PORLA Analyzer
to Improve Profitability of Oil Industry

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Finnish Measurement Systems Ltd
Finnish Measurement Systems Ltd

FMS

- Finnish Measurement Systems Ltd, based in Finland, is the leading supplier of automatic heavy oil and crude oil stability and compatibility analyzers.

- Our main product is Porla analyzer for oil refining process optimization, for blending of fuels, crude oils and bitumen, as well as for developing new oil products and processes.

- Our products are well known all over the world in oil refining industry, in oil production and in oil research institutes.

- About 30 oil company references, latest Sinopec, China and PDVSA, Venezuela
Porla Analyser

- Analyzer performs **complete analytical procedure fully automatically**

- Ideally suited to Visbreaking and hydrocracking processes

- High automation level saves operator time and reduces costs

- PORLA Pay-out Time is 1 - 2 Months depends on the operation
Benefits of PORLA

• One of the main reasons for this interest has been the high price of crude oil. Using PORLA allows oil companies and refineries to prepare feedstock crude oil blends more economically.

• The PORLA Fully Automatic Stability and Compatibility Analyser can measure oils with an asphaltene content as low as 0.05%, which is a twentieth of competitive instruments.

• D7112 is the ASTM test method for the PORLA.
**Automatic** Measurement of P-Value, Solvent Equivalent and Flocculation Ratio

**Accurate** Estimation of Stability and Compatibility Parameters

**Analytical Procedure Used:**
- Variable Combination of Solvent Aromatic (Xylene, Toluene, etc.) and Paraffinic (Heptane, iso-octane, Cetane, etc.)
- Automatic Titration of the Three Solutions (Oil, Aromatic, Paraffin)
- Detection of Asphaltene Particles by Selective Detector (Back-Scattering) : Onset of Flocculation Is Called FR
- Automatic Calculation of Stability and Compatibility Figures

Any combination of aromatic and paraffinic solvents can be used.
Benefits of PORLA

- No need to filter samples to remove coke particles and other contaminants
- No Need For Experienced Operators
- High Automation Level - Proven Technology
- Low Labor Requirements
- Easy To Use And Maintain
- Less Time Consuming versus Manual Reference Method
- 1/6 of Manual Method Time
Some Features of Porla

- Automatic, Simple and Easy Operation
- Asphaltene Sensitive Detector
- Heavy and Crude Oil Compatibility Application
- Can Analyze Low Asphaltene Content Oils (<0.1%)

- One Variable and Three Fixed Dilution Ranges
- Fast Screening Option
- Measurement Mode for Light Samples
- Aromatic Solvent Evaporation Correction
- Operation at Elevated Temperatures
- Detector uses reflected light, sensitive to asphaltene particles
- Desk-top laboratory analyser
- Analyser simple to operate
- **Sample preparation time of 5 minutes**
- **3 sample** titration typically takes **90 minutes**
- Very quick to clean detector (**1 minute**)
- Analysis performed at slightly elevated temperatures to reduce reaction time
- Increased precision compared to manual and other methods – Better **Reproducibility and Repeatability by Porla**
- Results stored on PC hard drive, possible to print hard copy
- Weight : 35 kg
- Dimensions (40X53.5X40cm)
Pay by Savings ...

**Huge Savings**
Allows production process to operate closer to severity limit - huge cost savings possible!

**New Possibilities**
Crude oil blending more economically without risk of plugging troubles.

**Quick Pay Back**
Payback on investment in 1-2 months according to optimization level of process

**Less Operator Time**
Installation and training, including application build-up in customer's laboratory

User friendly
How much more profit
One Example...

Assumptions

**Optimized** Oil refinery, Annual Feed 10 MTON, Visbreaker Process, manual heavy oil stability analyses

Action

From manual to automatic stability analysis

Annual Increase in profitability

Reproducibility

Manual 0.2, Automatic 0.05 PV UNIT

0.1 P-Value

Unit: 1.000.000 USD Annually

CANNOT SAVE !!! >>> 1 500 000 USD !!!
Conclusions

• Substitution of manual stability analyses by Porla in monitoring of optimized visbreaker process:
  => 1.5 M.USD more profit annually
  => real pay-back within 1 month

• 3 times better precision v/s manual method in Hydrocracking process optimization
  => about 3% more vacuum distillation residue net conversion
  => real pay-back within 1-2 months
Conclusions

Preventing instability/incompatibility cases in blending of fuel oils:

=> profit 250,000 - 1,000,000 USD per case

Monitoring of processes and compatibility of crude oil blends in industrial plants is important to prevent plugging trouble and unit shut downs:

=> savings as result of minimized fouling problems and more economically selected blends of crudes
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<tr>
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<td>Neste Oil Ltd, Research Centre, Finland</td>
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<td>Shell Global Solutions, Netherlands</td>
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<td>Arabian Oil Company, Kuwait Institute for Scientific Research, Kuwait</td>
<td>Thai Oil, Thailand</td>
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PORLA Automatic Laboratory Analyser

Definitions and working principle
Stability and Compatibility

• **Instability** – Tendency of a Liquid Material to Form (or Initially Contain) Sediment upon Storage or Heating
  – Mechanism could be Asphaltene Precipitation or Oxidation and Polymerization Reactions

• **Incompatibility** – Tendency of a Liquid Material to Form Sediment upon Mixing with Another Liquid

• **Sediment** Measured during Stability and Compatibility Testing are:
  – Precipitated Asphaltenes
  – Fines Particulates (Catalyst, Scale) Possibly Acting as Precursor of Sediment and Aggregating the Asphaltenes
  – Carboneous Materials Dispersed in the Effluents or Feed
How are Stability and Compatibility Determined Manually?

- Dilution of OIL with an AROMATIC solvent
- Precipitation of Asphaltenes with a PARAFFINIC solvent
- Visual detection of precipitation by manual spot test or microscopy

ml Paraffin / g oil:

- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
Why stability analyses are so important in residuual conversion processes?

- **Increased yield of valuable components** by maximizing conversion v/s converted fuel oil stability
- **Decreased consumption of aromatic cutter stocks** (not always available)
- **Minimized amount of Off-Spec. products** in the final heavy fuel pool (compatibility)
- **Increased operability of key equipments** such as feed/product heat-exchanger
How PORLA works..

**INPUT:**
- OPERATOR NAME
- SAMPLE NAME
- METHOD
- STOCK SOLUTION DATA
- DENSITY
- SAMPLE QUANTITIES
- MEASURING PROFILE

**OUTPUT:**
- PARAFFIN CONSUMPTION
- EXTRAPOLATION LINE
- CORRELATION COEFF.
- P-VALUE, Pa, Po
- SOLVENT EQUIVALENT
- COMPATIBILITY PARAMETER

PORLA Automatic Laboratory Analyser
On One Screen....

1 Sample
(Few minutes preparation)

10 parameters

All in one

in 90 minutes
Detection Principle of PORLA

• Detector uses reflected light, sensitive to asphaltene particles

LIGHT SOURCE

OIL sample + Aromatic solvent

DETECTOR

Paraffinic solvent
Definitions/
Case studies of
 costs of
compatibility
problems

• Results of Visbreaker Products
• Results of Hydrocracking Products
• Results of Crude Oils
• Conclusions
Blends are compatible when the volumetric average solubility blending number is greater than the insolubility number of any component of the blend.
Compatibility Parameters

\[ TE = \frac{I_N}{(1 - \frac{V_H}{25d})} \]

\[ S_{BN} = I_N \left(1 + \frac{V_H}{5}\right) \]

**TE** = toluene equivalent

**\( V_H \)** = maximum n-heptane can be added to 5 ml of oil

**\( d \)** = density of oil

**COMPATIBILITY MODEL**

Compatibility criterion

\[ S_{BN_{mix}} > I_{N_{max}} \]

\[ S_{BN_{mix}} = \frac{V_1 S_{NB1} + V_2 S_{BN2} + \ldots}{V_1 + V_2 + \ldots} \]
Main Causes of unstable oils

1. Upset in a residue conversion unit, resulting in a less stable bottoms stream and unstable blend after dilution with normal diluents
2. Blending of two stable fuels of completely different origin (e.g. Middle East residue with parafinic residue)
3. Blending in the wrong order
Case Study 1

- Far East Refinery switched crudes during a weekend. The new crude slate contained less 520C+ (1000 F+) material, but the settings of the visbreaker were not changed.
- The resulting visbroken residue had a lower stability reserve but was blended with the usual amount of diluents, causing the fuel oil to be unstable and off-spec on filterable solids (0.35 %w instead of 0.10%w).
- In this case, a local customer was willing to buy the product at a significantly reduced price.
- Total costs were estimated to be amount 250,000 US$
Case Study 2

- A large depot in Scandinavia received 90,000 tonnes of fuel produced in four batches and blended them together.
- The first batch turned out to be incompatible with the other three batches, turning the blend off-spec on filterable solids.
- The cost of recovery was 6.5$/tonne or 560,000$ (excluding manpower and loss of reputation).
Case Study 3

- A Trading company in the Middle East received an order for 10,000 tonnes of 180 cSt fuel. They have access to 380 cSt from port A (containing visbroken material) and straight-run parafinic LR from port B.
- The Captain of the product tanker was instructed to go to port A first. However, for undisclosed reason, the captain decided to go to port B and loaded LR first. A few days later, the 380 cSt fuel was added (bottom loading!) in port B.
- After delivery to a power station, the local diesel engine had to be stopped due to the excessive sludge content and damage to the engine, leaving the region was without electricity.

- Estimated Damage > 1 M USD
PORLA Automatic Laboratory Analyser

Results of Visbreaker Products
THERMAL CRACKING UNIT

FEED → LIGHT ENDS

FEED → MIDDLE DISTILLATES

MIDDLE DISTILLATES → HEAVY BOTTOM

HEAVY BOTTOM → CUTTER STOCK

CUTTER STOCK → STABILITY ANALYSIS

STABILITY ANALYSIS → HEAVY FUEL OIL
CORRELATION OF P-VALUE AND PROCESS TEMPERATURE OF VB-UNIT
## Neste Oil Ltd Data

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<th>Residue (450°C)</th>
<th>Residue (435°C)</th>
<th>Residue (420°C)</th>
<th>Feed Stock</th>
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<td>P-Val</td>
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Results of Hydrocracking Products
Optimization of H-Oil Process Using PORLA

• Maximizing Conversion versus Fuel Oil Stability
  (Conversion main limitation: Stability of Residual Product)

• Decreased Consumption of Aromatic Cutter Stocks

• Increased Operability of Key Equipment Such As Feed/Product Heat Exchanger
H-OIL UNIT

Light Ends

Mid. Distillates

Vac. Distillates

FEED (1)

H-OIL VR

Cutter Stock: LCO, HCO,...

STABILITY ANALYSIS

STABILITY

TIME

Heavy Fuel Oil

(1) typical feed: SR VR from Conventional Crude, SR AR from extra heavy crude
H-Oil PROCESS

- Catalytic Hydroconversion Process for Upgrading Petroleum Residue
- Utilizes an Ebullated-Bed Reactor
- Long Cycle Length (over 3 years)
- Temperature: 410 - 440°C
- High Hydrogen Pressure: 100 - 200 bar
- Space Velocity: 0.25 - 1.5 hr\(^{-1}\)
- On-line Catalyst Addition: 0.3 - 2.5 kg/m\(^3\)
PORLA precision study v/s time: repeatability/intra labo. reproducibility

IFP tested ....

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<th>level</th>
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<th>intra. Lab. Reproducibility $RL$</th>
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<td>0,014</td>
<td>0,019</td>
</tr>
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- PORLA precision 3 times better than manual method
- PORLA measurement very stable v/s time ($r_L = R_L$)
- PORLA: precision not dependant on operator
Utilization of PORLA on H-Oil Product

- Extensive comparison with the manual method
  - 4 very different feedstocks:
    - Arabian Heavy Conventional V.R.
    - 3 A. R. from extra heavy crudes from Venezuela (Boscan, Morichal) and Canada (Cold Lake)
Utilization of PORLA on H-Oil Product

• Parameters to be compared:
  
  – FR5/1 (manual method): 0.35 (very stable) to 0.80 (border-line/unstable)
  – p-value: 1.8 (very stable) to 1.0 (unstable)

• Net V.R. Conversion: 50 to 65%m/m
Utilization of PORLA on H-Oil Products

Extensive study of all H-oil streams, wide variation of feed stocks and stabilities. The key points found were:

– P-Values by Porla and manual method were equal and Porla results were 3 times more accurate than manual method results (confidence interval +/-0.06 Porla v/s +/- 0.14 manual)

– Between Porla and manual method FR5/1 values there was a constant correlation (FR5/1PORLA = 0.84 FR 5/1 Manual) and Porla results were 3 times more accurate (+/- 0.014 Porla v/s +/-0.043 manual)

– No feed stock effect between Porla and manual method
PORLA Automatic Laboratory Analyser

Results of Crude Oils
### STABILITY AND COMPATIBILITY ANALYSES OF ATHABASCA BITUMEN

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<tr>
<th>QC</th>
<th>P-Value</th>
<th>IN</th>
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<td>10</td>
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<td><strong>Average</strong></td>
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<td>s</td>
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### ANALYSES OF RUSSIAN CRUDES

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<td>-</td>
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* Analyzed indirectly by mixing with **HFO heavy fuel oil**