Asian Journal of Applied Sciences (ISSN: XXXX – XXXX)
Volume XX– Issue XX, XXXXXXXX 201X

HAZOP Study and Determination of Safety Integrity Level Using Fault Tree Analysis on Fuel Gas Superheat Burner, Ammonia Unit, Petrochemical Plant – East Java

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ABSTRACT— *Safety is an essential requirement in the course of production in the industry. Security in the factory needs to be considered, especially against malicious nodes such as burner. In this research analysis to determine opportunities hazard that could happen to superheat burner. The magnitude of the risk of harm must be balanced with the security system (SIS). So the system superheat burner analyzed by the method HAZOP and SIL safety level calculated through the method of FTA. Based on research conducted in this thesis, superheat burner has a high danger risk (high risk) component TT-1005 and PT-1018. The level of security superheat burner classified SIL 1 with PFD 4.38x10-2, so do redesign the SIS to achieve SIL 2. PFD system of 0.0099 is achieved by adding 2 ESDV on line check fuel gas and purges gas and increase the pressure switch on each function pressure switch. (PSHH, PSL, PSLL).*

Keywords— burner, safety, SIS, FTA, SIL.

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1. INTRODUCTION

The main products of the fertilizer industry Petrochemical East-java is nitrogen and phosphate fertilizers. Fertilizer industry requires major raw materials; ammonia, sulfuric acid and phosphoric acid [1]. To produce ammonia, the main in gradient of natural gas and nitrogen. One of the important process steps in the manufacture of ammonia is to produce steam that is used to support the production of the factory. The function of steam as a heat source as a fluid heat exchanger, as fluid for pneumatic control valve, etc. Supply needs of steam conducted through the steam conditioning process that is integrated in the steam system. Phase manufacture of high quality steam include: steam supply, dieresis, steam generating, steam separation and steam superheating.

In the process of steam generation needed some equipment, among others: De-erator, and Heat Exchanger, Steam high pressure Burner. Superheat steam process burner works at a pressure of 120kg / cm2 and a temperature in the range of 300-500 ° C. Plant recorded throughout the year 2014-2015 has been a trip seven times in ammonia plant. Twice partly as a result of superheat burner failed to maintain stability control complement system [1]. The trip to the factory surely disrupts production activities and corporate losses. Superheat steam system is a system that is very critical [2], because the operational temperature and relatively high working pressure. So the greater the chances of the occurrence of hazards and risks serious consequences. Proved that the instrument mounted on superheated have a higher risk of harm than the other nodes. Therefore Instruments installed outside superheat also have levels of extreme danger risk [3]. Then the security of the steam system must be considered because they affect the quality of the products of steam. So that the risk can be reduced to a minimum through maintenance, calibration and business risks decreased.

When the system state is out of control, it would require an analysis of the SIS security system as a whole, with the identification and prevention fail state. [4]. A burner has the potential hazards and risks are great at a petrochemical industry for the plant are oil and gas. As the components that are vulnerable to fire and exploded, enter the fuel consumption is hazardous high into the system so that the necessary existence of a safety system to prevent an explosion, an accident, even the loss of a human life [5]. First have to identify hazards in the system using Hazard analysis and Operability Study (HAZOP). Through HAZOP can do testing on every part of the process to determine the possibility of deviation from the state of design. Understanding the causes and consequences from hazards. Of the existing problems, the researchers conducted "Hazard and Operability Study (HAZOP) and safety instrumented system (SIS) by the method of Fault Tree Analysis. So the SIS on Fuel Gas Burner superheat can improve system security and reduces the risk of imminent danger.

2. MATERIAL AND METHOD

2.1 *Primary Reformer Steam (Superheat Burner)*

He production process is facilitated ammonia steam with high temperature and high pressure. Steam is used here to support the ammonia plant utilities, among others as a working fluid turbine, compressor, and a heat source as the media heat exchanger, used by the instrument to power pneumatic system. Steam produced by equipment called steam system as shown in Figure 2.1. In this system is the integration of several important nodes, among others; de-eretaor, steam drums, heat exchangers, and superheat primary reformer. In research carried out analysis on the primary superheat steam reformer burner. Superheat steam burner generates heat that burned advanced directly through the media coil tube using fuel gas methane (CH_4). So that the steam generated has a pressure of + 120kg / cm2 and temperature + C°520. Figure 1.

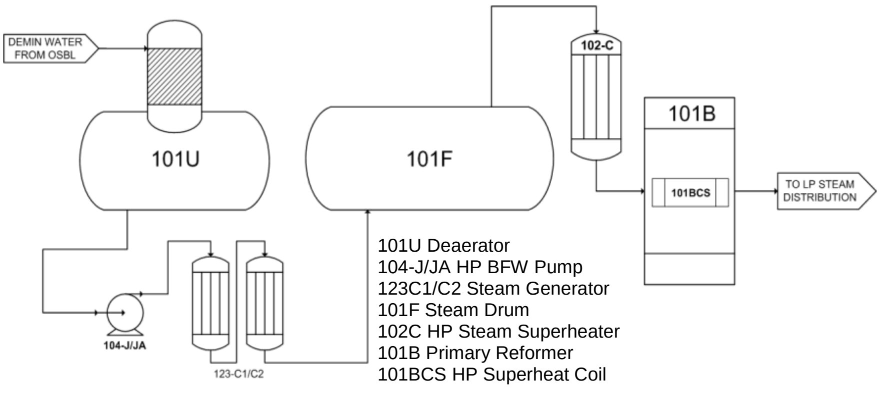

Figure 1 : Process Flow Diagram of Steam System

Steam produced by the system are distributed and utilized into three levels based on the pressure of steam, among others:

a. High Pressure (HP) Steam + 120kg / cm2
   HP steam is used to drive turbines and 103JT 101JT. The heat source heater 173C and 172C1
b. Medium Pressure (MP) Steam + 40kg / cm2
   MP Steam obtained from the extraction 101JT, 103JT as well as the supply of WHB used for the manufacture of ammonia, turbine propulsion, and re-boiler at 140C
c. Low Pressure (LP) Steam + 4kg / cm2
   LP Steam is obtained from steam turbine discharge, the flash of blow down drum 156F, 157F is used to drive turbines JT, and steam service. [1]

2.2 *Hazard and Operability (HAZOP) Study*

Hazard and Operability Study HAZOP or referred to is the method used to analyze the hazards in a system. The system uses qualitative techniques to identify potential hazards by using your word. HAZOP is used to describe any part of the process to be known deviations from the design which has been made and assess the causes and consequences that pose a danger to the system. From the schematic next system built guidewords appropriate system. The HAZOP analysis contains several important elements:

- The analysis process is a creative process that systematically use some guideword to identify deviations into the potential dangers of the design process and use this aberration as "triggering device" as a guide in the analysis of identification potential hazards, impact or the consequences that may occur.
- HAZOP analysis performed by personnel with basic knowledge about the process and analyzed using a logical mindset in every definition of the potential hazards.
- Any problems that finished identified, documented in an assessment table.

In HAZOP analysis there are some parameters that are standard in determining the value and level of danger in every component. Parameters used include; likelihood, consequence, and risk matrix. Likelihood is the chance of risk of harm to the components. Parameters used refers to the likelihood that the standard criteria likelihood "Production Departmen I PT. PKG "shown Table 1.

Table 1. : Criteria Likelihood PT. Petrokimia Gresik [1]

No	*Ranking*	*Discription*
1	*Brand New Excellent*	Risk frequency of occurrence is less than four times in 10 years
2	*Very Good / Good Serviceable*	Risk of 4-6 times in 10 years
3	*Acceptable*	Risks occur between 6-8 times in 10 years
4	*Below Standard / Poor*	Risks occur between 8-20 times in 10 years
5	*Bad / Unacceptable*	Risk occurs 10 times in 10 years

Parameter consequence describes the level of danger of the impact caused by the risk of deviations from the desired state or operating out of control. Reviews carried out based on the impact and the effect on factory activity and production. Standards to determine the consequence refers to the standard criteria factory consequence I PT. PKG shown by Table 2.2.

Table 2. Criteria Consequence PT. Petrokimia Gresik [1]

No	*Ranking*	*Discription*
1	*Insignificant*	Sources of risk (elements / components / objects in the activity) are not impacted at all, consequently no significant effect on the continuity of activities, so that activities remain implemented
2	*Minor*	Sources of risk (elements / components / objects in the activity) have little impact, resulting in little impact on the continuity of activities, so that activities still happen
3	*Moderate*	Sources of risk (elements / components / objects in the activity) of a moderate impact, the result was the continuation of activities, so that activities still happen
4	*Major*	Sources of risk (elements / components / objects in the activity) have a major impact, consequently significantly to the continuity of the activity, but the activity can still be implemented, although not optimal
5	*Catastrophic*	Sources of risk (elements / components / objects in the activity) have an enormous impact, the consequences are very significant to the continuity of activities, so that activities cannot be implemented

Parameter risk ranking is the result of multiplying the likelihood and consequence hazard criteria will be displayed in the matrix, where Risk = Consequence (C) x Likelihood (L), which is shown by Table 2.3.

Table 3.: Risk Matrix ranking PT. Petrokimia Gresik [1]

Likelihood	Consequence				
	1, *Insignificant*	2, *Minor*	3, *Moderate*	4. *Major*	5, *Catastrophic*
1.*Brand New Ecxellent*	L1	L2	L3	L4	M5
2.*Good*	L2	L4	M6	M8	M10
3.*Acceptable*	L3	M6	M9	M12	H15
4.*Poor*	L4	M8	M12	H16	H20
5.*Unacceptable*	M5	H10	H15	H20	H25

Where:
L =*low risk*
M = *moderate risk*
H =*high risk*

2.3 Safety Integrity Level (SIL)

SIL is the security level of safety instrumented system (SIS). SIL is defined as SIL 1, 2, 3, and high 4.Semakin SIL levels, the better the security of SIS. SIL major parameters measured by PFD (Probability Failure on Demand) for categorized SIL 1 if the value is greater PFD equal to 0:01 and smaller than 0.1. For categories other SIL levels can be seen in Table 4. SIS better performance is achieved with the availability of higher security. SIS Performance is enhanced with the addition of redundancy, more frequent testing, and the use of error detection. Some understanding of how the three levels of SIL implemented is critical to the security of the process in determining the SIL. With an understanding of the importance of the safety aspects of the SIS, including what is needed to achieve different SIL. [9]

Table 4: Safety Integrity Level for SIF [9]

SIL categories	***PFD SIF***	***RRF= (1/PFD)***
NR- not requirement	$1 \leq PFD$	$RRF \leq 1$
SIL 1	$10^{-2} \leq PFD < 10^{-1}$	$10^{1} < RRF \leq 10^{2}$
SIL 2	$10^{-3} \leq PFD < 10^{-2}$	$10^{2} < RRF \leq 10^{3}$
SIL 3	$10^{-4} \leq PFD < 10^{-3}$	$10^{3} < RRF \leq 10^{4}$
SIL 4	$10^{-5} \leq PFD < 10^{-4}$	$10^{4} < RRF \leq 10^{5}$

Source: ISA TR 84.00.02-2002

Safety integrity level (SIL) is determined by calculating the probability of a failure will occur using the equation.

$$\lambda = 1/MTTF \quad (2.1)$$

Where: λ = *failure rate* (laju kegagalan); MTTF = Mean Time To Failure
Likelihood obtained from the comparison of the operating time of the components of the average number of component failures to the time following failure.

$$Likelihood = \frac{\text{Operating time}}{MTTF} \quad (2.2)$$

The determination of the SIL is very important in the manufacturing lifecycle stages SIL. Met ode in SIL calculations using quantitative methods derived from the calculation of the repair data as well as instrument implemented. After components that define the configuration of equipment arranged in Moon channel. If the equipment connected in series, the series will be calculated failure rate. For configuration Moon channel the formula used to calculate the PFD is [10]:

$$PFD_{1oo1} = \lambda^{DU}\, x\, \frac{TI}{2} \quad (2.3)$$

$$PFD_{1oo2} = \frac{\lfloor(\lambda^{DU})^2 x TI^2\rfloor}{3} \quad (2.4)$$

$$PFD_{1oo3} = \frac{\lfloor(\lambda^{DU})^3 x TI^3\rfloor}{4} \quad (2.5)$$

$$PFD_{2oo2} = \lambda^{DU}\, x\, TI \quad (2.6)$$

$$PFD_{2oo3} = (\lambda^{DU})^2\, x\, TI^2 \quad (2.7)$$

$$PFD_{2oo4} = (\lambda^{DU})^3\, x\, TI^3 \quad (2.8)$$

Where:

PFD_{MooN} = *Probability Failure on Demand Average*
λ^{DU} (Lambda) = *failure rat*
TI = *Interval time / test function (hour)*

$$PFD_{sys} = PFD_s + PFD_l + PFD_{fe} \quad (2.9)$$

Where:
PFD_{sys} : PFD rate from safety function-safety related system
PFD_s : PFD from sensor *subsystem*
PFD_l : PDD from DCS
PFD_{fe} : PFD from final *element subsystem*

2.4. Flowchar of Research

This research stage following the steps as shown in Figure 2. In more detail includes the following activities:

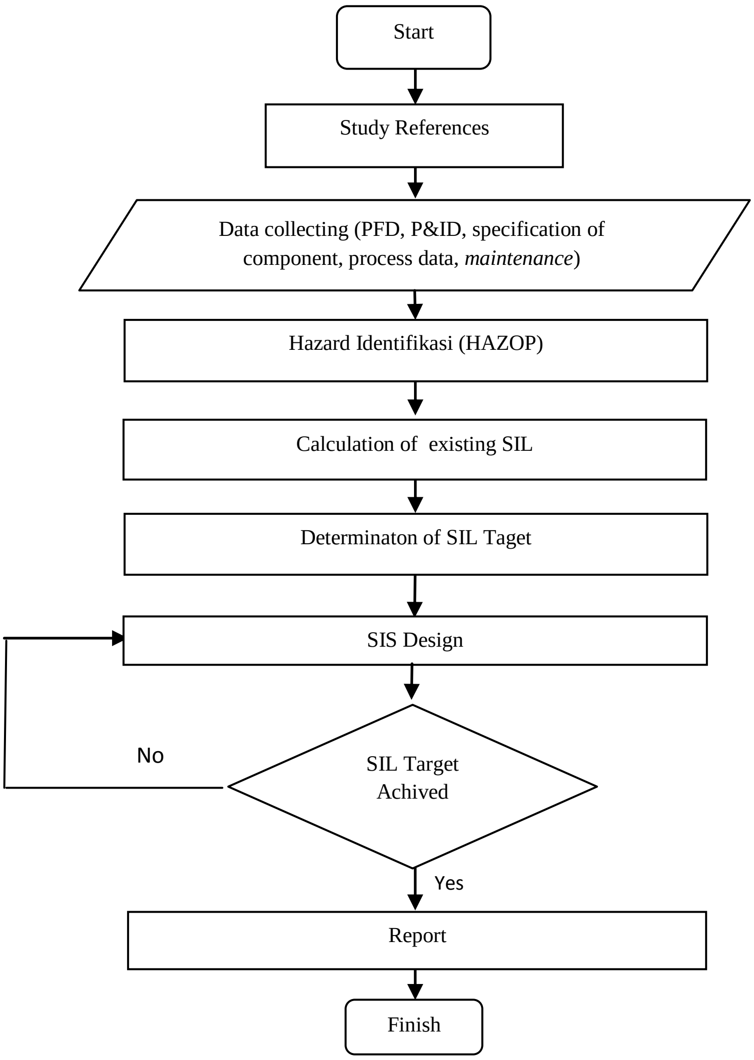

Figure 2. Flowchart of the research

Step-step research activities include;

a. Literature by searching literature journals, books and other publications related to the theme research.
b. The data collection is done by taking pictures of the P & ID, PFD, component specifications, the data maintenance of nodes superheat burner (101BBS), primary reformer (101B) server. Data retrieval the recording process for one month.
c. Hazard identification was conducted using HAZOP (Hazard Operability Study). Covering risks, opportunities danger, deviation superheat processes that occur on the burner, so that the risk value can be determined based on the level of frequency and consequences occur.
d. SIL calculation obtained by the existing FTA method by calculating each PFD components that represent each event. SIL value superheat burner system is calculated from the total PFD SIS components that make up the node superheat. So that the security level of the system can be known.
e. Determining Target SIL as a follow-up analysis of the risks and SIL calculation of existing plant to produce recommendations to minimize the danger to the value of SIL consensus in a way component members add safety and security activities to reduce the risk. Level SIL upgraded one notch higher.
f. The design of the SIS as an effort to increase security by adding and changing the configuration of the security system.

3. ANALISYS AND DISCUSION

To produce steam carried out in several stages, carried on with de-erator dieresis 101U, continued preheat the heat exchanger 123 C1 / C2, the separation between the vapor and liquid phase in the steam drum 101F. Dry steam is produced with advanced high temperature heating with heating coil 101B primary reformer. Activity form directly through the combustion burner superheat. Product specification steam has a temperature = 520 ° C and pressure = 120kg / cm2. Steam products further distributed to the ammonia unit. Vapor product consists of three types; high pressure (HP), medium pressure (MP), and low pressure (LP). Each product is used according to need. So that the primary role of reformer very vital because directly related to combustion and processes with process variables are relatively high, further analysis is focused on the primary node reformer in the form of coil superheat and Uren superheat.

Potential hazards assessed based on the log sheet and the data obtained from the DCS data history, data is sampled with acquisition pattern every four hours of operation at the primary reformer transmitter 101B. Potential hazards of known trends based on average data deviation operations. Obtained through the guide word expressed by the deviation. Temperature transmitter 1005 (TT1005) loop temperature control to maintain the temperature of steam output. P & ID superheat Burner is shown in Figure 3.2.

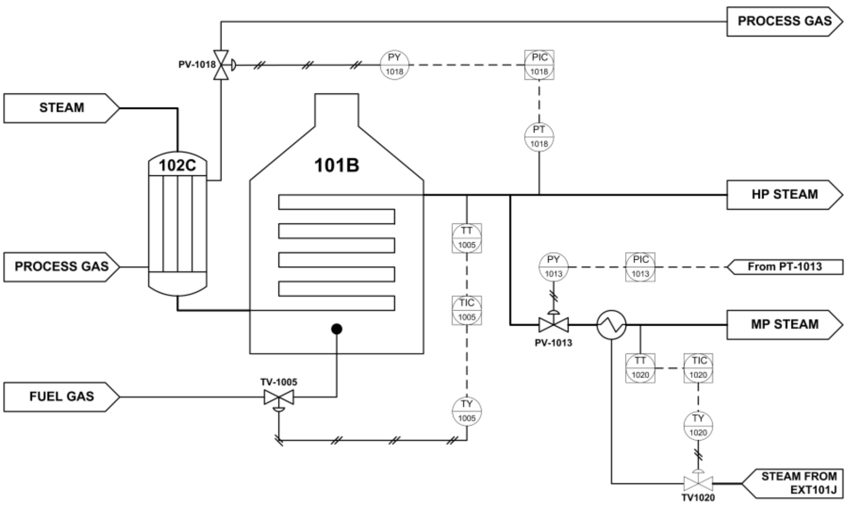

Figure 3. P&ID *Superheat Burner*

From the historical data can be further built TT1005 control chart graph. Indicated that the process has deviated to the value are above and below the mean value. Furthermore, the determination guideword and high and low deviation is shown in Figure .4.

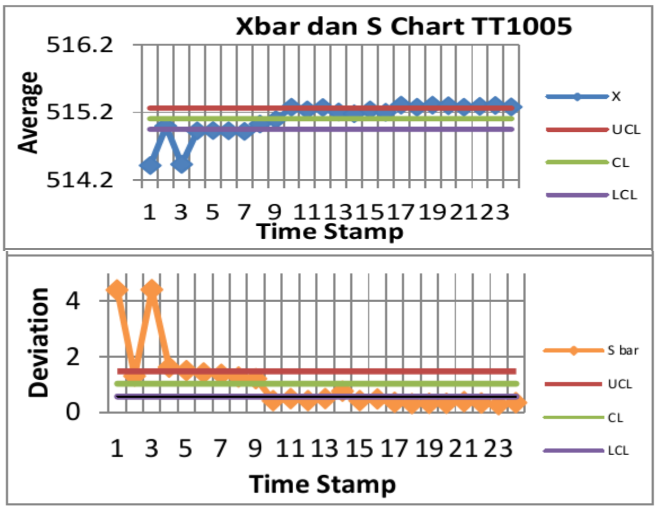

Figure.4. **:** Control Chartn of Bar-S TT-1005

Table 5. Guideword of node superheat burner

No.	***Coponent***	***Description***	***Guideword***	***Deviation***
1	TT1105	*Temperature Transmitter*	*High*	*High Temperature*
			Low	*Low Temperature*
2	PT1018	*Pressure Transmitter*	*High*	*High Pressure*
			Low	*Low Pressure*
3	TT1020	*Pressure Transmitter*	*High*	*High Pressure*
			Low	*Low Pressure*
4	PT1013	*Temperature Transmitter*	*High*	*High Temperature*
			Low	*Low Temperature*
5	FI1031	*Flow Transmitter*	*More*	*More Flow*
			Less	*Less Flow*
6	TI1336	*Temperature Transmitter*	*High*	*High Temperature*
			Low	*Low Temperature*
7	TV-1005	*Control Valve*	*Open*	*Fail to open*
8	PV-1018	*Control Valve*	*Close*	*Fail to close*
9	PV-1013	*Control Valve*	*Open*	*Fail to open*
10	TV-1020	*Control Valve*	*Open*	*Fail to open*

Levels of risk are expressed in a matrix. To provide value parameter refers to the likelihood and consequence of each standard. Likelihood value is determined using data maintenance, instrument calibration obtained from Dept. Maintenance. As for the components for which data are available traceability data contained in the manual book OREDA (Offshore Reliability Data) 2002.

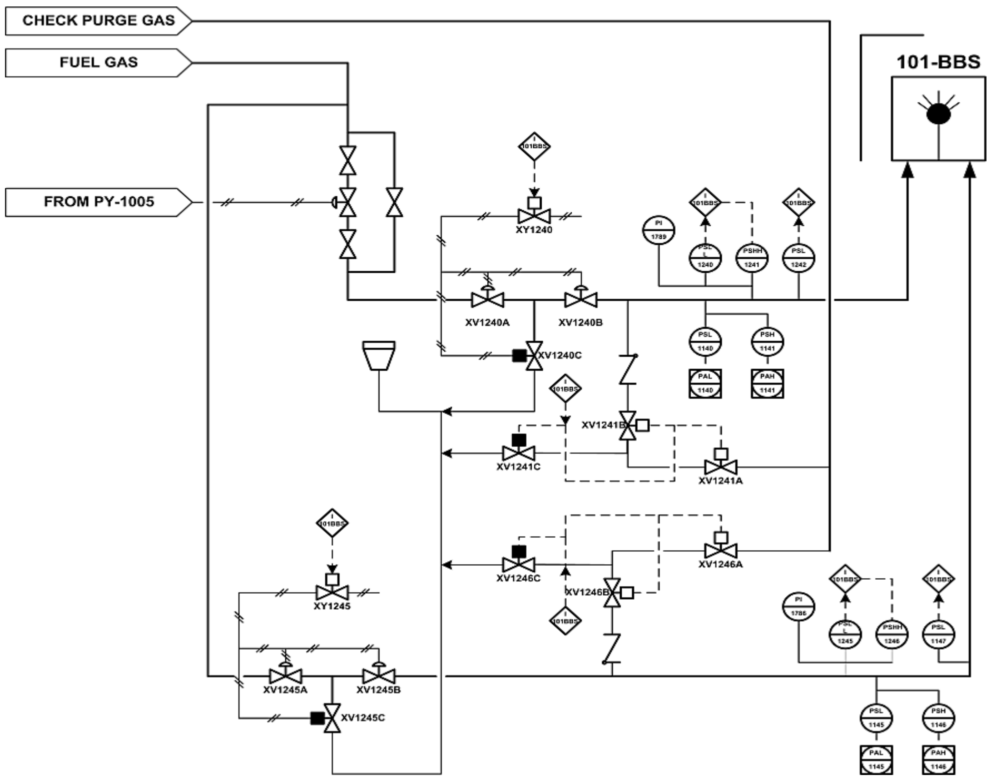

Figure 5. : P & ID Superheat Burner

Likelihood value is calculated by dividing time operating instrument against the mean time to failure (MTTF). So as to superheat node burner at risk for each component Consequence is determined to seek severity (severity) impacts that occur the risk of deviations from the desired state. Based on the standard process data and operational implementation (SOP) ammonia plant can then be determined according to the severity level of consequences category table 2.

Table 6. Likelihood, Consequence and Risk Ranking in Superheat burner

No.	**Component**	***L***	***C***	***RR***
1	TT1005	4	5	H20
		4	5	H20
2	PT1018	4	5	H20
		4	5	H20
3	PT1013	3	2	M6
		3	2	M6
4	PT1020	2	3	M6
		2	3	M6
5	FI1031	2	3	M6
		2	2	M6
6	TI1031	1	2	L2
		1	2	L2
7	TV-1005	1	3	L2
8	PV-1018	1	3	L2
9	PV-1013	1	2	L2
10	TV-1020	1	2	L2

Security systems burner superheat implement security layer Safety instrumented system (SIS). SIS consists of a sensing element in the form of switches, controllers such as PLCs, the final element in the form of valve / solenoid valve. The security system installed on the components that have a high chance of danger. Fuel burner using methane gas (CH_4) is supplied from the fuel gas. Direct burning combustion manifold which has two gases feed pipe line for supplying the gas burner and each line has a safety system SIS. SIL calculation by the method of the FTA, the SIS system superheat burner using PFD value derived from the data maintenance. Because there are limited data maintenance, then the pressure switch components, PLC and solenoid valve XY1240 XY1245 using values based OREDA 2002. The failure rate of the components of SIS PFD superheated burner shown in table 7.

Table 7.: Values & PFD component failure rate superheat Burner.

NO	Instrumen	*Failure Rate*	PFD	SIL
1	*Pressure Switch* – PSHH – PSLL – PSL – PSHH – PSLL – PSL	$2.00x10^{-6}$ $2.00x10^{-6}$ $2.00x10^{-6}$ $2.00x10^{-6}$ $2.00x10^{-6}$ $2.00x10^{-6}$	$8.76x10^{-3}$ $8.76x10^{-3}$ $8.76x10^{-3}$ $8.76x10^{-3}$ $8.76x10^{-3}$ $8.76x10^{-3}$	2 2 2 2 2 2
2	PLC *Safety Manager*		$1.43\ x10^{-4}$	3
3	*Final Element* – XY1240 – XV1240 – XY1245 – XV1245 – XV1241 – XV1246	$4.800x10^{-7}$ $2.211x10^{-5}$ $4.800x10^{-7}$ $2.162x10^{-5}$ $2.163x10^{-5}$ $2.163x10^{-5}$	$2.102x10^{-3}$ $1.250x10^{-2}$ $2.102x10^{-3}$ $1.195x10^{-2}$ $1.196x10^{-2}$ $1.196x10^{-2}$	2 1 2 1 1 1

Through analysis of the FTA, the calculation of the value of the SIL superheat burner searched through the stages shown in Figure 6.

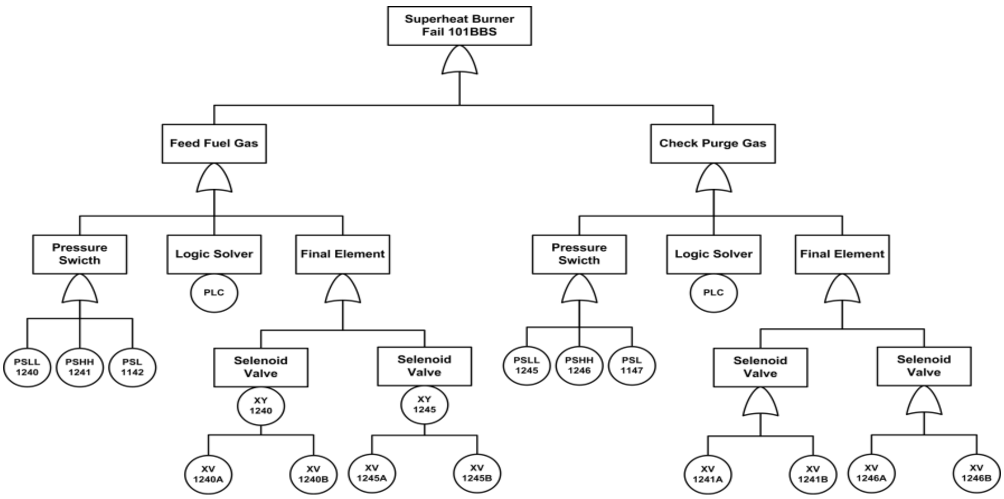

Figure 6.: FTA Superheat Burner.

Through analysis of the FTA SIL superheat value calculation burner is calculated as follows.

$$PFDsb = PFDfuel\ gas \cup PFD\ check\ purge\ gas$$

$$PFDsb = (PFDs \cup PFDl \cup PFDfe) \cup (PFDs \cup PFDl \cup PFDfe)$$

$$PFDsb = (PFDs \cup PFDl \cup PFDfe) \cup (PFDs \cup PFDl \cup PFDfe)$$

$$PFDsb = \left(\left((8.760x10^{-3}x3\ ) + 0.000143 + (1.250x10^{-2} + 1.19510^{-2}\right)\right) + (8.76x10^{-3}x3\ ) + 0.000143 + (1.196x10^{-2} + 1.196x10^{-2}))$$

$$PFDsb = 2.45x10^{-2} + 2.38x10^{-2}$$

$$PFDsb = 4.8310^{-2}$$ (SIL 1)

An increase in SIL, once obtained is calculated PFD of SIS system superheat SIL burner system. Moon SIS channel configuration obtained by sensing combination element (pressure switch) and the final element (valve) and the value PFD tabulated tables 4.4 and 4.5 as well as SIL combination of SIS in Table 8.

Table 8.: Value PDF and SIL Pressure Switch

Configures	PFD *Pressure Switch*	SIL
	λ 0.000002	
1oo1	$8.760x10^{-3}$	2
1oo2	$7.674x10^{-5}$	4
1oo3	$6.722x10^{-7}$	4

PFD calculation of the pressure switch using a data failure rate of Oreda book in 2002 for maintenance of data showing the absence of failure for 20 years operating ammonia plant. So for now on SIS superheat burner consists of three pressure switch (PSHH, PSLL, PSL) to the fuel feed line and a gas line purge gas check. Overall ESDV value of existing SIL 1. So as to achieve the necessary modifications to the configuration ESDV from Table 4.6 written SIL 2 can be achieved with a combination of configuration ESDV 6 and switch after. PFD value and the SIL of a variety of configurations do a combination of the sensing element and final element in table 9.

Table 9 : Value PFD and SIL Final Element ESDV

Konfi guration	PFD *Final element*					
	XV1240	XV1245	XV1241	XV1246	XY1240	XY1245
	λ $2.21x10^{-5}$	λ $2.16x10^{-5}$	λ $2.16x10^{-5}$	λ $2.16x10^{-5}$	λ $4.80\ x10^{-7}$	λ $4.80\ x10^{-7}$
1oo1	$9.684\ x10^{-2}$	$9.468\ x10^{-2}$	$9.474\ x10^{-2}$	$9.474\ x10^{-2}$	$2.102\ x10^{-3}$	$2.102\ x10^{-3}$
1oo2	$1.250x10^{-2}$	$1.195x10^{-2}$	$1.197x10^{-2}$	$1.197x10^{-2}$	$5.893\ x10^{-6}$	$5.893\ x10^{-6}$
1oo3	$1.816\ x10^{-3}$	$1.698x10^{-3}$	$1.701x10^{-3}$	$1.701x10^{-3}$	$1.859\ x10^{-8}$	$1.859\ x10^{-8}$
2oo2	$1.937x10^{-1}$	$1.894x10^{-1}$	$1.895x10^{-1}$	$1.895x10^{-1}$	$4.205\ x10^{-3}$	$4.205\ x10^{-3}$
2oo3	$3.751x10^{-2}$	$3.586x10^{-2}$	$3.590x10^{-2}$	$3.590x10^{-2}$	$1.768\ x10^{-5}$	$1.768\ x10^{-5}$
2oo4	$7.266x10^{-3}$	$6.790x10^{-3}$	$6.803x10^{-3}$	$6.803x10^{-3}$	$7.434\ x10^{-8}$	$7.434\ x10^{-8}$

Tabel 10.: The resulting value is a combination SIL SIS Fuel Gas Line

NO.	*Sensing Element*		SIL *Logic Solver* PLC	*Final Element*				SIL SIS
				ESDV		*Solenoid Valve*		
	Configures	SIL		Configures	SIL	Configures	SIL	
1	1oo1	2	3	1oo3	2	1oo1	2	2
2	1oo1	2	3	2oo2	0	1oo2	4	0
3	1oo1	2	3	2oo3	1	1oo3	4	1
4	1oo1	2	3	2oo4	2	2oo2	2	2
5	1oo2	4	3	1oo3	2	1oo1	2	2
6	1oo2	4	3	2oo2	0	1oo2	4	0
7	1oo2	4	3	2oo3	1	1oo3	4	1
8	1oo2	4	3	2oo4	2	2oo2	2	2
9	1oo3	4	3	1oo3	2	1oo1	2	2
10	1oo3	4	3	2oo2	0	1oo2	4	0
11	1oo3	4	3	2oo3	1	1oo3	4	1
12	1oo3	4	3	2oo4	2	2oo2	2	2

An increase in SIL base on the voting system targets Moon SIL 2 can be achieved through the six combinations; switch between sensing element and final element (ESDV) Table 4.6. Calculation combination table SIS-2 has a combination of numbers 1, 4, 5, 8, 9. From the comparison calculation of some combination of SIS system, then obtained the system reaches SIL 2 combination number 5 with PFD 0.010. The combination of the number 5 is composed of sensing element 1oo2, 1oo3 ESDV (XV1241-1246) and 1oo1 (XY1240 and 1245) and requires additional instrument 6 and the second pressure switch control valve and the second solenoid valve. When compared to the combination of X number also achieves SIL 2. Implementation of an increase in SIL with the addition ESDV actuator configured 1oo3 and 1oo2 pressure switch sensing element generates a configuration that can be applied to SIS superheated burner, shown in Figure 4.5.

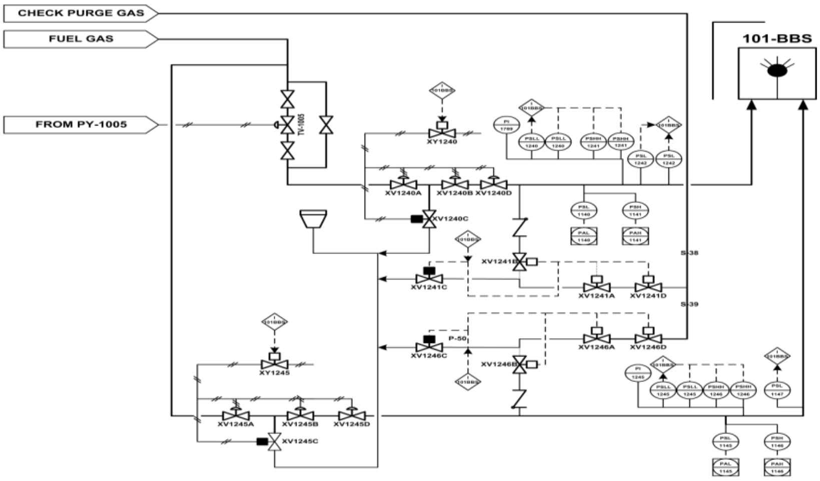

Figure 7.: P & ID SIS Superheat Burner

Through a combination of SIS number 5 configuration using FTA method obtained SIL value calculation of superheat following burner.

$$PFDsb = PFDfuel\ gas \cup PFD\ check\ purge\ gas$$
$$PFDsb = (PFDs \cup PFDplc \cup PFDfe) \cup (PFDps \cup PFDplc \cup PFDfe)$$
$$PFDsb = (PFDs \cup PFDplc \cup PFDfe) \cup (PFDps \cup PFDplc \cup PFDfe)$$
$$PFDsb = ((7.674x10^{-5}x3) + 1.43x10^{-4} + (1.816\ x10^{-3} + 1.698\ x10^{-3} + 2.102x10^{-3} + 2.102x10^{-3})) + ((7.674x10^{-5}x3) + 1.43x10^{-4} + (1.701x10^{-3} + 1.701x10^{-3}))$$
$PFDsb = 0.0099$ (SIL 2)

4. CONCLUSION

Based on research that has been done, it concluded as follows; Components PT-1018 and TT-1005 have a risk ranking of 20 were classified as high risk categories. While component of PT-1013, TT-1020 is included in moderate category, so it is necessary to reduce these risks by redesigning SIS for improve the SIL system. Superheat burner existing value SIL system for one with the PFD of the components of the final element ESDV having a value PFD greater than other component and Improved SIL system superheat burner reached SIL 2 with PFD 0.0099 by adding 2 pieces ESDV install series on each line feed fuel check gas and purge gas as well as the addition of a pressure switch again in any function switch (PSHH, PSL, PSLL).

5. ACKNOWLEDGEMENT

The authors would like to thank the Institute for Research and Community Service (LPPM ITS), Institut Technologi Sepuluh Nopember, Surabaya. With supporting financing the research. Also, the authors would like to thank the anonymous referees for their comments on the eelier version of this work.

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ANNEX-1.

HAZOP *Node superheat burner*

NO	Component	Description	Guide word	Deviation	Cause	Consequences	Safeguard	L	C	RR	Recommendation
1	TT1005	Temperature Transmitter	High	High Temperature	More flow of feed fuel gas on superheat burner	Overpressure, potentially cause leaking on tube and blown in burner	Control valve TV1005 High pressure alarm PAH1141 Interlock 101BBS with PSHH1241 actuating Control Valve XV1241A & XV1241B	4	5	H20	Calibrate for time period Preventive maintenance . Redesign SIS burner
			Low	Low Temperature	Less flow of feed fuel gas on superheat burner	Bad steam quality, steam cannot reach the design temperature	Control valve TV1005 Low Pressure alarm PAL1140 Interlock 101BBS with PSLL1241 actuating Control Valve XV1241A & XV1241B	4	5	H20	Preventive maintenance Calibrate for time period Redesign SIS burner
2	PT1018	Pressure Transmitter	High	High Pressure	Burning temperature in superheated too high	Overpressure Cause leaking or mechanical damaged for steam pipe, 101-C, 102-C	Control valve PV1018A & PV1018B failsafe in fail open state	4	5	H20	Prenventive maintance Overhaul every turn around
			Low	Low Pressure	Less steam flow & Burning temperature in	Poor steam quality	Control valve PV1018A & PV1018B failsafe in fail open state	4	5	H20	Prenventive maintance Overhaull every turn around

NO	Component	Description	Guide word	Deviation	Cause	Consequences	Safeguard	L	C	RR	Recommendation
					superheated too low						
3	PT1013	Pressure Transmitter	High	High Pressure	Burning temperature in superheated too high	Overpressure cause mechanical damaged for steam pipe line	PAH alarm high indicator Control valve PV1013 failsafe in fail close state	3	2	M6	Calibrate for time period
			Low	Low Pressure	Less steam product from Primary Reformer 101-B	Less steam distributed to ammonia system unbalance	Control valve PV1013 failsafe in fail close state	3	2	M6	Give alarms system for indicating an PAL
4	TT1020	Temperature Transmitter	High	High Temperature	Less water flow from 104J/JA into de superheater	Pressure increase	TAH alarm high indicator Control valve PV1020 failsafe in fail close state	2	3	M6	Calibrate & preventive maintenance for time period
			Low	Low Temperature	More water flow from 104J/JA into de superheater	Bad steam quality for medium steam distribution	Control valve PV1020 failsafe in fail close state	2	3	M6	Give alarms TAL for indicating Calibrate & preventive maintenance
5	FI1031	Flow Transmitter	More	More Flow	More flow from gas service	Pipe overpressure May be cause a pre-ignition on pipe Superheat burner overheat, potentially explosion on superheat burner	PSHH 1241, PSH 1141, and PAH Safety system actuating interlock I 101BBS to cut off gas flow	2	3	M6	Calibrate & preventive maintenance for time period
			Less	Less Flow	Lacking on gas pipe	Superheat burner cannot reach design temperature, poor steam quality	PSL1142. PSL1140, Alarm on DCS PAL 1140, Safety system actuating interlock I 101BBS to cut off gas	2	3	M6	Calibrate & preventive maintenance for time period

NO	Component	Description	Guide word	Deviation	Cause	Consequences	Safeguard	L	C	RR	Recommendation
							flow				
6	TI1336	Temperature Transmitter	High	High Temperature	Flow process gas too high	Steam temperature inlet superheat burner too high	Loop temperature control TT-1005	1	2	L2	Check and scheduling service
			Low	Low Temperature	Low flow of process gas	Cannot reach steam temperature design.	Loop temperature control TT-1006	1	2	L2	Check and scheduling service
7	TV-1005	Control Valve	Open	Fail to open	System control fail no signal control	No gas flow into burner	Line by pass Pressure regulator valve	1	3	L3	Check and scheduling service
8	PV-1018	Control Valve	Close	Fail to close	System control fail no signal control	Flow process gas too high steam temperature from 102C, overpressure steam inlet primary reformer	Line by pass hand valve manually operated	1	3	L3	Check and scheduling service
9	PV-1013	Control Valve	Open	Fail to open	System control fail no signal control	Cannot distribute MP steam	Line by pass with hand valve manually operated	1	2	L2	Check and scheduling service
10	TV-1020	Control Valve	Open	Fail to open	System control fail no signal control	Steam quality for MP distribution decreasing	Line by pass valve manually hand operated	1	2	L2	Check and scheduling service