National Transportation Safety Board

S/S Norway Boiler Explosion
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Norwegian Steam Association Report, April 14, 1983
(translated portions)

Evaluation of the Steam Plant Aboard S/S Norway

(14 pages including cover)

[NCL cover letter to Report]
From: Leif Borresen
To: Kaptein Haugen
Date: 28.4.1983

Report from Kjelforeningen Boiler Association
Please find attached the report from Mr. Kraugruds visit on board in connection with the course in water treatment.

The experts from Boiler Association has done an evaluation based on the inspection on board and on the assessment of the received instructions and drawing equipment. This evaluation should be taken into close consideration.

The different technical modifications suggested will be discussed at a later moment when all parts incuded have been given time to study the report.

The quick heating and cooling, with the involved increased danger for microcracks in the *drums* should be taken into special consideration.

During the two last dockings, *micro cracks* were observed in the upper *drum* that required the discharge/effluents (??) after the *class' directions*.

Boiler Association has recently taken into use new and modern laboratories in Oslo where they hold courses in water treatment and water analysis. We would recommend that you plan so that the ship's engineers/machine operators one by one can go through this short course before they return to the ship.

Together with Boiler Association we will have a closer look at the different suggestions, and will if needed consider them incorporated in the *docking specifications*.

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EVALUATION OF THE

STEAM PLANT

ABOARD

S/S NORWAY

NORWEGIAN STEAM ASSOCIATION

Oslo 2, 14 April 1983

Carsten Kraugerud

Senior Engineer

CONTENT:

SUMMARY

Based on Senior Engineer Kraugerud's underway operation evaluation during the period 3/11 – 3/18 this year, and review of drawings and specification which was provided, we have accomplished an evaluation of the steam system Installed aboard S/S Norway.

The review includes an evaluation of the Boiler construction and operational Reliability. Certain details of the plant are also discussed.

The evaluation concludes that the plant has not been subjected to any damage Which have resulted in failure. It should be noted that there is a need to focus On proper operation and maintenance to achieve satisfactory operational Results.

This report concludes further that the boilers should be in good material condition and that the construction of them allow for continued operation and maintenance. One would have to accept the higher operational and maintenance costs compared with modern boilers. With systematic monitoring of the boilers, acceptable operating and maintenance costs may be achieved.

Successful operation of the boilers may be achieved by sensible use and And proper training of the shipboard operating engineers. A enthusiastic Approach of the engineers may be the deciding factor for a good Operating result.

As recommended in the evaluation, there is a number of points regarding The construction which requires improvement to ascertain safe operation Of the boilers. A couple of recommendation to improve safety are provided.

INTRODUCTION

In this evaluation we accomplished a review of the steam plant aboard S/S Norway. The evaluation is accomplished based on information which Surfaced during Senior Engineer Kraugerud's observations during the Underway period 3/11 – 3/18 this year.

During this underway period, Senior Engineer Kraugerud advised the Shipboard engineers of modern water treatment method for steam systems. A number of questions and issues regarding the steam plant operation were Discussed. During these discussions, ongoing operational problem were Brought to light and comments are provided in this evaluation.

Kraugerud inspected the steam plant during the underway period. The result Of the inspection is provided in the evaluation. We received some drawings And specifications of the steam plant which have examined and comments are provided in this evaluation.

The steam plant can be divided into two main part, the

The Boilers
The Steam turbines with the main condensers

The main focus in the evaluation is the Boilers.

If it is desired, we would like to return to the ship for a closer review of The steam turbines. In this case, we will require additional information For the installation.

1. REVIEW OF THE BOILERS CONSTRUCTION AND THE IMPACT ON THE STEAM PLANT OPERATION.

General

We have studies the boilers aboard S/S Norway with great interest, Both aboard the vessel and review of the drawings and specifications.

In reviewing the boilers aboard S/S Norway, we are dealing with boilers that was of recognized type construction in earlier years. It is, therefore, required to take special considerations when operating And maintaining these boilers. In relation to boiler built today, much Emphasis must made on use of available experience when operating This type boilers. When selecting Operating Engineers for these boilers, it would be desirable to select Engineers that view the boiler Operation with dedication and craftsmanship.

It is our opinion that the construction of the boilers is suitable for further operation and maintenance. With adequate precautions , It should be any danger for future total casualties. This is contingent Upon utilizing available experienced personnel and provide the Training available for this type boilers.

The maintenance cost for these boilers will be higher than cost for Modern boilers. A systematic monitoring of the boiler may Keep the maintenance cost at an acceptable level.

The operating cost will be higher when comparing with modern Boilers. The main reason is that the efficiency rating is some 5 percent higher. With proper operation of the boilers, an efficiency rating of 87 percent may be achieved and must be considered acceptable.

The main problem, in our opinion, is sensible use of the boilers. It should be understood that the best operational approach is to Run with optimal load over longest possible time period. The Operating conditions for boilers are not favorable and we will Explain which improvements can be done.

1.2. Boiler load.

Typically the boilers are constructed with three drums of large diameter. The drum walls are thick and the boiler construction Reflects large material weights. When lighting off the boilers, Large masses must be warmed up. If the boilers are warmed up And loaded too fast, substantial heat stress will cause micro Cracking of the drums. We see this as being the main problem. Refitting old boiler with modern burner automation has often Turned out unfavorable. Modern burner automation will vary The boiler load faster that the boiler were designed for. Micro cracking of the drums is often the result and the cracks May be large enough to require drum replacement. We will Discuss this in detail later in this report. We want to point out That even loading at longest possible time intervals will reducing the potential for cracking.

The maximum loading of the boilers is given to be 90 tons/hour. This will give a specific fire box loading at 1,48 MW/m3. This is A very high value with high load in the single tubes in the fire box. It also causes high demand of the re-circulation system. The fire box side wall tubes has poor circulation which has caused Damage. A circulation calculation can clarify this point and provide Recommendation for improvement.

The water level regulators are set to provide a variation of plus-minus 375 mm. The water level should be maintained above the center of steam drum and level variations should minimized.

With the boilers in their present condition, it would advisable to Operate them with moderate and even loads considering the Circulation conditions and the potential cracks in the drums. Considering the fire boxes and the super heat temperatures, Not using water injection, moderate loading is advisable. These conditions will be discussed later in this report.

Our conclusion is that the boiler loading should be limited to 60-75 percent of maximum load. This is some 60 tons steam per hour. If the loading drop much below this load range, the super heat temperature will be impacted and wet steam may affect the LP turbine rotors.

The optimal loading is, therefore, 60 tons/hours and minimal load Variations.

1.3. Boiler super heater.

It is our opinion that the super heater is installed far back in the

Passages and is resulting super heat temperature is affected by The load unless it is regulated. It is undesirable to regulate the Temperature since it affects the boiler loading and access air.

Presently, the steam temperature is regulated by feed water injection In the steam between the first and second sections of the super heater. This method is questionable, the injection water will evaporate totally And hereby leave traces of salt in the feed water. These salt will Accumulate on the heat transfer surfaces and causing corrosion. The feed water injected should be 0,2 uS/cm, which is totally desalted. As per feed water standard used today, the natrium would be at least 10 to high to be suitable for this type of injection.

Another method of controlling the steam temperature would be to install an inter cooler between, this, however, could prove difficult. Another possibility would be to install an external cooler which would Looped between the upper and lower drums.

1.4. Boiler fire box(furnace).

The maximum boiler steam capacity is 90 tons/hour which equates To 1,48 MW/m3. This is a very high value and correspond to 0,5 sec. delay for burner flame out.

The boiler construction allows for relativity large areas of the fire box Which are not cooled. The fire temperature is very high and is very demanding on the fire box brick maintenance. The high load and poor cooling of the fire box is causing slag deposits. For this reason, as addressed above, it is not recommended to operate the plant above 60-75 percent of maximum load.

1.5 Boiler burners. Sooth problems.

Each boiler is fitted with 5 burner each including air and fuel regulators. In considering the unsymmetrical positioning of the oil burners, good combustion may be difficult to achieve(0.5 sec. at maximum loading). To obtain favorable combustion much maintenance work must be done. Centering of the burners in the registers are required. With so many burners installed, it may be insufficient combustion air throughout the fire box and sooth will accumulate. It is our observation that it may be beneficial to initiate cost analyzes for installation of a new arrangement with fewer burners. Much better burner are available on the market which could be used replace the existing burners.

Release of sooth from steam plant depends on the following conditions:

A) Oil burners and adjustments.
B) Fire Box loading and combustion delay.
C) Fire room geometry.
D) Quality of the fuel.

A, B and C above are very unfavorable on Norway's steam plants. In Item D above, the quality of "Bunker C" have changed over the last years. Increase of the fire room volume is required along with using burners which can adjusted individually to minimize sooth accumulation.

It is our understanding that it will difficult to correct A, b and C above. It would a better approach to replace the burner equipment. The sooth accumulation may minimized by using water emulsion burners. Fuel additives may also help.

1.6. Boiler steam drums. Water separation.

The steam drums are not fitted with cyclones or demisters. The drums are of large diameter, but good water separation equipment in the drums is essential. Related to the circulation calculation of the boilers, A study to for installation of this equipment may prove beneficial.

1.7. Conclusion.

In our opinion and in interest of improving the steam plant operation, it is recommended to continue working on the following points:

A) Accomplish new circulation calculation to correct critical points.
B) Investigative replacement of the burner equipment.
C) Investigate installation of an external indirect super heater to regulate the steam temperature.
D) Investigate installation of demisters in the steam drums.

2. REVIEW OF BOILER OPERATIONAL SAFETY

2.1. General.

After a close review of the boiler construction and have inspected the circumstances onboard, we don't see any reason for the boilers to sustain any failure from to would lead to a total loss of the boilers.

It should be understood, however, that the construction and installation is from earlier years, and the boiler operation and maintenance must be done accordingly. Investigations will show that most boiler failures are caused by insufficient water level. In the following, we will address some view point in regards to water level controls.

Another common reason for boiler failures is damage from corrosion and scale accumulation. It also important that the boiler are properly laid up when they are placed out of service.

When lighting off a steam plant, initial acid treatment following by proper treating of the water is required.

The Following need to be achieved:

A) Establish satisfactory mechanical conditions.
B) Establish satisfactory chemical and electrochemical conditions.

In reference to A, the boiler's construction and even loading is of importance.

Rapid load changes may result in micro cracking of the drums which may later result in large cracks and the drums will eventually have to be replaced. This may well happen to the boilers aboard S/S Norway. We believe that the spare drums which are onboard should remain there for future use as drums may not be repaired and will have to be replaced.

Establishment of proper chemical and electrochemical values are contingent upon proper boiler water treatment. We will take closer at the water treatment methods onboard and provide recommendations.

2.2. Water level control.

As per the information provided to us, Watch keeping of the steam plant is bases on a Third Assistant Engineer standing watch in the fire room. The boilers are equipped with automatic water control system which is provided by Siemens and is two point regulating system. As mentioned earlier, the water level variation is plus – minus 375 mm. In considering the side wall single tubes, the water level should be Maintained slightly above the center of the drum and water level variations should be minimized.

It is our understanding that this installation do not meet the E0 certification from Veritas. The Siemens units are a single control

Unit which trips at high or low water levels. The only other means of Monitoring the water level is the sight glasses on each boiler.
It is our opinion that only one water level control system may a single failure point and that that operating personnel should be to see the water level sight glasses from their normal watch standing station.
The sight glass are not fitted with the green and red sectors which is the case on a modern boiler installation. It is recommended that existing sight glasses are replaced with a new type which is manufactured by the YARWAY Company.

2.3. Production of feed water.
Feed water for the boiler are made by four shipboard evaporators of which two are bi-evaporators for water quality improvement purposes. We have not had the opportunity to examine the water quality closely, but the water quality is poor as per the readings taken onboard. Modern low pressure evaporators will produce distilled water of higher quality.

It is our opinion that the existing evaporator installation may contribute to a catastrophic boiler failure. We have not looked at operational economic factor of the evaporators, but they producing some 700 – 800 tons per day of which is consumed by hotel services and sanitary use. We see lack of adequate water as urgent matter and should be improved soonest. One alternative is to provide water for hotel and sanitary need from seawater using reverse osmoses units. The boiler Feed water could then be made by a smaller evaporator which should improve the water quality.

We feel the existing method of producing fresh water for boiler feed And other uses is very costly and risky. New methods should be explored at the earliest opportunity.

2.4. Treatment of feed water, boiler water and condensate.
The water treatment is done by using "Ultra Marine Boiler water treatment" from Drew Chemical. This system is intended for Turbine Plants with pressure up 64 Bars and is well suited for the steam plant and turbine installation aboard S/S Norway. An examination of water treatment program onboard proved satisfactory and all test results were properly logged.

Several details were noted and are as follows:

A) It is vital for the water treatment that water sample analyzes are done correctly. The analyses and sampling equipment are somewhat primitive and it be good to obtain modern equipment such as photo electric comparators etc. from Drew Chemical. New modern equipment is not dependent upon Engineer's ability to see colors. We may be able to assist in this matter if desired.

B) Training of operating personnel in proper water analyzes techniques is of great importance. We recommend that all engineers onboard S/S Norway to attend a 2-3 days training course in modern day analyzes and basic boiler water treatment for steam plants.

C) The control of salinity in boiler water and condensate is of great importance. The equipment use aboard S/S Norway was inadequate for this purpose. Equipment upgrade is needed soonest.

2.6

According to our opinion one should continue the work to improve safety of the damp kettels production with the following points:

A:
It should be undertaken a closer evaluation of the running of the damp kettle plants so that one can obtain as equal loads as possible.

B:
It should be undertaken a closer explanation/report of the water level control. The ”water level glasses” should be exchanged with modern ”water level glasses” which tells if the glasses are full or empty with the use of colours.

C:
It should be undertaken a closer evaluation of the production equipment for ”mate” (delivery/feed) water. It seems most relevant to produce sanitarywater from sea water with the use of equipment based on reversed osmosis. The need for ”mate”(delivery/feed) water for the damp plant can be covered with a low pressure evaporator system. To be able to obtain perfect ”mate” (delivery/feed) water one would have to consider to polish the evaporated water by using a softening installation/system.

D:
It should be undertaken a closer evaluation of the possibilities of obtaining more modern equipment for analysis of the water treatment.

E:
It should be undertaken a closer evaluation of the importance of the training of the machine operators. A 2-3 days introduction course seems to be a relevant.

F:
It should be undertaken a closer evaluation of whether or not there should be installed a conductivity meter to be able to control the damp quality.

G:
It should be undertaken a closer evaluation of whether one should obtain dosage equipment for continious dosing phosphate on ”the drums”, as well as mydrazinhydrate in the ”mate” (delivery/feed) water pipes.

H:
It should be undertaken a closer evaluation of the possibilities of obtaining equipment for constinious blow off of the kettels’ damp drums.

3. EVALUATION OF THE STEAM TURBINE INSTALLATION AND THE MAIN CONDENSERS.

3.1. General.

As mentioned earlier, we have very little information regarding the steam turbine installation. Kraugerud did not have much of an opportunity to study them during the underway period. The following is some comments regarding the installation which we Reasonable and should be address here.

3.2. Monitoring of turbine pressure drop.

The Siemens monitoring and alarm system installed in the engine control room will read the steam pressure drop across the turbine. The system did not monitor the pressure drop over each stage of the turbines which we view as a deficiency. It is important that the Operators stay within the given pressure and temperature range. The turbines is equipped with a trip valve which will stop the turbine if the axial movement of the rotor is excessive. The turbine is also fitted with a high shut down feature.

Oslo 2, 14 April 1983

NORWEGIAN STEAM ASSOCIATION