“Sceptic to Convert”
– ITS A PIPELINE STORY.

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BP – Public Affairs

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Intertek – Passed away recently – passed on his passion for this technology and at the same time became a good friend.
Agenda

• Introduction
• Setting the Scene
• Quality Bank Analysis - UK
• Forties Pipeline System
  • Vision
  • Deployment of Chemometrics Technology
• Near Infra Red Quality Bank analysis
• PT5 Technology – Applications
  • Advanced Crude Assay
  • Crude Quality Tracking
  • Crude Blending – CDU optimisation
• PT5 Technology
• Organic Deposition
• Exploration and Production Division Aberdeen.
  • Quality Bank Analysis – Centre of Expertise
• Process Assurance Group – PT5 Applications - Teesside
  • Solutions focused group involved in a range of applications throughout the hydrocarbon supply chain
  • Chemometric Modelling
  • Process Engineering
  • Research
Introduction – Setting the Scene
Setting the Scene - Quality Bank Analysis

Analysis of the oil flowing from individual platforms into a shared pipeline system. This provides information with which to derive the fiscal valuation of crude from each field.
• Quality Bank Analysis
  • Value Realisation within shared Pipeline Infrastructure

• Intertek Aberdeen responsible for undertaking the Quality Bank analysis for the 3 major pipeline systems within the UK.
  • Forties Pipeline
  • Ninian and Brent
  • Flotta

• Underpinned by Accurate Measurement of
  • Mass & Volume
  • Crude Quality
Quality Bank Sampling and Analysis

**Sampling**

Comply with ISO 3171, Weekly Flow Proportional Samples

**Analysis**

Weekly Light End Analysis. (N2, CO2, C1, Cn+ where n = 5, 6, 7, 8) H2O, Sed

True Product Worth - C5+ Analysis – frequency agreed based on Commercial Agreements and on variability of platform Composition.

(N2, CO2, C1 to C4, C5 ~ 550+ Res)

Historically - Tended to be Monthly or Quarterly
$ Billions Dollars – exported via pipeline systems
Underpinned by:

Accurate Measurement of Quantity

Fiscal Sampling

Analysis – Accredited Laboratory

Why?
Reduce Uncertainty
# Quality Bank Analysis - UK

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Forties Pipeline</th>
<th>Ninian</th>
<th>Brent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Compn</td>
<td>N2,CO2,C1 to C4, C5+,C6+ or C6,C7+</td>
<td>N2,CO2,C1 to C5, C6+</td>
<td>N2,CO2,C1 to C4, C5+</td>
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<tr>
<td>ASTM D2892</td>
<td>C1 - C4,</td>
<td>C1 - C4</td>
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<td>C5 - 150</td>
<td>C5 - 165</td>
<td>15 - 165</td>
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<td>150 - 250</td>
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<td>550+</td>
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<tr>
<td>Total</td>
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<td>100</td>
<td>100</td>
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<tr>
<td>General Analysis</td>
<td>Density (150 - 250, 250 - 350)</td>
<td>Density (350+)</td>
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<tr>
<td></td>
<td>Sulphur (350 - 550)</td>
<td>Sulphur (350+)</td>
<td>Sulphur (350+)</td>
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<td>Sulphur (550+)</td>
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<tr>
<td></td>
<td>Vis @ 100°C (550+)</td>
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<td>Vis @ 80°C (350+)</td>
</tr>
</tbody>
</table>
Forties Pipeline System.
Forties Pipeline System
BP’s Vision – 2001

The Hydrocarbon Accounting process will be fully automated with on-line transfer for all input and output data and this will be supported by on-line analysis & measurement data and web based reporting.
2001 - BP had Vision to Transform their Hydrocarbon Accounting System

Processes are increasingly cumbersome for customers with growing numbers of users.

Technology has moved ahead of the system

Too much manual intervention – data transfer, input and checking

Monthly deadline pressures on customers and Pipeline operators.

Time to receive analysis, run and check accounts
Feasibility Study.
Stage 1

- Feasibility of Carry Out On-Line Analysis Offshore
- Options for Online analysis and anticipated problem areas
- Financial Model for Delivery
- Conclusion NIR combined with Chemometrics modelling is the most appropriate combination
- Gas Chromatography, Mass Spec, Raman, NIR

Stage 2

- Ascertain which Parameters could be predicted using NIR
- Chemometrics/NIR combination had to meet the same uncertainty as conventional analysis
- Exhaustive review of all analysis carried out to determine uncertainty values for each attribute
Outcome

- **Light End Composition, N2, CO2, C1 – C6+**

- **TBP – True Boiling Point Curve**
  - ASTM D2892
  - ASTM D5236/D1160

- **Effect of Distillation Reproducibility on Property Value**

  Sulphur/Viscosity – Fuel Oil/Vacuum Bottoms
  SG on Gasoline/Kerosene Fraction
Feasibility Study - Instigated

Outcome

• PT5 Technology could determine each attribute to the level of accuracy required for the Provision of the Hydrocarbon Accounts.

• Representivity of samples used for Hydrocarbon Accounting analysis significantly improved.

• Introduction of PT5 facilitates introduction of genuine monthly simulations and monthly hydrocarbon accounts.

• Decision made to deploy PT5 Technology and build pipeline chemometrics model

• **BP FPS – Dilemma**

• Mechanism for deployment

• Intertek funded deployment of this technology within the FPS
Near Infrared, Quality Bank Analysis.
Intertek PT5 Technology

Using PT5 Technology

Scan
Spectra
Quality Tracking
Property Prediction

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**Terminology**

**Chemometrics** is the field of extracting information from multivariate chemical data using mathematical and statistical tools.

**NIR** is a technique which can be used to identify molecules by analysis of their constituent bonds. Each chemical bond in a molecule vibrates at a frequency which is characteristic of that bond.

**PT5 – Advanced Chemo metric Modelling**
Why Use NIR?

NIR spectra are fast to collect
NIR spectra can be compared with database samples to check consistency
Transferable between spectrometers
Multiple wavenumbers (4,000cm\(^{-1}\) – 10,000cm\(^{-1}\))

Typical NIR absorbance reproducibility (ABB MB3600 at 1 AU)

- Toluene 0.002 AU
- Light Crude 0.002 AU
- Intermediate Crude 0.004 AU
- Heavy crude 0.010 AU
PT5 NIR System
Near Infra Red - Spectrum

A = Aromatics  O = Olefinics  P = Paraffinics  I = Isoparaffinics  L = nParaffinics

KARO  KISO  KENE  NARO  KAROL  KOX  PAROX
The basic postulate is that the same spectrum equates to same properties.
When an Unknown sample is then measured, its spectra is compared with the data base and if a match is found, the associated properties can be assumed.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Spectra</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>Spectra 1</td>
<td>Prop 1 Prop 2 Prop 3 Prop 4 Prop 5 Prop 6 Prop n</td>
</tr>
<tr>
<td>Sample 2</td>
<td>Spectra 2</td>
<td>“           ”</td>
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<tr>
<td>Sample 3</td>
<td>Spectra 3</td>
<td>“           ”</td>
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<tr>
<td>Sample 4</td>
<td>Spectra 4</td>
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<tr>
<td>Sample 5</td>
<td>Spectra 5</td>
<td>“           ”</td>
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<td>Sample 6</td>
<td>Spectra 6</td>
<td>“           ”</td>
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<tr>
<td>Sample n</td>
<td>Spectra n</td>
<td>“           ”</td>
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</tbody>
</table>
How does it work?

For a new feed or product, PT5 looks for the closest spectral neighbours in a reference database. The new properties are then calculated as a function of these neighbouring properties.

Property $X = f(\text{Prop}[S1, S2, S3, S4, S5])$
Impact of PT5 Technology

Turnaround times have been reduced from Avg 12 to 3 Days
Representiivity of Accounts increased

Intertek have obtained formal ISO17025 Accreditation for the PT5NIR Technology for this application
PT5 Technology Applications.
Applications – PT5NIR

Upstream Application’s
- Production
- Pipelines
- Separation Facilities
- Export Facilities
- Tank Farm

Hydrocarbon Trading:
- Crude, Condensate
- LPG, LNG

Compositional data available for each shipment enables Value Determination

Refinery Tank Farm
- Crude Blending

Dynamic Crude Blend Optimisation:
Knowing the composition of each crude allows the correct crude blend to be fed to the CDU

Refinery Crude Distillation

Rigorous dynamic simulation of CDU with on-line crude composition predicts side-draws and updates constraint sets within the APC
Key Services and expertise

Production and Refinery Support

Combination of lab and field based analytical services

- Centre of Excellence
- Carry out in excess of
- 750 Conventional TBP’s per year for Exploration through to Refining Studies
- High Temp Simulated distillation capability
- NIR > 1000 Hydrocarbon composition of live fluids
  - Subject Matter Experts
  - Laboratory Capability
  - Client Base
- Access to world class universities
- Develop the product to meet clients demands
- Not reliant on clients data
**PT5 Applications**

**Typical Properties**

<table>
<thead>
<tr>
<th>1) Live Crude (Light Ends)</th>
<th>2) Live Crude (Full Analysis)</th>
<th>3) Stabilised Crudes</th>
<th>4) Gasoline</th>
<th>5) Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distillation</strong> (either wt% or vol%)</td>
<td><strong>Mass%, Vol%, Molecular Weight and SG for all cuts below</strong></td>
<td><strong>Distillation (either wt% or vol%)</strong></td>
<td><strong>IBP</strong></td>
<td><strong>IBP</strong></td>
</tr>
<tr>
<td>N2</td>
<td></td>
<td>IBP - 15</td>
<td>IBP</td>
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</tr>
<tr>
<td>CO2</td>
<td></td>
<td>15 - 45</td>
<td>D10</td>
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<tr>
<td>C1</td>
<td></td>
<td>45 - 60</td>
<td>D50</td>
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<td>C2</td>
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<td>60 - 75</td>
<td>D90</td>
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<td>C3</td>
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<td>75 - 90</td>
<td>FBP</td>
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<td>IC4</td>
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<td>E70</td>
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<td>NC4</td>
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<td>IC5</td>
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<td>120 - 135</td>
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<td>NC5</td>
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<td>135 - 150</td>
<td>E180</td>
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<td>C6</td>
<td></td>
<td>150 - 165</td>
<td>RON</td>
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<td>C7+</td>
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<td>165 - 200</td>
<td>MON</td>
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<td>GOR</td>
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<td>200 - 250</td>
<td>Aromatics</td>
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<td>Oil Density</td>
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<td>250 - 300</td>
<td>Benzene</td>
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<td>Dry Density</td>
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<td>300 - 350</td>
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<td>Sulphur 350+</td>
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<td>Sulphur 550+</td>
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<td>Viscosity 350+</td>
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<td>Viscosity 550+</td>
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</tr>
</tbody>
</table>

**Mass%, Vol%, Molecular Weight and SG for all cuts below**

- IBP - 15
- 15 - 45
- 45 - 60
- 60 - 75
- 75 - 90
- 90 - 105
- 105 - 120
- 120 - 135
- 135 - 150
- 150 - 165
- 165 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- 350 - 400
- 400 - 450
- 450 - 500
- 500 - 550
- 550+

**Distillation (either wt% or vol%)**

- IBP - 15
- 15 - 45
- 45 - 60
- 60 - 75
- 75 - 90
- 90 - 105
- 105 - 120
- 120 - 135
- 135 - 150
- 150 - 165
- 165 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- 350 - 400
- 400 - 450
- 450 - 500
- 500 - 565
- 550+

**Sulphur**

- 350+
- 550+

**Viscosity**

- 350+
- 550+

**API Gravity**

- **TAN**
- **Pour Point**

**Flash Point**

- Cloud Point
- Cetane
- CFPP

**Distillation** (either wt% or vol%)

- IBP
- D10
- D50
- D90
- FBP
- E70
- E100
- E150
- E180
- RON
- MON
- Aromatics
- Benzene

**Oil Density**

- Dry Density

**Flash Point**

- Cloud Point
- Cetane
- CFPP

**Aromatics**

- Benzene

**Cloud Point**

- Cetane
- CFPP

**Cetane**

- CFPP

**CFPP**

- IBP
- D10
- D50
- D90
- FBP
- E70
- E100
- E150
- E180
- RON
- MON
- Aromatics
- Benzene
Crude Quality Tracking
Case Study Crude Type XX

Demonstrating PT5Crude Discrimination…

- Four samples of crude type XX from a 6 month period
- Sample_03 NIR spectra different to rest of family
- API higher but Sulphur Lower – similar price per barrel, this crude appears to be more valuable
- Looking at the 565DegC residue however reveals it to be higher.
- Netback calculations showed Sample_03 to be $1/bbl lower value when processing compared to the other three samples

<table>
<thead>
<tr>
<th>SampleID</th>
<th>API</th>
<th>Sulphur</th>
<th>565°C+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample_01 05/09/11</td>
<td>32.8</td>
<td>0.9</td>
<td>7.6</td>
</tr>
<tr>
<td>Sample_02 06/11/11</td>
<td>33.8</td>
<td>0.8</td>
<td>6.0</td>
</tr>
<tr>
<td>Sample_03 19/01/12</td>
<td>37.9</td>
<td>0.3</td>
<td>11.6</td>
</tr>
<tr>
<td>Sample_04 23/02/12</td>
<td>33.0</td>
<td>0.8</td>
<td>6.22</td>
</tr>
</tbody>
</table>
PT5 covers every stage of the refinery
Organic Deposition
Assessing Blend Stability
Existing Methodology

Current Methodology

Three ASTM methods exist for stability testing:


General Summary

- Uses pure components (i.e. Toluene/Heptane, Cetane/1-MethylNaphthalene)
- Assesses precipitation of asphaltene using optical density at a single wavelength

Our Question: How do these tests relate to real crude blending?
Assessing Blend Stability Considerations

- Not processing pure materials, processing blends of crude oils
- Crude is a complex material, what about the interaction between crude oils when blended?
- Stability is assessed as materials are added, what about if blends are stored for any length of time?
- What if the quality of the crude changes, how does this affect the stability of the blend?
- These methods are specific to asphaltene, what about precipitation of other components (crystalline organics, wax etc.)
- These methods use optical density at a single wavelength to observe asphaltene precipitation, is this optimal to see smaller particle formation?
- *PT5 can be used to determine Organic Deposition*
Thank you

Any Questions?