Evaluation of Environmental Factors for Improving Safety, Case Study on Boiler Instrument Processing Unit IV & VI PT.Pertamina Persero

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***Abstract*— Boiler is one of the equipments that has strategic role in a plant, therefore boiler failure should be avoided wherever possible. One of boiler failure causes is environmental factor. The influence of environment and reliability is assessed to get the instrument system performance. Based on maintenance historical data, Mean time to Failure (MTTF), Failure rate (λ) and Probability Failure Demand (PFD) of each instrument can be calculated. From the analysis, it is known that environment condition shave correlation to PFD value. Environmental conditions at RU-VI Balongan, location have greater influence on the PFD compared to the environmental conditions in RU Cilacap. By reviewing three environment variables that are environment temperature, relative humidity and SO2content in the air, the level of SO2 contenting the air has the most impact compared to the other 2 factors. The SO2 content has uncertainty value measurement =0.108 in RU-IV Cilacap and uncertainty value measurement =0.071 in RU-VI Balongan.**

Index Term*— *instrument , boiler, reliability, safety, environment.

I. INTRODUCTION

PT. Pertamina Persero here in after referred to Pertamina is a big company, Pertamina is a state-owned company that stirring the field of exploration and processing energy includes oil, gas, new &renewable energy. Pertamina owns several oil processing units scattered throughout the territory of Indonesia where in large number of instrument share operated in the processing unit. Instrument equipments always maintained and operated properly so that the level of reliability and the system are assured during plant operation and poses no hazard. More over level of safety integrity instrument equipment share maintained to avoid accident [1-2].

To determine level of hazard at an operation plant, it is required to do analysis and hazard identification periodically using Hazard and Operability Study (HAZOP) method.

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In reality though HAZOP is already available and implemented, there is still accidents occur due to instrument failure. This situation occurs because of maintenance activity is suspected has not been done optimally due to the negligence of operator and unprepared implementation of standard operating procedures [1].

Environmental conditions also have an influence on the life time of instrument equipment, where instrument equipment of a plant with certain condition can have different growth of damage compare with another plant. In this opportunity, study is done related to environment effect on instrument equipments performance.

Safety reliability level production process is strongly influenced by the reliability of the instrument associated with the rate of failure. The rate of failure can be traced through history data associated with the maintenance of the instrument toward time and the time required for repairs. By knowing these data, the level of reliability and maintenance can be planned according to the needs of management [2].

Level Reliability can be planned in the level of reliability; 0.1- 0.19 implementation reliability wear out, 0.20-0.49 ,weak; 0.5-079 moderate; 0,8-0.89 Strong and 0.0-1.0 Powerful. The Reliability design associated with maintenance activities. The frequency of maintenance related to the cost of replacement of components, operator wages and loss of production. To reduce the cost of maintenance is needed so that the level of reliability of the cost analysis can be determined [2].

Predetermined level of reliability associated with the safety system, in which the existence of instrument not only to ensure product quality, energy consumption efficiency but necessary in safety guards. For safety escort can be reached through guarantees maintenance of the instrument [1].

II. MATERIALS AND METHODS

Boiler is pressure vessel which works based on the combustion system to produce heat energy in vapor form which is processed by heating water to become steam. Steam as boiler product with a certain level of pressure and heat is needed for process activities through the mechanism of heat exchanger. Boilers, divided into four blocks consisting of generation part where water vapor is transformed from the steam dram. The second part of the boiler is the transmission system, where the steam that has been generated from the steam dram pipe, the third part is the heat transfer equipment where steam is utilized for a particular process and part of the fourth form of harnessing energy recovery equipment for recovery rest. In the fourth part of the required instrument in the form of sensors, transmitters, controllers and actuators are used for monitoring and control to ensure the continuity of the production process [4-5].

Boiler systems generally consist of a feed water system, steam system, and combustion systems. Feed water system provides water supply to boilers with certain quality through automation system according to the needs of the planned steam. Steam control system collects and controls the steam production which is in the boiler with a certain capacity and process variables such as temperature, pressure, and level and flow rate. Furthermore, the steam product is passed through piping system to the end user's system. The value of the process variable guaranteed by the instrument equipments which will be studied. One example of process variable is vapor pressure, controlled by control valve as final element then this pressure variable is monitored in control room. The combustion system is controlled by ratio control of air and fuel. This control maintains the ratio between air and fuel to reach complete combustion. The boiler water supply which will be converted in to steam is derived from the make-up water and diluted condensate. An outline of the boiler shown in Figure 1 [6-8]

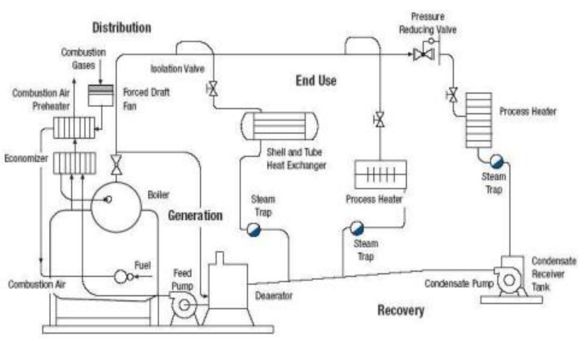

Fig 1. Process Flow Diagramof Boiler **[8]**

Boiler assessment is taken to boilers that are installed in the oil refinery processing unit IV&VI Pertamina, located in Cilacap and Balongan. The study of environmental factors that could influence to the instrument equipments covering; ambient temperature, relative humidity and content of SO2 in the air ambient Data collection includes; document or process drawing and its supporting boiler system includes Process Flow Diagram, Piping and Instrument Drawing and historical maintenance data of instrument equipments installed in boiler. Boiler used in Pertamina is boiler using fuel gas and fuel oil. The boiler plant is clustered into four main processes nodes; fuel oil supply, fuel gas supply, boiler feed water and high pressure steam as product. The entire instrument equipments historical data on each node are collected and traced subsequently to become the subject of analysis related to the calculation of the mean time breakdown failure (MTBF), Mean time To Failure (MTTF), Failure rate (λ) and the Failure Probability Demand (PFD). Waibull distribution is an extension of the exponential distribution and is widely used to model the phenomena on of damage to the rate of decay depends on the age of the components (Kececioglu, 1991). Probability Density Function with three parameter Weibull Solid function probability (FPP) is refers [2-7].

$$f(t)=\frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}}, \qquad (1)$$

Where:

t=timedecay, tγ≥

β=shape parameter, β>0

η=scale parameter, η>0

γ=location parameter, ∞<γ<∞

Weibull Distribution of Reliability, There liability function of which is; [1]

$$R(t) = 1 - F(t) = \exp\left\{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}\right\} \qquad (2)$$

Failure rate in Weibull distribution as the function of the rate of decays: [2]

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{R(t+\Delta t) - R(t)}{R(t)\Delta t} = -\frac{dR(t)}{R(t)dt},$$

$$\lambda = \frac{1}{MTTF} \qquad (3)$$

Meantime to Failure (MTTF), The MTTF function for the three parameters [2]

$$MTTF=\gamma + \eta\Gamma\left[\frac{1}{\beta}+1\right] \qquad (4)$$

Component share arranged in parallel: For three parameters [2].

$$MTTF = \gamma+\Gamma\left(\frac{1}{\beta}+1\right)\left(3\eta-\left\{3\left(\frac{1}{\left[2\left(\frac{1}{\eta}\right)^{\beta}\right]^{\frac{1}{\beta}}}\right)\right\}+\frac{1}{\left[3\left(\frac{1}{\eta}\right)^{\beta}\right]^{\frac{1}{\beta}}}\right) \qquad (5)$$

And probability of failure demand [8].

$$PFD=\frac{\lambda \times TI}{2} \qquad (6)$$

For identifying cause and the consequences of perceived mal operations of equipment and associated operator interfaces in the context of the complete system. It accommodates the status of recognized design standards and codes of practice but rightly questions the relevance of these in specific circumstances where hazards may remain undetected. The data required is the maintenance history data from all components of the boiler approximately five consecutive years are filmed from the log book department maintenance PT.Pertamina processing unit IV. [2-5].

III. Results and Discussion

Assessment of environmental conditions is done by pick out environmental data include; temperature, humidity and SO2 content in the air at two plants which have two different locations. Analysis level of influence of environmental conditions is conducted to determine the reliability and instrument performance. Data of temperature environment obtained from data records of Meteorology and Geophysics Body (BMKG). Environmental temperature data collected over a period of five years from 2009 to 2013. Image of temperature data at two plant location RU IV Cilacap and RUVI Balongan is shown in Figure 2.

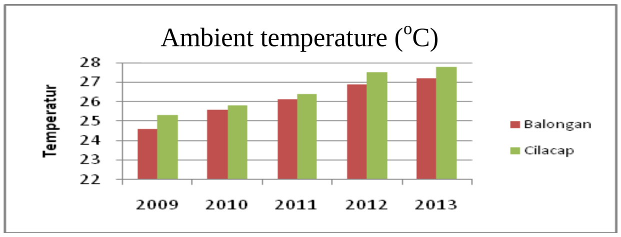

Fig 2. Ambient temperature rate per year (2009-2013)

Relative humidity data acquisition is also accessible from the Meteorology, Climatology and Geophysics (BMKG). The data acquired is data relative humidity within five years from 2009 to 2013. Data relative humidity at two locations in Cilacap and Balongan plant is shown in Figure 3.

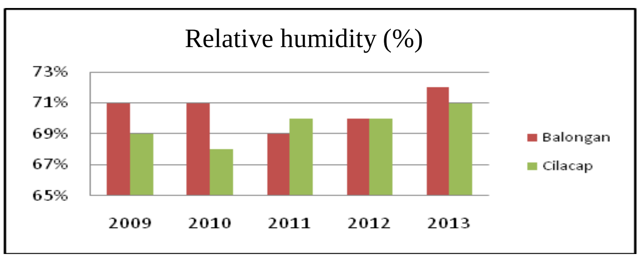

Fig 3. Relative humidity rate per year (2009-2013)

The dissolved sulfur dioxide ambient (SO2) content is an important environmental factor that is also analyzed. SO2 is one of the air pollutants that have a dominant impact on an industrial location. The most adverse impact on the SO2 content is accelerating the rate of corrosion on plant material. Data of SO2 content in the air obtained from the Regional Environmental Body (BLHD) for Balongan and Cilacap location is shown in Figure 4.

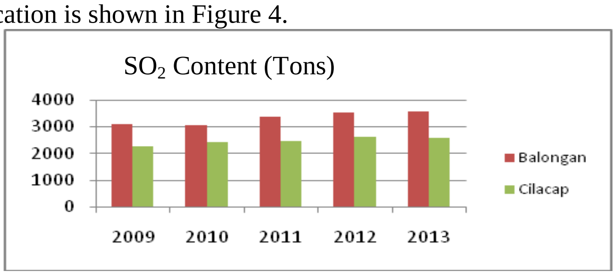

Fig 4. SO_2 rate content per year (2009-2013)

Instrument equipment reliability can be seen through analysis of MTTF and PFD. The analysis was conducted based on maintenance data of the system within a certain time. The higher the value, the better the MTTF reliability of the instrument equipments. Determination of Target Risk is done in consultation with the engineers in PT. Pertamina related with which instrument systems are often damaged and have big impact. Calculation result of MTTF and Probability Failure on Demand (PFD) of each instrument is shown in Table I.

TABLE I
MTTF value, Failure rate dan PFD instrument boillerRU VI Balongan

No	Entity Number	MTTF	Failure rate	PFD
1	052TT-901A	10584	9,44E-05	0,413
2	052FT-901A	18816	5,31E-05	0,232
3	052FV-901A	10260	9,74E-05	0,426
4	052FIC-902A	16236	6,15E-05	0,269
5	052PT-905A	12636	7,91E-05	0,436
7	052PT-908A	80880	1,24E-04	0,541
8	052FT-904A	11592	8,62E-05	0,377
9	052HIC-908A	27984	3,57E-05	0,156
10	052FV-903A	10296	9,71E-05	0,425
11	052PT-911A	17100	5,84E-05	0,256
12	052FT-903A	14323	6,98E-05	0,305
13	052PIC-911A	12852	7,78E-05	0,340
15	052FT-911A	13140	7,61E-05	0,333
16	052FV-911A	92480	1,08E-05	0,473
17	052FIC-911A	20448	4,89E-05	0,214
19	052HIC-921A	13140	7,61E-05	0,333
20	052PT-939A	10088	9,91E-05	0,434
21	052FT-912A	35448	2,82E-05	0,123

Processing Unit which is Plan A and Plant B then performed comparative study. A plant, Pertamina RU IV Cilacap and B plant Pertamina RU VI Balongan. Both using instrument equipments with the same specifications,

TABLE II
MTTF value, Failure rate dan PFD instrument boillerRU IV Cilacap

No	Entity Number	MTTF	Failure Rate	PFD
1	052PV-408	10662	9,38E-05	0,411
2	052FT-407	35448	2,82E-05	0,124
3	052HIC-491	21552	4,64E-05	0,203
4	052PIC-491	26352	3,79E-05	0,166
5	052PT-408	26256	3,81E-05	0,167
6	052PIC-408	21552	4,64E-05	0,203
7	052PT-416	9960	1,00E-04	0,440
8	052HIC-412	26352	3,79E-05	0,166
9	052FIC-412	20448	4,89E-05	0,214
10	052FT-408	13140	7,61E-05	0,333
Cont..				
11	052PT-414A	28992	3,45E-05	0,151
12	052PV-412	9248	1,08E-04	0,474
13	052FT-406	35184	2,84E-05	0,124
14	052FIC-406	16692	5,99E-05	0,262
15	052FV-406	16980	5,89E-05	0,258

16	052LG-428	26352	3,79E-05	0,166
17	052HIC-405	26256	3,81E-05	0,167
18	052FT-402	16692	5,99E-05	0,262
19	052TT-477	35136	2,85E-05	0,125
20	052TT-404	20448	4,89E-05	0,214

Study of variables that have the most influence on the rate of damage to the instrument as well as areas where the environment has a greater influence is done from three existing environment variables. From the analysis carried out which related to the targeting of risk, analysis o f MTTF and PFD, comparative both plant toward environmental influence and impact on the performance of the instrument as shown in Table1 and Table 2.

Environmental influences and the failure of the instrument equipment assessed by considering the correlation among them through regression method, withy is the instrument PFD value which is the system response and x is the environmental factors as independent variables. The relationship of independent variables and the response is assessed through regression equation. Then the calculating value through regressions compared to the actual value. The difference value becomes residual value. The residual value is then used to calculate the Sum Square of Residual (SSR) which is used to calculate the uncertainty value of the measurement. Comparative study carried out by comparing the value of the uncertainty measurement (μ), and analysis of the PFD of the environmental conditions of each site. The value of μ is the uncertainty value of each environmental variable and instrument equipment Probability of failure demand (PFD) value, the greater the uncertainty measurement the greater the environmental measurement factors influence to instrument and more affect to the value of the PFD. The results of each environmental factor for two plants shown in Table 3. [10-11].

TABLE III
Uncertainty value of environmental factor Plant 1 & 2

Location	Temperature (^oC)	Rh (%)	SO_2 (Tons)
Balongan	0.107	95	0.108
Cilacap	0.059	60	0.071

Based on the calculation note that the content of SO2 has the highest value of uncertainty among other environmental process variables, namely temperature and humidity The greater the uncertainty the greater the influence of process variables on the instrument, in this case a high level of SO2 content has the highest impaction the value of the PFD instrument. PFD value describes the chances of damage to the instrument within a certain time. The greater PFD value the greater chance of failure on the instrument.

Based on maintenance data in both plant, it is known that the biggest instrument equipment damage due to corrosion is in RU VI Balongan with value of 37% and 21% in RU IV Cilacap. This is consistent with the environment data of both plants. Cilacap area has an average higher temperature than Balongan area, where humidity levels and SO2 content are lower. Temperature level will affect the speed of the red sox reaction in corrosion. The higher the temperature the faster the corrosion occurs. With increasing temperature, the kinetic energy particle increases in which it will increase the probability of collision of particles at red ox reactions. Correlation of environmental temperature in the District Balongan and District Cilacap has are relatively small difference=0,48^{o}C so that the effect on the instrument performance is relatively small. It is the same with the difference of humidity variable which relatively small or nearly equal [10-11].

The SO2 content in those two locations has significant difference among these three environment conditions. SO2 is an air pollutant that influences corrosion process quickly. In the atmosphere, SO2 reacts with water vapor in the air so that it will form sulfuric acid as the follow in reaction. SO2+H2O→H2SO3 (sulfuric acid) and SO3+H2O→H 2SO4 (sulfuric acid) These exactly lead instruments in RU VI Balongan to become faster corrode and damage. Sulfuric acid is a corrosive element and when exposed to rain water can cause acid rain and lowering the water pH so that the pH becomes less than three. The sulfuric acid will be absorbed continuously and repeatedly where it will accelerate the rate of corrosion. Rusty instruments further are contaminated bySO2 gas that serves as a catalyst of increasing formation on advanced corrosion. There is a significant difference of uncertainty value within both plants. This is consistent with the environmental conditions data of both plants. Uncertainty value of temperature measurement, humidity and SO2 content in RU VI Balongan are higher than RU IV. Therefore the instrument rate of damage at Balongan is higher compared with in Cilacap area. That is influence of the geographical position of the regions. RU VI Balongan open to the access public transportation with high occupancy compared with in Cilacap. Intensiveness traffic of vehicles across Balongan region contributing high level air pollution so SO2 content in the air is higher and in the Balongan don't support sulfured recovery facility [12-15].

IV. CONCLUSION

The uncertainty of temperature measurement in RU IV Cilacap location =0.059, uncertainty of humidity measurement =0.060 and the uncertainty of radiation exposure measurement of SO2 content =0.071. As for the RU VI Balongan area, the uncertainty temperature measurement=0.107, the uncertainty measurement of relative humidity=0.095 and the uncertainty measurement of SO2 content=0.108. It is known that the measurement of uncertainty level value of three variables process in Balongan area is higher than Cilacap area. SO2 uncertainty level values is the highest compared with other environmental process variable values, therefore the SO2 exposure is considered to have the greatest influence on the reliability and performance of instrument equipments. The growth of instrument equipments damage in Balongan become higher than in Cilacap area. In Cilacap there Sulfur Recovery Unit, the sulfur content of Cilacap in recovery so cut no discharge of sulfur into the air from the refinery unit. In

Balongan no sulfur recovery unit so that the project is urged to be built.

ACKNOWLEDGMENTS

To the organizations devoted to the Community, the Institute of Technology who has been supporting the activities of the funds primarily for publication. Hopefully, the financial assistance provided always able to motivate the authors that further publications can be maintained. Thanks to its compact team members so that the work can be completed, in particular thanks to Mr. Anton for his help, especially to prepare the manuscript writing

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