Risk Mapping of Bogie S2HD-9C Production Process that Take Effect on Production Fulfillment at PT. Barata Indonesia (Persero)

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***Abstract*— PT Barata Indonesia (Persero) is one of leading metal works company in Indonesia. It has 3 main business line which are engineering procurement and construction (EPC), industrial tools manufacturing, and foundry. As the company's strategic objective in delivering quality product and service to the customer, PT Barata Indonesia should maintain their production process properly. One of the featured product of PT Barata Indonesia is bogie. The production process of bogie shows a fluctuative delivery fulfillment. It can be proved by the contract amendment information. Risk management can be used as the method to manage risk inside the production process of bogie. Therefore, this research is aimed to identify risks that may occur from each activities of bogie S2HD-9C's production process. The risk identification is done by using fault tree analysis method in order to determine the root cause of each activity performed. The risk evaluation is done by using FMEA method which can classify the effects of failure based on the severity and occurrence of failure. Then continue to the risk mapping and risk mitigation determination for bogie S2HD-9C's production process. Loss that caused by the emergence of risk also determined using value at risk method. Moreover, risk profile dashboard will be provided as the tools in managing risk.**

***Keywords*—Fault Tree Analysis (FTA), FMEA, Production Process, Risk Dashboard, Risk Management, Risk Map, Risk Mitigation, Value at Risk**

I. INTRODUCTION

PT Barata Indonesia is one of the government company in Indonesia which has 3 main business line. There are, engineering procurement and construction (EPC), industrial tools manufacturing, and foundry (PT. Barata Indonesia, 2013). Some products of PT Barata Indonesia are, bogie, mill roll, pipeline, road rollers, storage tank, and also ball tank.

PT Barata Indonesia is a leading bogie supplier in Indonesia with 100% local demand fulfillment. Moreover, PT Barata Indonesia penetrated United States market with 1,500 bogie delivered since 2012. Bogie's supply both local and worldwide shows a positive trend. This condition forced PT Barata Indonesia to maintain the commitments to give a competitive service in terms of quality, price, and delivery (PT. Barata Indonesia, 2013).

As the company's strategic objective in delivering quality product and service to the customer, PT Barata Indonesia should maintain their production process properly. Moreover, quality and service of product should be addressed as company's competitive advantage in order to compete in the global market. Competitive advantage that brings higher income to the company can be fulfilled with organization of production, higher application, and as low as possible production costs (Wang, Lin, & Chu, 2011).

In fact, PT Barata Indonesia currently facing some obstacles regarding to the company's strategic objective. The production process of PT Barata Indonesia cannot achieve zero defect production. Although the order of product is the same, the completion of product still not good enough. It can be proved by the number of contract amendment information. Both machineries used and people also made some contribution to the production condition. For example, some of the machines inside the workshop needs several preventive maintenance to maintain its condition. Unfortunately, the worker who has responsibility to maintain the machine were not doing their job. Because of that, some of the machines used broken down. Moreover, the equipments used for the production of bogie is less sophisticated and the production planning is not good enough. So, that condition make the probability of delivery lateness become higher.

This condition makes the company have to reschedule their completion date of product and make some amendment for the contracts with the customer. In the middle of 2015, PT Barata Indonesia have established commercial and risk bureau whom responsible to company's risk management. Unfortunately, there were no risk assessment performed on bogie S2HD-9C's production process. Usually the production department makes a small notes for every defects occurred on each batch of production. But there were no further analysis or assessment in order to handle any possibilities of risk.

Risk might be a driver of strategic decisions because of its uncertainty (Institute of Risk Management, 2010). The strategic decisions made by a company will determine the achievement of their strategic objectives in the future. PT Barata Indonesia need to understand the risk that embedded inside their company in order to achieve their objectives. Risk management can be used as the method to understand and anticipate risk inside the company. The focus of risk management is the assessment of significant risks and the implementation of suitable risk treatments (Institute of Risk Management, 2010). By implementing risk management PT Barata Indonesia will be able to increase the probability of achieving objectives, improve minimize losses, and prevent the risks to be occurred again in the future.

Based on previous explanation, this research is aimed to identify risks that may occur from each activities of bogie S2HD-9C's production process. The risk identification is done by using fault tree analysis method in order to determine the root cause of each activity performed. The risk evaluation is done by using FMEA method which can classify the effects of failure based on the severity and occurrence of failure. Then continue to the risk mapping and risk mitigation determination for bogie S2HD-9C's production process. In order to make the risk monitoring activity easier, this research will provide risk profile dashboard as one of the research output by using macro excel software. With the output of this research, PT Barata Indonesia are expected to minimize the risk that occurred in bogie S2HD-9C's production process

II. RESEARCH METHODOLOGY

A. Brainstorming and Initial Identification Stage

Initial identification stage consists of brainstorming and identification of existing condition in workshop 1 PT Barata Indonesia, accompanied by responsible division in workshop 1 which is Industry Division. So the objective of this research can be obtained which is developing the risk mapping of Bogie S2HD-9C's production process.

1. Data Collection Stage

Data collection stage is done by conducting interviews, reviewing company's data, and also questionnaire. All of the data obtained will be used as the input of risk mapping construction of Bogie S2HD-9C's production process

2. Data Processing Stage

The data processing stage will be done through the completion of several process such as, questionnaire validation, risk evaluation by using FMEA method, risk mapping, risk mitigation, value at risk, and develop risk profile dashboard.

3. Analysis Stage

In this stage, the analysis and data interpretation activity will be done. This stage will be based on the result of data processing stage. Several data analysis that will be conducted are, production process analysis, risk analysis, risk assessment analysis, risk mapping analysis, mitigation analysis, dashboard analysis, and value at risk analysis.

4. Conclusion Stage

In this stage, the conclusion and suggestion will be determined. The given conclusion and suggestion will be based on data analysis and interpretation which has been done before. Conclusion will answer the objectives of research and the suggestion will be given for the company and further research.

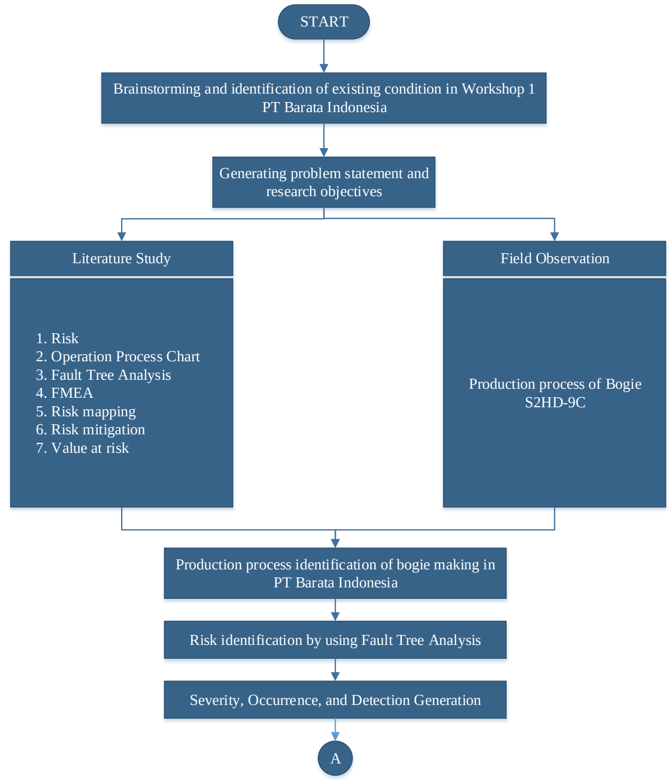

Figure 1. Flowchart of Research Methodology

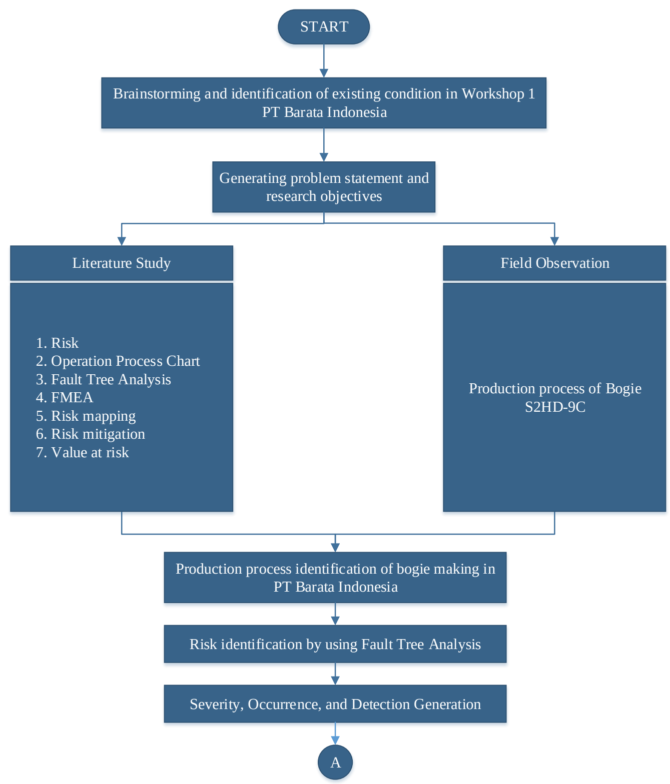
Figure 1. Flowchart of Research Methodology

III. DATA COLLECTION AND PROCESSING

A. *Production Process Identification*

The first stage that need to be done is determine the production process of Bogie S2HD-9C. The production process will be determined using Operation Process Chart (OPC) method.

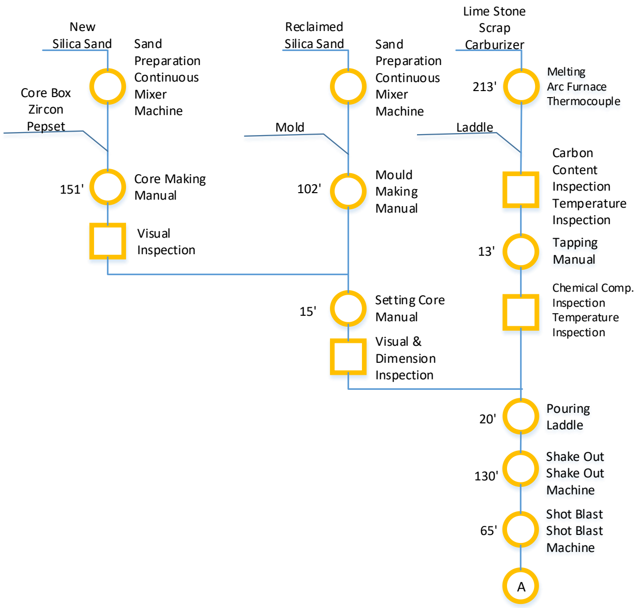

Figure 2. Production Process Identification

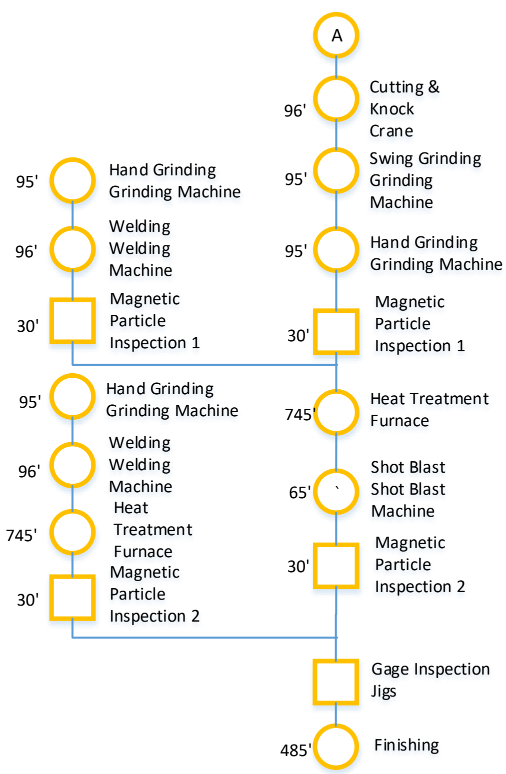

Figure 2. Production Process Identification (con't)

B. *Risk Identification and Assessment*

Risk identification process will be done by using Fault Tree Analysis (FTA) method. The risk will be identified from each activities performed. Then each risk will be assessed by using FMEA method.

Table 1. Risk Identification

Risk Code	Risk	RPN
R1	Broken Compressor	8
R2	The pattern is not completely cleaned	16
R3	Broken Pump	120
R4	Improper mixing	6
R5	Bad coating	32
R6	Broken Furnace	24
R7	Broken Compressor	8
R8	The pattern is not completely cleaned	12
R9	Broken Pump	168
R10	Improper mixing	6
R11	Broken corebox	12
R12	Broken core	10

Table 1. Risk Identification (con't)

Risk Code	Risk	RPN
R13	Bad coating	48
R14	Incomplete core	6
R15	Broken core	10
R16	The core and parting lines is not completely cleaned	8
R17	Loose material left behind	90
R18	Broken core	4
R19	Raw material doesn't meet standard	8
R20	Broken thermocouple	4
R21	Broken Furnace	80
R22	Improper chemical composition	8
R23	Improper chemical composition	24
R24	Improper ladle setting	20
R25	Temperature higher than standard	6
R26	Temperature higher than standard	16
R27	Pouring time too long	6
R28	Broken belt conveyor	112
R29	The casting was shake when the temperature is high	12
R30	Malfunctioned crane	96
R31	Casting cannot be pulled out	30
R32	Broken belt conveyor	112
R33	The casting was shake when the temperature is high	12
R34	Malfunctioned crane	96
R35	Casting cannot be pulled out	12
R36	Malfunctioned crane	30
R37	Setting need a longer time to finish	16
R38	Malfunctioned impeller	112
R39	The casting still has a rough surface	36
R40	Setting need a longer time to finish	4
R41	Cutting result doesn't meet standard	12

Table 1. Risk Identification (con't)

Risk Code	Risk	RPN
R42	Setting need a longer time to finish	4
R43	Line full	50
R44	The casting need a lot of grinding	48
R45	The casting still need to be processed	40
R46	The fluid is not applied well	24
R47	Improper inspection	48
R48	Broken MPI tools	48
R49	Zone 1 defect discovered	192
R50	Setting need a longer time to finish	8
R51	Line full	40
R52	Casting need a lot of welding	40
R53	The casting still need to be processed	8
R54	Broken furnace	16
R55	Undisciplined method	12
R56	Thermocouple broken	16
R57	The casting cannot be pulled out from the machine	12
R58	The casting need a longer time to cool down	4
R59	Casting need heat treatment process	48
R60	The clamp cannot hold the work piece	6
R61	Line full	60
R62	Broken CNC machine	48
R63	work piece cannot meet the dimensional standard	12
R64	Setting need a longer time to finish	8
R65	The casting dimension doesn't meet requirement	8
R66	Nuts and bolts cannot be set	8
R67	Wrong arrangement of product	12

C. Risk Mapping

After the risk already identified and assessed by using FMEA method, then all of the risk will be plotted into risk map in order to determine the classification of risk based on its category. There are three categories such as, high risk, medium risk, and low risk.

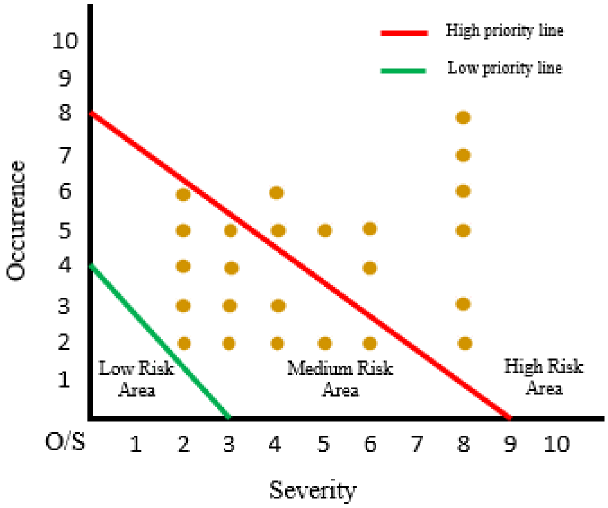

Figure 3. Risk Map

The result of risk map is 45 medium risk and 22 high risk. Next, the risk with category high risk will get a corrective action or mitigation in order to manage the risk

D. Risk Mitigation

The risk mitigation is the way to manage the risk in order to reduce the probability of risk occurred. There are four classification of risk mitigation such as, avoid, transfer, mitigate, and accept. There are 15 avoid risk, 4 transfer risk, 13 mitigate risk, and 13 accept risk.

E. Value at Risk

Value at Risk is the way to develop the loss caused by the emergence of risk. In the calculation process, there will be several data needed such as, lateness time data, repair cost data, and also electricity cost data. Using the 95% confidence interval, the probability of loss will be obtained.

Table 2. Simulation Result

Code	Risk	Loss
R13	Bad coating	VaR @ Rp 429,778
R17	Loose material left behind	VaR @ Rp 156,224
R26	Temperature higher than standard	VaR @ Rp 193,200
R43	Line full	VaR @ Rp 260,912
R44	The casting need a lot of grinding	VaR @ Rp 216,247
R45	The casting still need to be processed	VaR @ Rp 55,805
R47	Improper inspection	VaR @ Rp 215,891
R49	Zone 1 defect discovered	VaR @ Rp 461,706
R51	Line full	VaR @ Rp 482,307
R52	Casting need a lot of welding	VaR @ Rp 452,010
R59	Casting need heat treatment process	VaR @ Rp 519,998
R61	Line full	VaR @ Rp 1,038,504

Table 2. Simulation Result (con't)

F. Risk Profile Dashboard

After the loss calculation already performed, the risk profile dashboard will be constructed. Risk profile dashboard is aimed to help PT Barata Indonesia to manage the risk embedded in production process of Bogie. There are several functions that can be accessed through the dashboard such as, risk database, risk assessment, risk mitigation, risk updating, and loss calculation. The construction of risk profile dashboard will use Microsoft Excel Software.

IV. CONCLUSION/SUMMARY

There are 67 identified risk of bogie S2HD-9C production process. First thing to do is conducting risk assessment by using FMEA method. Then each risk will be evaluated based on the RPN number. The highest RPN number was obtained from R49 which is zone 1 defect discovered with 192 and lowest RPN number was obtained from R58 which is casting need a longer time to cooldown with 4. There are 22 risk which categorized as high risk and the rest of the risk are categorized as medium risk. Risk mitigation is addressed to the high category risk. Based on the mitigation effort determination proportion, there are 15 avoid effort, 13 mitigate effort, 13 accept effort, and 4 transfer effort.

Value at Risk is done by using variance-covariance method. There are 12 high risk that calculated from 21 high risk identified. Based on the calculation result the highest loss caused by the emergence of risk occurred in R61 which is line full in machining process with the amount of Rp 1,038,504. Meanwhile, the lowest value of loss caused by the emergence of risk occurred in R45 which is casting still need to be processed in grinding process with Rp 55,805.

V. ENCLOSURE

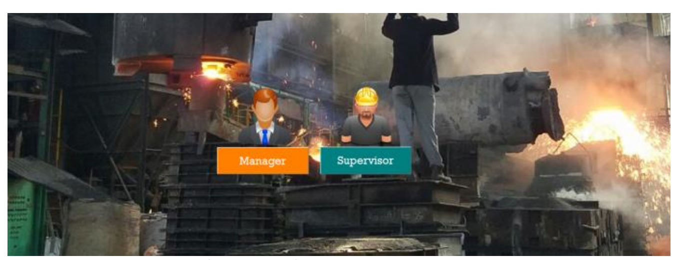

Figure 4. Home page of Risk Profile Dashboard

Figure 5. Manager Login

Figure 6. Supervisor Login

Process	Activity Code	Activity	Risk Code	Risk	Risk Criteria	Potential Effect	Risk Driver	Risk Control
Molding	A1-1	Clean the pattern using compressed air	R1	Broken Compressor	Machine	Molding process cannot be finished	Improper maintenance	Maintenance scheduling and better production planning
			R2	The pattern is not completely cleaned	Man	Bad mold quality	Less experienced operator	Monthly training by supervisor
	A1-2	Fill the flask with sand and level the surface with steel	R3	Broken Pump	Machine	Molding process cannot be finished	Improper maintenance	Maintenance scheduling and better production planning
			R4	Improper mixing	Man	Bad mold quality	Less experienced operator	Monthly training by supervisor
	A1-3	Clean the mold surface and coat the surface	R5	Bad coating	Man	Bad mold quality	Less experienced operator	Monthly training by supervisor
	A1-4	Dry the mold	R6	Broken Furnace	Machine	Drying take a longer time to finish	Improper maintenance	Use manual burner
Core Making	A2-1	Clean the core box using compressed air	R7	Broken Compressor	Machine	Core making process cannot be finished	Improper maintenance	Maintenance scheduling and better production planning
			R8	The pattern is not completely cleaned	Man	Bad core quality	Less experienced operator	Monthly training by supervisor
	A2-2	Fill the core box with sand and level the surface with steel	R9	Broken Pump	Machine	Core making process cannot be finished	Improper maintenance	Maintenance scheduling and better production planning
			R10	Improper mixing	Man	Bad core quality	Less experienced operator	Monthly training by supervisor
			R11	Broken corebox	Machine	Bad core quality	Improper maintenance	Maintenance scheduling and better production planning

Risk Treatment | Risk Assessment | Logout

Figure 7. Risk Database

Process	Risk Code	Risk	Severity	Occurrence	Detection	RPN	Risk Category
Molding	R1	Broken Compressor	2.00	2.00	2.00	8.00	
	R2	The pattern is not completely cleaned	4.00	2.00	2.00	16.00	
	R3	Broken Pump	8.00	5.00	3.00	120.00	
	R4	Improper mixing	3.00	2.00	1.00	6.00	
	R5	Bad coating	8.00	2.00	2.00	32.00	
	R6	Broken Furnace	3.00	2.00	4.00	24.00	
Core Making	R7	Broken Compressor	2.00	2.00	2.00	8.00	
	R8	The pattern is not completely cleaned	3.00	2.00	2.00	12.00	
	R9	Broken Pump	8.00	7.00	3.00	168.00	
	R10	Improper mixing	3.00	2.00	1.00	6.00	
	R11	Broken corebox	2.00	6.00	1.00	12.00	
	R12	Broken core	2.00	5.00	1.00	10.00	
	R13	Bad coating	6.00	4.00	2.00	48.00	
Setting Core	R14	Incomplete core	2.00	3.00	1.00	6.00	
	R15	Broken core	2.00	5.00	1.00	10.00	
	R16	The core and parting lines is not completely cleaned	4.00	2.00	1.00	8.00	
	R17	Loose material left behind	6.00	5.00	3.00	90.00	
	R18	Broken core	2.00	2.00	1.00	4.00	

Risk Database | Risk Mitigation | Logout

High Risk
Medium Risk
Low Risk

Figure 8. Risk Assessment

Process	Risk Code	Risk	Risk Treatment			
			Avoid	Transfer	Mitigate	Accept
Molding	R1	Broken Compressor	Scheduled and preventive maintenance		Allocate idle time for machine	
	R2	The pattern is not completely cleaned	Training by supervisor		Improve supervision	
	R3	Broken Pump	Scheduled and preventive maintenance		Allocate idle time for machine	
	R4	Improper mixing	Training by supervisor		Improve supervision	
	R5	Bad coating	Training by supervisor		Improve supervision	
	R6	Broken Furnace	Scheduled and preventive maintenance			Use manual burner
Core Making	R7	Broken Compressor	Scheduled and preventive maintenance		Allocate idle time for machine	
	R8	The pattern is not completely cleaned	Training by supervisor			
	R9	Broken Pump	Scheduled and preventive maintenance		Allocate idle time for machine	
	R10	Improper mixing	Training by supervisor		Improve supervision	
	R11	Broken corebox	Training by supervisor		Improve supervision	Take another corebox
	R12	Broken core	Training by supervisor		Improve supervision	Take another core
	R13	Bad coating	Training by supervisor		Improve supervision	
	R14	Incomplete core	Training by supervisor		Improve supervision	Take another core
	R15	Broken core	Training by supervisor		Improve supervision	Take another core

Risk Database | Risk Assessment | Logout

Figure 9. Risk Mitigation

Process	Risk Code	Risk	Severity	Occurrence	Detection
Molding	R1	Broken Compressor	2	2	2
	R2	The pattern is not completely cleaned	4	2	2
	R3	Broken Pump	8	5	3
	R4	Improper mixing	3	2	1
	R5	Bad coating	8	2	2
	R6	Broken Furnace	3	2	4
Core Making	R7	Broken Compressor	2	2	2
	R8	The pattern is not completely cleaned	3	2	2
	R9	Broken Pump	8	7	3
	R10	Improper mixing	3	2	1
	R11	Broken corebox	2	6	1
	R12	Broken core	2	5	1
	R13	Bad coating	6	4	2
Setting Core	R14	Incomplete core	2	3	1
	R15	Broken core	2	5	1
	R16	The core and parting lines is not completely cleaned	4	2	1
	R17	Loose material left behind	6	5	3

Risk Database | Risk Mitigation | Risk Assessment | Loss Calculation | Logout

Figure 10. Risk Update

Figure 11. Loss Calculation

Table 3. Risk Mitigation

Risk Code	Risk	Risk Treatment			
		Avoid	Transfer	Mitigate	Accept
R3	Broken Pump	Scheduled and preventive maintenance	-	Allocate idle time for machine; provide spare part	-
R5	Bad coating	Training by supervisor	-	Improve supervision	-
R9	Broken Pump	Scheduled and preventive maintenance	-	Allocate idle time for machine; provide spare part	-
R13	Bad coating	Training by supervisor	-	Improve supervision	-
R17	Loose material left behind	Training by supervisor	-	Improve supervision	-
R21	Broken Furnace	Scheduled and preventive maintenance	-	Allocate idle time for machine; provide spare part	-
R26	Temperature higher than standard	Check the temperature before pouring	-	-	Repair
R28	Broken Belt Conveyor	Scheduled and preventive maintenance	-	Allocate idle time for machine; provide spare part	-
R30	Malfunctioned crane	Scheduled and preventive maintenance	-	Allocate idle time for machine; provide spare part	Use another crane
R32	Broken Belt Conveyor	Scheduled and preventive maintenance	-	-	-
R34	Malfunctioned crane	Scheduled and preventive maintenance	-	Allocate idle time for machine; provide spare part	Use another crane
R38	Malfunctioned impeller	Scheduled and preventive maintenance	-	Allocate idle time for machine; provide spare part	-
R43	Line full	-	Employ worker from another station	-	Proceed to next process
R44	The casting need a lot of grinding	-	Employ worker from another station	-	Hold the product
R45	The casting still need to be processed	-	-	-	Repeat grinding

Table 3. Risk Mitigation (con't)

Risk Code	Risk	Risk Treatment			
		Avoid	**Transfer**	**Mitigate**	**Accept**
R47	Improper inspection	Training by supervisor	-	Improve supervision	-
R48	Broken MPI tools	Scheduled and preventive maintenance	-	Provide spare part	Use available mpi machine
R49	Zone 1 defect discovered	-	-	-	Repair
R51	Line full	-	Employ worker from another station	-	Adding operator
R52	Casting need a lot of welding	-	Employ worker from another station	-	Hold the product
R59	Casting need heat treatment process	-	-	-	Repair
R61	Line full	-	-	-	Extra shift for machining process
R62	Broken CNC machine	Scheduled and preventive maintenance	-	Provide spare part	Use available machine

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