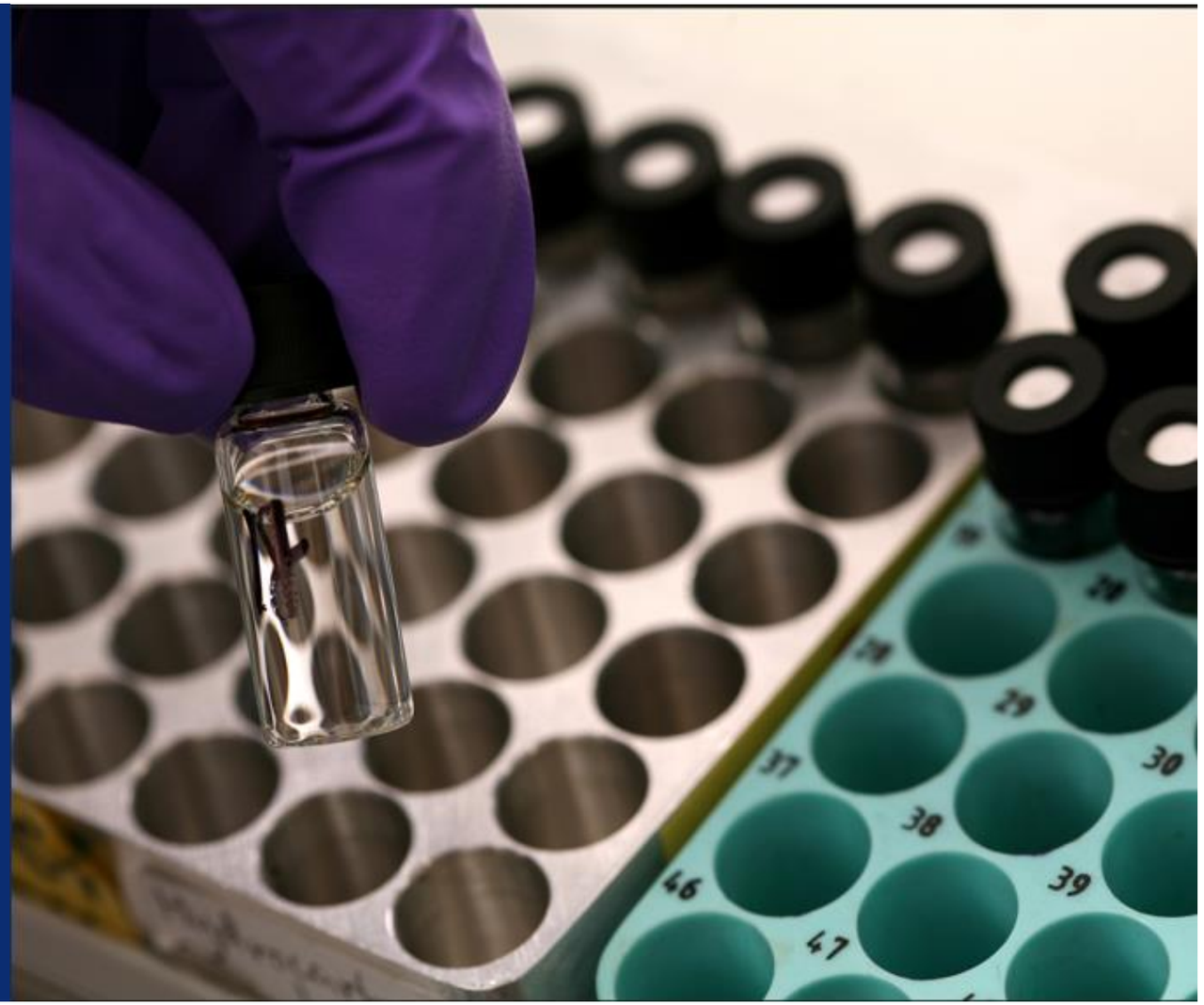
Performs custom blending and standard/custom distillation/fractionation

**Global Laboratory Services**

Perform analysis using ASTM tests for standard properties, and in-house developed tests for special properties, (i.e. RCY, vacuum distillation, asphaltene stability).

**Contract Laboratories**

Strategically located around the world to perform CVX equivalent batch distillations and lab testing



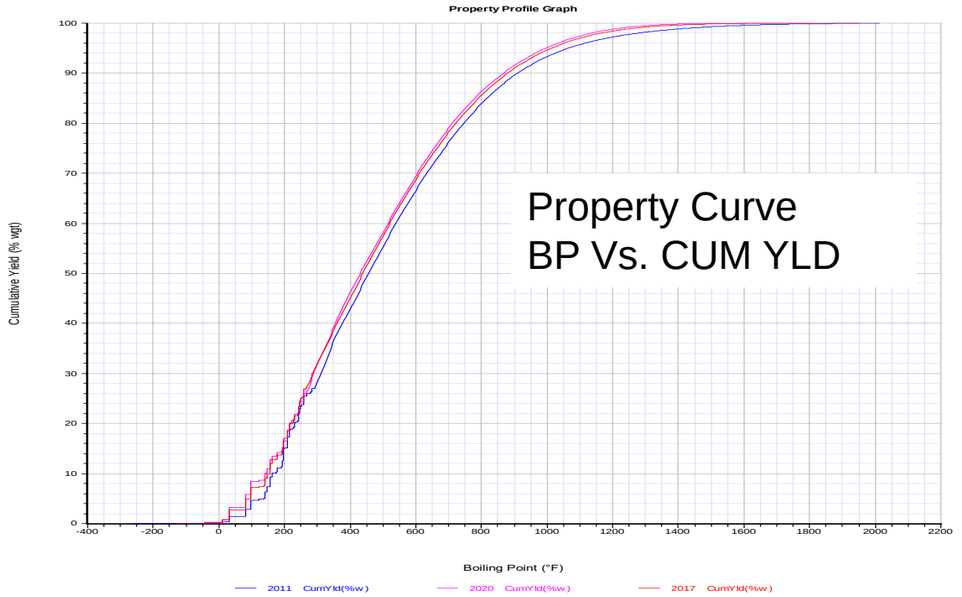
# Analysis

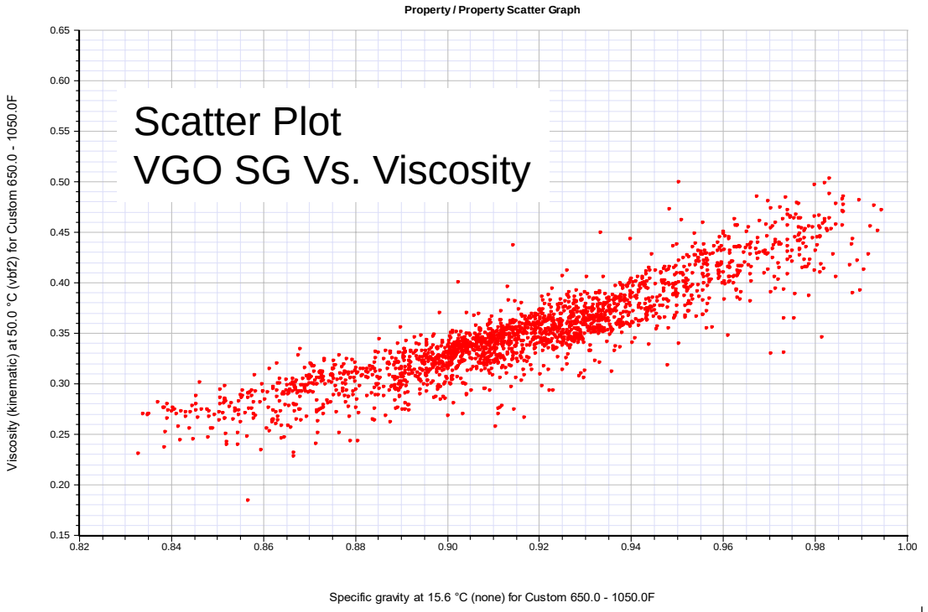
**Chevron analysts work up the assays using AVEVA USC Desktop tools tuned to Chevron's assay data and property correlations.**

– Redundant and mass balanced measurements are collected for critical properties that impact a crude's value

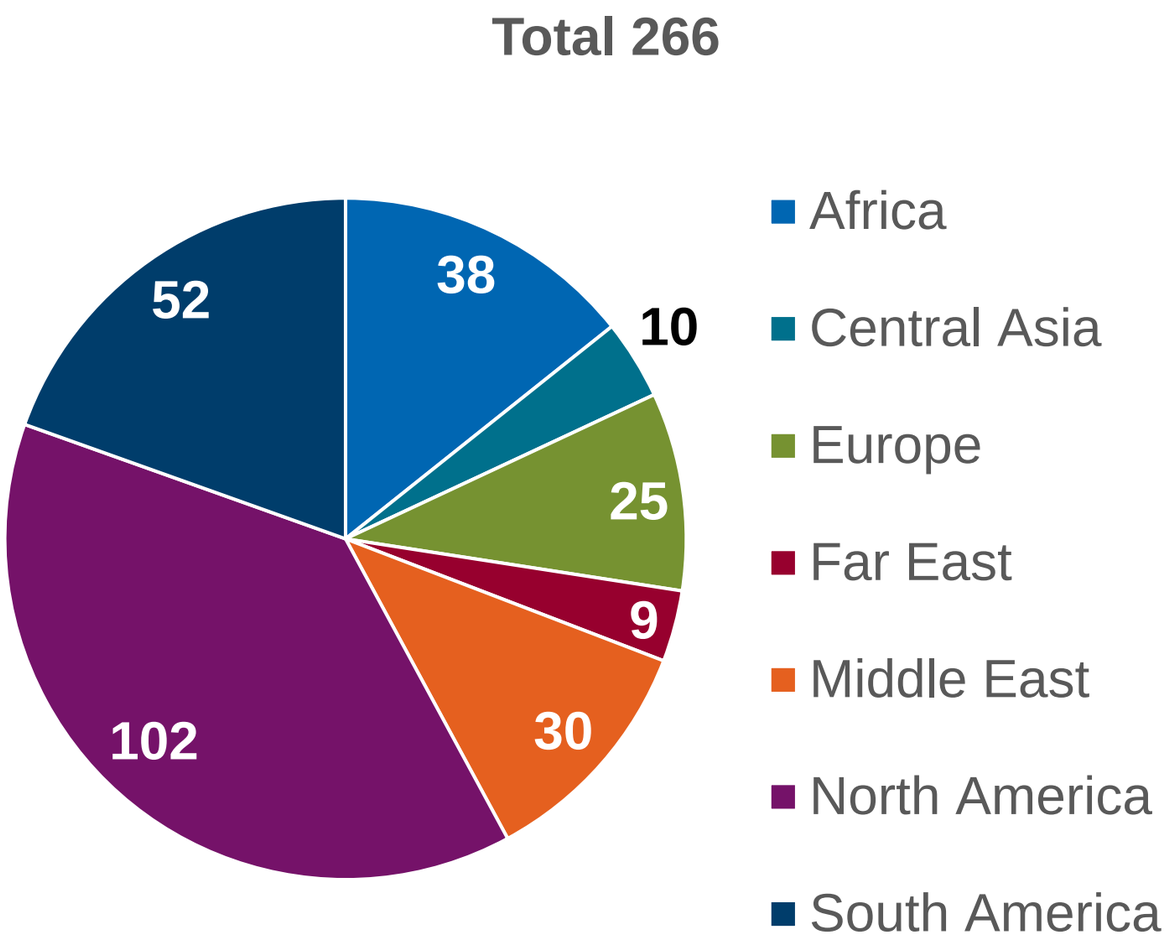
  - Mass Balance: Sulfur, Nitrogen, Yield, etc
  - Redundant measurements:
    – WVGO+VRES=ARES
    – LVGO+MVGO+HVGO=WVGO

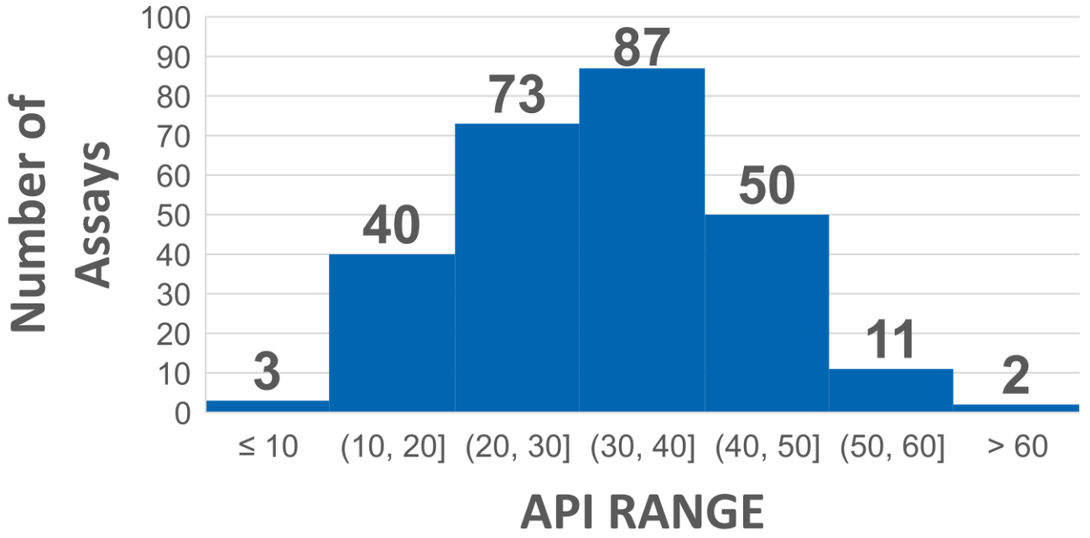
- Property Curves are checked to detect errors and ensure consistency with historical assays of the same crude
- Scatter Plots for whole crude and cut property vs specific gravity data are used to validate property values and identify outliers.

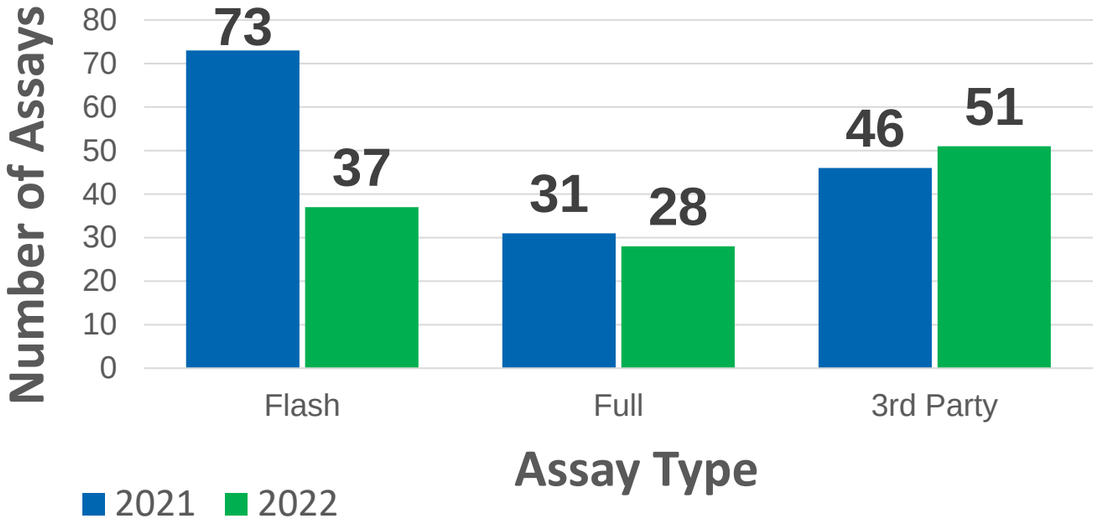


# Chevron's 2021-2022 Assay Updates



# Carbon Intensity

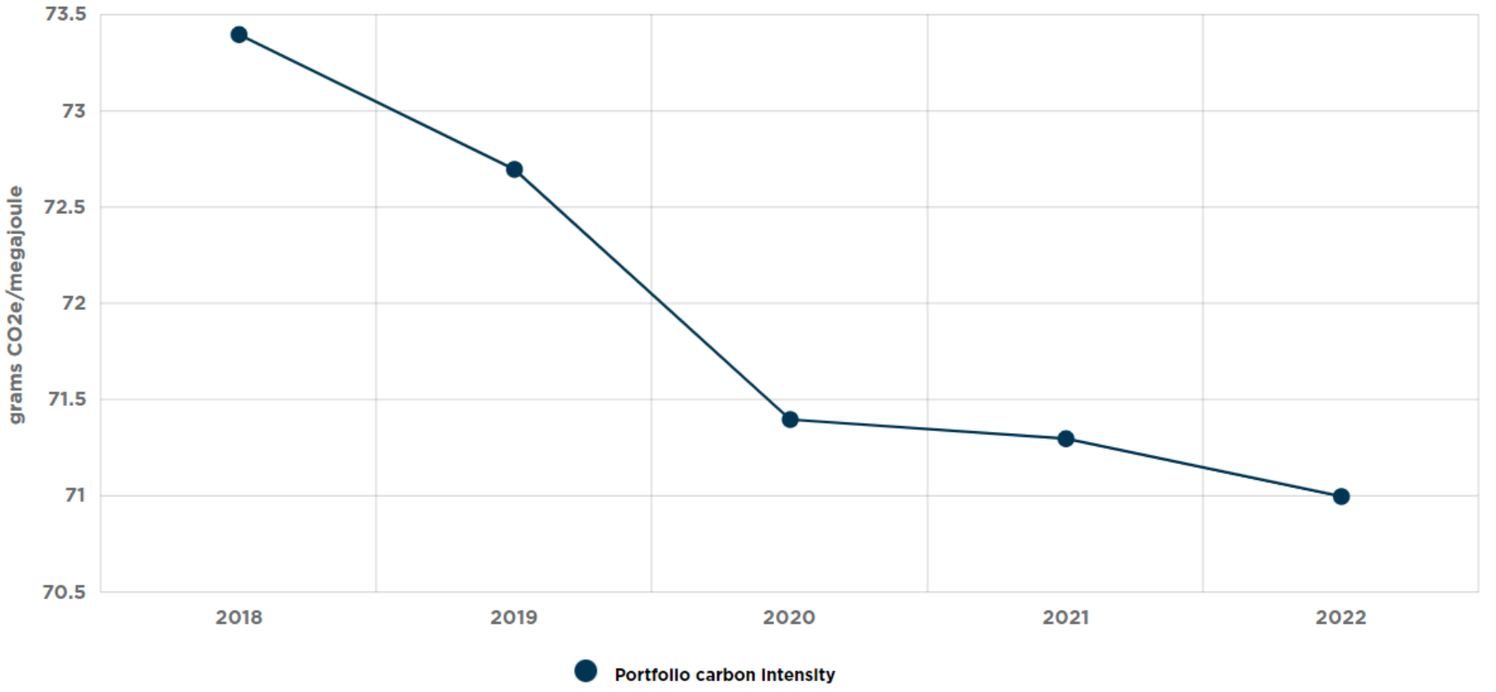
**What is Carbon Intensity**

**Measure of carbon dioxide and other greenhouse gases (CO2e) per unit of activity, like generating a product**

**Chevron's Portfolio Carbon Intensity (PCI) represents the full value chain carbon intensity of the products we sell, including our own emissions, emissions from third parties, and emissions from customer use of our products.**

**Chevron's Portfolio Carbon Intensity Calculator tool is publicly available[2]. The tool is subject to Chevron's website terms of use.**

## Portfolio Carbon Intensity [1]




| Portfolio carbon intensity | 2022 | 2021 | 2020 | 2019 | 2018 |
|---|---|---|---|---|---|
| Portfolio carbon intensity (grams CO2e/megajoule) | 71 | 71.3 | 71.4 | 72.7 | 73.4 |



1) www.chevron.com/sustainability/performance/chart-generator
2) www.chevron.com/-/media/chevron/sustainability/documents/portfolio-carbon-intensity-calculator-tool.xlsx

# Real-Time Crude

Chevron is currently evaluating AVEVA's Real-Time Crude (RTC) technology for generating crude oil assays

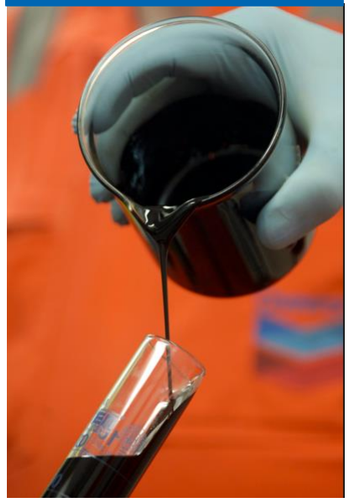
- Process Insights ANALECT® RefinIR™
  - Extended-range infrared (IR) spectrum using small sample size (~20mL) in minutes (8-15 min)
- AVEVA RTC Software to analyze spectra to generate a complete crude oil assay

## Use Case for RTC

- For reducing laboratory resource utilization:
  - Replace most of the current lab testing for Flash Assays and Rapid Crude Yield
- For optimizing Refinery crude processing with accurate and immediate data:
  - 'Just-In-Time' adjustment of assay upon the arrival of a crude cargo
    - Pipeline delivery with intermix / contaminations
    - Crude with wide swing of variation and seasonal changes
    - Offspec opportunity crudes

# Real-Time Crude Assay Workflow

**20 mLs Crude**

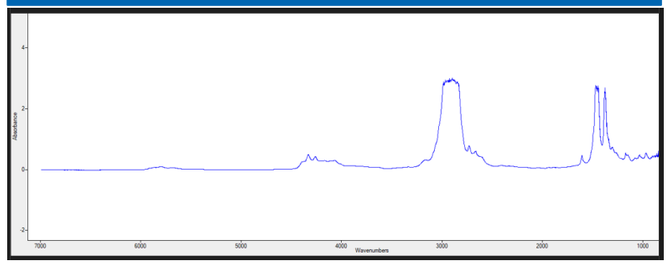


**Required Lab Measurement:**

**API/Density***

**ANALECT® RefinIR™**


**Mid + Near IR Spectra**



**AVEVA USC Desktop w/RTC**

**+**

**Basis Crude Assay****

**Crude Assay Report**

**Data Comparison of Selected Crude Oils**

| | | |
|---|---|---|
| COUNTRY | [redacted] | |
| STATE | | |
| CRUDE | [redacted] | IR of 21-179_20230913_141009 |
| REFERENCE | | IR20230913_141009 |
| SAMPLE DATE | | |
| ANALYSIS QUALITY | Yes | |
| **WHOLE CRUDE INSPECTIONS** | | |
| Gravity, °API | 27.7 | 27.7 |
| Specific Gravity | 0.8888 | 0.8888 |
| Sulfur, wt % | 3.39 | 3.30 |
| Mercaptan Sulfur, ppm | 107 | 56.3 |
| Dissolved H2S, ppm | 0.000965 | |
| Nitrogen, ppm | 1360 | 1290 |
| Pour Point °F | -28.2 | -25.7 |
| Pour Point °C | -33.4 | -32.0 |
| Acid Number, mg KOH/g | 0.210 | 0.213 |
| Back-Blended Acid, mg KOH/g | 0.188 | 0.172 |
| Viscosity @ 40 °C (104 °F), cSt | 12.2 | 12.6 |
| Viscosity @ 50 °C (122 °F), cSt | 9.05 | 9.36 |
| Asphaltenes, C7, % | 2.72 | 3.97 |
| Nickel, ppm | 15.2 | 15.5 |
| Vanadium, ppm | 58.6 | 56.5 |
| Characterization Factor, K | 11.83 | 11.83 |
| MCR, wt% | 7.18 | 7.56 |
| **TBP YIELDS, VOL %** | | |
| Butanes and Lighter | 1.910 | 2.068 |
| Light Gasoline (55-175 °F) | 5.624 | 5.804 |
| Light Naphtha (175-300 °F) | 10.513 | 10.707 |
| Heavy Naphtha (300-400 °F) | 9.202 | 8.836 |
| Kerosene (400-500 °F) | 8.797 | 8.661 |
| Atm. Gas Oil (500-650 °F) | 13.569 | 12.883 |
| Lt Vacuum Gas Oil (650-800 °F) | 12.215 | 12.472 |
| Hvy Vacuum Gas Oil (800-1050 °F) | 16.967 | 17.604 |
| Vacuum Residuum (1050 °F+) | 21.204 | 20.965 |

*Needed to ensure samples are heated to the appropriate temperature

** Basis crude assay is an existing assay in the AVEVA USC Assay Library

# Real-Time Crude Data Evaluation

## Yield and API Comparison

| Measurements | Type | Crude | Distillate Fractions | | | | | | | | | | | Residue Fractions | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut | Crude | 15-70°C | 70-100°C | 100-150°C | 150-200°C | 200-250°C | 250-300°C | 300-350°C | 350-370°C | 370-450°C | 450-500°C | 500-550°C | 370°C+ | 550°C+ |
| Yield (%vol) | First crude (TFA) | | 5.37 | 3.40 | 7.55 | 8.29 | 7.96 | 7.93 | 8.26 | 2.38 | 12.20 | 6.36 | 5.60 | 46.95 | 22.79 |
| | Second crude (IR) | | 5.54 | 3.55 | 7.59 | 7.95 | 7.84 | 7.64 | 7.79 | 2.70 | 12.22 | 6.70 | 5.82 | 47.32 | 22.58 |
| | Difference | | -0.18 | -0.14 | -0.04 | 0.34 | 0.12 | 0.29 | 0.46 | -0.32 | -0.02 | -0.34 | -0.21 | -0.37 | 0.21 |
| API | First crude (TFA) | 27.70 | 86.45 | 68.57 | 55.34 | 50.42 | 43.01 | 36.30 | 30.91 | 26.14 | 20.65 | 16.52 | 13.53 | 9.69 | 1.96 |
| | Second crude (IR) | 27.70 | 86.66 | 68.89 | 56.74 | 51.03 | 43.10 | 36.19 | 30.22 | 25.82 | 21.07 | 17.05 | 14.05 | 9.60 | 1.18 |
| | Difference | 0.00 | -0.21 | -0.32 | -1.39 | -0.61 | -0.09 | 0.12 | 0.69 | 0.32 | -0.42 | -0.53 | -0.53 | 0.09 | 0.78 |

## Crude Oil Property Comparison

| Measurements | Viscosity at 20°C/68°F (cSt) | Viscosity at 40°C/104°F (cSt) | Sulphur (%wgt) | Nitrogen (ppm) | Basic Nitrogen (ppm) | TAN (mgKOH/g) | Pour Point (°C) | Wax (%wgt) | UOPK | $C_7$ Asphaltenes (%wgt) | MCRT (%wgt) | Vanadium (ppm) | Nickel (ppm) | Iron (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| First crude (TFA) | 25.2 | 12.2 | 3.39 | 1364.0 | 386.0 | 0.19 | -33.4 | 8.3 | 11.83 | 2.72 | 7.18 | 58.6 | 15.2 | 1.5 |
| Second crude (IR) | 25.9 | 12.6 | 3.30 | 1286.0 | 345.9 | 0.17 | -32.0 | 8.3 | 11.83 | 3.97 | 7.56 | 56.5 | 15.5 | 2.9 |
| Difference | -0.72 | -0.40 | 0.09 | 77.94 | 40.1 | 0.02 | -1.39 | -0.06 | -0.01 | -1.25 | -0.38 | 2.05 | -0.25 | -1.42 |

| KEY | |
|---|---|
| | Difference more than 3 tolerances |
| | Difference between 2 and 3 tolerances |
| | Difference between 1 and 2 tolerances |
| | Differences not highlighted if one or more yields <0.2 % wgt |

| Property | Tolerance | |
|---|---|---|
| Yield | 1 | %wgt/%vol |
| Density | 0.005 | g/cc |
| API | 1 | |
| Viscosity | 10 | % rel |
| Sulphur | 10 | % rel (0.01% min) |
| Nitrogen | 10 | % rel (10ppm min) |
| Basic Nitrogen | 10 | % rel (10ppm min) |
| TAN | 20 | % rel (0.2mgKOH/g min) |
| Pour/Cloud/Freeze | 5 | °C |
| Wax | 20 | % rel (1% min) |
| Refractive Index | 0.001 | |
| UOPK | 0.1 | |
| Asphaltenes/MCRT | 10 | % rel (1% min) |
| Metals | 10 | % rel (2ppm min) |

All Data Extracted from AVEVA USC Desktop Crude Comparison Report

TFA=Transportation Fuels Assay

IR= IR Spectra (Real-Time Crude Assay)

## The End

# Questions?