LINER DIAMETER MEASUREMENT SERVICE REPORT

Client: -

Vessel: -

Engineer: -

Location: -

Date: -

General Data

Vessel:	-
Owner/manager:	-
Flag:	-
Engine type:	6S60MC-C
IMO:	-
Running hours:	50380
Built:	2010
Device used:	LDM Generation 4
Stroke:	2292

Definitions

- Wear is the difference between the original diameter of the liner from the current measured. i.e. (602.23 – 600.00=2.23 mm)

- Maximum Wear is defined by the engine maker and is set at 0.8% of the Standard diameter of the Liner. i.e. (600 x 0.008=4.8mm)

- Ovality is the Difference between the Fore-Aft and Port-Starboard measurement at the same Level. i.e. ((P-S) 600.80 – (F-A) 601.32=0.52 mm)

The clover measurement shows the detailed contour of the cylinder liner for a selected level. It is consisted of 30 diameter measurements every 10 degrees and are plotted on a polar graph showing the deviation from a pure circle in more detail. The purpose of the measurement is to analyse if cylinder honing will be needed for correcting the cylinder geometry, and to also trace possible root causes when there are deviations so that countermeasures can be made. The clover measurement is usually taken in the TDC position for the second piston ring. This position is called TDC2 in the LDM table. The reason for choosing this position is to be close to the maximum wear level and at the same time avoid hitting coke deposits in top land in case the device is somewhat inclined during the measurement.

Cylinder Liner History

Ship name: -

Max allowable wear 4.8

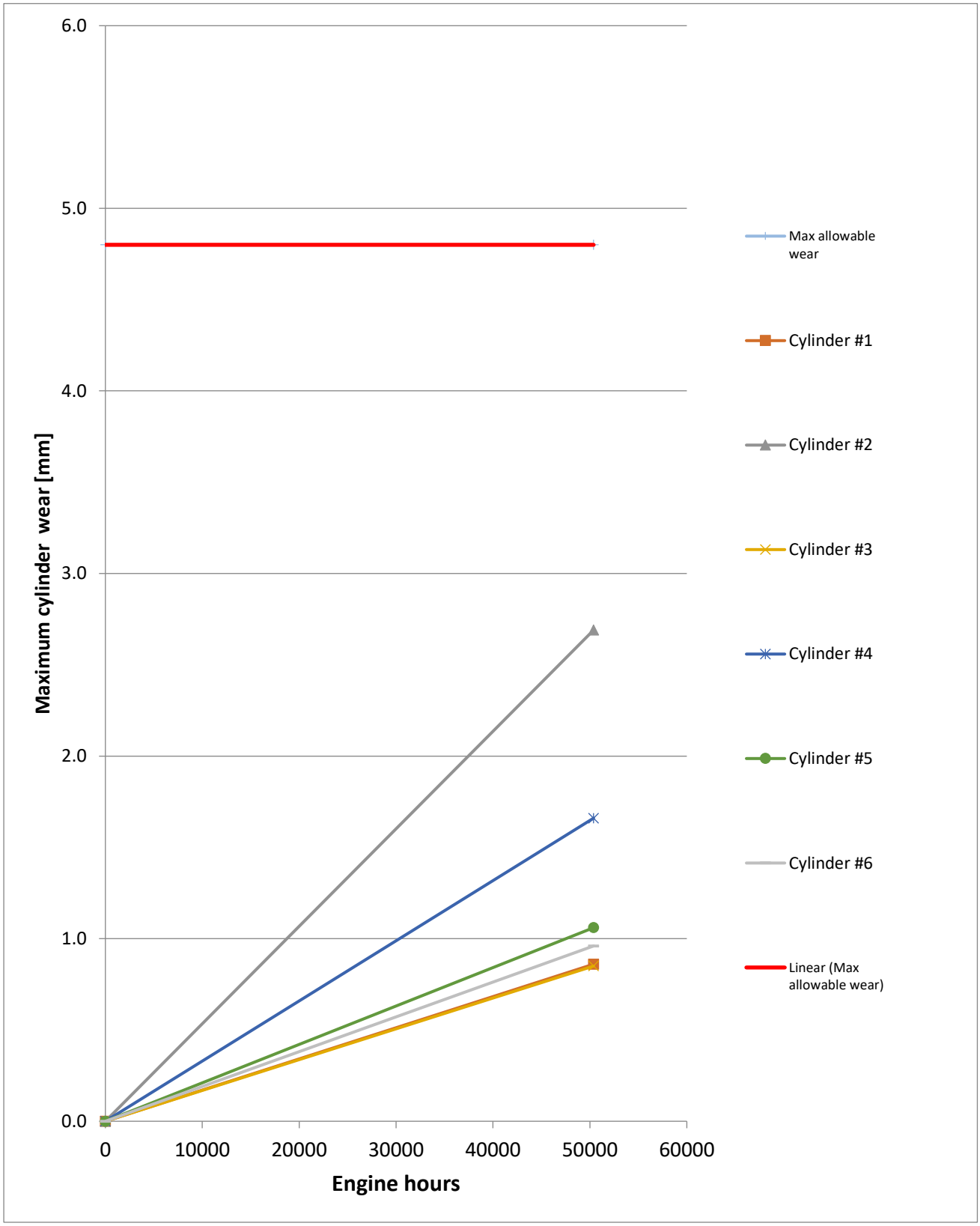
Date	LINER RUNNING HOURS			
M/E Running hours	**0**	**50380**	**Average Wear[mm]**	1.347
Cylinder #1	50380	0.86	**Expected End running hours:**	129192.28
Cylinder #2	50380	2.69	**AVG Specific wear rate [mm/1000 Rh]**	0.027
Cylinder #3	50380	0.85	**MAN STD wear rate [mm/1000 Rh]**	0.07
Cylinder #4	50380	1.66		
Cylinder #5	50380	1.06		
Cylinder #6	50380	0.96		

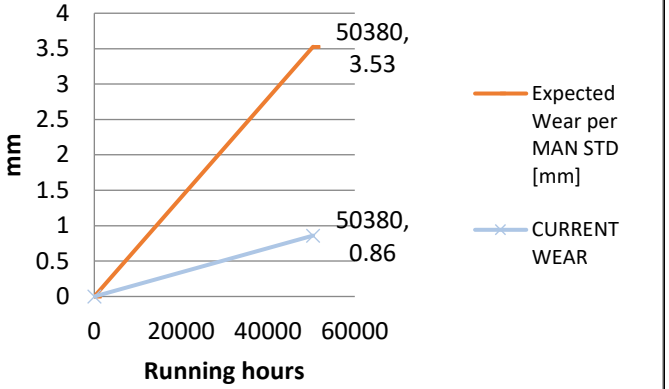
CALCULATIONS PER LINER				
	mm/1000 Rh	**Expected Running hours**	**Hours when unit replaced**	**Expected Wear per MAN STD [mm]**
Cylinder #1	0.02	281191	0	3.53
Cylinder #2	0.05	89897	0	3.53
Cylinder #3	0.02	284499	0	3.53
Cylinder #4	0.03	145677	0	3.53
Cylinder #5	0.02	228136	0	3.53
Cylinder #6	0.02	251900	0	3.53

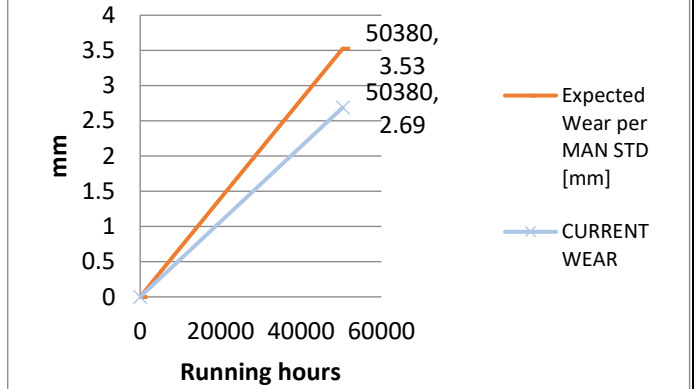
The cylinder wear was found to be between 0.85 mm and 2.69mm with an average of 1.347 mm corresponding to an average specific wear rate of 0.027 mm/1000h.

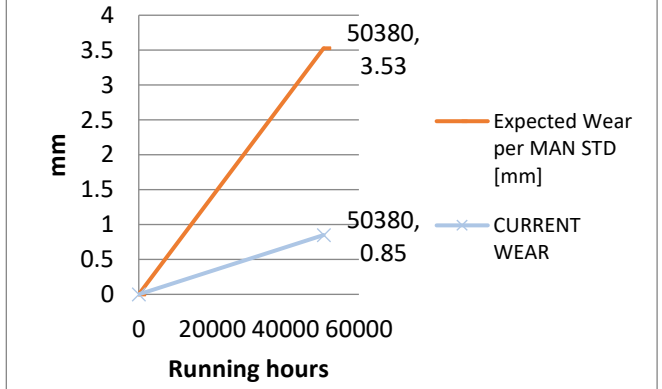
Nominal diameter (600 mm) was used for computing wear for all cylinders for simplicity.

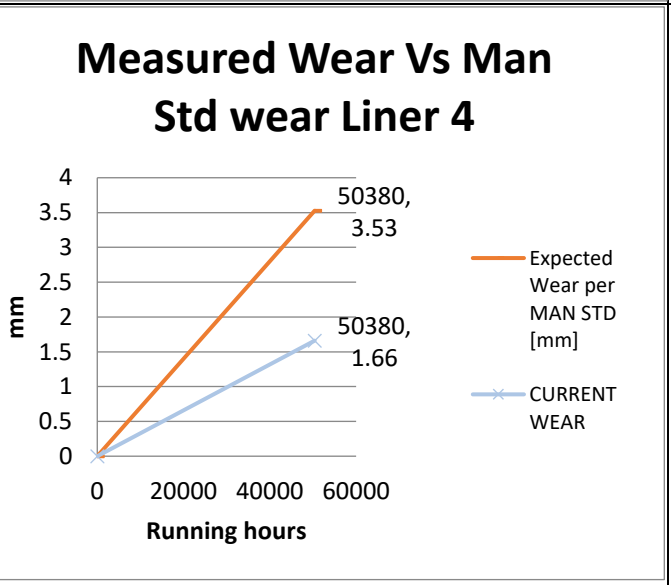
The Graph below shows the current wear for all units

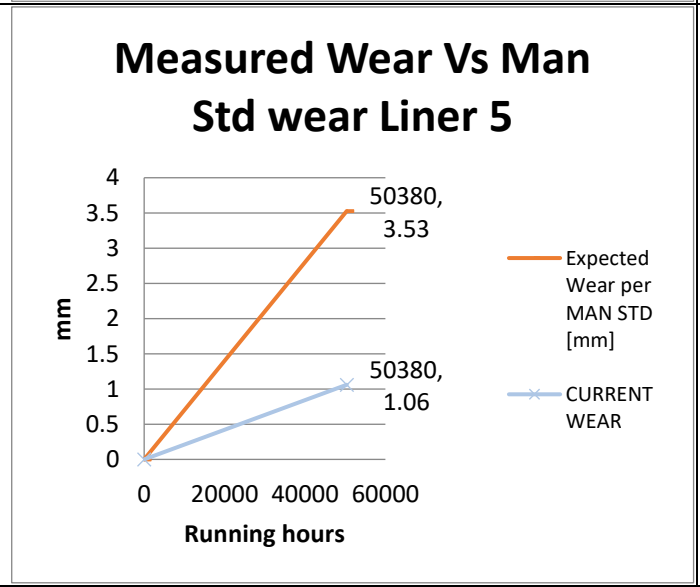


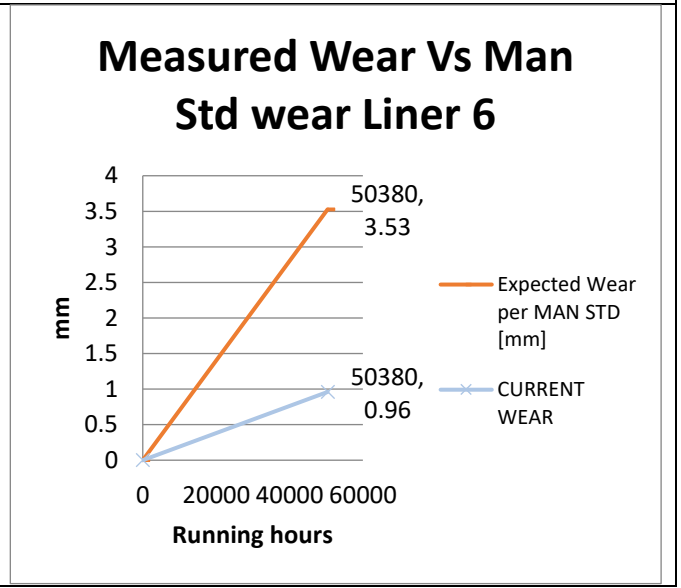

Measured Wear Vs Man Std wear liner 1
mm
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20000
40000
60000
Running hours
50380, 3.53
50380, 0.86
Expected Wear per MAN STD [mm]
CURRENT WEAR


Measured Wear Vs Man Std wear Liner 2
mm
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20000
40000
60000
Running hours
50380, 3.53
50380, 2.69
Expected Wear per MAN STD [mm]
CURRENT WEAR

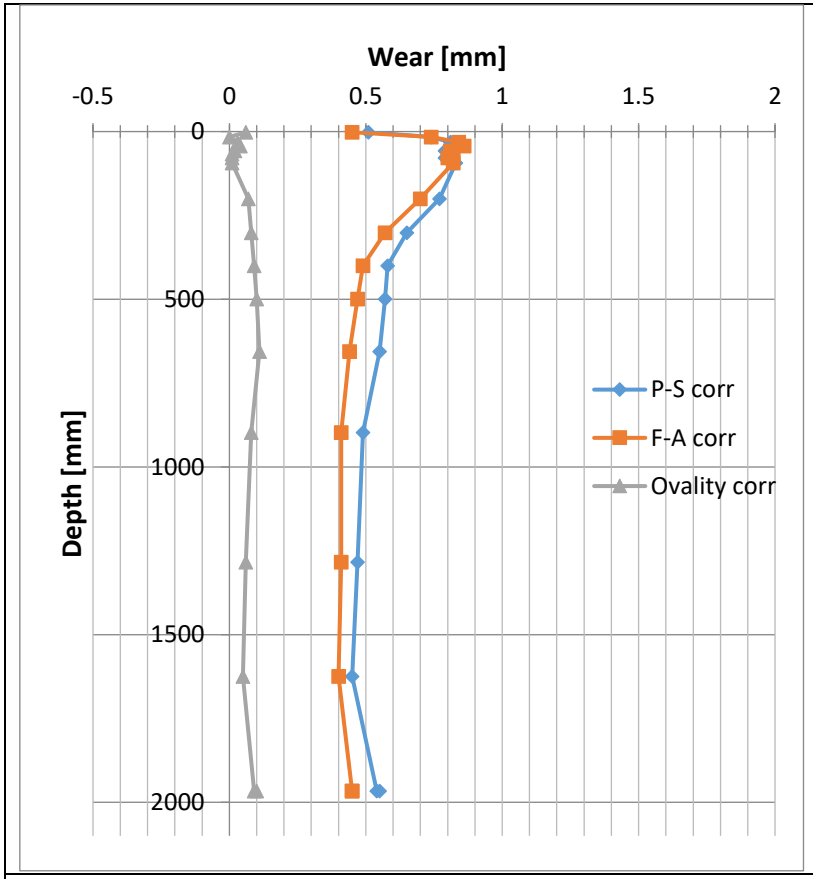

Measured Wear Vs Man Std wear Liner 3
mm
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20000
40000
60000
Running hours
50380, 3.53
50380, 0.85
Expected Wear per MAN STD [mm]
CURRENT WEAR


Measured Wear Vs Man Std wear Liner 4
mm
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20000
40000
60000
Running hours
50380, 3.53
50380, 1.66
Expected Wear per MAN STD [mm]
CURRENT WEAR


Measured Wear Vs Man Std wear Liner 5
mm
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20000
40000
60000
Running hours
50380, 3.53
50380, 1.06
Expected Wear per MAN STD [mm]
CURRENT WEAR

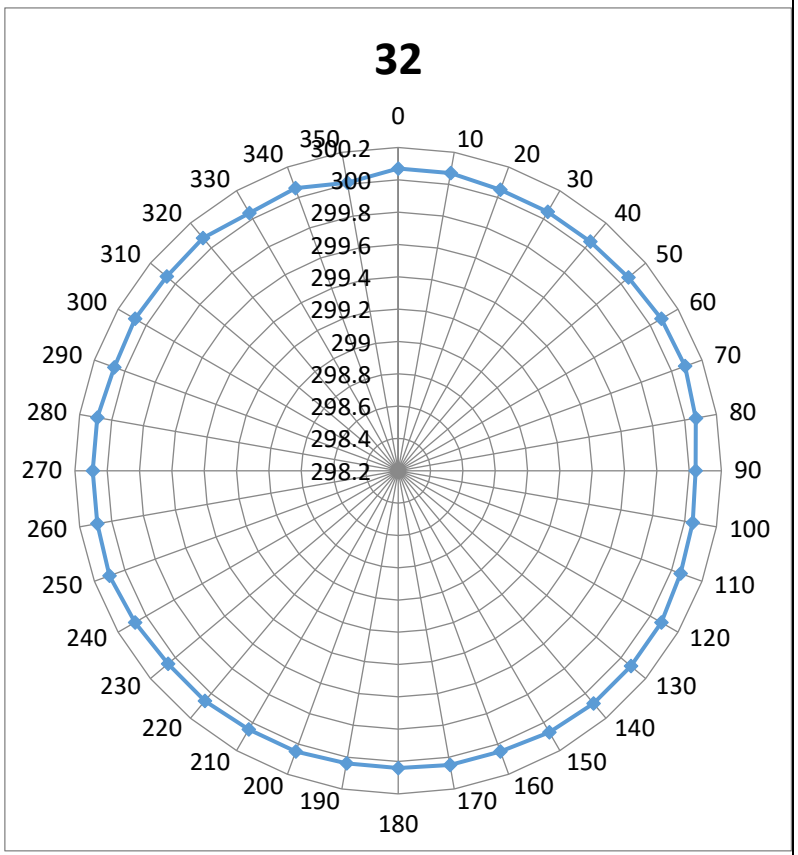

Measured Wear Vs Man Std wear Liner 6
mm
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20000
40000
60000
Running hours
50380, 3.53
50380, 0.96
Expected Wear per MAN STD [mm]
CURRENT WEAR

Detailed Analysis of Liners



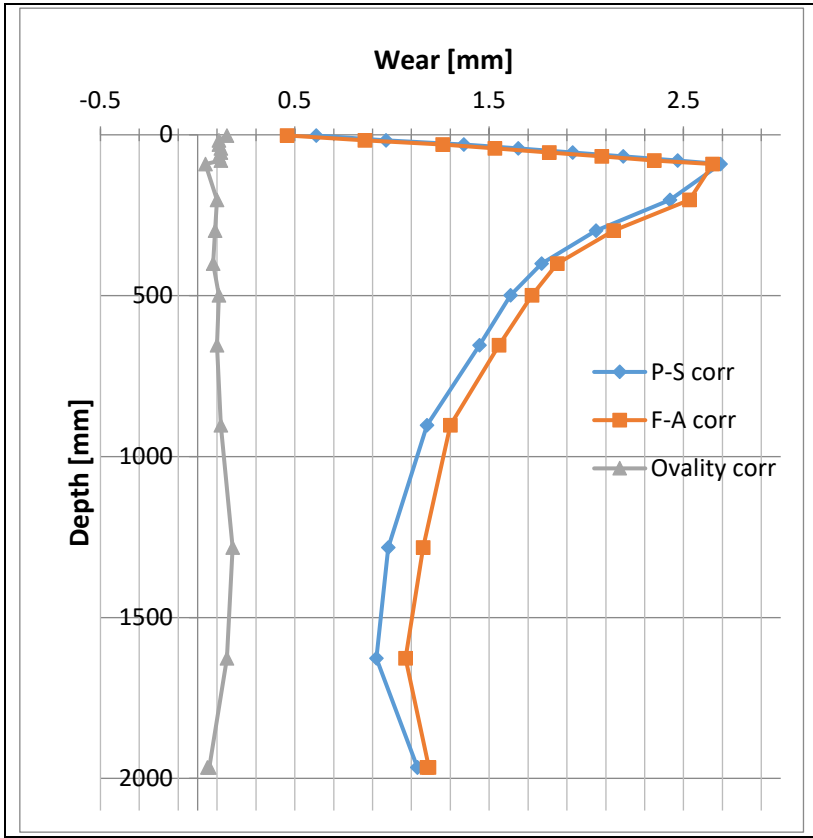
LINER 1	
Liner Running Hours	50380
Max wear P-S:	0.82mm@ 43mm
Max wear F-A:	0.86mm@ 43mm
Clover Ovality max	0.87@ TDC2
Top Piston crown	Oil on top
Blow-by	No
Cold Corrosion	Major
Scuffing	No
Rings Condition	Scuffed
Wave cut Grooves	Worn

Id	Depth	P-S	F-A
17 (TDC1)	2	600.51	600.45
16	16	600.74	600.74
15 (TDC2)	31	600.81	600.84
14	43	600.82	600.86
13 (TDC3)	57	600.79	600.81
12	67	600.81	600.82
11 (TDC4)	78	600.79	600.80
10	93	600.83	600.82
9	200	600.77	600.70
8	302	600.65	600.57
7	400	600.58	600.49
6	499	600.57	600.47
5	656	600.55	600.44
4	897	600.49	600.41
3	1284	600.47	600.41
2	1624	600.45	600.40
1 (Ref)	1966	600.54	600.45



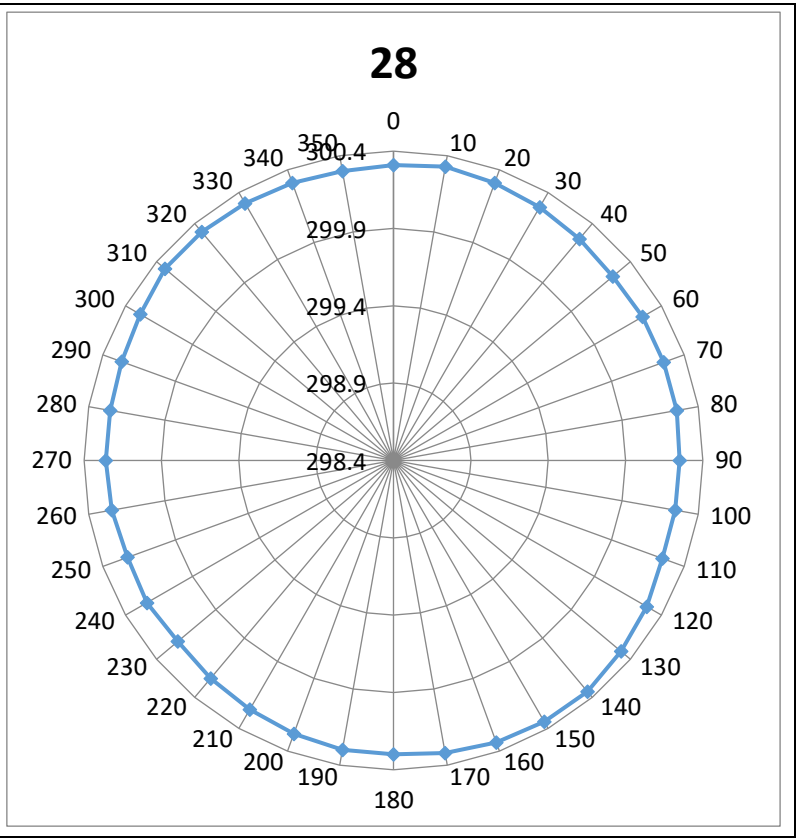
Note: The above Graph shows the liner diameter profile analysis of a wear patter. Wear starts to increase gradually from 500mm with max wear near the top. Oil leakage found on top of the piston crown indicating a leaking fuel injector. Signs of cold welding are visible just above the scavenge ports.

Note: A clover measurement was done at 32mm from TDC2 after completing the wear measurement. Ovality at piston ring area is ~0.12mm and the shape is almost circular.



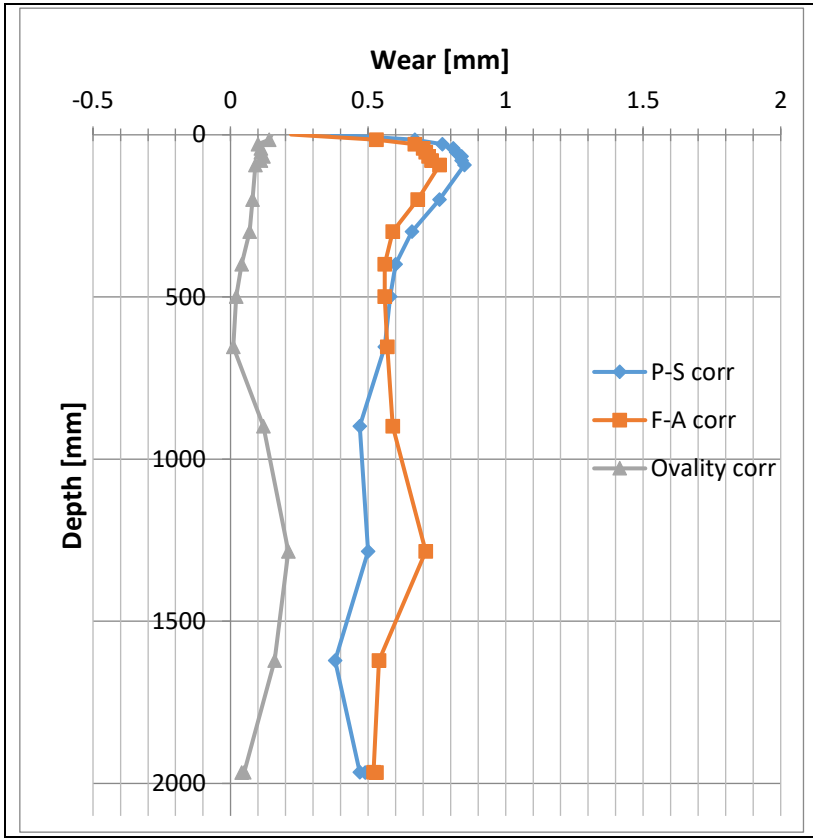
LINER 2	
Liner Running Hours	50380
Max wear P-S:	2.69mm@ 91mm
Max wear F-A:	2.65mm@ 91mm
Clover Ovality max	0.2@ TDC1
Top Piston crown	Oil on top
Blow-by	At Ring 1-2-3
Cold Corrosion	Major
Scuffing	Yes
Rings Condition	Scuffed
Wave cut Grooves	Worn

Id	Depth	P-S	F-A
17 (TDC1)	2	600.61	600.46
16	17	600.97	600.86
15 (TDC2)	30	601.37	601.26
14	42	601.65	601.53
13 (TDC3)	55	601.93	601.81
12	67	602.19	602.08
11 (TDC4)	80	602.47	602.35
10	91	602.69	602.65
9	202	602.43	602.53
8	298	602.05	602.14
7	400	601.77	601.85
6	499	601.61	601.72
5	654	601.45	601.55
4	903	601.18	601.30
3	1283	600.98	601.16
2	1627	600.92	601.07
1 (Ref)	1966	601.13	601.19



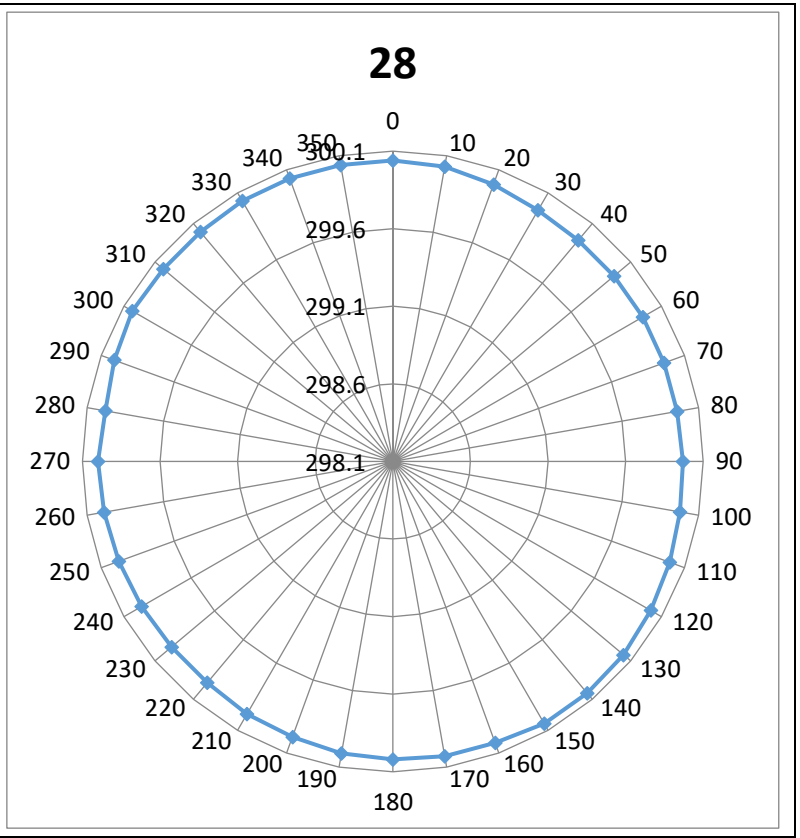
Note: The above Graph shows the liner diameter profile analysis of a wear patter. Wear starts to increase gradually from 1600mm with max wear near the top. Oil leakage found on top of the piston crown indicating a leaking fuel injector. Liner is suffering from scuffing Sharp burns were found on scavenge port edges.

Note: A clover measurement was done at 28mm from TDC1 after completing the wear measurement. Ovality at piston ring area is ~0.20mm and the shape is almost circular. Signs of blow by gas at Ring land 1-2-3 was seen at visual inspection through the scavenge ports. Injectors appear to have poor atomization spray pattern with result spreading fuel on liner wall and then transferred to piston rings affecting the oil film distribution and the build-up of sludge.



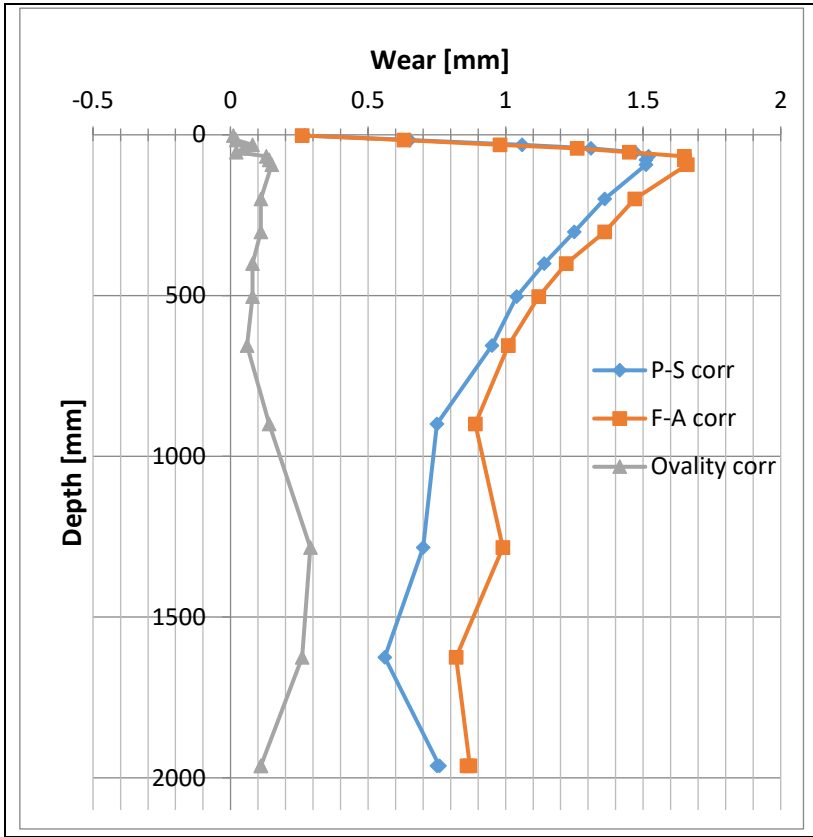
LINER 3	
Liner Running Hours	50380
Max wear P-S:	0.85mm@ 93mm
Max wear F-A:	0.76mm@ 93mm
Clover Ovality max	0.17@ TDC1
Top Piston crown	Oil on top
Blow-by	No
Cold Corrosion	Minor
Scuffing	Yes
Rings Condition	Scuffed
Wave cut Grooves	Worn

Id	Depth	P-S	F-A
17 (TDC1)	-1	600.37	600.22
16	15	600.67	600.53
15 (TDC2)	29	600.77	600.67
14	42	600.81	600.70
13 (TDC3)	54	600.82	600.71
12	66	600.84	600.72
11 (TDC4)	79	600.84	600.73
10	93	600.85	600.76
9	200	600.76	600.68
8	298	600.66	600.59
7	399	600.60	600.56
6	499	600.58	600.56
5	654	600.56	600.57
4	899	600.47	600.59
3	1284	600.50	600.71
2	1621	600.38	600.54
1 (Ref)	1965	600.47	600.52



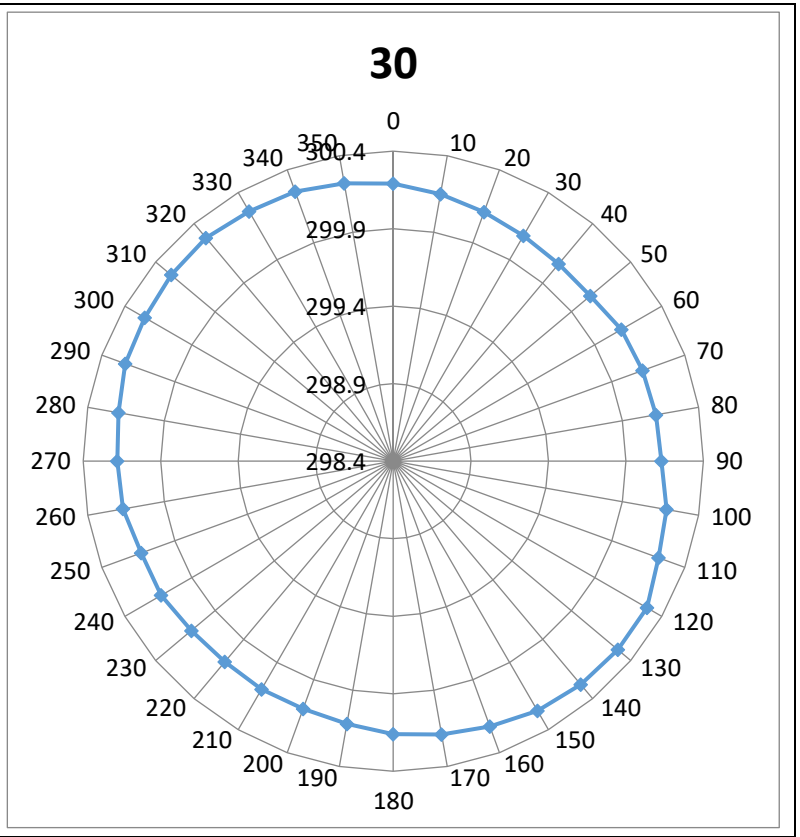
Note: The above Graph shows the liner diameter profile analysis of a wear patter. Wear starts to increase gradually from 600mm with max wear near the top. Oil leakage found on top of the piston crown indicating a leaking fuel injector. Liner is suffering from scuffing Sharp burns were found on scavenge port edges. Furthermore, minor signs of black lacquer were visible through the scavenge ports. The result of high humidity in the scavenging air, impacting the cylinder oil, producing alkaline material, forming a patch of deposits. Harmless to the engine and will be worn away when the air becomes dryer.

Note: A clover measurement was done at 28mm from TDC1 after completing the wear measurement. Ovality at piston ring area is ~0.17mm and the shape is almost circular.



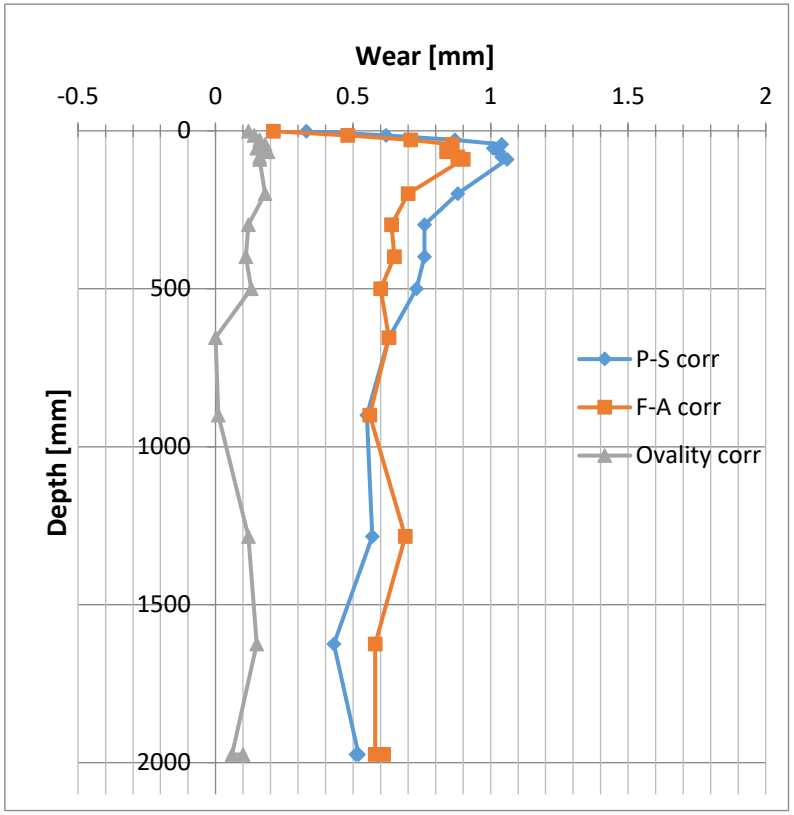
LINER 4	
Liner Running Hours	50380
Max wear P-S:	1.52mm@ 67mm
Max wear F-A:	1.66mm@ 93mm
Clover Ovality max	0.41@ TDC2
Top Piston crown	Oil on top and rust
Blow-by	No
Cold Corrosion	Major
Scuffing	Yes
Rings Condition	Scuffed
Wave cut Grooves	Worn

Id	Depth	P-S	F-A
17 (TDC1)	2	600.27	600.26
16	16	600.65	600.63
15 (TDC2)	31	601.06	600.98
14	42	601.31	601.26
13 (TDC3)	54	601.47	601.45
12	67	601.52	601.65
11 (TDC4)	78	601.51	601.65
10	93	601.51	601.66
9	199	601.36	601.47
8	302	601.25	601.36
7	401	601.14	601.22
6	503	601.04	601.12
5	655	600.95	601.01
4	899	600.75	600.89
3	1284	600.70	600.99
2	1625	600.56	600.82
1 (Ref)	1963	600.76	600.87



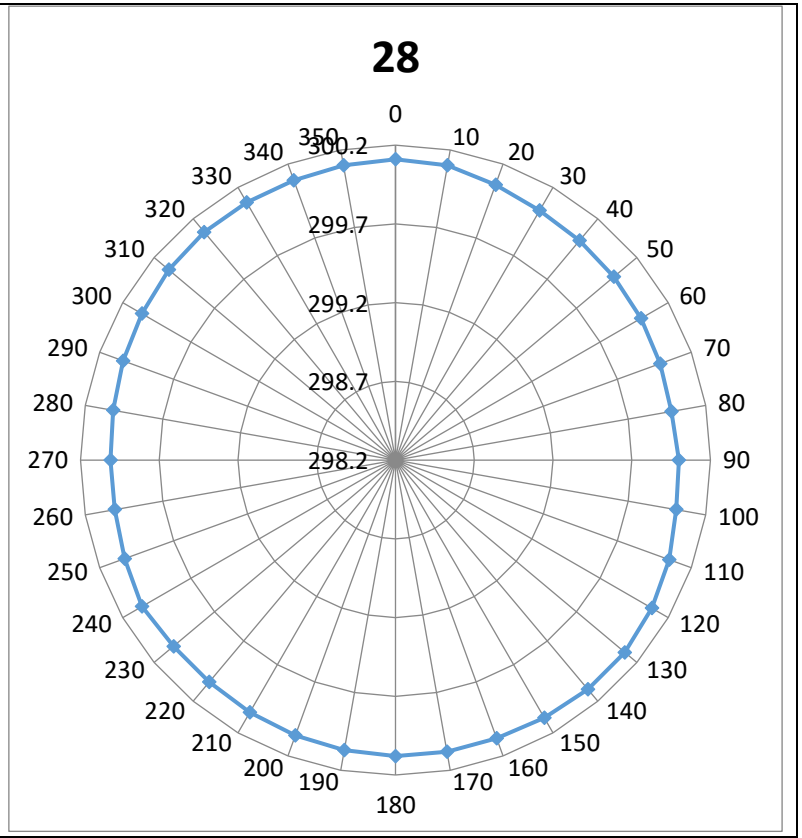
Note: The above Graph shows the liner diameter profile analysis of a wear patter. Wear starts to increase gradually from 900mm with max wear near the top. Oil leakage found on top of the piston crown indicating a leaking fuel injector. Liner is suffering from scuffing Sharp burns were found on scavenge port edges. Scoring marks where visible on visual inspection, deriving from oil film break down, must be treated with increasing oil feed rate to make rings run again. May otherwise evolve into major scuffing. Trace of water were visible on top piston crown, urgently need to check for water leakage.

Note: A clover measurement was done at 30mm from TDC2 after completing the wear measurement. Ovality at piston ring area is ~0.41mm and the shape is more oval at P-S (320®-130®).



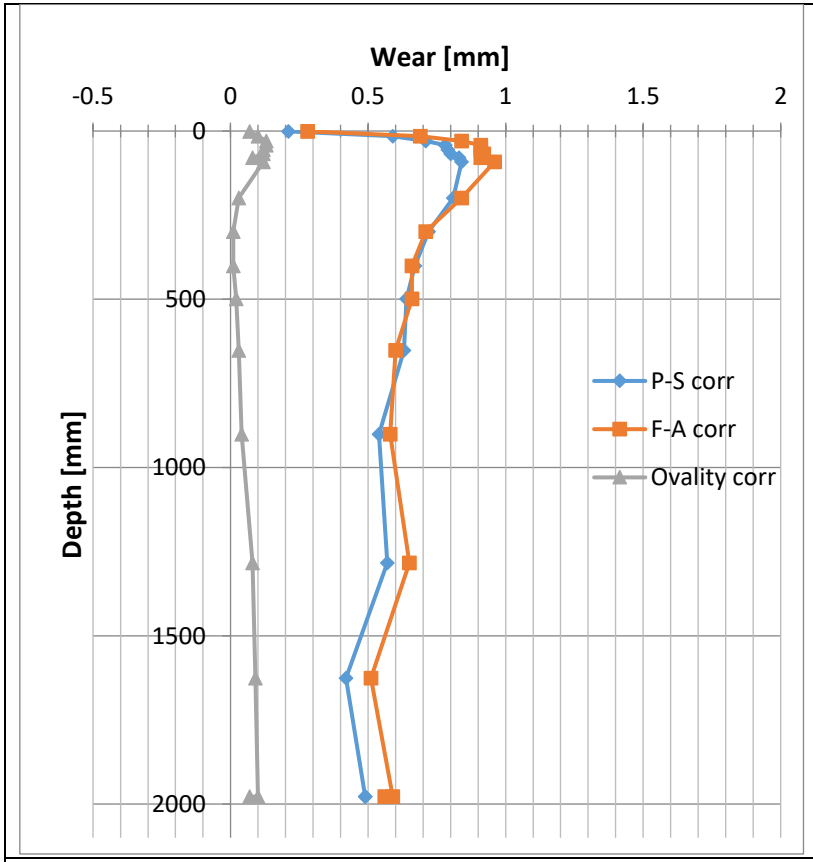
LINER 5	
Liner Running Hours	50380
Max wear P-S:	1.06mm@ 91mm
Max wear F-A:	0.90mm@ 91mm
Clover Ovality max	0.20@ TDC2
Top Piston crown	Trace of oil
Blow-by	No
Cold Corrosion	Yes
Scuffing	Minor
Rings Condition	Normal
Wave cut Grooves	Worn

Id	Depth	P-S	F-A
17 (TDC1)	1	600.33	600.21
16	15	600.62	600.48
15 (TDC2)	29	600.87	600.71
14	43	601.04	600.86
13 (TDC3)	55	601.01	600.86
12	66	601.03	600.84
11 (TDC4)	82	601.04	600.88
10	91	601.06	600.90
9	199	600.88	600.70
8	297	600.76	600.64
7	399	600.76	600.65
6	500	600.73	600.60
5	655	600.63	600.63
4	900	600.55	600.56
3	1284	600.57	600.69
2	1625	600.43	600.58
1 (Ref)	1974	600.52	600.58



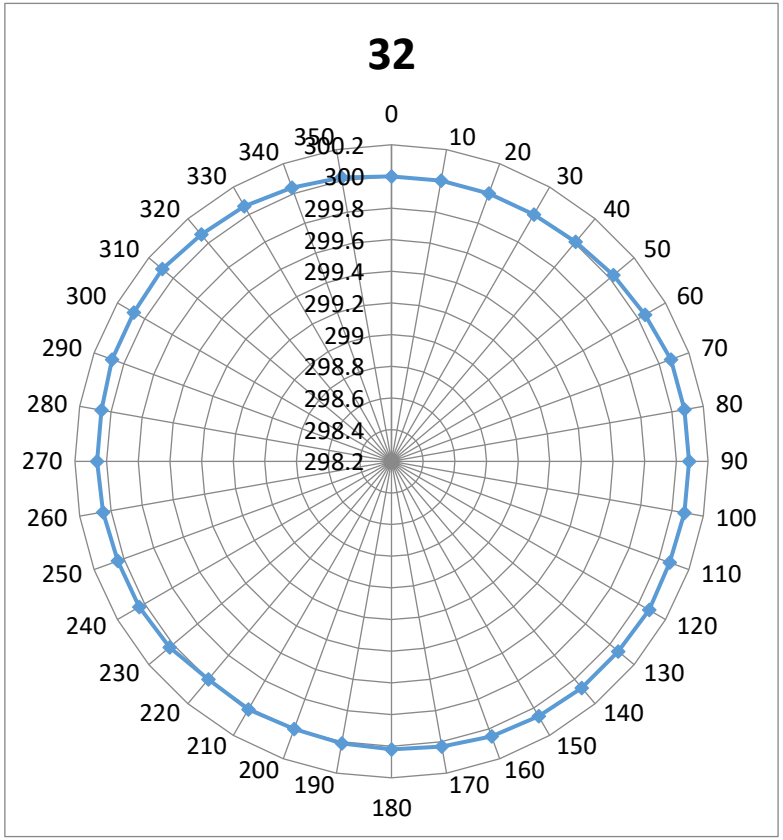
Note: The above Graph shows the liner diameter profile analysis of a wear patter. Wear starts to increase gradually from 600mm with max wear near the top. Liner is suffering from minor scuffing Sharp burns were found on scavenge port edges. Furthermore, minor signs of black lacquer were visible through the scavenge ports. The result of high humidity in the scavenging air, impacting the cylinder oil, producing alkaline material, forming a patch of deposits. Harmless to the engine and will be worn away when the air becomes dryer.

Note: A clover measurement was done at 28mm from TDC1 after completing the wear measurement. Ovality at piston ring area is ~0.20mm and the shape is almost circular.



LINER 6	
Liner Running Hours	50380
Max wear P-S:	0.84mm@ 91mm
Max wear F-A:	0.96mm@ 91mm
Clover Ovality max	0.16@ TDC2
Top Piston crown	Trace of oil
Blow-by	No
Cold Corrosion	Yes
Scuffing	No
Rings Condition	Scuffed
Wave cut Grooves	Worn

Id	Depth	P-S	F-A
17 (TDC1)	1	600.21	600.28
16	15	600.59	600.69
15 (TDC2)	30	600.71	600.84
14	42	600.78	600.91
13 (TDC3)	55	600.79	600.91
12	68	600.80	600.92
11 (TDC4)	79	600.83	600.91
10	91	600.84	600.96
9	199	600.81	600.84
8	299	600.72	600.71
7	401	600.67	600.66
6	499	600.64	600.66
5	652	600.63	600.60
4	901	600.54	600.58
3	1283	600.57	600.65
2	1626	600.42	600.51
1 (Ref)	1978	600.49	600.59



Note: The above Graph shows the liner diameter profile analysis of a wear patter. Wear starts to increase gradually from 600mm with max wear near the top.

Note: A clover measurement was done at 32mm from TDC2.Ovality at piston ring area is ~0.16mm and the shape is almost circular.

Summary

The inspection of --- gave a good overall impression of the current cylinder condition. Low wear rates were evident in terms of the current running hours of the engine which is at 50380 hrs having overall wear of 1.347 mm thus giving a high wear rate of 0.027 mm/1000 Rh.

Comparing the wear trend graphs of the individual units it can be observed that wear rate is lower than the makers limits in relation to the running hours per unit on all units set by Man B&W.

On visual inspection wave cut grooves on all Units are worn and not visible.

Signs of cold corrosion were visible on all units at scavenge ports visual inspection.

Unit 2 appeared with major oily sludge/deposits on the piston ring land which indicates that fuel injectors may not operate as designed with poor atomization of fuel with result spreading fuel on liner wall and then transferred to piston rings affecting the oil film distribution and the build-up of sludge.

Trace of water was found on Unit 4.

Piston rings on Units 2-4 are not normal. Units 2-4 rings appeared scuffed and CC coatings destroyed. Refer to CTM report from further analysis.

Liners 2-4 are suffering from scuffing: Sharp burrs were found on scavenge port edges on unit 2-4.

Furthermore, the clover pattern in the liner diameter profile analysis which could only be carried out on units 1-2-3-5-6 which shows ovality nearly circular.

DEFINITIONS	LINER 1	LINER 2	LINER 3	LINER 4	LINER 5	LINER 6
MAX WEAR	0.86 mm	2.69 mm	0.85 mm	1.66 mm	1.06 mm	0.96 mm
BLOW-BY GAS	No	YES	No	No	No	No
PISTON CROWN	Oil on top	Oil on top	Oil on top	Oil on top and rust	Trace of oil	Trace of oil
SCUFFING	No	YES	YES	YES	Minor	No
COLD CORROSION	Major	Major	Minor	Major	YES	YES

Recommendations

Based on the measurements and analysis we recommend the following actions:

- Check units 1-4 Fuel Injectors for correct operation. Found to be leaking on units.
- After overhauling fuel injectors monitor with frequent scavenge inspections for the condition of the liner, rings and sludge deposits to evaluate conditions.
- Monitor scavenge air temperature for any deviations of lower than normal which can cause condensation and cold corrosion.
- Sweep test and if high Fe content proceed with makers recommended countermeasures.
- Maintain engine working parameters in maker's recommended limits in order to avoid excessive wear and to prolong lifecycle of the cylinders.
- Careful examination of the cylinder oil feed system in order to verify the correct operation of Lubricators spray, feed rate, timing and BN number.
- Check source of water leak needs to be found and rectified.
- Consider honing to refresh the liner surfaces on all units in order to prolong liner life.

LINER 1		LINER 2	
			

LINER 3		LINER 4	
			

LINER 5		LINER 6