Analysis Report

Date:	Ref. no:	Pages:
19.11.2008	08-21693	1 (2)

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Oil Analysis

Appendices: 7

Reason

On assignment from IPCO Power, FRAS Technology performed microscope analysis of particles in oil.

Method of analysis

Each sample was prepared by applying a drop of oil between two glass plates. The samples were then inspected by an Olympus BX60 microscope using transmitted light and a 1000x magnification objective. To investigate cat-fines in particular, Scanning Electron Microscopy (SEM) was employed.

3 mL of each sample was diluted in 80 mL petroleum distillate. 2 mL of this solution was filtered through a 0.8 µm membrane filter. 30 mL was filtered first through a 5.0 µm and then a 0.8 µm filter. All three filters for each sample were inspected by a Zeiss Evo 50 scanning electron microscope equipped with x-ray spectroscopy for element identification.

Samples

The following 2 samples were analyzed:

Sample number	Sample date	Machine, Equipment	Sample point
4944	23.09.08	SCH BR 230908	Directly before Reducer
4945	23.09.08	SCH AR 230908	Directly after Reducer

Date of analysis

Week 43-46, 2008

FRAS technology

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Results

Light microscope:

Both samples appear to contain the same types and quantities of particles. Some flaky particles that were black in appearance (i.e. they are solid) were observed. These particles have a feret max (max diameter) of 5-10 µm. Several transparent particles, which appear to have been embedded with smaller solid particles were also observed. There were also several very small solid particles (feret max of < 1µm), and spherical structures, that are most likely air bubbles, that were observed.

Scanning electron microscope:

A few spherical shaped structures containing Al + Si (cat fines) were found in both samples. It does not appear that the composition or the structures of the cat-fines of the two samples are different.

Summary

Based on our findings using the optical microscope, both samples contain the same particle structures. To inspect the shape and surface structure of such small particles, optical microscopes are not suitable. To investigate the presence and structure of cat fines in particular, Scanning Electron Microscopy was used. By detecting secondary electrons from the specimens, spherical shaped particles composed of Al+Si (i.e. cat-fines) were found in both samples. There is not any difference in the cat-fines between the two samples taken before and after the Reducer.

Performed by
Tormod Lundberg

FRAS technology

Verified by
Sølve Fjerdingstad

Attachments: The findings in this document has been reviewed and approved John Olav Nøkleby, Senior Principal Engineer in Det norske Veritas (DnV) and Board Member of FRAS Technology. Please see enclosed letter.

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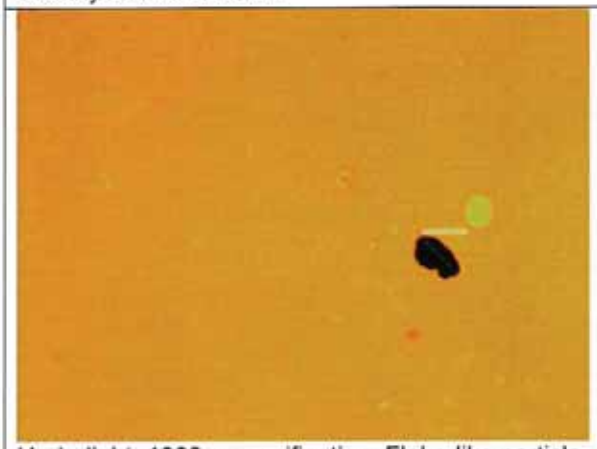
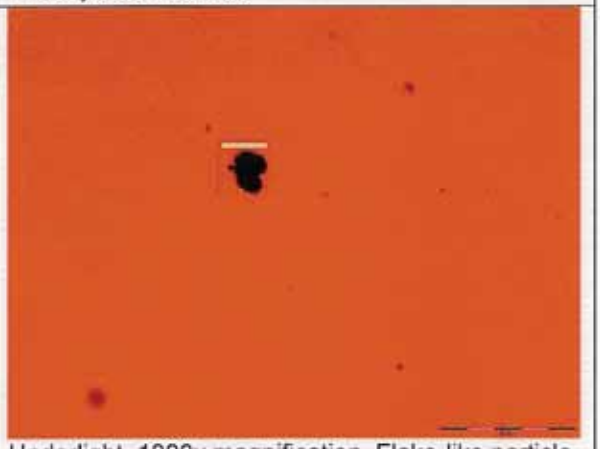
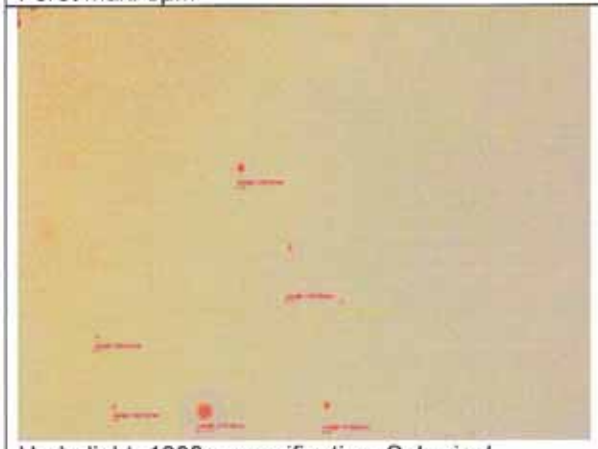
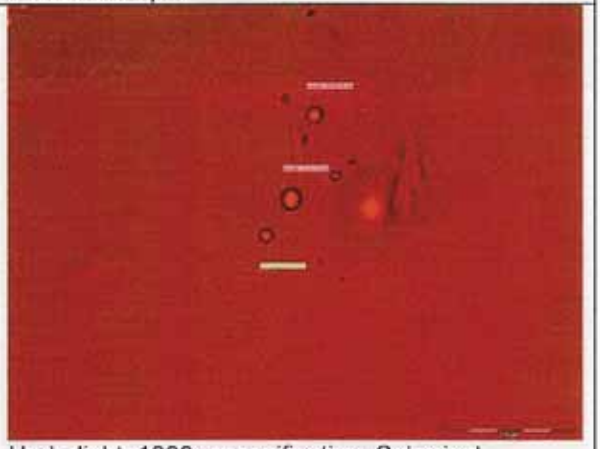
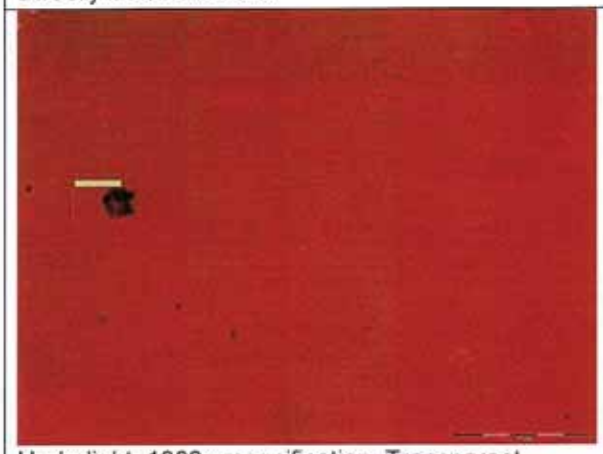
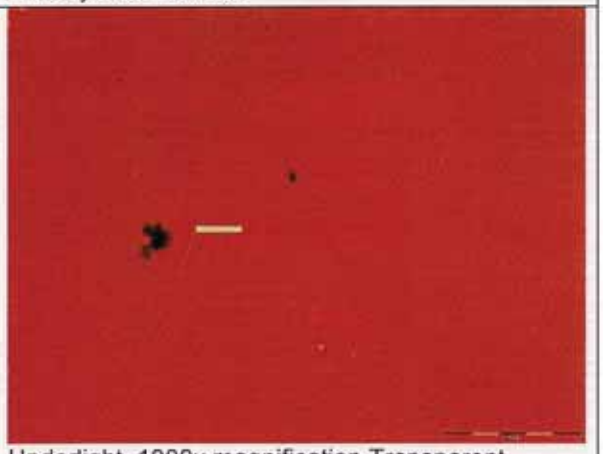
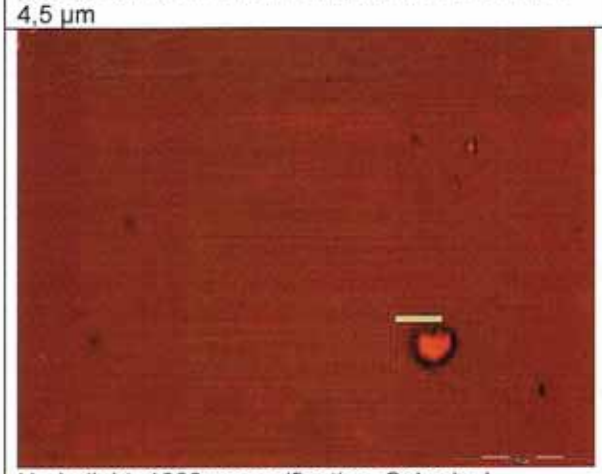
Appendix 1

Date: 28.10.2008 *Ref. no:* 08-21693

4944 - SCH BR 230908	4945 - SCH AR 230908
Directly before Reducer	Directly after Reducer
	
Underlight, 1000x magnification. Flake-like particle. Feret max: 8µm	Underlight, 1000x magnification. Flake-like particle. Feret max: 7µm
	
Underlight, 1000x magnification. Spherical structures. Indicates cat-fines, and this was confirmed with SEM. Diameter: 1-3 µm	Underlight, 1000x magnification. Spherical structures. Indicates cat-fines, and this was confirmed with SEM. Diameter: 1-3 µm

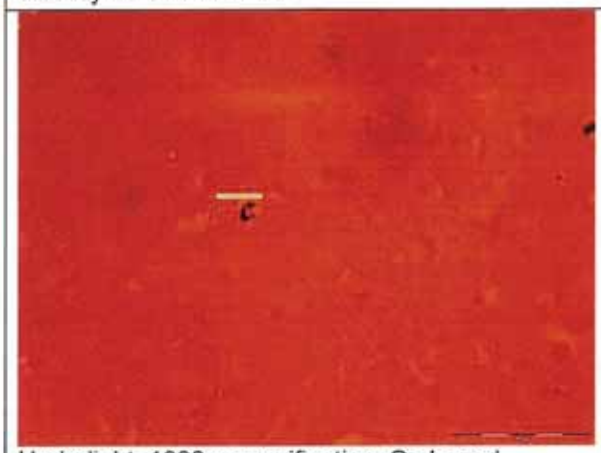
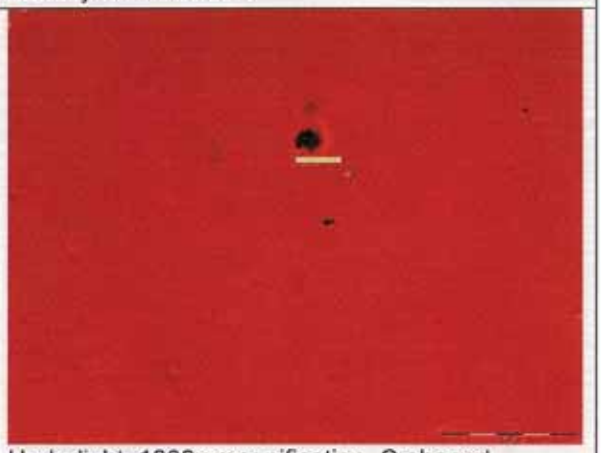
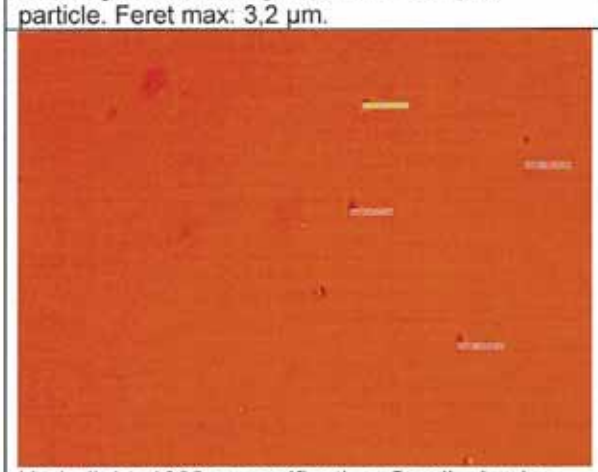
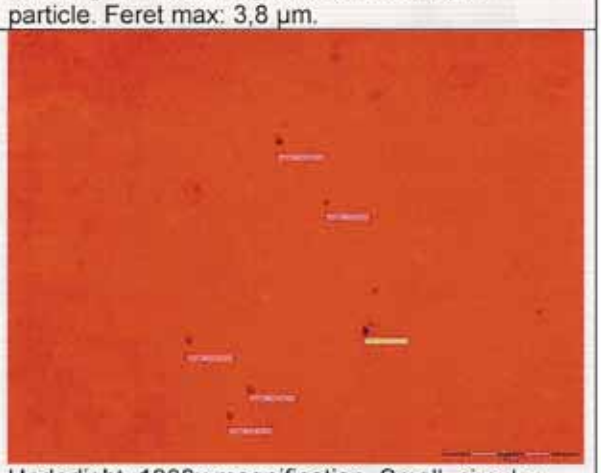
Appendix 2

Date: 28.10.2008 *Ref. no:* 08-21693

4944 - SCH BR 230908	4945 - SCH AR 230908
Directly before Reducer	Directly after Reducer
	
Underlight, 1000x magnification. Transparent particle embedded with solid particles. Feret max: 4,5 µm	Underlight, 1000x magnification.Transparent particle embedded with solid particles. Feret max: 6 µm
	
Underlight, 1000x magnification. Spherical, transparent particle with rough surface. Diameter: 6 µm	Underlight, 1000x magnification.Spherical, transparent particle with rough surface. Diameter: 5,1 µm

Appendix 3

Date:	Ref. no:
28.10.2008	08-21693

4944 - SCH BR 230908	4945 - SCH AR 230908
Directly before Reducer	Directly after Reducer
	
Underlight, 1000x magnification. C-shaped particle. Feret max: 3,2 µm.	Underlight, 1000x magnification. C-shaped particle. Feret max: 3,8 µm.
	
Underlight, 1000x magnification. Small, circular, solid particles. Diameter ≤ 1 µm.	Underlight, 1000x magnification. Small, circular, solid particles. Diameter ≤ 1 µm.

Appendix 4

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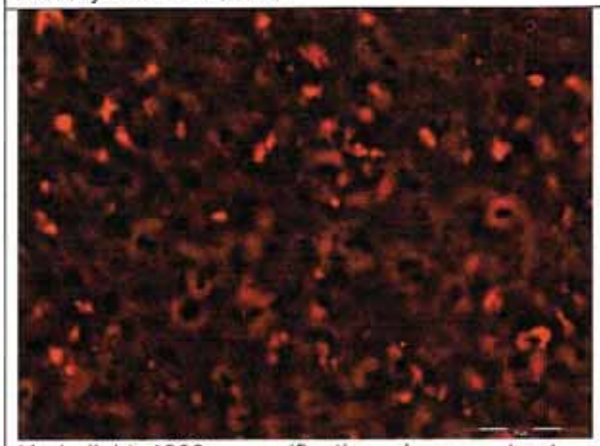
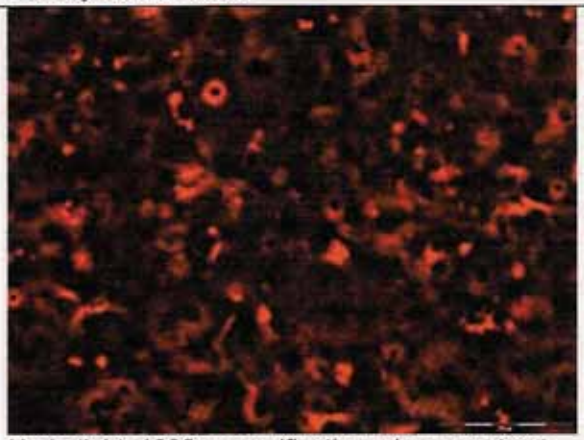
4944 - SCH BR 230908	4945 - SCH AR 230908
Directly before Reducer	Directly after Reducer
	
Underlight, 1000x magnification, phase contrast. Similar structures as for sample 4945	Underlight, 1000x magnification, phase contrast. Similar structures as for sample 4944.

Appendix 5

Date:	Ref. no:
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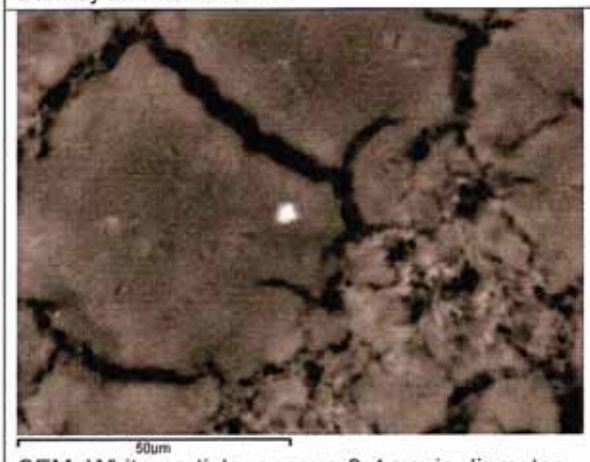
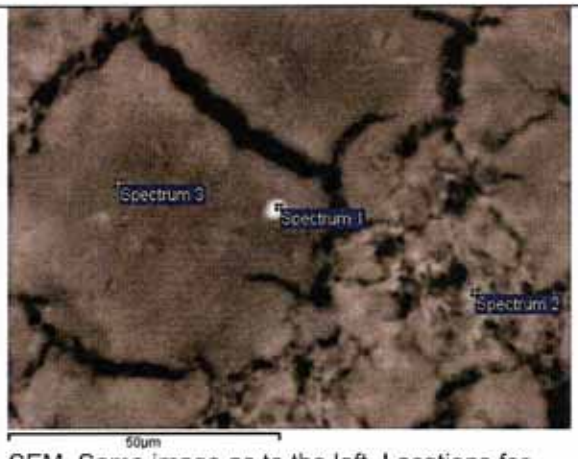
4944 - SCH BR 230908

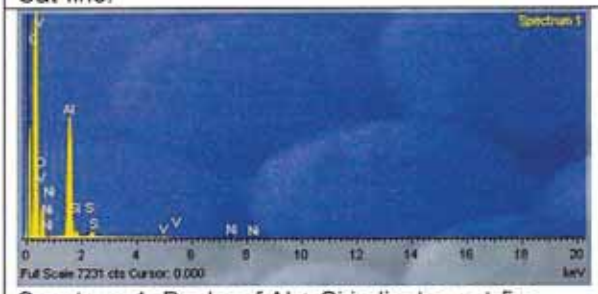
Directly before Reducer



SEM. White particle, approx. 3-4 µm in diameter. Cat-fine.



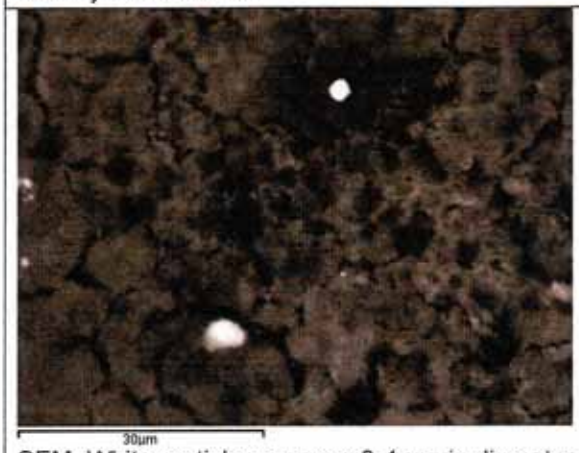
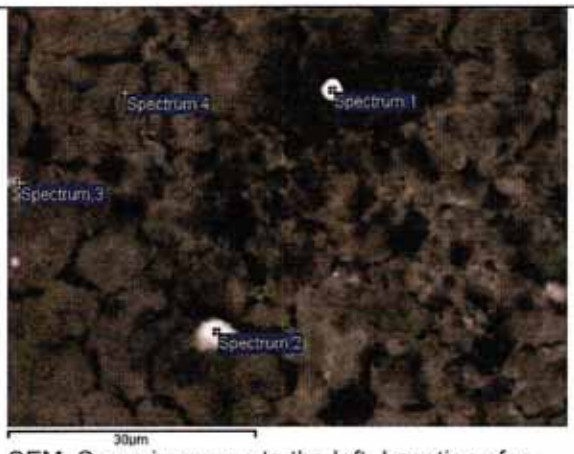
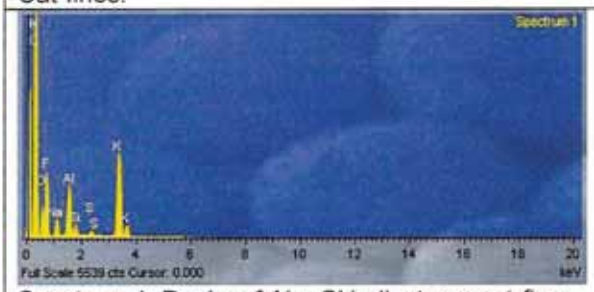
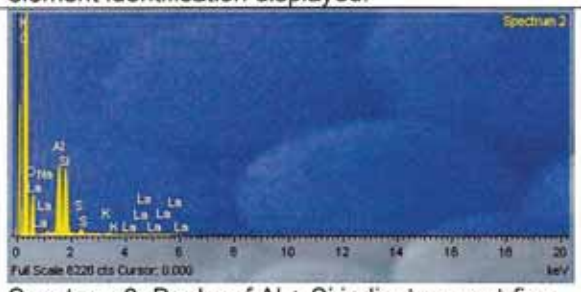
SEM. Same image as to the left. Locations for element identification displayed.



Spectrum 1. Peaks of Al + Si indicates cat-fine.

Appendix 6

Date: 28.10.2008 *Ref. no:* 08-21693

4945 - SCH AR 230908	
Directly after Reducer	
	
SEM. White particles, approx. 3-4 µm in diameter. Cat-fines.	SEM. Same image as to the left. Locations for element identification displayed.
	
Spectrum 1. Peaks of Al + Si indicates a cat-fine.	Spectrum 2. Peaks of Al + Si indicates a cat-fine.

Appendix 7

Date:	Ref. no:
28.10.2008	08-21693

Oil Samples on Arrival:

4944 - SCH BR 230908
Directly before Reducer

4945 - SCH AR 230908
Directly after Reducer

Ås, 18.11.2008

TO WHOM IT MAY CONCERN

I have reviewed FRAS report, ref.no.08-21693. It is evidenced in the report that spherical, solid particles with diameter 3-4 microns, and with main constituents Al and Si, have been found present in the oil sample. Most likely the particles are oxides of Al and Si respectively. If so, they are very hard and abrasive particles that could be harmful for sensitive components of the piping system through which the oil flows.

The exact origin of the particles cannot be concluded from the analyses. Al and Si oxides are found in sand including sand blasting agents, in grinding tools and other places. It is, however, also known that oil refineries use particles of Al and Si as "catalytic fines", particles used to enhance the refinery process. "Catalytic fines" are supposed to remain within the refinery, but it is known that they is some cases accidentally have been delivered with certain oil products. The appearance, shape, size, and chemistry of the particles shown in the report, are all consistent with the hypothesis that they originate from a refinery's "catalytic fines".

Best regards,

FRAS technology

John Olav Nøkleby
Senior Principal Engineer, Det norske Veritas
Board Member, FRAS Technology