Improving the quality of pipeline insulation with high-density Calcium Silicate material

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Abstract. The problem currently being faced is the occurrence of pipe leakage due to corrosion under insulation. The purpose of this study is to provide an overview of the specifications and ways of applying high-density calcium silicate insulation material as a substitute for rock wool mineral insulation material that has been used since the beginning of the refinery construction. This research method used the application research method with the case study approach method, which is a case study of pipe leakage problems due to corrosion under insulation. The results showed that the emergence of corrosion problems under insulation was due to rock wool mineral material storing and depositing water in the insulation. The observations also showed that after the insulation was replaced, the temperature of the steam fluid in the piping increased by 9-14°C and the results of observation through window inspection revealed that the calcium silicate condition remained dry and the piping condition did not indicate corrosion. The results of this study indicated that high-density calcium silicate material was suitable and also recommends corrosion control under insulation by replacing rock wool mineral material into high-density calcium silicate.

Keywords: Corrosion under insulation, mineral rock wool, calcium silicate.

1. Introduction

One component is inseparable in the operation of pipelines in the crude oil refinery processing unit component of heat insulation material in the process pipe. This heat insulation material serves to isolate the pipe against environmental temperature so that the process of transfer of fluid through the pipe, the fluid does not experience heat loss and does not occur because of exposure to heat in the environment that can endanger the environment. The specification of heat insulation material which has been commonly used is rock wool mineral combined with an aluminium cover, so it is impermeable to environmental influences. The use of rock wool mineral material as heat insulation is based on Bechtell International Job Drawing Specifications No.14177, 1980, BINT Specs N Heat Insulation with rock wool mineral material specifications for crude oil, steam, and other process pipes with high temperatures.

Problems faced from the results of inspections carried out on pipe insulation that has entered the age of 15-20 years found external corrosion of the pipe and wet conditions on the inside of rock wool minerals as presented in Figure 1 and Figure 2. Further inspection results show that the installation of piping leaks is pipes wrapped in rock wool mineral insulation and has been used since 1980 [7]. In addition to the condition of rock wool mineral insulation, which is moist and wet, it has also been found that rock wool minerals have become lumps of crust. The condition of rock wool minerals that
are damp and wet is thought to be a cause of corrosion under insulation and results in the reduction of heat in the fluid flow in the piping, as presented in table 1.

**Table 1. Steam pipe temperature data with rock wool mineral insulation**

| No. Pipa | Dia. (Inch) | Pipeline service | Actual (°C) | Design (°C) |
|----------|-------------|------------------|-------------|-------------|
| P.10 LLS.1 | 10 | Low Low Press Steam | 108 | 130 |
| P.12 LS. 2 | 12 | Low Press Steam | 238 | 275 |
| P.10 LLS.3 | 10 | Low Low Press Steam | 110 | 130 |
| P. 10 LLS.4 | 10 | Low Low Press Steam | 114 | 130 |
| P. 14 LS.5 | 14 | Low Press Steam | 242 | 275 |

Source: Pertamina RU V (July 2017)

**Chart 1. Steam Pipe Temperature graphic with Rockwool mineral insulation**

The mechanism of corrosion under rock wool mineral insulation occurs because between the insulation and the surface there is moist air and water vapor which is thought to originate from water leaks through the gap of the insulation cover connection which is trapped inside the insulation.

The condition of rock wool mineral damage furthermore has an impact on the temperature propagation of the aluminum rock wool mineral rock aluminum material cover, presented in the table. 2

The remedial effort to overcome this problem is to replace the leaking pipeline and indicated leak with a similar pipe and replace the rock wool mineral insulation with the specification of high-density calcium silicate heat insulation material. For this reason, this research is conducted to provide answers to the problem of corrosion of pipes under insulation (CUI).
The objectives to be achieved through research activities are (1) Providing an overview of Calcium Silicate heat insulation material, covering the advantages and disadvantages of calcium silicate material specifications compared to rock wool mineral material and (2) the application method for the specification of calcium silicate as piping heat insulation in the oil and gas processing plant, reducing the potential for corrosion under insulation.

The choice of high-density calcium silicate heat insulation is based on the consideration that the high-density calcium silicate material does not absorb and does not store water so that the conditions are always dry. It is also based on some of the advantages of calcium silicate material compared to rock wool mineral materials, including (1) the component material does not require binders that can be oxidized and smoldering (2) capable of serving temperatures of 1050°C (3) low chloride content <10 ppm (4) easily removed and replaced (5) no exothermic reaction (6) does not cause irritation, and (7) low maintenance costs (8) high energy savings [9]. With these advantages, it is believed that the use of
calcium silicate material is more suitable for use and does not cause corrosion under insulation (CUI). The results of this study are very important to be able to give confidence to company management in replacing rock wool mineral insulation material into calcium silicate material on a broad refinery operating equipment such as process line up pipes, heat exchangers, columns, vessels, and other similar refinery operation equipment.

2. Method
This research is applied research or used research with a case study approach. The research approach method used is a case study approach method, namely a case study of corrosion under insulation (corrosion under insulation) processes in the Pertamina RU V Balikpapan refinery. In this study, the researcher also acted as an inspection engineer and served as quality control, quality assurance, and quality control of the work results of refining equipment repair.

The main research material is high-density calcium silicate heat insulation material which has been used as heat insulation in the process pipe in the Pertamina RU V complex hydro skimming operation unit [7]. The calcium silicate material specifications are as presented in Table 3. [1,12].

![Table 3. Calcium silicate specification](source)

The procedure for installing calcium silicate heat insulation in the process pipe (a steam pipe, feed pipe intake of crude oil and the production process pipe is carried out with the following stages and work steps [10]:

![Figure 3. Component of heat insulation](source)
a. The work of installing calcium silicate heat insulation can be carried out on condition that the equipment is not operated has been freed from a heat source, a pressure source and is not non-humid/wet
b. Prepare calcium silicate heat insulation material, following the diameter of the pipe to be protected, make sure the thickness of the material to be used is appropriate
c. Prepare work equipment including pliers, screwdriver, putty knife, and rust/corrosion cleaning tools, other auxiliary work equipment as needed on-site, work safety equipment and personal protective equipment (PPE)
d. Remove the existing rock wool mineral insulation up to the piping can be done well man funds
e. Clean the remnants of material, disposal, and rust with mechanical cleaning equipment and clean the dust by spraying pressurized wind
f. Coating the specifications of the anti-corrosion coating material with a minimum thickness of 100-micron DFT
g. Install aluminium foil (insulation inner layer) covering the entire surface of the piping, including closing the heating pipe facility (heating coil) and tie it well with corrosion-resistant gasper plate
h. Install the calcium silicate insulation covering the aluminium foil protector piping, make sure if there is a connection of the heating pipe (steam coupling) position is installed outside the insulation
i. Install the inspection window (window inspection), so that the shape, dimensions, and configuration can be inspected properly and safely
j. Mount the calcium silicate binding plate so that the calcium silicate pair is well integrated, dense, solid, and sturdy
k. Install a calcium silicate cover jacket with a specification of corrugated aluminium material with a minimum thickness of 1 (one) mm and a minimum overlapping of 3 (three) cm
l. Install the gasper band with the material specifications of the stainless-steel plate, including the lock, and make sure it can tie the corrugated aluminium jacket properly
m. Install the inspection window cover, tie it with bolts and make sure there is no gap for water to enter by installing hot silicon in the aluminium jacket connection gaps including the connection on the steam coil pipe
n. Conduct a final inspection with the relevant parts (final inspection) by involving the asset holder, quality control (QC & QA), maintenance, record and document the results of the final inspection, making sure all relevant parties have signed the final inspection report form (as an attached document for completion of work / PSSR)
o. The process piping is operated by the operating officer, followed by the monitor to the results of the installation of calcium silicate heat insulation, making sure the external temperature indication of the corrugated aluminium jacket is within safe limits with an indication that it can be held with the palm for > 5 minutes.

Corrosion engineering inspection methods under calcium silicate heat insulation are carried out as follows [1,2,12].

a. Prepare inspection equipment consisting of pliers, screwdrivers, and shells to open inspection windows (window inspection)
b. Open the inspection window, remove the calcium silicate window cover, and open the inner insulation layer of aluminium foil pipe cover
c. Perform a visual inspection, use a flashlight if the lighting is not enough, clean the surface of the pipe with a cloth rag/cleaning cloth
d. The process pipe is indicated corrosion if there are brown spots and special odour
e. Clean rust/corrosion, coat corrosion protection coating, install aluminium foil, install calcium silicate window coverings, attach aluminium jacket, and attach gasper band
f. Record and document the results of corrosion inspections under insulation
g. Inspection of insulation under insulation is carried out periodically once a year or adjusting to the needs if it is suspected and predicted there are symptoms of corrosion under insulation.

The parameter to be observed is the temperature parameter of the fluid in the pipeline, i.e., how much influence the change in fluid temperature before and after the replacement of piping insulation using high-density calcium silicate material and corrosion during operation. Other operating variables such as pressure and fluid flow are not measured because they are given and according to operating requirements.

**Figure 4.** Installation of calcium silicate heat insulation

**Figure 5.** Calcium silicate material installed

**Figure 6.** Insulation after calcium silicate and the aluminium cover are installed
3. Result and Discussion

Since July 2017, a partial specification of high-density calcium silicate material has been applied as a partial replacement for rock wool mineral material. This modification of calcium silicate heat insulation material was carried out based on the proposed change in material specifications No. MOC.783 / E15143 / 2012-S5 [11], results of the engineering study No.MOC-082/15320/2012-S2, Recommendations for changes to the Doc. No.0491 / REK / E15143 / 2014, Recommendations for changes to the Doc. No.0492 / E15143 / 2014 and Recommendations for changes to the Doc. No.0493 / E15143 / 2014 [3,4,5]. Proven to not corrode under insulation (corrosion under insulation/CUI) [11]. Comparison of the use of high-density calcium silicate heat insulation compared to existing rock wool mineral materials as presented in the table.

### Table 4. Comparison of Calcium Silicate and Mineral Rock Wool Material Specifications

| No. | Specification                  | Calcium Silicate | Mineral Rock Wool |
|-----|--------------------------------|------------------|-------------------|
| 1   | Intensity                      | Tidak menangkapapi | Menangkap bahan organik untuk penambahan stabilitas dan daya tahan |
| 2   | Service Temperature            | 1090°C           | 700°C             |
| 3   | Thermal Conductivity           | 0.78 W/mk at 100°C | 0.85 W/mk at 10°C |
|     |                                | 0.25 W/mk at 10°C | 0.30 W/mk at 10°C |
| 4   | Compresive Strength            | % reduction in thickness at 60 Psi load | % Reduction thickness at 0.50 Psi load |
| 5   | Fire Resistance                | Non combustible  | Non combustible   |
|     |                               |                  |                  |
| 6   | Effect of Heat                 | Tidak memberi efek termal | Bekerar memberi efek termal |
| 7   | Chloride Content               | ≤ 10 ppm         |                   |
| 8   | Re Use                         | Memiliki daya  | Memiliki daya     |
|     |                                | daya lepas  | daya lepas       |
| 9   | Health Hazard                  | No effect          | Banyak bahaya    |
| 10  | Cost Performance               | High              | Low               |
|     | - Inventory Cost               | High              | Low               |
|     | - Maintenance Cost             | Good              | High              |
|     | - Saving Energy                |                  |                   |

Source: Sulardi, 2016 [10]

### Table 5. Steam Pipe Temperature Data with high-density calcium silicate

| No.Pipa | Dia. (Inch) | Pipeline service       | Actual (°C) | Design (°C) |
|---------|-------------|------------------------|-------------|-------------|
| P.10 LLS.1 | 10         | Low Low Press Steam    | 132         | 130         |
| P.12 LS.2  | 12         | Low Press Steam        | 277         | 275         |
| P.10 LLS.3 | 10         | Low Low Press Steam    | 132         | 130         |
| P.10 LLS.4 | 10         | Low Low Press Steam    | 138         | 130         |
| P.14 LS.5  | 14         | Low Press Steam        | 285         | 275         |

Source: Pertamina RU V (December 2017)
Chart 3. Steam Pipe Temperature Graphic with High-Density Calcium Silicate

Table 6. Data on the external temperature of the aluminium pipe steam pipe cover after using calcium silicate

| No. | Pipe Dia. (Inch) | Pipeline service | Aktual (°C) | MAWT (°C) |
|-----|------------------|-----------------|-----------|-----------|
| P.10 LL | 10               | Low Low Press Steam | 34        | 45        |
| P.12 LS     | 12               | Low Press Steam   | 36        | 45        |
| P.10 LL | 10               | Low Low Press Steam | 32        | 45        |
| P.10 LL | 10               | Low Low Press Steam | 37        | 45        |
| P.14 LS   | 14               | Low Press Steam   | 32        | 45        |

Source: Pertamina RU V (December 2017)

Chart 4. Graphic on the external temperature of the aluminium pipe steam pipe cover after using calcium silicate

Table 7. Monitor Data on Piping Conditions and Calcium Silicate Insulation Conditions

| Measuring Point | Pipeline service | Month | Piping Condition | Insulation condition |
|-----------------|------------------|-------|------------------|----------------------|
| 1               | Low Low Press Steam | 6     | Not corroded     | Dry                  |
| 2               | Low Press Steam   | 6     | Not corroded     | Dry                  |
| 3               | Low Low Press Steam | 6     | Not corroded     | Dry                  |
| 4               | Low Low Press Steam | 6     | Not corroded     | Dry                  |
| 5               | Low Press Steam   | 6     | Not corroded     | Dry                  |

Source: Pertamina RU V (December 2017)
Data from the observation of the temperature of the steam fluid flow shows that, after replacing the mineral wool material with high-density calcium silicate, this has a positive effect on significant temperature rise in the temperature of the steam in the low-low pressure steam pipe with an increase of up to 34°C, while an increase in the low line steam up to 19°C. Increasing the temperature of the steam fluid flow in the piping is also followed by a decrease in the temperature of the aluminium cover (maximum allowable temperature) from the original condition of 50-52°C (exceeding MAWT: 45°C) to 32-37°C vs 45°C (under MAWT: 45°C). Piping condition monitor results through window control also show insulation conditions that remain dry and piping conditions not indicated corrosion after 6 (six) months of using calcium silicate material as presented in table.7.

The change and modification of wool skirt mineral heat insulation material to high-density calcium silicate material was applied for the first time in the Hydrosking Unit complex, precisely as heat insulation to 4 (four) E-1-08 A / B and E-1- heat exchanger equipment. 08 C / D. And in the next stage will be replaced by similar insulation on refinery operating equipment such as piping, vessels, columns, reactors, and other heat exchangers to reduce heat loss in refinery equipment with operating temperatures > 1200°C. The shape, dimensions, and configuration of the high-density calcium silicate heat insulation material installation refer to Job Drawing document No.14177, 2015, BINT Specs N Heat Insulation Specifications. For this matter, it is necessary to prepare a material quality plan (RMB) and a repair work quality plan (RMPP) as a basis for preparing materials, fabrication, and installation on site. For this need also to be prepared as-built drawings after the heat insulation replacement work is completed as a material for updating the pipe flow data diagram (PFD) and process instrumentation and diagrams (PI & D).

The benefits of the change in rock wool mineral heat insulation material to high-density calcium silicate from the five quality aspects are (1) from the quality aspect of using high-density calcium silicate material can reduce the potential for corrosion under insulation (2) from the cost aspect can save maintenance costs and reduce losses heat worth> Rp. 500,000,000 per day of operation (3) from the aspect of delivery shows that it can serve temperatures up to 1050°C and maintenance of calcium silicate is better and more reliable (4) from the safety aspect shows that calcium silicate material does not burn (5) from the moral aspect workers become more confident because the innovations made can solve problems in their work environment properly and safely. The monitoring data shows that high-density calcium silicate is proven to be a good insulator, can reduce heat loss, and can control corrosion well.

4. Conclusions
Based on the description of the problem, the results of research and discussion, it can be concluded:
  a. The use of high-density calcium silicate insulation material proved to be suitable for controlling corrosion under insulation.
  b. The application of high-density calcium silicate has been proven to be able to improve the quality of serviceability proven by being able to reduce heat loss in the piping (heat loss) and can reduce heat exposure on the surface of the cover of the insulation within the safe limit (MAWT).

5. Suggestions
With the results of this study, suggestions can be made to do the following things.
  a. The success of replacing high-density calcium silicate heat insulation in the HSC refinery unit has been recommended for replacement of refinery operating equipment such as piping, vessels, columns, reactors, and other heat exchangers to reduce heat loss in refinery equipment with operating temperatures > 1200°C at the HCC refinery unit and Balikpapan. I refinery unit [3,4,5]
  b. The shape, dimensions, and configuration of high-density calcium silicate heat insulation material replacement refer to Job Drawing document No.14177, 2015, BINT Specs N Heat Insulation Specifications. For this reason, it is necessary to prepare a material quality plan
(RMB) and a work quality improvement plan (RMPP) as a basis for preparing materials, fabrication, and installation on-site [9].

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