6/5 1: Sendt Chief Eng. + gitt mr Smith

Drew Chemical Corporation One Drew Chemical Plaza, Boonton NJ 07005, 201 263-7600

May 13, 1981

Mr. Svenn Dahl, Senior Vice President
Technical Operations
Norwegian Caribbean Lines
One Biscayne Tower
Miami, Florida 33131

Dear Mr. Dahl,

S.S. Norway - Boilers Number 21,22,23 and 24 - Tube Ruptures

As per your request during my visit to the captioned vessel please find below my report pertaining to the referenced tube ruptures.

After boarding the vessel Mr. Ken Hodgson and this writer contacted your goodself, Mr. Odd Olsen, and Chief Engineer Mr. Fossen, it was at this time that we discussed at some length the problems with the boiler and associated systems of the subject vessel. It was decided that a thorough inspection of the boiler plant would be necessary before any conclusion could be drawn as to the cause of the plant failure.

It was evident from observation that the tubes had failed in distinct groups and a definite pattern had been established. It was further deduced that the tube failure was closely associated with high radiant heat locations within the furnace. To confirm the above observation a straight edge was placed along the angular surface of the burner quarls closest to the side wall, this straight edge aligned perfectly with the failure of the first tube where, it appeared, the most serious damage had occurred. This failure pattern was consistant along both side walls of the boiler. It appeared that the tube failure had occurred in exact alignment with the mid section of the top burner in each furnace row. It is precisely in this vicinity where the highest radiant heat would be expected.

The configuration of the boiler burners were two vertical rows either side of a center line. The first row, outer, consisted of three fires, the second row, inner, consisted of two burners one above the other. The two upper burners of each row both showed considerable buildup of carbon, asphaltene and possibly tramp metallic deposits. It was surmised by one of the vessel's engineers that the deposits would also contain quantities of vanadium, sodium, sulfur and catalytic fines as it was evident that they were present in the fuel oil analysis in quite considerable quantities, i.e. the vanadium in the fuel oil was

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never less than 500 ppm. Indications that the catalytic fines had eroded the atomization orifices of the burner nozzles was apparent and the deleterious effects of this phenomenon was fully explained to all those in attendance at this boiler inspection. This explanation was reinforced at a later time by reference to an article from the Norwegian Scientific Institute describing the effect of catalytic fines in diesel engine injectors. It was further recommended that the boiler burner nozzles be changed at intervals of no longer than two days, replacing the present four day schedule. This recommendation was made in order that the nozzle orifices be plug gauged to verify that the atomization holes remained within specification size.

Inspection of boiler number 22 furnace confirmed those observations made in the first boiler furnace (number 24 boiler).

Inspection of the steam-water drum of number 24 boiler confirmed that an excellent magnetite film existed upon all internal surfaces exposed to view. Several photographs of this boiler drum internals were taken. Superficial trace rust marks were observed, however, these were easily removed by wiping with a lint free cloth thus exposing the desired magnetite surface underneath.

Inspection of those boiler tubes removed also showed a good, firm, well established magnetite film throughout except in the region of tube failure. The surfaces of the steel in the immediate vicinity of tube rupture showed some signs of acid corrosion, high temperature oxidation or a combination of both. An independent analysis of the tube metal in this region confirmed the presence of tramp elements i.e. copper, zinc, and iron. This information was given by the chemist employed to analyze the boiler tube material.

Verification that ingress of sulfamic acid to the boiler feed system had occurred was given by Mr. Fossen, Chief Engineer. This most unfortunate event had occurred during the acid cleaning of one of the plants evaporators, the acid leaking from the seawater side into the steam coils, eventually draining back via the drain lines to the low pressure condensate system, which on S.S. Norway is common with the high pressure steam drain system. From this point the acid together with feed water was taken by the feed pumps to the three onload, steaming, boilers.

By checking with Dr. Libutti of Drew Ameroid Research and Development Laboratories, it was verified that under the physical conditions within the boilers sulfamic acid would most likely dissociate into an ammoniacal compound plus sulfuric acid.

The basic chemical reaction is shown in the equation below:

NH_2SO_3H	$+H_2O$	$\longrightarrow$	NH_3	$+ H_2SO_4$
Sulphamic Acid	+Water	$\longrightarrow$ Heat	Ammonia	Sulphuric Acid

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The above equation indicates that the dissociation under the effects of heat and pressure results in the production of ammonia and sulfuric acid. The production of ammonia, a volatile component, would clearly explain the strong ammoniacal smell experienced in the machinery spaces at the time of the acid contamination. Ammonia, being volatile, would travel through the system with the steam escaping to any point in the engine room where steam pervades the atmosphere. Concurrent to the release of ammonia, sulfuric acid, formed by the dissociation of sulfamic acid, would, by natural circulation be transported with the feed water to all sections of the boiler internals. Classical acid attack of the boiler internals, especially at high radiant heat zones, would follow almost immediately. This acid attack no doubt explains the failure in rapid succession of the three steaming boilers.

Compounding the acid attack is the rapid generation of hydrogen ions at the metal surface. These ions being particularly small atomic particles can penetrate the interstitial crystalline metallic formation of the boiler tube metal. This impregnation of the crystalline lattice can lead to the formation of methane gas at any point where the hydrogen contacts the carbon of the steel. Production of the methane molecule, with a relative size differential from a single hydrogen ion of approximately 20,000 times greater, leads to rapid fissuring of the boiler tube steel. The only method by which this phenomenon can be detected is by analysis of the steel for the presence of methane gas: detection, in the boiler tube steel, of hydrogen ions is physically impossible. The seriousness of hydrogen ion impregnation of boiler tube steel cannot be overemphasized.

Inspection of boiler number 24 steam drum, as mentioned earlier, showed particularly good magnetite film adherence, this excellent well bonded film indicates, superfically, that the boiler internals did not suffer extreme damage except in those areas specifically affected by high radiant heat transfer. It is therefore surmised that further damage will be limited to minimal depletion of the magnetite film. This film can be rebuilt by the addition of Amerzine dosages approximating 50% above normal for three to four weeks.

Drew Ameroid recommendation that each boiler should be filled with town water and 0.5% to 1% solution of GC and circulated for two hours was executed accordingly. This effectively neutralized and passivated the boiler tube steel.

It was further recommended that the ship's staff recommence dosing SLCC-A immediately. Further it was recommended that the evaporators in use be dosed with the recommended quantities of Ameret as per directions provided by Mr. Ken Hodgson some little time ago as this will reduce the chances of having to acid clean again and thereby remove the danger of further acid ingress into the boiler feed system. It is recommended that each of the evaporators be supplied with a dosing system for Ameret in this way Saf-Acid should not thereafter be a necessary part of the cleaning materials aboard this highly sophisticated ship. We recommend that the ship's engine staff pay particular attention to the phosphate test value of the boiler waters, particular attention should also be paid to the pH value of the condensate and boiler waters. Amerzine values should be kept at 50% higher than normal for the next four weeks in order that the black magnetite film lost during the recent accident be restored. It is most important that the phosphate-alkalinity readings be kept in balance with the coordinated phosphate treatment limits as set out in our UltraMarine Pressure Chart. Extra boiler water checks should be made in order to verify this recommendation.

A plug gauge should be made to check the orifice diameter of each of the boiler burner nozzles each time they are overhauled.

It is also felt that it would be prudent policy to carry boiler makers and extra tube plugs for the next month of two. As it is not known to what extent the hydrogen ions have infiltrated into the molecular crystalline construction of the tube metal, further casualties could occur and long term effects are not unknown in this particular type of damage. It is therefore emphasized again that extra care should be taken to keep the water treatment within the prescribed limits.

During our conversations with Mr. Fossen, the chief engineer, it was elucidated that average boiler water makeup per day approached 200 tons. It was further verified the pH of this makeup water was invariably between 5.6 and 6. As the deaerator was found to be in good working order it is surmised that it is this low pH and excessive makeup quantity that dictates the use of 30 liters of SLCC-A per 24 hour period. For this reason we recommend strongly that any, and all, steam leaks in the engine spaces be repaired as soon as possible. This will not only cut down the quantity of makeup feed required but will also limit the consumpsion of SLCC-A. A good point to note here is that although Miami town water costs approximately 50 to 60 cents per ton to make an equivalent quantity of distilled water costs each vessel approximately 8 to 10 dollars. Using 200 tons of distilled water a day at a cost of $10.00 per ton for 350 days in a year, (allow 15 days for docking) a cost adjacent to U.S. dollars 700,000 is incurred. Any cutdown, therefore, in the makeup feed required would be a direct credit to the operating costs of the vessel.

Appended to this letter - report please find the analytical results of water samples from boilers number 21,22, and 23 together with the water samples of evaporator number 11 and number 12. A copy of the field service representative's comments and recommendations are also attached to this document, as are three sets of photographs taken during the visit to the vessel, could you please pass two sets to the Chief Engineer, Mr. Fossen.

It is hoped the above describes clearly our findings at the investigation of the failure of the captioned boilers.

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FIELD SERVICE REPRESENTATIVE REPORT FORM – II

NORWEGIAN CARIBBEAN LINES
MIAMI

Date 5/8/81 (D/M/Y) Location Miami
Vessel S/S Norway (NO) Flag (NO)
Engineers Contacted Mr. Fossen Title C/Engr.
Mr. Odd Olsen Port Engr.
Mr. Svenn Dahl " "

FIELD SERVICE REPRESENTATIVE'S COMMENTS:

Change the water in all boiler's circulate with town water which has a 1/2 to 1% solution of GC. Circulate for two hours this will neutralize any remaining acid in boiler, drain boiler then flush with town water.
Refill with distilled water and dose as per initial dosage for UHP boilers.
Run test every hour till plant settles down.
Pay particular attention to pH values of boiler. Check condensate feed water & feed tanks for pH regularly till all signs of acid disappear.
Keep Amerzine values 50% higher than normal for next 3 to 4 weeks to build back the black magnatite coating lost during recent accident.
Adjunct-B=Phosphate. GC=Alkalinity must be kept in balance with coordinated phosphate limits set out in UHP chart check hourly.
We would also stress it is most urgent that the mechanical problems or dearator be fixed so as to reduce the dosage of SLCC-A, it looks like the nozzles are stuck.
Also evaporators must be put back on line as soon as possible using Ameret as descaler both dosage points to be utilized as per drawing supplied by Drew.
We feel this will reduce chances of having to acid clean and thereby remove danger.
We feel it would be a prudent policy to carry a boilermaker and tube plugs for the next four to six weeks. We still do not know to what extent the hydrogen atoms have infiltrated into the molecular construction of the tube metals, further casualties could occur almost immediately, however long term effects are also a possibility extra care should be taken to keep water treatment within the prescribed limits.

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CHIEF ENGINEER

FIELD SERVICE REPRESENTATIVE

DREW TECHNICAL DEPARTMENT

Distribution: White-Vessel; Yellow-Technical Department; Pink-Supervisor; Blue-Field Service Representative

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