NTSB ~~D025~~
D035

"SS Norway"

Main Propulsion Boiler Number 24

Inspection Report

MI 7647

Introduction.

Harris Pye Marine attended the vessel 'SS Norway' in the Port of Miami, USA, to carry out an inspection of main propulsion boiler 24. This was a follow up inspection to that carried out on boiler 21 during November 2002 with a view to providing an up to date condition report

On arrival the boiler was cool and ready for entry.

Inspection.

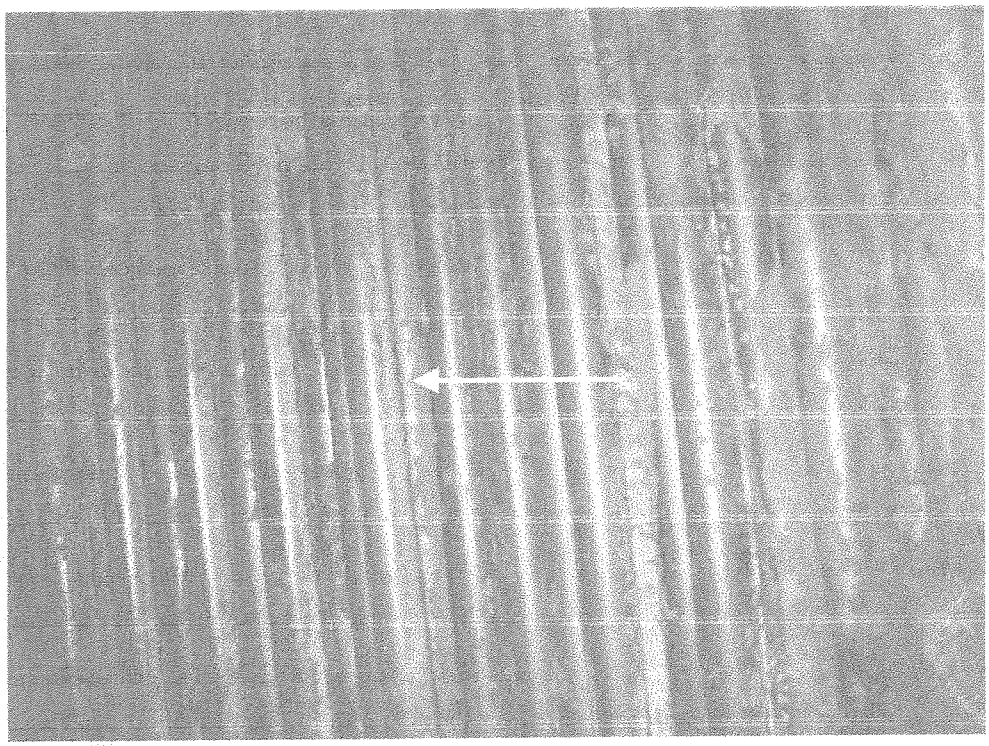
Cladding / insulation.

The external cladding and insulation of this boiler was found to be in good order. No visible signs of significant gas leakage were found.

Furnace Inspection

The furnace of boiler #24 was found to be in a very poor condition. All tubes forming the furnace envelope were heavily coated in combustion products and unburned fuel. The tubes of the screen wall have experienced significant overheating and distortion as have the tubes of the generating bank behind. (see fig 1).

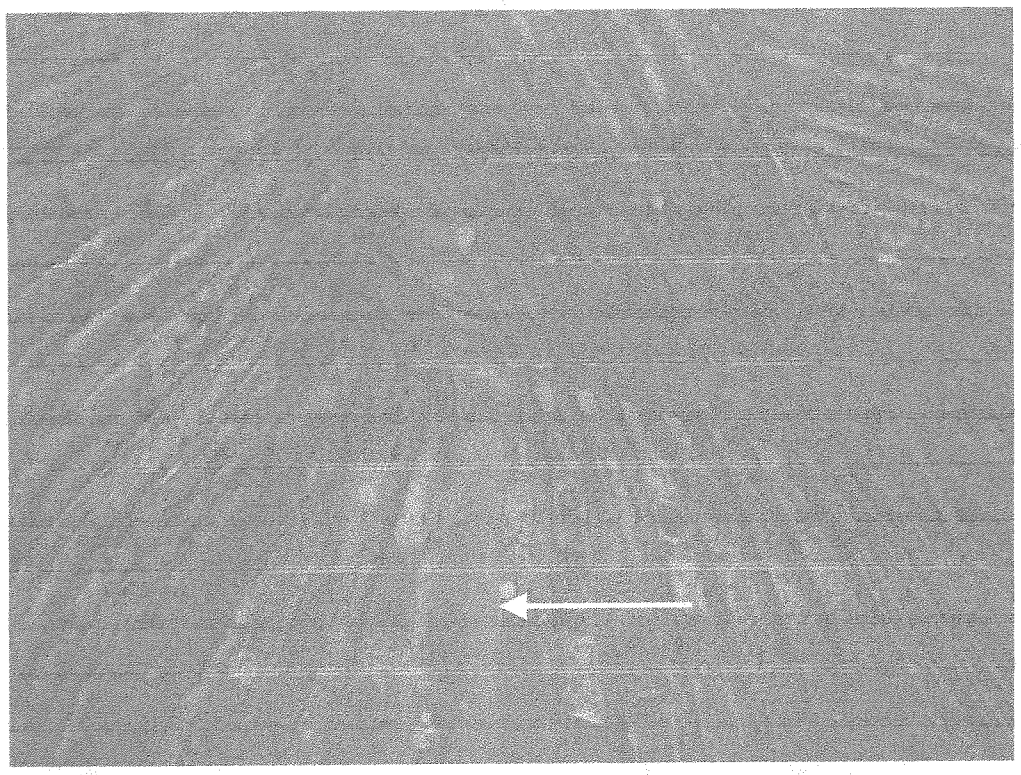
Fig 1.



The most notable effect of the distortion is the closing of the gas spaces between the tubes of the screen wall and generating bank (see fig 1 above). The reduction in the gas spaces has allowed a built of slag to form in some areas thus further reducing the passage of the gas flow from the furnace.

One rear wall tube (see fig 2) has been plugged with the remaining tube having burned away.

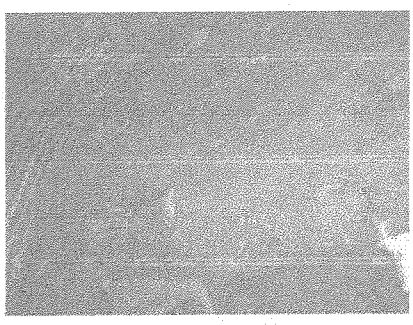
Fig 2.



The refractory of the furnace is in an extremely poor condition. Severe slagging of the front burner wall, furnace floor and rear wall has occurred . Refractory around the burner quarls, approx. 50 – 80 mm thick, has spalled away in areas with the remaining refractory becoming insecure. (Figs 3 & 4).

Fig 3.

Fig 4.



The refractory of the front and rear walls in way of the ends of the screen and generating banks has fallen away in numerous areas thus exposing the steel casing of the windbox (Fig 5). The casing where this has occurred can be seen to have significant distortion.

Fig 5.

Screen tube – generating bank steam drum baffle area.

Inspection of the area between the screen tube and generating tube steam drum connections revealed a significant loss of refractory. Refractory attached to the steam drum offers protection from the high temperatures in this area however in this boiler this protective layer has come away exposing the steam drum to the full heat of the furnace. (See fig 6).

Fig. 11.

The tubes in the [illegible] continued to show heavy deposits of unburned fuel and combustion products. Moreover, secondary superheater support brackets were found to have cracked (seen as highlighted (fig. 11)) however they have as yet not fallen out completely.

Fig. 12.

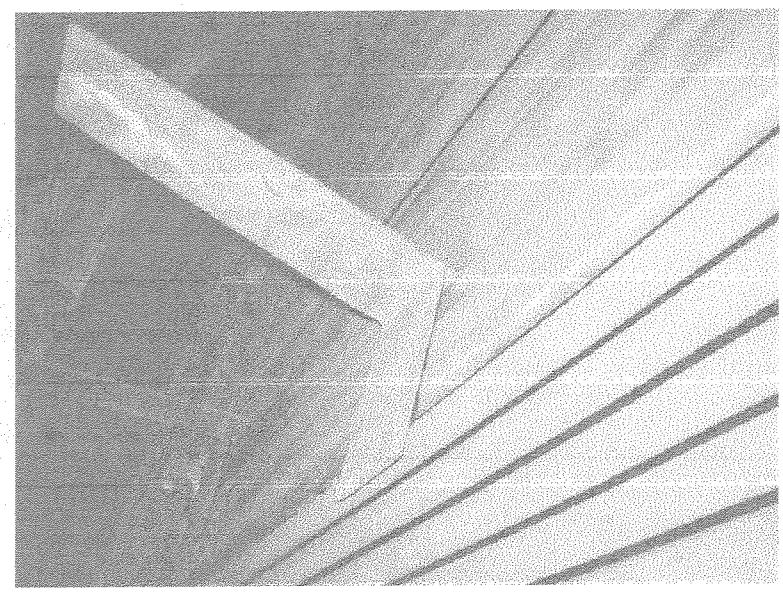
The washing process had left a deposit of wet combustion products in the bottom of the arcade around the tubes. (fig 13).

Fig 13.

Secondary superheater - primary superheater arcade.

Inspection of this area found all tubes, supports and refractory to be in good order. All drains were clear and opened up for the washing process. All stainless steel spacer brackets were found to be in good order and in place. (Fig 14).

Fig 14.

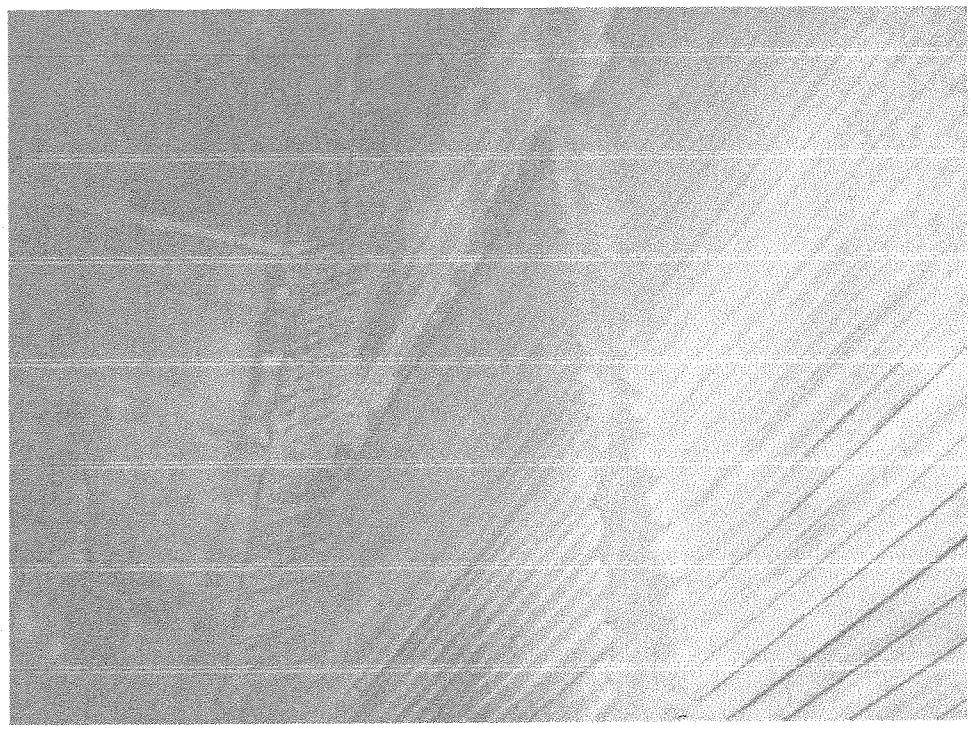


Primary superheater – bottom bare tube economiser.

The primary superheater was found to be in good order externally with all support brackets securely in place. (Fig 15).

Note: No internal tube access possible.

Fig 15.



Bare tube economiser.

Access to this area was limited to the top and bottom. Discussions with ships staff highlighted the fact that failures have been experienced in this unit and that it is known that renewal is required. Evidence of plugged tubes could be seen however the support arrangement was in good order.

Note: No internal tube access possible.

Cast iron economiser.

Discussions with ships staff indicated that this unit has been renewed relatively recently. Some small mechanical damage was noted to the cast iron fins however the general geometry, external condition and support arrangement were found to be in good order.

Note: No internal tube access possible.

Sliding Feet

Inspection of the sliding feet showed no indication of movement. Lubrication pipework was in place however the feet appeared dry. (Figs 16 & 17).

Fig 16.

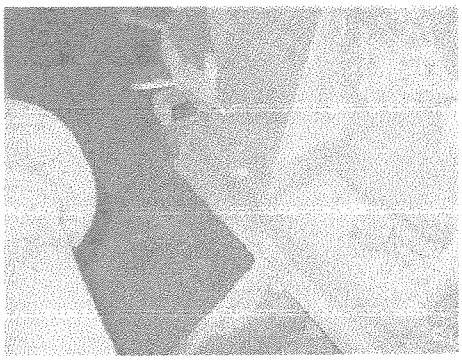
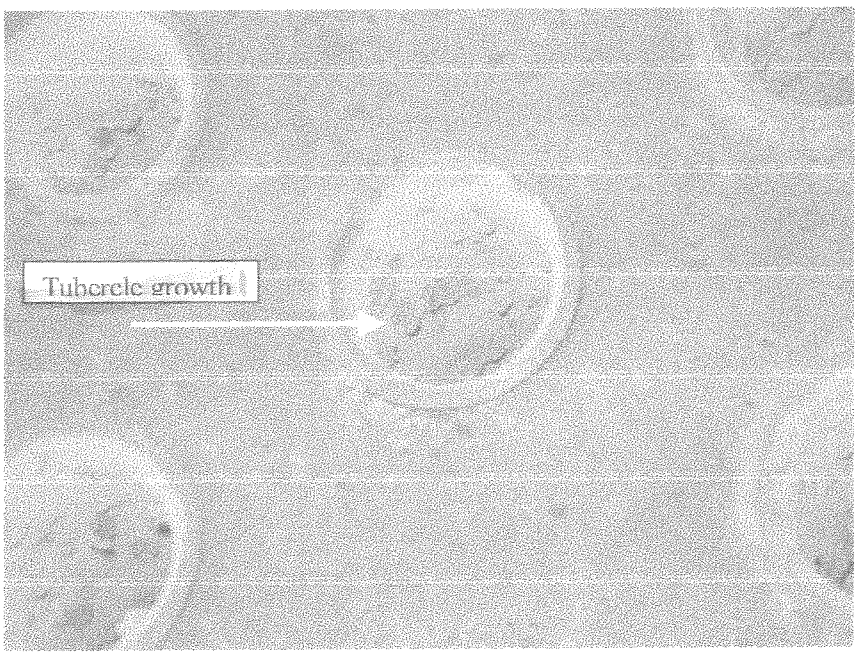


Fig 17.

Steam drum inspection.

Inspection of the steam drum revealed a significant amount of tubercle growth in all tubes. (Fig 18). Mechanical removal of sample tubercles, where accessible, showed the dark oxide from active corrosion. Clearing this oxide away revealed an underlying pit. Substantial numbers of these were noted during the fibre optic inspection of sample tubes in different areas of the boiler.

Fig 18.



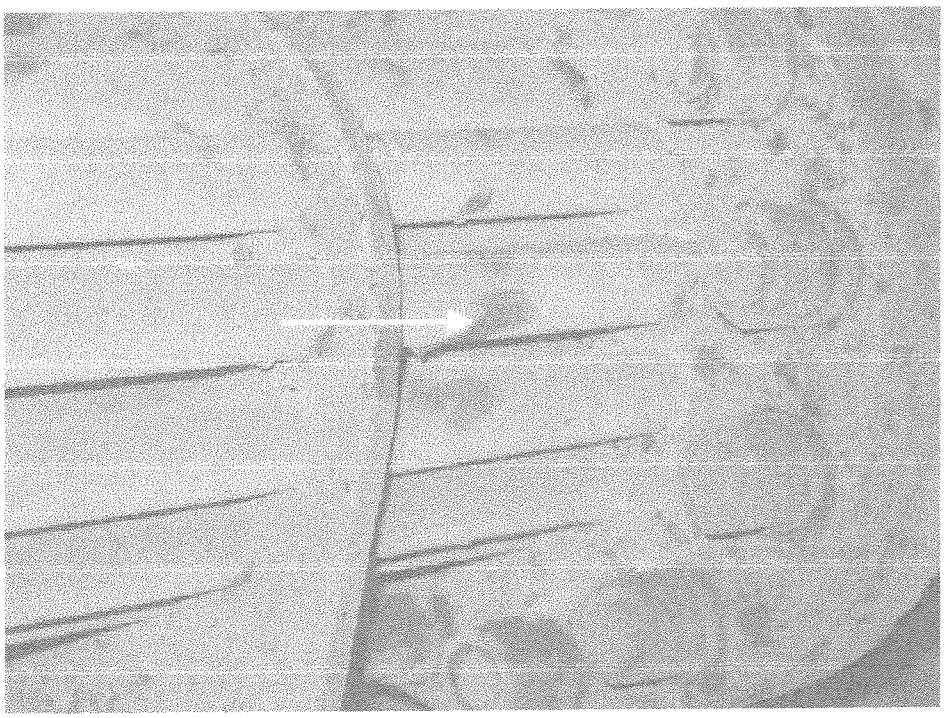
The following tubes were found to be plugged. Locations are referenced from top row, roof tubes:

Row Number	Number of tubes plugged
1	2
2	2
3	1
4	5
5	3
6	3
13	1
14	1
Total	18

Desuperheater.

The control desuperheater located in the steam drum was found to have areas of significant corrosion. The aft end of the inboard tube bundle was found to have an area of deep pitting adjacent to the support plate (highlighted fig 19). One individual pit is approx. 2-3mm in depth.

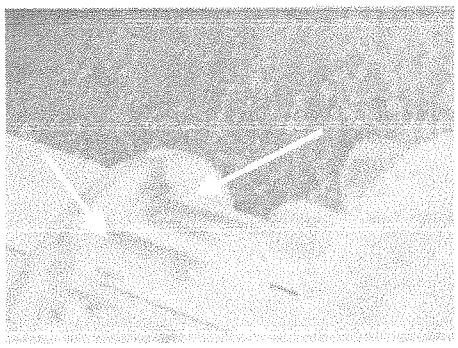
Fig 19.



Also noted in way of the support plate was an area where fretting between tube and support sheet had worn away a portion of the tube (fig 20 & 21).

Fig 20.

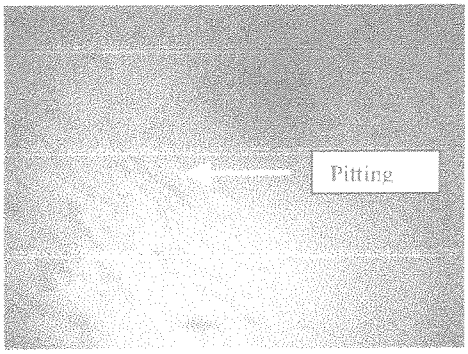
Fig 21.



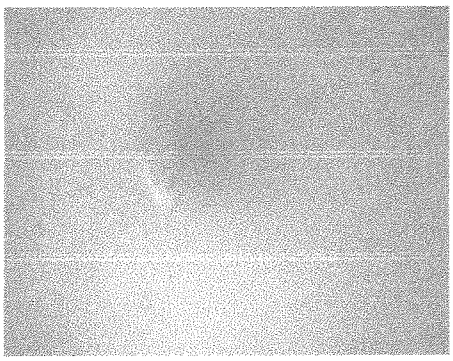
Fibre optic inspection.

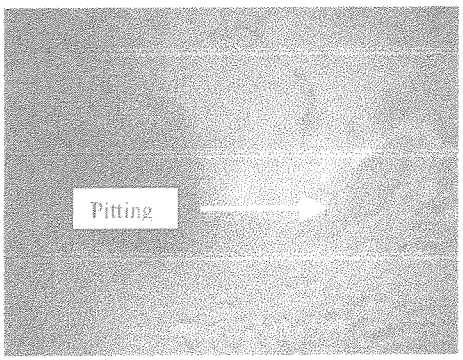
Following are photographs taken with the fibre optic endoscope of the internal surfaces of sample tubes from the following areas:

Roof / side wall tubes.

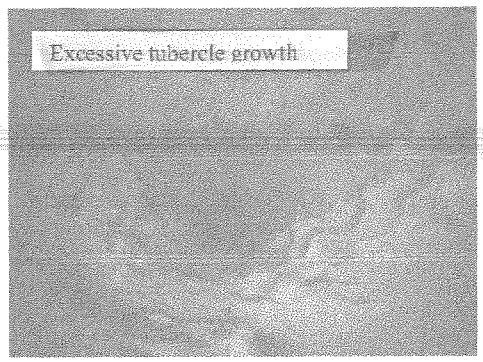


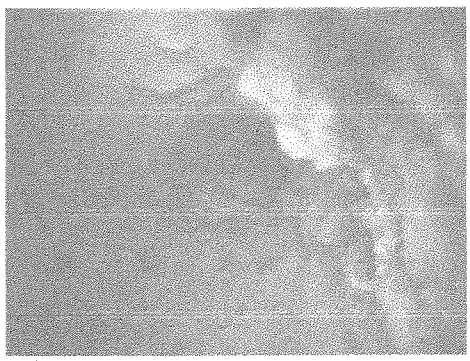
Screen / floor tubes.

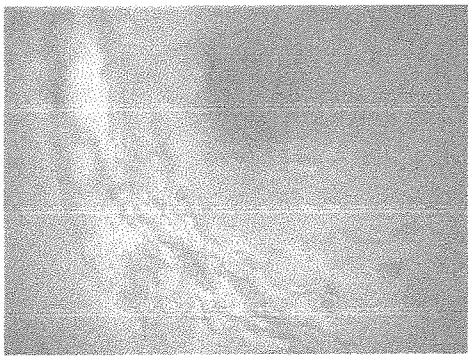




Generating tubes.

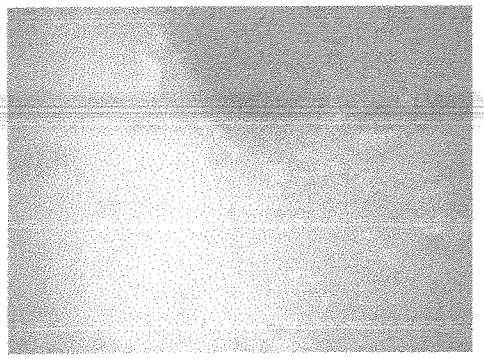






Primary superheater support tube.

Secondary superheater support tube.



Conclusions.

From the inspection of boiler #24 it is apparent that the problems that give concern are in the areas of the furnace and generating areas on both the gas and steam / water side. Problems are also know to exist in the bare tube economiser however this is known to the owners and no access was possible to the internal surfaces of the tubes in this area.

The condition of the tubes forming the furnace envelope clearly indicate that they have been exposed to excessive temperatures. The colour of the tubes where not coated in unburned fuel or combustion products indicates this. Distortion of the tubes can also be seen and this is more notable in the screen wall and generating bank. The distortion in the latter areas has had the effect of closing the gas spaces between each tube, the spaces of which are of utmost importance in providing an even flow path for combustion gasses to leave the furnace. The causes for the distortion found can be considered as a combination of the following:

1. Steam / water side contamination.
2. Incorrect combustion.

In considering item 2 above first, it can be seen on entering the furnace that the combustion process is experiencing problems. Slagging of the furnace refractory has occurred with a significant amount, approx. 80mm thick, breaking away. Slagging is a process where incomplete combustion of fuel allows remaining deposits to soak into the surface of the refractory. The porosity of the refractory determines the rate at which these impurities are absorbed and the depth they penetrate. On shutting down and cooling of the boiler these impurities solidify to give a glass like surface. When the boiler is fired again this area expands at a faster rate than the refractory itself with the result that the contaminated area breaks away. This can be seen to have occurred in numerous areas of the furnace however the break down of refractory forming the burner throats directly affects the combustion process.

In considering item 1 above. To prevent steam / water side deposits from forming is impossible irrespective of what treatment program is in place. Small deposits will always form however it is the control of these that is the key to maintaining the maximum heat transfer through the tubes. The fibre optic inspection revealed a significant deposit of scale on the inside of all tubes inspected. Some tubes, particularly those of the generating bank were found to have considerable deposits on their internal surfaces. These deposits reduce the heat transfer of the tube material and consequently the production of steam is reduced. To counteract this and maintain output it would be normal for the firing rate to be increased to compensate. Further increase in firing subjects the tube material to more prolonged periods of excessive temperatures while at the same internal deposits are increasing as a result of steam blanketing. The combined result of the above is deterioration of the tube material with thermal oxidation taking place and physical distortion. Continued reduction of heat transfer leads to increased gas temperatures across other areas of the boiler and these can lead to other problems developing particularly in the area of the secondary superheater.

The fibre optic inspection also revealed a significant amount of tubercle growth in the tubes of the screen wall and generating bank. This tubercle growth was found in other areas however to a lesser degree. Tubercle growth is a hard covering that covers a site of corrosion. Removal of these where accessible revealed the dark oxide of active corrosion that when cleared revealed pitting. The amount of tubercle growth and pitting found indicates that oxygen corrosion is active in this boiler.

All refractory in the furnace and secondary superheater arcade was found to be in an extremely poor condition. The baffle above the generating bank that is fitted to the steam drum has come away in areas exposing the drum to the full heat of the furnace. The refractory on the rear wall and the front and rear walls in way of the screen / generating tubes has also fallen away in areas. This has exposed the steel casing behind the refractory to the furnace heat and significant distortion has taken place. Distortion and burning of the access door frames in way of the steam drum baffles has occurred due to the break down of the protective refractory. Renewal of the burner wall refractory and reforming of the quarls will significantly improve combustion however it should be considered for a burner study to be carried out.

The condition of the steam drum located desuperheater gives great cause for concern. As highlighted in the report, areas of corrosion were noted particularly at the aft end of the inboard bundle. Severe pitting was noted along with grooves caused by fretting of the tube during expansion / contraction through the tube support baffle. Any failure of the desuperheater bundle will allow slugs of water to be carried back to the superheater. The effect of this would be quenching of the superheater header at the point of return and thermal shock. Evaporation of water droplets will also leave deposits normally washed away during the nucleate boiling process in the generating area of the boiler. Build up of these deposits will occur if any leakage goes unchecked and the problems that can develop are reduction in heat transfer, irregular heat transfer and corrosion.

Please note that access was not possible to the internal surfaces of the primary or secondary superheaters to evaluate the results of any carry over or their internal condition.

The sliding feet, as reported showed no signs of lubrication. These are extremely important parts of the boiler construction and the ability to move during expansion should not be inhibited.

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The sample of scale secured from the steam / water side was analysed in a laboratory with the results as detailed in the relevant section of this report. In summary however the findings indicate a possible condenser problem. The copper content is extremely high and this has the effect of accelerating the corrosion process significantly by purely electrolytic means.

In considering all the foregoing the writer of this report puts forward the following recommendations:

Recommendations.

1. Renewal of the tubes of the screen wall and generating bank.
2. To consider the renewal of the tubes forming the furnace roof, side wall and rear wall.
3. Renewal of all refractory in way of the furnace, burners, generating area, steam drum baffles.
4. Renewal of casings in way of the refractory repairs.
5. Renewal of both tube bundles of the desuperheater.
6. Renewal of the bare tube economiser. (NCL already aware of this item).
7. Sliding feet to be confirmed free and lubricated accordingly.
8. Carry out burner study.

General.

The writer of this report would like to thank the Chief Engineer and his staff for the assistance afforded the survey team during their time onboard.

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