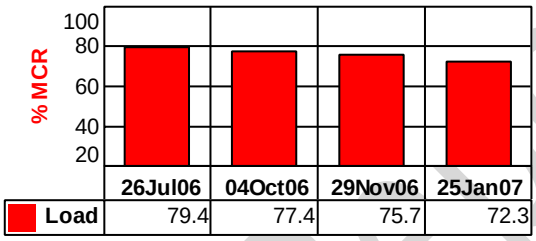
Cylinder Oil Drain Analysis & Engine Performance Report

Samples Landed	: SINGAPORE - 26 Jan 07
Received at Analysis Labs	: 29 Jan 07
Engine	:SAMSUNG MAN B&W 12K90MC
MCR	: 74,640 bhp @ 94 rpm
Next Samples Due	: 33,700 Engine Hours (approx.)

Conditions at time of Sampling

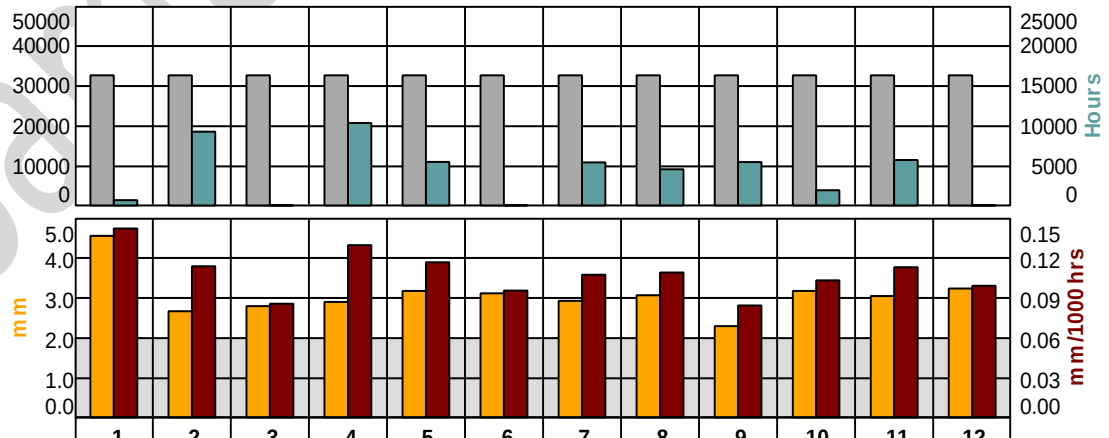
Total Engine Running Hours	: 32,670 hours
Engine rpm at time of sampling	: 90.6 rpm
Cylinder Oil Consumption	: 30.5 Litres/hr
Sulphur % content of fuel	: 2.6% (Before Engine)
Vanadium content of fuel	: 87 ppm
Atmospheric Humidity / Temperature	: 93% / 26°C



Red - Higher Blue - Lower	Sample Submission Form	Flame Marine Calculation
Power (bhp)	54,090	53,975
% MCR	64.0	72.3
Feed Rate (g/BHPh)	0.51	0.51

- Source of power reported in Sample Submission Form is not indicated.
  Effective Power from Diesel Analyser is used in Flame Marine calculation.

Running Hours and Wear Rates



	1	2	3	4	5	6	7	8	9	10	11	12
Liner Total Hours	32670	32670	32670	32670	32670	32670	32670	32670	32670	32670	32670	32670
Hours Since Last O/h	784	9304	148	10392	5540	148	5488	4643	5533	2010	5792	148
Liner Max Wear	4.55	2.67	2.8	2.9	3.18	3.12	2.93	3.07	2.3	3.18	3.05	3.24
Wear Rate Since New	0.1427	0.1143	0.0861	0.1302	0.1172	0.0959	0.1078	0.1095	0.0848	0.1037	0.1135	0.0996

- The wear rate since new at last overhaul is high for Units 1, 2, 4, 5, 7, 8, 10 and 11
- Liner maximum wear of unit 1, 5, 6, 8, 10, 11 and 12 is high.

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Findings & Recommendations

Power and Performance Condition

- **Power by Diesel Analyser indicates that engine load is lower than 29th Nov 2006 report.**
- **Measured Averages compared to indication in the Engine Shop Test Performance Curve for the load of 72.3% MCR show:**
  - **True load is close to 72.3% MCR** - indicated by low variance in Engine rpm, Fuel Rack, Turbo-charger rpm and Pscav.
  - **Torque is high** - indicated by higher Fuel Rack relative to Engine speed.
  - **Combustion may be late** - indicated by lower Pmax-Ptdc.
- **Power balance is disrupted by high deviation in MIP for Units 1, 6 and 12.**
- **Rate of pressure change line (dp/da) is not displayed to check if positioning of the TDC line is correct on the indicator diagrams.**

  Please ensure that TDC line is correctly adjusted after recording performance and provide diagrams with the dp/da line displayed.

Fuel Oil

- **Fuel corresponding to RMG380 was delivered on 17 Jan 07 at Singapore.**

  Cat-fines, although well within specification, are high enough to cause abrasion in the engine. Care should be taken to ensure efficient clarification of the fuel.
- **Fuel Oil Temperature at 129°C before Main Engine is within recommended range for current 296cst fuel oil in use.**

  We suggest that fuel temperature at inlet to the fuel pump be maintained at higher end of the recommended range in DnVPS bunker analysis report, to allow for heat loss between measuring point and inlet to main engine injection pumps.

Combustion

- **Unstable combustion is indicated by:**
  - Fuel contamination in all Units.
  - Burning of cylinder lubricant in Units 6, 7, 8, 10 and 11.
  - Incomplete combustion in Units 3 and 6 to 11.
  - Signs of late combustion in Units 1, 3 and 6 to 11.
  - High Soot in Units 3 and 6 to 11.

We recommend to check injectors of Units 3, 6, 8, 10 and 11.

Wear

- **Influence of combustion on wear**
  - Combustion conditions are influencing wear in Units 1, 3 and 6.
- **Skirt Abrasion**
  - Skirt abrasion is influencing wear in Units 1 and 7.
  - Skirt abrasion is influencing wear in Units 3 and 6 which should reduce as running-in is completed.
  - Units 8, 10, 11 and 12 are also affected by skirt abrasion.
- **Ring Groove Wear**
  - High Chromium in Units 1, 3, 6 and 7 indicates wear of the piston ring groove coating.
- **Cat-fines** are causing abrasive wear in Units 1, 3, 6 and 7.

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Findings & Recommendations

- **Wear is lower in most units than previous report.**

  Wear in Unit 6 is higher than normal but should reduce as running-in is completed. All other units are within limits of normal wear.

  We recommend to inspect pistons of Units 1 and 6

Water

- **High Water in all Units poses risk of emulsification and disruption of cylinder lubricant.**

  There are signs that high Water in Units 3 and 6 may be causing emulsification/ increase of viscosity, and contributing to wear.

  There are signs that high Water in Unit 11 is causing emulsification/ increase in Viscosity but water does not appear to be having any influence on Wear.

  As a precaution, we recommend that the Air Cooler and Water Separator serving Units 3 and 6 are inspected and drains checked for obstructions in order to eliminate water ingress.

  Sampling Procedure should be followed carefully as incorrect sampling can cause high Water in the CDO samples. It is important that a correct reading for water is obtained as it is the indicator for unusual Water ingress into the combustion space.

  Note that the first liquid from the Sampling Cock should be run off to waste as water may accumulate in the line prior to commencement of sampling.

System Oil Contamination

- System oil reserve is adequate to maintain satisfactory lubrication and crankcase cleanliness. The amount of contamination by cylinder drain oil is within acceptable limits.

Feed Adjustment

- **HMI Setting:** 65%

  The directly calculated feed rate is within the recommended range for fuel Sulphur of 2.64%.

- **Cylinder Drain Oil (CDO) analyses indicate adequate reserve for current Fuel and Engine Load when account is taken of Fuel and System Oil contamination.**

  The cause of combustion instability need to be addressed in order to maintain both piston cleanliness and low wear.

- **We recommend to maintain current feed setting until the next set of samples confirms possibility to reduce.**

Flame Marine

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Cylinder Lubricator Setting & Feed Rate

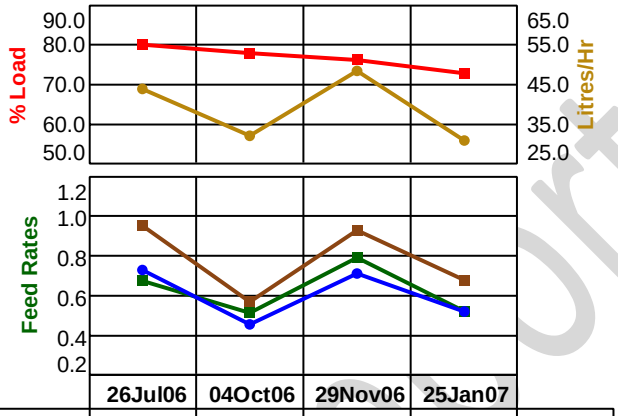
Sulphur Content of Fuel: 2.64%$_{\text{Before Engine}}$
Reported Consumption: 31 Litres/hr $_{@50°C}$
Effective Power: 53,975 bhp = 72.3% MCR

BN of Cylinder Oil In Use: 70
Source: Sample Submission Form
Source: Diesel Analyser

Feed Setting

- **HMI Setting:** 65%

Specific Feed Rate



	26Jul06	04Oct06	29Nov06	25Jan07	
% Load	79.4	77.4	75.7	72.3	% MCR
CLO Consumption	43.41	31.70	47.92	30.50	Litres/hr
Sulphur	3.71	2.21	3.62	2.64	%
HMI Setting	93		93	65	%
HMI @ 0.19 x S%	91	56	88	66	%
HMI @ 0.25 x S%	119	72	116	84	%
Direct Calculated	0.66	0.51	0.78	0.51	g/BHPh
0.19 x S%	0.719	0.447	0.702	0.512	g/BHPh
0.25 x S%	0.941	0.560	0.918	0.669	g/BHPh

- Using effective power of 53,975 bhp, consumption of 30.5 Litres/hr and SG of 0.93 @ 15°C corrected to 0.908 for oil temp of 50°C, feed rate calculates as follows:

$$\text{Specific Feed by direct calculation: } \frac{\text{Litres/hr} \times SG_{@\ 50°C} \times 10^3}{\text{bhp}}$$

Specific Feed = 0.51 g/BHPh

Density correction factor of 0.00064 per °C is used in Flame Marine calculation.

The directly calculated Feed Rate is within the recommended range for fuel Sulphur of 2.64%.

Accuracy of calculated feed rate is subject to reliability of reported Consumption and Effective Power.

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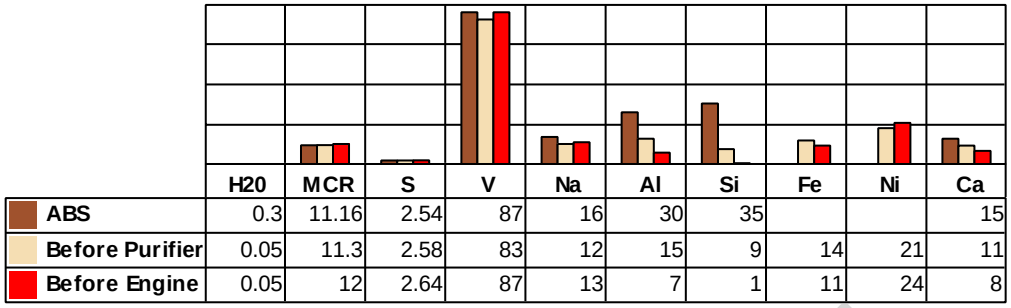
Fuel Oil

Fuel Oil Analysis

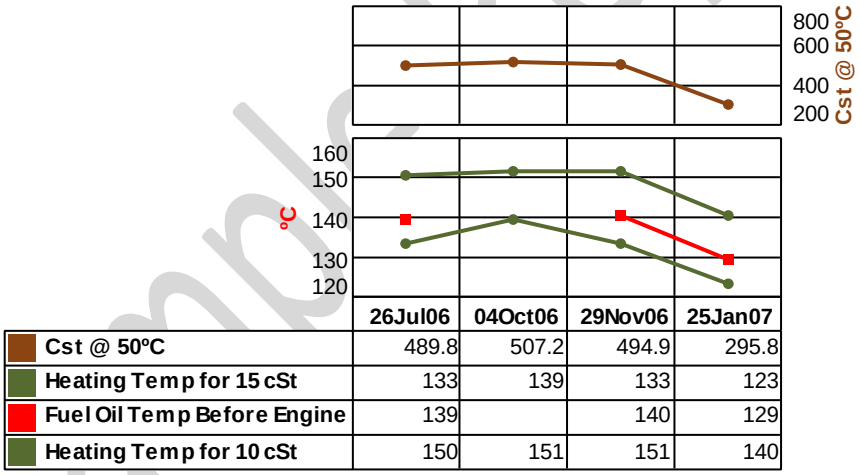
Fuel of 296 cst was delivered at Singapore on 17 Jan 2007.



	H20	MCR	S	V	Na	Al	Si	Fe	Ni	Ca
ABS	0.3	11.16	2.54	87	16	30	35			15
Before Purifier	0.05	11.3	2.58	83	12	15	9	14	21	11
Before Engine	0.05	12	2.64	87	13	7	1	11	24	8

- Water content in ABS Bunker Analysis is satisfactory.
- High Cat-fines pose high risk of abrasion in fuel pumps, injectors and cylinder units. Caution should be exercised in the treatment of the fuel to ensure efficient separation and filtration. .
- High Cat-fines in Before Purifier sample relative to ABS analysis on 17th Jan 2007 indicates poor settling.
- Lower Cat-fine content in Before Engine fuel sample relative to the Before Purifier sample suggests satisfactory clarification.

Fuel Oil Temperature (Inlet to Engine)



	26Jul06	04Oct06	29Nov06	25Jan07
Cst @ 50°C	489.8	507.2	494.9	295.8
Heating Temp for 15 cSt	133	139	133	123
Fuel Oil Temp Before Engine	139		140	129
Heating Temp for 10 cSt	150	151	151	140

- Fuel Oil Temperature at 129°C before Main Engine is within recommended range for current 296cst fuel oil in use.

  We suggest that fuel temperature at inlet to the fuel pump be maintained at higher end of the recommended range in ABS bunker analysis report, to allow for heat loss between measuring point and inlet to main engine injection pumps.

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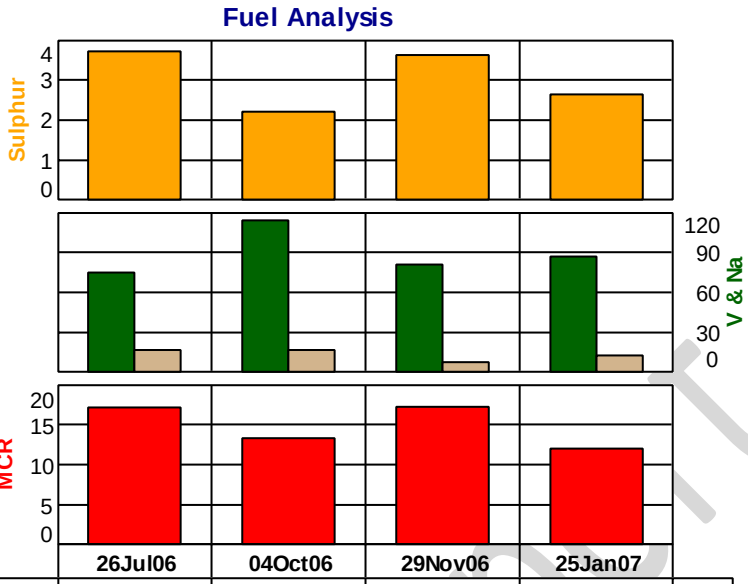
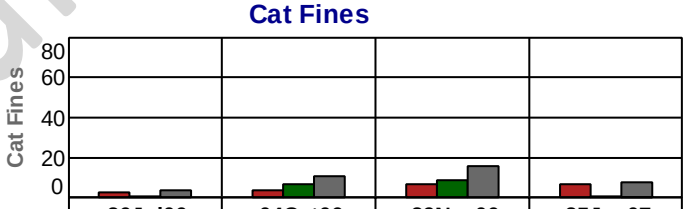
Fuel Oil

Fuel Oil Trends



Samples from	Bunker	Before Engine	Before Engine	Before Engine	
Sulphur	3.71	2.21	3.62	2.64	%
Vanadium	75	114	81	87	ppm
Sodium	17	17	8	13	ppm
MCR	17.11	13.3	17.2	12	%

- **Sulphur** at 2.64% is lower than 29 Nov 2006. Amount of acid condensation is expected to be lesser due to lower Sulphur and reduced Fuel consumption at lower Engine Load.
- **Vanadium** at 87 ppm is similar to 29 Nov 06, posing similar risk of Vanadium deposits in the nozzle rings and on the blades of the turbo-chargers.
- **Sodium** at 13 ppm is low. Sodium:Vanadium ratio is outside the 3:1 danger zone and should not affect the melting point of Vanadium nor increase the risk of Vanadium deposits.
- **MCR** (Micro Carbon Residue) at 12% is normal and should allow complete combustion with low risk of carbon deposits. MCR is a measure of the ability of the fuel to burn completely.



Samples from	Bunker	Before Engine	Before Engine	Before Engine	
Aluminium	3	4	7	7	ppm
Silicon	1	7	9	1	ppm
Cat Fines	4	11	16	8	ppm

- **Cat-fines** (Al + Si) at 8 ppm are low and should not pose any risk of abrasion in the engine.

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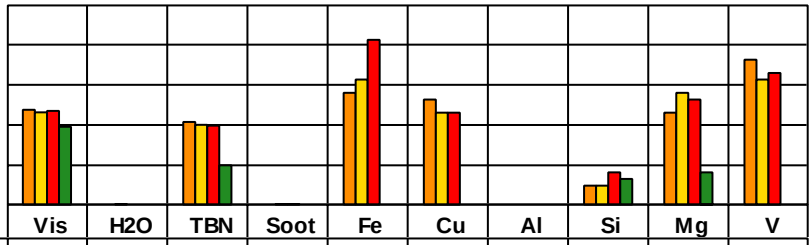
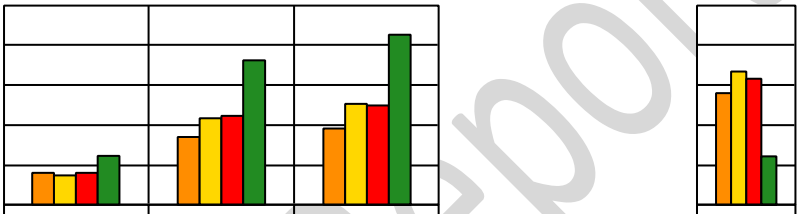
System Oil

- **System oil reserve is adequate to maintain satisfactory lubrication and crankcase cleanliness. The amount of contamination by cylinder drain oil is within acceptable limits.**



	Vis	H2O	TBN	Soot	Fe	Cu	Al	Si	Mg	V
04 Oct 2006	14.46	0.1	12.62	0.1	17	16	0	3	14	22
29 Nov 2006	14.05	0.2	12.17	0.2	19	14	0	3	17	19
25 Jan 2007	14.27	0.1	12.07	0.2	25	14	0	5	16	20
New Crankcase Oil	11.87		6.04	0.1	0	0	0	4	5	0



	Dispersancy	Phosphrous	Zinc
04 Oct 2006	78	120	130
29 Nov 2006	75	142	159
25 Jan 2007	78	145	157
New Crankcase Oil	98	210	240

	Calcium
04 Oct 2006	6660
29 Nov 2006	7940
25 Jan 2007	7520
New Crankcase Oil	2920

- Small increase in Viscosity, TBN, Vanadium and Calcium, relative to New Oil, points to minor contamination by Cylinder Drain Oil.
- Dispersancy is high and adequate to maintain piston cleanliness. Soot is slightly higher than normal.
- Water is within the advised level of 0.2%, and the recommended limit of 0.5%

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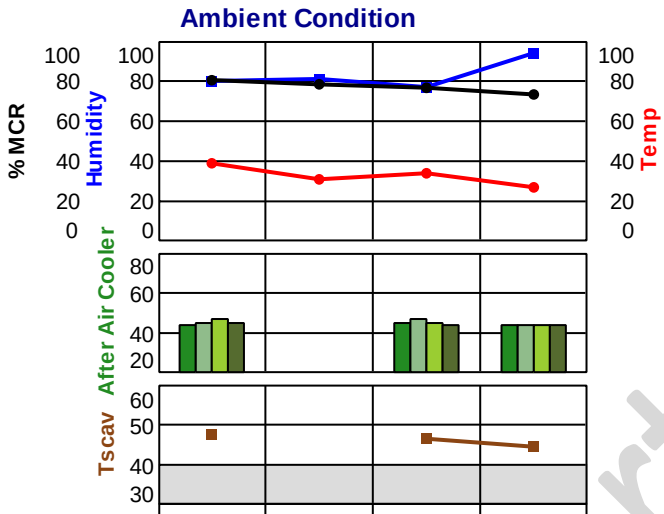
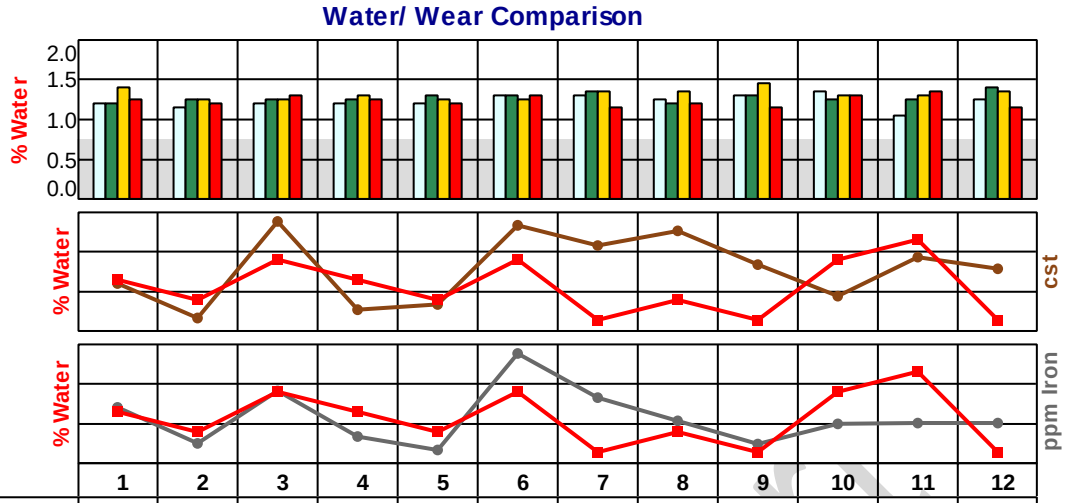
Ambient Condition



	26Jul06	04Oct06	29Nov06	25Jan07	
Humidity	79	80	76	93	%
Temp	38	30	33	26	°C
Load	79.4	77.4	75.7	72.3	% MCR
After Air Cooler (1)	44		45	44	°C
After Air Cooler (2)	45		47	44	°C
After Air Cooler (3)	47		45	44	°C
After Air Cooler (4)	45		44	44	°C
Tscav	47		46	44	°C

- Variations in atmospheric humidity and temperature influence the amount of Water entering the turbo-chargers with the mass of air required for given engine load.
- Current satisfactory scavenge air temperature after air coolers of 44, 44, 44 and 44°C should assist efficiency of water condensation at the air-cooler and amount of water that can be removed from the scavenge air. Eventual amount of water entrained in the scavenge air will depend on efficiency of the water separators and drainage arrangements.

Ambient Condition

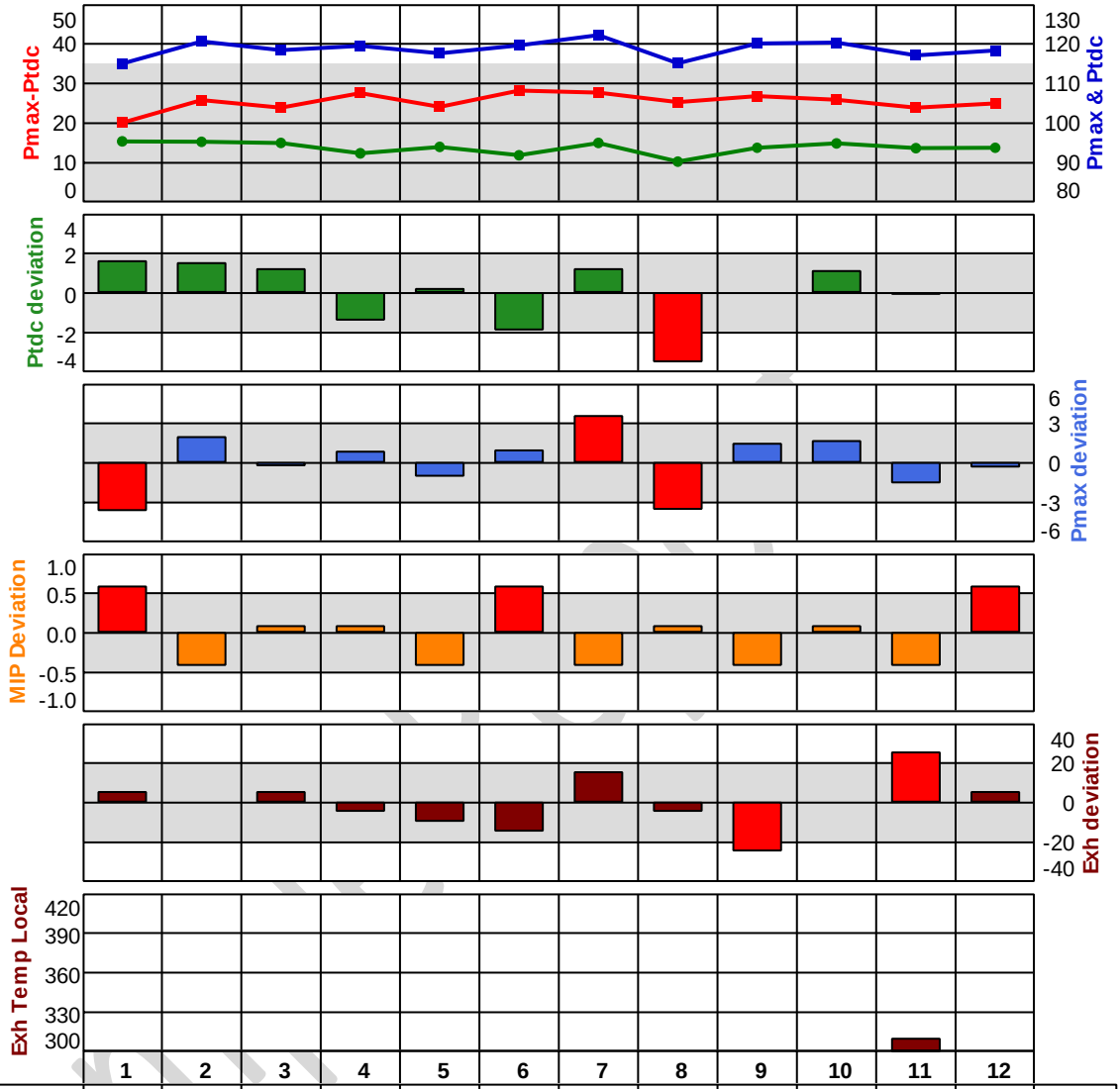


	1	2	3	4	5	6	7	8	9	10	11	12
26 Jul 2006	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.1	1.3
04 Oct 2006	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.2	1.3	1.3	1.3	1.4
29 Nov 2006	1.4	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.5	1.3	1.3	1.4
25 Jan 2007	1.25	1.2	1.3	1.25	1.2	1.3	1.15	1.2	1.15	1.3	1.35	1.15
Viscosity	22.75	21.5	24.99	21.8	21.99	24.85	24.12	24.65	23.43	22.29	23.7	23.28
Iron	116	68	138	77	59	188	129	98	67	94	95	95

- High Water in all Units poses risk of emulsification and disruption of cylinder lubrication.
- Water is diluted by System Oil contamination in Units 10 and 11.
- High Water in Units 3, 6 and 11 appears to be causing emulsification/increase in Viscosity and to be causing wear in Units 3 and 6.

Performance & Combustion

Cylinder Parameters



	1	2	3	4	5	6	7	8	9	10	11	12	
Pmax	114.5	120.1	117.9	119	117.1	119.1	121.7	114.6	119.6	119.8	116.6	117.8	kg/cm²
Ptdc	94.9	94.8	94.5	91.9	93.5	91.4	94.5	89.8	93.3	94.4	93.2	93.3	kg/cm²
Pmax-Ptdc	20	25	23	27	24	28	27	25	26	25	23	25	kg/cm²
MIP	15.5	14.5	15	15	14.5	15.5	14.5	15	14.5	15	14.5	15.5	kg/cm²
Exh Temp Local	290	285	290	280	275	270	300	280	260	285	310	290	°C

- Data from the SEMS Diesel Analyzer indicate:

Ptdc - Deviation from mean is high for Unit 8

Pmax - Deviation from mean of Units 1, 7 and 8 exceeds recommended limits of +/- 3 kg/cm^2.

Pmax-Ptdc - Pressure rise is within B&W recommended safe limit of 35 kg/cm^2.

MIP - Deviation from mean of Units 1, 6 and 12 exceeds recommended limit of +/-0.5 kg/cm^2, disrupting the power balance.

Exh Temp - Deviation from mean of Units 9 and 11 are high.

Performance & Combustion

Comparison with Engine Shop Test Performance Curve

Red - Higher Blue - Lower		Performance Curve (72.3% MCR)	Measured Average	% Variance
Engine speed	rpm	93.2	90.6	2.79
Fuel Rack	mm	101.6	106.5	4.82
Ptdc	Kg/cm²	95.4	93.3	2.20
Pmax	Kg/cm²	126.1	118.2	6.26
Pmax-Ptdc	Kg/cm²	30.7	24.9	18.89
MIP	Kg/cm²	15.5	14.9	3.87
Turbo-Charger	rpm	9,106	9,302	2.15
Pscav	Kg/cm²	-	2.0	-
Exh Temp	ºC	276.5	284.6	2.93

- Measured Averages compared to indication in the Engine Shop Test Performance Curve for the load of 72.3% MCR show:
  - **True load is close to 72.3% MCR** - indicated by low variance in Engine rpm, Fuel Rack, Turbo-charger rpm and Pscav.
  - **Torque is high** - indicated by higher Fuel Rack relative to Engine speed.
  - **Combustion may be late** - indicated by lower Pmax-Ptdc.

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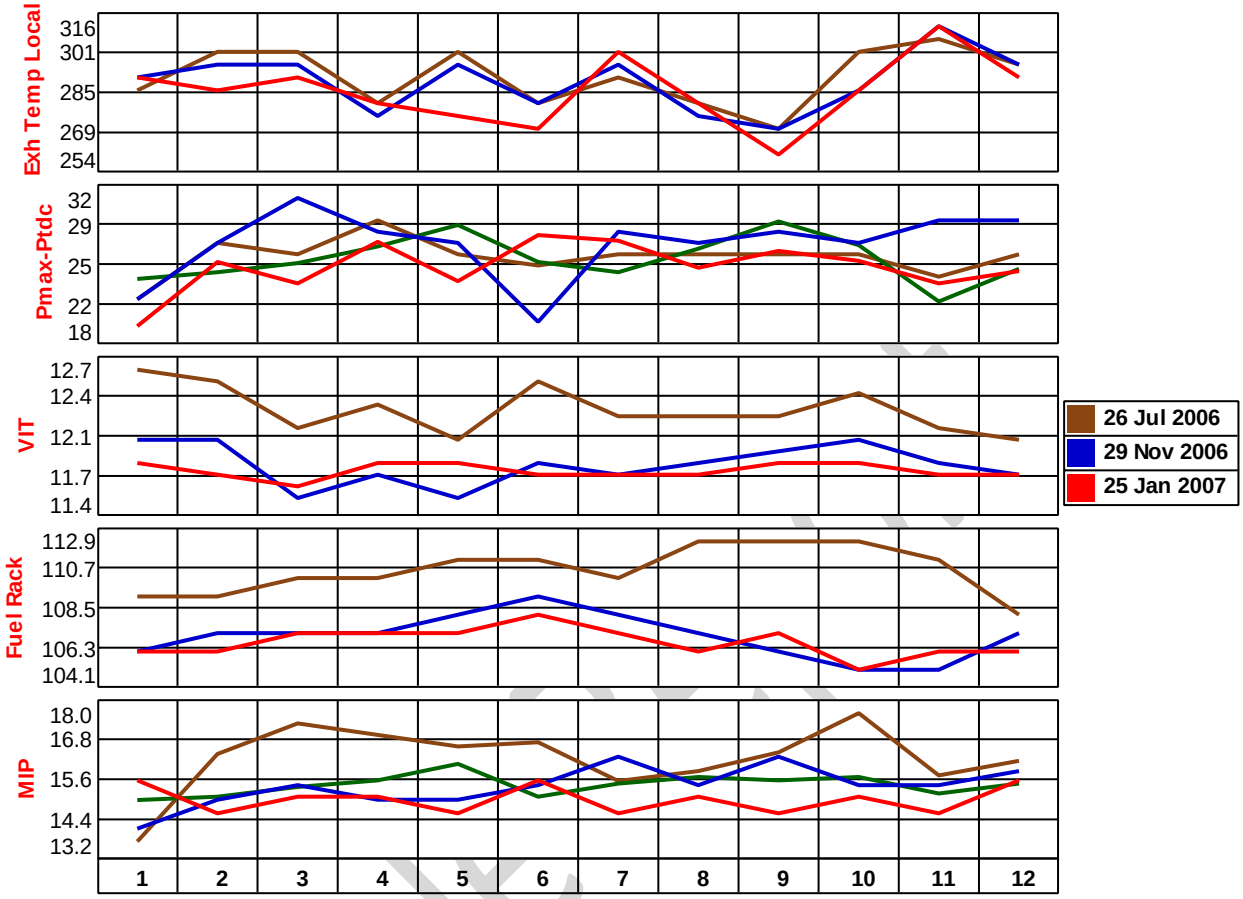
Performance & Combustion

Performance Evaluation



- Higher Exhaust and lower Pmax-Ptdc suggest that combustion is later than 29 Nov 06 report for Units 4, 7 and 8
- Higher Pmax-Ptdc and lower Exhaust in Unit 6 suggest that combustion is earlier than 29 Nov 2006.

Indicator Diagram

- Rate of pressure change line dp/da is not displayed to check if positioning of the TDC line is correct on the indicator diagrams.

  If TDC line is not correctly positioned, Ptdc and MIP will not be reliable and will provide a false indication of the Engine power balance.

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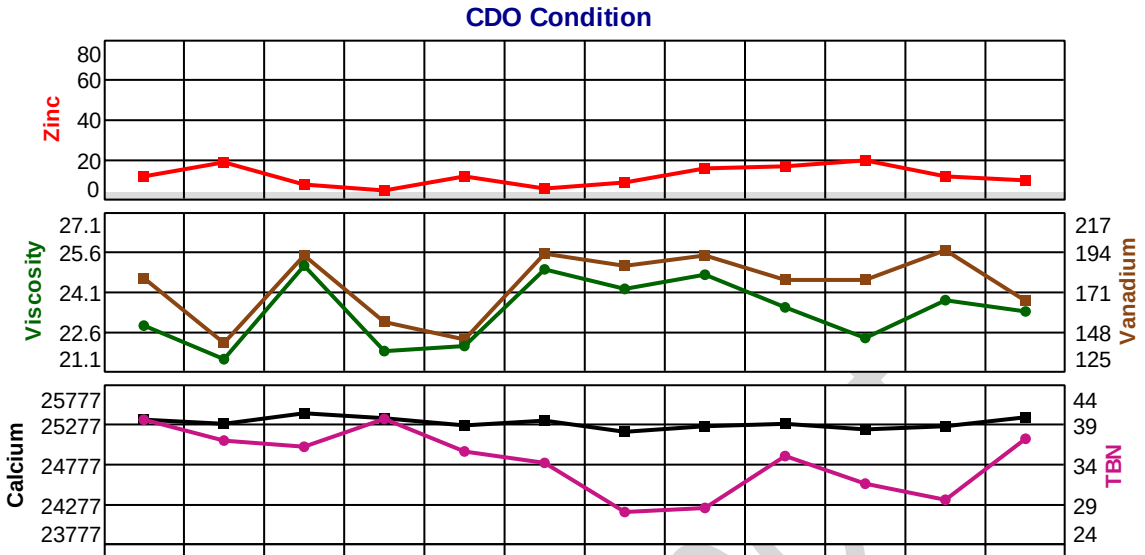
Performance & Combustion

CDO Condition



	1	2	3	4	5	6	7	8	9	10	11	12	
Zinc	11	18	7	4	11	5	8	15	16	19	11	9	ppm
Vanadium	178	141	191	153	143	192	185	191	177	177	194	165	ppm
Viscosity	22.75	21.5	24.99	21.8	21.99	24.85	24.12	24.65	23.43	22.29	23.7	23.28	cst
Calcium	25310	25260	25390	25330	25240	25300	25160	25230	25260	25190	25230	25340	ppm
TBN	39.15	36.56	35.79	39.26	35.21	33.79	27.68	28.19	34.64	31.2	29.21	36.79	mg/KOH

- **Zinc** indicates**:**
  - leakage of system oil into under-piston space of all Units is normal.
- **Vanadium/ Viscosity** indicate:
  - high contamination of CDO by unburned fuel in all Units.
  - contamination of CDO by unburned fuel and system oil in Units 10 and 11.
- **TBN/ Calcium** indicate:
  - dilution of CDO by Fuel and/or System Oil in Units 7, 8, 10 and 11.
  - burning of Cylinder lubricant in Units 6, 7, 8, 10 and 11

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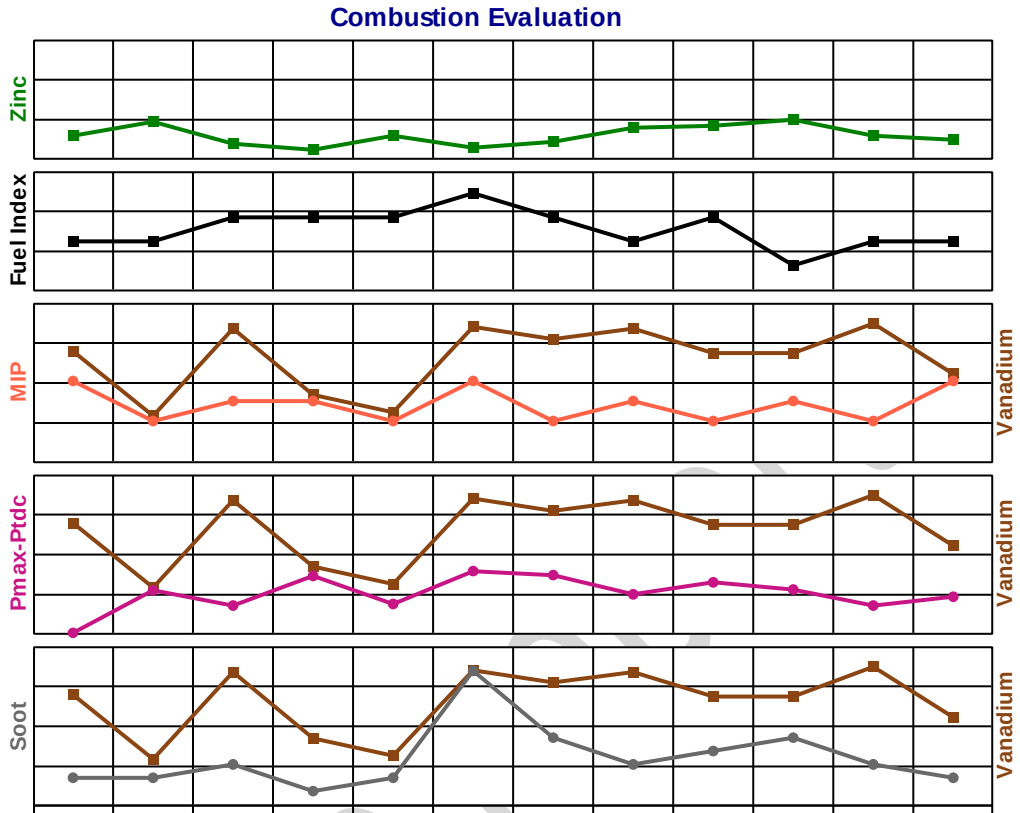
Performance & Combustion

Combustion Evaluation



	1	2	3	4	5	6	7	8	9	10	11	12	
Zinc	11	18	7	4	11	5	8	15	16	19	11	9	ppm
Vanadium	178	141	191	153	143	192	185	191	177	177	194	165	ppm
Fuel Index	106	106	107	107	107	108	107	106	107	105	106	106	mm
MIP	15.5	14.5	15	15	14.5	15.5	14.5	15	14.5	15	14.5	15.5	kg/cm²
Pmax-Ptdc	19.6	25.3	23.4	27.1	23.6	27.7	27.2	24.8	26.3	25.4	23.4	24.5	kg/cm²
Soot	0.4	0.4	0.5	0.3	0.4	1.2	0.7	0.5	0.6	0.7	0.5	0.4	%

- **Engine Performance/ CDO analysis point to:**
  - **Incomplete** combustion in Units 3 and 6 to 11
  - **Late** and/or **Incomplete** combustion in Units 1, 3 and 6 to 11
  - **Possibility of Blow-by** in Units 3 and 6 to 11.

  (when account is taken of variation in dilution by Fuel and System Oil contamination)

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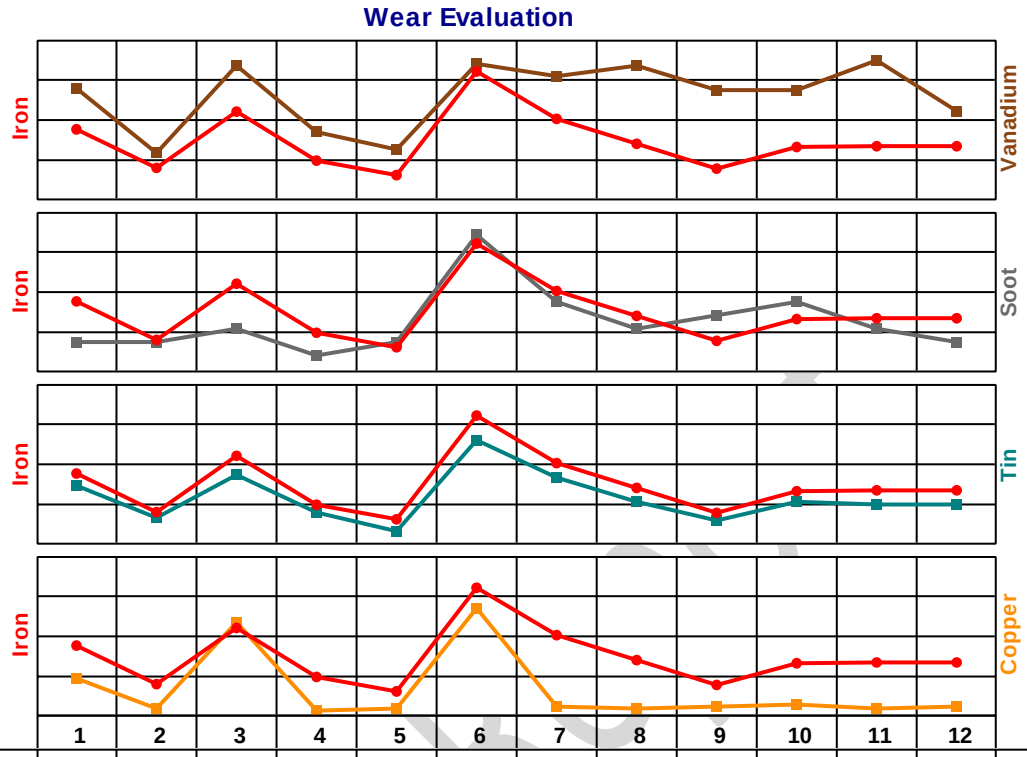
Performance & Combustion

Wear Evaluation



	1	2	3	4	5	6	7	8	9	10	11	12	
Vanadium	178	141	191	153	143	192	185	191	177	177	194	165	ppm
Iron	116	68	138	77	59	188	129	98	67	94	95	95	ppm
Soot	0.4	0.4	0.5	0.3	0.4	1.2	0.7	0.5	0.6	0.7	0.5	0.4	%
Tin	27	15	31	17	10	44	30	21	14	21	20	20	ppm
Copper	18	3	46	2	3	53	4	3	4	5	3	4	ppm

- **Influence of combustion on wear**
  - Combustion conditions are influencing wear in Units 1, 3 and 6.
  - There are no signs that combustion conditions are having any significant influence on wear in Units 2, 4 and 6 to 12.
- **Skirt Abrasion**
  - Units 1, 3, 6, 7, 8, 10, 11 and 12 appear to be affected by abrasion between piston skirt and liner wall.
  - Low Tin and Iron in Units 2, 4, 5 and 9 indicate normal free movement of the pistons, and that abrasion between piston skirt and liner wall is insignificant.

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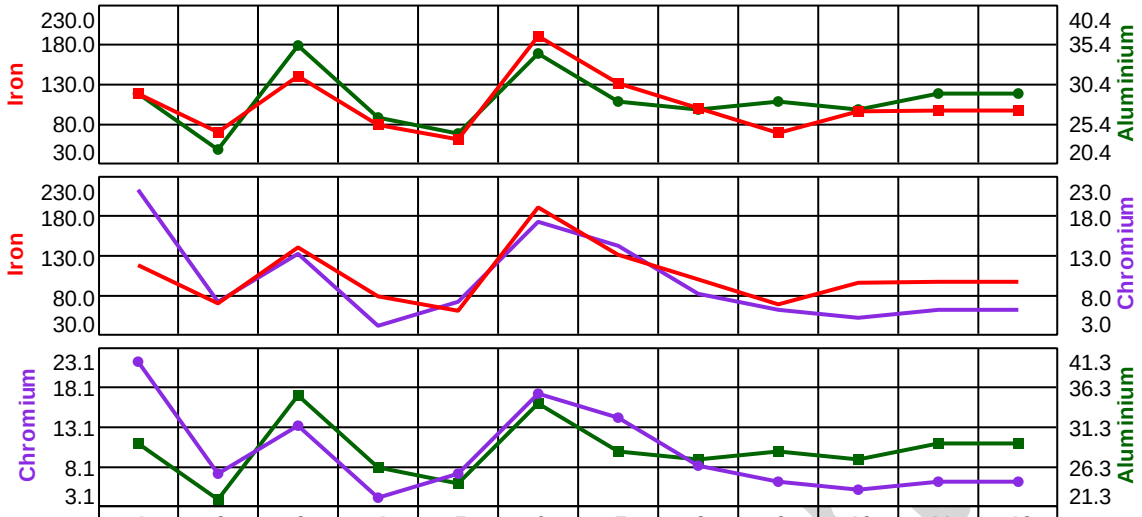
Performance & Combustion



	1	2	3	4	5	6	7	8	9	10	11	12	
Aluminium	29	22	35	26	24	34	28	27	28	27	29	29	ppm
Iron	116	68	138	77	59	188	129	98	67	94	95	95	ppm
Chromium	21	7	13	4	7	17	14	8	6	5	6	6	ppm
Chromium	21	7	13	4	7	17	14	8	6	5	6	6	ppm

- **Influence of Cat-fines on Wear**
  - Cat-fines are influencing wear of the liner, rings and ring grooves in Units 1, 3, 6 and 7 as indicated by correlation of Aluminium, Chromium and Iron.
  - There are no signs that Cat-fines are having any significant influence on Wear in Units 2, 4, 5 and 8 to 12.
- **Ring Groove Wear**
  - High Chromium indicates wear of ring groove in Units 1, 3, 6 and 7.

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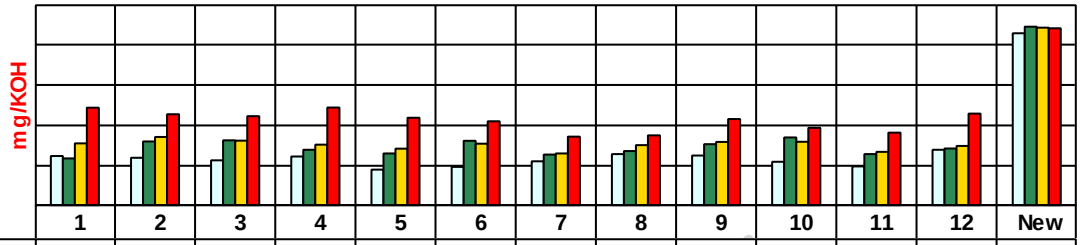
Cylinder Drain Oil Analysis Trends

CDO Contamination & Condition

A sample of Chevron Taro Special HT 70 from Sample Ship dated 25th Jan 2007 is used to compare the change in properties of the Cylinder Drain Oil (CDO).

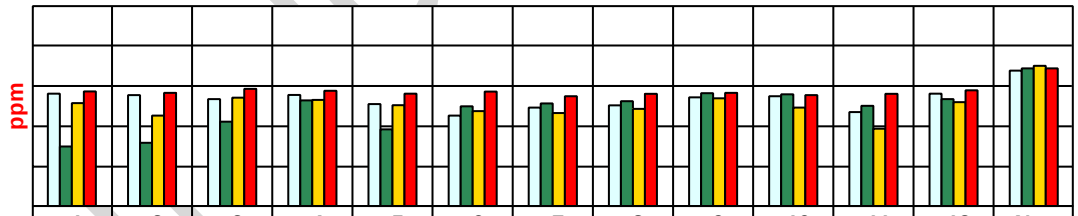
TBN



	1	2	3	4	5	6	7	8	9	10	11	12	New
26 Jul 2006	20	19	18	20	15	16	18	21	20	18	16	22	69
04 Oct 2006	19	26	26	22	21	26	21	22	25	27	21	23	71
29 Nov 2006	25	27	26	24	23	25	21	24	26	26	22	24	71
25 Jan 2007	39	37	36	39	35	34	28	28	35	31	29	37	71

- Less acid condensation than 29th Nov 2006 is expected with current Sulphur and reported Engine Load.
- The same TBN of the CDO as 29 Nov 06 is expected with current acid condensation and reported lubricant consumption.
- Variation in TBN between Units is due to dilution by fuel and system oil contamination.
- Units 7, 8 and 11 have more contamination than other Units.
- Units 1 and 4 have less contamination than other Units.
- Alkaline reserve appears to be adequate for current fuel and engine load.

Calcium



	1	2	3	4	5	6	7	8	9	10	11	12	New
26 Jul 2006	25240	25190	25070	25200	24910	24550	24800	24870	25120	25160	24660	25240	25960
04 Oct 2006	23580	23700	24360	25030	24120	24840	24930	25000	25250	25220	24860	25070	26030
29 Nov 2006	24940	24550	25110	25040	24880	24690	24630	24760	25090	24800	24140	24970	26110
25 Jan 2007	25310	25260	25390	25330	25240	25300	25160	25230	25260	25190	25230	25340	26030

- Calcium is higher than previous reports due to reduced dilution by fuel and system oil contamination.

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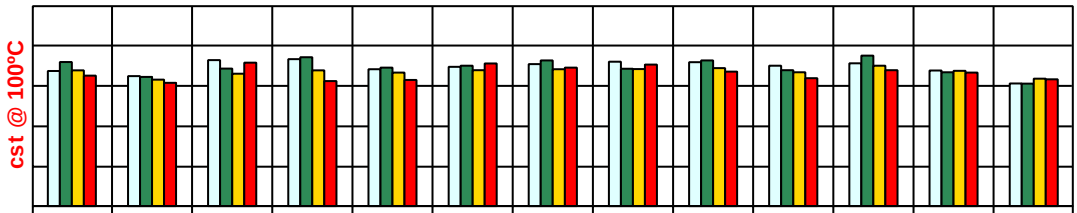
Cylinder Drain Oil Analysis Trends

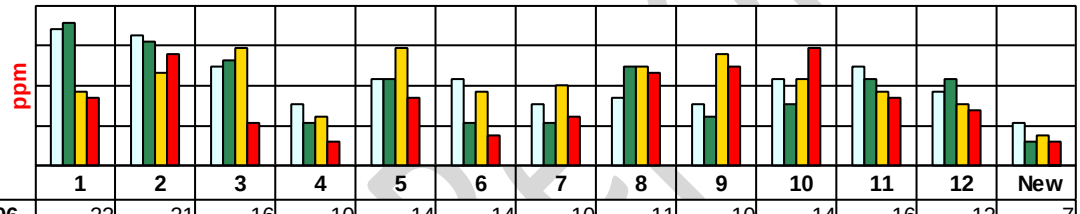
Viscosity



	1	2	3	4	5	6	7	8	9	10	11	12	New
26 Jul 2006	23.6	22.7	25.4	25.6	23.9	24.3	24.7	25.2	25.1	24.5	24.9	23.6	21.4
04 Oct 2006	25.1	22.5	24.0	25.9	24.1	24.5	25.4	23.9	25.4	23.7	26.2	23.4	21.4
29 Nov 2006	23.7	22.1	23.1	23.7	23.3	23.7	23.9	23.9	24.0	23.3	24.5	23.6	22.2
25 Jan 2007	22.8	21.5	25.0	21.8	22.0	24.9	24.1	24.7	23.4	22.3	23.7	23.3	22.1

- Low Viscosity in Units 1, 2, 4, 5 and 9 to 12 can be due to reduced fuel contamination and/ or system oil contamination.
- Normal Viscosity is maintained for Units 3, 6, 7 and 8.

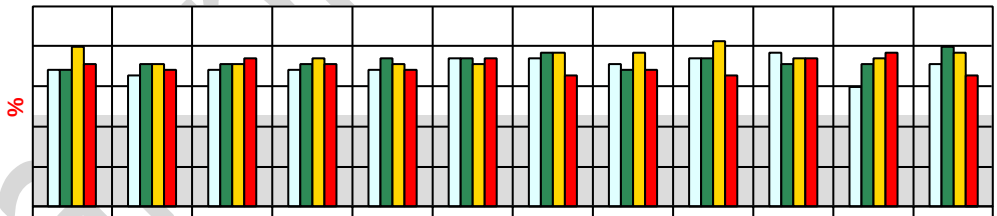
Zinc



	1	2	3	4	5	6	7	8	9	10	11	12	New
26 Jul 2006	22	21	16	10	14	14	10	11	10	14	16	12	7
04 Oct 2006	23	20	17	7	14	7	7	16	8	10	14	14	4
29 Nov 2006	12	15	19	8	19	12	13	16	18	14	12	10	5
25 Jan 2007	11	18	7	4	11	5	8	15	16	19	11	9	4

- Leakage of System Oil into the under-piston spaces is low and normal for all Units.

Water



	1	2	3	4	5	6	7	8	9	10	11	12
26 Jul 2006	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.1	1.3
04 Oct 2006	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.2	1.3	1.3	1.3	1.4
29 Nov 2006	1.4	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.5	1.3	1.3	1.4
25 Jan 2007	1.25	1.2	1.3	1.25	1.2	1.3	1.15	1.2	1.15	1.3	1.35	1.15

- High Water in all Units poses risk of emulsification and disruption of cylinder lubrication.
- Water is diluted by System Oil contamination in Units 10 and 11.

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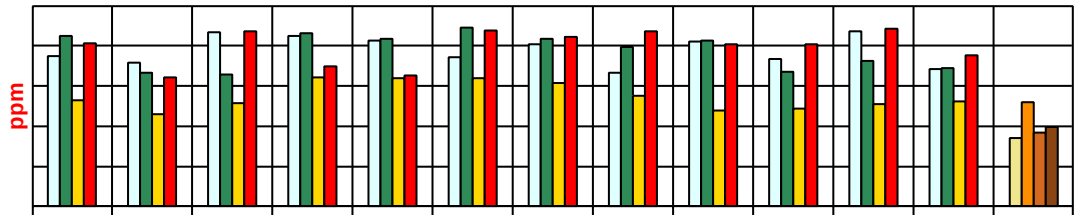
Cylinder Drain Oil Analysis Trends

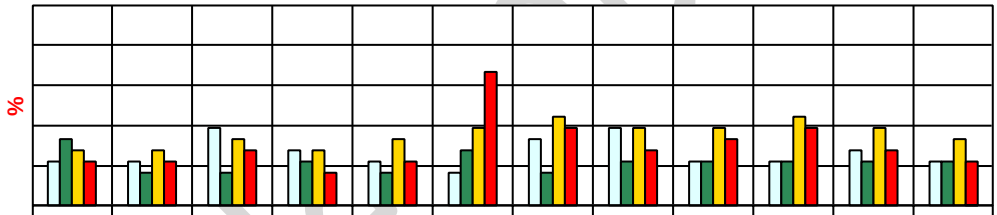
Vanadium (Before Engine)



	1	2	3	4	5	6	7	8	9	10	11	12	Fuel
26 Jul 2006	164	157	190	186	181	163	177	146	180	161	191	150	75
04 Oct 2006	186	146	144	189	183	195	183	174	181	147	159	151	114
29 Nov 2006	116	101	113	141	140	140	135	121	105	107	112	115	81
25 Jan 2007	178	141	191	153	143	192	185	191	177	177	194	165	87

- Vanadium in all Units is higher than 29 Nov 06 due to higher vanadium fuel.
- High Vanadium in all Units relative to vanadium content of the fuel indicates that the amount of fuel or fuel ash passing the ring pack is higher than normal.
- Units 6, 7, 8 and 11 are most affected by fuel contamination.
- System Oil contamination is diluting Units 10 and 11 meaning that the Fuel contamination is higher than the analyses indicate.

Soot



	1	2	3	4	5	6	7	8	9	10	11	12
26 Jul 2006	0.4	0.4	0.7	0.5	0.4	0.3	0.6	0.7	0.4	0.4	0.5	0.4
04 Oct 2006	0.6	0.3	0.3	0.4	0.3	0.5	0.3	0.4	0.4	0.4	0.4	0.4
29 Nov 2006	0.5	0.5	0.6	0.5	0.6	0.7	0.8	0.7	0.7	0.8	0.7	0.6
25 Jan 2007	0.4	0.4	0.5	0.3	0.4	1.2	0.7	0.5	0.6	0.7	0.5	0.4

- High Soot in Units 1, 2, 3 and 5 to 12 indicates unstable combustion.
- Normal Soot in Unit 4 indicates satisfactory combustion.
- System Oil contamination is diluting Units 10 and 11 meaning that combustion instability is greater than the analyses indicate.

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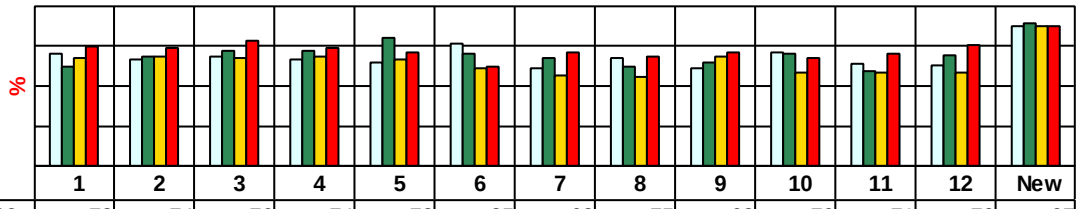
Cylinder Drain Oil Analysis Trends

Dispersancy



	1	2	3	4	5	6	7	8	9	10	11	12	New
26 Jul 2006	78	74	76	74	72	85	68	75	68	79	71	70	97
04 Oct 2006	69	76	80	80	89	78	75	69	72	78	66	77	99
29 Nov 2006	75	76	75	76	74	68	63	62	76	65	65	65	97
25 Jan 2007	83	82	87	82	79	69	79	76	79	75	78	84	97

- Dispersancy in all Units indicates that CDO is lightly burdened with fuel and lubricant debris.
- Dispersant reserve in all Units is adequate to maintain piston cleanliness.
- Dilution of the CDO samples by System oil leakage in Units 10 and 11 means that debris is greater than the analyses indicate.

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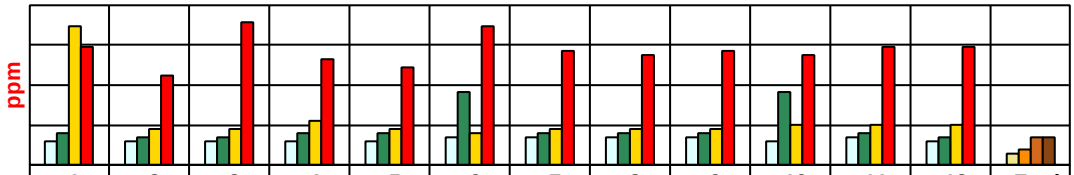
Cylinder Drain Oil Analysis Trends

Wear Indicators

N.B. Higher contamination by Fuel and System Oil in Units 7, 8 and 11 means that Iron, Tin, Copper and Chromium wear debris may be higher than analyses indicate.

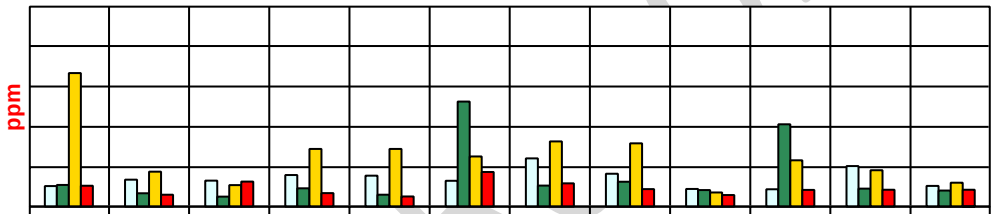
Aluminium (Before Engine)



	1	2	3	4	5	6	7	8	9	10	11	12	Fuel
26 Jul 2006	6	6	6	6	6	7	7	7	7	6	7	6	3
04 Oct 2006	8	7	7	8	8	18	8	8	8	18	8	7	4
29 Nov 2006	34	9	9	11	9	8	9	9	9	10	10	10	7
25 Jan 2007	29	22	35	26	24	34	28	27	28	27	29	29	7

- High Aluminium in all Units indicates presence of cat-fines and poses risk of abrasion.

Iron



	1	2	3	4	5	6	7	8	9	10	11	12
26 Jul 2006	114	148	143	172	169	142	260	179	99	97	220	115
04 Oct 2006	120	76	58	102	69	560	117	137	93	440	101	90
29 Nov 2006	710	190	119	310	310	270	350	340	80	250	198	132
25 Jan 2007	116	68	138	77	59	188	129	98	67	94	95	95

- High wear in Unit 6 is indicated by high Iron ppm.
  - High Iron in Unit 6 should reduce on completion of running-in.
- Normal wear in Units 1 to 5 and 7 to 12 is indicated by low Iron ppm but may be higher in Units 7, 8 and 11 when account is taken of Fuel and System Oil contamination.
- At 148 hours since overhaul wear high Iron in Unit 6 should reduce and stabilise when running-in is completed. At 148 since overhaul wear in Units 3 and 12 is low indicating that running-in is proceeding satisfactorily.
- Wear is slightly higher than 29 Nov 06 in Unit 3.
- Wear is slightly lower than 29 Nov 06 in Unit 9.
- Wear is lower than 29 Nov 06 in Units 1, 2, 4 to 8, 10, 11 and 12.

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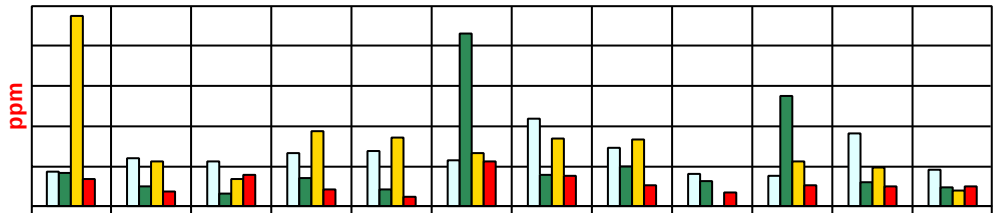
Cylinder Drain Oil Analysis Trends

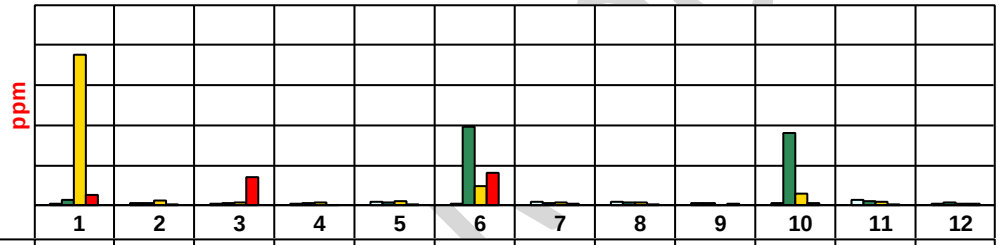
Tin



	1	2	3	4	5	6	7	8	9	10	11	12
26 Jul 2006	34	47	44	52	54	45	85	57	32	30	71	36
04 Oct 2006	33	20	13	28	17	167	31	39	25	107	24	19
29 Nov 2006	184	44	27	73	67	52	66	65	0	44	38	16
25 Jan 2007	27	15	31	17	10	44	30	21	14	21	20	20

- High Tin in Units 1, 3, 6, 7, 8 and 10 points to a slight disturbance of piston alignment.
- Low Tin in Units 2, 4, 5, 9, 11 and 12 indicates that piston movement is free and normal.
- High Tin in Units 3 and 6 should reduce and stabilise when running-in is completed.

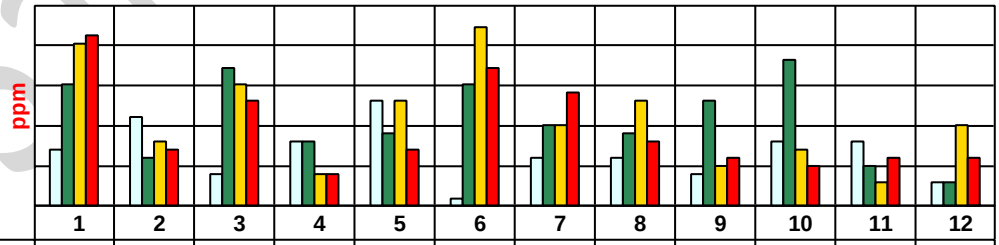
Copper



	1	2	3	4	5	6	7	8	9	10	11	12
26 Jul 2006	4	5	4	4	7	4	7	7	5	5	10	4
04 Oct 2006	10	5	5	5	6	126	5	6	5	116	8	6
29 Nov 2006	240	9	6	6	8	32	6	6	2	20	7	4
25 Jan 2007	18	3	46	2	3	53	4	3	4	5	3	4

- High Copper in Units 1, 3 and 6 can be due to abrasion between the piston skirt copper band and liner wall or due to abrasion of the piston rod sealing rings.
- High Copper in Units 3 and 6 should reduce and stabilise when running-in is completed.

Chromium



	1	2	3	4	5	6	7	8	9	10	11	12
26 Jul 2006	7	11	4	8	13	1	6	6	4	8	8	3
04 Oct 2006	15	6	17	8	9	15	10	9	13	18	5	3
29 Nov 2006	20	8	15	4	13	22	10	13	5	7	3	10
25 Jan 2007	21	7	13	4	7	17	14	8	6	5	6	6

- High Chromium in Units 1, 3, 6 and 7 indicates wear of the piston ring groove coating.
- High Chromium in Units 3 and 6 should reduce and stabilise when running-in is completed.

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Sampling Notes

Please ensure the following:

- Collection of Cylinder Drain Oil (CDO) samples to be synchronized with recording of full Engine Performance Data as scheduled by company Technical Department.

  Fuel Rack to be locked when CDO Samples are being collected and performance recorded (This is in line with MAN B&W recommendation).
- CDO samples to be collected at normal operating load or between 85 to 90% MCR.
- Ensure that piston rod diaphragm is free of excessive sludge when samples are collected. If possible, under-piston space should be cleaned in port prior to sample collection.
- Record HMI setting and stroke setting for each Unit in the Sample Submission Form.
- Measure cylinder oil consumption, as accurately as possible, over 2 to 3 hours during collection of CDO samples and recording of Engine Performance.
- Record Ambient Temperature and Relative Humidity in the shaded area on the wing of the Bridge at the time of sampling. Values to be recorded in the Sample Submission Form.

Samples Required

Fuel Oil

- **Before Purifier** - One sample taken line before Fuel Oil Purifier.
- **Before Main Engine** - One sample taken from line before Main Engine Fuel Injection Pump.

System Oil

- **New System Oil** - One sample taken at convenient point in the topping up line.
- **Crankcase Oil** - One sample taken from Main Lubricating Oil pump discharge.

Cylinder Oil

- **New Oil** - One sample taken from convenient point on the line to Lubricator Pump.
- **Cylinder Drain Oil** - One sample taken from under-piston drain line of each Unit.

Documents Required

- Completed Sample Submission Form
- Completed Engine Performance Data sheet (company Standard Form).
- Copy of Main Engine Power Calculation sheet (if available).
- Printout from Electronic Diesel Analyzer (Tabulated Data and Indicator Diagram). If possible, provide archive data on diskette.
- Copy of Bunker Analysis Results for the Fuel in use.
- Copy of Main Engine Shop Test datasheet or Performance Curve - Once only.

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