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Risk Management and Safety System Assessment from Power Plant Steam Boiler in Power Systems Unit 5, Paiton-Indonesia

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ABSTRACT

Steam power plant (CPP) is a power plant that is widely used in Indonesia. Part of the power plant system that has a high risk of danger is a Boiler and therefore in danger of such a system is necessary to study and review of safety systems for the prevention of danger arising in the Boiler. Therefore hazard analysis used in this study using HAZOP. Selected node is economizer, steam drum, superheated and reheated which is the main constituent components of the boiler system. Guide word and deviation determined based control chart constructed from the data of each of the components during the month of March 2013. Likelihood estimation was based on data maintenance power plant unit 5 for 5 years, while the estimated consequences done based criteria as well as the risks posed by the control chart. The result of multiplying likelihood and consequences by risk matrix and risk criteria of the components produced. Based on the analysis, it is known that the components that have the highest risk of harm is the steam drum level transmitter, is have extreme risk criteria. In addition, there is also extreme risk the superheated outlet pressure transmitter. To reduce the risk in the system required routine maintenance and calibration. And to increase Safety Integrity Level transmitter need additional redundant. The biggest danger to the entire node is due to the fire. Therefore, an analysis of emergency response plan to respond to events that include fire evacuation maps, duties and responsibilities of each person as well as preventive measures and counter measurement.

INTRODUCTION

Steam power plant (SPP) is a lot of power plants installed in Indonesia. Generally, thermal power generation system consists of a main component, boiler, turbine, generator and condenser (Ali Musyafa, Ronny, D.N., 2012). One of the most important parts of a steam power plant system is the boiler. Boiler is a component that is used to convert water into steam through a heating process. Steam is then used to drive a turbine and a generator coupled to generate electric power. Boiler system consists of three main systems, namely the feed water system, fuel system, and steam systems. Paiton is a plant that has the largest capacity in Indonesia (Asmudi, 2007).

Paiton existence for the people, have the potential to big harm, both derived from the components themselves, as well as from outside. So it cannot be denied that safety becomes paramount in this process. Every year many workers died from accidents generation that occurs in the workplace. This is caused by conditions that plant safety minimizes (Dhillon, B.S., 2005). Therefore, the safety system is required on all components involved in the production process, especially for large risk component failure, such as the boiler is working at high temperature and pressure (Ebeling,Charles E., 1997).

Based on these reasons, it is necessary to study risk management by way of hazard identification and risk analysis using HAZOP method, and system safety analysis do associated with the emergency response plan is made for the most endangered big risk. Related the analysis done with the cause of failure that may arise in the four major components namely; boiler, economizer, steam drum, superheated, and reheated hereinafter referred to as nodes. Components on each node, bounded on the transmitter and control valve screens are accessed from the generation DCS- power plant Paiton Unit 5.

MATERIALS AND METHODS

The data used in this study are documents and from pictures of the process in the boiler unit 5 UP Paiton plant. These documents include process flow diagram (PFD), piping and instrumentation diagram (P&ID),

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maintenance data or time to failure of each component contained in the steam turbine, the data process on each component of the boiler in full operation throughout the day taken for one month, on March 1, 2013 until March 31, 2013. The data is sampled once every hour for 24 hours. This data will be used for the determination of risk and risk analysis at the individual components of the boiler. The method used in identifying hazards is to use analytical methods Hazard and Operability Analysis (HAZOP). The steps in the identification of hazards using HAZOP method is as follows:

- Determine the node / point based study P & ID data has been obtained. In this study, the node is determined based on the main components that make up the boiler system, the economizer, steam drum, superheated, and reheated.
- At each node, determined what components are contained in the section, which regulate all the processes that take place, from input to output. For example, a flow transmitter, temperature transmitter, pressure transmitter, valve and safety components are supporting the process on the node. The determination of this component is based on the components contained in the boiler plant DCS screens Paiton unit 5.
- Determine guideword using process data taken from each component during March and draw a chart based on the data, then the data that formed the trend seen from the graph to find the value of deviation.
- Perform analysis of the causes of deviations predetermined and assess its consequences and what safeguards are owned by a single node in the system.

Estimate of the Risk:

Risk estimation is done through an analysis of the two parts of the Likelihood and Consequences: Likelihood is the frequency of the possibility of a risk can occur on a component at a given time period (Ebeling,Charles E., 1997). Necessary to estimate the likelihood that the data maintenance is recorded at Work Order on the Performance and Maintenance Control, Operation and Maintenance Power Plant unit 5 UP Paiton. Of the data on each failure, then look for the value of MTTF, which is the average time, that component failure. Likelihood values obtained from the comparison between the numbers of operational days per year to the value of MTTF. Therefore, plants have never stopped in producing electricity and run the company in a single day of production for 24 hours. Having determined the criteria of likelihood component (Ebeling,Charles E., 1997). The time period is used for research during the period of 5 years, so the likelihood is determined by Equation (1).

$$Likelihood = \frac{43800}{MTTF} \tag{1}$$

As for the components that are not included in the maintenance of existing data in the Plant, MTTF at the failure rate can be from the data contained in the Offshore Reliability Data. (OREDA) in 2002 (Iviana Juniani, Anda, 2008). The equation used is as follows:

$$MTTF = \frac{1}{\lambda} \tag{2}$$

Consequences, was determined qualitatively based on how big the losses of the hazards that have been identified (Ebeling,Charles E., 1997). Consequences can be viewed in terms of damage to the components cannot be resumed, in terms of their effects on humans, or in terms of the costs incurred as a result of the hazards posed. In addition, the estimated Consequences can be done based on a control chart constructed from the data on the process of each component (SINTEF, 2009).

Risk analysis is done by combining the likelihood and Consequences that have been calculated on the estimated phase. The combination of both is obtained by using a risk matrix as shown in Table 1 (Montgomery, Douglas C., 1999).

Analysis of Emergency Response Plan (ERP), is done by determining the most risk and most likely a major effect on the system when a failure occurs. The most influential risk can be determined based on the analysis of HAZOP worksheet. Having determined what safety measures are taken if the risk of such failures occurred and what the response is taken for humans exposed in such a risky place. In this analysis, obtained an evacuation map, so as to facilitate the evacuation process when the risk of exposure.

Table 1: Risk Matrix

Likelihood	*Consequences*				
	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
A (Almost certain)	H	H	E	E	E
B (Likely)	M	H	H	E	E
C (Moderate)	L	M	H	E	E
D (Unlikely)	L	L	M	H	E
E (Rare)	L	L	M	H	H

Results:

In conducting a risk analysis, it is necessary to limit (boundary) of the system being analyzed, i.e. boiler. In this study, boiler grouped into four node / point of the study, the economizer, steam drum, superheated, and reheated. Because of the number of components on each node is too much, and then the assessment can be simplified into a single components of each node, which is the component that has the highest risk.

a. ***Economizer*;** economizer section there are four components that support a feed water preheating system derived from the feed water pump that led to the steam drum. The components in the form of pressure transmitters, temperature transmitters, flow transmitters, and control valve. These components are used to set the input economizer, while the arrangement of the components shown in Figure 1.

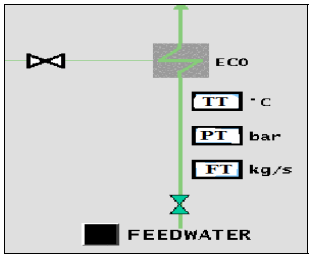

Fig. 1: Diagram of Economizer.

Guide Word and Devition:

Based on data from existing processes, can be constructed from the data graph from economizer inlet pressure transmitter (50LAB40CP001) shown in Figure 2. Of the graph is known that the pressure readings from the transmitter tends above average, amounting to 171 366 bar, so that the local word used is high, the deviation is high pressure. Control chart is also used to determine your word, also used for estimation Consequences are based to the data that forms the boundary line. For example, for 50LAB40CP001, the data has reached the finish line third, so the consequence is worth 3.

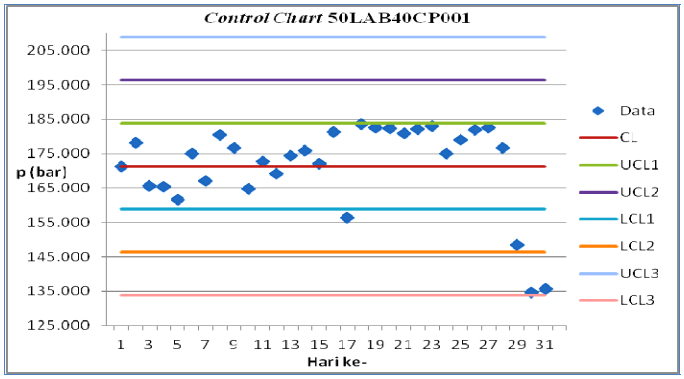

Fig. 2: Control Chart of 50LAB40CP001.

Estimation Likelihood:

Likelihood estimation is built based on the data obtained from the maintenance Work Order on the Performance and Maintenance Control, Operation and Maintenance Power Plant unit 5 UP Paiton. Likelihood

criteria sought by using the ratio between operating time with Mean Time to Failure (MTTF). The likelihood can be determined by using equation (1) and equation (2). Word economizer deviation and local likelihood Table shown in Table 2 and Table 3.

Table 2: Guide Word and Deviation of Economizer component.

Instrument	Guide Word	Devition
50LAB40CF901	High	High Temperature
50LAB40CT002	High	High Pressure
50LAB40CP001	More	More Flow
50LAB40AA101	Part of	Part of Instrumentation

Table 3: Criteria of Likelihood Economizer component.

Instrument	MTTF	*Likelihood*	Criterion of Likelihood
50LAB40CF901	9180.146	4.771	B
50LAB40CT002	202020.202	0.217	E
50LAB40CP001	303030.303	0.145	E
50LAB40AA101	98619.329	0.444	E

b. *Steam Drum,* flow chart of steam drum shown in Figure 3. As follows:

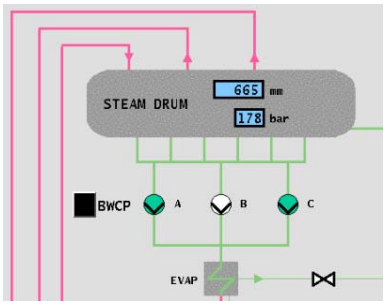

Fig. 3: Diagram Steam Drum.

Guide Word and Devition:

Table 4: Guide Word and Deviation Steam Drum Component.

Instrument	Guide Word	Devition
50HAD10FL901	More less	More Level
50HAD10FL901	Less	Less Level
50HAD10CP901	High	High Pressure
50HAG12CT001	More	More Temperature
50HAH51CT001	Low	Low Temperature

Estimation Likelihood:

Table 5: Criterion of Likelihood Steam Drum Component.

Instrument	MTTF	Likelihood	Criterion of Likelihood
50HAD10FL901	9066.877	4.831	B
50HAD10CP901	16353.230	2.678	D
50HAG12CT001	14184.690	3.088	C
50HAH51CT001	2956.251	5.926	A

c. *Superheated:*

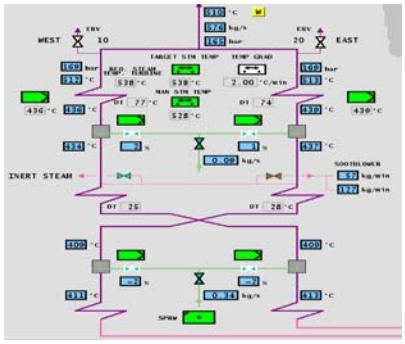

Fig. 4: Diagram *Superheated.*

Australian Journal of Basic and Applied Sciences, 7(11) Sep 2013, Pages: 349-356

Guid Word and Deviasi:

Table 6: Guide Word and Deviation of Superheated Component.

Instrument	Guide Word	Devition
50HAH51CT001	Low	Low Temperature
50LAE11AA101	Part of	Part of Instrumentation
50LAE11AA101	Less	Less Flow
50HAH71CT902	High	High Temperature
50LBA10CT901	Low	Low Temperature
50LBA10CP001	High	High Pressure
50LBA30CT001	Low	Low Temperature
50LBA30CP901	High	High Pressure
50LBA30CF901	More	More Flow

Estimation Likelihood:

Table 7: Criterion of Likelihood Superheated Component.

Instrument	MTTF	Likelihood	Criterion of Likelihood
50HAH51CT001	2956.215	5.926	A
50LAE11AA101	4726.381	9.267	A
50HAH71CT902	19880.716	2.203	D
50LBA10CT901	19880.716	2.203	D
50LBA10CP001	52910.053	0.828	E
50LBA30CT001	19880.716	2.203	D
50LBA30CP901	9127.903	4.798	B
50LBA30CF901	5170.732	8.471	A

d. *Reheated:*

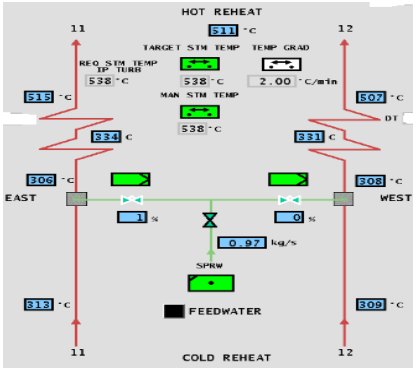

Fig. 5: Diagram of Reheated.

Guide Word and Deviations:

Table 8: Guide Word and Deviation Superheated Component.

Instrument	Guide Word	Devition
50LBC11CT001	High	High Temperature
50LBC12CT001	High	High Temperature
50LAF11AA101	Part of	Part of Instrumentation
50LAF11AA101	More	More Flow
50HAJ11CT901	High	High Temperature
50HAJ12CT901	Low	Low Temperature
50LBB11CT901	Low	Low Temperature
50LBB12CT901	Low	Low Temperature

Estimation Likelihood:

Table 9: Criterion of Likelihood Superheated Component.

Instrument	MTTF	*Likelihood*	Criteria *Likelihood*
50LBC11CT001	19880.716	2.203	D
50LBC12CT001	19880.716	2.203	D
50LAF11AA101	4566.873	9.591	A
50HAJ11CT901	10730.550	4.082	B
50HAJ12CT901	19880.716	2.203	D
50LBB11CT901	19880.716	2.203	D
50LBB12CT901	19880.716	2.203	D

Analysis of Emergency Response Plan (ERP):

Based on HAZOP risk analysis worksheet above, it can be seen that the dangers that pose the greatest risk is fire. Fires can occur in all parts of the boiler, the boiler package both inside and outside the boiler room. The leading cause of fires in the boiler water level in the steam drum is too low, exceeding the lower limit specified and lighters that are in the furnace does not work when the fuel is supplied to the combustion chamber. The purpose of the ERP is to maximize the safety of all existing personnel and minimize damage from fire or explosion. In addition, to ensure smooth communication during emergency handling and to immediately restore operation as soon as possible.

Evacuation map:

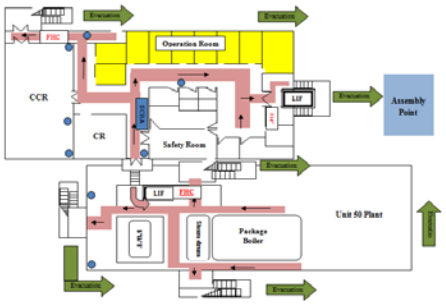

Fig. 6: Evacuation Map.

Discussion:

General prevention:

The person who first discovered the fire ;

- The person who first discovered the fire should immediately shout for help and to give a warning to others who were around Location which can still hear his voice.

Immediately contacted the Control Room Engineer with number 4444 and turn on the nearest fire alarm

- Provide detailed information regarding the location of the fire, many people involved as well as the consequences.
- Give attention to those who are victims. An employee who is not trained or have not completed the first aid training is not allowed to move the wounded. If victims can walk alone, it must be immediately toward a predetermined assembly point.
- For employees who have been trained to use fire extinguishers and fire management have the training, should try stoped fire using extinguishers available around the site, until the fire team arrived. This is only done if the employee properly trained and in a safe condition.

The Emergency Incident Controller (EIC):

- Initiate Emergency Alarm to turn on, and using the public address outside power plant location to call the fire department and medical personnel if necessary.
- Regulate access fire trucks and first aid teams as needed.
- Ensure that all personnel involved in the incident known amount.
- Ensure all emergency services secure in handling
- Completing the Emergency Incident report.
- Ensure all data is written on the Accident (Injuries) Record Book.
- For fatal events, the EIC must keep the area around the scene of the fire cleared, cultivated not spread, and safe. The area is maintained until the police came to investigate.

Shift Core Team and Shift Fire Team:

- After hearing the fire alarm, immediately gathered at the meeting place or at a place indicated by radio.
- Must use PPE and Fire Protective Clothing
- Wear breathing apparatus only when required or instructed by Team Leader
- Trying to extinguish the fire only if safe to do so and should take into account the safety of themselves.

Fire Warden:

- Fire Warden will guide and coordinate the evacuation of employees at the location.
- Ensure that guests had been to the assembly point
- Stay in touch with employees and contractors

- Evacuation is directed through the place / safe route, then remains at the assembly point until no further instructions. Stand by the radio channel - 1 for the instruction of shift manager.

Conclusion:

Based on the data analysis and discussion that has been done can be concluded that the greatest danger to the fourth node boiler, occurs at the level transmitter steam drum level during conditions with less likelihood criterion is A that means there is more than 5 times in 5 years and consequence criteria is 4, so the risk is worth Extreme risk. In addition, there are also extreme risks on the superheated outlet pressure transmitter is a likelihood criterion B, criterion consequence is 4. To reduce these risks, can be done with regular maintenance, calibration routine at the transmitter as well as the addition of redundant transmitters, so it will increase the reliability of the system and potential hazards can be reduced.

Based HAZOP worksheet, note that the greatest risk is in the boiler fires. Therefore, needs to make emergency response plan to fire hazard that occurs in boilers, each include personnel responsibilities, preventive measures, mitigation measures, and evacuation maps to minimize the risk of loss during emergency conditions. The results of this study can be applied to Paiton, especially for boiler systems. With the HAZOP table, it can be a precaution against possible risks, It is profitable for the company, because of the possible dangers of the plant can be reduced, so that the costs for maintenance and repairs will also be reduced.

REFERENCES

Ali Musyafa, Ronny, D.N., 2012. Hazard and operability study in Pulpurizzer of the steam power plant, IJSTE, International Journal of Science and Technology, 1(3): ISSN: 2255-5297.

Asmudi, 2007. "Analysis of performance Boiler to power degradation in PLTU PT. Indonesia Power UBP Perak". Journal of final project Teknik Sistem Perkapalan ITS.

UNEP. Devices of Thermal Energy: Boiler and Fluid thermal Terms. URL:http://www.energyefficiencyasia.org/docs/ee_modules/indo/Chapter - Boilers....pdf

Dhillon, B.S., 2005. "Reliability, Quality, and Safety for Engineers". London : CRC Press.

Ebeling,Charles E., 1997. "An Introduction to Reliability and Maintainability Engineering". Singapore: The McGraw-Hill Companies, Inc.

Iviana Juniani, Anda, 2008. Implements Met ode HAZOP in Prose's Identification hazard and Risk Analysis at Feed water System in Unit Power plant Paiton, PJB. Proceeding Engineering KKK. PPNS, ITS.

SINTEF, 2009, Industrial Management. "Offshore Reliability Data Handbook 4th Edition". OREDA Participants, 2000.

Montgomery, Douglas C., 1999. "Introduction to Statistical Quality Control 6th Edition". United States of America.

Standards Association of Australia, " Australian Standard : Risk Management AS/NZS 4360".

PMI - Health and Safety (H&S) – 450. 2005. "Emergency Management Procedure". Safety and Fire System Department PT. Paiton.

Annex -1: HAZOP WORKSHEET.

No.	Component	Deviation	Concequenes	Safeguard	L	C	R	Recomendations
1.	Presure transmitter Inlet Economizer (50LABOCP001)	High Presure	a. Flow rate increase. b. Explosion occurs because the pressure is too high c. the combustion process flue gass plus high pressure caused a fire on the pipeline econimizer	Control Valve 50LAB40AA101	E	3	M	a. adjust the pressure on the feed pump b. making event for lower pressure feed water c. installation of a high pressure alarm alerts the operator CCR d. perform the calibration once a year tranmiter
2.	Level Transmiter 2v3 (50HAAD10FL901)	Less Level	a. overheating occurs on the walls of water pipes in the steam drum, which can cause a crack in the pipe b. In case of fire / explosion due to continuous heating c. Boiler water circulation pump (BWCP) makes faulty if it continues to operate	Vontrol valve to drain and level switch 50HAD10CL001	A	4	E	a. BWCP immediately turn off to avoid damage, as it continues to operate b. at least 2 levels of alarm installation, LAL and LALL (BS EN 61508 suction 6.1.1.1.) c. Perform recalibration transmitter annually d. Perform maintenance transmitter periodically, at least once every 2 months (WBA suction 70.79.250.) e. increase the flow of water entering the steam drum

3.	Pressure Transmiter Main steam Outlet Superheted (50LBA30CP901)	High Pressure	a. there is damage / disruption in superheater tube b. turbine blade damage if the pressure is too high c. fires can occur on the main steam piping to the turbine	Safety valve and vent	B	4	E	a. making event for the main steam pressure b. perform maintenance and calibration routine and periodic, preventive maintenance once every 2 months and 1 year recalibration every time c. The use of high pressure alarm (PAH and PAHH) d. Care to vent and safety valve to reduce the pressure, at least two months
4.	Temperature Transmiter Inlet Reheater Line 1 (50LBC11CT001)	High Temperature	a. do not need to take a long time to change the cold water feed to the hot water reheter b. feed water has a vapor before exiting the reheater c. reheater corrosion occurs on the pipe	Control valve spray water line 1, 50LAF11AA101	D	3	M	a. Regular maintenance on the heater control valve water spray to prevent corrosion, at least 2 months b. the use of high temperature alarm c. spray water control valve open line 1 d. add coal water on input reheater