TECHNIUM

*Technium Vol. 18, pp.14-22 (2023)*
*ISSN: 2668-778X*
*www.techniumscience.com*

# Analysis of Internal Boiler Water Treatment Maintenance System on Boiler Operation in KM. BUKIT RAYA

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**Abstract**. Boilers are auxiliary machines on ships that are usually used to produce pressurised steam that is needed on ships, namely for heating fuel, lubricating oil, and heating water for accommodation and machinery. In the operation of boilers on ships, it is determined by the quality of water to produce good boiler performance. The purpose of this research is to analyse the boiler water treatment system to determine the quality of ship boiler water using water quality testing standards based on the American Society Mechanical Engineer (ASME). Standard parameters set by ASME are pH and conductivity measurements, Alkalinity measurements, Hardness measurements, Silica and iron measurements in ship boiler water KM. Bukit Raya. From the results of the analysis of boiler water taken from sampling feed water boilers on ships KM. Bukit Raya shows the results of the analysis of boiler water on pH with the measured pH value still in the standard set by ASME, namely 10.5-11.5, boiler water analysis of hydrate alkalinity in samples 1,2,4 is still within ASME standards 200 - 400 ppm while the measurement of hydrate alkalinity exceeds the standard set by ASME of 420 ppm, excessive hydrate alkalinity will cause scale formation, boiler water to calcium obtained for samples 1-3 still meet ASME standards, namely trace, analysis of boiler water to Magnesium obtained for samples 1-3 still meet ASME standards, namely trace, analysis of boiler water to silica obtained silica measurements are still within the standards set by ASME 150 max.

**Keywords**. Boilers, ASME, standard parameters.

## 1. Introduction

The boiler is a machine used to produce very high pressure steam[1] and is needed on ships, including for heating fuel, lubricating oil, and heating water for accommodation and machinery. This boiler is a closed vessel that can produce hot steam[2] with a pressure greater than one atmosphere, by heating the water in the closed tube with hot gas media resulting from the combustion of a mixture of fuel and air when the ship is on a voyage or when the ship is anchored. To be able to produce steam, the boiler really needs a heated medium, namely fresh water. The water used in the steam generation process greatly affects the condition of the boiler[3]. Thus, the quality of water must be considered and maintained so that it is always in good condition, so that the boiler will always be in good condition too.

The water pipe boiler requires a better quality of filling water compared to the fire pipe boiler because evaporation in the water pipe boiler occurs in a fast time, so if the quality of filling water is not good, the level of impurities contained in the water will settle at the bottom of the water drum and can slow down the steam generation time. The availability of hot steam is essential for the smooth operation of machinery that requires it, for example for F.O. fuel heating, lubricating oil heating, accommodation heating during the cold season, fresh water heating, and others. Shipping activities can be disrupted if the production of hot steam experiences problems, due to the influence of poor equipment and work of boiler components or other causes that cause the boiler to experience interference. In reality, steam boilers often experience disturbances, as has happened on board KM. Bukit Raya ship owned by PT Pelni (Persero). If this is not resolved immediately, it will affect the condition of the boiler, such as the emergence of scale on the pipes in the steam drum so that it can slow down the steam generation time, and the company will incur additional costs for the addition of Chemical Dosing. Motivated by the difference between theoretical statements that differ from the reality that occurs, the authors are interested in conducting research with the title "Analysis of the Internal Boiler Water Treatment Maintenance System in the Operation of the KM. Bukit Raya Ship Boiler ".

Some relevant research results are studies that conduct pH analysis using a pH meter and alkalinity analysis using the acid-base titration method where H2SO4 and 0.02 N solutions are used as standard solutions. Based on the analysis conducted on the boiler feed water of Ajamu, Air Batu and Pabatu PKS, the pH is 8.27; 8.54 and 8.40 respectively. And for total alkalinity, 13.6; 17.6 and 12 ppm respectively. The results of pH and alkalinity analysis in boiler feed water already meet the quality of boiler water standards set according to SNI 06-6989-11-2004. Another study found that boiler performance can be maintained with proper water treatment plant should be installed to ensure water purity, and a number of chemicals should be added for subsequent boiler feed water quality control and blowdown implementation should be reset when there is an increase in concentration beyond the allowable limit as set by the manufacturer and Alkalinity should not exceed 20% of the total concentration.

## 2. Methodology

### *2.1. Research Type*

This research uses descriptive research type with quantitative approach. Quantitative research methods are based on the philosophy of positivism, used to research on certain populations or samples, data collection using research instruments, data analysis is quantitative / statistical, with the aim of testing predetermined hypotheses. Quantitative research method is a scientific approach that uses numerical and statistical data to measure, quantify, and analyse phenomena[4]. Quantitative research revolves around collecting data that can be measured quantitatively, such as surveys, experiments, or secondary data analysis[5]. The goal is to identify patterns, relationships, and trends that can be statistically tested. This method focuses on generalisation and objectivity, allowing researchers to draw conclusions that are based on quantitative evidence. Quantitative research is often used in social sciences, economics, natural sciences, and various other fields. It provides a solid foundation for data-driven decision-making, problem-solving, and scientific research.

Descriptive research is research conducted to determine the value of independent variables, either one or more (independent) variables[6] without making comparisons, or connecting with other variables. Descriptive research is a research approach that aims to describe or explain the characteristics or nature of a phenomenon or population without manipulating certain variables[7]. This research focuses on data collection and in-depth analysis to identify patterns, relationships, or certain characteristics in a context. The goal is to provide a clear picture of what is being observed. Data collection methods commonly used in descriptive research include surveys, observation, case studies, and documentation analysis[8]. The results of descriptive research produce in-depth descriptions, allowing for a better understanding of the phenomenon, and are often used as a basis for further research or decision-making.

Based on this theory, quantitative descriptive research is data obtained from a sample of the research population analysed in accordance with the statistical methods used[9]. Descriptive research in this study is intended to obtain a description and information about the boiler water treatment programme on board KM. Bukit Raya. The research object focuses on the implementation of the water treatment boiler programme for ship operations on KM. Bukit Raya.

### 2.2. Research Data

The types of data used in this study are primary data and secondary data[10]. Primary data is data obtained directly from the object under study[11]. Primary sources are data sources that directly provide data to data collectors. Secondary data is a data source that does not directly provide data to data collectors, for example through other people or through documents[12]. Secondary data, among others, is presented in the form of data, documents, tables on research topics. This data is data that is directly related to the research being carried out.

### 2.3. Data Data Collection Technique

Data collection techniques are the means used by researchers in collecting their research data[13]. Based on this understanding, it can be said that the research method is a method used to collect the data needed in research. The techniques used to collect data in this study are (1) Interview, the interview method is a process of direct interaction between the researcher or interviewer[14] and the respondent or research subject. Interviews can be conducted in the form of structured interviews (certain questions have been prepared in advance) or unstructured interviews (free discussion). Interviews can be conducted face-to-face, over the phone, or via video. The interview method is a question used to obtain information from respondents related to research material, in this case the boiler water treatment programme on board KM. Bukit Raya. (2) Documentation, the documentation method is to search for and collect data on things in the form of notes, transcripts, books, newspapers, magazines, minutes, reports, agendas and so on from various types of documents or written sources[15]. The purpose of this data collection technique is to collect data that already exists or has been recorded previously for use in analysis or research. By using this technique, researchers can utilise and analyse existing data to support their research or analysis. Documentation in this case is related to the maintenance programme and bolier operation on board KM. Bukit Raya. (3) Observation, the observation method is a complex process, a process for making observations of the object of research related to water treatment boilers on board KM. Bukit Raya. Observation involves direct observation of the behaviour, event, or situation to be studied. Observation can be participatory (the researcher gets involved in the observed event) or non-participatory (the researcher only observes without getting involved).

### 2.4. Research Methods

ASME (American Society of Mechanical Engineers) is a professional organisation that develops engineering standards and guidelines for various aspects of industry, including mechanical engineering[16]. ASME has various standards that are used in the machinery and manufacturing industry to ensure the safety, reliability, and efficiency of machinery and equipment systems. ASME focuses more on technical standards, engineering codes, and best practices for engineers and engineering professionals. However, ASME has many technical committees that develop standards related to various aspects of mechanical engineering, and some of these standards can be used in a research and development context. Examples of ASME standards relevant in research include ASME B31.1 (Engineering Standard for Electrical Energy Piping), ASME Boiler and Pressure Vessel Code, and many others. So, while ASME is not a research method, the organisation has standards and guidelines that are important in the mechanical engineering discipline, which can be used as references in research projects involving mechanical engineering equipment and systems. This research was conducted by analysing several boiler water samples taken from the KM. Bukit Raya ship owned by PT Pelni (Persero) in accordance with the standard parameters set by the American Society Mechanical Engineer (ASME), namely (1) Measurement of pH and conductivity, pH and conductivity measurements are carried out by inserting boiler water into a glass beaker dipping the pH and conductivity meter to the limit of the tool. (2) Alkalinity measurement, alkalinity measurement begins with putting 25 ml of sample water into Erlenmeyer, then drop 2-3 phenolphthalein indicator. If red P.Alkalinity (ppm $CaCO_3$ = 0), if red titrated with 0.02 N $H_2SO_4$ solution until coloured P.Alkalinity (ppm $CaCO_3$ = 0) = ml titrant x 40 drop 2-3 drops Total Alkalinity solution will be green. Then titrate with 0.02 N $H_2SO_4$ solution until it turns a greyish red colour where total alkalinity (as ppm $CaCO_3$ = total ml x 40). Hydrate alkalinity (as ppm

$CaCO_3$ = total ml x 40, 2 P.alkalinity - Total Alkalinity. (3) Hardness measurement, the total hardness of the boiler water sample to be tested contains a lot of suspended solids filtered first, measure 25 ml of sample and pour into a titration cup. Adding 5 drops of total hardness buffer then stirred, then added 1 tablet total hardness indicator stirred. If the solution is blue in colour it means the total hardness is zero and Calcium Hardness measurement is not necessary. If reddish or purple means there is hardness and continued by filling the burette with 0.02 EDTA solution titrating the sample with EDTA solution with stirring until the red colour disappears read ml of EDTA titrant solution. Total Hardness (ppm $CaCO_3$) = ml titrant x 40. Calcium hardness analysis of 25 ml boiler water sample in Erlenmeyer (titration cup), adding 5 drops of calcium hardness buffer reagent and adding 1 pin calcium indicator powder (table calcium indicator). If a burgundy colour is visible, then continue titration with versenate solution until blue. Calcium hardness as ppm $CaCO_3$ = ml titrant x 40. Magnesium Hardness Analysis Magnesium Hardness = Total Hardness - Calcium Hardness. (4) Silica measurement, silica measurement begins with filtering 50 ml of boiler water sample first then do 10 times dilution, namely 10 ml of water sample plus demin water to a volume of 100 ml. Enter 25 ml of water sample into a 40 ml cell. Put 25 ml of demin water as a blank into another cell. Add 3 ml each of silica acid reagent stir and let stand for 10 minutes. After 10 minutes add 1 spatula full of sodium citrate and stir. Place the sample cell on the right side and the blank cell on the left side of the reading disc. Rotate the reading disc until it gives the same colour as the water sample, reading ppm silica on the reading disc. For solutions that are diluted 10 times ppm silica = 10 x reading on the reading disc. If not diluted directly do the reading on the reading disc. Place on the hole on the left. Rotate the color disc so that it gives the same colour to both observation slits, reading the iron concentration listed. (5) Iron Measurement, the purpose of measuring iron in boiler water is to ensure the safe operation of the boiler, maintain good water quality, extend the service life of the equipment, and avoid corrosion problems and equipment damage that can negatively affect the performance and efficiency of the heating system. The main purpose of iron measurement is to monitor the iron level in the boiler water. High levels of iron can cause corrosion of the boiler system and pipework, potentially damaging equipment and reducing their service life. By monitoring the iron regularly, preventative care can be taken to control corrosion. Iron measurement is also necessary to ensure that the boiler water complies with established safety and performance standards. Certain standards may set a maximum limit of iron allowed in boiler water, and these measurements allow boiler operators to ensure that they are meeting those regulations. The iron content measurement begins by filling the observation tube with boiler water to the 5 ml limit mark, adding 1 ampoule of ferrover iron and pouring the entire contents into the water sample shaking the tube to mix well. If the sample contains iron the water will turn orange in colour. Insert the observation tube in the hole on the right. fill the other observation tube with clear water and place it in the hole on the left. Rotate the color disc so that it gives the same colour in both observation slits, reading the iron concentration listed.

## 3. **Results and Discussion**

### *3.1. Boiler Water Analysis*

From the results of the analysis of boiler water on KM. Bukit Raya ship with reference to the American Society Of Mechanical Engineers (ASME) Standard carried out from several samples at different times tested in a chemical laboratory that analyses the boiler water using the ASME method, it can be concluded that this study has undergone a series of tests on several boiler water samples taken in different time spans. The testing process was carried out in a chemical laboratory in accordance with the protocols and guidelines set out in the ASME standard. The ASME method is used as the main foundation in this analysis process, covering sample collection techniques, measurement of water quality parameters, and overall evaluation of the ship's boiler water condition. The analysis results obtained are very important in monitoring and ensuring the quality of boiler water that meets the safety and performance standards of the ship. Thus, the application of the ASME method in the analysis of boiler water on board KM. Bukit Raya maintains the integrity of the boiler system, prevents operational problems, and supports the overall efficiency of critical ship operations in sailing in different waters.

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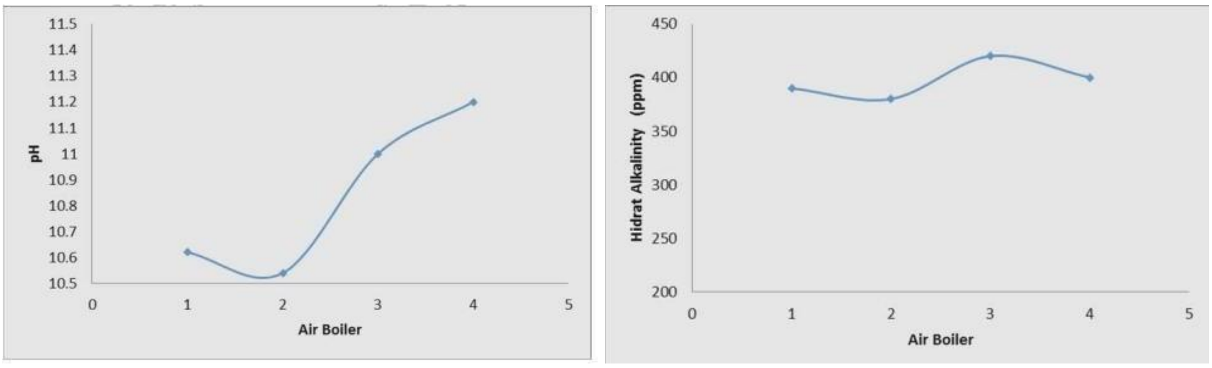
**Table 1.** Boiler Water Analysis Data

| No | Parameters | Air Boiler | | | | Control Limit ASME |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| 1 | pH | 10.42 | 10.64 | 11.23 | 11.15 | 10.5-11.5 |
| 2 | Hidrat Alkalinity (pppm) | 380 | 375 | 415 | 395 | 200-400 |
| 3 | Calcium (ppm) | Not detectable | Not detectable | Not detectable | 6 | Not detectable |
| | Magnesium (ppm) | Not detectable | Not detectable | Not detectable | 4 | Not detectable |
| | Total hardness | Not detectable | Not detectable | Not detectable | 10 | Not detectable |
| 4 | Silica (ppm) | 110 | 100 | 80 | 217 | 150 max |
| 5 | Fe (ppm) | 0.60 | 1.0 | 0.8 | 1.2 | 1.0 max |
| 6 | Conductivity (micromhos /cm) | 3000 | 2500 | 2000 | 3500 | 3000 max |

*3.2. Discussion*

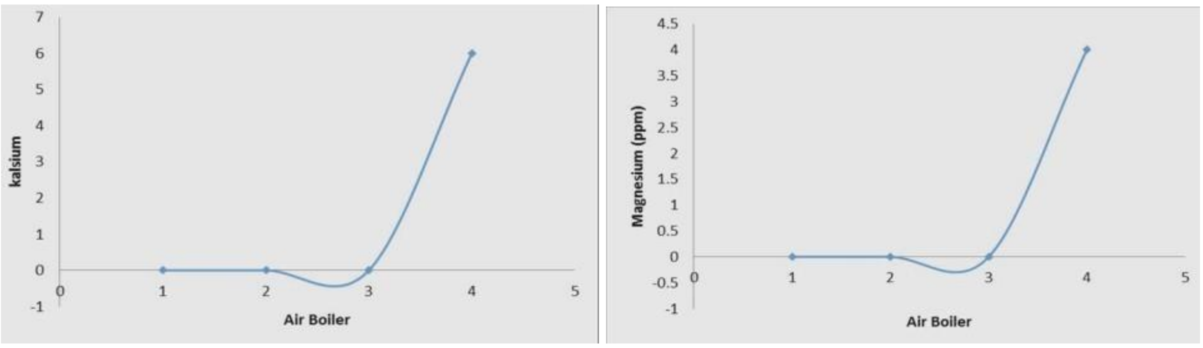
Graph analysis of boiler water against pH as shown in Figure 1a, the measured pH value is still at the standard set by ASME, which is 10.5-11.5 if the pH is below or above the set standard, the corrosion rate is getting bigger, so it is necessary to add Alkali booster so that the pH rises and if the pH is above the set standard then do blow down so that the pH of the water drops.




(a) (b)

Figure 1. Graph of Boiler Water Analysis Against
(a)pH dan (b)Hidrat Alkalinity

In Figure 1b graph of boiler water analysis of hydrate alkalinity in samples 1,2,4 is still within ASME standards 200-400 ppm while in sample 3 obtained hydrate alkalinity measurement of 420 ppm this exceeds the standards set by ASME hydrate alkalinity excess cause of scale formation. Where the constituent alkalinity of bicarbonate anions (HCO3-), carbonate (CO3 2-) and hydroxide (OH-) where the influence of bicarbonate anions is very large in the formation of scale.




(a) (b)

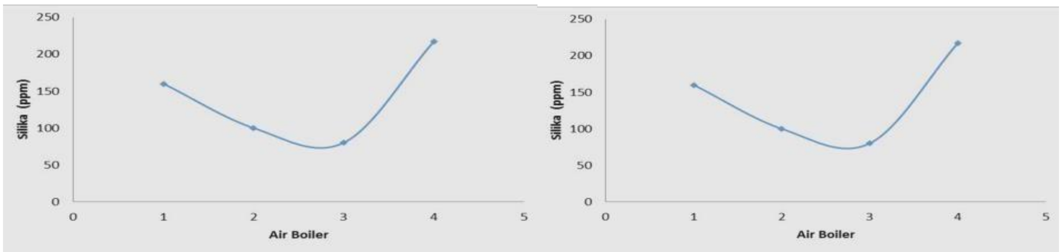
Figure 2. Graph of Boiler Water Analysis Against
(a)Calcium dan (b)Magnesium

Analysing boiler water for calcium is an important step in monitoring water quality in boiler systems. Calcium is one of the minerals that can be found in water and is usually present in the form of calcium carbonate (CaCO3)[17]. Analysis of calcium in boiler water usually involves water sampling, laboratory testing, and interpretation of the results. With good monitoring and analysis, boiler operators can maintain good water quality, prevent problems such as scale formation, and keep boiler performance and efficiency in optimal condition. Calcium analysis in boiler water has several purposes and benefits including scale prevention, chemical compaction treatment, and water quality evaluation. In Figure 2a graph of boiler water analysis of calcium obtained for samples 1-3 still meet ASME standards, namely trace, while in sample no.4 calcium detected at 6 ppm this is due to the processing of boiler feed water in the softener unit which is a tool that functions to bind Ca2 + ions in a saturated state so that Ca2 + ions can escape where calcium that escapes can cause crust or deposits in the boiler so it needs to be removed if calcium escapes into the boiler. The addition of phosphate chemicals in the boiler functions to bind calcium ions into soft deposits so that they do not become crust or deposits. The deposits formed can be directly disposed of by blow down.

Analysis of boiler water for magnesium is one of the important steps in monitoring water quality in boiler systems. Analysis of magnesium in boiler water typically involves water sampling, laboratory testing, and interpretation of the results. With good monitoring and analysis, boiler operators can maintain good water quality, prevent problems such as scale formation, and keep boiler performance and efficiency in optimal condition. Magnesium is one of the minerals that can be found in water. Magnesium, along with calcium, is one of the main components that can lead to the formation of scale or mineral deposits called "scale" on heating surfaces in boilers. Magnesium analysis helps in monitoring the level of magnesium in water and allows for suitable preventive measures to control scale formation. The concentration of magnesium in water can also affect the hardness of the water. Hard water can lead to problems such as scale formation and corrosion in boiler systems. Magnesium analysis helps in evaluating the level of water hardness and overall water quality. In Figure 2b graph of boiler water analysis of magnesium obtained for samples 1-3 still meet ASME standards, namely trace, while in sample no.4 detected Magnesium of 4 ppm this is due to the processing of boiler feed water in the softener unit which is a tool that functions to bind Mg2 + ions in a saturated state so that Mg2 + ions can escape where magnesium that escapes can cause crust or deposits in the boiler so it needs to be removed if magnesium escapes into the boiler. The addition of phosphate chemicals in the boiler functions to bind calcium ions into soft deposits so that they do not become scale or deposits. The deposits formed can be directly disposed of by blow down.

Analysis of boiler water for silica is an important step in the monitoring of water quality in boiler systems. Silica is a chemical compound that can be found in water and has a potentially significant impact on boiler operation[18]. Analysis of silica in boiler water typically involves water sampling, laboratory testing, and interpretation of the results. With good monitoring and analysis, boiler operators can maintain good water quality, prevent problems such as scale formation, and keep boiler performance and efficiency in optimal condition. Silica analysis is an important part of preventive maintenance and effective boiler management. High silica levels in boiler water can lead to the formation of silica scale on boiler heating surfaces. Silica scale is a hard, solid deposit that can reduce heat transfer and heating efficiency. Silica analysis helps in monitoring the silica concentration in the water and enables suitable preventive measures to control scale formation. In Figure 3a graph of the analysis of boiler water against silica in samples 1-3 obtained silica measurements are still within the standards set by ASME 150 max but in sample 4 obtained silica levels of 200 ppm this exceeds the standards set by ASME to reduce silica levels by blow down, namely removing the boiler water contained in the boiler where silica in the boiler undergoes a cycle the longer the silica levels will be greater if it has exceeded the limits set by ASME then the water vapour will be carried into the process or also often called carry over.

Analysis of boiler water for iron (Fe) is an important step in monitoring water quality in boiler systems. Iron is one of the minerals that can be found in water. Analysis of iron in boiler water usually involves water sampling, laboratory testing, and interpretation of the results. With good monitoring and analysis, boiler operators can maintain good water quality, prevent problems such as corrosion, and keep boiler performance and efficiency in optimal condition. Iron analysis is an important part of preventive maintenance and effective boiler management. Iron in boiler water can cause corrosion or damage to boiler components, including pipes and heating surfaces. Corrosion caused by high levels of iron can reduce equipment life and affect boiler performance. Iron analysis helps in monitoring the level of iron in water and enables suitable precautions to control corrosion. In Figure 3b the graph of boiler water analysis of Fe in samples 1-3 already meets the standards set by ASME but in sample 4 Fe levels are obtained exceeding the standards set by ASME Fe residues that exceed the set limits can cause corrosion of the boiler, the use of oxygen scavenger chemicals that function to bind oxygen that escapes into the boiler by adding Sodium Sulfite so that no corrosion problems occur in the boiler because Sodium Sulfite will react with oxygen to form sodium sulfate deposits.




(a) (b)

Figure 3. Graph of Boiler Water Analysis Against
(a)Silica dan (b)Fe

In Figure 4 graph analysis of boiler water on conductivity obtained in samples 1-3 already meet the limits set by ASME is 3000 (micromhos/cm max but in sample 4 obtained conductivity of 3500 (micromhos / cm this is due to the initial content of conductivity in the boiler feed water is high so that the boiler will experience a cycle which can increase the conductivity that can cause flooding and carry over in the boiler this can be reduced by removing boiler water or blow down.

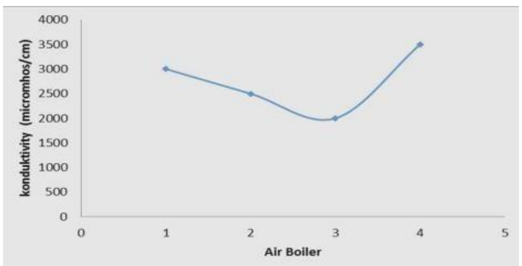



Figure 4. Graph of Boiler Water Analysis Against Conductivity

### *3.3. Results*

From the results of the analysis of boiler water taken from the boiler feed water sample on the KM. Bukit Raya ship obtained the results of the boiler water analysis graph of pH according to Figure 1a measured still in the standard set by ASME, namely 10.5-11.5. In Figure 1b Graph analysis of boiler water against hydrate alkalinity in samples 1,2,4 still within ASME standards 200 - 400 ppm while in sample 3 obtained hydrate alkalinity measurement of 420 ppm this exceeds the standards set by ASME hydrate alkalinity excess cause of scale formation. In Figure 2a graph of boiler water analysis of calcium obtained for samples 1-3 still meet ASME standards, namely trace. In Figure 2b graph of boiler water analysis of Magnesium obtained for samples 1-3 still meet ASME standards, namely trace. In Figure 3a graph of boiler water analysis of silica in samples 1-3 obtained silica measurements are still within the standards set ASME 150 max.

## 4. Conclusion

The results of several samples taken on boiler water samples used on board KM. Bukit Raya owned by PT Pelni concluded that the quality of boiler water in samples no.1 to no.3 has met the standards set by ASME, while the results in the 4th sample show the average value of the boiler water samples analysed exceeds the standards set by ASME as can be seen in the Hardness levels, namely Calcium chemicals worth 6 ppm and Magnesium with a value of 4 ppm. Silica 217 ppm, Conductivity 3500 (micromhos/cm, Fe 1.2 are still above the control limit. The provision of chemical-based liquids in the form of H3PO4, NaOH, Oxygen Scavenger, and blowdown with the determination of regulated levels turns out to be able to make parameters in accordance with ASME standards. In the process of water treatment management on boiler water in the KM. Bukit Raya ship boiler must be maintained in order to maintain the quality of boiler water to keep the boiler operating optimally. It is necessary to maintain electrical automation maintenance on the boiler to maintain the continuity of the optimal combustion process so that all water treatment processes in boiler water run well.

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