



PORLA Stability and Compatibility Analyzer

Dr Juha Vilhunen – Managing Director
Mr Jurg Walvogel – Product Manager
Finnish Measurement Systems Ltd



www.finmeassys.com



FMS Ltd is developer and manufacturer of laboratory and on-line analyzers for oil industry, production and research

Analyzers in product range of FMS Ltd:

- Porla Crude and heavy fuel oil stability and compatibility analyzer
- New Generation Porla analyzer
- Porsas On-line p-value analyzer
- Samuli On-line cloud point analyzer
- Bisom Porla bitumen solubility analyzer

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Our main product is **New Generation PORLA Analyzer** for oil refining process optimization, for blending of heavy fuel oils, crude oils and bitumen, as well as for developing new oil products and processes.

New Generation PORLA will produce a full set of stability and compatibility parameters such as:
P-value, Pa, Po, Xmin, FRmax, FR5/1, In and Sbn by one run.



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HISTORY OF FMS LTD

- FMS was established as subsidiary of Neste Oil Plc 1996
- A planned gradual dilution of Neste ownership was agreed upon
- First, business activities focused to Scandinavia and Russia
- Application development was carried out in close collaboration with prominent global partners
- FMS Ltd spin-offed from Neste Oil Plc totally 2010
- Company privately owned, fully independent global
- Investing to product/application development with prominent players has been continued during history of the company
- The present main market areas of FMS Ltd are Scandinavia, Europe, Asia and Russia

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Experience of FMS key persons on oil industry and development of analytical instruments for oil and petrochemical industry:

Dr Juha Vilhunen, MD of FMS (PhD Analytical Chemistry)

- Neste Oil Ltd, Corporate technology, Director 12 years 1985-1997
- FMS Ltd, Managing Director since 1997
- ACA Systems Ltd, President 2002-2008
- Adjunct Professor, Jyväskylä University, since 2002
- Senior Business Development Advisor, Kuopio Innovation Ltd, since 2009

Jurg Waldvogel, Product Manager of FMS

- Neste Oil Ltd, Corporate technology, Senior Technologist 16 years
- FMS Ltd, Product Manager since 2002

During their career FMS Ltd key persons have developed more than 100 measuring instruments for oil, petrochemical and paper industry

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Porla analyzer, standard method ASTM D7112 since 2005

Applications developed in collaboration with:

- ExxonMobil/Soluble Solutions, USA
- IFP/Axens, France
- NCUT, Canada
- Neste Oil Ltd, Finland
- Nynas, Sweden



PORLA HISTORY

- 1986 Monitoring and optimization of different refinery units, reporting only P-value (Neste)
- 1994 Developing of new detector design (Light reflection)
- 1999 Change of measurement procedure to obtain full set of parameters (IFP)
- 2001 Addition calculation of compatibility parameters (NCUT, ExxonMobil)
- 2005 ASTM standard method accepted
- 2009 Developing of special Bisom model for bitumen (Nynäs)
- 2013 Addition of measurement program for asphatene-free oils
- 2015 Launcing of New Generation Porla analyzer

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PORLA APPLICATIONS

- Monitoring blending of heavy fuel oils
- Monitoring blending of marine fuels
- Optimization of thermal cracking/visbreaking processes
- Optimization of hydrocracking processes
- Monitoring mixing of crude oil and feedstock blends for refineries
- Monitoring mixing of crude oil export blends
- Monitoring blending of bitumen
- Facilitating tar sand production processes
- Cargo based monitoring of opportunity crudes
- Supporting tendering, dosing and control of process chemicals (antifoulants)

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ADVANTAGES OF PORLA ANALYZER

- Enables oil refineries to select more economic crude oil blends with minimized risk of fouling problems
- Determination full set of stability and compatibility parameters (FRmax, Xmin, P, Pa, Po, FR5/1, TE, In and Sbn) by one run
- Reporting also ExxonMobil heavy and crude oil blending model parameters In and Sbn
- Capability to analyze stability and compatibility parameters of low asphaltene content oils
- Offer unique method to analyze compatibility parameters of asphaltene-free oils
- ASTM test method D7112 since 2005

OTHER ADVANTAGES OF PORLA

- User-friendly, highly automated sample preparation and analytical procedure minimizing operator time and mistakes
- Fast screening mode to determine optimal running parameters for unknown samples
- Self cleans at the end of the test procedure
- Possibility to use different paraffinic and aromatic solvent combinations

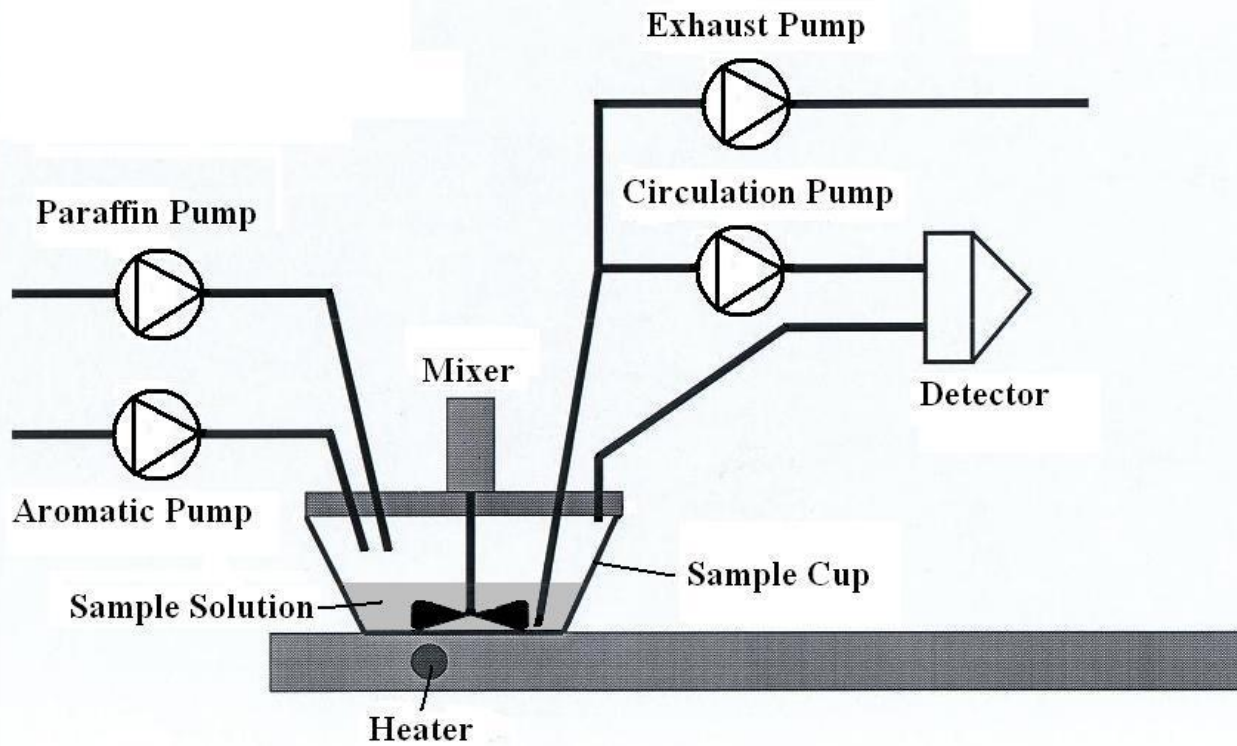


BENEFITS OF PORLA

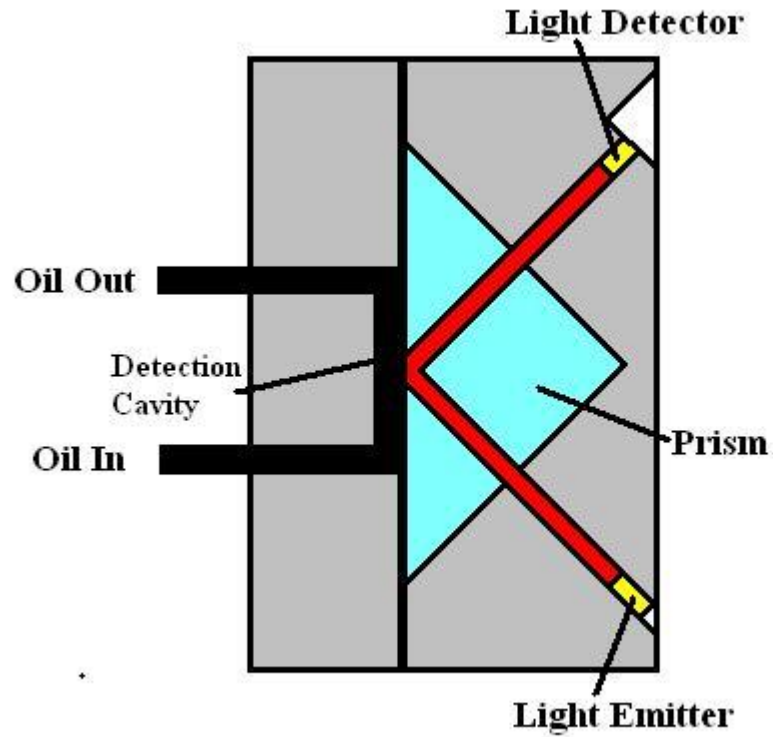
- Maximizing profitability of refinery processes
- Minimizing production of off-spec products
- Selecting crude oil and feedstock blends more economically and preventing shutdowns of refinery units/refineries
- Enabling optimal and profitable use of opportunity crudes
- Preventing production of incompatible crude oil and feedstock blends for refineries
- Minimizing production of incompatible crude oil export blends
- Optimized selection, use and costs of process chemicals (antif.)
- Increasing profitability of tar sand production processes
- Production of bitumen, which corresponds to customer needs

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PORLA Flow Chart



PORLA Detector





Definition of parameters

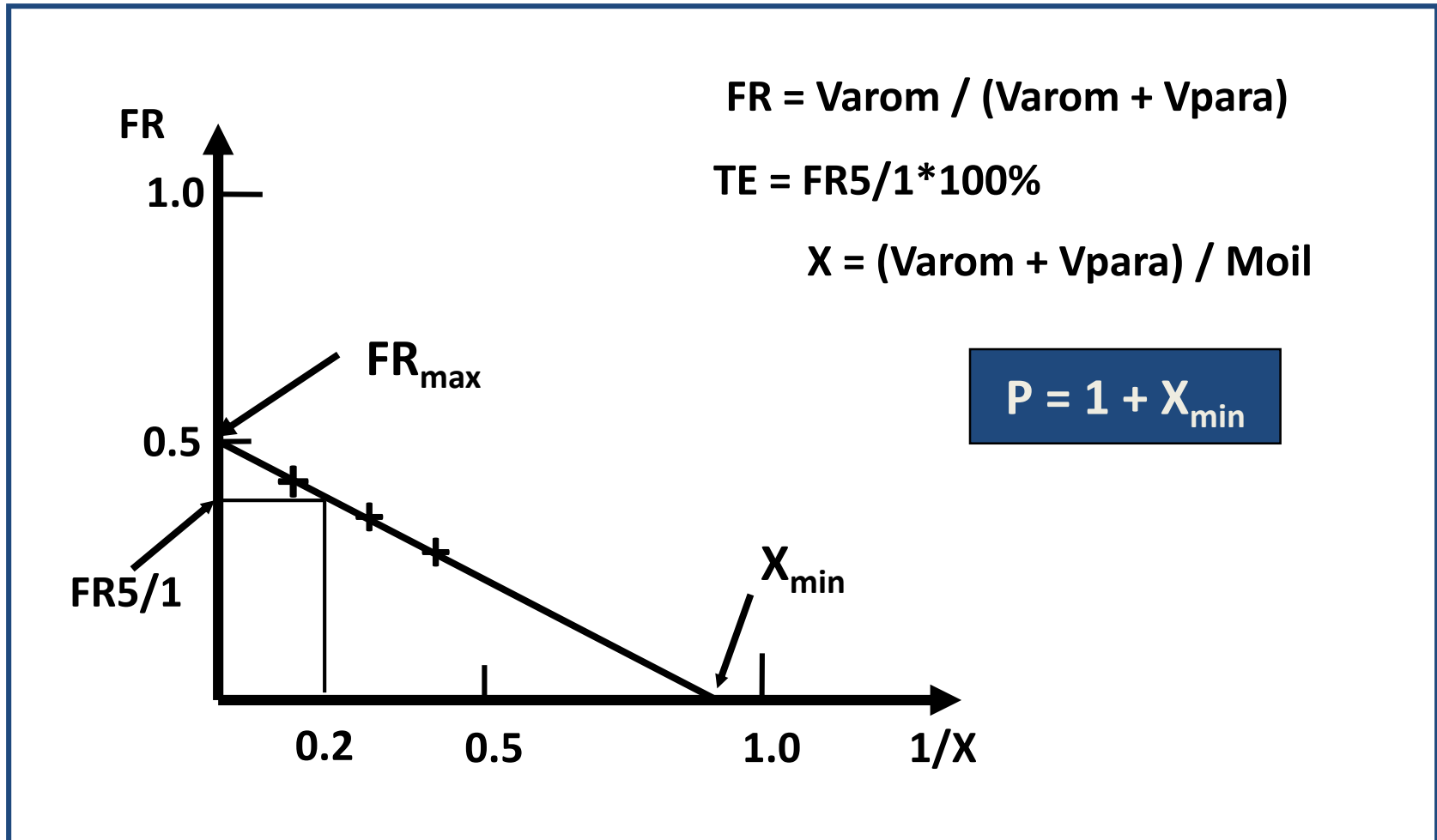
- P-value, define state of peptization of asphaltenes in oil
- Pa, peptizability of asphaltenes
- Po peptization power of oil medium,
- FR5/1 or xylene equivalent, measure of oil aromaticity, the smaller the value the more aromatic is oil
- FRmax, flocculation ratio at infinite dilution
- Xmin, paraffinic solvent consumption of pure oil
- In, insolubility number, the higher the bigger precipitation risk
- IN_{mix}, is the highest IN of components of the blend
- SBN, solubility blending number, ability of oil to keep asphaltenes in solution, the higher the lower precipitation risk
- SBN_{mix}, volumetric average of SBNs of blend components



Definition of parameters

- P-value, smallest 1 i.e. oil is unstable and can precipitate asphaltenes without addition of any paraffins; bigger P-values indicate higher stability of oil with respect of asphaltene precipitation
- Typical P values: $P > 1.35$ for usual fuels, $P > 1.5$ with $P_a > .45$ and $P_o > 0.8$ for bunker fuels
- FR5/1 or xylene equivalent, measure of oil aromaticity, the smaller the value the more aromatic is the oil
- A high aromaticity means that more paraffinic fluids can be added without flocculation of asphaltenes
- IN, insolubility number, inverse measure of ability of asphaltenes to stay in solution. The higher the number, the higher the risk of asphaltene flocculation. IN of asphaltene-free fluids is 0. IN of a blend is equal to the highest IN of all fluids of the blend.
- SBN, solubility blending number, ability of oil to keep asphaltenes in solution, the higher the lower precipitation risk
- SBNmix, volumetric average of SBNs of blend components, all hydrocarbon fluids have a SBN number.

CALCULATION OF STABILITY FIGURES



CALCULATION OF STABILITY FIGURES

$$P = 1 + X_{\min} \text{ or } P_o / (1 - P_a)$$

$$P_a = 1 - FR_{\max}$$

$$P_o = FR_{\max} * P$$

P_a = peptizability of asphaltenes

P_o = peptizing power of the oil matrix

FR_{\max} = maximum flocculation ratio (at $1/X=0$)

Blending Model Parameters

$$I_N = \frac{TE}{(1 - V_H/25d)}$$

$$S_{BN} = I_N (1 + V_H/5)$$

TE = toluene equivalent

V_H = maximum n-heptane can be added to 5 ml of oil without precipit.

d = density of oil

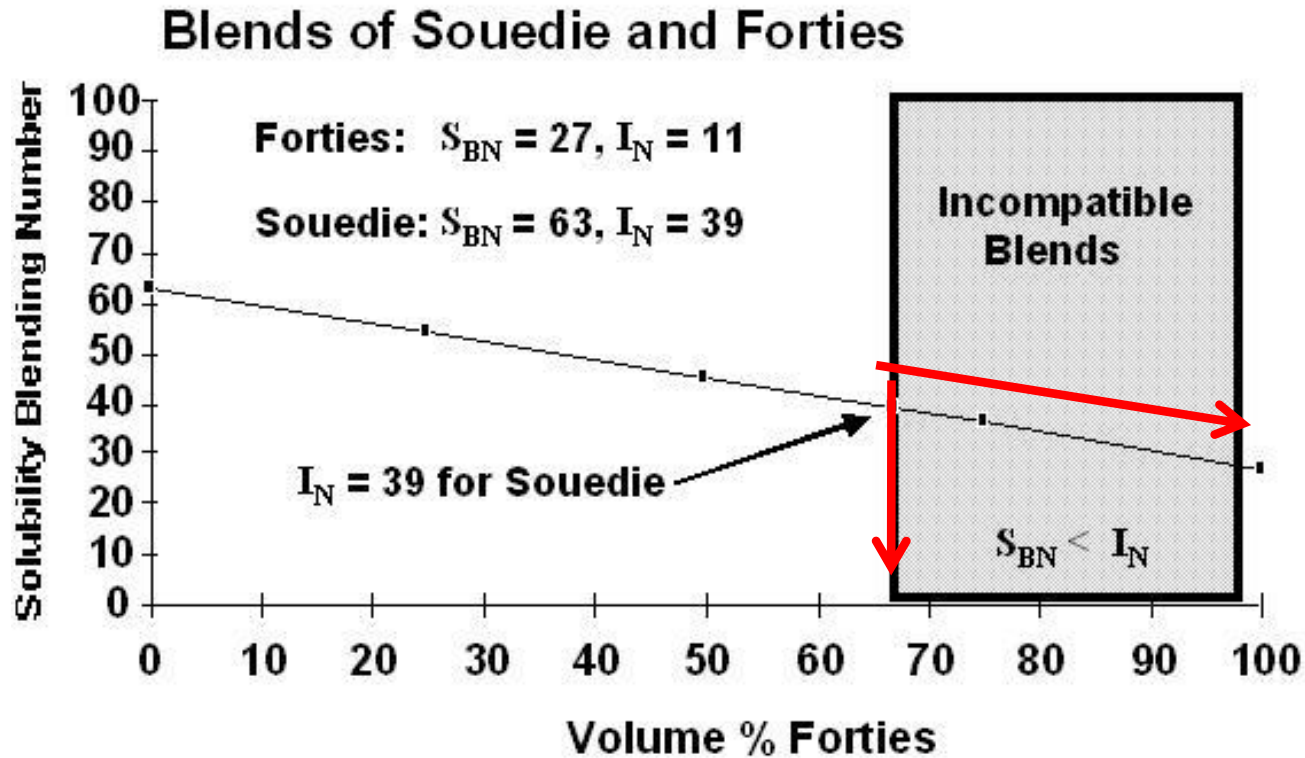
COMPATIBILITY MODEL:

Compatibility criterion

$$S_{BNmix} > I_{Nmax}$$

$$S_{BNmix} = \frac{V_1 S_{NB1} + V_2 S_{BN2} + \dots}{V_1 + V_2 + \dots}$$

Compatibility Area



Blends are compatible when the volumetric average solubility blending number is greater than the insolubility number of any component of the blend



PORLA PROCEDURE

- Select method
- Prepare stock solution from oil and aromatic solvent
- Weigh stock solution to three sample cups
- Load sample cups to carroussel of analyzer
- Type sample data to operating screen
- Start measurement
- Store and print results



PORLA METHOD

- **Detector system:** based on reflection of visible light
- **Limit of the method:** depends on sample, users have reported direct analysis of oils down to 0.05-0.1% asphaltenes, special analytical procedure for asphaltene-free oils,
- **Sensitivity of method for suspended coke particles:** principle and wavelength of detector (reflection of light) make it asphaltene sensitive with minor disturbance of coke particles
- **Potential improvement of fidelity data:** operation is based on continuous development, new solutions realized with steps (generations of analyzers)
- **Duration of measurement:** full procedure 3 titrations 60-90 min, sample preparation few min.
- **Automatic aspects of measurement:** fully automatic and guided procedure, sample prep few min
- **Advancements in the optical detection system:** minor interferences due to coke or other particles. No detector change for different samples.

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PORLA METHOD AND MARKET

- **Correlation between parameters of PORLA and other method:** different methods applying different solvent combinations give different results
- **Routine or research analyzer:** Porla has been used both for routine laboratory analyses and research purposes
- **Reliability of Porla (does it require frequent calibrations and maintenance):** automated calibration procedure of solvent pumps is carried out by balance, is simple and takes few minutes, pumps are very stable and durable, minor maintenance actions
- **Availability of Porla analyzer:** FMS Ltd is manufacturer, distribution by local representatives or directly by FMS
- **Overview of customers/users of the equipment over the world:** operation of FMS has focused so far mainly to Scandinavia, Europe, Russia and Asia; - Worth mention: half of the biggest oil companies of the world are business partners of FMS and have acquired Porla analyze

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BUSINESS PARTNERS OF FMS LTD



National Centre for Upgrading Technology

'a Canada-Alberta alliance for bitumen and heavy oil research'



Kirishinefteorgsintez



Kuwait Institute for Scientific Research

On One Screen....

Operator jwa

mix amount g place paraffin ml Aromat ml Oil g

Samplename Oil2_a2 Testrun 15.0 4 10 10.0

Total oil g 40.0 o/a 1/2 7.5 1 11.8 5.0

Total arom g 20.2 o/a 1/1 11.0 2 8.5 7.3

Oil Dens g/ml 1 o/a 2/1 15.0 3 5.8 10.0

D g/cm³ Xylene 0.863 Low floc.rate

Intensity: 10.00 Ready 0sec Start Normal oper.

Paraffin ml Parameters

	FR	1/X	paraffin ml	Time
1/2	0.325	0.140	24.0	10:31
1/1	0.271	0.234	22.8	11:12
2/1	0.204	0.348	22.8	11:51

FR max 0.41 Pa 0.59

Xmin 1.43 Po 0.99

Slope -0.58 r² 1.000

Store FR5/1 0.29 IN 40.7

Print P-val 2.43 SBN 99.0

21.8.02 9:54 EXIT

FR=f(1/X)

1/X	FR
0.140	0.325
0.234	0.271
0.348	0.204

1 Sample

(Few minutes preparation)

10 parameters

All in one run

In 60-90 minutes

PARAMETERS AND PUMP CALIBRATION MENU

Parameters
✕

Mixing time (s)	20	Cup capacity (ml)	70
Circulation time (s)	20	Test Run Int. Limit	6
Suction line empty time (s)	25	Detection Sensitivity	0.005
Aromat dose time (s)	45	Aromat evaporate rate (g/h)	0.9
Cleanse time (s)	45	Step wait time (s)	70
Cleanse cycles	3	Paraffin step size (ml)	0.7
Paraffin pump rate (ml/s)	0.061		
Aromat pump rate (g/s)	0.109		
Exhaust pump rate (g/s)	0.4		

Pump calibration

Paraffin pump ▾

Paraffin D g/cm³

Heptane ▾ 0.694



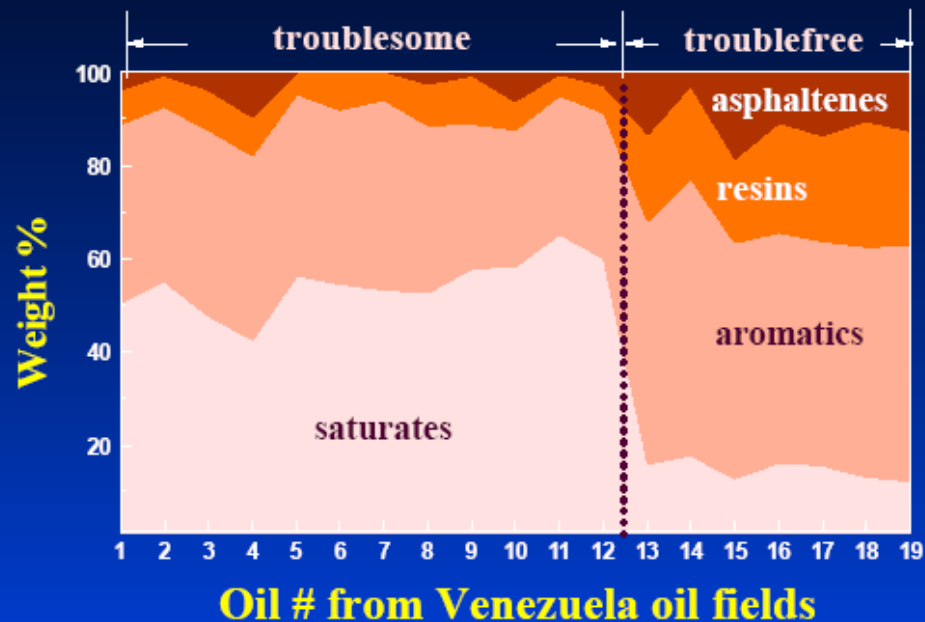
Repetitive analyses of Visbreaker residues obtained at different process temperatures

Repetitive analysis	P-val (450°C)	P-val (435°C)	P-val (420°C)	P-val Feedst
Run 1	1.24	1.92	2.48	5.50
Run 2	1.32	1.98	2.45	5.14
Run 3	1.27	1.98	2.40	4.92
Run 4	1.29	1.98	2.49	5.02
Run 5	1.22	1.98	2.53	4.92
Run 6	1.27	1.98	2.47	4.92
Average	1.27	1.97	2.47	5.07
s	0.035	0.024	0.041	0.23
r	0.028	0.019	0.033	0.18

STABILITY AND COMPATIBILITY ANALYSES OF ATHABASCA CRUDE/BITUMEN

QC	P-Value	IN	SBN
1	3.66	28.1	102.1
2	3.61	26.9	96.4
3	3.80	26.3	99.3
4	3.79	26.1	98.2
5	3.89	26.9	103.6
6	3.67	25.2	91.8
7	3.85	25.3	96.7
8	3.86	24.7	94.7
9	3.64	25.9	93.5
10	3.81	25.3	95.6
Average	3.76	26.1	97.2
s	0.10	1.0	3.7
r	0.06	0.6	2.3

High asphaltene content is not necessary to associate with high risk of trouble



Carbognani, L. and Espidel, J.: "Characterization of Solid Deposits from Production Facilities. Identification of Possible Causes of Deposits Formation," *Vision Technologica*, Vol. 3, No. 1, 35-42.



Evaluation of compatibility risks of opportunity crudes of oil refineries in Europe for crude assay using blending model parameters

Crude oil	P-value	I_N	S_{BN}
Crude 1			31,7
Crude 2	2,6	50,4	75,8
Crude 3A	-	-	11,9
Crude 3B	-	-	38,9
Crude 4	1,9	39,8	71,8
Crude 5	-	-	44,6
Crude 6	2,4	30,2	67,5
Crude 7	4,1	23,8	97,1
Crude 8	3,0	23,0	63,0

Blending Crude 2 with Crudes 1, 3A, 3B and 5 can be a risk

Blending Crude 4 with Crude 1, 3A and 3B can be a risk

Blending Crude 3A with any asphaltene containing 2, 4, 6, 7 and 8 can be a risk

Variations of stability and compatibility parameters of different cargos of same brand crudes

Crude oil	P-value	I_N	S_{BN}
Bashra	2,6	34,2	89,1
Bashra 2	2,4	30,5	72,0
CPC	-	-	11,9
CPC 2	-	-	38,9
Iran Heavy	2,2	36,9	81,1
Iran Heavy 2	2,3	32,9	74,3
Iran Light	2,3	23,5	54,6
Iran Light 2	4,1	23,8	97,1
REB	3,7	24,3	81,4
REB 2	3,0	23,0	63,0



Conclusions



- **Porla is used by prominent oil and service companies**
- **Easy check for potential compatibility issues**
- **Usable for crude, residue, heavy and light fuel oils and bitumen**
- **High automation level and self diagnostic**
- **Easy use with less work power**
- **Porla is a powerful tool to optimize feedstocks and processes of oil industry**
- **Opportunity crudes will be a fast growing new application area**

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Thank you for your interest!

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